Detection of tree areas using Google Earth images in Banda Aceh, Indonesia

− Comparison between the pixel based and the object based image analysis −

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In order to monitor changes of tree areas after the 2004 tsunami, the aptitude of the pixel based and the object based image analysis for Google Earth images were compared. Satellite images, which taken in 2004, 2009 and 2013, were downloaded from Google Earth Pro as maximum resolution. They were georeferenced based on a topographic map. The land cover/use was classified to 9 classes by the pixel based and the object based image analysis with supervised learning. The overall accuracy by the pixel based image analysis was 0.65-0.71. By the object based image analysis, it was 0.65-0.71. Although tree areas were misclassified to paddy field, ponds and grassland by methods, user's and producer's accuracy by the object based image analysis were higher accuracy than the pixel based.
Keywords：Classification, Land cover/use, Monitoring, Recovery, Supervised learning

I Introduction

It is important to monitor and manage land cover / use in developing countries with increasing population. Especially, after large-scale disaster, unscrupulous developing is tending to occur in the recovery process (Reis, 2008; Balamurugan and Anubhooti 2015). Sometimes vegetation areas were not recovered, and even slight leftover vegetation areas were developed. Remote sensing data are useful for monitoring land cover changes after disaster (Eguchi et al., 2008, Joyce et al., 2009). However, they are expensive for time series analysis. It is effective to use images from Google Earth for monitoring and managing land cover / use. Because, we can use high spatial resolution images without a fee (Hu et al., 2013; Boardman, 2016; Malarvizhi et al., 2016; Wibowo et al., 2016). In order to explore appropriate classification methods for this new data, the pixel based and the object based image analysis, which have been typical methods for land cover classification, were applied for Google Earth images.

II Materials and Methods

1. Study Site

Banda Aceh is the capital of Aceh Province located on the island of Sumatra, Indonesia (Fig-1, 5°33'N, 95°19'E, 61.36 km^2). The city is lowland and flat area stretch on the north coast of Sumatra Island (BAPPEDA Banda Aceh 2009). The city is 61.36 km^2 in large with population is 250,303 in 2015 (BPS Banda Aceh, 2016). Griffin et al. (2013) estimated over 90% of mangroves within Aceh were destroyed by the 2004 tsunami.

2. Images

The images were downloaded from the Google Earth Pro (4800×3318 pixels), and they were taken on June 6th 2004, June 16th 2009 and May 8th 2013. The 39 images for each year were mosaic as one image using Adobe Photoshop CS4 (Adobe) then georeferencing in ArcGIS 10 (ESRI), and producing 0.5 meter spatial resolution with RGB.

3. Classification

The pixel based classification and the object based classification, which was supervised classification, were applied for mosaicked images using ERDAS IMAGINE 9.3 (ERDAS). The nine categories of land covers was set up, Bareland, Beach, Building, Grassland, Paddy Field, Ponds, Road, Trees and Water, and then 71 training data for the classification and 164 testing data for accuracy assessment was collected represent the 9 land covers categories in Banda Aceh. Training data and testing data were collected by visual interpretation on Google Earth.

The pixel based image analysis is to automatically categorize all pixels in to land cover classes based on each pixel value. On the other hand, the object based image analysis consist of image segmentation which is divided the image in to homogenous, continuous and contiguous object, and classification by an extensive variety of features that include pixel value, texture, and form (Gao and Mas 2008).

The overall accuracy and kappa coefficient was measured by error/confusion matrix using the point of

testing data as reference and compare with the result of classification of each class category (Congalton 1991; Story and Congalton, 1983).

III Results and Discussion

In both classifications, the result shown almost similar pattern. In 2004 the north part of Banda Aceh was dominated by ponds area, and then the building area was laying in the centre part, the paddy field in the south part, and the trees covers were spread in all part of the city. In 2009 and 2013 images the north part is dominated by the water area, while the building area still laying in centre part and move to the south part where the paddy field still growing, and the trees covers were spread in all part of the city (Fig-2).

The overall accuracy and Kappa are shown in Table-1~6. The producer's accuracy indicated the probability of a reference pixel/feature being correctly classified and user's accuracy is indicative of the probability that a pixel/features classified on the map/image actually represents that category on the ground and the kappa is the degree agreement of both accuracy (Congalton 1991; Story and Congalton, 1983). The overall accuracy was shown the pixel based was relatively has higher accuracy in classify the 2004 image with 0.71 (kappa 0.67) compare the object based 0.65 (kappa 0.60) however the object based has higher value in detecting the tress covers. Then the object based was relatively has higher accuracy in classify the 2009 image 0.71 (kappa = 0.67) compare pixel based 0.68 (kappa = 0.64); and 2013 image 0.70 (kappa 0.66) compare pixel based 0.65 (kappa 0.60) and the object based has higher accuracy for trees covers in 2009 and 2013.

The comparison of accuracy of each land cover in 2004 were shown the pixel based classification were higher in Bareland, Building, Grassland, Paddy field, Ponds and Road, while Beach were almost similar with results of the object based classification. The object based results were better in Trees and Water. In the 2009 image, the object based classification were slightly higher in classified Trees and Ponds, while almost similar in all other land use with the pixel based classification. In the 2013 image, accuracies by the object based classification were shown relatively higher except for Bareland and Water.

IV Conclusion

In order to explore appropriate classification methods for Google Earth images, the pixel based and the object based image analysis, which have been typical methods for land cover classification, were applied for Google Earth images. Although tree areas were misclassified to paddy field, ponds and grassland by methods, user's and producer's accuracy by the object based image analysis were higher accuracy than the pixel based.

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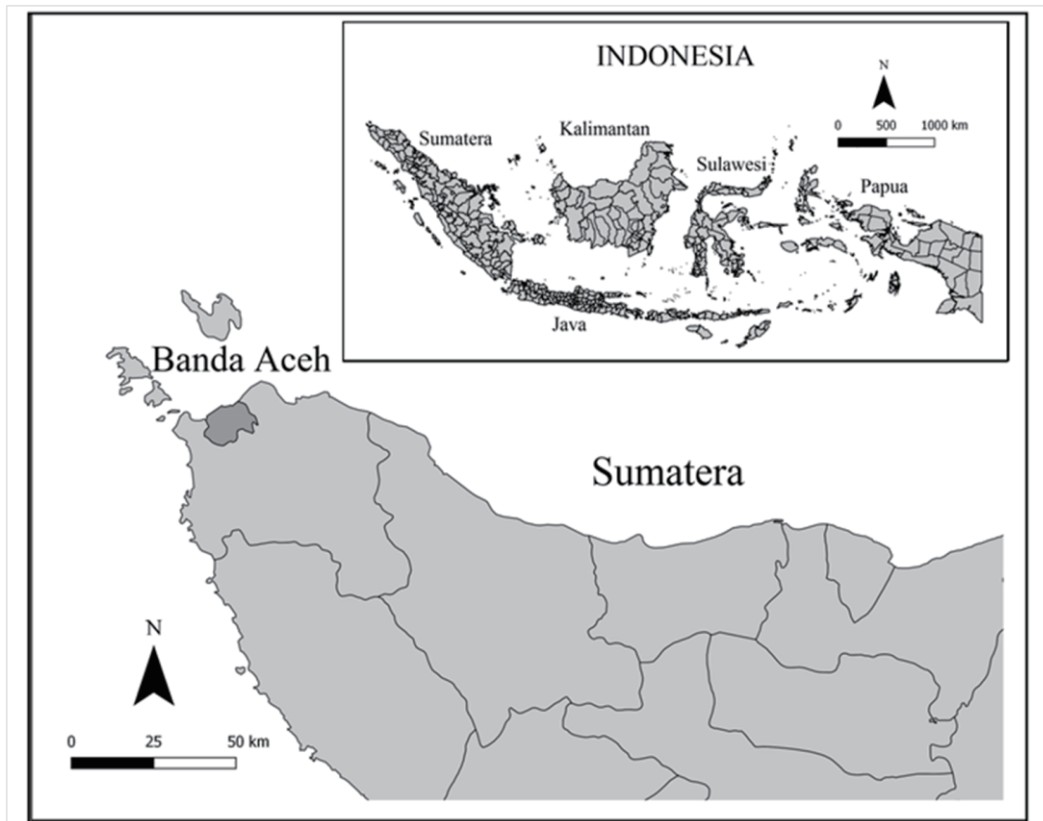
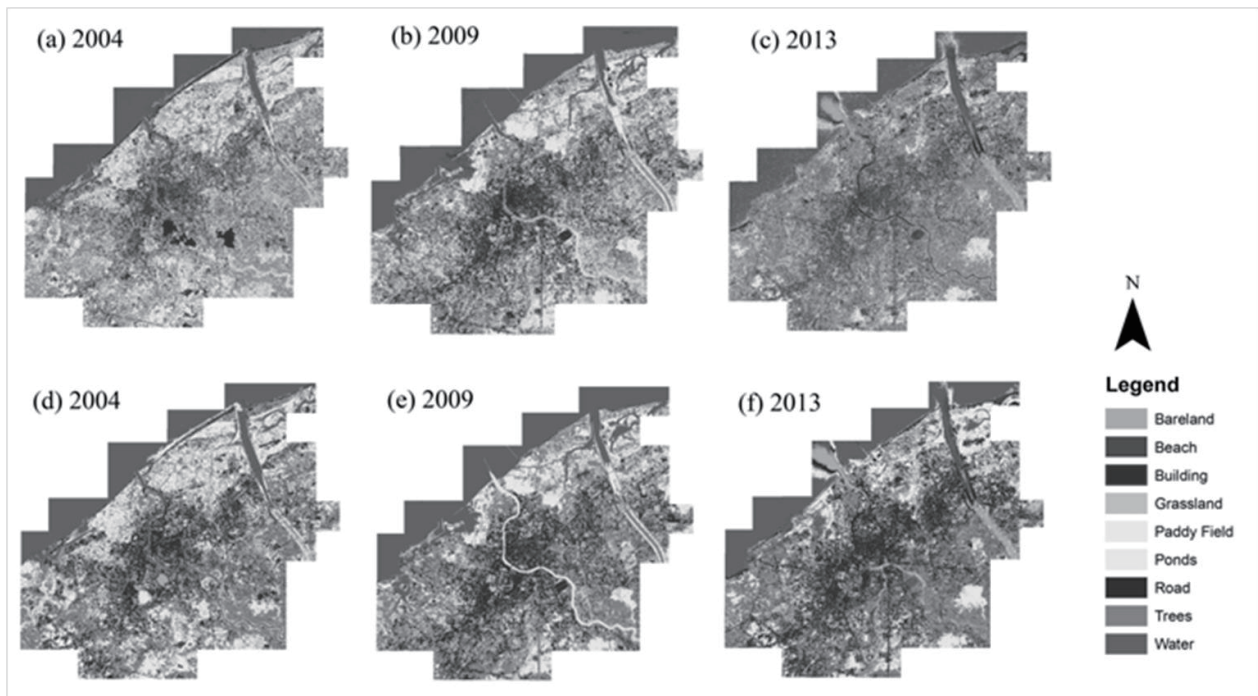Fig-1. Banda Aceh the capitol of Aceh Province, Indonesia

Fig-2. Banda Aceh Land Covers in 2004, 2009 and 2013. (a)~(c) were classified by pixel based image analysis. (d)~(f) were classified by object based image analysis.

Table-1. Accuracy matrix of pixel based image analysis in 2004.

Classified Data	Reference									Total	User
	Bareland	Beach	Building	Grassland	Paddy Field	Ponds	Road	Trees	Water		
Bareland	10	1	0	0	2	0	3	0	0	16	0.63
Beach	1	14	0	0	0	1	1	0	0	17	0.82
Building	0	1	15	0	0	0	3	0	0	19	0.79
Grassland	0	0	1	8	5	2	4	0	0	20	0.40
Paddy Field	0	0	0	3	11	0	3	1	0	18	0.61
Ponds	0	1	0	0	1	15	0	2	0	19	0.79
Road	2	0	0	0	0	0	14	0	0	16	0.88
Trees	0	0	0	0	3	4	0	13	0	20	0.65
Water	0	0	0	0	0	3	0	0	16	19	0.84
Total	13	17	16	11	22	25	28	16	16	0.71	Overall
Producer	0.77	0.82	0.94	0.73	0.50	0.60	0.50	0.81	1.00		

Kappa = 0.67

Table-2. Accuracy matrix of pixel based image analysis in 2009.

Classified Data	Reference									Total	User
	Bareland	Beach	Building	Grassland	Paddy Field	Ponds	Road	Trees	Water		
Bareland	11	0	2	1	0	0	1	1	0	16	0.69
Beach	0	10	0	1	0	1	5	0	0	17	0.59
Building	2	0	15	1	0	0	0	1	0	19	0.79
Grassland	0	0	0	14	3	1	1	1	0	20	0.70
Paddy Field	0	0	0	1	11	2	0	4	0	18	0.61
Ponds	0	0	1	0	0	12	0	5	1	19	0.63
Road	0	3	1	1	0	0	11	0	0	16	0.69
Trees	0	0	0	2	4	4	0	10	0	20	0.50
Water	0	0	0	1	0	0	0	0	18	19	0.95
Total	13	13	19	22	18	20	18	22	19	0.68	Overall
Producer	0.85	0.77	0.79	0.64	0.61	0.60	0.61	0.45	0.95		

Kappa = 0.64

Table-3. Accuracy matrix of pixel based image analysis in 2013.

Classified Data	Reference									Total	User
	Bareland	Beach	Building	Grassland	Paddy Field	Ponds	Road	Trees	Water		
Bareland	12	0	1	0	0	0	2	0	1	16	0.75
Beach	0	10	1	0	0	0	5	0	1	17	0.59
Building	3	2	10	0	2	0	2	0	0	19	0.53
Grassland	0	2	1	9	0	0	2	6	0	20	0.45
Paddy Field	0	0	0	1	15	0	0	2	0	18	0.83
Ponds	0	0	1	1	1	10	1	2	3	19	0.53
Road	0	2	1	1	0	0	11	0	1	16	0.69
Trees	0	0	0	2	2	0	2	14	0	20	0.70
Water	0	0	1	0	0	1	0	2	15	19	0.84
Total	15	16	16	14	20	11	25	26	21	0.65	Overall
Producer	0.80	0.63	0.63	0.64	0.75	0.91	0.44	0.54	0.71		

Kappa = 0.60

Table-4. Accuracy matrix of object based image analysis in 2004.

Classified Data	Reference									Total	User
	Bareland	Beach	Building	Grassland	Paddy Field	Ponds	Road	Trees	Water		
Bareland	8	0	2	1	0	1	4	0	0	16	0.50
Beach	0	16	1	0	0	0	0	0	0	17	0.94
Building	2	2	13	1	0	0	1	0	0	19	0.68
Grassland	0	0	0	7	6	3	3	1	0	20	0.35
Paddy Field	0	0	0	3	4	5	5	1	0	18	0.22
Ponds	0	1	0	0	2	14	0	2	0	19	0.74
Road	0	4	0	1	0	2	8	1	0	16	0.50
Trees	0	0	0	0	0	0	1	19	0	20	0.95
Water	0	0	0	0	0	1	0	1	17	19	0.89
Total	10	23	16	13	12	26	22	25	17	0.65	Overall
Producer	0.80	0.70	0.81	0.54	0.33	0.54	0.36	0.76	1.00		

Kappa = 0.60

Table-5. Accuracy matrix of object based image analysis in 2009.

Classified Data	Reference									Total	User
	Bareland	Beach	Building	Grassland	Paddy Field	Ponds	Road	Trees	Water		
Bareland	12	0	2	0	0	0	1	1	0	16	0.75
Beach	0	9	0	3	0	0	5	0	0	17	0.53
Building	3	0	15	0	0	0	0	0	1	19	0.79
Grassland	0	0	0	14	3	1	0	2	0	20	0.70
Paddy Field	0	0	0	2	10	0	0	6	0	18	0.56
Ponds	0	0	0	0	0	11	0	6	2	19	0.58
Road	0	2	1	2	0	0	11	0	0	16	0.69
Trees	0	0	0	1	1	0	2	16	0	20	0.80
Water	0	0	0	0	1	0	0	0	18	19	0.95
Total	15	11	18	22	15	12	19	31	21	0.71	Overall
Producer	0.80	0.82	0.83	0.64	0.67	0.92	0.58	0.52	0.86		

Kappa = 0.67

Table-6. Accuracy matrix of object based image analysis in 2013.

Classified Data	Reference									Total	User
	Bareland	Beach	Building	Grassland	Paddy Field	Ponds	Road	Trees	Water		
Bareland	12	0	2	0	0	0	2	0	0	16	0.75
Beach	5	11	0	0	0	1	0	0	0	17	0.65
Building	2	3	10	0	0	0	4	0	0	19	0.53
Grassland	0	0	0	8	5	3	4	0	0	20	0.40
Paddy Field	0	0	2	2	10	0	3	1	0	18	0.56
Ponds	0	1	0	0	1	15	0	2	0	19	0.79
Road	1	0	1	0	0	0	13	1	0	16	0.81
Trees	0	0	1	0	0	0	0	19	0	20	0.95
Water	0	0	0	0	0	3	0	0	16	19	0.84
Total	20	15	16	10	16	22	26	23	16	0.70	Overall
Producer	0.60	0.73	0.63	0.80	0.63	0.68	0.50	0.83	1.00		

Kappa = 0.66