ANALYSIS OF LAND USE SPATIAL PATTERN CHANGE OF TOWN DEVELOPMENT USING REMOTE SENSING

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Abstract. The Assessment of the physical character of a city is considered relatively easier than the social-cultural aspects. It is important to recognize the type of city form and to predict the behavior of people in the city and its surrounding. Due to those characteristics, the study of the pattern of physical development of the city is required. The objective of research is to analyze the change of spatial pattern of the city due to the city growing by remote sensing. The multitemporal data of Landsat 5/7/8 year 2000, 2006 and 2015 in Jabodetabek area were used. The classification technique had been done and it produced five classes of land uses. Those are water, built-up area, vegetation, other land use and no data. The results of the analysis in Jabodetabek area (Jakarta, Bogor, Depok, Tangerang and Bekasi) show that there was land use changes from vegetation and other land use area to built-up area with an average accuracy of 78% in each year. The pattern of physical development of the city looks linear from year 2000 until year 2006, which is confirmed as concentric pattern from year 2006 to 2015. Based on those analysis, it confirmed that the city development in Jakarta as the center was influenced by the spatial land development of the surrounding cities of Depok, Bogor, Bekasi and Tangerang. The pattern of spatial development from 2000 to 2006 in Bogor, Bekasi and Depok areas is Linear pattern, whereas from 2006 - 2015 the pattern of spatial development shows Propagation Concentric pattern. For Tangerang Region in 2000-2015 its development is patterned Propagation Concentric.

Keywords*: Analysis, Spatial, Remote Sensing, Pattern, Development.*

1 INTRODUCTION

A city is a system of human life network characterized by high population density, heterogeneous and materialistic social economic strata. The city is also a magnet of great attraction to human beings, due to the high level of urban facilities service, the dream of the number of jobs and the ease of reach (Birtanto 2016)

Assessing the physical character of a city is considered easier because the physical form is easier to "see" and "feel" than the socio - cultural aspects. Yet the reality is that although it is easy to see, with a wide range of human settled in vast urban areas, sometimes the physical visual analysis of the city will be very different from the actual situation (Rifai 2011)

Remote sensing technology is a technology that can provide better information without direct contact with the object or area to be observed and in some time imaging (Lillesand *et al.* 2015). The use of remote sensing technology in forestry sector is considered to be a proper choice for detecting dynamics of land cover and land use changes, cheaply and relatively cheaper (Syam *et al.* 2012).

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A research had been conducted on measuring the accuracy of data including its interpretation as well as to study the pattern of physical development of Surakarta city using remote sensing image (Arminah 2002). "The increasing of urban population growth, caused the increases demand in the economic, social, cultural, political and technological aspects which lead to an increasing need of a bigger urban space. On the other hand, the city space is fixed and limited, resulted in the increase needs for space and the land functions which will always take up space in the suburbs (fringe area)." This phenomenon of urban sprawl is referred as "invasion" and the process of physical exposure to the outer city is referred as "urban sprawl" (Yunus 1994).

In accordance to the characteristics of a city with its detailed and comprehensive, a study of the physical development patterns of the city requires relatively detailed data. To obtain this data, several ways have been developed, from a very traditional way using terrestrial surveys to the use of satellite technology which completed with high precision of GPS networking systems and good imaging systems. Satellite imagery and aerial photographs can produce a large-scale of building maps that ultimately can help to design the city in high-precision designs. These needs spur the development of remote sensing imagery capabilities.

The method of Enhanced Built-Up and Bareness Index (EBBI), Soil Adjusted Vegetation Index (SAVI) and Modified Normalized Difference Air Index (MNDWI) was effective and simple to be implemented and can be used for extraction built-up area in other areas (Sinha *et al.* 2016)

Monitoring the physical pattern of urban development is usually observed horizontally. In addition, it is also need to be observed vertically, so it can observe the development of alteration of buildings. The appearance of the pattern of urban physical development can be seen visually at a particular location or point, but on a very wide area of course required a technology that able to observe widely with effective and efficient. Using Landsat imagery along with socio-economic data in post-classification analysis can mapped the dynamics of spatial changes and identify urbanization processes. Land use/land cover statistics, taken from Landsat in 1976, 1988 and 2000, revealed that the built-up area had grown about 47 km^2. The road network has influenced urban spatial design and development patterns, so that the expansion of built areas has vertical growth and horizontal growth, linear along main roads (Mundia *et al.* 2005). The remote sensing satellite data is very useful for monitoring the pattern of physical development of the city (Mundhe 2016). Based on the remote sensing data in four different years (1999, 2004, 2010 and 2014) and based on the temperature retrieval method, the results show that the expansion of built-up area in Jingzhou has not a correlation with the speed of population growth (Wang *et al.* 2018).

The objectives of this research aim to analysis the land use spatial pattern using change of town development using remote sensing.

2 MATERIAL AND METHODOLOGY

In this study, the method consists of several steps, namely: determining the location, data used, data processing, classification, pattern of physical development of the city, and analysis of the phenomenon of the research area.

2.1 Location

Research location is in Jabodetabek (Jakarta, Bogor, Depok, Tangerang, Bekasi), a megapolitan area in Indonesia. This location was chosen due to its relatively short time experiencing of rapid changes or settlement developments and availability of very large accessible data (Figure 2:1).

2.2 Data

The data used in this study consist of primary and secondary data. Primary data consists of multispectral of Landsat 5 and Landsat 7, year of 2000, 2006, 2013 and 2015 (Figure 2-2). Secondary data used in the form of administrative boundaries, infrastructure and river network, and data from field surveys.

Figure 2-1: Study location of research activities (Jabodetabek)

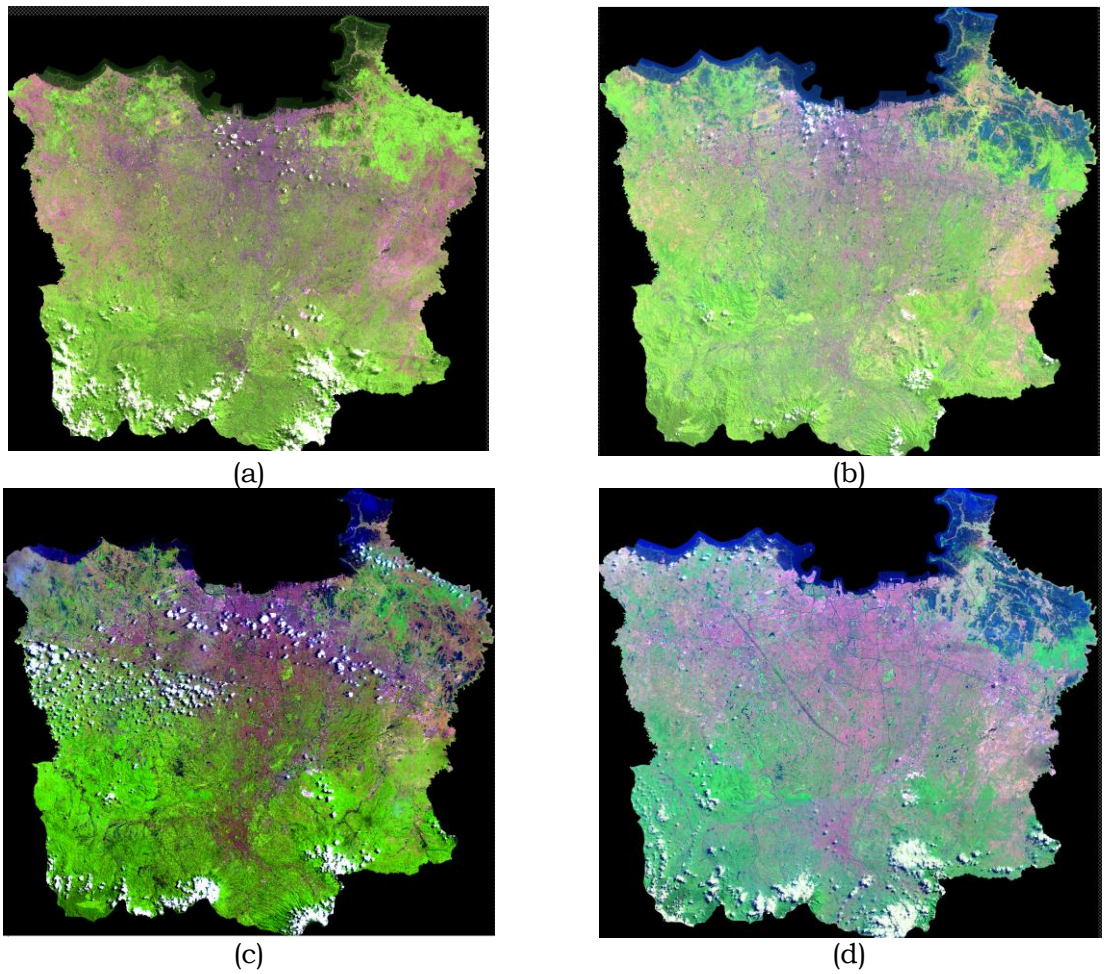

Figure 2-2: Landsat Image 5/7 Jabodetabek Area Years of: (a) 2000, (b) 2006, (c) 2013 and (d) 2015.

2.3 Image Processing

The data used in this research consist of Landsat 5/7/8 which processed radiometric correction and geometric correction, mosaic between scenes and data path contiguously because Jabodetabek area consists of 2 path/row. Data of 2000, 2006, 2013 and 2015 imageries, then classified into several classes as needed.

2.4 Classification

There are five land cover classes namely blue as for water class, red as cleared land use, magenta as for land, green as vegetation and white as for no data. Water class is used to classify some classes of water surface objects, such as sea, lake/reservoir and river. Land classes referred as group of some non-vegetation objects such as ponds and open lands. Vegetation is a group of forest, plantations, fields, mixed garden and paddy fields for rice or intercrop fields (*palawija*). Land of built-up area is a cluster of objects for settlements, markets, shops, offices, industries, ports, terminals, airports and roads. No data is identify as a class of cloud-covered object. The accuracy analysis of the land classification was assessed using 35 points sampling on the Landsat classification result at the specific location from the five regions with reference from Ikonos image retrieved from Google Earth.

2.5 Determination of Physical Town Patterns

Determination of urban physical pattern in this study is followed the model according to Northam in Yunus (1994), that urban physical distribution is divided into three kinds, namely the concentric development pattern, (Figure 2-3):

a. The concentric development pattern (concentric development) is the physical propagation of the city that has a flat nature on the outside, tend to be slow and shows the morphology of a compact city.
b. The pattern of physical development is linear/linear (ribbon/linear/axial development) that is the physical spreading of the city that follows the pattern of the road network and shows unequal distribution in each part of urban development.
c. The leap-frog/cheche pattern of physical propagation of a city that does not follow a particular pattern is called a springing development.

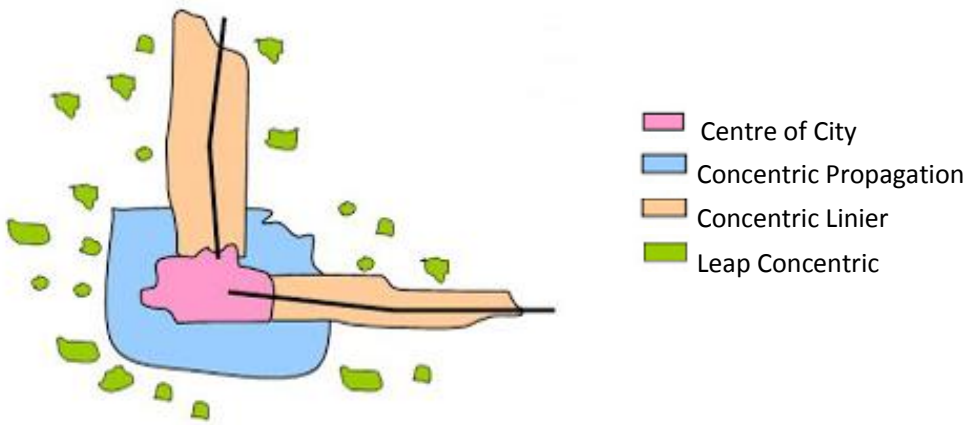

Figure 2-3: Physical of Propagation Models Source: Northam in Yunus (1994)

2.6 Analysis

The analysis was conducted to monitor changes in land cover and urban physical development pattern in Jabodetabek area both quantitatively and qualitatively referring to the model developed by Northam. Analysis is working to see the pattern of city development in the case of study area that is Jabodetabek. Determination of classification area conducted using quantitative calculation analysis, while the determination of land development pattern was built using qualitative analysis based on literature review to determine the pattern of development of Jakarta, Bogor, Depok, Bekasi and Tangerang. The physical development pattern of the city consists of 3 types, they are: concentric development, ribbon/linear/axial development and leap frog/checher board development.

3 RESULT AND DISCUSSION

3.1 Classification of Land Cover.

The result of land cover classification using Landsat-5, Landsat-7 and Landsat-8 data for Jabodetabek area can be seen in Figure 3-1. From the results of the classification of the data of 2000, 2006, 2013 and 2015, the image of 2013 is not sufficient to be analyzed. Therefore, for next analysis data 2013 will be ignored. So that spatial pattern of development city form will only be used data of 2000, 2006, and 2015 (Figure 3-1).

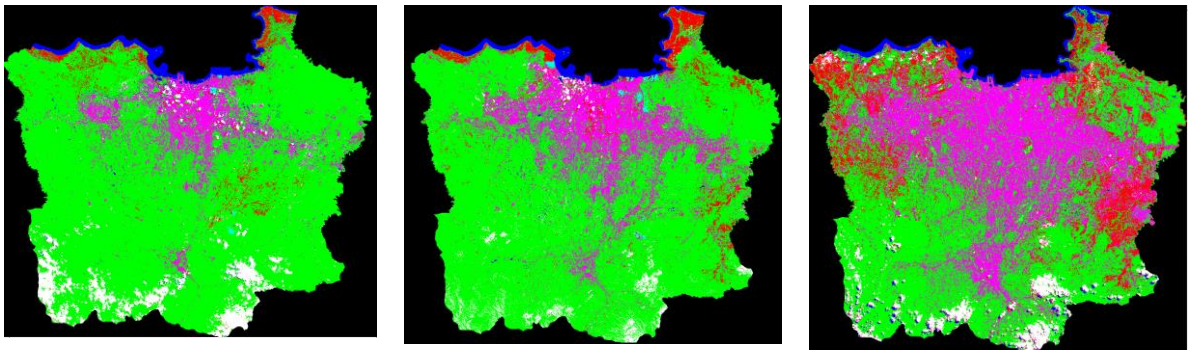

Figure 3-1: Image Classification of Land Use / Land Coverage of Greater Jakarta Jabodetabek

Table 3-1: Land Cover Area of Jabodetabek Year 2000, 2006 and 2015 in units of Hectares (Ha).

Year	2000 (Ha)	2006 (Ha)	2015 (Ha)
Water	18,198.8	16,789.5	19,355.6
Usage of others	19,714.7	32,110.2	89,501.7
Built-up Area	85,203.4	106,518.0	208,768.0
Vegetation	522,713.0	513,586.0	347,915.0
No data	47,441.7	22,994.9	30,760.8

Table 3-2: Accuracy Test of Land Built in Jabodetabek

Regency	Sample Point Built up Area Year 2015	IKONOS Data (Google Earth)		Accuracy
		True	False	
Jakarta	7	7	0	100%
Depok	7	6	1	85%
Bogor	7	6	1	85%
Bekasi	7	4	3	71%
Tangerang	7	4	3	71%
Average				78%

Statistically, land cover area in Jabodetabek in each year can be seen in Table 3-1, with an average accuracy of 78% in each year. The accuracy test can be seen in Table 3-2. The lack of maximum accuracy is due to the presence of cloud cover data and cloud shadows in the research area.

The data in Table 3-1, shows that there was a very significant development from 2000, 2006 until 2015, where the land cover of vegetation area decreased. The addition of others land use area from 2000, 2006 to 2015 was 19,714.7 Ha, 32,110.2 Ha, to 89,501.7 Ha, while the built-up area was 85,203.4 Ha, 106,518.0 Ha and 208,768.0. The addition of the area of built up area largely derived from the cover of vegetation land and another land from derived cover vegetation land into open land. This resulted in the decreased of vegetation land cover from 2000, 2006 to 2015 that is from 522.713.0 Ha, 513,586.0 Ha to 347,915.0 Ha. The area of water has decreased from 2000 to 2006 while the increasing number occurred from 2006 to 2015 because there are cloud and shadow which resulted in the classification accuracy rate at only about 78%. The considering condition that the land built-up area in Jabodetabek will continue to increase, will result in the reduce of land availability due to accommodate humans needs. Therefore it is recommended to develop the city in vertically rather than in horizontally.

The analysis of land cover changes in various areas of Jabodetabek which is located in Jakarta, Bekasi Regency, Bogor Regency, Bekasi City, Bogor City, Depok City, Tangerang City, South Tangerang City and Tangerang Regency from 2000, 2006 and 2015 can be seen in Table 3-3, 3-4 and 3-5. In general, changes in the built-up area in every regency or city in Jabodetabek increased as shown in (Figure 3-2).

Table 3-3: Land Cover Area of Jabodetabek Year 2000 (Ha)

Year 2000	DKI Jakarta	Bekasi Regency	Bogor Regency	Bekasi City	Bogor City	Depok City	Tangerang City	South Tangerang City	Tangerang Regency
Water	1,360.88	1,250.64	594.96	235.88	96.14	22.38	171.98	46.32	553.43
Usage of others	2,114.24	7,055.35	4,642.73	402.13	146.55	212.13	231.99	47.60	4,498.08
Built Land	38,481.27	11,910.24	4,668.53	5,385.67	2,613.17	3,264.19	7,531.26	3,798.06	7,278.46
Vegetation	19,291.68	111,708.29	247,978.92	7,961.08	7,719.23	16,479.64	9,598.51	12,408.94	89,023.86
No data	3.069,91	1,410.41	40,032.87	479.39	674.06	82.64	606.58	105.75	948.74

Table 3-4: Land Cover Area of Jabodetabek Year 2006 (Ha)

Year 2006	DKI Jakarta	Bekasi Regency	Bogor Regency	Bekasi City	Bogor City	Depok City	Tangerang City	South Tangerang City	Tangerang Regency
Water	229.36	800.79	519.60	26.67	0.69	122.14	161.57	147.17	294.37
Usage of others	4,448.47	15,696.12	4,110.79	318.31	72.96	76.75	697.84	103.31	5,934.63
Built Land	40,540.72	14,366.71	11,477.20	6,998.05	2,846.97	4,959.65	9,646.26	5,627.59	9,929.31
Vegetation	16,311.85	101,259.88	264,197.66	6,962.67	8,226.08	14,647.58	6,739.74	10,374.43	84,275.97
No data	2,614.46	807.91	17,541.69	71.69	63.02	232.42	375.76	78.58	1,106.97

Table 3-5: Land Cover Area of Jabodetabek Year 2015 (Ha)

Year 2015	DKI Jakarta	Bekasi Regency	Bogor Regency	Bekasi City	Bogor City	Depok City	Tangerang City	South Tangerang City	Tangerang Regency
Water	198.27	2,351.40	3,697.47	3.90	22.11	25.52	19.51	11.91	710.28
Usage of others	2,732.42	31,450.10	19,145.96	739.39	234.88	953.35	2,265.79	728.95	29.661.39
Built Land	49,336.60	38,712.45	40,635.61	10,763.56	6,956.07	11,111.21	11,855.72	9,881.33	28,634.18
Vegetation	11,654.54	59,940.09	210,095.02	2,900.36	3.961.13	7,887.46	3,755.97	5,707.96	40,996.42
No data	399.42	1,717.53	25,315.70	57.45	75,52	84.05	243.44	76.11	2,733.04

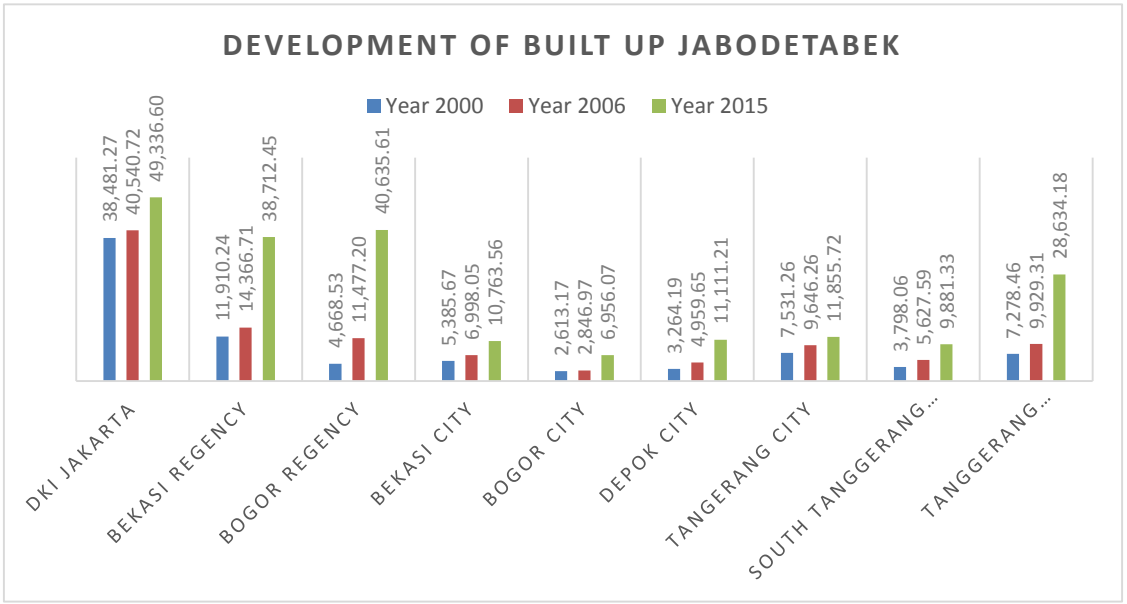

Figure 3-2**:** The Built-Up Area in Jabodetabek Year 2000, 2006 and 2015

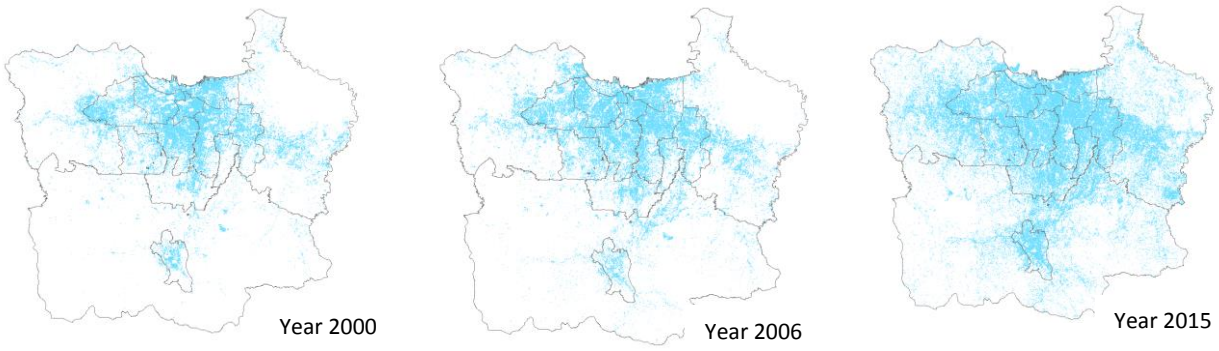

Figure 3-3: Physical Development Pattern of Jabodetabek Year 2000, 2006, and 2015

3.2 Analysis Development of Built-Up Pattern

The pattern of physical development of built-up area in Jabodetabek is very different in every regency or city. Jakarta City from 2000 to 2015 was concentrated in the urban areas, thus forming a pattern of propagation concentrations, because Jakarta has no additional land for constructed land development, so Jakarta is the new center of spatial development of the Depok city, Bogor, Bekasi and Tangerang and its surrounding. This illustrates that Jakarta is the main city that exists with the surrounding small towns of Bogor, Depok, Bekasi and Tangerang. City and Regency of Bogor and Depok has similar pattern of physical development of the city patterned of Concentric Linear from year 2000 until year 2006. This can be seen that there is a change of built-up area along the road, whereas from year 2006 to year 2015 pattern of physical development of town shows a Propagation Concentric pattern, because the development of land conversion was built by means of propagation that is concentrated in the city center. The Bekasi city from 2000 to 2006 shows the Concentric Linear pattern of physical development of the city, but from 2006 until 2015 the physical development pattern of the city showed a Leap concentric. Meanwhile, for Tangerang city or Regency, the pattern of physical development of the city has started from 2000 until 2015 with the patterned of Concentric Propagation. This can be seen in Figure 3-3.

4 CONCLUSION

Land cover changed of ponds and open lands area from 2000, 2006 to 2015, was 19,714.7 Ha, 32,110.2 Ha, to 89,501.7 Ha, while the built-up area was 85,203.4 Ha, 106,518.0 Ha and 208,768.0 Ha, and vegetation decreased from 2000, 2006 to 2015 that is 522,713.0 Ha, 513,586.0 Ha to 347,915.0 Ha, with an average accuracy of 78% in each year. The pattern of development of Jakarta from 2000-2015 is in the form of Propagation Concentric Pattern. Within 5 years Jakarta became a new center as the main city of the small towns of Bogor, Depok, Bekasi and Tengerang. Year 2000-2006 Depok, Bogor and Bekasi formed a Linear Concentric pattern, while from 2006 and 2015 shows patterned of Propagation Concentric. Tangerang city from 2000-2015 experienced a change pattern of pattern development of propagation concentric pattern.

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