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Procedia - Social and Behavioral Sciences 227 (2016) 574 – 582

Procedia
Social and Behavioral Sciences

CITIES 2015 International Conference, Intelligent Planning Towards Smart Cities, CITIES 2015,
3-4 November 2015, Surabaya, Indonesia

Study of distribution and slope aspect approach to increase public green open space on Special Capital Region of Jakarta using high resolution imagery

Arista Nurbaya^{a*}, Alinda FM Zain^b, Ruchyat Deni Djakapermana^c

^a*Sekolah Pascasarjana Institut Pertanian Bogor, Jl. Raya Dramaga, Kampus IPB Dramaga, Bogor 16680*

^b*Departemen Arsitektur Lanskap, IPB Jl. Lingkar Akademik, Kampus IPB Dramaga, Bogor 16680*

^c*Departemen Pengelolaan Sumberdaya Alam dan Lingkungan, IPB Jl. Padjajaran, Kampus IPB Baranangsiang, Bogor 16144A*

Abstract

Urbanization has made Jakarta's land use changed rapidly for urban development, which resulted on Green Open Space (GOS) marginalization. This study uses GIS and remote sensing integration to produce the distribution Public GOS map and give alternative ecological approach to support government commitment of providing 20% GOS. The result shows Public GOS is 5.44% with highest percentage on Central Jakarta. The study also shows that East Jakarta is the most potential area for GOS expansion to more than 2,890.22 ha and final Public GOS can reach by 14.50% from total mainland area.

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Peer-review under responsibility of the organizing committee of CITIES 2015

Keywords: SPOT-6; Image Processing; Pansharpening; RS and GIS integration; Urban Green Space

* Corresponding author. Tel.: +62 811150384; fax: +0-000-000-0000 .
E-mail address: anurbaya@yahoo.com

1. Introduction

Jakarta as part of largest concentration of urban population in Indonesia (Firman, 2007), has problem in providing enough GOS area. Land demand for urban use and other form of urban development in fringe, convert and change of agricultural lands resulting loss of green open space (Malaque et al., 2007). Urbanization replaces vegetated surfaces with impervious built surfaces (Gill et al., 2007). Jakarta has less green open space as a result of less restrained urban development (Rosalina, 2013). Jakarta has been lost green open space for 23% during 1972-1997 period (Zain, 2002).

However, urban greenspaces provide areas within the built environment where such processes of shading, evaporative cooling, and rainwater interception, storage and infiltration functions can take place (Whitford et al., 2001). In a changing climate, the functionality provided by urban greenspace becomes more important (Gill et al., 2007). Jakarta as one of the most vulnerable coastal city to climate change in Southeast Asia (Firman et al, 2011), needs more GOS to mitigate the climate change effect. Because improving urban green space provides valuable ecosystem services, reduce disaster risks, conserve urban biodiversity, and help in climate adaptation and mitigation (Govindarajulu, 2014). Jakarta needs to increase GOS to keep its carrying capacity to accommodate 12,5 million inhabitants by end of 2030 (DKI, 2012).

Act 26/2007 set the target 30% GOS for city region, which is by ownership typology divided as Public and Private, and government obligated to provide 20% Public GOS. Public GOS is owned and managed by municipality or city government and be used for social interest, while the Private is personal or private belonging. The enhancement of Public GOS area in Jakarta has been implemented by local government. Two of most responsible institution of Jakarta Government that is City Park and Cemetery Office and Marine, Agriculture and Food security Office were recorded around 156.67 ha new area for GOS purposes has been acquisitioned since 2001. So far, the policy of Public GOS land acquisition not satisfied enough to ensure the achievement of the target in accordance with GOS target stipulated in Perda No. 1/ 2012 about Spatial Plan Jakarta Province 2030 (DKI, 2012). In fiscal year 2014 budgeted land acquisition was Rp1.9 trillion with total realization only 21% of it (Fitriani, 2015), with area of about 2-4 ha (Bappeda, 2014). Most problems were due to the price discrepancy between the requested land owners (Rosana, 2015), also the absence of a master plan RTH Jakarta became drawbacks (DPP, 2013).

Masterplan plays important role in realizing GOS target, because planning is a process to achieve the goal. Developing the availability of GOS, it is necessary to analyse current situation that deals with the physical, quality, functional, ecological and environmental as well as the economic aspects of green spaces in the city (GK 2008). The most important thing in the physical aspect is the quantity of GOS that can be shaped as spatial data. Thus in this study, we consider the importance to conduct spatial data study of current Public GOS. And also we propose an ecological aspects approach put forward in the form of slope as a potential alternative to the addition of Public GOS. The result is expected can enrich considerations for policymaker towards Public GOS target.

To obtain GOS spatial data within area coverage can be used remotely techniques (Remote Sensing / RS). Remote sensing offers broad scale, readily repeated measures of vegetation and particularly suited to change detection (Lawley, 2015). With the integration of RS and GIS (Geographic Information System) can improve output efficiency and accuracy of mapping as an input in the planning and management of the area (Danoedoro, 2012). Integration of RS and GIS has been widely used for environmental and urban resources studies (Weng, 2010). Taking into account the conditions of highly heterogeneous land use of Jakarta, in this study we use high resolution satellite imagery to facilitate the identification process of GOS.

2. Methodes

2.1 Study Site Description

This study is in Special Capital Region of Jakarta, located at 106.22'42" - 106.58'18" E and 5.19'12" - 6.23'54" S. Administratively bordered on the western by Tangerang City (Banten Province), the southern part by Bogor Municipality (West Java Province), the eastern part by Bekasi City (West Java Province), in the northern part by Java Sea. Jakarta has total area 7,659.02 km², divided into 6 municipalities consist of 662.33 km² land area including 110 islands in Kepulauan Seribu municipality. This study site only covered land area 645.80 km² without Kepulauan Seribu. Jakarta has hot tropical climate with humidity between 75-99 per cent. Jakarta called as delta city with 13

river outfall trough the city. Jakarta lies in the lowlands with a height of between 0-10 meters above sea level, some of the land has lower than sea level and affected by tides. Average yearly precipitation reach 2,000 mm highest on January, temperature variate between 23.42°C to 31.07°C with humidity 77.97%, and the population on 2014 reach 10,075,310 inhabitants, average population density reached 15,211.92 people/Km² (BPLHD, 2015).

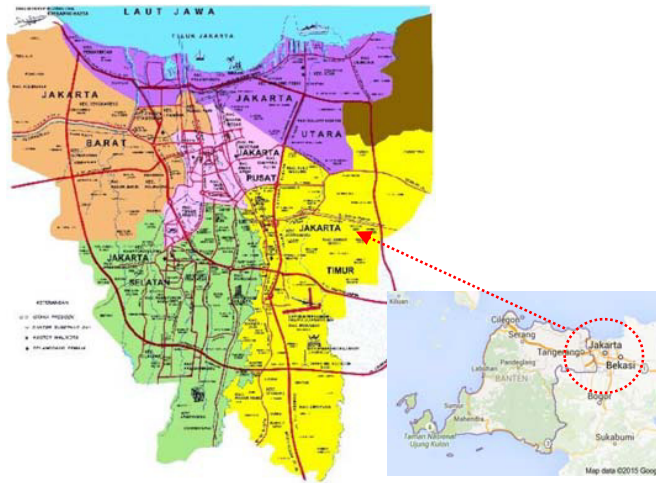


Fig. 1. Study site – Special Capital Region of Jakarta Land Area (BPLHD, 2015)

2.2. Data Analysis

For data analysis we use image of SPOT-6 under JP2 format with spatial resolution 6m/1.5m multispectral and panchromatic acquired in August 2013 (DPP DKI Jakarta), Jakarta 2030 Spatial Plan map (RTRW), Jakarta 2014 Detail Spatial Plan map (RDTR), DPP DKI Jakarta's GOS Map, DEM acquired from ASTERGDEM in July 2015 and other data literature.

2.2.1. Public GOS identification

In this study, data processing begins with image restoration, including the process of image mosaic, geometric correction, cropping the image using administrative map of Jakarta (mainland). In order to identify Public GOS, the image of SPOT-6 improved its spatial resolution by pan sharpening. The spatial enhancement use image fusion between multispectral band (6m) and panchromatic band (1.5 m). The product has the spatial resolution of the panchromatic image and the spectral characteristics of the multispectral image (Vrabel, 1996). The Brovey Transform is a well-known method of pan sharpening technique to combine two different spatial resolution images (Danoedoro, 2012). Brovey transform is a simple numerical method used to combine two digital images of different spatial and spectral resolution (Siwi and Yusuf, 2014). Figure 2 show the spatial enhancement result.

Furthermore, it is necessary to improve the contrast to ease interpretation and identification of Public GOS process. Although SPOT - 6 already has BLUE band, but the results from the artificial Natural Color process can produce better true color. Artificial Natural Colors produced by transformation process utilizing NIR, Red and Green bands (Jaya, 2014). It is expressed as follows:

$$\begin{aligned}
 RED &= RED \\
 GREEN &= (3*GREEN + NIR) / 4 \\
 BLUE &= (3*GREEN - NIR) / 4
 \end{aligned}
 \tag{1}$$

When compared with the standard true color, Natural Color display manipulation is easier to interpret. Figure 3 shows the comparison between Standard True Color and Artificial Natural Color. Public GOS is then delineated

base on local government asset data, RDTR, DPP DKI Jakarta's GOS Map and refer to the definition of GOS ownership typology according to Permen PU No. 5 / PRT / M / 2008.

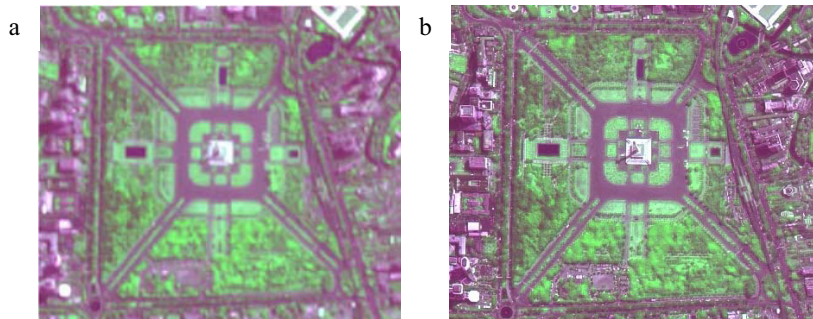


Fig. 2 . MONAS – SPOT-6 image (a) Multispectral 3-1-2, res. 6m ; (b) Brovey Transform 3-1-2, res. 1.5m
(Source image: DPP DKI, 2015)

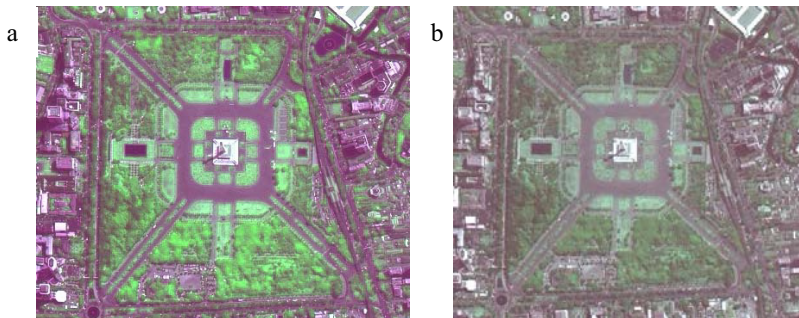


Fig.3. MONAS – SPOT-6 image (a) Standard True Color; (b) Artificial Natural Color

2.2.2 Study of Distribution and Slope Aspect Approach

Study of Public GOS distribution is obtained by overlay identification result with the Green Zone Plan of Jakarta 2030 Spatial Plan map (RTRW). Next, we recommend the potential addition of Public GOS outside of Green Zone Plan. We analyze a potential site by considering ecological factors i.e. slope. The slope is part of the character of the landscape and an ecological analysis (Bell, 1999). Moreover, in maintaining the balance of environment carrying capacity, it need to determine the density of the area with a slope of more than 25 % (Permen PU No. 06 / PRT / M / 2007). Thus, in this study we produced additional potential Public GOS by extracting steep more than 25% at green area. The greenery area refers to Jakarta 2013 NDVI map (Nurbaya *et al.*, 2015).

3. Result and Discussions

1. Public GOS Distribution

Table 1 shows the Public GOS data asset to be targeted to identify the distribution. From total registered data assets of local government, 4,259.04 ha (6.43 %) , only 3,604.80 hectares (5.44 %) can be defined as Public GOS, the remaining of 589.25 ha (0.89 %) is Private GOS owned by government (Nurbaya *et al.*, 2015). Approximately 70 % of Public GOS locations have been identified and mapped to describe the patterns of distribution of Public GOS. The main difficulty in the identification are mostly the absence of name board, land occupation for other purpose, site damage and unidentified, inaccuracy asset data and weak location knowledge since thousands small site were spreading over Jakarta. This also means that if local government improves the data asset inventory and well

understood that GOS plays important role in urban environment so that doing better management, the actual quantity more than 5.44% of Public GOS is not impossible. There's also need to make up a brave detail definition of Public GOS, in order to facilitate local government compiling their data asset. Figure 4 (a) shows the Public GOS distribution map.

Distribution pattern can be seen from Public GOS percentage each municipalities as shown in Table 2. Central Jakarta has the highest percentage of Public green space (6.52 %), because most of urban parks that exist today have built since the Netherlands occupation as part of Batavia city design, such as Suropati Park, Taman Merdeka, Lapangan Banteng Park and others (DPP, 2007)

Table 1. List of Data Asset and Identification Result of Green Open Space Jakarta 2014 (Nurbaya et al. 2015)

Green Open Space Form	Green Open Space Data Asset	By Definition Permen PU 05/2008		Green Open Space based on Ownership Typology				Identification Result	
		Public	Private	Public		Private		Qty	Area (ha)
				Qty	Area (ha)	Qty	Area (ha)		
Green Way	645.13 ^{c)}	j !		1,537	645.13			11,708	358.58 ^{c)}
Perfecting Green Way	30.66 ^{a)}	j !			30.66			2	1.60
City Ornament	0.11	j !			0.11				
Gas Sta. Refunction	3.34	j !		21	3.34			16	2.22
Urban Forest	677.19	j !		89	677.19			69	637.58
Sport Facility	0.81	j	!			2	0.81	16	31.54
Cemetery	789.62	j !		73	600.77	25	188.85	70	517.64
Agriculture	5	j*		1	5			1	5.00
Private Green Space	13.46		j !			41	13.46		
Building Park	386.94		j			188	386.94		
Interactive Park	31.33 ^{a)}	j !		114	31.33			66	81.24
Urban Park	83.28	j !		8	83.28			8	89.74
Neighborhood Park	193.22	j !		1,171	193.22			1,057	176.41
Recreation Park	1,238.37	j !		9	1,238.70			8	414.31
Water Body Border	50.83	j !		114	50.83			3,049	78.1
Coastal Borer	44.76 ^{b)}	j !		1	44.76			1	44.76
High Voltage Electric								1,089	86.04
Greenway		j !							
Others (Rail way Border)	64.98	j !		6	64.98			6	43.93 ^{c)}
Total	4,259.04				3,604.80		589.25		2,524.76
Percentage	6.43%				5.44%		0.89%		3.81%

Jakarta Land Area = 66,233 ha

Source: City Park and Cemetery Office; Marine , Agriculture and Food Security Office;BPLHD; *permanent agriculture; ^{a)}data not complete; ^{b)}Angke Forest; ^{c)}Spatial analysis.

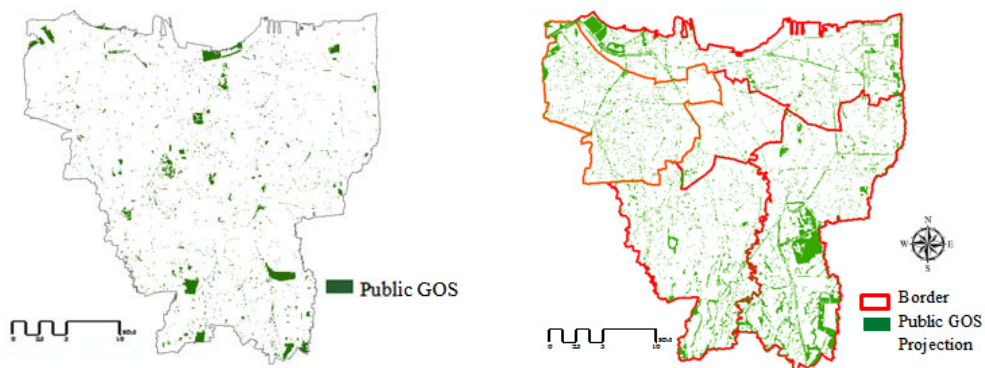


Fig. 4. (a) Public GOS Distribution map ; (b) Public GOS projection each municipality

Furthermore, West Jakarta has the smallest percentage of Public green space (2.25%), as result of limited Public GOS development. Since the Jakarta General Spatial Plan (RUTR) year 2005, the urban development is set to the east and west as well as reducing the pressure development in the north. Development in the southern region as

catchment areas began to be restricted (Rosalina, 2013). This condition affect to the dominance of settlement land use in West Jakarta, which until 2008 was detected for 70.64 % (Perda DKI Jakarta No. 1/2014). West Jakarta become concentration of residential area with population density reaches 18,761 people/Km². It is second most densely populated after the Central Jakarta (BPLHD, 2014). Private GOS area is not calculated automatically as the difference between Total GOS and Public GOS. This means that Public GOS that has been delineated not always entirely be greenery, it can be either pavement or open land for interaction facility. Private GOS obtained as result of overlay Public GOS map over NDVI map. It is around 9.50% (6,290.08 ha).

Table 2. Distribution of GOS in Jakarta

Municipality	Total Area		Total GOS		Public GOS		Private GOS	
	ha		ha	%	ha	%	ha	%
North Jakarta	14,116.60		1,429.18	10.12%	514.84	3.65%	1,210.58	8.58%
West Jakarta	12,491.90		1,411.14	11.30%	280.88	2.25%	1,277.81	10.23%
Central Jakarta	4,883.50		302.01	6.18%	318.22	6.52%	166.30	3.41%
East Jakarta	18,562.00		4,204.45	22.65%	727.68	3.92%	3,740.63	20.15%
South Jakarta	14,526.10		2,548.10	17.54%	609.89	4.20%	2,134.79	14.70%

2. Increasing Public GOS

2.1. Public GOS Projection from Green Zone Plan

In RTRW 2030, Jakarta Provincial Government has set Green Zone Plan with an area of 8,082.2 ha (12.2%). This map is a development strategy to achieve Public GOS 20%, consisting of protected and cultivated green space. Protected green space is part of the GOS that have natural characteristics need to be preserved for the local ecosystem protection purposes or for the larger areas protection purposes. Cultivated green space is the green space outside the protected green space used for planting, development, maintenance, and greening necessary as a means of economic, ecological, social and aesthetic (Perda DKI Jakarta No. 1/2014). We overlay the Public GOS distribution map with Green Zone Plan map to understand which area in Jakarta have been planned to be Green Space but so far could not be acquired yet. This output will let us know where and how to prioritize increasing Public GOS.

Table 3 shows the projection of Public GOS each municipality. Breakdown by municipality intended to facilitate the relevant authorities in determining the target of providing GOS land. Projection of highest Public GOS addition is East Jakarta for 15.57 %, meanwhile their current Public GOS is only 3.95 % from the total area. This condition can certainly be a priority allocation of new land acquisition. Likewise, another municipality that has range of less than 4% of Public GOS as in North Jakarta and West Jakarta also need to give attention for more Public GOS. Figure 4(b) shows GOS projection each municipality.

Table 3. Public GOS projection

Municipality	Total Area		Total Public GOS		Green Zone Plan - RTRW 2030				Projection for Public GOS addition	
	ha		ha	%	Green Zone		Public GOS within Zone		ha	%
					Ha	%	ha	%		
North Jakarta	14,116.60		514.84	3.65%	1,757.03	12.45%	219.76	1.56%	1,537.27	10.89%
West Jakarta	12,491.90		280.88	2.25%	1,234.95	9.89%	338.44	2.71%	896.51	7.18%
Central Jakarta	4,883.50		318.22	6.52%	377.64	7.73%	181.20	3.71%	196.44	4.02%
East Jakarta	18,562.00		727.68	3.92%	3,212.48	17.31%	322.26	1.74%	2,890.22	15.57%
South Jakarta	14,526.10		609.89	4.20%	1,500.05	10.33%	336.61	2.32%	1,163.44	8.01%
TOTAL	64,580.10		2,451.51		8,082.15		1,398.27		6,683.88	

By understanding the projections of each municipality, the priority of the new land acquisition may also consider to form Green Infrastructure for the maximum green space benefit, especially to accommodate climate change in urban areas (CCAP, 2011). Connected GOS ensure the protection of wildlife, recreational and cultural experiences, and also provide environmental services such as flood protection and control microclimate (CH, 2006).

3.2.2 Slope Aspect Potency

Figure 5(a) shows the area of the city that has a slope of more than 25 % (14.04°) by processing DEM map. We extract the map to be area outside Green Zone Plan map and Public GOS map. We obtained potential area of 3,223.67 ha. Furthermore, by considering economic and social aspects that built up area is irreversible, we conducted another extraction to determine the vegetated areas only, and the result is 399.66 ha (0.6 %). This area is the potential for the addition of a Public GOS with slope aspect (Figure 5b).

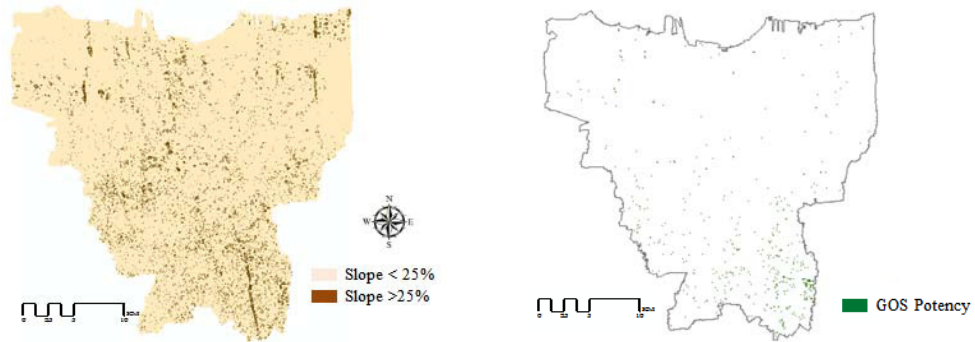


Fig. 5.(a) The slope map of the Jakarta; (b) Addition potency of a Public GOS with slope aspect

3.2.3 Total Public GOS Potency

This last sub chapter will summarize all projection and potency of Public GOS to see how much available area can be used to increase Public GOS. Projection based on the Green Zone Plan is 6,683.88 ha. Another potential area from slope approach aspect obtained for 399.66 ha. Meanwhile, we've got verified Public GOS 3,604.80 ha. Thus, by overlaying all maps, Jakarta Public GOS can be reached 9,608.30 ha (14.50%). Figure 6 displays the final result for total GOS potency. As seen from map, the potency spreading to mostly at East Jakarta and South Jakarta. It is recommended to prioritize East Jakarta for Public green open space expansion as that region has the highest available green area which possible to convert.

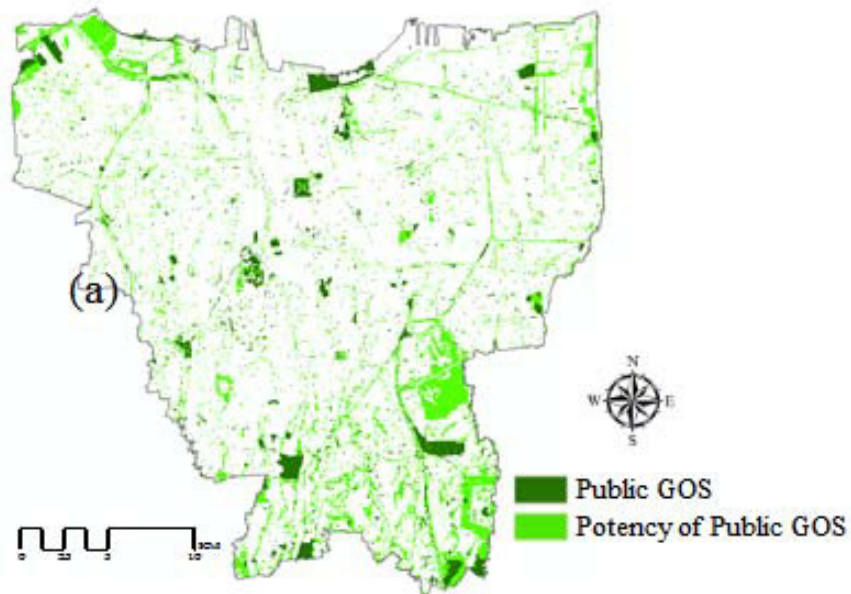


Fig. 6. Total Public GOS and its potency

4. Conclusions

This study demonstrates Public GOS identification using SPOT-6 imagery. The result of study shows that total Public GOS is 5.44% (3,604.80 ha) and more than 70% location area have been identified and mapped to describe the patterns of distribution of Public GOS. By improving the data asset inventory and doing better GOS management by local government, the actual quantity more than 5.44% of Public GOS is not impossible. Highest percentage is Central Jakarta with 6.52% (318.22 ha) and lowest in West Jakarta with 2.25% (280.88 ha). Largest Public GOS is East Jakarta with 727.68 ha. Analyzing resulted from Green Zone plan shows that highest projection of Public GOS addition is in East Jakarta for 15.57 % with more than 2,890.22 ha. This condition can certainly be a priority allocation of new land acquisition. Breakdown by municipality intended to facilitate the relevant authorities in determining the target of providing GOS land. Total projection based on Green Zone Plan is about 6,683.88 ha, then by considering potential additional Public GOS of the slope aspect approach which obtained for 399.66 ha, final Public GOS of Jakarta can be reached 9,608.30 ha (14.50 %) by 2030. The figure is very promising in achieving the target of 20% Public GOS, and off course it is important to have strong Government commitment to secure available area and search for any possible expansion.

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