

Vegetation type classification and vegetation cover percentage estimation in urban green zone using pleiades imagery

Bambang Trisakti*

Remote Sensing Application Center, LAPAN-Pekayon

E-mail: btris01@yahoo.com, bambang.trisakti@lapan.go.id

Abstract. Open green space in the urban area has aims to maintain the availability of land as a water catchment area, creating aspects of urban planning through a balance between the natural environment and the built environment that are useful for the public needs. Local governments have to make the green zone plan map and monitor the green space changes in their territory. Medium and high resolution satellite imageries have been widely utilized to map and monitor the changes of vegetation cover as an indicator of green space area. This paper describes the use of pleiades imagery to classify vegetation types and estimate vegetation cover percentage in the green zone. Vegetation cover was mapped using a combination of NDVI and blue band. Furthermore, vegetation types in the green space were classified using unsupervised and supervised (ISODATA and MLEN) methods. Vegetation types in the study area were divided into sparse vegetation, low-medium vegetation and medium-high vegetation. The classification accuracies were 97.9% and 98.9% for unsupervised and supervised method respectively. The vegetation cover percentage was determined by calculating the ratio between the vegetation type area and the green zone area. These information are useful to support green zone management activities.

1. Introduction

In general, the development of urban areas resulted in an increasing number of settlement areas and the decreasing of open green space areas. In the regulation of minister of Public Work No.05 of 2008, it was explained that the open green space is elongated or clustered area, that its utilization is more open, where the plants grow naturally or planted by human [1]. Open green space has some functions including the function of ecological, social and cultural, aesthetic and economic. Law No. 26 of 2007 on spatial planning explains that 30% of the urban area has to be open green space, where 20% of open green space for public area and 10% of it for private area [2].

Currently, the Jakarta government are pursuing the target to provide open green space area up to 30%, where the city government responsible to 16% of the open green space, and privat parties responsible the remaining 14% of it. To achieve the target, the Jakarta government will annually spend 5 billion to increase 6% of open green space in Jakarta until 2030, and it was already stated in Regulation No.1 of 2012. In connection with the implementation of this program, City Planning Department of East Jakarta has coordinated with Remote Sensing Application Center (Pusfatja) LAPAN to be able to take advantages of satellite remote sensing data utilization to monitor the open green space in East Jakarta region. The monitoring activities using satellite imagery will be very



helpful to know the last condition of vegetation cover, and to find out the land cover change occurred in the green zone area.

Utilizations of remote sensing data for monitoring changes in the open green space and to map land cover in urban areas have been conducted using medium and high spatial resolution remote sensing imagery. Some research studies were carried out using medium resolution satellite data (Landsat TM, Landsat ETM + and Landsat 8 OLI) for monitoring the changes of green space area [3], vegetation greenness level [4] as well as land use mapping [5] in urban areas. On the other hand detail scale mapping needs high spatial resolution satellite imagery, such as IKONOS, Quicbird or Pleiades. Some research studies were also used those high resolution satellite imageries to classify land cover and then used the land cover information to analysis urban green space [6], to map greenways in the city [7], and to digitally extract urban green space [8] [9]. Furthermore various types of data such as digital aerial photograph, satellite imagery and time series data were used to get more detail and accurate information related to green space and urban environment [10], and also the combination of LIDAR data and multi spectral imagery [11] were used to produce information of green space and urban building distribution. But the common method to map green space based on remote sensing data were to identify the vegetation cover, where the vegetation cover can be extracted using various classification methods or extracted using various indexes such as Normalised Different Vegetation Index (NDVI), Modified Soil Adjusted Vegetation Index (MSAVI) and chlorophyll index [4, 9, 12]. In contrast to the object appearance on the medium spatial resolution imagery, the object appearance on the high spatial resolution imagery up to submeter unit (less than 1 meter) becoming very detail, so the separation of vegetation from other objects around the vegetation (such as building or open land) becomes more difficult.

In this research activity, the high spatial resolution Pleiades imagery was used to classify vegetation types and estimate vegetation cover percentage in the green zone. Pleiades imagery has 0,5 meter spatial resolution, so this satellite imagery can be used is to identify tree canopy and single house building accurately, and it will be a suitable data for monitoring the vegetation cover in urban areas.

2. Research Method

The study area of this research was covered area surrounding Halim Perdana Kusuma Airport in East Jakarta, as shown in figure 1. This study area was selected due to various vegetation types and vegetation density. The use of Pleiades imagery with high spatial resolution was expected to be able to identify the various vegetation types in the study area accurately. The Pleiades imagery used was Pleiades-1A obtained from Technology and Data Center, LAPAN. The imagery was recorded on May 12th 2015, and it was already corrected for ortho systematic and processed for pansharpening (data fusion between 2 meter spatial resolution of multi spectral band and 0,5 meter spatial resolution of panchromatic band). So the Pleiades imagery had already 0,5 meter spatial resolution in multi spectral band (Blue, Green, Red and Near Infrared). Detailed information of Pleiades-1A is shown in table 1.

Tabel 1. Detail information of Pleiades-1A imagery used in this Research

Data	Processing level	Waktu perekaman	Spectral resolution	Spatial resolution
Pleiades-1A	Ortho Sistematic Without ground control points: 3m (CE90)	12 May 2015	Pan: 480-830 nm	0.5 m
			Blue: 430-550 nm Green: 490-610 nm Red: 600-720 nm Near Infrared: 750-950 nm	2 m

Source: <http://www.satimagingcorp.com/satellite-sensors/pleiades-1/>

Research flowchart is shown in figure 2. The whole data processing can be divided into three main processes, as follow: 1) vegetation and non vegetation separation process (vegetation cover mapping),

2) vegetation types classification process, and 3) estimating vegetation cover percentage in the green zone. Based on the results from the previous research conducted at the same location [9], vegetation and non vegetation pixels in the Pleiades imagery can be separated through two separation stages. In the first stage, the combination algorithm of Normalized Difference Vegetation Index (NDVI) and blue band was performed to the Pleiades imagery, then the histogram was adjusted to make the pixel value of non vegetation becoming zero, and then the result was saved as a new data. In the second stages, threshold values were determined to separate between pixels of vegetation and pixels-like vegetation, that they were still mixing from the first stage's result. This method made the process becoming easier to determine threshold values for accurately separating between vegetation pixels and non vegetation pixels.



Figure 1. Pleiades imagery of Halim Perdana Kusuma Airport

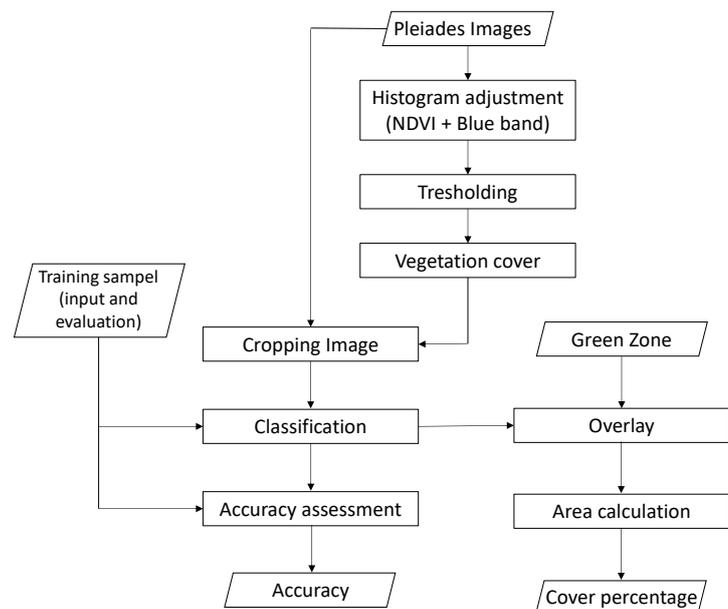


Figure 2. Reserach Flowchart

Vegetation pixels or vegetation cover area obtained from the first process was used to crop Pleiades imagery for obtaining the imagery inside the vegetation cover area. Vegetation types inside the vegetation cover area were identified using composite RGB 321 image (true color composite) and composite RGB 423 (false color composite). There area several types of vegetation were recognized inside the area. Spectral patterns for all vegetation type were plotted and analyzed to determine whether there is any differences of pixel value at each vegetation type. The difference of the pixel values can be used to separate the vegetation type in the study area. The vegetation types were classified using the unsupervised classification method (classification without using training samples) and supervised classification method (classification using training samples). The number of classified classes were determined by identifying the vegetation types found in the study area. The classes of vegetation types in this research were divided into 3 classes: sparse vegetation, low-medium vegetation and medium-high vegetation.

Unsupervised classification was done using ISODATA unsupervised method [13], and it used the following setting parameters: maximum iteration 100, maximum classes 50 and pixel unchanged threshold 98%. The classification result produced 50 classes, which were then reclassified and labelled into three classes of vegetation types that previously determined. Supervised classification was done by collecting training samples for three classes of vegetation types. Each class used around 30 training

samples, then classification process was performed using Maximum Likelihood Enhanced Neighbor (MLEN) method. According to the previous result, MLEN method has a higher accuracy than other maximum likelihood methods [14]. The classification results of vegetation type were tested using confusion matrix. Training samples were needed in the confusion matrix, the training samples were different with the training samples for classification input. The result from the confusion matrix was consist of user accuracy, producer accuracy and overalls accuracy of the classification result.

Furthermore, the classification results was overlaid with polygon of green zone. In this research, polygons of green zone was simulation polygon that created as examples to calculate the percentage of vegetation cover in the green zone. The percentage of vegetation cover was calculated by the following equation:

$$P_{Veg(i)} = \frac{A_{Veg(i)}}{A_{GZ}} \times 100\% \quad (i = 1,2,3) \quad (1)$$

$$P_{Total} = \frac{A_{Veg1} + A_{Veg2} + A_{Veg3}}{A_{GZ}} \times 100\% \quad (2)$$

Where, P, A, Veg 1, Veg 2, Veg 3 and A_{GZ} are vegetation cover percentage (%), area, sparse vegetation, low-medium vegetation, medium-high vegetation, and green zone area respectively.

3. Result and Discussion

Figure 3a shows the separation result of vegetation and non vegetation in the study area, where green indicates vegetation area while black indicates non vegetation area. The vegetation area is also called vegetation cover area. The result of vegetation cover in figure 3a was verified by doing visual comparison between appearances of vegetation cover in figure 3a with appearances of vegetation in figure 1 (Composite RGB 321 of Pleiades imagery). By this comparison, it can be known that vegetation can be separated well with non vegetation around it (such as runway, settlement, water and open land). Figure 3b shows an example result of the vegetation cover in urban areas. Left side is Pleiades imagery in urban area, and right side is the overlay picture of vegetation cover area and Pleiades imagery. Separation of vegetation from non vegetation was done accurately along the main roads and among the dense building. The information of vegetation cover area was then used to crop the Pleiades imagery for obtaining the Pleiades imagery inside the vegetation cover area.

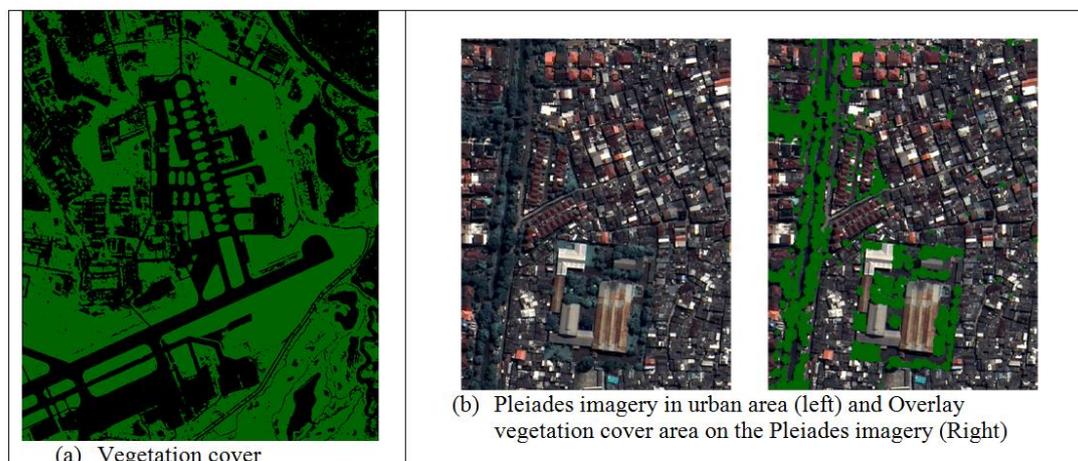


Figure 3. Vegetation cover result and Its visual verification

Based on the results from visual observation by using a composite RGB 321 (true color composite) and RGB 423 (false color composite) of Pleiades imagery in the vegetation cover area, vegetation

types could be divided into four classes, those were: sparse vegetation (vegetation mixed with soil), low vegetation (such as grass field and other low plants), medium vegetation (like bushes and other plants with a height approximately equal to house building), and high vegetation (dense trees with heights exceeding house building). But in practice it is quite difficult to determine the boundary of medium vegetation, so it causes trouble to separate between low vegetation and medium vegetation, or between medium vegetation and high vegetation. Therefore, the classes of vegetation types were divided only into three vegetation types, those are: sparse vegetation, low-medium vegetation and medium-high vegetation.

Classification of vegetation types was done using two methods, ISODATA unsupervised and MLEN supervised methods. ISODATA unsupervised method was conducted using fixed setting parameters: maximum iteration 100, Maximum classes 50 and pixel unchanged threshold 98%. This classification resulted in 50 unlabelled classes, then the 50 unlabelled classes were reclassified and labelled into three classes of vegetation types (sparse vegetation, low-medium vegetation and medium-high vegetation). While MLEN method required training samples from the three classes of vegetation types as input data. Each class used 30 training samples. The MLEN classification directly produced three classes of vegetation types (sparse vegetation, low-medium vegetation and medium-high vegetation). The classification results using unsupervised and supervised classification method are shown in figures 4a and 4b. Furthermore, the accuracy testing was carried out using the confusion matrix, and the testing results are shown in table 2. The level of accuracy (producer accuracy, user accuracy and overall accuracy) for both the classification results did not differ significantly, and the accuracy of all classification were high accuracy more than 90%. Overall accuracy for unsupervised classification was around 97.9%, while the supervised classification was around 98.9%. Therefore, both classification methods performed good results, and can be used to classify vegetation types accurately from Pleiades imagery.

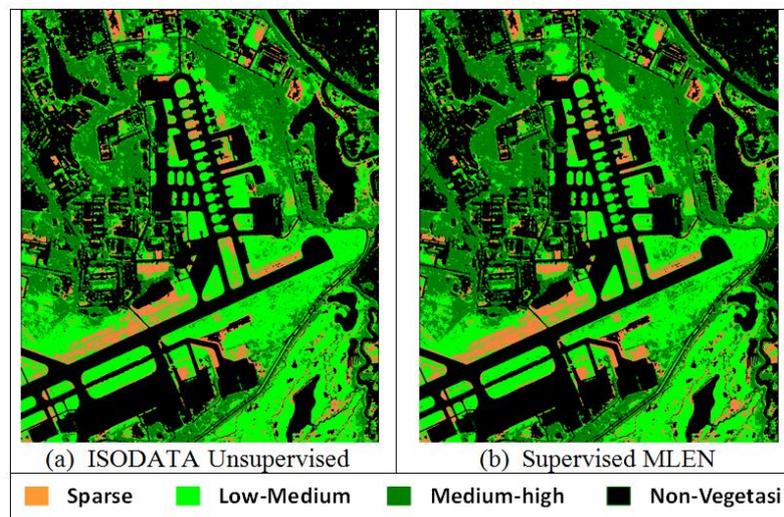


Figure 4. Vegetation type classification using unsupervised and supervised methods

Table 2. Accuracy result of vegetation type classification

Method	User Accuracy (%)	Producer Accuracy (%)	Overall Accuracy (%)
ISODATA Unsupervised	98,5	97,7	97,9
MLEN Supervised	99,1	98,7	98,9

The last proces is to estimate vegetation cover percentage inside the green zone. In this resarch, two polygons of green zone (GZ1 and GZ 2) were created in the study area as a simulation to calculate the

vegetation cover percentage inside the green zone. The calculation of vegetation crop percentage can be done for all vegetation types. Figure 5 shows two simulation polygons of the green zone (GZ1 and GZ2) which are overlaid on Pleiades imagery and the classification result of vegetation types. By doing the visual observation, we can know that GZ1 and GZ2 are consisting of vegetation cover and non vegetation cover (building on GZ1 and open areas on GZ2).

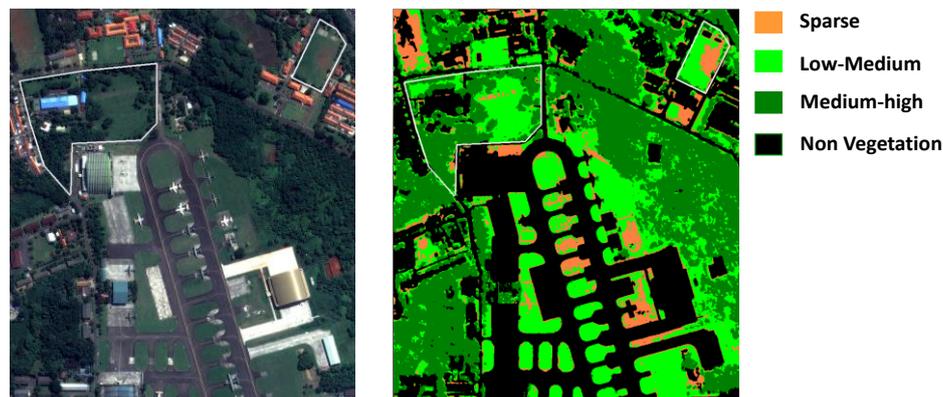


Figure 5. GZ and GZ2 are overlaid on imagery(left) and classification result (Right)

The calculation results of vegetation type area, percentage of each vegetation types cover, and percentage of total vegetation cover and non vegetation cover inside GZ1 and GZ2 are shown in table 3. GZ1 had vegetation cover percentage around 84.8%, which is consisting of sparse vegetation (2.9%), lower-medium vegetation (32.4%) and medium-high vegetation (49.5%). While GZ2 had vegetation cover percentage around 93.5%, which is consisting of sparse vegetation (29.3%), low-medium vegetation (53.1%) and medium-high vegetation (11.1%). This kinds of information can be used by local governments to monitor the last condition vegetation cover in the green zone, to evaluate the existing plan map of the green zone, and to make a better policy for green zone management activities.

Table 3. Accuracy result of vegetation type classification

Green Zone	Sparse	Low-Medium	Medium-High	Non Vegetation	Vegetation
GZ1					
Area (ha)	0,145	1,607	2,454	0,756	4,206
Percentage (%)	2,9	32,4	49,5	15,2	84,8
GZ2					
Area (ha)	0,292	0,528	0,110	0,065	0,930
Percentage (%)	29,3	53,1	11,1	6,5	93,5

4. Conclusion

Very high spatial resolution Pleiades imagery was used to map vegetation cover, classify vegetation types and estimate vegetation cover percentage in the green zone, and the results were verified qualitatively and quantitatively. Vegetation cover can be obtained accurately using combination of NDVI and blue band. Vegetation types in the study area were classified into sparse vegetation, low-medium vegetation and medium-high vegetation using ISODATA unsupervised and MLEN supervised methods. The accuracy of both methods did not differ significantly, where the overall accuracies were 97.9% and 98.9% for unsupervised and supervised method respectively. The

vegetation cover percentage was determined by calculating the ratio between the vegetation type area and green zone area. This information will be useful to support green zone management activities.

Acknowledgement

The Author thank to officials of Remote Sensing Application Center, LAPAN, who have facilitated this research activity, and the author also thank to official of Technology and Data Center who has fulfilled the request of the author to provide Pleiades data at the study area.

5. References

- [1] Kemen PU 2008 *Pedoman penyediaan dan pemanfaatan ruang terbuka hijau di kawasan perkotaan* (Dirjen Penataan Ruang, Departemen Pekerjaan Umum)
- [2] Rahmy W A, Faisal B and Soeriaatmadja A R 2012 Kebutuhan Ruang Terbuka Hijau Kota pada Kawasan Padat, Studi Kasus di Wilayah Tegallega, Bandung *Jurnal Lingkungan Binaan Indonesia* **1**
- [3] Mahmoodzadeh H 2007 Digital Change Detection Using Remotely Sensed Data for Monitoring Green Space Destruction in Tabriz *Int. J. Environ. Res.* **1** 35-41
- [4] Rao Y, Zhu X, Chen J and Wang J 2015 An Improved Method for Producing High Spatial-Resolution NDVI Time Series Datasets with Multi-Temporal MODIS NDVI Data and Landsat TM/ETM+ Images *Remote Sens.* **7** 7865-7891
- [5] Hu T, Yang J, Li X, and Gong P 2016 Mapping Urban Land Use by Using Landsat Images and Open Social Data *Remote Sens.* **8** 151
- [6] Simarmata M 2012 Kajian Ketercukupan Ruang Terbuka Hijau Berdasarkan Jumlah Penduduk Kota Pematangsiantar *Jurnal Akar* **1** 91-103
- [7] Andriyani E P 2012 Pemetaan Greenways Menggunakan Citra Quickbird Di Kota Surakarta *Jurnal Bumi Indonesia* **1**
- [8] Trisakti B 2016 Utilization Very High Spatial Resolution Pleiades Data to Identify Vegetation and Its Density *Seminar Nasional Penginderaan Jauh Depok Indonesia 27 July 2016*
- [9] Zylshal, Sulma S, Yulianto F, Nugroho J T and Sofan P 2016 A support vector machine object based image analysis approach on urban green space extraction using Pleiades-1A imagery, *Model. Earth Syst. Environ* **2** 54
- [10] Caccetta P, Collings S, Hingee K, McFarlane D and Wu X 2011 Fine-scale monitoring of complex environments using remotely sensed aerial, satellite, and other spatial data, *2011 International Symposium on Image and data fusion (ISIDF 2011)* Tengchong Yunnan China 9-11 August 2011
- [11] Li X, Meng Q, Li W, Zhang C, Jancso T and Mavromatis S 2014 An explorative study on the proximity of buildings to green spaces in urban areas using remotely sensed imagery *Annals of GIS* **20** 193–203
- [12] Nichol J dan Lee C M 2005 Urban vegetation monitoring in Hong Kong using high resolution multispectral images *International Journal of Remote Sensing* **26** 903
- [13] Adam S, Vitse L, Johannsen C and Monbliu J 2006 Sediment Type Unsupervised Classification Of The Molenplaat, Westerschelde Estuary, The Netherlands *EARSeL eProceedings* **5** 2
- [14] Trisakti B 2012 Peningkatan Akurasi Hasil Klasifikasi Penutup Lahan menggunakan Metode Maximum Likelihood *Prosiding PIT MAPIN XIX Makasar Indonesia 7-8 Juni 2012*