Comparison of Forest Fire-affected Area in 1998, and 2000 of Borneo Island *

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Abstract

Forest fire is one of dominant factor affecting land-use and land cover change, especially in Sumatra and Borneo island. A huge forest fire had occurred in 1982/1983, since then regular forest fire have been occuring in Borneo. Identifying where and when the fire occurred is important information for forest fire manajemen and rehabilitation activities. Multisensor and multidate of remote sensed data (Landsat TM, and SPOT VEGETATION), and hotspot information derived from NOAA were utilized. Fire affected area were identified by combining information of Landsat TM, hotspot position derived from NOAA and Spot Vegetation images. Forest fire affected areas were maped based on monthly and annually basis. Degree of vegetation recovery were evaluated based on Normalized Difference Water Index (NDWI) monthly data. Estimated fire affected area in 1998 and 2000 in Borneo is 3.449 million ha and 0.12 million ha, respectively. Difference fire affected areas distribution pattern and vegetation recovery process were identified.

Introduction

After a huge forest fire disaster in 1982/1983, Borneo island have been hit by several forest fire. The most severe forest fire was occurred in 1997/1998 during the El Nino-Southern Oscilation (ENSO), in which forest fire devastated millions hectare forest and other land use/land covers. In 2000, again fire have occurred, which had less impacts in term of area coverage. For the purpose of fire-affected area rehabilitation, it is important to know impacted area distribution and its capability to recover naturally. Many studies have been conducted to identify spatio and temporal aspects of forest fire, using remotly sensed data. Various sensor with difference resolution and coverage have been applied to study forest fire. NOAA-AVHRR (National Oceanic Atmosphere Administration-Advanced Very High Resolution Radiometer) (Stegert, Rucker, and Hoffman, 2001), Landsat TM/Landsat ETM (Sunuprapto and Hussin, 1999), SPOT, SPOT Vegetation (Ceccato and Flasse,2001., Chen and Cihlar, 1997), and Radar (Radio Detecting and Ranging) (Shimada, Minami Misawa and Isoguchi, 2003), have been widely used with good result.

In comparison with other satellite sensor, SPOT vegetation relatively a new sensor. SPOT Vegetation has just been launched in Mach, 1998 onboard SPOT 4. It was designed to provide accurate measurement of basic characteristic of vegetation canopies. It has 1 km x 1 km spatial resolution with 4 bands spectral resolution (Blue band: 0.43 – 0.47µm, Red: 0.61 – 0.68µm, NIR: 0.78 – 0.89 µm, SWIR: 1.58 – 1.75 µm). The SWIR band sensitive to temperature of earth surface, therefore have capability to detect fire scar. SPOT vegetation with an algorithm able to provide 10 day-composite synthesis data, which radiometrically corrected and minimum cloud interfere.

The research aim at following objectives: (a) Explore methodologies to utilize SPOT Vegetation to estimate forest fire-affected areas, (b) observing fire affected areas pattern of 1998 and 2000 fire occurrence, (c) monitoring vegetation recovery after fire. The information derived will be used for rehabilitation effort of fire affected areas.

Location, Materials and Methods

Study area covers the whole islands if Borneo. The materials used are 99 scenes data of Spot Vegetation, 27 scenes in 1998 (9 months), 36 scenes in 1999 (12 months), and 36 scenes in 2000 (12 months), two Landsat images in 1998: before and after forest fire Landsat and digital vector map of Borneo islands.

Registration Digital Images to Base Map: All imagery data were corrected based on digital vector maps of Borneo Island. The projection system was Geographic projection and datum Clarke 1866. After correction Contrast Enhancement were applied to all of the images.

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Calculate Index of Vegetation: Spot vegetation consist of 4 bands, band 1, 2, and 3 represent Blue, Red, and Near Infra Red (NIR) bands, while band 4 is Short Wave Infra Red (SWIR). SWIR is sensitive to temperature changes. Response of these bands to healthy and fire affected areas is presented in Fig 1. Digital Number (DN) of SWIR is higher the band 1, 2, 3 in burned vegetation but is lower in healthy vegetation. Index of Normal Difference Water Index (NDWI) calculates by an equation followed: *(Nir – Swir) (Nir + Swir)*. NDWI value ranges from minus 1 to plus 1, and negative value related to burned vegetation condition

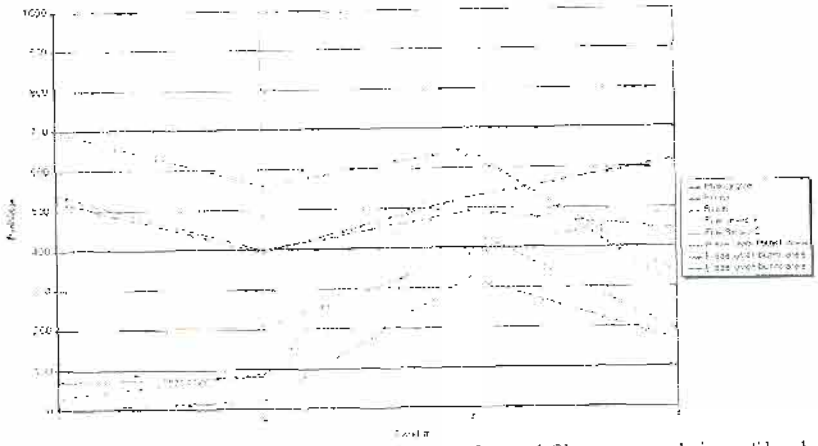

Fig 1. Spectral response of Spot Vegetation bands on difference condition of land cover

Determine Local Maximum Filter: Monthly data of Vegetation Spot consist of 3 composite images, which represent image data dated 1-10, 11-20 and 20-30 of the month. In order to reduce impact of cloud, 3 composite images were merged by applying Local Maximum Filter (LMF)

Determine Threshold Value of NDSWIR: Threshold value is determined-value to differentiate between healthy and burned vegetation. Deciding threshold value is most critical step. It is conducted by overlaying Hotspot data derived from NOAA with Spot Vegetation Data. Visual interpretation of Landsat data also were utilized during deciding threshold value

Result and Discussion

a. Fire affected areas identification

Fire affected areas identification was started by deciding a thresholds value of NDSWIR index. It was conducted by comparing the threshold result calculation with visual interpretation of Landsat and hotspot position data. Finally we concluded that NDSWIR below 0 gave the best conformity with visual interpretation of Landsat and Hotspot data derived from NOAA.

Total affected area of forest fire in 1998 was calculated from March 1998 to December 1998, in 2000 was calculated from January to December 2000, meanwhile forest fire in 1999 was not calculated due bad data when images were received. Total forest fire affected areas in 1998 and 2000 were significantly different. It was estimated fire affected areas in 1998 and 2000, 3.449 million hectares and 0.12 million hectares, respectively. Beside the magnitude, their distribution occurrence pattern also showed remarkably difference. In 1998, forest fire occurrence mostly were concentrated in East Kalimantan, while in 2000, there are only small area in East Kalimantan, and sporadically occurred in southern part of Borneo (Fig.1 and Fig 2).

In term of time dimension, forest fire affected areas in 1998 was very high since April to June, and gradually was decreasing until December. In 2000, forest fire affected areas gradually was increasing from January to September, and was decreasing since then (Fig 1 and Fig 2). Monthly forest fire in 2000, followed normal monthly precipitation (Fig 3), while in 1998 associated with an exceptional drought caused by the El Nino/Southern Oscillation (ENSO) (Siegert, Ruecker, Hinrichs & Hoffmann, 2001)

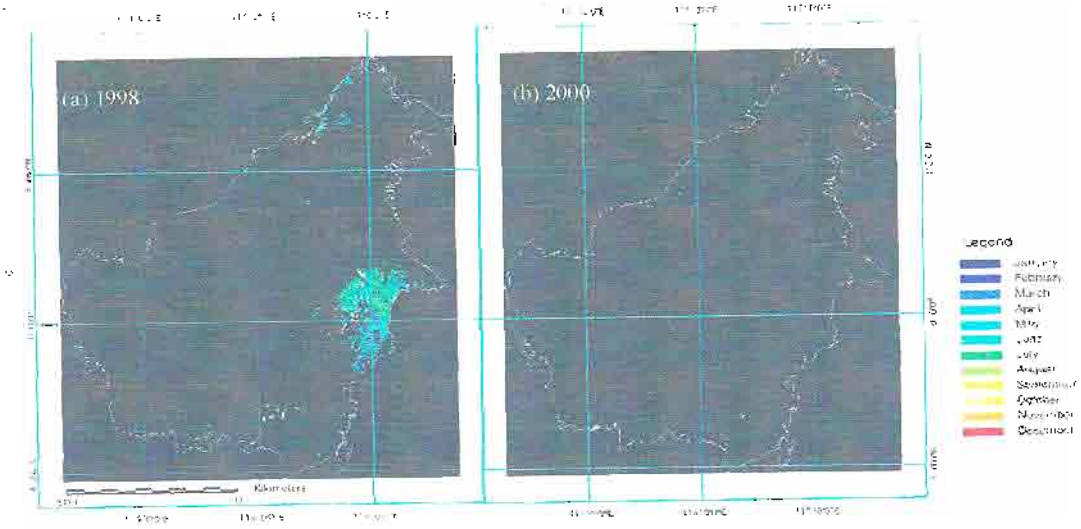

Fig. 1 Monthly forest fire affected area: (a) 1998 and (b) 2000

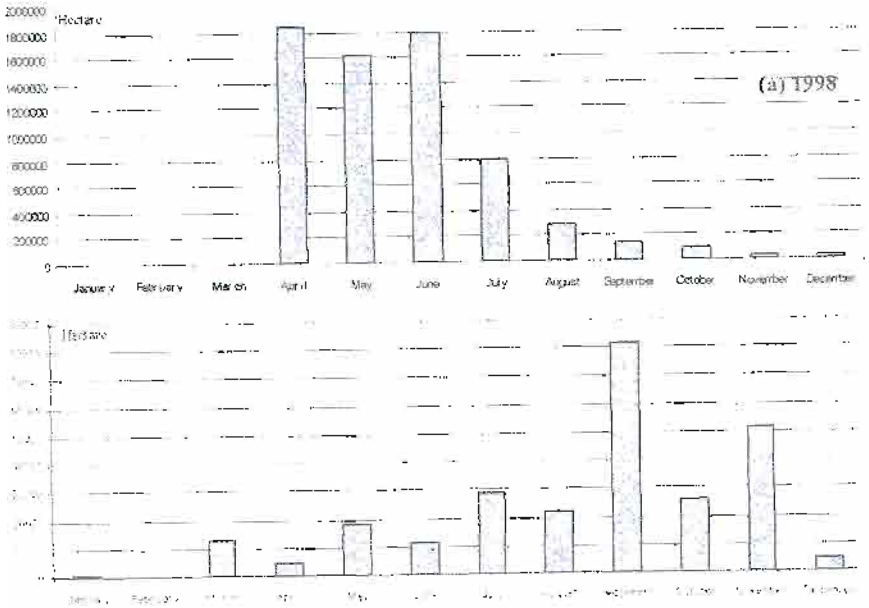

Fig. 2 Monthly forest fire affected area (a) 1998 and (b) 2000

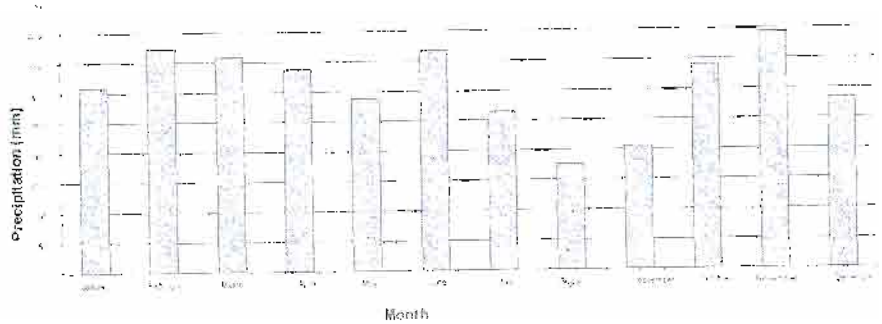

Fig. 3. Mean monthly precipitation from 3 climate stations

b. Vegetation recovery of fire affected areas

Vegetation recovery was observed by investigating the dynamics changes of NDSWIR value. To understand the dynamics changes, two sites of burning and healthy vegetation were taken as sample area. The result is presented in Figure 4. Value of NDSWIR of healthy vegetation during 3 years observation shows stable, fluctuation only occurring during the drought season in August, which was lower than in rainy seasons.

Value of NDSWIR of burned vegetation is lower than healthy vegetation. It took almost one year to reach stable value of NDSWIR at a certain level, however, the value is still lower compare to NDSWIR of healthy vegetation. This imply that forest fire have affected the degree of vegetation recovery.

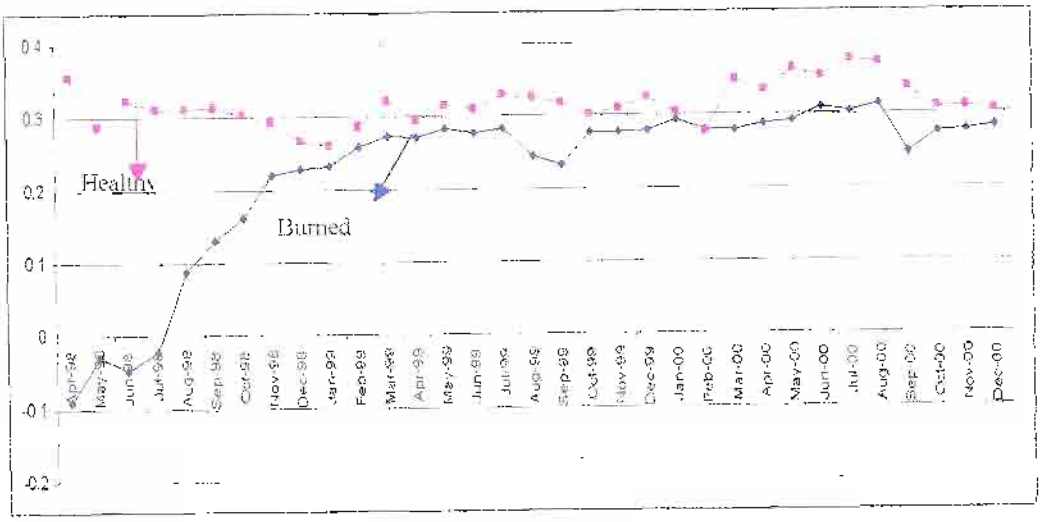

Fig. 4 Dynamic changes of monthly NDSWIR during 1998 - 2000

One factor that influenced the degree of recovery is frequency of repeated fire and the degree of forest fire. We have followed the vegetation recovery process during 1998 forest fire that is started in April 1998. We found that there were some areas which still under influenced by fire even already 5 months after the fist fire have occurred (Fig. 5). These kinds of areas should be paid more attention due to some reasons : (a) the area is susceptible to fire, that may influenced its surrounding areas, (b) the area is difficult to recover naturally. Human intervention to speed up recovery process and fire prevention is urgently needed

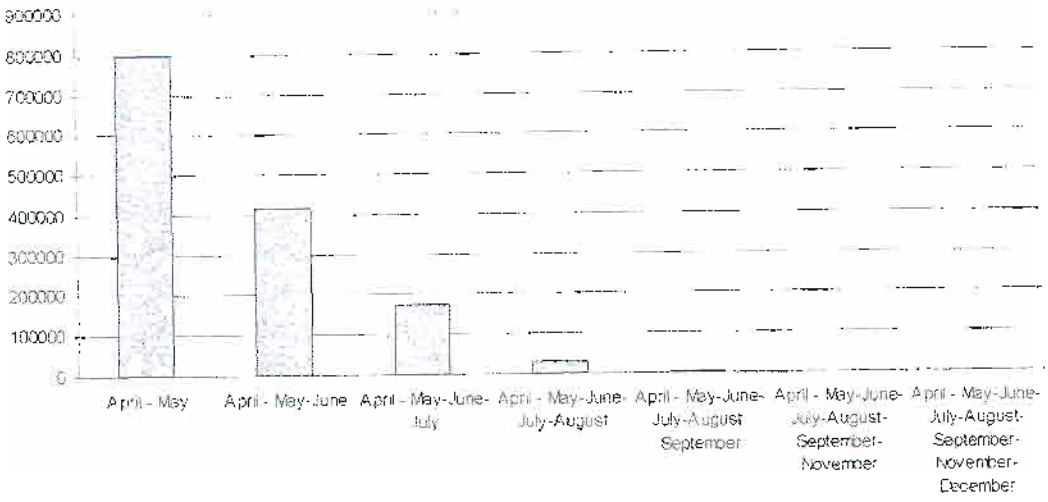

Fig. 5. Length of fire influenced on vegetation recovery

Conclusion

Forest fire affected in 1998 and 2000 was 3.449 million ha and 0.12 million ha. respectively. Their distribution pattern showed significantly difference. Forest fire in 1998 concentrated in East Kalimantan, while in 2000 distribute sporadically in southern part of Borneo.

SPOT Vegetation could be used to estimate and observe forest fire-affected areas and its distribution pattern. Dynamics changes of monthly composite NDWI, represented degree of recovery of fire affected areas and it could help to determine most high priority areas for artificial forest rehabilitation.

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