EXTRACTING KEY FOR LANDCOVER CHANGE USING MULTITEMPORAL PALSAR IMAGES & ITS CALIBRATION TO RELEVANT OPTICAL IMAGES

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ABSTRACT

Continuous monitoring of landcover change is very important in developing countries. Especiallly the rapid deforestation (partially caused by wildfire) will influence not only the local but also regional upto global climate and biodiversity. Current monitoring using optical sensor (LANDSAT) is established but in tropical area has serious drawback: cloudcover. The result is: unhomogenous landcover, since the imagesmosaic comes from different time, partially in month or year just for cloud reduction.

Spaceborn PALSAR images is hypothetically suitable to solve the problem. There are three question to be answered in this research: (1) How to derivate landcover from SCANSAR – which is continuously shoot the earth during night time. (2) How to derivate landcover from default modus of PALSAR (i.e. FBS) with some other polarimetric images and make a quasi pan-sharpened PALSAR images. (3) How to calibrate the unsupervised classified images to optical sensor (AVNIR and/or LANDSAT) on the calibrated field.

1. INTRODUCTION

Needs on active remote sensing techniques are increasing mainly to the climatic conditions in Indonesia that often covered by cloud. In addition to the applications to map the topography, radar also offers applications for mapping of landcover with its polarization elements. From various available sensors, ALOS PALSAR sensor has got lots of attention. The use of radar in general requires special knowledge because the data that is displayed is completely different with the data from the optical sensor.

This paper discusses the elements of radar polarimetry in general, the characteristics of ALOS PALSAR Polarimetry (POLSAR) and test several techniques to map landcover, imprisonment and the ability to specifically detect land burned in a region. A comparison to relevant optical images is necessary to extract key for landcover change.

1.1 Polarization of Electromagnetic Wave

Polarization is an important element of a elektromagnetic wave. Polarization is defined as a streamlining and regularity eletric and magnetic components of waves, in a field perpendicular to the direction of the waves. Elektromagnetic waves can be characterized by behavior Electrik vector field as a function of time. Propagation waves can elektromagnetik illustrated in Figure 1.

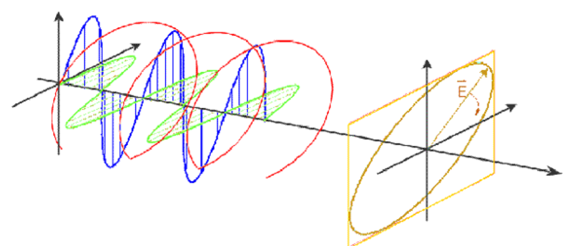


Figure 1: Illustration of electromagnetic propagation

As seen in Figure 1, electric field vectors have a horizontal component (green) vertical (blue), and when combined produce red vectors.

The form of the wave vectors in the electrical field can also be predicted or random, or a combination of both. Components of random noise such as the pure, where the frequency can not be observed, as well as patterns of its amplitudo. Examples of components that can be predicted is a monochromatic sine wave, with a constant, single frequency, and the constant amplitudo A elektromagnetic waves which do not have a random component that has been called fully polarized.

1.2 Polarization in the Radar System

How to create a system of polarisized radar waves? Radar uses as an antenna that is designed to send and receive waves from special electromagnetic polarization. The antenna can be a fad, including horns, waveguides, and enhanced patches. In each shape, electrical and mechanical properties such that the waves emanated almost entirely polarisized. In a simple radar system, the same antenna is often arranged so that the same polarization with the receiving antenna. (Giuli 1986).

Signal with the orthogonal polarization components in the base is required to produce a wave with any polarization. Two types of polarization basis of the most common is the linear horizontal or H, and linear vertical or V. Circular polarization is also used for certain types of applications, such as weather radar. Components of the radar base is marked with the type R (a circle to the right) or L (circle to the left).

Radar in a more complex system, has its antenna to be designed to emit and receive waves more than one polarization. In the shed, the waves have more than one polarization can be emanated separately, using a switch to direct energy to a different part of the antenna in a sequence (such as the H and V). In some cases the two can be used simultaneously, for example, a circular polarization can be emanated with the supply of H and V antennas simultaneously, with signals that have the same strength and phase difference of 90 ° (Figure 1).
Because the waves can change the polarization of the dispersed waves to be different from the polarization of the reflected waves, radar antenna is often designed to receive the different polarization components of the electromagnetic wave simultaneously. For example, the H and V of an antenna can receive the two orthogonal components of the wave coming, and the system saves the two signals are different.

Beam polarization and received waves is written with the pair of symbols, and radar use H and V linear polarization can be written as:
- HH - for horizontal beam and horizontal receive (HH),
- VV - for vertical beam and vertical receive (VV),
- HH - for horizontal beam and vertical receive (hv), and
- VH - for vertical beam and horizontal receive (VH).

Two first polarisation called one type polarization, because the waves that emanated and received are the same. The second polarization is called with a cross-polarization because the waves emanated with the received wave has a different polarization.

A radar system can have any level of complexity of polarization:
- Single polarization – VV, HH, VH or HV
- Double Polarization – HH-HV, VV-VH, or HH-VV
- Full polarization - HH, VV, HV, and VH

1.3. Polarimetry Image interpretation

One of the main goals of a remote system is to create a thematic map of the earth's surface, which shows the type of material for each location was recorded by radar. Type of material can be estimated from polarimetric radar data using computer-based classification algorithm. Pixels or groups of pixels as the classes that have a useful geoscientific interpretation.

To process polarimetric radar, using many parameters can improve the accuracy of the results interpretation. However, measurement noise, system calibration, understanding of the scattering mechanisme is a challenge that must be solved to obtain the better classification results.

1.4 ALOS PALSAR

ALOS PALSAR is a radar system that has full polarization. As listed in Table 1, PALSAR polarimetri operated using a 14 MHz bandwidth, and 16 MHz sampling frequency. Speed recording is fixed at 240 Mbps; so, the coverage can be limited by half of the high resolution (on the single and dual polarization), which operates with a coverage of 70 km. To expand its coverage, from the corner of the fountain on the corner is limited less than 30.1 degrees. This is in accordance with the five pieces of operated antenna elevation pattern for polarimetry.

Table 1: Characteristics of ALOS PALSAR Polarimetri (Shimada et al 2007)

Items	Values
Off nadir angles	7.9~30.1(degrees)
Image swath	30.6 km at off nadir 21.5
Number of bits	5
Sampling frequency	16.0 MHz
Band width	14.0 MHz
PRF	~2000Hz
Transmission power	2 Kw
Data rate	240Mbps
$NE\sigma^0$(dB)	-31.1(hh), -32.3(hv), -31.1(vh), -32.3(vv)
SA in range (dB)	46.8(hh), 24.7(hv), 27.1(vh), 44.7(vv)
SA in azimuth (dB)	20.6(hh), 21.4(hv), 21.5(vh), 21.9(vv)
Resolution(R)	31.2m(ground range)
Resolution (A)	20m(4look)
Cross-pol. cross talk	-25dB (specification): Measurements: -28.08 ~ -34 dB

2. METHODS

2.1. Research Location

Research was conducted in the area of Pekan Baru in Riau Province (Figure 2). Reasons for the selection of this location is that the level of land/forest fire in Pekanbaru have a very high level, occurs almost every year. However, this fire is mostly done by human land clearing for agriculture and for other purposes.

2.2. Visual Composition and Analysis RGB

The simplest way to classify is to use the visual interpretation. An interpreter to learn how the features on the surface of the earth is depicted in an image, and the interpreter's mind fill in something that is missing based on the knowledge and experience.

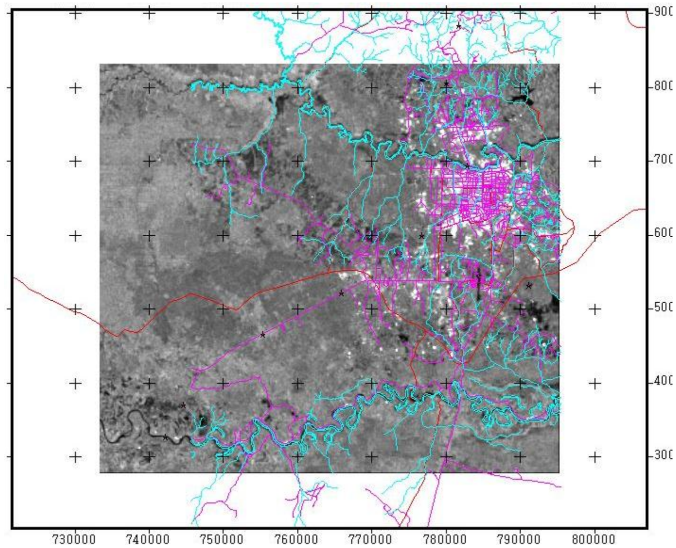


Figure 2: Location of research and the image of ALOS PALSAR 2008/05/03.

To interpret the images visually, some multi polarimetry data channel can be displayed in color, so that features can be identified by a particular interpreter. Sample preparation is a simple image of a color that is based on a combination of HH = red, green = HV, and VV= blue. In this combination it has been known that water has the reflection of VV higher than HH, and vegetation to have a reflection of HH is higher than HV.

Based on the above, a combination of polarimetric canals is tried to color in a digital analysis or classification, using supervised and not supervised classification method.

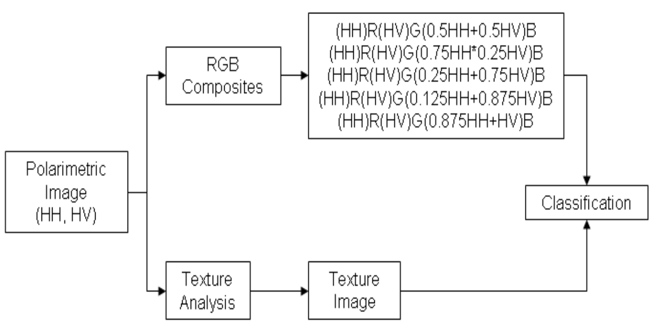


Figure 3: Flow Diagram data processing for classification.

Table 2: The composition is applied to the RGB.

No	Red	Green	Blue
1	HH	0.5HH+0.5 HV	HV
2	HH	0.75HH+0.25 HV	HV
3	HH	0.25HH+0.75 HV	HV
4	HH	0.125HH+0,875 HV	HV
5	HH	0.875HH+0,125 HV	HV

2.3. Texture analysis

Texture is a form of spatial variation of images intensity, which is understood as a change. In remote sensing, the texture information is very important, although still used in the application only as a complement of spectral information.

The use of texture to obtain the character of an object in the image is rarely used because this approach has a high level of difficulty. But basically, this texture can reflect a change in the condition of the surface of the earth. So that in the application necessary modeling-physical modeling. This research is based on texture analysis using its grey value. This method provides a general overview of the most optimal, has been implemented in some commercial software (Zheng et al 2004, Lee et al 2004).

The indicators used in the analysis of texture that is generally found using Co-Occurrence, where eight matrik fruit texture applied so that:

1. mean,
2. variance,
3. homogeniity,
4. contrast,
5. dissimilarity,
6. entropy,
7. second moment, and
8. correlation.

Co-occurrence is matrix of relative frequency of pixel values that occur in the two windows separated by a certain distance and direction. Shown is the number of instances of a relationship between a pixel with its surrounding (Haralick et al 1973, Anys et al 1994).

3. RESULT & DISCUSSION

Some combinations of RGB can be seen in Figure 3. Appear in the image: he water component is very easy to recognize, as well as the location of dense settlement, which is the color pink. The object recognition is very limited and difficult.

RGB combination technique is carried out to determine the features with more sharp, but also to distinguish between the size of the value of the reflection component of the HH and HV on an object. Thus it can be discovered at when HH and HV can be used to identify a particular object.

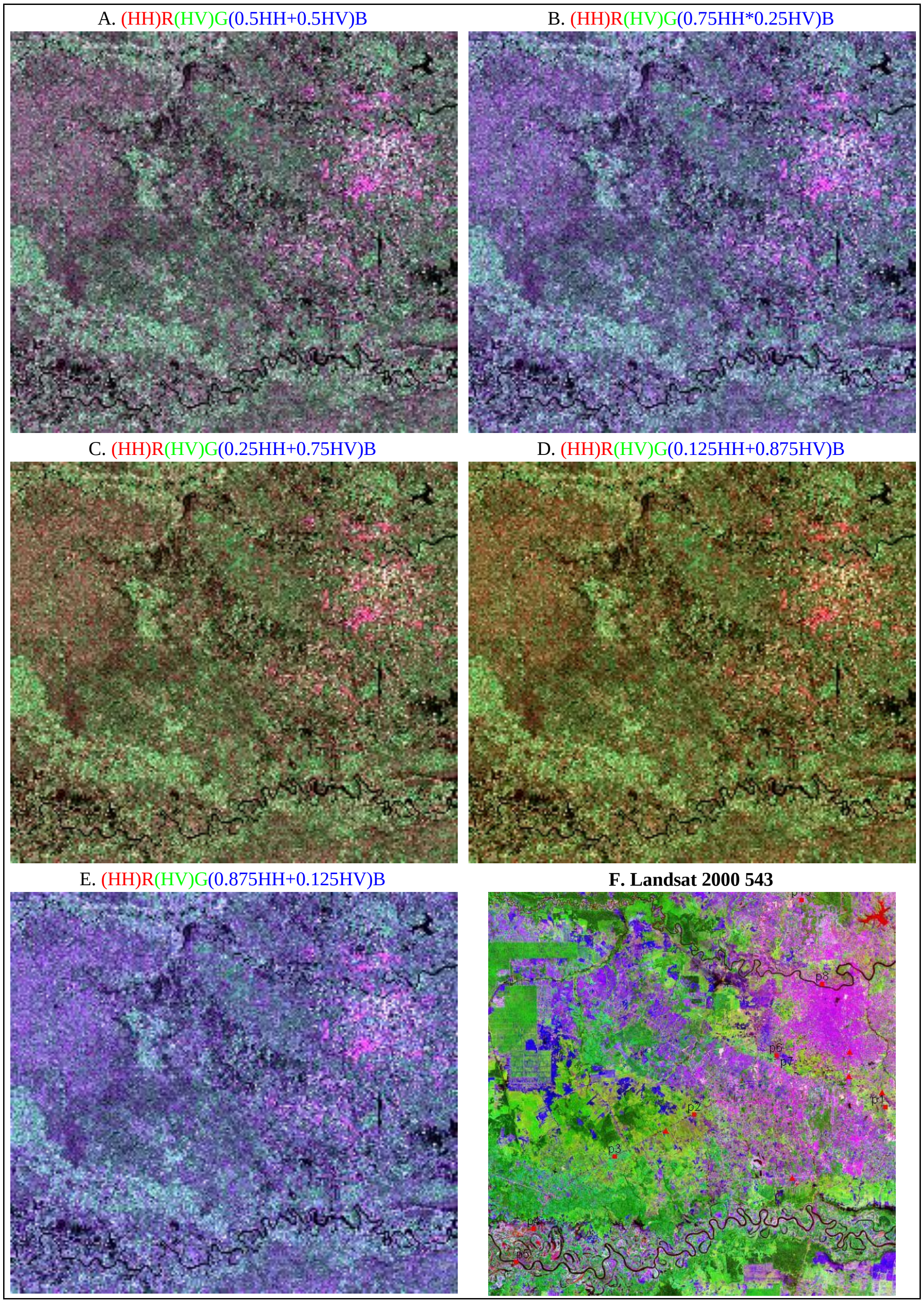


Figure 3: composition components polarimetri (HH, hv) into a combination of RGB.

Fifth combination of HH and HV to blue spectrum, is also seen that the addition of weight of HV on a combination of HH and HV resulted that the vegetation is easier to recognize. Water component in all combination is equally easy to recognize, even though this will need to be confuse when the land is empty, or it is soft texturized objects. But settlement would occur when the higher component of HH.

With the fifth example of that combination, it can be said that object identification can be done, even it is limited to the visual identification, and associative aspects should be included in the interpretation by interpreters.

When compared with the results of a combination of optical image such as Landsat (Figure 2-F) then the second type of data is not comparable. However, although the geometry processing does not begin with geometry correction, but the image of ALOS is very accurate (Figure 3).

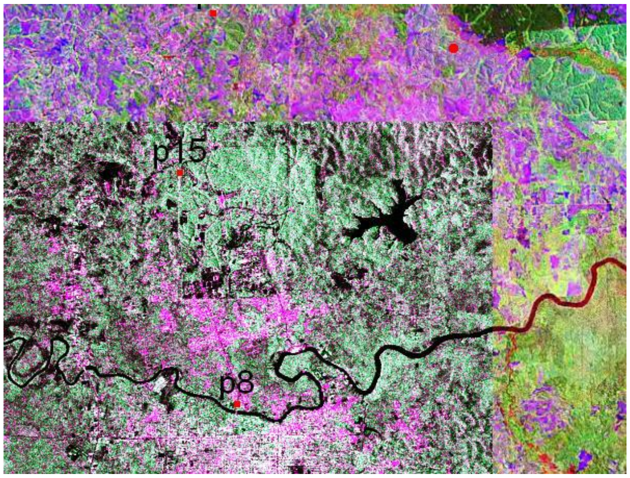
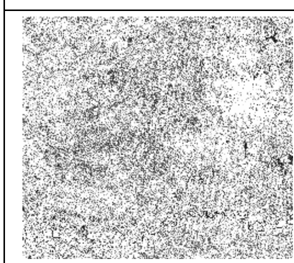
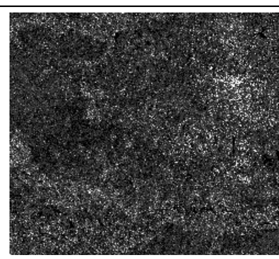
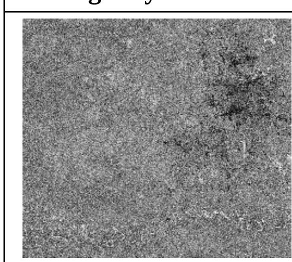
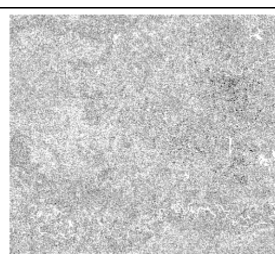


Figure 4: Comparison of geometry and Landsat ALOS (Results geometric Correction with topographic map).

3.2 Imagery Texture Co-occurrence

Results of analysis for some texture components (mean, variance, dissimilarity, homogenity, and contrast) can be seen in Figure 5 for both polarization (HH and HV).

From Figure 5 it can be seen that the second component has a polarization response to a different texture. However, the classification or identification of objects based on the data is still difficult.

HH	HV
Variance	
	
Homogenity	
	

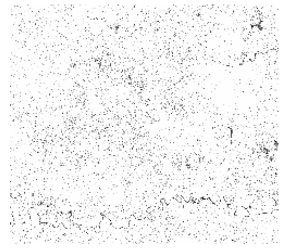
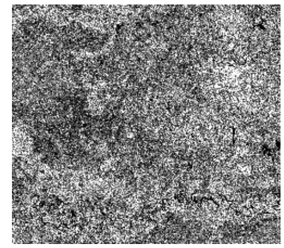
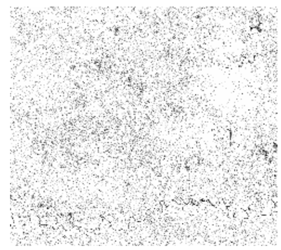
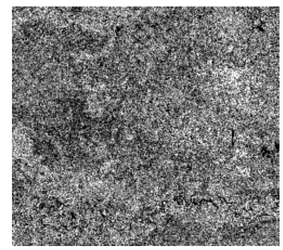
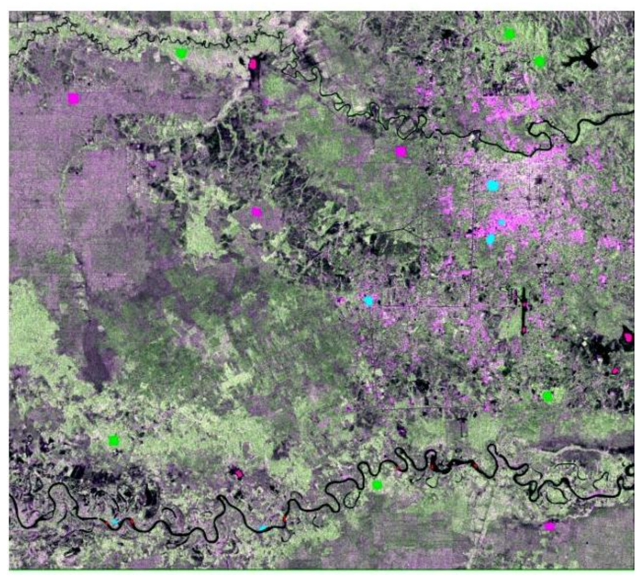
HH	HV
Contrast	
	
dissimilarity	
	

Figure 4: Image texture analysis results for HH and HV

3.3. Land Cover Classification

In the classification of land cover, both data (HH and HV) is used, added to the average of the HH and HV. RGB combination of the three and the results of training samples for supervised classification can be seen in Figure 6 and Figure 7 respectively. Training sample taken using the 2000 Landsat image of the validated with field data.



Bare land 2 — Settlement
Vegetation — Water
Bare land 1

Figure 6: Location training samples.

The division of classes into two bare land has the reasons firstly, Bare Land 1 is the area that really does not have any object on the ground, while Bare Land 2 is in the area of land where imprisonment is almost flat with the land such as shrubbery, the farm, that difficult recognized visually but have a soft texture in the area that's completely empty.

By using a separate sample, the classification results with the maximum likelihood is tested. Results of accuracy testing in general is:
- Overall Accuracy = (15457/21803) 70.89%
- Kappa Coefficient = 0:59

Test the accuracy of the results in detail can be seen in Table 3 and Table 4. The commission declares an error pixels become the property of another class even though labeled as the class you want. Omission errors represent pixels in the incoming class of sampled classification but failed to enter in the pixels in the correct class.

Tabel 3: Commission dan Omission accuracy test with separated sample

Class	Commission Percent	Omission Percent	Commission Pixels	Omission Pixels
Water	33.11	10.45	725/2190	171/1636
Settlement	14.75	27.05	389/2638	834/3083
Vegetation	9.73	33.78	768/7897	3636/10765
Bare land 2	51.88	17.93	4200/8096	851/4747
Bare land 1	26.88	54.33	264/982	854/1572

Producer accuracy is a result of the probability of a classification method classifed pixel to class A for example, where the sample is actually the class A also. And last, User Accuracy is a statement of probability of a pixel into the class A classification method where the pixels represent the class into A.

Tabel 4: Parameter of accuracy test of classification result

Class	Producer Accuracy		User Accuracy	
	Percent	Pixels	Percent	Pixels
Water	89.55	1465/1636	66.89	1465/2190
Settlement	72.95	2249/3083	85.25	2249/2638
Vegetation	66.22	7129/10765	90.27	7129/7897
Bare land 2	82.07	3896/4747	48.12	3896/8096
Bare land 1	45.67	718/1572	73.12	718/982

From Table 3 it can be said that there is a lot of confusion in determining which class a pixel value of pixels is indicated as a particular class (commission) and the value of the pixels removed from the same class (omission). There are a large portion of pixels in a class designation Water and Bare Land 2 (shrub, agricultural land), but on the other hand, many other classes of its pixel.

From Table 4 it can be said that it is difficult to express the consistency of the classification for the fifth grade from Producer Accuracy and Accuracy its Users. From the fifth class settlements tend to be most consistent, but there is confusion in the water or classified vacant / bare Land 1 (Figure 7).

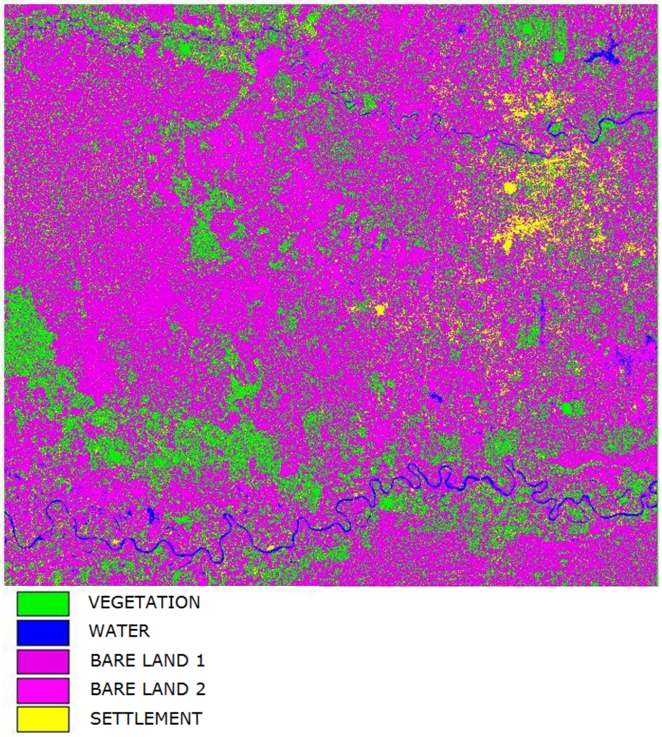


Figure 7: Results of supervised classification with maximum likelihood.

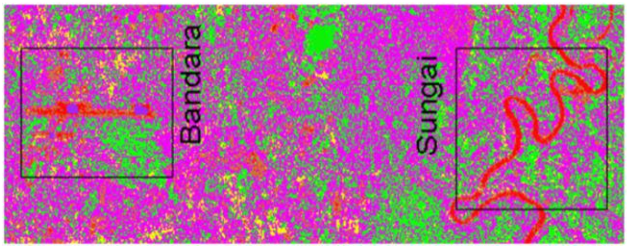


Figure 8: confusion between Bare Land (Bandara/Airport) with Water (Sungai/River).

3.4. Identification of Burned Land

Some things that can be said in the identification of the location of land or forest fires, that its appearance in the image is very difficult to recognize. However, when classification results plotted on a map, the location of a fire is located on open land (which consisted of shrub or agricultural land). So not in the center of the forest (Figure 9).

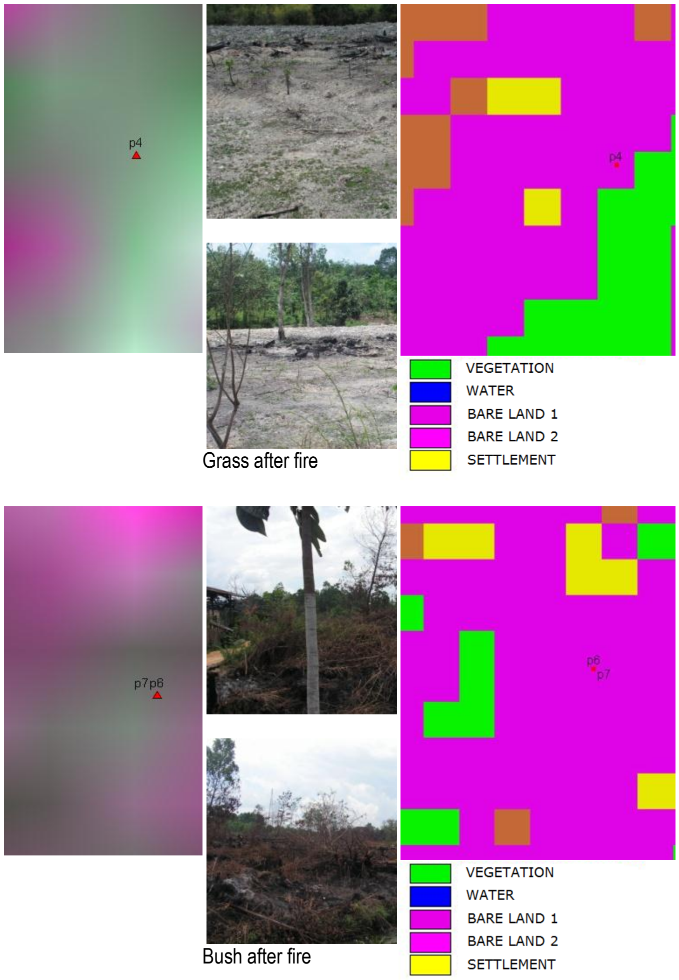


Figure 9: Land and burnt phenomena in the image and location on the image classification.

4. CONCLUSION

Some of the conclusions that can be taken based on the results of this research are as follows.

1. Radar imagery ability in general and ALOS PALSAR in particular is very important for mapping in Indonesia because of its ability penetrate clouds and enough temporal resolution.

2. Landcover mapping applications using polarimetry (HH, HV) still require further study, because with the use of dual polarization only, the ability to distinguish or identify the objects or features in the earth's surface is very limited. It is necessary for the full polarization (HH, HV, VH, and VV). Unfortunately, during ALOS campaign, only 2 session of full polarimetry per year is availlable, and the relevant optical images in the research area (including AVNIR) is not always available.

3. Ability of ALOS PALSAR image is also very limited in identifying the location of forest fires or land, especially the micro scale. Spatial image resolution is less, because most of the burned area have is a very small.

4. Extracting key for landcover change using multitemporal palsar images & its calibration to relevant optical images is therefore need further study and its required a more regular full polarimetry PALSAR images with availlability of relevant optical images (AVNIR or similar).

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