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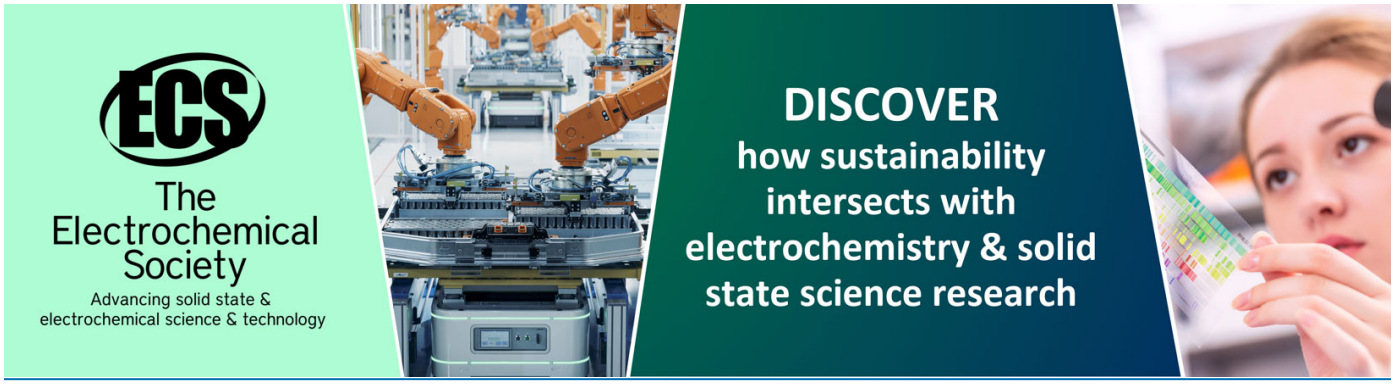

Study about factors influencing transition of green open spaces based on analysis of land use in Depok City, West Java, Indonesia

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Abstract. Most green open spaces in Jakarta, the capital city of Indonesia, are susceptible to conversion into urban use. In Jakarta, land development is progressing to the point where there is no room for additional land development, resulting in a shift to land development in other cities, especially the urban areas surrounding Jakarta, Jabodetabek. This study focused on land development in Depok City located south of Jakarta. Depok is influenced strongly by land development in Jakarta, and further economic growth is expected. The purpose of this study is to reveal the changes in the area of green open spaces to investigate the transition of green open spaces in Depok and to identify the factors influencing the transition of green open spaces in Depok. ERDAS 9.1 Software was used to analyze the changes in the area of green open spaces in 1995–2015. To identify the factors influencing the transition of green open spaces, binomial logistic regression analysis was used. It was revealed that the area of green open spaces has rapidly decreased from 2005 (9789.28Ha) to 2015(5157.80Ha) in Depok. The results of logistic regression analysis showed Logit Y = 2.575 − 0.118 X1 − 0.012 X2. Two factors particularly influenced the transition of green open spaces, the proximity to educational areas or main roads was associated with reductions in green open spaces.

Keywords: green open spaces, land use, Depok City

1. Introduction

Indonesia has the fourth largest population in the world with a fast-growing economy, and further economic growth is expected in the near future. With continued growth, urban land development is progressing rapidly and green open spaces are changing to urban land use areas at an increasing rate. Most green open spaces in Jakarta, the capital city of Indonesia, are susceptible to conversion into urban use. Therefore, it is necessary to increase the protected areas in the future. According to Law No. 26-the spatial planning law, established in 2007, each city must have green open spaces with an area of at least 30% of the total area of the city. The government of Jakarta has been promoting measures for the expansion of green open spaces, such as planting roadside trees. However, a large part of Jakarta is covered by impervious surfaces such as pavement and buildings and the city has only a few green open spaces left; thus, the achievement of the Law No. 26 target does not seem possible [1]. In Jakarta, land development is progressing to the point where there is no room for additional land development, resulting in a shift to land development in other cities, especially the urban areas surrounding Jakarta, Jabodetabek.

The environment, land use management strategies, and socio-economic factors are the major causes of land use changes [2]. Some factors are caused by local and social changes and land conditions [3]. When new jobs are created by establishing factories and commercial facilities, housing demand in that location may increase. There is a possibility that new houses are built around existing transportation routes, stations, schools, hospitals, and commercial buildings. The environmental factor, such as being located in the outside of flood zone, is also considered when constructing new houses.New housing construction reduces the area of available green open spaces [4]. The population growth, the emergence of new town projects and large manufacturing centers, greater job opportunities, and the availability of easy transportation all contribute to urbanization and suburbanization [5].

In the Jabodetabek metropolitan area, the distribution of land use within the city should be studied to solve land use problems by proposing new plans for keeping green open spaces while maintaining the economic growth. In Indonesia, urbanization may progress in cities other than the Jabodetabek metropolitan area in the near future. By identifying the factors influencing the transition of green open spaces to other uses by land development in Jakarta, it is possible to create timely and effective plans for the other cities.

2. Study Purpose

The purpose of this study is to reveal the changes in the area of green open spaces to investigate the transition of green open spaces in Depok and to identify the factors influencing the transition of green open spaces in Depok.

3. Study Method

3.1. Study Area

This study focused on land development in Depok Citylocated south of Jakarta, geographically located at coordinates 6°19′00″–6°28′00″S and 106°43′00″–106°55′30″E. Depok is a part of the Jabodetabek metropolitan area, which is the largest and the most strategic metropolitan area in Indonesia. Jabodetabek consists of Jakarta, Bogor City, Bogor Regency, Depok City, Tangerang City, South Tangerang City, Tangerang Regency, Bekasi City, and Bekasi Regency [6]. This area will be further developed as a strategic region to support national economic growth [7].

Depok is one of the newly developed areas in West Java, formed by Law No. 15 in 1999. Depok has a tropical climate and the difference in seasonal rainfall amounts is small. The tropical climate supports agriculture by providing rainfall all year round but it is necessary to consider the distribution of land use within the city, especially, the availability of green open spaces. Depok is a commercial and a public utilities center, where water is stored to supply groundwater to the city of Jakarta. Moreover, it is a hotspot for educational and residential development. Depok is strongly influenced by land development in Jakarta, andfurther economic growth is expected. Further economic growth in Jakarta will also put extra pressure on Depok.

Based on the data from the Central Statistics Agency of Depok [8], the total population of Depok was approximately 2,179,810 in 2016 and the annual population growth rate of 2010–2016 was 3.53%. The total land area of Depok is 200.29 km^2, which includes 11 districts, Beji, Bojongsari, Sawangan, Pancoran Mas, Cipayung, Sukma Jaya, Cimanggis, Tapos, Limo, Cilodong, Cinere.

3.2. Materials and Methods

In this study, ERDAS IMAGINE 9.1, ArcGIS 10.2.2, and IBM SPSS Statistics19 tools were used for analysis. ERDAS IMAGINE 9.1 was used to analyze the changes in the area of green open spaces in 1995–2015, ArcGIS 10.2.2 was used to analyze the land use in Depok, and IBM SPSS Statistics19 was used for statistical analysis. The Landsat satellite images were processed using the steps of layer stack, geometric correction, subset image (cutting the image of the study area), land cover classification, and accuracy assessment.

To identify the factors influencing the transition of green open spaces, binomial logistic regression analysis was performed:

$$\text{Logit}(Y) = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_iX_n$$

Description: Y = Dependent Variable, X = Independent Variable, a = Constant, b_i = Coefficients of Independent Variables, i for 1,2,3, ... n

The logistic regression formula was developed using data from 2005 to 2015. In this study, the dependent variable is defined as the area of green open spaces converted into non-green open spaces. The independent variables included the distance from commercial areas, industrial areas, educational areas, hospitals, rivers, lakes, main roads, a highway, a highway entrance, railroad stations, and inundation-prone areas.

In order to separate the areas where the green open space is decreasing and the areas where the green open space is maintained, the analysis was conducted at 1-km resolution. The number of cells was 239; 78 cells were extracted as the area where the green open space was greatly reduced from 2005 to 2015 and 14 cells were extracted as the area where the green open space was maintained. Land use data for 2015 are provided by the Depok Municipal Spatial Planning Bureau.

4. Results and Discussion

4.1. Changes in the area of green open spaces

The processing of Landsat imagery revealed the percentage of the land cover in Depok with 80% accuracy. Landsat images for the years 1995 (TM), 2005 (TM), and 2015 (ETM+) were used; the image for 1995 revealed the extent of Depok with 87.02% accuracy, the image for 2005 with 88.24% accuracy, and the image for 2015 with 85.16% accuracy. The results of land cover classification (green open space and non-green open space) are shown in Table 1 and the green open space maps of Depok are shown in Figure 1. The results showed that the area of green open spaces has rapidly decreased from 2005to 2015in Depok. The area of green open spaces was 9789.28 Ha in 2005, 48.88% of the total area of the city.The area of green open spaces was 5157.80 Hain 2015, 25.75% of the total area of the city.

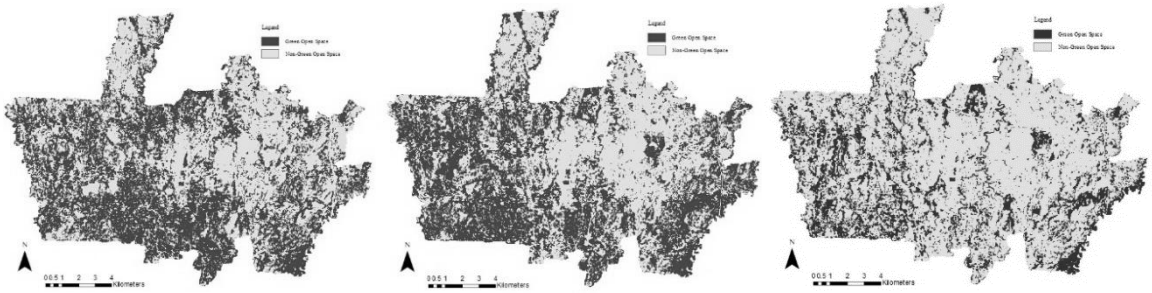

Figure 1. Green Open Space Maps of Depok

Table 1. Land Cover in Depok

Land Cover	1995		2005		2015	
	Area (Ha)	Percentage (%)	Area (Ha)	Percentage (%)	Area (Ha)	Percentage (%)
Green Open Space	10002.49	49.94	9789.28	48.88	5157.80	25.75
Non-Green Open Space	10026.51	50.06	10239.72	51.12	14871.20	74.25
Total	20029	100	20029	100	20029	100

4.2. Factors influencing the transition of green open spaces

The result of the binomial logistic regression analysis can be expressed by the following equation:

Logit (area of green open spaces converted into non-green open spaces) = 2.575 − 0.118 × Distance from educational areas − 0.012 × Distance from main roads

Using the p-value of each independent variable, the distance from educational areas and distance from main roads were found to be statistically significant at the 5% level, but the distance from commercial areas, industrial areas, hospitals, rivers, lakes, a highway, a highway entrance, railroad stations, and inundation-prone areas were not statistically significant at the 5% level. The coefficients, odds ratio, odds ratio atthe 95% confidence interval, and p-value of each variable are shown in Table 2.

Table 2. Results of logistic regression analysis

Variables	Coefficient	Odds Ratio	Odds Ratio at the 95% Confidence Interval	P Value
Distance from educational areas	−0.118	0.889	0.807 − 0.979	0.017
Distance from main roads	−0.012	0.988	0.978 − 0.999	0.031
Intercept	2.575			

The results suggest that the distance from educational areas and main roads werethe main factors influencing the transition of green open spaces in Depok. By using each main road, access from Depok to Jakarta, Bogor, and Tangerang is possible. The number of motor vehicles, especially the number of motorcycles, is rapidly increasing in Depokeach year. The spatial structure of the city along with the transportation network that depends mostly on private vehicles leads to a decrease in green spaces and in urban environmental quality [9]. No relation between the reduction in the area of green open spaces and the distance from railroad stations was detected by the results. There is also no relation between the reduction in the area of green open spaces and the distance from the entrance of a highway. It is possible to easilytravel to other cities by using motor vehicles on main roads in Depok. The number of schools, as well as the number of students in elementary schools, junior high schools, and high schools has increased in recent years.

The large number of people who work in Jakarta but live in Depok has tremendously increased the property development in this city. Most of the residential area in Depok has high building density and widespread asphalt pavement cover [10]. The reduction of the area of available green open spaces has actually been caused by new housing construction in Depok. The number of residential buildings has increased in areas where the living conditions have improved, and distance from educational areas and distance from main roads are among the major factors reducing the area of green open spaces in Depok.

5. Conclusion

The area of green open spaces has rapidly decreased in Depok from 2005 to 2015. The proximity to educational areas or main roads was associated with reductions in green open spaces because the number of residential buildings has increased in areas where living conditions have improved. It is important to develop green open spaces (e.g., city parks) that children and families can easily access to. Currently, there are only a few city parks in Depok that cover 294.38 Ha, only 1.47% of the total area of the city, according to the Depok Municipal Spatial Planning Bureau [11]. It is also important to increase the area of green open spaces by planting street trees. The street trees in Depok cover an area of 56.39 Ha, 0.28% of the total area of the city.

There is still vacant land available with an area of 692.48 Ha in eight districts of Depok, 3.46% of the total area of the city. Although new buildings may occupy that land in the future,it is necessary to develop green open spaces in that land. The regulations on green open spaces in the spatial plan of Depok for the provision and utilization of public green open spaces include the development of roof gardens and vertical gardens in densely populated areas. It is necessary to put effort into the development of roof gardens and vertical gardens to improve the environmental quality in Depok.

By developing green open spaces within a short distance of educational areas, the function of the space for environmental education could be emphasized. This study reveals that the distance from the

educational areas influences the reduction of green open spaces as new knowledge; thus, this factor should be considered in future development plans as a survey component.

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