

MAPPING BURNT AREAS USING THE SEMI-AUTOMATIC OBJECT-BASED IMAGE ANALYSIS METHOD

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Abstract. Forest and land fires in Indonesia take place almost every year, particularly in the dry season and in Sumatra and Kalimantan. Such fires damage the ecosystem, and lower the quality of life of the community, especially in health, social and economic terms. To establish the location of forest and land fires, it is necessary to identify and analyse burnt areas. Information on these is necessary to determine the environmental damage caused, the impact on the environment, the carbon emissions produced, and the rehabilitation process needed. Identification methods of burnt land was made both visually and digitally by utilising satellite remote sensing data technology. Such data were chosen because they can identify objects quickly and precisely. Landsat 8 image data have many advantages: they can be easily obtained, the archives are long and they are visible to thermal wavelengths. By using a combination of visible, infrared and thermal channels through the semi-automatic object-based image analysis (OBIA) approach, the study aims to identify burnt areas in the geographical area of Indonesia. The research concludes that the semi-automatic OBIA approach based on the red, infrared and thermal spectral bands is a reliable and fast method for identifying burnt areas in regions of Sumatra and Kalimantan.

Keyword: *Burnt area, Landsat 8, OBIA*

1 INTRODUCTION

Forest and land fires occur every year in Indonesia, particularly in the dry season. They are a potential threat to sustainable development as they have a direct impact on ecosystems which contribute to increased carbon emissions and on biodiversity (Tacconi, 2003). The occurrence of forest fires in Indonesia also has an impact on regional issues in Southeast Asia, such as creating transportation barriers, especially air transportation ecosystem damage; and a decline in the quality of life of the community, for example in social, economic and health terms. To avoid repeated events, protection of forests from fires is needed by providing fire location data and information. According to Clark and Bobble (2007), the location of fires

can be seen from burning areas by using remote sensing technology. Remote sensing is one method that can be used to map burnt areas relatively quickly, it can be done simultaneously, can reach large and remote areas, and it produces reliable accuracy (Cochrane, 2003). Information on burnt area is needed to determine the environmental damage caused, the impact on the environment, the carbon emissions generated, and the rehabilitation process needed. The abilities of remote sensing technology can provide a picture that matches an object on the Earth, so that through its temporal capabilities, it can perform monitoring that can provide information that is compatible with damage to forests in Indonesia.

Much research has been conducted on mapping areas using remote sensing data, ranging from the use of low-resolution to medium-resolution satellite imagery. Fuller and Fulk (2001) used NOAA-AVHRR and Landsat TM to map burnt areas in Kalimantan, while Giglio et al. (2009) mapped actively burning areas using MODIS sensors. Bastarrika et al. (2011) used Landsat images to map burnt areas in the European Mediterranean basin. In addition, Torralbo and Benito (2012) employed MODIS and Landsat to map such areas in Spain. Identification of burnt areas in Kalimantan has also been made by Suwarsono et al. (2013) using MODIS.

Various methods have been developed to map areas accurately. By using the difference method of Normalized Burn Ratio (dNBR), Cocke *et al.* (2005) mapped burnt areas from Landsat 7 ETM data. By applying commission errors, contextual hybrid algorithms and logistic regression, Bastarrika et al. (2011) mapped burnt areas in the European Mediterranean basin based on Landsat TM. Likewise, Suwarsono et al. (2013) identified burnt areas from MODIS, based on the vegetation index (NDVI) variable, the burnt index (NBR), and reflectance values. Liu et al. (2017) employed simple algorithms, Burned Area Extraction and Dating (BAED), extract burned parameters from Landsat images, and MODIS NDVI images.

A recent method that has been used in remote sensing is object-based classification. According to Darwish et al. (ND), the basic principle of this method is to utilise information related to form, texture, and context from images. According to Baatz et al. (2008), two steps in OBIA are segmentation and

classification. The selection of objects based on image analysis (OBIA) uses image objects that have homogeneous pixels (Comert et al., 2019).

The purpose of this study is to develop remote sensing data models for detecting burnt areas by using the semi-automatic OBIA approach.

2 MATERIAL AND METHODOLOGY

2.1 Location and Data

The locations in this study were Riau, South Sumatra, South Kalimantan and West Kalimantan provinces. These were chosen because forest fires occur in these areas almost every year. The selected fire period was the peak fire season of 2015. This was a season with particularly severe fires in Indonesia because 2015 also coincided with an El Niño event. The data used in the study are Landsat 8 data from September 23, 2015 for Riau and South Sumatra, while for South Kalimantan the data are from September 13 and for West Kalimantan they are from September 9, 2015. The Landsat 8 image data are the result of direct acquisition from the LAPAN ground station.

2.2 Method

2.2.1 Image Processing

Changes in altitude, in satellite position, and rotation of the earth's surface movements when retrieving data and curvature of the earth will cause geometric distortion. It is therefore necessary to perform geometric correction so that the image coordinates are in accordance with the geographic coordinates, and the position of the images matches others to produce images with certain projection systems (Purwadhi, 2001).

Table 1-1: Description of Landsat 8 Imagery

Characteristic	Description
Spatial Resolution	15m Panchromatic Operational Land Imager (OLI) 30m Multispectral OLI 30m Thermal Infrared Sensor (TIRS)
Temporal Resolution	Resembled 16 Days
Scene Size	170 km x 185 km
Bands	Coastal Aerosol 0.43-0.45 μm Blue 0.45 – 0.51 μm Green 0.53-0.59 μm Red 0.63 – 0.67 μm NIR 0.85 – 0.88 μm SWIR1 1.57 -1.65 μm SWIR2 2.11 – 2.29 μm Pan 0.50 – 0.68 μm Cirrus 1.36 – 1.38 μm TIRS1 10.60 – 11.19 μm TIRS2 11.50 – 12.51 μm

Source: earth observing system, 2019

Atmospheric interference factors will affect the reflectance value of an object, so radiometric correction is needed to increase the value of the original pixel, but ensuring that it does not become larger due to scattering or smaller due to absorption (Ji & Peters, 2007).

To establish the accuracy of the burnt areas, band combination was performed based on the usefulness of each band found on Landsat. Band 4 has a long electromagnetic wave spectrum range of 0.630 – 0.680 μm , which functions to distinguish vegetation from the sloping part of the spectrum, which is very important for ecology because it reflects the health of the vegetation. In combination with other bands, there will be a vegetation index can be produce such as NDVI, which allows the measurement of plant health more precisely. Bands 6 and 7, with a short-wave infrared spectrum known as SWIR, are very useful for distinguishing wet soil

from dry earth. Rock and soil that look similar in other bands often have a strong contrast in SWIR. Band 10 is an infrared thermal band, or TIR, which is used to observe heat on the surface of the Earth.

The aim of this study is to identify burnt areas by combining the health of vegetation, as the main component affected in fires, and the temperature of the soil, because the forest fire areas usually retain heat for several days. Several band combinations were made in the study. The first of these was of bands 4, 5, and 10, followed the combination of bands 5, 6 and 10, and then of bands 5, 7 and 10. Subsequently, after performing the band combination, the object-based image analysis (OBIA) semi-automatic approach was employed by using the free SAGA software (System for Automated Geoscientific Analyses) GIS. In determining the class of burning, interpretation was made by comparing areas based on high-resolution imagery and field data (Figure 2-1).

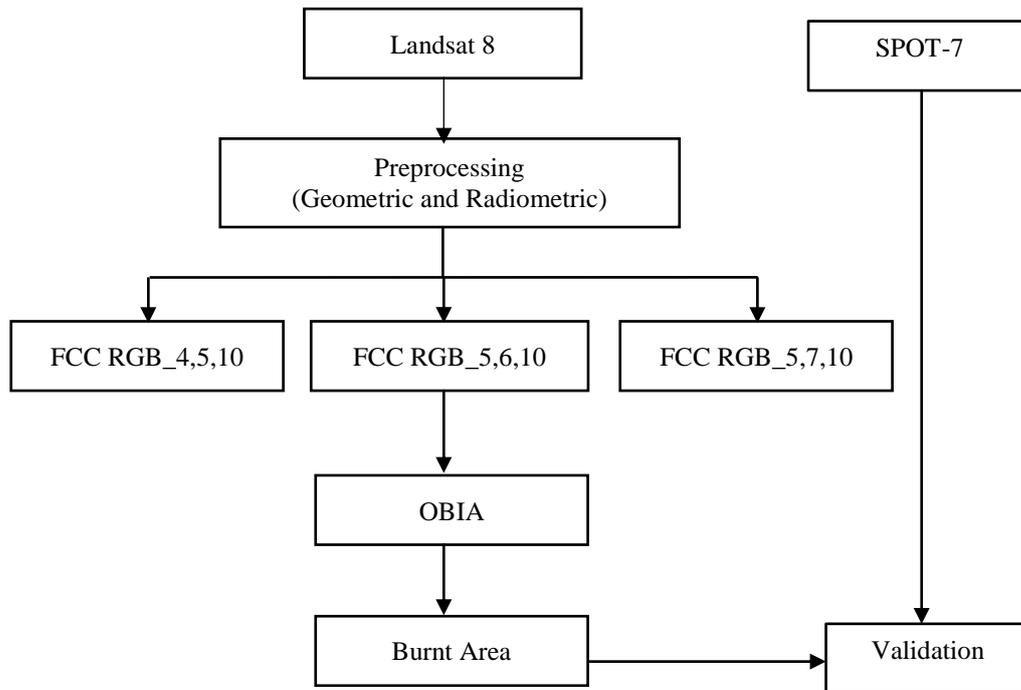


Figure 2-1: Research flow chart

3 RESULTS AND DISCUSSION

Object-based methods using Landsat 8 data can identify areas that have been burnt by land forest fires in Indonesia, especially the study area, which covers Riau province. In the future, it is the intention to also map South Sumatra, South Kalimantan and West Kalimantan. In the various combinations there were visual differences, namely in the combination of bands 4,5 and 10, bands 5,6,10 and bands 5,7,10. In Riau Province, as shown in Figure 3-1, the three combinations were able to identify the burnt areas, even though on the date in question it was cloudy and the burnt area was relatively small.

In South Sumatra, as shown in Figure 3-2, the wider area allowed clear identification of the active burning area, as well as of previously burnt areas. The difference in each band combination is clearly seen in the province of South Kalimantan, as shown in Figure 3-3, where the 4,5,10 combination showed burnt areas less clearly than the 5,6,10 5,7,10 and 6,5,4 combinations. This is probably caused by reflectance from the

health of the vegetation itself, which cannot be captured by band red, while the nature of the SWIR band allows it to capture areas of drought on the Earth's surface. This is related to the burnt area that occurred in South Kalimantan Province one of them is caused by drought. This is different to the case of the province of West Kalimantan, as shown in Figure 3-4, where the burnt area is relatively small and there is still visible smoke.

This method is relatively quicker and does not require complex devices, such as those that are visually digitized or otherwise method, so that each stakeholder can do the mapping easily; the speed will also benefit them in making decisions.

In addition, because the method applied is only semi-automatic, it still requires interpretation from the researcher in determining training samples from the burnt areas, so this might cause minor errors. These could occur if the burnt area has the same characteristics as the open land. Further research therefore needs to be conducted

on how to distinguish burnt areas from forest fires on open land. It will be clearly seen pattern of difference burnt areas using band combination at the study site, this can be established by further calculations such as omission or commission error. Determination of the right band combination to be applied needs to be chosen wisely and carefully so

that determination of the burned area is more accurate.

It is suggested that further research be conducted on the use of the semi-automatic OBIA method for areas with more specific geographical conditions, taking into account variations in vegetation, soil and topography. It may improve the accuracy.

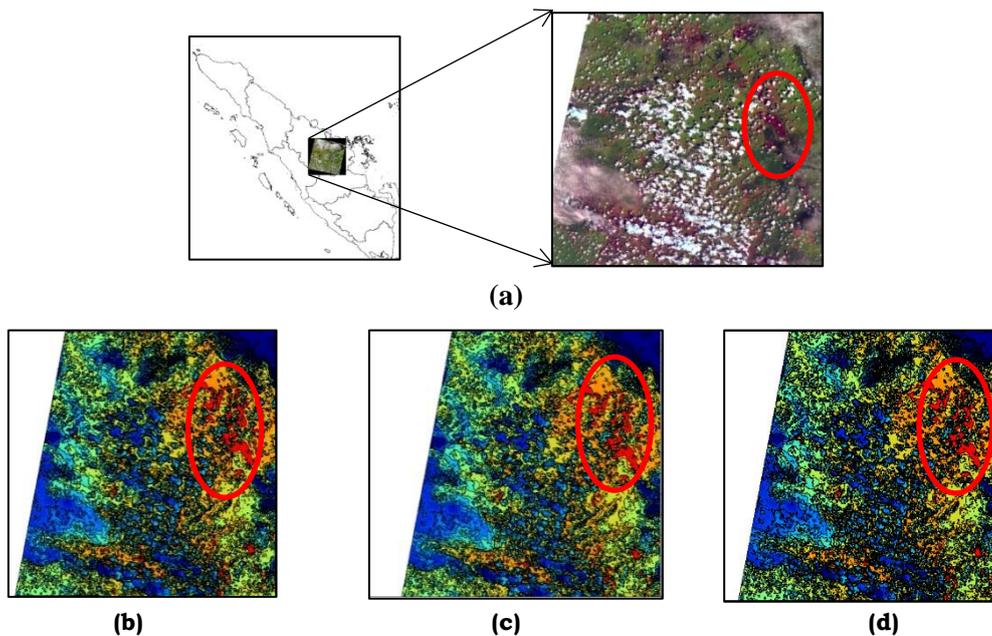


Figure 3-1: Results of the identification from the semi-automatic object-based image analysis of Landsat 8 images on 23 September 2015 for Riau Province, based on the: (a) RGB_6,5,4 band combination; (b) RGB_4,5,10 band combination; (c) RGB_5,6,10 band combination; and (d) RGB_5,7,10 band combination.

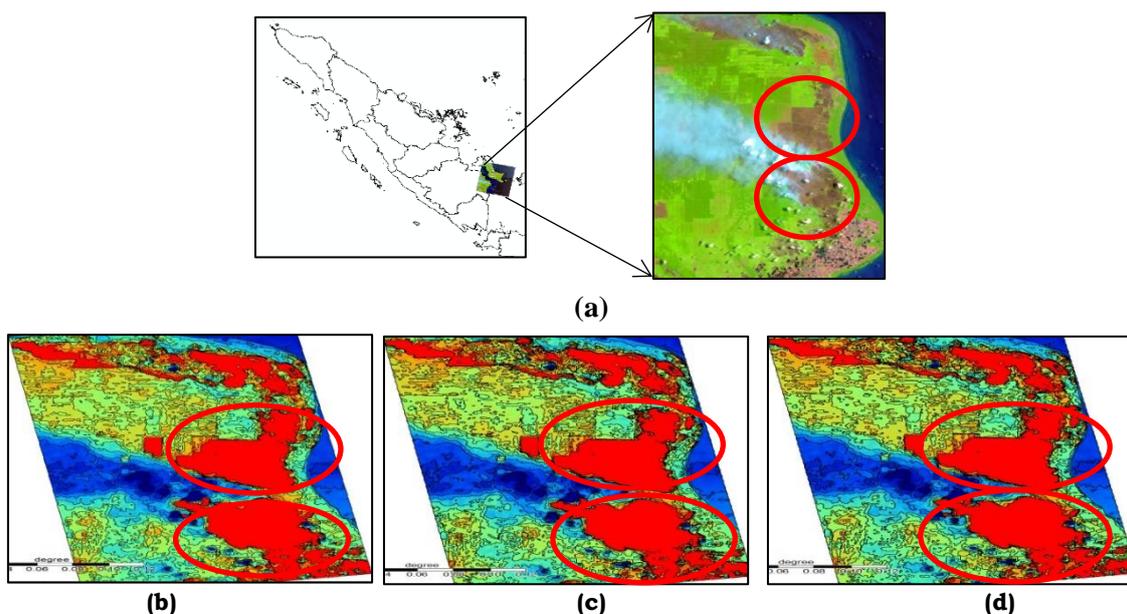


Figure 3-2: Results of the identification from the semi-automatic object-based image analysis of Landsat 8 images dated 23 September 2015 for South Sumatra Province, based on the: (a) RGB_6,5,4 band combination; (b) RGB_4,5,10 band combination; (c) RGB_5,6,10 band combination; and (d) RGB_5,7,10 band combination.

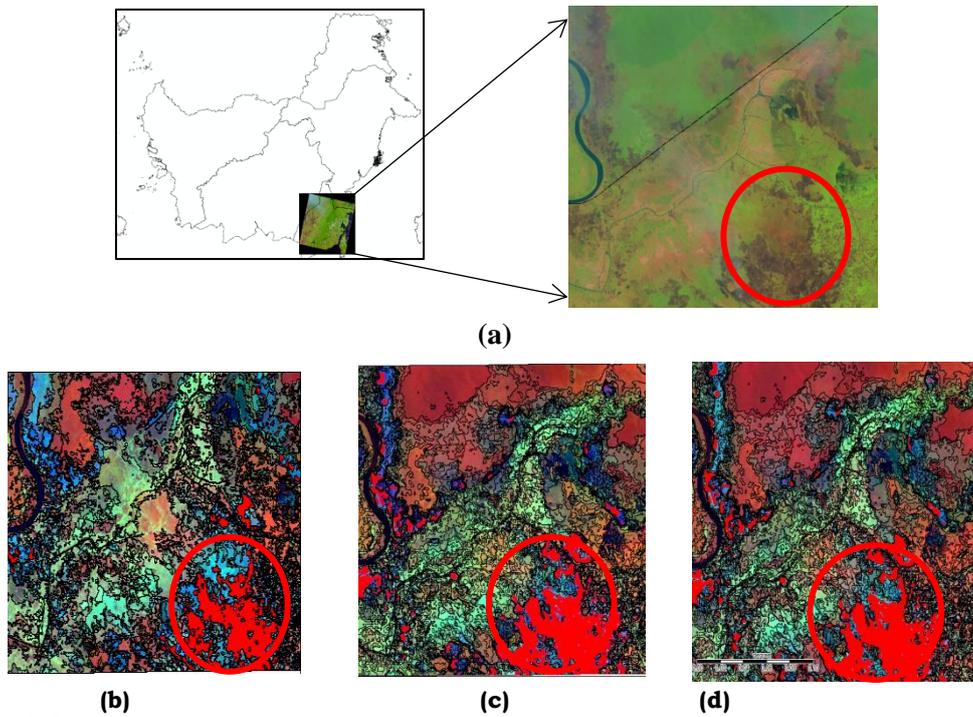


Figure 3-3: Results of the identification from the semi-automatic object-based image analysis of Landsat 8 images on 13 September 2015 for South Kalimantan Province, based on the (a) RGB_6,5,4 band combination; (b) RGB_4,5,10 band combination; (c) RGB_5,6,10 band combination; and (d) RGB_5,7,10 band combination.

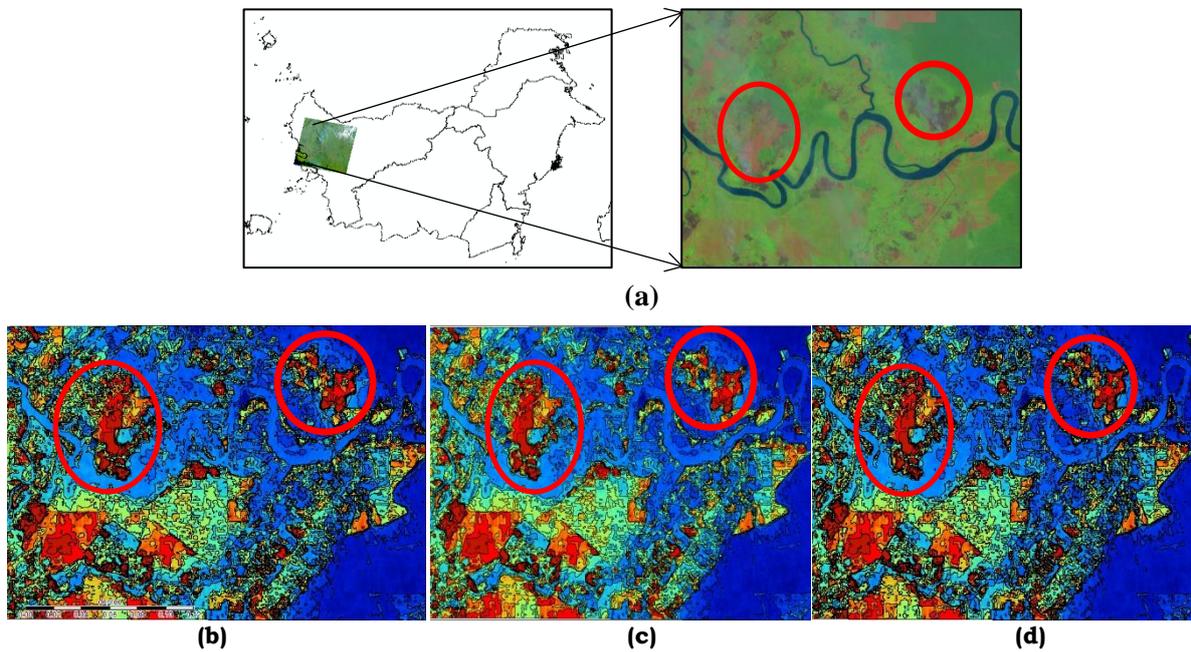


Figure 3-4: Results of the identification from the semi-automatic object-based image analysis of Landsat 8 images dated 09 September 2015 for West Kalimantan Province, based on the: (a) RGB_6,5,4 band combination; (b) RGB_4,5,10 band combination; (c) RGB_5,6,10 band combination; and (d) band combination RGB_5,7,10.



Figure 3-5: Comparison image between burnt areas detected from semi-automatic OBIA Landsat 8 identification and visualization burnt area from SPOT-7, locations A, B and C.

Comparison with high-resolution images

A SPOT-7 image dated 23 September 2015 was available for part of South Kalimantan. The image was composed of RGB true colour, whereas in it, the burnt area looks black or blackish brown. The data were used to visually compare a burnt area detected from semi-automatic OBIA identification and from SPOT-7 (see Fig. 3-5). From the results of the visual comparison, it can be seen that the burnt area detected by the semi-automatic OBIA method was the same as that seen from SPOT-7.

Although this method has been tested to be more effective and quicker, this study chose locations based on the fact that they often experience fires, namely Riau, South Sumatra, West Kalimantan and South Kalimantan. More specific geographical conditions, such as vegetation, soil, and topography, were not considered.

4 CONCLUSION

It is concluded that the semi-automatic object-based image analysis based on red, infrared and thermal spectral bands is a reliable and fast method for identifying burnt areas in regions of Sumatra and Kalimantan. It is suggested that further research be conducted on the use of the semi-automatic OBIA method for areas with more specific geographical conditions,

taking into account variations in vegetation, soil and topography.

However, this study has the disadvantage of only focusing on one date in one area; further research should cover different times in one area and also apply these to other areas. In addition, research should focus on relatively small burning areas, as forest fires in Indonesia cover relatively small areas but are spread over several points.

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AUTHOR CONTRIBUTIONS

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