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Application of the AR4 Model Image of Landsat 8 on Land Cover Classification in Central Sulawesi Grand Forest Park

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Abstract

The objective of the study is to understand the accuracy level as a result of Landsat 8 AR4 models image in the land classification within a certain class in the Central Sulawesi Grand Forest Park areas. The Landsat 8 image of AR4 model being developed by Akhbar and Ida Arianingsih (2015; published, 2016) is the modified model of separately AR4-50 image and the image of the SBP-AR4-50 model homogeneity based on Landsat 7 ETM^+ and SPOT 5 XS imagery, which was developed by Akhbar et.al. (2013).The study is trial application of Landsat 8AR4 models has been done for a small area (7384.74 ha), geographically located in 119° 54'56.41"E - 120° 00' 28.32" E and 0° 48 '23.29 "S - 0 ° 58' 31.44" S. All satellite images have been tested for 4 group of land cover type (25-class, 15 class, 10 class and 9 class). The result shows a greatest overall accuracy of 97% in land cover and consisting 96% of Kappa accuracy, and it is categorized as very good category.

Keywords: Landsat 8 image, AR4 model, Land Cover.

INTRODUCTION

Grand Forest Park of Central Sulawesi as Nature Conservation Areas is located in Palu and Sigi Regency, covered about 7384.74 ha. The enhancement is needed to find the appropriate management as well as to ensure the beneficial function. Nature Conservation Area, the Grand Forest Park plays roles as flora and fauna collection site, native or non-native. These roles are related to the functionality of the park such as research site, education, science, cultivation support, culture, tourism and recreation site.

In the last ten years, this park has impaired due to the local activities by some group of communities that gave threaten the existence of Nature Conservation Areas. The activities categorized as illegal manner such as uncertified god mining, dryland cultivation, grazing, illegal logging and wildlife poaching. By the consideration of the nature sustainability then, its need to managed fairly and seeking the way through to stop for any illegal activities. These will have achieved by the collaboration between government and local communities around the park. Local government both city and regency are need to arrange a comprehensive plan, doing monitoring and evaluation to support the sustainable management and in same way provide services to the peoples.

One of the supporting infrastructure that has been widely used in the planning, monitoring and evaluation of Grand Forest Park is the geographic information system (GIS) and remote sensing (RS)with the main data source of satellite imagery and digital maps. It was considered adequate to provide the quick and precise spatial data. Hansen et. al. (2000); Liu et. al. (2003); Thenkabail et. al. (2009); Gong et. al. (2013), stated that the remote sensing has been implemented as an important and effective tool for land cover monitoring. Remote sensing served such a fast, a quick, an easy and a precise information of spatial diversity of earth. According to Jia et. al. (2014), the source data of remote sensing is defining as important factor of land cover classification. Then, according to Gumma et. al. (2011); Gong et. al. (2013), the Landsat data is commonly being used to classifying the land cover.

However, the result accuracy is still doubtable especially on the decision making phase, since this system are still relying to analytical method and the satellite images consisting of high mixing pixel land object, so it still often wrongly classified the type of cover or land use. Lu et. al. (2011) stated that the problem of mixedpixels for moderate and coarse resolution image is the challenge of land mapping. A traditional image classification method of pixel per pixel is ineffective in coping with mixed-pixel problems. The sub-pixel-based method is also ineffective separating the pixels of one land cover from another one.

Observing to the land pixel mixing on the satellite image, medium resolution (10-30 meters) in the digital land cover and land use classification, Akhbaret.al. (2013), is trying to develop a satellite image analysis model based on Landsat7ETM^+ and SPOT 5 XS imagery, labeled as AR4-50 separate imagery model and homogeneity imagery model SBP-AR4-50. The separate satellite image model AR4-50 equipped by the average capability of land separating pixels'object which are statistically 1811.98 to 1972.08 (moderate-good), with the class accuracy of land use/land cover using the homogeneity image model of SBP-AR4-50, which is totally (confusion matrix) 72.15%-87.17%, the accuracy level of land map generator for agricultural land/forestry is good-excellent category on the Landsat 7 ETM^+ and SPOT 5 XS images.

According to Akhbar, et.al. (2014), 50 classes model in small coverage area (<50,000 ha) could improve split power and land use and land cover class segmentation respectively 83.31% and 99.08% by using Landsat image, as well as 67.10% and 77.76% by using SPOT 5 XS image. Accuracy test result of land use/cover class used confusion matrix method obtained overall accuracy 72% to 88%, and kappa statistical value 0.7174 to 0.8774.Furthermore, Akhbar and IdaArianingsih (2105; published, 2016), had develop an application model using Landsat 8 imagery and labeled as AR4 Landsat 8. The precision of the classification result of land use and land cover by AR4 model is over 85% in average.

Acharya and Ray (2005), define the classification is image segmentation technique based on the similarities among pixels in the area. Chang and Ren (2000), define the image classification as grouping process of pixels into classes, so each classes are representing of the entity with each specific property.

Based on the above, it is necessary to conduct a similar study through the development of AR4 satellite imagery application especially for the smaller area such as Central Sulawesi Grand Forest Park. The study is expected to provide the best solution to resolve the problem in digital image analysis as well as an input for Grand Forest Park manager to understand the types of land cover and land developments in their working area.

EXPERIMENTAL ANALYSIS

Problem Analysis

Based on the problems identification of the medium resolution utilization (30m), then the research question whether the application of image of Landsat 8model AR4 can assign the accuracy values for more than 85% of the land cover classification and how many classes of land cover would generate within the accuracy if it will apply in the 7384.74 ha of Grand Forest Park area?

Research Objective

The objective of the study is to determine the accuracy level of satellite image of Landsat 8 model AR4, in the land cover classification in certain classes in Central Sulawesi Grand Forest Park area.

The Benefit of Research

The usefulness of the results of this study are:

1) Expected to beneficial for the science and technology development especially on remote sensing, an incentive for the lecturer, researchers and students to develop new theories of forestry remote sensing.
2) Become an input to the management of Grand Forest Park to determine the types of land cover and the land use developments in the working area.

METHODS

The purpose of the study is seeking and to develop an appropriate technology of classification which is served an accurate result, accessible and low cost. Within such consideration and it specification of Landsat image 8, however it has been used by enthusiastic considering the land cover scale, 11 band bases, its use quite widely in agriculture, particular survey and mapping. Meanwhile, the misclassification of land object in the digital classification process are still exist as a problem, especially the implementation of unsupervised classification. Schematically the flow of the study is presented in figure 1.

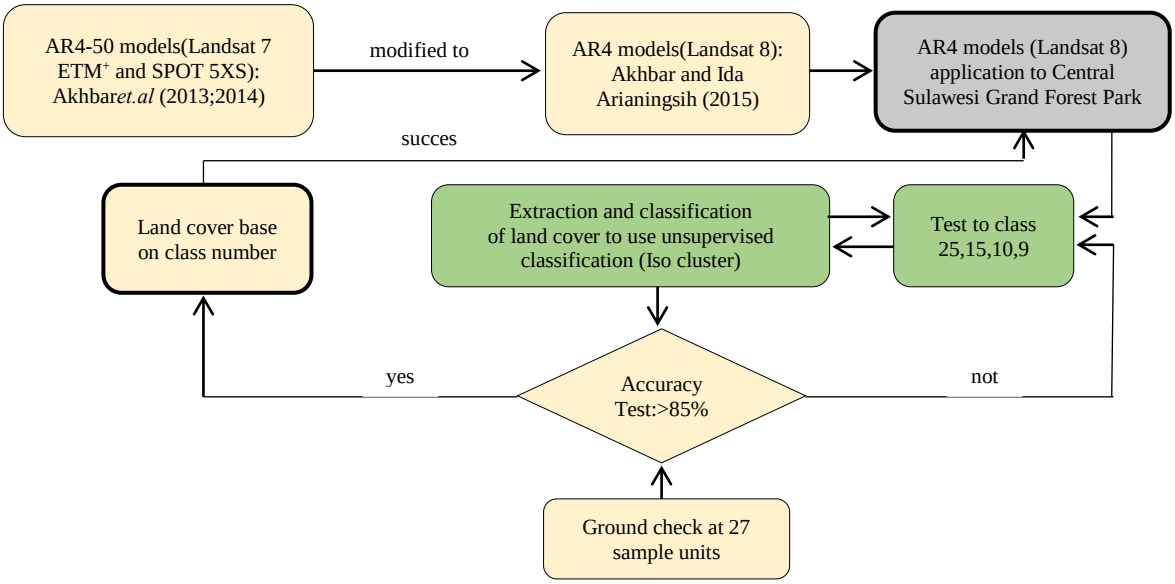

Figure 1: The Research Flow Framework

This is a descriptive study because the analysis has been conducted only on image of Landsat 8. The applied method intends to examine the data and information of Landsat 8 images, then analyzed to the spectral images pixel classes (land object). All data and information from the images band of spectral pixel values is interpreted to define the land cover. The interpretation process is supported by current land cover and land use map and data result of previous studies.

At the first stage the study has done through AR4 model images of Landsat 8making, using the formula **PCAband$_{652}$UBand$_{763}$UBandI$_{L63}$**. The result of the formulation then proceeds to the unguided classification process (isocluster). Manako, et.al. (2000), stated that the performance method of unsupervised classification (isodata) could be raised by fixing the input parameter. While, Sateesh and Sandip (2011) stated that the unsupervised classification (isodata) is easy to be implemented for image classification.

The further stage is field checking to ensure the land cover classification result in the images, at the >85% threshold match. The study has been done from August 2015 to November 2015.

Research is located in the region of Central Sulawesi Grand Forest Park covering 7384.27 ha, located in the Palu and SigiRegency. Geographically, the site is located at 119° 54'56.41"E - 120° 00' 28.32" E and 0° 48'23.29"S - 0° 58' 31.44" S. The study site as shown in Figure 2.

Remote sensing imagery that been used is Landsat 8(geometrically corrected), path/row: 114-61, recorded at March 29, 2013. Other materials are: the printer ink, quarto paper size A4, and a notebook. Work equipment of field checking consisting of: The Global Positioning System (GPS), tally sheet, pencils and pens, digital cameras, ruler, meter roll. Equipment for data processing of spatial and non-spatial and reporting consisting of: a compatible computer, printer, Quantum-GIS version 2.4, ILWIS version 3.7software, Microsoft Office Excel 2007, Microsoft Office Word 2007, as well as map of Central Sulawesi Grand Forest Park.

The ground checking using 27 sample point location (SPL) and intentionally set (purposive sampling), followed by the accuracy test of the land cover classification through compliance/suitability method of land on the interpretation of land object in the images and SPL land(confusion matrix method). When the result of accuracy test complies with the threshold >85% then the analysis is complete with good - excellent category, otherwise it will match with less – intermediate category when the result is ≤85%.

Confusion matrix is a common practice employed for assessment of classification accuracy. The matrix compares information obtained by reference sites to that provided by classified image for a number of sample areas. Accordingly, overall accuracy, producer's and user's accuracies, and Kappa statistic were calculated from the error matrix (Congalton and Green, 2009 in Kindu et.al., 2013).

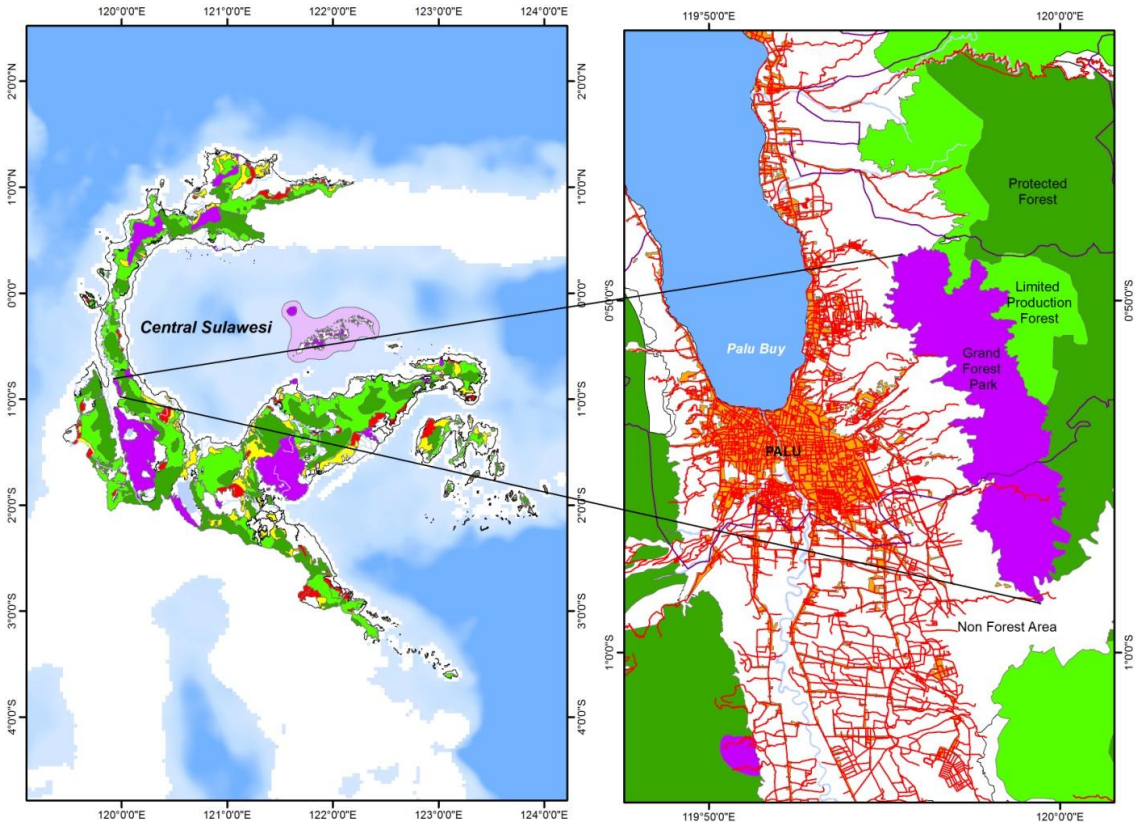

Figure 2: The Study Sites

RESULT AND DISCUSSION

The Values of Spectral Analysis of Landsat 8 AR4 Models Image

The values spectral analysis of Landsat 8 AR4 models image is presented in the Table 1,2,3 and figure 3below:

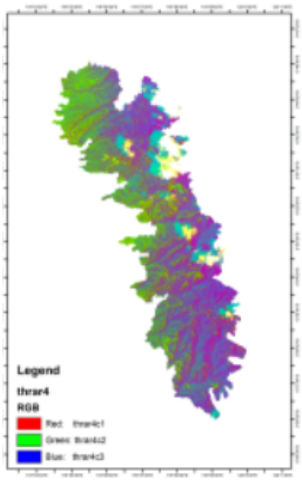

Figure 2. AR4 Images

Table 1. ***Statistics of Individual Layers***

# Layer	Min	Max	Mean	Std
1	15212,0000	65237,0000	26521,7849	4833,1876
2	2768,0000	19599,0000	7844,0912	2307,3165
3	9538,0000	24155,0000	15756,7621	1152,4352
4	6343,0000	29372,0000	9229,6589	2572,1957
5	7357,0000	36772,0000	13165,1864	2945,8978
6	7933,0000	36526,0000	10004,4706	3058,7456
7	-6264,0000	10304,0000	3160,7159	1320,1446

Table 2. ***Correlation Matrix***

# Layer	1	2	3	4	5	6	7
1	1,00000	0,37267	0,34504	0,86761	0,90544	0,89085	-0,04359
2	0,37267	1,00000	-0,12684	0,76328	0,64392	0,72405	-0,24070
3	0,34504	-0,12684	1,00000	0,06862	-0,01775	0,33293	-0,81100
4	0,86761	0,76328	0,06862	1,00000	0,97194	0,95577	-0,04561
5	0,90544	0,64392	-0,01775	0,97194	1,00000	0,90400	0,13695
6	0,89085	0,72405	0,33293	0,95577	0,90400	1,00000	-0,29970
7	-0,04359	-0,24070	-0,81100	-0,04561	0,13695	-0,29970	1,00000

Table 3. ***Covariance Matrix***

# Layer	1	2	3	4	5	6	7
1	9,024766e+006	1,605593e+006	7,424810e+005	4,167085e+006	4,980582e+006	5,088023e+006	-1,074408e+005
2	1,605593e+006	2,056757e+006	-1,303042e+005	1,750095e+006	1,690927e+006	1,974178e+006	-2,832513e+005
3	7,424810e+005	-1,303042e+005	5,130996e+005	7,858094e+004	-2,328609e+004	4,533969e+005	-4,766829e+005
4	4,167085e+006	1,750095e+006	7,858094e+004	2,556093e+006	2,845321e+006	2,905160e+006	-5,983974e+004
5	4,980582e+006	1,690927e+006	-2,328609e+004	2,845321e+006	3,352772e+006	3,147013e+006	2,057586e+005
6	5,088023e+006	1,974178e+006	4,533969e+005	2,905160e+006	3,147013e+006	3,614559e+006	-4,675462e+005
7	-1,074408e+005	-2,832513e+005	-4,766829e+005	-5,983974e+004	2,057586e+005	-4,675462e+005	6,733048e+005

Table 1,2,3 shows the result of multiband analysis in Landsat 8image and it was arranged into the AR4 image by the combined mathematical operations (Union = U) to the input images with the formula: $AR4_{Landsat\ 8}$ = (U $PCAband_{652}$ $Band_{763}$ U $BandIL_{63}$). It is need to be clarify that the $layer_{1\text{-}2\text{-}3}$ on $PCAband_{652}$ image is the same as $PCAband_{6\text{-}5\text{-}2}$. Whereas the layers $_{4\text{-}5\text{-}6}$ in the $band_{763}$is also same to $band_{7\text{-}6\text{-}3}$, and the same image were also found for $layer_7$and $bandIL_{63}$ images.

Table 3 shows the results of covariance matrix analysis between seven band combinations. In $PCAband_{652}$ image, $band_6$ gave the largest contribution (42.40%), followed by $band_3$ in the image $band_{763}$ (16.98%), $band_6$ in the image $band_{763}$ (13.37%), $band_7$ in the image $band_{763}$ (12.01%), $band_5$ in the image of $PCAband_{652}$ (9.66%), bandIL63 (3.16%), and $band_2$ in $PCAband_{652}$ image (2.41%). These results show the indication of entire imagery band in new image of AR4.

According to Dana et.al. (2015), PCA is a distinguished method to telemetry images analysis. The method is pursuing the different objectives, which are: reduction of data dimensions, discovering the image changes with different temporal conditions, and clarification of particular phenomena. In this method, data or image bands are put in a new space and new components means, replaced the former components and bands. In the new space, each new component is a linear combination of the former bands according to the following relation.

The table 2 show the correlation values (r) of Landsat 8 AR4 models image in the region of Central Sulawesi Grand Forest Park. The entire seven layers, has a values of non-linear spectral correlation. These conditions make the combination of the seven-layer band in complimentary. Danoedoro (2012) ensure that the lower band channels correlation it would take higher completion. Furthermore, those strongly correlated channel bands then the pixel distribution among two band presence linier.

The value of the pixel correlation of Landsat 8 in the AR4 models image in Central Sulawesi Grand Forest Parkis can be explained as follows:

- The $layer_1$ ($band_6$) in $PCAband_{652}$ image, is contain a spectral correlation value of pixels with $layer_{2\text{-}3\text{-}4\text{-}5\text{-}6\text{-}7}$ or $band_{5\text{-}2\text{-}7\text{-}6\text{-}3\text{-}IL63}$ between -0.04 to 0.91. In $layer_2$ ($band_5$) in $PCAband_{652}$ image, is contain a spectral

correlation value of pixels with $layer_{1-3-4-5-6-7}$ or $band_{6-2-7-6-3-IL63}$ between -0.13 to 0.76. In $layer_3$ ($band_2$) in PCA$band_{652}$ image, is contain a spectral correlation value of pixels with $layer_{1-2-4-5-6-7}$ or $band_{6-5-7-6-3-IL63}$ between -0.02 to 0.35.

- At the $layer_4$ ($band_7$) in $band_{763}$ image, is contain a spectral correlation value of pixels with $layer_{1-2-3-5-6-7}$ or $band_{6-5-2-6-3-IL63}$ between -0.05 to 0.97. In $layer_5$ ($band_6$) in $band_{763}$ image, is contain spectral correlation value of pixels with $layer_{1-2-3-4-6-7}$ or $band_{6-5-2-7-3-IL63}$ between -0.02 to 0.91. In $layer_6$ ($band_3$) in $band_{763}$ image, is contain a spectral correlation value of pixels with $layer_{1-2-3-4-5-7}$ or $band_{6-5-2-7-6-IL63}$ between -0.30 to 0.96.
- At the $layer_7$ ($bandIL_{63}$) in $bandIL_{63}$ image, is contain a spectral correlation value of pixels with $layer_{1-2-3-4-5-6}$ or $band_{6-5-2-7-6-3}$ between -0.04 to 0.14.

The Result of Land Classification

The result of the transformation is the Landsat 8 AR4 models image then was classified through the unsupervised classification method of isocluster based. The purpose of the classification is to gain the land cover information. The Landsat 8AR4 models image is further extracted to be classified into several number classes, consisting of consisting of 25 classes, 15 classes, 10 classes and 9 classes. According to Indarto and Faisol (2012), the extraction is raster data analysis and that would use to take or to extract raster data cell based on attributes or locations.

The result of isocluster image classification is followed by land objects interpretation. The results interpretation such: forests, cultivations, scrub, settlement and clearing area. From the 25-class image classification results is obtained an information that the forest is composed by 7 types of pixels' classes, shrubs consists of 3 pixels' classes; the cultivation area consists of 2 pixels' classes; agricultural is consist of 3 pixels' classes; settlement is 2 pixels' classes; and 11 pixels 'classes of cloud. Meanwhile the classification of 15-class, define that the forest is consists of 10 pixels' classes, clearing area is consisting of 1 pixels' class, 1 pixel for cloud, whereas 2 classes for cultivation area, shrub, agriculture and settlement area respectively.

In the image classification result of 10-class, forest is composed by 2 pixel classes as the same with shrub, clearing area and cloud. The cultivation and agriculture site has the same 2 pixels' classes. Then in the classification of 9-class is consist of 3 pixel classes, 1 pixel for shrub, 1-pixel for agriculture, 1 pixel for clearing area (mining, barren land), and 1 class for cloud and shadow respectively.

Akhbar (2014), define land cover as the appearance of the object in the image based on a group of image pixel classes yet, the land object not be separated into land use classes, due to the same spectral values in between. Furthermore, the land use is the appearance the land object based on the land pixel classes and can be separated into the same land classes. The land object appearance is presence by the clear and firm land boundaries among land object, or it usually clear presence of human activities in that areas.

According to Martínez and Mollicone (2012), stated that the land use function can be expressed through hierarchical relationships between the key land elements and these functional relations are based on thresholds reflecting the presence, relevance and predominance of the key land elements in the observed area.

Accuracy Assessment of Classification Result

The accuracy assessment of the land cover has been done through confusion matrix and Kappa method. The assessment was implemented by making the contingency matrix.

- The results of image classification accuracy assessment of 25 classes is obtained the overall accuracy values of 93.26% and Kappa accuracy of 91.11%. These values show that appropriateness of classification results with the field conditions, is set at the satisfactory level. The accuracy Procedures values shows the satisfactory level of the accuracy of land cover. Likewise, the user's accuracy value except the cultivation type of land cover classes, consist of 77.78% of accuracy value.
- The result of image classification assessment in 15-classis consisting of 94.38% for overall accuracy and 93.31% accuracy of Kappa. It can be concluded that the classification is satisfactory in term of filed condition. The value of accuracy procedures of cloud object and clearing is satisfactory categorized. While the user's accuracy testing shows the satisfactory level for most object except cultivation area and shrub.
- The results of image classification accuracy assessment for 10 classes, is define 95.50% of overall value and 94.65% of Kappa accuracy. It can be concluded that the classification result of 10-class is appropriate to the field condition as well as satisfying. While the procedure's accuracy and users of each object classes are also satisfying.
- The result of image classification accuracy assessment for 9-class is define 97% of overall accuracy and 96% of Kappa. The accuracy assessment result of overall accuracy, Kappa, Procedure's and user's show the result of image classification in 9 classes are at the satisfactory level and it shows the actual field conditions.

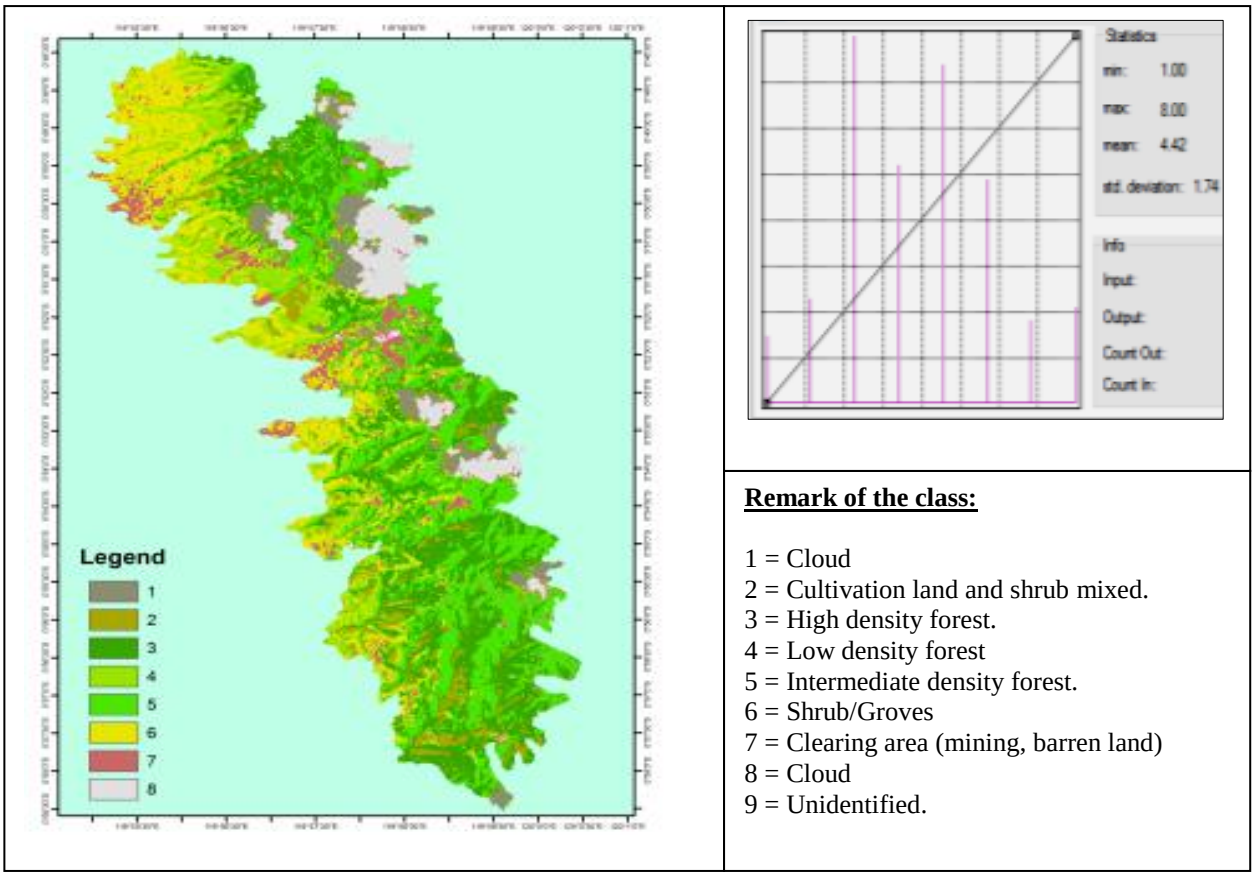

Figure 4: The Result of Land Cover on 9-class of Landsat 8 AR4 Model Image

The results of the classification of 9 classes matched with the field conditions, and it greater than three previous classes, i.e., 25 classes, 15 classes and 10 classes. Based on each accuracy value in every class shows increasing of number of class mean weaker on accuracy. Danoedoro (2012), explained that the higher number of classes might have lower accuracy. It also explained, the numbers of classes should be balance with the separability among the high classes.

According to Sutanto (1994) ≥80% of classification accuracy values is categorized as very good. While Abellera (2005) stated that the ≥85% accuracy is can be considered satisfactory.Akhbaret.al. (2013) using Landsat7ETM$^+$ produces an overall accuracy values (overall accuracy) reaching to 87.17%. Furthermore, Sonobe et.al. (2017), stated the vegetation indices (VIs) based on shortwave infrared bands (bands 6 or 7) could improve the classification accuracy, and using a combination of all derived data from Landsat 8 OLI data have resulted 94.50% overall accuracy. Rumadaet.al.(2015), gave explanation that the Landsat 8 image can be used to identify the land use change of mangrove forest in Ngurah Rai Grand Forest Park, with the high accuracy (90%). While Sampurno and Thoriq (2016) also stated that the Landsat 8 classification through maximum likelihood classification method (MLC) in Sumedang Regency, have resulted 10 classes of land cover with overall and kappa accuracy respectively 99.61% and 99.51%. This result is appropriate to the USGS (>85%).

CONCLUSION

The result of land cover classification in Central Sulawesi Grand Forest Park, based on AR4 models image, 9-class of classification consisting 97% of accuracy. The values is greatest compare to other classes (25-class, 15 class and 10-class). This accuracy value is exceeding from the accuracy threshold with was set 85%.

AR4 models image are still on the development phase and its application is limited to a medium resolution satellite (Landsat 8 imagery), while for wider application then the result models are needed to be tested to the high resolution satellite images.

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