Urban Green Space Evaluation Using Object-Based Classification of High-Resolution Satellite Imagery: A Case Study of Kertajaya and Dharmahusada, Surabaya

Hepi Hapsari HANDAYANI, Rochamukti RIZCANOFANA

Abstract: Digital classification method consists of pixel-based and object-based approaches. An object-based classification is the most effective method to extract feature of high-resolution satellite imagery. One of the application is for mapping and evaluating urban green space. This research uses the WorldView-2 imagery covering Kertajaya and Dharmahusada Development Units. Evaluation of land use/cover and a green ratio is based on the classification results.

Keywords: object-based classification, high-resolution satellite imagery, urban green space.

1. Introduction

Rapid urbanization in this decade causes serious problems so that the land-use is becoming more important in urban planning. Since, serious environmental damage, a physical and psychological condition of people living in cities, the development of urban green space is more vital than ever. Availability of urban green space in cities should be monitored since its presence can reduce pollutants from transportation and the effect of urban heat islands, to maintain biodiversity or to develop leisure facilities. The emergence of remotely sensed satellite imagery has many available amenities for various mapping applications, including monitoring for urban green space. However, with high-resolution imagery, spectral values of objects of the same type become more heterogeneous and it may become necessary to use new features such as texture or neighborhood to improve the results of classifications (Blaschke et al., 2000; Flanders et al., 2003).

Rather than using a per-pixel classification, object-based image analysis has been proposed as an alternative. These approaches allow pixels to be re-grouped within homogenous segments and a large set of features to be computed, which can be spectral, textural, contextual or spatial. The use of this method bridges image processing and GIS functionalities in an object-based environment for handling in the GIS world (Benz et al., 2004; Câmara et al., 1996).

In this context, the main objective of this study is to map urban green space from WorldView-2 satellite image extending to multiclass classification. Urban green space (UGS) is a part of an urban area populated by plants and vegetation to support benefit directly or indirectly for the city due to safety, comfort, well-being and beauty. The model of a typology of urban green space can be naturally such as forest, natural reserve, or conservation, then intentionally planted such as garden, park, green corridor, or cemetery. Several levels of segmentation are applied for classification in order to reach the best result. The final goal is to evaluate the land use/cover and the portion of UGS in the study areas.

2. Study area and Data

The study area is two Unit Developments (UD), Dharmahusada consisting of 12 sub-districts and Kertajaya consisting of 13 sub-districts (Fig.1). WorldView-2 image used in this study was acquired in May 2012.

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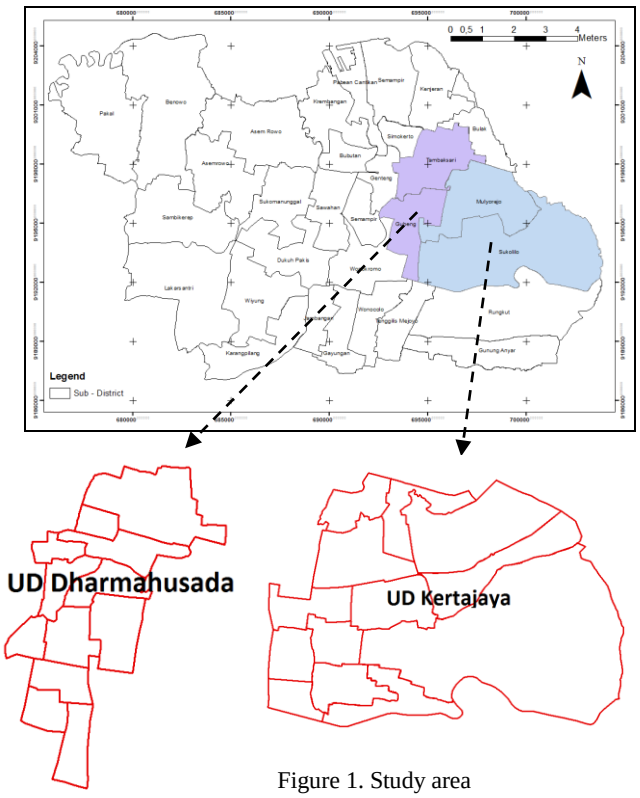


Figure 1. Study area

Twelve points are selected from a base map with a scale of 1:1000, used as Ground Control Points (GCPs) for the geometric correction process (Fig. 2).

(a)

(b) (c)

Figure 2. (a). The strength of figure for 12 GCPs for geometric correction of image. (b). The corrected Dharmahusada imagery (c). The corrected Kertajaya imagery.

3. Methods

In this study, land use/cover is divided into 10 classes consisting of built-up (residential, industrial, commercial), road and parking lot, greenway/green corridor, bareland, playground/grassland, cemetery, river, garden, pond, and mangrove. The object-based classification processing is conducted through three stages, namely segmentation, region merging, and example-based classification. Several values of watershed depth and full lambda are employed to reach the best result as shown in Figure 3. The watershed depth is segmentation algorithm based on the concept of hydrologic watersheds. The darker a pixel is, the lower its "elevation" is. A watershed algorithm sorts pixels by increasing greyscale value, partitioning the image into basins (regions with similar pixel intensities) based on the computed watersheds. The result is a segmentation image, where each region is assigned in the mean spectral values of all the pixels that belong to that region. Full lambda algorithm is employed to merge adjacent segments based on a combination of spectral and spatial information.

Based on Figure 3, the best result is obtained by using watershed depth 30 lambda 90, where segmentation can build a region in accordance with the appropriate class based on interpretation of pattern, tone and texture feature.

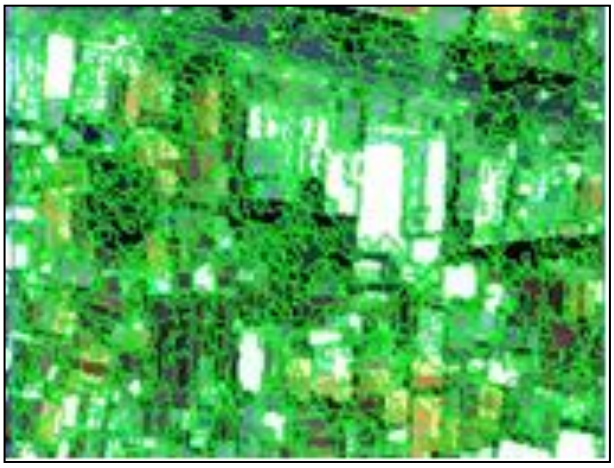
4. Results

4.1. Results of classification

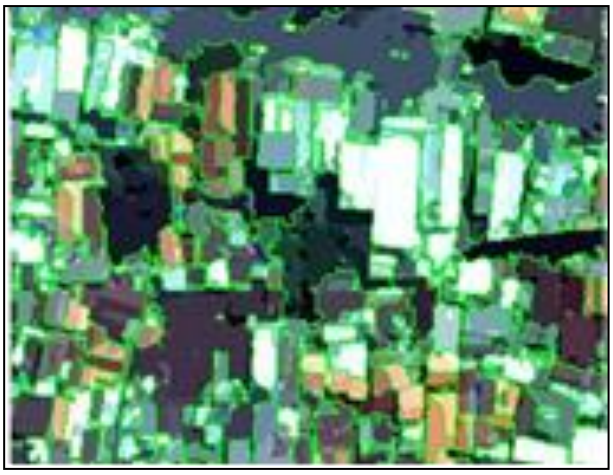
Completing example-based classification, 325 training samples are selected to represent all land use/cover based on segmentation. 10 classes are created with algorithm K-Nearest Neighbor with 3 parameters as presented in Figure 4.

4.2. Accuracy assesment

Mapping accuracy (MA), user accuracy (UA), and kappa coefficient (Cohen, 1960) of two study areas are listed in Table 1. For both study areas, the overall accuracies are more than 60%, with kappa coefficients are in around 0.9. Another accuracy assessment



(a)



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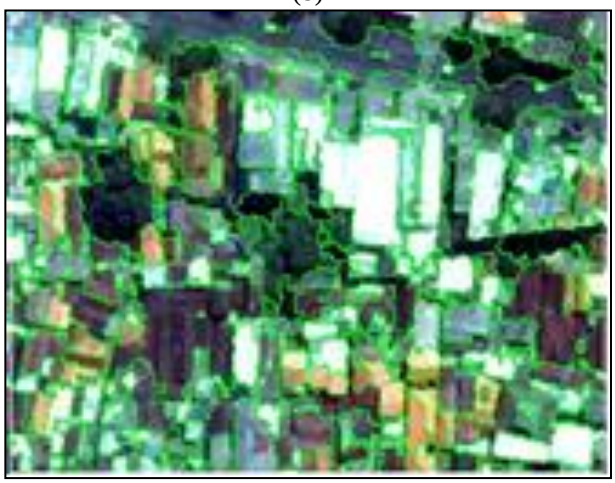
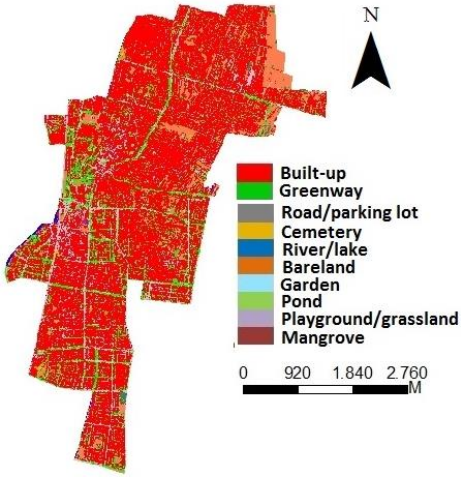


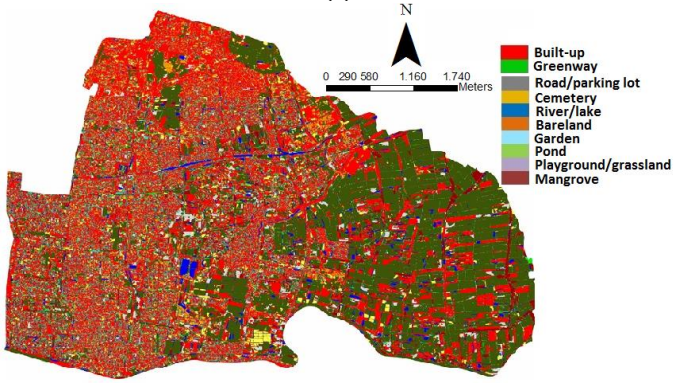
(c)

Figure 3. (a).Watershed depth 30, lambda 45 (b).Watershed depth 75, lambda 90 (c).Watershed depth 30, lambda 90.

conducted in this study is to employ ground truth test which is 4 points for each class so that there is total of 40 points in both areas chosen randomly. This test is intended to ensure that the generated classes are.



(a)



(b)

Figure 4. Land use/land cover classes (a).Dharmahusada (b).Kertajaya

corresponded to the real condition.

Table 1. Accuracy of classification

LU/LC	Dharmahusada		Kertajaya	
	MA	UA	MA	UA
Average	89.07	93.52	88.59	92.95
Kappa coefficient	0.95		0.92	
Ground truth test	0.975		0.925	

5. Discussion

Based on 10 classes of land use/cover generated as presented in Table 2, there are 5 classes included in UGS i.e greenway, playground/grassland, cemetery, garden, and mangrove. For Dharmahusada region, the UGS is dominated by greenway class that it can be a green corridor along the pedestrian, road, or river. While in Kertajaya region, UGS is dominated by mangrove that grows on the east coast of the region. The east coast of Surabaya is conservation area for mangrove as well as the bird. Although, built up class consisting of residential,

commercial, and industrial is remained becoming the largest land use/cover in both areas. In Kertajaya, another dominating land use/cover is a pond. Since the region is located near the coast, the use of suitable land is especially for a fish pond.

Table 2. Land use/cover

	Dharmahusada(Ha)	Kertajaya (Ha)
Built-up	1,209.3	1,774.9
Greenways	147.0	122.5
Bareland	144.8	239.9
Playground/grassland	11.8	104.5
Cemetery	10.9	112.9
River	5.6	120.5
Road and parking	196.1	342.4
Pond	1.5	1,362.1
Garden	5.0	151.7
Mangrove	0.0	232.0

Comparing two study areas, the green ratio of Kertajaya is greater than that of Dharmahusada as presented in Table 2. Since Dharmahusada is located closer to the CBD so that investment sector drives many developments of building either for residential, office or other commercial segments. For proportional green ratio and built-up ratio per sub-district can be seen in Figure 5. Green ratio per sub-district in the Dharmahusada area, there is no more than 20%. While in the Kertajaya area, there are three sub-districts whose green ratio is more than 20%.

Table 2. Green ratio and built-up ratio

Study area	Area (Ha)	Green Ratio	Built-up Ratio
Dharmahusada	1,732.2	10.1%	69.8%
Kertajaya	4,563.4	15.9%	38.9%

5. Conclusion

1. Land use/cover for the two study areas is dominated by built-up class.
2. Green ratio of Kertajaya is higher than that of Dharmahusada. Mangrove is found on the east coast of Dharmahusada as the conservation area.
3. Bareland is a fairly large class found in the two study areas. This area is potential for UGS increasing the green ratio of the areas.

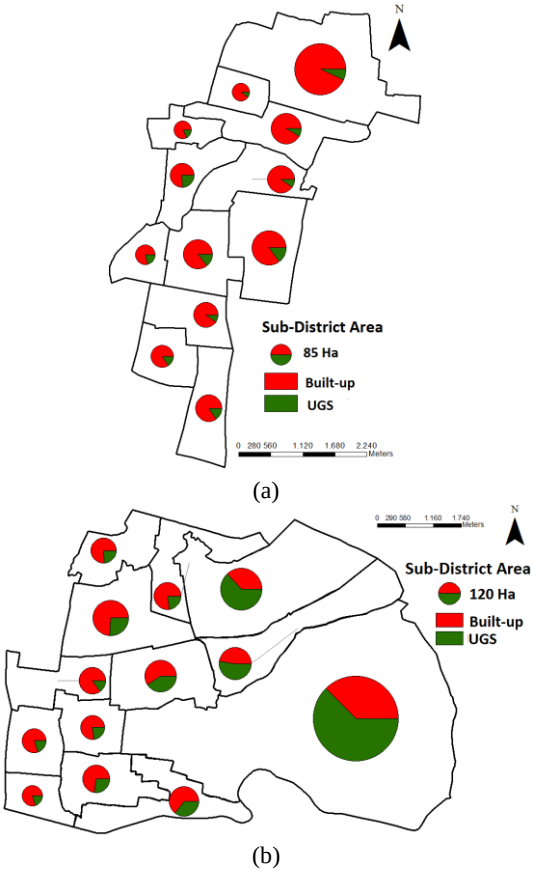


Figure 5. Green and built-up ratio per sub-district.

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