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III. Land Cover Change in Jabotabek Region

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1. Introduction

General land use and cover change in Indonesia has been predominated by two trends, namely deforestation and urbanization-suburbanization Indonesia has more than 120 million ha of tropical forest, the second largest area after Brazil. Deforestation significantly causes loss of species diversity and ultimately leads to species extinction, and to disruption of the hydrological cycle. It also contributes significantly to global warming and greenhouse effect.

In contrast to urbanization in the West, urbanization of metropolitan regions in Southeast Asian countries is often characterized by uncontrolled urban expansion and chaotic land use (Yokohari *et al.*, 2000). Agglomeration and growth of population in the center of the region often lead to expansion of urbanized areas beyond rural areas, which are dominated by agricultural activity. This expansion has resulted in land use conversion from agriculture to urban uses and the emergence of a new landscape in Asia characterized by a mix of agricultural and non-agricultural land uses (McGee, 1991; Sui and Zeng, 2001).

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). This study presents the results of research project on LUCC in the capital city of Indonesia, carried out at the Faculty of Agriculture, Bogor Agriculture University (IPB). The research is devoted to the mapping of land use/land cover of Jakarta Metropolitan Region (also known as Jabotabek) by using combination of remote sensing and in-field data of different spatial and temporal resolution.

Our main objective was to study temporal change and spatial distribution of land cover change within Jabotabek. We carried out the study in three stages by using GIS and remote sensing software packages. First, to analyze land cover change from remote sensing data. Second, to conduct spatial and temporal analysis of land cover change in the study area. Third, to discuss the driving forces of land cover change in the region.

Jabotabek is located in the northern part of Java island and comprises 7 administrative areas within 3 provinces (Figure 1 and 2). 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 Tangerang and district of Tangerang. 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.

We studied temporal change in land use within Jabotabek by using Landsat MSS and TM data. Several studies have shown the utility of such data in land use surveys (Baban & Yusof, 2001; JI, 2001).

Landsat MSS image data for 1972 and 1983 and Landsat TM data for 1991 were sourced from the Tropical Rain Forest Information Center (Michigan, USA), a NASA's Federation of Earth Science Information Partners (funded by Lab. of Landscape Ecology & Planning, The University of Tokyo). Landsat TM 2001 was sourced from Indonesian National Institute of Aeronautics and Space (LAPAN). Topographic maps for 1990 (scale 1:25,000), used for geometric correction of the images, and aerial photographs for 1993 (1:50,000) were obtained from the National Coordination Agency for Surveys and Mapping (Bakosurtanal), Jakarta, Indonesia. GIS data set was sourced from National Land Bureau (BPN), Jakarta, Indonesia.

We carried out this study in several stages by using GIS and remote sensing software packages (Arc-Info 7 and ERDAS 8.3).First, we geometrically corrected the images of 1972, 1983, 1991 and 2001 by using the Bakosurtanal topographical map and a GIS vector data set from National Land Bureau (BPN), Jakarta, Indonesia. The data were transformed to the Universal Mercator (UTM) coordinate system using the Clarke 1880 spheroid in conformity with the topographic map. The root-mean-square error tolerance was set at a maximum of 1.

Second, we joined two overlapping Landsat scenes for each year of Jabotabek area to create a single image for each date by mosaic the individual images. For the Jabotabek region, GIS vector data was superimposed on Landsat raster data within the modeler process in ERDAS. The accuracy of geometric information in vector data and raster data of Landsat images is necessary for the successful superimposition of mosaic images of Jabotabek.

Third, we prepared maps on land cover through supervised classification of the images. Then, we make spatial distribution of land cover change since 1972 to 2001.

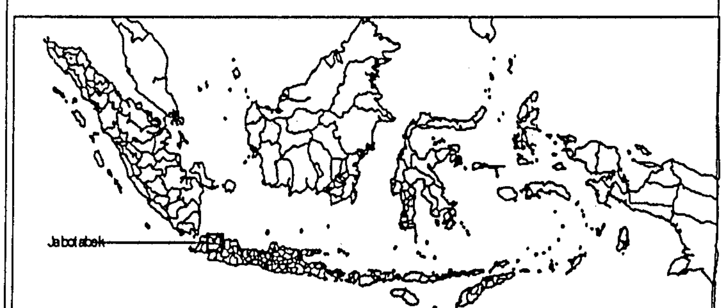

Figure 1. Indonesia and Jabotabek Region

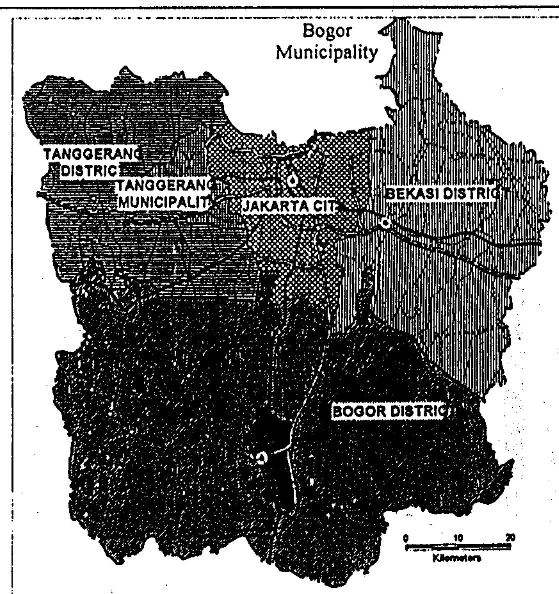

Figure 2. Local Administrative Boundaries in Jabotabek Region

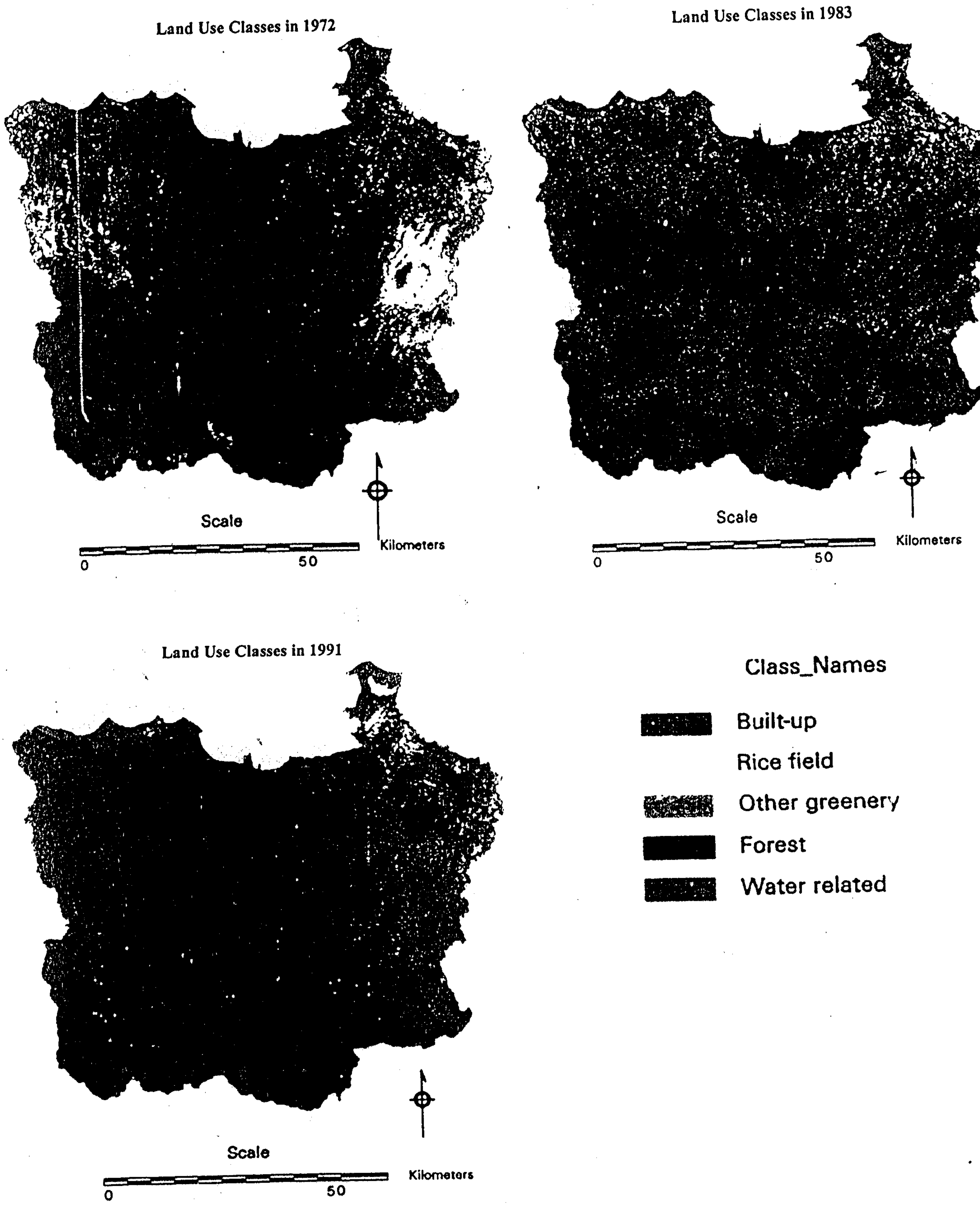

Figure 4. Comparison of Land Use Classes

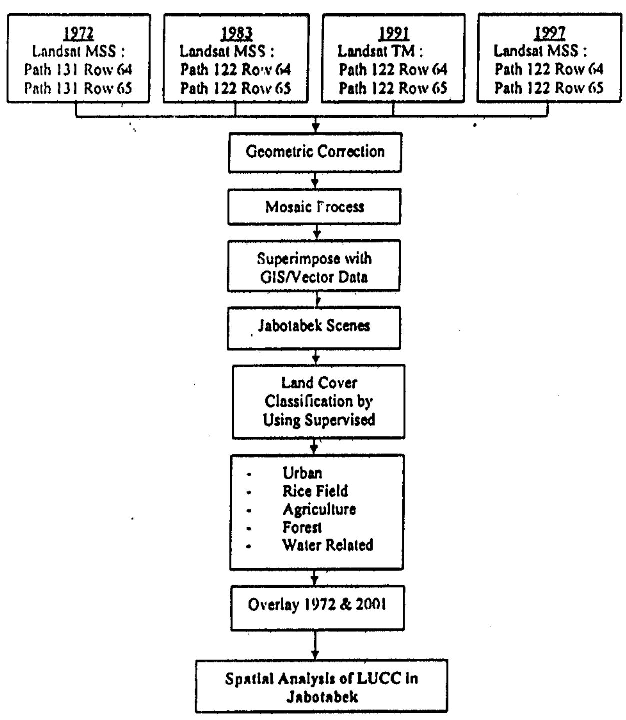

Figure 3. Flow Chart of Land Cover Analysis

2. Land Use/Cover Change

Spatial and temporal analysis of land cover of Jabotabek in 1972, 1983, 1991, 1997 (Figure 4); and 2001 (Figure 5), showed typical characteristics for each area. In general, near the core of Jabotabek, built-up areas are dominant, consisting of residential plots, government offices, and industrial and commercial establishments. The next range is dominated by green open spaces consisting of rice fields, and other greenery such as agricultural and cultivated land, mixed gardens, home gardens and plantation. Land for water-related uses constitutes only a minor component of the total land use. In Jabotabek, urbanization is growing in importance, and built-up areas are expanding rapidly, primarily because the population of this region is increasing

Table 1. Land Cover Change in Jabotabek Region from 1972 to 2001

Region	Total Area		Land Cover Change (ha)			Total
			Agriculture-Urban	Forest-Agriculture	Forest-Urban	
Jakarta City	ha	66,126.00	34,060.88	8.34	6.41	34,075.63
	%	100.00	51.51	0.01	0.01	51.53
Bogor	ha	355,346.00	15,002.12	3,584.13	24.49	18,610.74
	%	100.00	4.22	1.01	0.01	5.24
Tangerang	ha	141,408.00	31,103.32	19.55	5.28	31,128.15
	%	100.00	22.00	0.01	0.00	22.01
Bekasi	ha	148,437.00	31,610.85	25.60	3.38	31,639.83
	%	100.00	21.30	0.02	0.00	21.32
Total Botabek	ha	645,391.00	77,716.29	3,629.28	33.15	81,378.72
	%	100.00	12.04	0.56	0.01	12.61
Jabotabek	ha	711,317.00	111,777.17	3,637.62	39.56	115,454.35
	%	100.00	15.71	0.51	0.01	16.23

Spatial analysis over the range 0 to 5 km from the city center by Zain (2002) showed an increase of built-up areas with time where ratio of the most developed areas showed a rapid increase from nearly 70% in 1972 to more than 90% in 1997. We identified that Jakarta is located in this range. Generally, the area of agriculture land use in our study area decreased from 1972 to 2001 (Table 1). We found that in the Jakarta area, land cover change from agriculture to urban areas reached the highest rate while the agriculture land convert to urban areas around 34,060 ha. Development of office buildings, commercial establishments, and services were dominant in this core as the center of economic growth in Indonesia.

The rapid population growth and economic development in these regions threaten national efforts to preserve prime rice-producing areas. We found that built-up areas were encroaching on agricultural land, especially in the fringes of Jakarta city and the two adjacent satellite cities: Tangerang and Bekasi (Figure 6). The decrease of agricultural land in Bekasi is around 31,610.85 ha, followed by Tangerang (31,103.32 ha) and Bogor (15,002.12 ha). According to Zain (2002) the ratio of built-up areas in the range 5-20 km increased from nearly 20 % in 1972 to more than 80 % in 2001. We found that housing developments dominated in these areas especially since the boom in property business in the beginning of the1990s. The low prices and high access to the center of trade in these areas became the determining factors for conversion.

3. Jabotabek Region and Urbanization-suburbanization

Jabotabek Region is the largest urban concentration in Indonesia. The growth of the city has always been integrated with that of its surrounding areas (Botabek Region). Jabotabek's share of the national population is continuing to increase. In 1961, the population of Jabotabek Region was about 6.1% of the national population, but by 2000 it had reached more than 11% (Figure 7 and Table 2). Botabek Region has contributed significantly to this growth, especially since the1990s.

Table 2. Share of Jakarta and Botabek Regions to National Population

Region	Unit	1961	1971	1981	1991	2000
Jakarta City	Population	2906533	4576009	6555954	8729700	9720400
	%	2.99	3.84	4.33	4.77	4.78
Botabek	Population	3011455	3762068	5543986	9425983	12794587
	%	3.10	3.16	3.66	5.15	6.29
Jabotabek	Population	5917988	8338077	12099940	18155683	22514987
	%	6.10	6.99	8.00	9.92	11.07
Indonesia	Population	97085600	119208200	151314600	182940100	203456005
	%	100.00	100.00	100.00	100.00	100.00

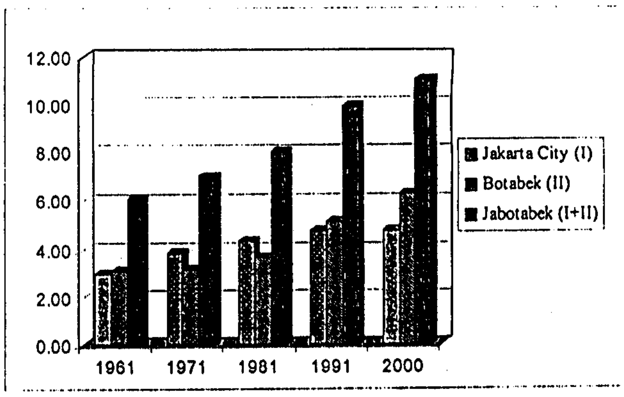

Figure 7. Population Growth of Jabotabek

Until the 1960s, Jakarta city was the main destination for national migration, and had the highest population growth rate in the country. During 1961-1971, the population of the city increased almost about 57%. In the1970s, the local government of Jakarta City declared the city as 'closed' for any migrants, in attempt to control population growth. The policy has never succeeded in stopping in-migration to the city. In-migrants to Jakarta were mainly lower class (in term of economic and education level) and young (Rustiadi and Panuju, 2000). Most of the migrants were motivated to move by economic reason. About 71% of migrants are economically active and working (91.9%), but many studies showed a significant number of disguised unemployment. The informal services sector provides most of the employment.

Since the 1970s, the population growth rate of Jakarta has slowed down. Between 1971 and 1981, it grew 43.3%, between 1981 and 1991 at 33.2%, and between 1991 and 2000 it was only 11.3% (Table 3). However, these figures do not mean that growth rate of the urban population within the boundaries of Jakarta has slowed; a lot of the new growth is concentrated just outside the boundaries of the city. The development of Jakarta's suburbs is the result of the suburbanization process, especially through the expansion of new housing and industrial areas. This is because urban areas of the Botabek region are absorbing more than their share of the growth of the city (Jakarta City), especially due to the accelerated growth of Tangerang and Bekasi (east and west

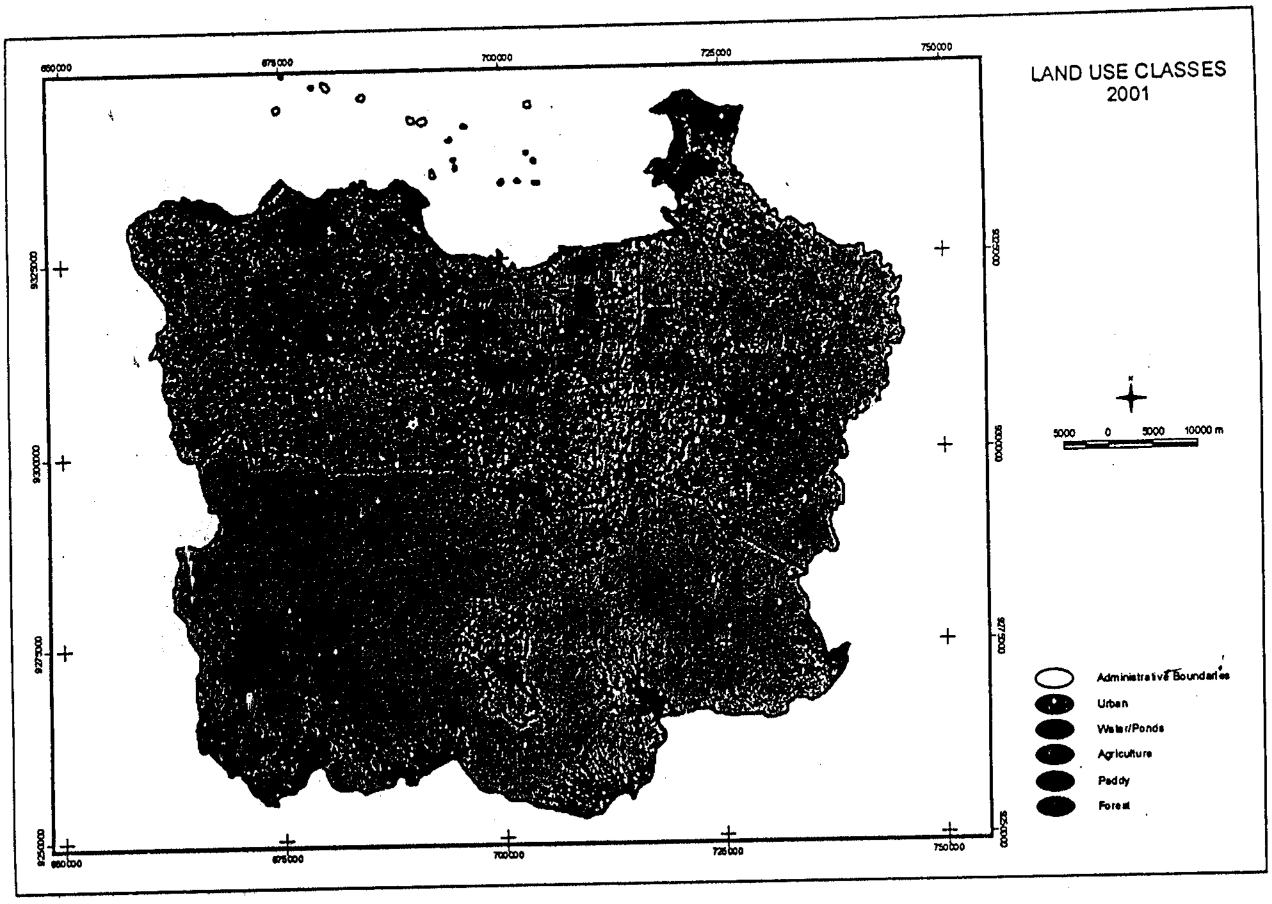

Figure 5. Land Use Classes in 2001

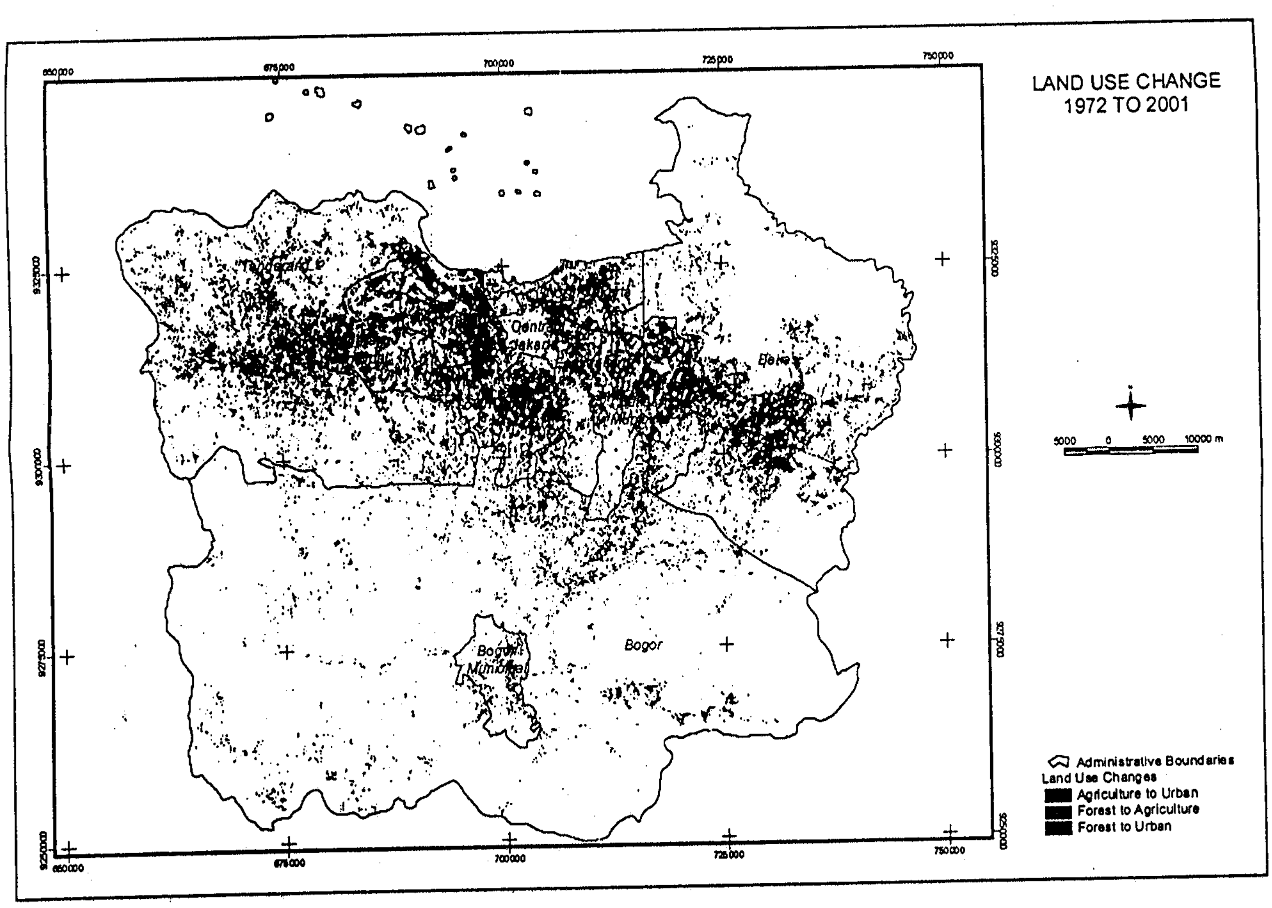

Figure 6. Land Use Change: 1972 to 2001

side of Jakarta City) in the last three decades. At its peak, this periphery zone (Botabek Region) grew by 70% between 1981 and 1991 (Figure 8).

The urban development of Jakarta suburbs were mostly a result of out-migration from Jakarta. It was the result initially of the expansion of *kampung*-type housing in the area closest to Jakarta's boundaries, and then by the development of real-estate-type housing and industry in more distant areas (Rustiadi and Kitamura, 1998; Rustiadi *et al.*, 1999). The suburbanization process has a strong relation with commuting, since most of populations living in the suburb areas are out-migrants or people who conduct business relation with Jakarta City. According to a survey by the Central Bureau of Statistics (1992) conducted in 1991 (BPS, 1992), about 96.0% of population living in Jakarta worked in Jakarta, percentage of Botabek inhabitants working in Jakarta City and their area are 47.8% and 50.4% for Bogor District, 55.5% and 43.5% for Tangerang District and 59.8% and 37.8% for Bekasi.

Since 1990, the population of Botabek passed out the population of Jakarta City (Figure 9). In spite of a relatively high population growth, the amount of out-migration outpaced the amount of in-migration. During period 1990-1995, the gap between out-migration and in-migration for Jakarta City widened. In the period, out-migration exceeded 823,045 (9.0% of Jakarta's population), while in-migration was 594,542 (6.5%). Despite steady overall growth in the population of Jakarta City, Central Jakarta District experienced negative growth of -1.4% in the period 1980 to 1990 and -3.0% in the period 1990 to 2000 while the population of Jakarta City's other districts continued to increase. The decrease in population in the center of Jakarta simply indicates a process of out-migration.

During the period 1975-1997, Jakarta City experienced rapid economic growth (9.0 % per year in average). Since the 1980s, its suburban areas experienced more than 12% economic growth on average (1984-1997). In 1997, the country faced a monetary crisis which caused negative growth (-15% on average) The Jabotabek Region suffered more(-18%) than the country as a whole. Many scholars believed that there was a strong relationship between the crisis and the suburban property booming in 1997.

Table 3. Population, population Density and Areas of Jabotabek region

Year	Indicator	Unit	Jakarta (I)	BOTABEK (II) Bogor	Tangerang	Bekasi	Total (II)	Total (I+II)
1961	Population		2906533	1468248	850390	692817	3011455	5917988
	Population Density	pop/km²	4910	486	642	433	507	905
	Area	km²	592	3020	1325	1600	5945	6537
1971	Population		4576009	1864652	1066695	830721	3762068	8338077
	Population Density	pop/km²	7796	617	805	520	633	1277
	Area	km²	587	3020	1325	1599	5944	6531
1981	Population		6555954	2823201	1515677	1205108	5543986	12099940
	Population Density	pop/km²	9971	935	1144	939	985	1924
	Area	km²	657	3021	1325	1284	5630	6287
1991	Population		8729700	4248038	2933653	2244292	9425983	18155683
	Population Density	pop/km²	13202	1257	2097	1512	1505	2622
	Area	km²	661	3379	1399	1484	6262	6923
2000	Population		9720400	5379279	4087181	3328127	12794587	22514987
	Population Density	pop/km²	14700	1553	2890	2243	2011	3206
	Area	km²	661	3463	1414	1484	6361	7022
1961 -1971 population growth (%)			57.4	27.0	25.4	19.9	24.9	40.9
1971 -1981 population growth (%)			43.3	51.4	42.1	45.1	47.4	45.1
1981 -1991 population growth (%)			33.2	50.5	93.6	86.2	70.0	50.0
1991 -2000 population growth (%)			11.3	26.6	39.3	48.3	35.7	24.0

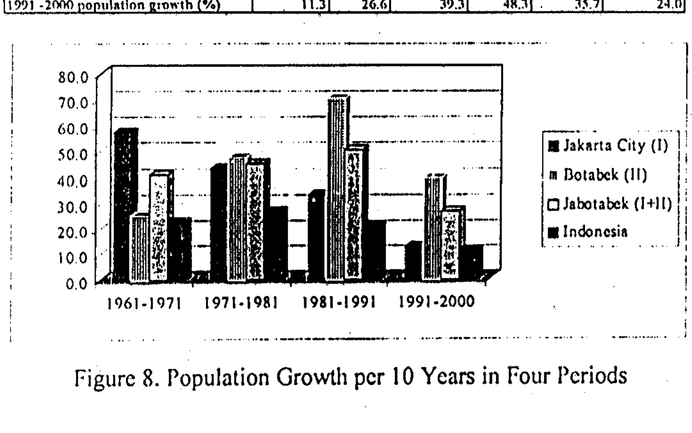

Figure 8. Population Growth per 10 Years in Four Periods

The Jakarta kampungs are inhabited mainly by rural migrants, who are mostly absorbed by the informal sectors or the margins of the formal sectors of the local economy (Somantri, 1995). Kampungs are usually located adjacent to urban centers. Kampung areas surround each of Jakarta's urban centers, from the core to the much smaller tertiary centers.

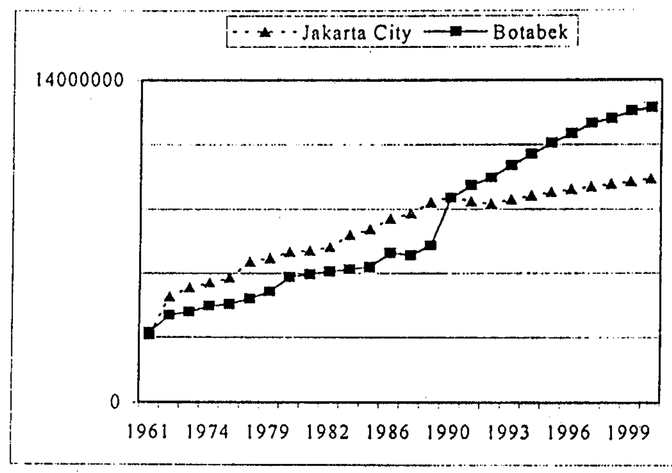

Figure 9. Population of Jakarta City and Botabek Region

There has been a process of systematic demolition of kampungs in Jakarta for many years, particularly in the central part of the city, forcing many of the former inhabitants to move to other areas. Most of the lower-classes have moved only short distances (intra-city migration), whereas the middle- and upper-classes have tended to escape from the kampung areas to more distant and less populated areas. Only the middle- and upper-classes can afford such a move, especially when it is to the suburbs (Somantri, 1995) and they become commuters as a consequence. The poor are prevented from moving into the suburbs by the high cost of suburban housing. Costs are high because of legally required minimum standards for structure size, lot size and building methods (Stanback, 1991). Consequently, the outward migration of the middle- and upper-classes dominate the process of suburbanization in the Jakarta metropolitan area (Rustiadi *et.al.*1999).

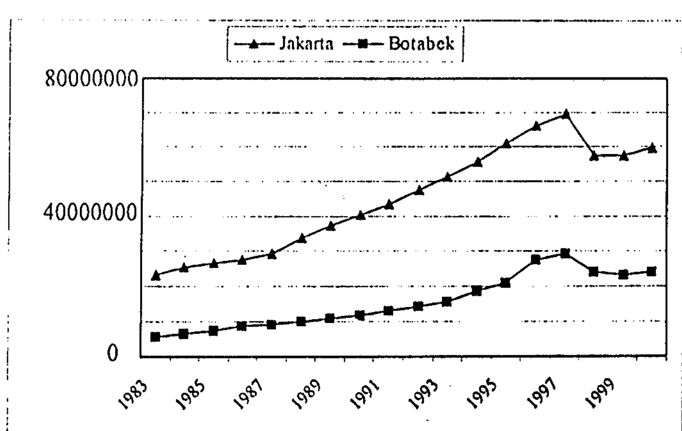

Figure 10. Gross Domestic Product of Jakarta City and Botabek Region

The conversion of rural land to urban use in the suburbs of Jakarta is mainly by land and building development in the private sector, and can be divided into formal and informal private development (Archer, 1994). Real-estate companies carry out most formal development. Informal private development of land, which is not held under a registered title, and is therefore outside the land use regulatory control system, takes place around existing *kampung* or urban settlements and along public roads. About 70% of the new construction in Jakarta's suburbs is developed informally by the owners themselves.

4. Concluding Remarks

Jakarta as capital-city of Indonesia with rapid economic growth became a magnet and attractive area for Indonesian people. Growth of population and urbanization in Jakarta plays an important role on land cover change, not only in Jakarta it self, but also in Jabotabek Region as a whole. The agglomeration process and urban expansion of Jabotabek Region are set to continue for several years but have passed the fastest growing period. Land use conversion in the region, especially from this country's prime agricultural land to urban activities, will still continue. The and use conversion problem has been a concern of national planners but there is no significant action has been taken. Over-urbanization in Jakarta and its surrounding districts has been encouraged by a national urban-bias policy and by centralized development planning.. In the Jabotabek region, this policy has impacted on several environmental and social problems such as frequent flooding, air and water pollution, congestion, urban sprawl, etc. 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 cope with the problems. An accurate spatial description of land use-cover change described in this paper is hoped to contribute to such needs.

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