Identifying Burnt Areas in Forests and Land Fire Using Multitemporal Normalized Burn Ratio (NBR) Index on Sentinel-2 Satellite Imagery

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Abstract:

Forest and land fires are global disasters that pose a serious threat to society, particularly during the dry season. Sumatra Island, located in Indonesia, is one of the areas prone to forest and land fires. It causes thick smoke every year which has implications for health and flight activities. It also threatens the 18,931 endemic plant species on the Sumatra Island so this needs to be monitored continuously for mitigation and recovery. This study aims to identify areas of past forest and land fires to support it. In this study, burnt areas were identified by utilizing Normalized Burn Ration (NBR) index on Sentinel-2 Satellite imagery using thresholding method. It is calculated as the ratio between the near-infrared (NIR) and short-wave infrared (SWIR) wavelengths. Both are very sensitive to vegetation and bare land so NBR is very potential for identification of burnt areas using multitemporal techniques. The results of this study indicated that the highest accuracy was achieved using the μ-2σ threshold model of dNBR, with the highest accuracy rate of 81.56% for the February 2019 fires. The results of this study suggest that the thresholding method using the NBR index can be utilized to identify burnt areas effectively.

Keywords:

burnt area, forest fire, land fire, NBR index, Sentinel-2, thresholding

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Page 385-394

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Baydaa Abdul Hussein Bedewy, Marwan H. Abdulameer

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Page 433-444

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Abdulrahman Mohsen Ahmed Zeyad, Arun Biradar

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Page 479-489

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Deeksha Rai Sharma, Rohini Ravindrasingh Raghuwanshi, Tanvi Chandak, Dipali Ramdasi

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Page 501-507

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Khaja Shareef Shaik, Naga Siva Kumar Thumboor, Siva Prasad Veluru, Naga Jagadesh Bommagani, Dorababu Sudarsa, Ganesh Karthik Muppagowni

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Page 509-517

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Shobha Chawla, Neha Gupta

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Syaharuddin, Fatmawati, Herry Suprajitno

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1. INTRODUCTION

Indonesia is the largest tropical rainforest in Asia and the third-largest in the world. According to Indonesia's Ministry of Environment and Forestry, the forest area in Indonesia reaches 125.81 million hectares by 2022, which is equivalent to 62.97% of Indonesia's land area [1]. The forest areas in Indonesia can be classified into various types, such as protected forests for protecting the environmental carrying capacity system (covering an area of 29.56 million hectares), permanent production forests for production timber (covering 29.23 million hectares), conservation areas for national parks, wildlife reserves, nature reserves (covering 27.41 million hectares), limited production forests (covering 26.8 million hectares), and convertible production forests (covering 12.79 million hectares) [1, 2]. However, Indonesia has been experiencing a continuous decrease in forest area over the years. One of the major reasons for forest loss in the country is the occurrence of forest fires. The largest forest fires in Indonesia happened in 1997/1998, which affected around 9.7 million hectares of land across several islands. Kalimantan was hit the hardest with 6.5 million hectares of burnt land, followed by Sumatra with 1.7 million hectares, Irian Jaya with 1 million hectares, Sulawesi with 0.4 million hectares, and Java with 0.1 million hectares [3].

The occurrence of forest and land fires in Indonesia is a frequent disaster, particularly during the dry season in various regions, causing enormous economic, social, and environmental losses and damages [4, 5]. Forest and land fires occurred especially in the Sumatra Island and Kalimantan Island every year. One of potential factor is both of them have peatland soil types. According to study [6-8], the distribution of peatlands affects the level of occurrence of forest fires in Sumatra and Kalimantan. This becomes even stronger when an El Nino occurs in Indonesia, the rate of forest fires in both increases. The smoke resulting from forest and land fires causes severe air pollution that can negatively impact the health of individuals residing in affected areas and even spread to neighboring countries [9, 10]. Besides that, the reduction of forest area and land degradation due to fires creates uncertainty in the restoration of ecosystem conditions [11]. Based on the significant losses caused by forest and land fires, it is crucial to implement effective fire disaster management efforts to minimize their impact.

According to data from the Indonesian Ministry of Environment and Forestry's Sipongi website, Bengkalis Regency has been one of the areas in Indonesia that have been severely affected by forest fires. From 2017 to 2021, the regency experienced fires that burnt an area of 25,745 hectares. The highest number of fires was recorded in 2019, which burnt 15,398 hectares [12]. The yearly fires in Bengkalis Regency are mainly caused by the fact that the area is covered with peatlands. When these peatlands catch fire, the soil is burnt entirely, and the resulting impact is the heating of organic matter that does not combust [13, 14]. The heating caused by the fires can reduce the water-holding capacity of organic matter, leading to the drying of the peat soil. Due to the low soil water content and reduced water absorption capability, burnt peat soil becomes more susceptible to re-ignition, increasing the likelihood of fires recurring [15, 16].

Remote sensing techniques can be used to identify forest and land fires by analyzing satellite imagery to obtain data and information on changes in land conditions before and after the fires. Several types of satellite imagery can be used to identify post-burnt areas, as was done [17, 18] using high-resolution Ikonos and GeoEye satellite images with the Support Vector