

Spatial analysis: Mapping potential land for sustainable urban forests using Landsat-TM satellite data imagery in East Jakarta

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Abstract. This paper discusses the development of urban forest areas in eastern Jakarta to encourage sustainable urban development and socio-economic environment balance. This research aims to calculate the urban forest area needs in sub-district of Makasar, Ciracas and Cakung sub-districts, East Jakarta. The method used is to calculate index of urban forest area requirement (Indeks Luas Hutan Kota / ILHK) with Marshal Edgewarth method approach. The potential land mapping using Landsat-TM satellite image data is further processed through spatial allasis using Geographic Information System (GIS). The results of this research indicate the existence of sufficient land potential and can function ecologically as urban forests, and able to be a driver for sustainable urban development.

Keywords: *Urban forests, potential land use, urbans Spatial*

1. Introduction

In some countries the urban forest has become one of the important components in sustainable city development [1]. Some cities in the world to apply index of forest area of the city, such as in Kuala Lumpur city forest area designated an area of 1.9 m² / resident, in Tokyo is set at 5.0 m² / resident, Lancashire United Kingdom accounted for 11.5 m² / resident, in New York determining forest area more fantastic city that is 60 m² / resident [2]. The condition of urban forest in DKI Jakarta currently raises the problem both from the broad side of the area and its ecological condition. If referring to the projection and development plan of urban forest area in 2030 is 1,587 ha, while the existing condition of urban forest is only 646 ha (BPLHD DKI Jakarta 2015). To support the creation of urban forest ecological function optimally and grow equitably, depth study is needed so that the urban forest in Jakarta able to grow and become an important part of an integrated process of sustainable city development. This study covers the determination of the area of urban forest and the potential for land to be optimized into urban forests.

Concepts developed in this study is partly, covering urban forest research and the involvement of surrounding communities [3]. Urban forest and mitigation against urban discomfort [4]. Related urban forest vegetation function [5]. Urban forest and carbon stock analysis in trees [6]. Urban forests and



the effects of rainwater runoff reduction [7], Urban forests and the potential to reduce carbon emissions [8]. Urban forest and socio-economic balance [9].

2. Methodes

The method of analysis in this research is used to analyze the main system, that is: (1) Calculation of City Wide Forest Index, based on data from the analysis of urban forest needs, environmental analysis, economic and cultural analysis. (2) Analysis of spatial pattern of growth of urban land use to calculate the vast potential of the urban forest. The calculation of this index number using Edgewarth Marshal method, this method index is calculated by combining the base year quantity and quantity of years (n), and then multiply by the price of the base year or year (n). the details of the equation is as follows:

$$ILHK = \frac{LHn1/LWn1}{LHn0/LWn0} \times 100 \times KLHKn1 \times IPLn1 \times IPEn1 \dots\dots\dots (1)$$

- ILKH = Urban Forest Index
- LHn¹ = Forest Area in the calculated year
- LHn⁰ = Forest Area in the base year
- LWn¹ = Area of the year counted
- LWn⁰ = Area in the base year
- KLHK = Urban Forest Needs
- IPL = Environmental Pollution Index
- IPE = Economic Growth Index

The index number is a statistical measure that shows changes in a variable or set of variables related to each other, either in time or place of the same or different. The index number is a relative number that is expressed in numbers, while the index numbers relative used in this study is the relative number of the most minor, namely one [1] to the relative number of the most big that ten [10] or the equation is [1 <index> 10] . The calculation of this index number using Edgewarth Marshal method, this method index is calculated by combining the base year quantity and quantity of years (n), and then multiply by the price of the base year or year (n).

Analysis of the spatial growth is the main part in landscape ecology research, which aims to connect several parts of the complex between landscape patterns and processes of landscape change. And to analyse it using the Geographic Information System (GIS) tools to manage geographically referenced spatial data. Processing and data analysis performed by rotation, and scaling coordinate conversion, coordinate conversion geography, registration and spatial analysis and statistics. The analysis contained in the database is done by using overlaying several layers needed.

3. Result and Discussions

The research location is generally conducted in Jakarta area, the location of the observation is in District Makasar, District Ciracas and District Cakung. Based on the Marshal Edgewarth equation, the calculation of observation year is assumed in 2015 while the base year calculation is in year 2000. The difference of difference of 15 years is considered to be Produce a relative number of figures. Data in 2015 is calculated on the basis of secondary data (BPS DKI Jakarta 2015) and data of 2000 primary satellite image data that has been processed using GIS tools. As for the details of the calculation of years of observations described in Table 1 and the base year calculation details are described in Table 2.

Table 1. Calculation of relative year 2015 observations.

No	Area of Observation	Index relative ((LH _n ¹ /LW _n ¹) x 100)		
		LH (ha)	LW (ha)	Index relative
1	District Makasar	35,43	2.165	2,20
2	District Ciracas	3,50	1.608	0,16

3	District Cakung	8,90	4.247	0,21
	Index Aggregate (n ¹)			0,86

Table 2. Calculation of relative year 2000 observations.

No	Area of Observation	Index relative ((LH _n ⁰ /LW _n ⁰) x 100)		
		LH (ha)	LW (ha)	Index relative
1	District Makasar	35,43	2.165	2,67
2	District Ciracas	3,50	1.608	0,70
3	District Cakung	8,90	4.247	0,82
	Index Aggregate (n ⁰)			1,40

From the calculation of base year 2000 and observation year 2015 will be obtained relative numbers, as illustrated in Table 3.

Table 3. Calculation of the relative numbers.

No	Area of Observation	Index relative $\frac{LH_n^1/LW_n^1}{LH_n^0/LW_n^0} \times 100$		
		2000	2015	Index relative
1	District Makasar	2,67	2,20	0,83
2	District Ciracas	0,70	0,16	0,23
3	District Cakung	0,82	0,21	0,26
Index Aggregate relative		1,40	0,86	0,61

Based on calculation of relative index, calculation of urban forest requirement Index of environmental pollution and economic growth index. then ILHK can be calculated as described in Table 4.

Table 4. Calculation of Urban Forest Area Index.

No	Area of Observation	Indek Relatif $\times KLHK_n^1 \times IPL_n^1 \times IPE_n^1$				ILHK
		KLHK	IPL	IPE	ILHK	
1	District Makasar	0,83	16.125	23,00	4,20	1,29
2	District Ciracas	0,23	18.363	79,50	4,80	1,59
3	District Cakung	0,26	20.836	63,90	5,50	1,88
Index Aggregate		0,61	18.441	55,47	4,83	1,59

The calculation results show that Makassar District has ILHK of 1.29, Ciracas Sub-district has ILHK 1.59 and District Cakung has ILHK of 1.88. Whereas if the three locations are combined then the aggregate of ILHK is 1.59. The city forest area index is a relative number, which will be used as a number in other calculation analyzes in this research.

Spatial analysis of urban forest is done to get the growth patterns of land use. The data used is digital remote sensing data through Landsat satellite imagery. For processing digital data used Geographic Information System (GIS). Satellite image data used in 2015 satellite imagery data.

The results of satellite image data and processed by the GIS, can be explained in Figure 1, Figure 2 and Figure 3. From the processed satellite imagery can be described in general terms that the land area with potential to become a forest-fringed town in the District Makasar was an area of 763 ha , illustrated in Figure 1.

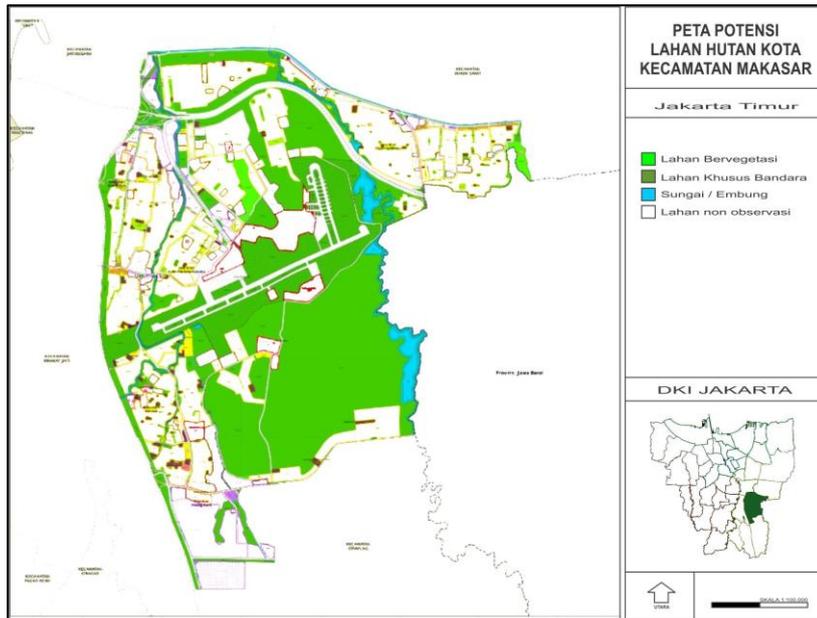


Figure 1. Map of Forest Land Potential of District Makasar.

From the results of satellite image processing can be described in broad outline that the area of trees with the potential to become urban forest in District Ciracas is an area of 554 ha, depicted in Figure2.

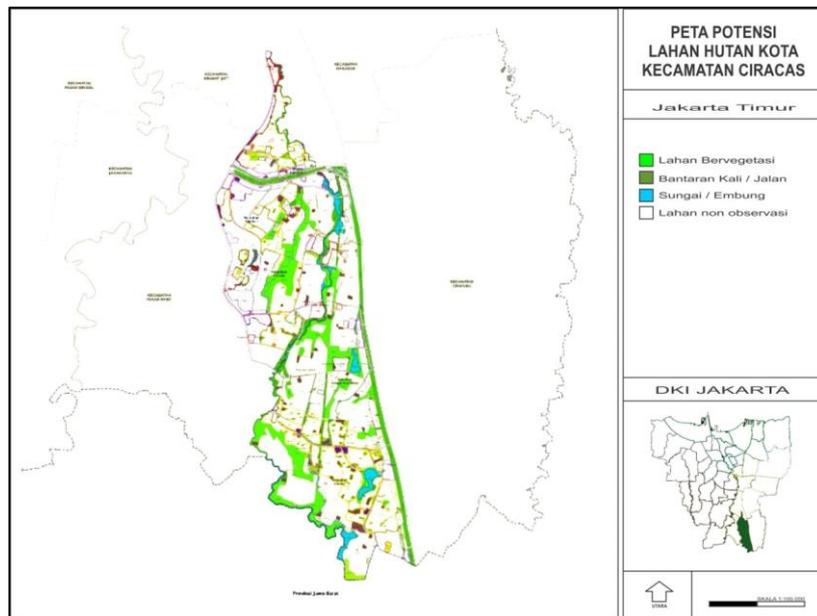


Figure 2. Map of Forest Land Potential of District Ciracas

From the results of satellite image processing can be described in broad outline that the area of trees with the potential to become urban forest in District Cakung is an area of 674 ha, depicted in Figure 3.

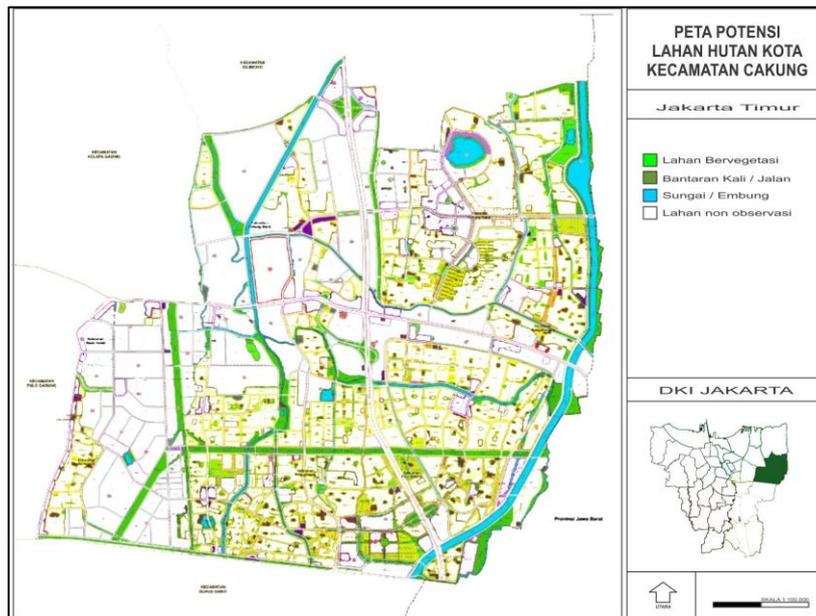


Figure 3. Map of Forest Land Potential of District Cakung

Table 5. Comparison of Potential City Forest Land.

Description	District Makasar		District Ciracas		District Cakung	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
An Area District	2,185.00		1,608.00		4,228.00	
Size Existing of Urban Forest	3.50	0.16	35.43	2.20	8.90	0.21
Size Potential of urban forest	763.70	34.95	554.16	34.46	647.05	15.30

From the results of comparison in Table 5, it can be described that in District Makasar from the area of 2.185ha, there is a potential for urban forest area of 763ha (34.95%). In District Ciracas from a total area of 1,608ha, there is a potential forest area of 554ha (34.46%). In District Cakung from the 4,228ha area, there is a potential for urban forest area of 647 ha (15.30%).

4. Conclusions

Development of urban forests for a sustainable development in Jakarta from the calculation of address that have District Makasar ILHK of 1.29, equivalent to the urban forest area of 252ha (14.68%). District Ciracas have ILHK 1.59 or the equivalent of the urban forest area of 426ha (16.06%) and District Cakung has ILHK of 1.88, equivalent to the urban forest area of 985ha (18.99%). As if the three locations are merged then ILHK aggregate of 1.59, equivalent to the urban forest area of 1.565ha (16.36%).

5. References

- [1] Weiland, Urike, Kindler, Annegret, Banzhaf, Ellen, Ebert, Annemarie, Reyes P and Sonia, (2011). Indicators for sustainable land use management in Santiago de Chile. Journal Elsevier, Ecological Indicators. University of Leipzig, Institute for Geography, Johannisallee 19a, 04103 Leipzig: Germany.
- [2] Qodriyanti, Nisa, Rahmad H dan Lilik B P, (2010). Distribusi dan Kecukupan Luasan Hutan

- Kota sebagai Rosot Karbondioksida dengan Aplikasi Sistem Informasi Geografi dan Penginderaan Jauh, Skripsi. Departemen Konservasi Sumber Daya Hutan dan Ekowisata. Fakultas Kehutanan IPB.
- [3] Zeng, Y, Y. Xu ., S. Li ., L. He., F. Yu., Z. Zhen., C. Cai, (2012). Quantitative Analysis of Urban Expansion in Central China, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume **XXXIX-B7**, Melbourne: XXII ISPRS Congress, 25 August – 01 September 2012. Australia.
- [4] Joye, Yannick, Willems, Kim., Brengman, Malaika dan Kathleen W, (2010). The effects of urban retail greenery on consumer experience: Reviewing the evidence from a restorative perspective. *Journal Elsevier of Urban Forestry & Urban Greening*: **9**, pp. 57–64.
- [5] Irwan, Siti N R, Khoisol, Ahmad, Hasanbahri dan Soewarno, (2012). Fungsi Vegetasi Pada Ruang Hijau Dan Hutan Kota Untuk Pengembangan Lanskap Ecosystem, Bagian Konservasi Sumber Daya Hutan, Fakultas Kehutanan UGM.
- [6] Lubis, Sofyan, Hadi S A dan Ismayadi S, (2013). Analisis Cadangan Karbon Pohon Pada Lanskap Hutan Kota di DKI Jakarta. *Jurnal Penelitian Sosial dan Ekonomi Kehutanan*: **10**, No 1, pp. 1-20.
- [7] Zhang, Biao, Gao d X, Na L and Shuo W, (2015). Effect of urban green space changes on the role of rainwater runoff reduction in Beijing, China. *Journal Elsevier of Landscape and Urban Planning*: **140**, pp. 8–16.
- [8] Visscher, Rachel S, Joan I N and Lauren L M, (2016). Homeowner preferences for wooded front yards and backyards: Implications for carbon storage. *Journal Elsevier of Landscape and Urban Planning*: **146**, pp. 1–10.
- [9] Rapoport, Elizabeth, Vernay and Anne L, (2011). Defining The Eco-city; A Discursive Approach. *Journal Management and Innovation for a Sustainable Built Environment*.