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Land changes monitoring using MODIS time-series imagery in peat lands areas, Muaro Jambi, Jambi Province, Indonesia

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Abstract

Function of peat land as the global climate regulator has been threatened by human activities through deforestation and forest degradation, including the peat lands in the Berbak National Park, Muaro Jambi. This area is covered by 110,000 hectares of peat lands. This study aimed to monitor the land changes using MODIS time-series datasets from 2001 to 2013. The study used the Normalized Difference Water Index (NDWI), which describes vegetation water content associated with rainfall. The results show that NDWI is quite sensitive to represent the changes in peat land, including seasonal changes. Most of the land changes was detected in August-October by the method. In many cases, it was necessarily coincident with the low rainfall and hotspot occurrences. Moreover, the land changes in peat land areas represent the temporal complexity affected by extreme climate variability, when it related with a high number of fires.

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Keywords: land use/land cover change; MODIS; NDWI; temporal analysis

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1. Introduction

Earth observation satellites are very applicable and useful for land use/cover change detection studies [1, 2]. Application of remote sensing data made possible to study the changes in land cover rapidly, low cost and high accuracy [3]. Monitoring and understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for land management. According to Setiawan and Yoshino [4], temporal characterization of vegetation dynamics in a long period can be used to detect change in Earth's surface, whether the change is gradual due to extreme climatic variations, or changes dramatically due to human or natural (e.g. land use change and forest fires).

Rapid population growth in Indonesia leads a peat land converted into agricultural land in order to support food security, paper industry raw materials, plantations and bioenergy development. Most of peat lands utilization is the conversion for agricultural land, pulp plantations and oil palm plantations. One of the main trigger is the government program to look for an alternative energy by utilizing palm oil as a renewable alternative energy. Human activities in the peat ecosystem has increased rapidly in the last two decades so that many areas of peat land become degraded and easier to burn [5].

Jambi Province is one of the largest carbon storage in Indonesia, particularly in Sumatra. Based on the Ministry of Forestry data, in 2011 Jambi Province has 676,341 hectares of peat land area. By this fact, Jambi Province placed as the seventh province with the largest peat land in Indonesia. This area is about 10% of the total national peat lands. It can be estimated that there will be a huge potential losses if the land is not managed properly. The distribution of peat lands in Jambi province are in the downstream area, mostly a part of east coast cluster of Sumatra. Sequentially, the largest peat land spread in East Tanjung Jabung (46%), Muaro Jambi (30%), and West Tanjung Jabung (20%).

Muaro Jambi is home to the Berbak National Park, a protected area in Indonesia's Ramsar. The national park has a total peat land area of about 110,000 hectares while the forest park (*Taman Hutan Raya* or Tahura) covers 60,000 hectares. Land use in the regency is dominated by dry agricultural land (293,256 hectares) followed by oil palm plantations (87,992 hectares) and wet agricultural land suitable for rice (17,000 hectares). Agriculture and mining (mostly petroleum mining) are the main economic sectors and respectively contributing 30% and 26% of gross regional economic product [6]. Oil palm plantations are the largest contributor of GDP in the agriculture sector. Unfortunately, high returns from oil palm and other agricultural uses put a high pressure on the forests in Muaro Jambi. Other factors in forest degradation are: a legacy of ineffective land use licensing prior to the establishment of the new regency; confusing forest boundary demarcation; land disputes; illegal logging; and peat fires due to drainage.

The objective of this research is to monitor the land use/land cover changes on peat land using multi-temporal data of NDWI during a known period in Muaro Jambi Regency, Jambi Province, Indonesia. Hotspot and climate data are also used as supporting data so we can find out that the changes detected by NDWI related to hotspot occurrence and climate.

2. Methodology

2.1. Study area

Muaro Jambi Regency is located at 103°10' E - 104°20' E and 1°15' S - 2°20' S, surrounded by Batang Hari and West Tanjung Jabung Regency in the west side, East Tanjung Jabung Regency in the east and north side, and South Sumatera in the south side. Muaro Jambi has a total area of 5,326 km^2 and divided into 153 villages and 11 districts, the districts are Jambi Luar Kota, Sekernan, Kumpeh Ilir, Maro Sebo, Mestong, Kumpeh Ulu, Sungai Bahar, and Sungai Gelam.

Based on the observation from Jambi Province Climatology Station in Sungai Duren, the average air temperature in Muaro Jambi in 2013 was 26.8°C and the highest temperature occurred in June 2013 was 33.3°C. Average air humidity in Muaro Jambi in 2013 was 85.8%, an average rainfall was 216.6 mm, and most rainy days were 24 days in May and December [7]. This regency is location of the Berbak National Park, a protected area of wetlands that are important in Southeast Asia. This area is also selected as an area of Ramsar (International Wetlands). Aside from Muaro Jambi, the park administratively located in East Tanjung Jabung Regency.