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Satellite Imagery Data: Dynamic Systems Model for sustainable urban forest in area of Halim Perdana Kusuma, East Jakarta

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Abstract. East Jakarta icon as a buffer and the lungs of the city is still a big dream of Jakarta. It is a classic problem that there is a struggle for land between current economic interests and sustainable environmental interests for the future. This paper discusses the development of urban forest area of Halim Perdana Kusuma, East Jakarta. The forest area according to regulations of existing city local governments is not enough to support sustainable urban development indicators. Therefore, it requires an extensive mapping of urban forest potential development accurately by utilizing satellite imaging technology. Landsat-TM satellite imagery data can provide a full picture of the potential land width for urban forest area development. The results of this satellite image will then be made into a model of urban forest as one of the indicators of sustainable urban development. This research aims to support sustainable urban development through environmental balance in the form of a green neighborhood revitalization and development of urban forests and to create socio-economic balance. This paper uses a dynamic system model to simulate the conditions of the region against the intervention performed in the potential area for development of urban forests which are derived from urban spatial analysis based on satellite image data, using GIS program as a tool. The result is a model of urban forest area which is integrated with a social and economic function to encourage the development of sustainable cities.

1. Introduction

In some countries, the urban forest has become an important component in planning sustainable urban development [13]. Developing a forest area of the city is expected to encourage the formation of an ideal city. The ideal city is often interpreted in four ways: (1) as a sustainable urban ecological system, (2) developing in a just manner, (3) the economy grows sustainably, (4) culturally able to develop a strong local identity [10]. City forest serves to mitigate urban discomfort [5]. City forest relates to vegetation function [3]. Urban forests are as carbon stocks in trees [4,7,12,15]. Urban forest and the effect of rainwater reduce runoff [14]. In addition, city forest creates socio-economic balance [9]. The institutional framework for sustainable development involves: a) a system with functions related to its environment, b) the existence of organizational structures and procedures governing the tasks, products, communities, resources and objectives of the organization, c) preparing the organization's resilience to changes in resources resulting from economic and political relations [6]. The background of sustainability is the desire for environmental, social and economic harmony. In the context of global industry, sustainability can be defined as current development [1,2]. All economic, environmental and social components are interrelated and cannot work independently, therefore a partnership approach to all problems [6,11] should be developed. One framework strategy for achieving sustainable development is to strengthen the institution by preparing the organization's resilience to resource changes due to economic and political relations [6]. The purpose of this research is to find out the potential of urban forest area by using satellite image data analyzed with GIS tool, and then to make a model with dynamic system analysis model. The result is a model of urban forest development for sustainable urban development.

2. Methodology

The analytical methods used in this research are spatial analysis and modeling analysis, which aim to find the relationship between the broad needs of urban forest and the spatial pattern of urban forest growth, and other variables as an integral part in achieving sustainable urban development.

1. Spatial analysis

Analysis of the spatial growth is the main part of landscape ecology research, which aims to connect several complex parts between landscape patterns and processes of landscape change. It is analyzed using Geographic Information System (GIS) tools to manage geographically referenced spatial data. Data processing and data analysis were performed by rotation, scaling coordinate conversion, coordinate conversion geography, registration and spatial analysis and statistics.

The analysis in the database was done by overlaying several layers needed. To determine the condition of the existing land cover classification provided by the forest or vegetation that could potentially be a forest, land cover spatial information was obtained through satellite imagery, as shown in table 1 and table 2.

Table 1. Region with the amount of carbon dioxide produced in 2015 [16].

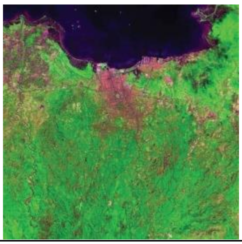
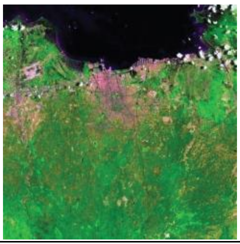
June 21, 1976	October 3, 1982	September 17, 2001	April 22, 2011
			
Vegetated Area Size 37.375ha (56.50%)	Vegetated Area Size 35.655ha (53.90%)	Vegetated Area Size 19.184ha (29.00%)	Vegetated Area Size 16.542ha (24.98%)

Table 2. Growth vegetated land cover size.

Region Size	**Location**	**Vegetated Land Cover Size (ha)**			
		1974	**1989**	**2005**	**2015**
2,163	Makassar	2,044	1,588	1,173	1,046

2. Modeling Analysis

The interaction between spatial land use patterns in urban areas and the pattern of urban forests is a complex system. The system dynamics method is one of the modeling techniques that can include complex and non-linear systems of multiple feedback relationships, which allow to conduct behavioral analysis and examine the long-term impact of a policy through the model [8]. The system dynamics model formulated is used for two things: (1) analyzing the environmental carrying capacity due to urban forest development, land use structure, and environmental quality as represented by ecological footprint variables. (2) examining some scenarios ahead in optimizing and controlling urban forests. The models analyzed are business as usual scenarios and compared with scenarios for applying sustainable urban development concepts through the application of eco-city concept as an alternative to the proposed scenario.

3. Result

The results of the interpretation of satellite imagery obtained by the division of the land cover categories are in the form of land vegetation (trees, bushes, meadows, fields), vacant land, bodies of water, non-vegetation (residential / buildings, roads) and no data (cloud, shadow clouds). In this study, the results of the image can be assumed as a forest of trees, while land vegetation in the form of shrubs and grass is assumed as a potential land to be reforested. The image fields and vacant land are assumed to be an area that can be converted into forest. The area of land cover based on satellite imagery in East Jakarta for each research area in the district of Makasar is presented in Table 3.

Table 3. Land cover vast area Makasar Sub-district study.

Areas of Observation	Land Cover Size (Ha)					
	Tree	Bush	Grass	Rice fields	Empty Land	Other
District Makasar	763.70	63.49	218.31	103.92	135.45	952.16
Sub-District Pinang Ranti	62.39	17.74	8.55	5.57	12.43	132.35
Sub-District Makasar	40.06	3.25	0.01	-	0.18	95.35
Sub-District Kebon Pala	59.36	4.54	0.59	4.20	2.27	149.87
Sub-District Halim PK	506.81	32.27	206.78	91.60	120.00	418.17
Sub-District Cipinang	95.08	5.69	2.38	2.55	0.57	156.42

The results of satellite image data processed with GIS are explained in Figure 1. From the results of satellite image processing, it can be described in broad outline that the area of trees with the potential to become urban forest in District Makasar is an area of 763.70 ha, and another potential area which can be developed into urban forest with a special intervention is an area of 1320 ha.

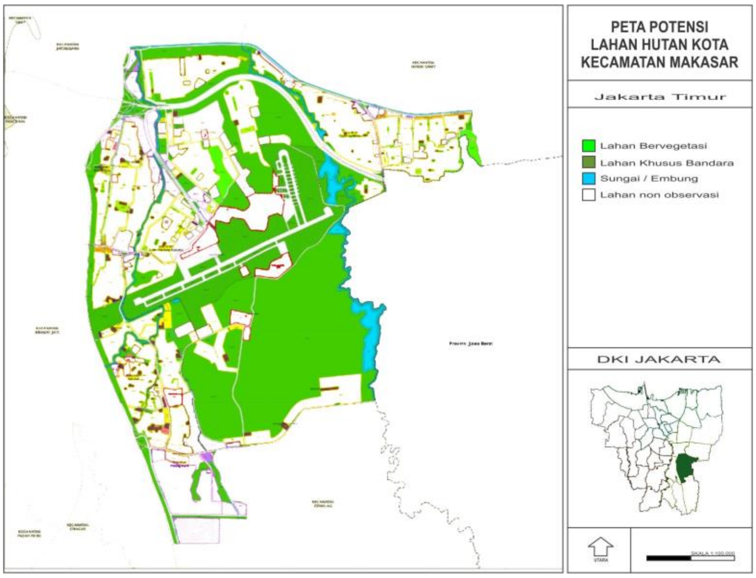


Figure 1. Map of Forest Land Potential of District Makasar

The carrying capacity of urban land is the urban limits of the city which is the object of observation. Carrying capacity of urban forest is a town's forest area limits built in accordance with the regulations that apply to the object of observation, located in East Jakarta. Population growth rate is a growth index in general. Although the intervention is done maximally, the urban forest area will still decrease because this modeling does not intervene all aspects due to other things. The intervention is assumed to increase forest cover city and get the level of GDP sustained. The intervention scenario was conducted with the Stock-Flow Diagram in modeling 'urban forests for sustainable development as depicted in Figure 2.

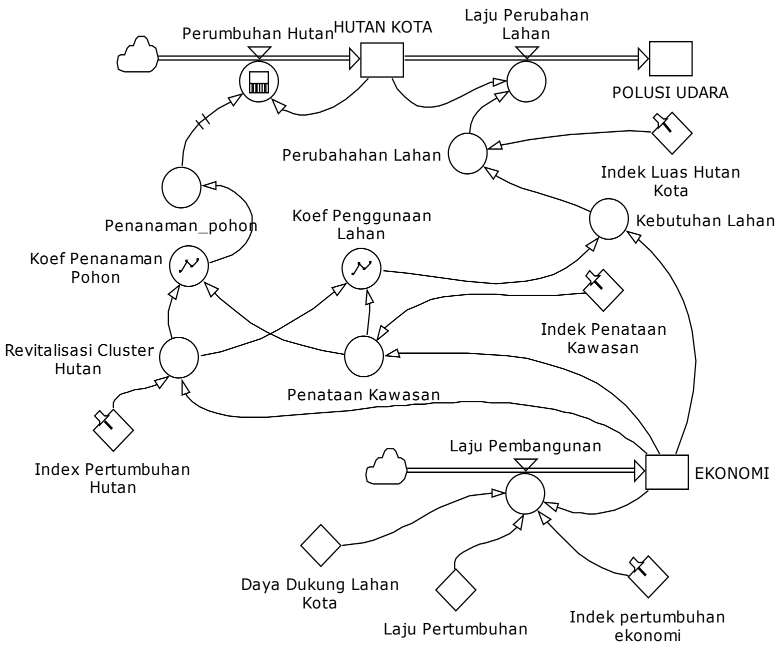


Figure 2. Stock-Flow Diagram modeling with intervention scenario.

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In this intervention model, on the urban forest and GDP, the graph function coefficients are applied to the planting of trees and the coefficient of land use is a representation of the concept of regional restructuring and revitalization of the forest cluster.

Delay function is applied to the forest growth on the assumption that the growth requires 30 years (age modeling assumptions). Index of regional restructuring and revitalization of the forest cluster creates slider function to get an ideal figure and it is considered sustainable. The results of simulation models of the intervention scenario are shown in Table 4, which shows the different number of urban forests, air pollution levels and the rate of GDP growth. If the number of the urban forest is lower than the initial model simulation scenario it will keep on declining, but it is able to reduce the level of pollution air.

Table 4. Simulation models of intervention scenarios of District Makasar.

Year	Urban Forest Index	Air pollution Index	GDP Index
2015	1.19	1.88	1.05
2020	1.54	2.02	3.11
2025	1.81	2.31	4.18
2030	1.97	2.73	5.01
2035	2.03	3.26	5.73
2040	2.03	3.86	6.36
2045	1.98	3.51	6.93

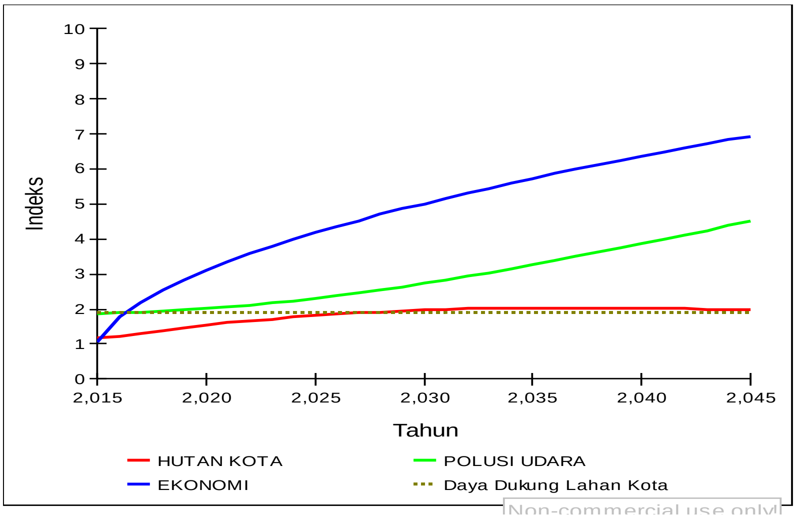

Figure 3. Graph modeling of behavior intervention scenario of District Makasar.

4. Conclusion

The result of satellite image data that wasprocessed with GIS and has the potential to be an urban forest in Makassar sub-district is 763 ha, and the potential can be developed with intervention to 1320 ha. Based on the simulation result, as illustrated in Figure 3, the effect of the intervention on changes in forest area is about the graph of modeling behavior in the intervention scenario. The graph indicates if the index of GDP increases, the air pollution index will follow to increase, but with specific interventions in the urban forest index that is in accordance with the increase of GDP index. The results of modeling with the conditions of urban forest index affect the index of GDP and air pollution. The GDP index in District Makasar increased by an average of 0:15, then followed by the air pollution index which is by an average of 0.10.The increase is equivalent to the increased levels of CO in the air which reaches an average of 3,574 tons/year.

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