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# UTILIZING LANDSAT 8 IMAGERY FOR MAPPING OF BURNED AREAS USING THE NORMALIZE DIFFERENCE VEGETATION INDEX (NDVI) AND NORMALIZE BURN RATIO (NBR) METHODS (Case Study: Part of Bengkalis Regency, Riau)

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**ABSTRACT**:This study aims (1) to map changes in the area of forest land in the western part of Bengkalis Regency in 2016 and 2021, (2) to determine the distribution of the area of forest burned in the western part of Bengkalis Regency, (3) to determine the severity of forest fires in the District of Bengkalis West Bengkalis.This study used the NDVI (Normalized Difference Vegetation Index) method by Huete et. Al by compositing band 5 (NIR) and band 4 (Red) on Landsat 8 imagery which was processed using ArcGIS software before and after a forest fire. As well as the NBR (Normalized Burn Ratio) and dNBR (Difference Normalized Burn Ratio) methods by Eidenshink et al by compositing band 5 (NIR) and band 7 (SWIR) on Landsat 8 images processed using QGIS software. For sampling using random sampling method and accuracy test using overall accuracy, user's accuracy, producer's accuracy, and kappa analysis. The results of this study are (1) the area of forest land in Bengkalis Regency continues to decrease every year, in 2016 the area of forest land903,920 ha and 2021 the total forest area is463,441 ha. (2)The area of forest land burned due to forest fires in Bengkalis Regency, which burned the least was 267.43 ha, while it was 1468.93 ha and the most extensive was 2186.53 ha.(3) Based on one forest fire distribution map, it is divided into 7 fire severity classes, namely high post-fire regrowth, low post-fire regrowth, no burning, low, medium-high and very high and the most dominant forest fire level is low-high.

*Keywords :Normalized Difference Vegetation Index, Normalized Burn Ratio,Landsat 8, Forest and Land Fire Severity.*

## 1. INTRODUCTION

Forest and land fires occur almost every year in Indonesia, especially in Sumatra and Kalimantan (Yulianti et al., 2013). In Southeast Asia, forest and land fires have become a common problem and have destroyed large forest areas since the last few decades (Hafni, 2017). These fires also cause damage to land cover, economic losses, and social problems (Yusuf et al, 2019). Forest and land fires often occur in Indonesia, one of which is in Riau Province where forest and land fires have occurred continuously since several years ago. In March 2016 the local government declared an emergency alert status and found 32 hotspots in Riau Province. And in 2016, 3,218 hectares of land were burned in Riau. Bengkalis Regency is an area that has the potential to experience forest and land fires every year. Based on the findings (Meteorology, Climatology and Geophysics Agency) BMKG recorded 21 hotspots in Bengkalis Regency in 2016. These fires occurred on peatlands, where peatlands are more difficult to control because fire can spread through the above-ground biomass and in the underground peat layer (Sumantri, 2007). Dry peatlands will burn easily, especially during the long dry season.

The data taken in this study were Landsat 8 OLI image data before and after the forest fire, hotspot data and administrative boundary data. The data is processed using QGIS, ENVI, and ArcGIS software to obtain NDVI and NBR values. Next will be classified as 5 classes of NDVI and 7 classes of NBR to get burnt areas. The results of the data processing produce a map of the burned area for determining the area of the burned area.

Remote sensing can be used to map burnt areas in Bengkalis Regency using the Normalized Difference Vegetation Index (NDVI) method which is useful for monitoring changes in vegetation on burnt land with band 5 (NIR) and band 4 (red) which are indexes that are widely used for identify former burnt areas (Viedma et al, 1997). The second method is the Normalized Burn Ratio (NBR) which is useful for obtaining the severity of fires that occur with band 5 (NIR) and band 7 (SWIR).
Forest and land fires can be considered as a potential threat to sustainable development because of their direct impact on ecosystems and human life, ranging from smoke haze pollution to degradation and reduction of forest land, causing losses in various sectors (Tacconi, 2003). Because of this, efforts are needed for countermeasures

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using remote sensing which can detect areas of former forest and land fires in Bengkalis Regency.

## 2. THE METHOD

### 2.1 Research Form

The quantitative method with an environmental/ecological approach to determine the impact of forest fires that occur. Quantitative data in this study are the NBR, dNBR index values and the distribution of burned forest area.

### 2.2 Time and Location of Research

The research was conducted from September 2021 to May 2022 with the study area being Bengkalis Regency, Riau Province with the following boundaries:

- ✓ To the north: Malacca Strait
- ✓ Adjacent South: Siak Regency and Kep Regency. Meranti
- ✓ To the East: Rokan Hilir Regency, Rokan Hulu Regency.
- ✓ West side: Strait of Malacca

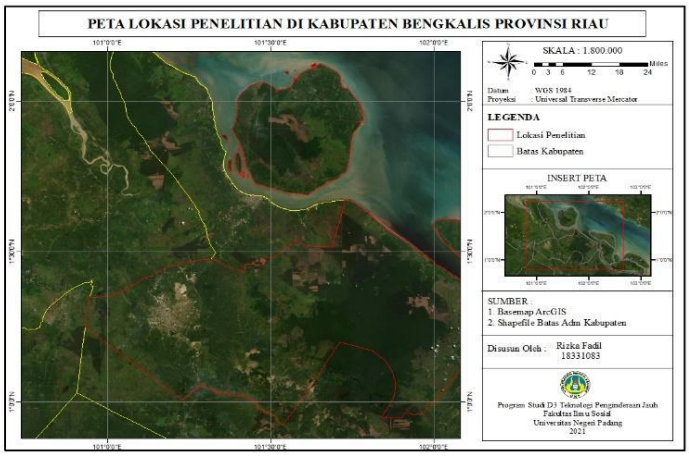


Fig 1.Research Location Map

### 2.3 Tools and materials

The tools and materials used to support the research are as follows:

| No | Tool | Utility |
|---|---|---|
| 1 | Core i3 Laptops | Data analysis |
| 2 | ENVI software | Data processing |
| 3 | ArcGIS software | Data processing |
| 4 | QGis software | Data processing |

| No | Material | Acquisition Time | Source |
|---|---|---|---|
| 1 | Landsat 8 Oil Satellite Image | January 2021 | USGS |
| 2 | Landsat 8 Oil Satellite Image | November 2021 | USGS |
| 2 | Hotspot distribution point data | 2021 | LAPAN Fire Hotspot |
| 3 | ShapefilesTopographic Map of Indonesia | 2021 | Ina Geoportal |

### 2.4 Data Analysis Techniques

#### 1. Radiometric Correction

Radiometric correction aims to change the Digital Number (DN) value to a Reflectance value and eliminate the effect of the atmosphere on the image reflectance value. In Landsat 8 imagery, radiometric calibration is performed automatically in the image processing software, and the software used is ENVI 5.3 .

#### 2. Cropping Data

Landsat 8 image cropping in the desired area to facilitate data processing in the area under study.

#### 3. NDVI (Normalized Difference Vegetation Index)

To get NDVI results before and after a forest fire, it is necessary to perform a band composite on the image using the ArcGIS software with the following formula:

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$$NDVI = (NIR - RED) / (NIR + RED)$$

**4. NBR (Normalized Burn Ratio)**

To generate NBR values before and after a forest fire is done using QGIS software as a value for the fire index with the formula:

**5. dNBR calculation**

From the results of NBR calculations before and after forest fires, it is necessary to calculate dNBR or the difference in NBR before and after fires which are used to separate burnt and non-burnt land (Key and Benson, 1999; Viedma et al, 1997 in Zubaidah A., Vetrita Y., 2012) which will be processed using QGIS software with the following formula:

$$dNBR = NBR1 - NBR2$$

**6. Identification of the Wide Distribution of Burnt Areas**

Identification of the wide distribution of burnt areas was carried out using Landsat 8 imagery later perform data processing from image analysis results to see the distribution of burnt areas in parts of Bengkalis Regency in 2021. The area of this area is obtained from processing the debt results with the Field Calculator tool in ArcGIS.

**7. Accuracy Test**

An accuracy test was carried out to assess the accuracy of data resulting from forest and land classification from processing using Landsat 8 imagery. Testing for accuracy is a process that shows the truth of the research conducted (Fibyana, 2020). Accuracy testing in this research uses overall accuracy, user accuracy, producer's accuracy and Kappa analysis.

## 3. RESULTS AND DISCUSSION

### 3.1 NDVI Outcome Map

Based on the results of the 2016 NDVI processing in parts of the Bengkalis Regency, a minimum value of -0.07 was obtained and a maximum value of 0.41. And also obtained 5 classification classes, namely land without vegetated red color, very low greenish orange color, low greenish yellow color, medium greenish light green color and high greenish dark green color.

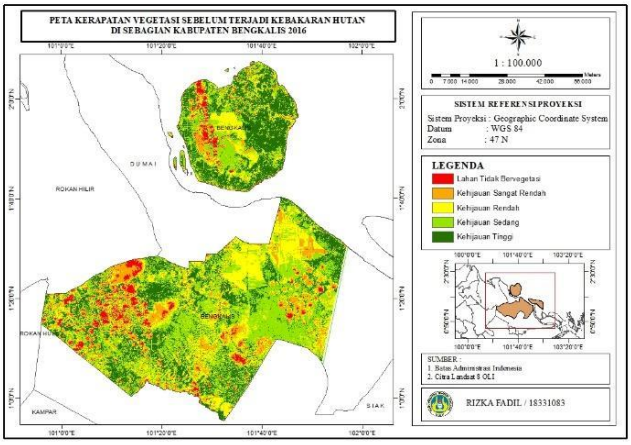


Fig 2. NDVI Map Before Forest and Land Fires

For non-vegetated land classes marked with red and very low greenness with orange color scattered throughout the district in the form of small polygons, low greenness marked with yellow is most abundant in Mandau and Pinggir Districts, moderate greenness is found in Rupat, Rupat Utara and Edge, the last one is the green that is found in Rupat and North Rupat Districts. The following is a map of vegetation density in 2021.

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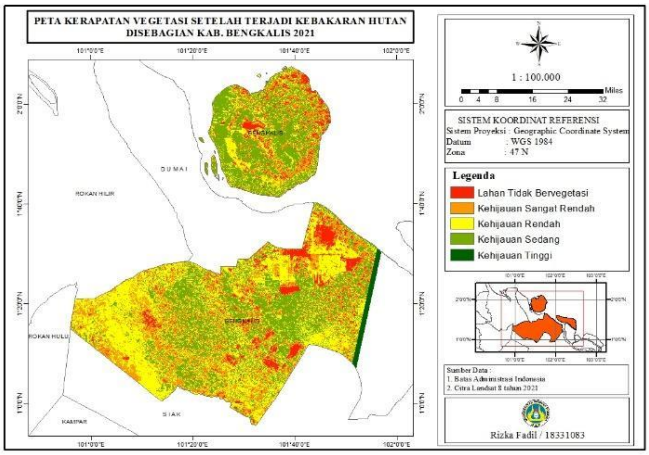


Fig 3. NDVI Map After Forest and Land Fires

## 2. Result Map No

For mapping the burned areas in parts of Bengkalis Regency using the NBR (Normalized Burn Ratio) method with Landsat 8 OLI imagery. This method can identify the severity of forest and land fires before the forest fire (pre-fire) and immediately after the forest fire (post-fire).

To get this NBR value, some processing is required, namely performing band 5 (NIR) and band 7 (SWIR) composites before and after a forest fire with the formula NBR = (NIR – SWIR) / (NIR + SWIR) in QGIS software with the Raster tool Calculator then does a class on symbology.

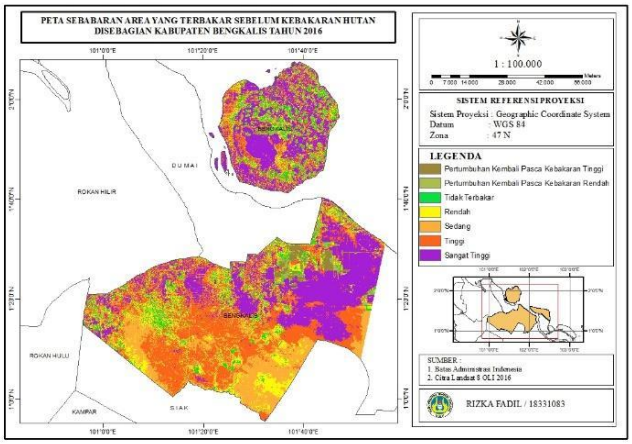


Fig 4.NBR Map Before Forest and Land Fires

From these results, the post-fire return growth class was low in the Bukit Batu sub-district, unburned was in Rupat Utara, Rupat, Mandau, Pinggir, Bukit Batu sub-districts in small pieces, low was in Pinggir sub-district, medium severity class was in Mandau sub-district, class The highest heights were found in the North North Meeting, Rupat and Bukit Batu Districts.

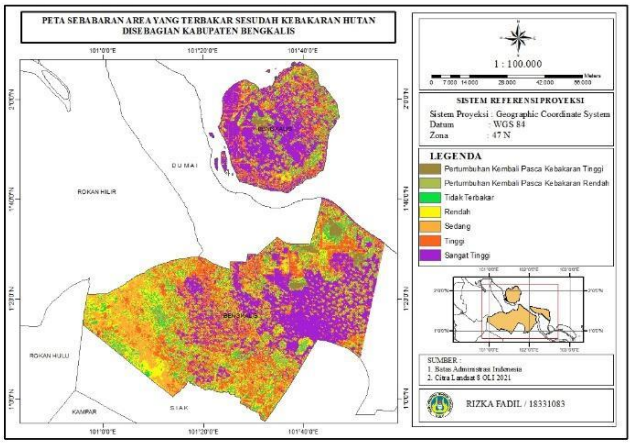

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Fig 5. the post-fire return growth class

The classification class for dNBR is the same as for NBR. Based on the results obtained, the low to moderate severity class dominates almost all sub-districts in Bengkalis and there is also a very high severity class found in Rupat and Bukit Batu sub-districts.

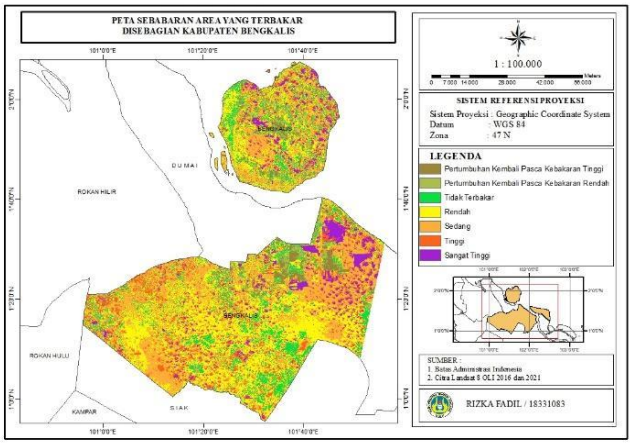


Fig 6. The classification class for dNBR

### 3.3 Wide Distribution of Burned Areas

To calculate the area of burned forest in the western part of Bengkalis Regency, use the dNBR results that have been previously processed, then use the Field Calculator tool in ArcGIS. The following table shows the area of forest burned.

Table 3. Distribution Area of Burnt Forest

| Severity Level | Area (ha) |
|---|---|
| High post-fire regrowth | 267,43 |
| Post-fire regrowth is low | 496,74 |
| Not burnt | 887,33 |
| Low | 2186,53 |
| Currently | 1468,93 |
| Tall | 548,40 |
| Very high | 400,5603 |

Based on the table above, it can be seen the distribution of burned forest areas in parts of Bengkalis Regency. The severity of the fire was low with a burn area of 2186.53 ha then with a moderate burn levelwide1468.93 ha. Then, with a high level of classification, 543.40 ha and 400.56 ha were burned in Bengkalis Regency with a very high level of severity based on the NBR value.

### 3.4 Accuracy Test

To find out the truth of the distribution of forests that are burned due to forest and land fires resulting from processing with Landsat 8 imagery, the fairs hotspot data is used as a reference for the sample. The number of samples used is 36 sample points which are determined by random or random sampling.

Accuracy testing in this research uses overall accuracy, user accuracy, producer's accuracy and Kappa analysis. Sample data collection is done by using random method sampling using the formula (McCoy, 2005) as follows:

**N** $= 2^2(90)(10) / 10^2$

$= 4 \times 90 \times 10 / 10^2$

$= 36$

Table 4. Confusion Matrix Classification of Fire Severity Levels

| dNBR Index | Not Burning | Low | Low-Medium | Medium-High | High Total |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Not Burned | 6 | 0 | 0 | 0 | 0 |
| Low | 0 | 7 | 2 | 0 | 0 |
| Low-Medium | 0 | 0 | 8 | 0 | 0 |
| Medium-High | 0 | 1 | 0 | 7 | 0 |
| Tall | 0 | 0 | 0 | 0 | 5 |
| Total | 6 | 8 | 10 | 7 | 5 |
| (producer) | 6 | 0 | 0 | 0 | 0 |

From the analysis of Landsat 8 imagery in 2016 and 2016, parts of Bengkalis Regency obtained changes in forest area over 5 years. Forest changes from 2016 to 2021 can be seen in Figure 7 and Figure 8 above. In 2016 the forests in Bengkalis Regency had wider forest land than in 2021, in 2021 it appears that there has been reduced forest in Bengkalis Regency due to forest and land fires in the past 5 years.

This change in forest area has decreased from high to low greenness in Rupat Utara, Rupat and Bukit Batu Districts as shown by the changing color of the map before and after the occurrence of forest and land fires. Areas that have good forest density in 2021 are in Pinggir and Bukit Batu Districts.

The NBR method is designed to identify burnt areas. The band used in this method is the NIR band which has a high reflectance to vegetation before a fire occurs and the SWIR band has a high reflectance to vegetation after a fire. This shows that a high NBR value can indicate good vegetation, while a low NBR value can indicate empty land or burnt areas. From the results of this processing, 7 classes of forest fire severity levels were obtained, classes with high fire severity were found in Pinggir, Mandau and, Bukit Batu sub-districts, while the very high class was dominated by the Bukit Batu sub-district in 2016. In 2021 the areas with the most There was forest fire and land was Rupat District.

Based on the results of dNBR processing, forest and land fires in Bengkalis Regency are dominated by Low to High classification levels, shown in yellow and orange. And the classification of not burning is found in Pinggir District but only in the form of dots.

Table 3 is the area of distribution of burnt forest in parts of Bengkalis Regency in 2021, based on the table above the distribution of burned forest area with a classification of high post-fire regrowth of 267.43 ha, a low post-fire regrowth classification of 496.74 ha, not burnt area of 887 .33 ha, classification low burnt area of 2186.53 ha, then with a medium burnt level of 1468.93 ha, high burnt classification level of 543.40 ha and 400.56 ha of areas in Bengkalis Regency burned with a very high severity level.

## 4. CONCLUSION

The area of forest land in Bengkalis Regency continues to decrease every year, in 2016 the area of forest land903,920 ha and in 2021 the number will decrease i.e. 463,441 ha, this is because of forest and land fires.

Forest fires in Bengkalis Regency are dominated by Low-high classification levels. The wide distribution of burned areas is dominated by a low-high classification level. Burning severity, low burning area of 2186.53 ha, medium area of 1468.93 ha, and a high burn area of 543.40 ha.

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