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# Utilization of Modified NDVI$_{red\ and\ red\ edge}$ algorithm for analysis of Mangrove ecosystem conditions in Lembar bay area of West Lombok Indonesia

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**ABSTRACT**

Efforts to collect data and information about the profile of coastal resources, especially mangrove ecosystems are very necessary. This can be done through in ventory activities that aim to obtain a clear and real picture of the condition and potential of mangrove vegetation on an ongoing basis. Therefore, thepurpose of this study is to utilize the modified NDVI$_{red\ and\ red\ edge}$algorithm to determine the condition of the mangrove ecosystem in the mangrove ecosystem area of LembarBay, West Lombok Regency. The research method used is a survey method approach with either direct or indirect surveys. The algorithm analysis of the vegetation index used in this study is NDVI$_{red\ and\ red\ edge}$. The results showed that the mangrove ecosystem area in the Lembar bay area, West Lombok, was mostly categorized in good condition, which was about 45.27% of the total area of the mangrove ecosystem. Most of the mangrove ecosystem areas with dense conditions are areas that are far from settlements and fishponds, dominated by natural mangroves which are very rarely visited by both local communities and outside communities so that the utilization rate is relatively low.

***Key word :*** *Mangrove ecosystem, NDVIred, and red edge, Vegetation index*

## Introduction

Mangrove ecosystems in the coastal areas and small islands of West Lombok Regency spread sporadically in some sections of the coastline. As a natural resource that has high potential, its existence is currently increasingly critical in terms of its area, distribution, population, and species diversity. The condition of the mangrove ecosystem on average has been damaged (degraded) at a severe level. Mangrove ecosystems that are still relatively good are only found in areas that have been designated as state forest areas such as the Bangko-Bangko Nature Tourism Park. Data on the development of the area of the mangrove ecosystem in West Lombok Regency from year to year has decreased. According to data from the Department of Marine Affairs and Fisheries of West Lombok Regency, the area of mangroves in 1999 was around 605,81 ha which then decreased to 438,54 ha in 2006 and decreased again to 425,13 ha in 2008 and 2011 the area became 307,17 ha (DKP Lobar, 2016). Thus, continuous monitoring is needed through inventory activities that aim to obtain a real and clear picture of the latest developments on the condition and potential of the mangrove ecosystem on an ongoing basis, so that further management efforts can be carried out appropriately by the principles of utilization with a conservative perspective.

One of the physical parameters used in monitoring mangrove spatial conditions is to look at the closure of mangrove density (Winarso and Purwanto, 2014). Mangrove density can be known through direct measurement to the field and by remote sensing (Sutaryo, 2009). The method of measuring density directly to the field produces high accuracy, but if it is done in a large mangrove area, it becomes ineffective and inefficient in terms of time and cost. Remote sensing is an alternative solution to the method of estimating density above the surface of mangrove forests.

According to Donoedoro (1996) identification of mangrove forest vegetation can be done through remote sensing because land and sea transitional areas provide a unique recording effect when compared to other terrestrial objects. The recording effect has a close relationship with the spectral characteristics of the mangrove ecosystem so that the identification process requires a transformation in this case using a vegetation index transformation. Estimation of mangrove forest density through field surveys combined with remote sensing data is considered an ideal and practical method (Heumann, 2011). In general, the vegetation index transformation is used for vegetation detection. In this study, we will analyze the condition of mangrove vegetation based on the value of the Normalized Difference Vegetation Index (NDVI) algorithm on Sentinel-2B satellite imagery because this algorithm is one of the most commonly used algorithms for vegetation index (Green *et al.,* 2000; Danoedoro, 2012; Wicaksono *et al.,* 2016)

The vegetation index is an algorithm applied to satellite imagery to highlight aspects of vegetation density or other aspects related to density, such as biomass, Leaf Area Index (LAI), chlorophyll concentration. Or more practically, the vegetation index is a mathematical transformation that involves several channels at once to produce a new image that is more representative in presenting aspects related to vegetation (Danoedoro, 1996). Furthermore, Jensen (1998) said that there are several types of vegetation index analysis methods, including; NDVI (Normalized Difference Vegetation Index), GI (Green Index), and WI (Wetness Index). Based on this phenomenon, it is necessary to study the density of the mangrove ecosystem by using the transformation of the vegetation index, in this case using the modified NDVI algorithm to identify mangrove density using a combination of red, red edge, and infrared bands on Sentinel 2B satellite imagery. Satellite images with high spatial resolution have the opportunity to map mangrove densities in more detail (Winarso and Purwanto, 2014).

The analysis of the condition of the mangrove ecosystem was carried out based on the analysis of the vegetation index on the Sentinel 2B satellite image. The vegetation index transformation, in this case, is a modification of NDVI which utilizes the red-edge, red, and near-infrared bands. Based on the research results of Sukuryadi *et al.* (2021) showed that the use of a combination of these three bands in the modified $NDVI_{\text{red and red-edge}}$ algorithm has a higher accuracy rate than using only the red-edge bands in mangrove ecosystem vegetation. According to Xie *et al.* (2018), this modification of the vegetation index can increase the coefficient of determination (R2) in estimating leaf area index (LAI) by 10% compared to using only the red-edge band on the vegetation index of maize and wheat. Therefore, the purpose of this study is to utilize the modified $NDVI_{\text{red and red-edge}}$ algorithm to determine the condition of the mangrove ecosystem in the mangrove ecosystem area of Lembar Bay, West Lombok Regency.

## Materials and Methods

### Site map of research

The location of the research was carried out in the mangrove ecosystem area of Lembar bay, Lembar District, West Lombok Regency, Indonesia which is one of the sub-districts where most of the area is in the coastal area as shown in Figure 1.

### Image Processing

Sentinel-2B image is a satellite image level that has been corrected radiometrically and geometrically. Therefore, the next step is to perform an extraction to obtain the value of the vegetation index through spectral transformation. The most common and widely used spectral transformation for mapping and modeling mangroves is the vegetation index. The vegetation index that will be used in this study is a modified vegetation index algorithm (Xie *et al.,* 2018) as in the following algorithm.

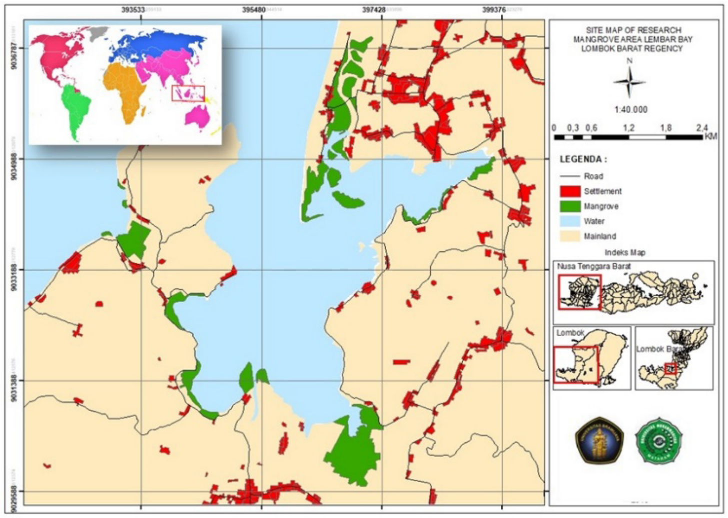


**Fig. 1.** Site map of research

$$NDVI_{red\&RE} = \frac{NIR - (\alpha * red + (1-\alpha) * RE)}{NIR + (\alpha * red + (1-\alpha) * RE)}$$

Where; NIR: Near-infrared; RE: Red-Edge band (band 5); á [0, 1]

The resulting NDVI value ranges from -1 to +1. Dense vegetation is represented by values close to 1, water bodies have values close to -1, while the NDVI for bare land tends to be close to zero. The classification of the vegetation cover index is determined based on the range of calculated NDVI values. The number of density classifications refers to the Guidebook for Inventory and Identification of Mangroves published by the Directorate General of Land Rehabilitation and Social Forestry of the Ministry of Forestry Indonesia (2005). The classification is as follows:

1. Thick/good crown density (70-100% or 0, 43≤NDVI≤ 1.00)
2. Moderate/sufficient crown density (50-69% or 0, 33≤ NDVI≤0, 42)
3. Rare/bad crown density (<50% or -1, 00≤NDVI≤ 0.32)

## Results

Based on the quality standard for damage to mangrove forests with a digital number (DN) with a range of NDVI values according to the Ministry of Forestry (2005) and canopy density estimates (Kesuman, 2010). Based on the results of the study, it shows that the range of vegetation index values extracted through the use of the modified NDVI algorithm in the combination of red, red-edge and infra-red bands of Sentinel 2B satellite imagery ranges from -0.351 to 0.729 and the estimated canopy density is divided into three classes, namely the bad category with an area of 104. 95 Ha (37. 81%), the moderate category with an area of 46.97 Ha (16. 92%), while the good category with an area of 125,65 Ha (45,27%) as shown in Figure 2 and Table 1.

## Discussion

The density of mangrove vegetation is one aspect that affects the characteristics of the vegetation in the image. Vegetation density is generally expressed in the form of a percentage to determine the level of

**Table 1.** Categories of mangrove ecosystem condition

| | Category of mangrove condition | Estimation of Canopy Density (%) | Interval of NDVI Values | Area (ha) Percentage |
|---|---|---|---|---|
| Bad (rare) | <50 | 0 – 0.32 | 104.95 | 37.81 |
| Moderate | 50 – 70 | 0.33 – 0.42 | 46.97 | 16.92 |
| Good (dense) | >70 | 0.43 – 1.00 | 125.65 | 45.27 |
| Total | 277,57 | | | |

vegetation density through the use of a vegetation index algorithm on remote sensing digital images. The vegetation index is an algorithm assigned to an image (usually on a multichannel image) to highlight aspects of vegetation density or other aspects related to density, such as biomass, Leaf Area Index (LAI), chlorophyll concentration, and so on. Practically, this vegetation index is a mathematical transformation that involves several channels at once and produces a new image that is more representative in presenting the phenomenon of vegetation (Danoedoro, 2012).

The vegetation index is an algorithm assigned to an image (usually on a multichannel image) to highlight aspects of vegetation density or other aspects related to density, such as biomass, Leaf Area Index (LAI), chlorophyll concentration, and so on. Practically, this vegetation index is a mathematical transformation that involves several channels at once and produces a new image that is more representative in presenting the vegetation phenomenon (Danoedoro, 2012). Furthermore, said Jensen *et al.* (2012) that there are several types of vegetation index analysis methods, including NDVI (Normalized Difference Vegetation Index) and SR (Simple Ratio).

The Sentinel-2B Multi-Spectral Instrument (MSI) satellite image has 13 spectral bands stretching from visible and Visible and Near Infrared (VNIR) to Short-Wave Infrared (SWIR), where this image displays four spectral bands at 10 m namely blue classical (490 nm), green (560 nm), red (665 nm) and near-infrared (842 nm); six bands at 20 m namely four bands in the spectral vegetation (705 nm, 740 nm, 783 nm, and 865 nm) and two large SWIR bands (1610 nm and 2190 nm); and three bands at a spatial resolution of 60 m dedicated to atmospheric correction and cloud screening (443 nm for aerosol uptake, 945 nm for water vapor capture and 1380 nm for cirrus cloud detection).

NDVI (Normalized Difference Vegetation Index) is one of the most widely used vegetation indices. The algorithm, which is made quite simple, has significant weaknesses, namely external factors that are not considered, such as noise due to atmospheric disturbances and background factors in the form of soil and wavelength sensitivity used in satellite sensors to detect vegetation. Sentinel 2B satellite imagery has satellite sensors that have high sensitivity in detecting vegetation that other satellite sensors do not have, namely the Red edge band, which consists of bands 5, 6, 7, and 8a. The peripheral red band is known to be more sensitive to biophysical parameters such as vegetation density compared to other bands (Zhu *et al.*, 2017).

The $NDVI_{red\ and\ red\text{-}edge}$ index (Normalized Differences Vegetation Index Red and Red Edge) is a modified NDVI algorithm that is more detailed and utilizes the red, red-edge, and infra-red bands that have better accuracy than using only the red-edge band on the vegetation index (Xie *et al.*, 2018). Therefore, the use of this index is strongly supported by sentinel satellite imagery which has a red edge

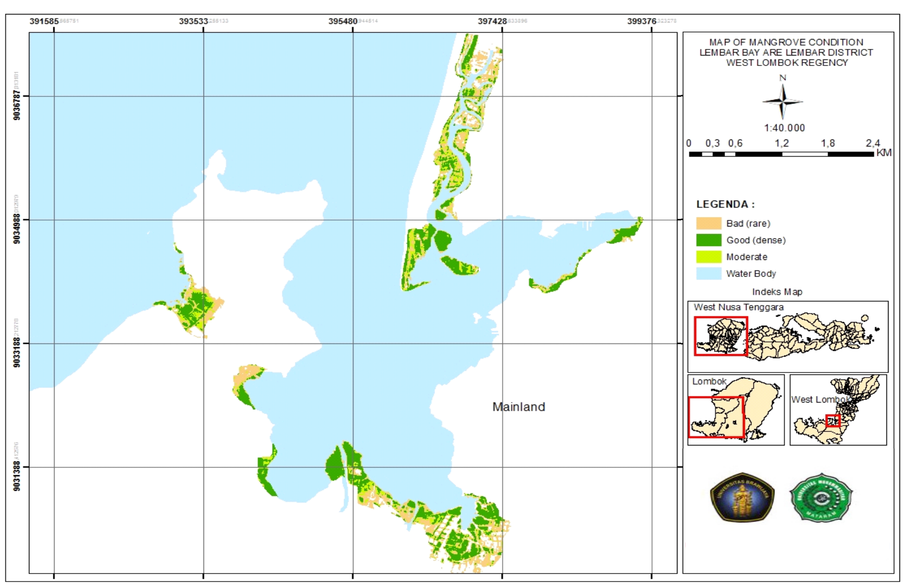


**Fig. 2.** Map of mangrove ecosystem condition

band. The vegetation index utilizes a combination of red (red; 665 nm), near-infrared (842 nm), and red edge bands, which consist of 5 (705 nm), 6 (740 nm), 7 (783 nm), and band 8a (865 nm) in the 2B sentinel satellite imagery. The use of red edge bands on the vegetation index has also been shown to be able to map mangrove biomass better than other vegetation indices such as NDVI and DVI (Zhu *et al.,* 2017). This index has an advantage in the combination of the red band and edge red used. The peripheral red band is known to be more sensitive to biophysical parameters such as vegetation density compared to other bands (Zhu *et al.*, 2017).

Based on the research results of Sukuryadi et al. (2021), from the 4 red edge bands owned by Sentinel 2B satellite imagery, it shows that the results of the comparison of the use of 4 red-edge bands in the $NDVI_{red\ and\ red\ edge}$ vegetation index modification algorithm show that the red edge band (B5; 705 nm) has the highest accuracy because it has a high accuracy value. The lowest RMSE (0.05) with a high correlation value and coefficient of determination between the vegetation index value in the image with a field density value of 0.90 and 82%, respectively (Figure 2). Therefore, the extraction of the vegetation index from the modified $NDVI_{red\ and\ red\text{-}edge}$ algorithm will be used to map the condition of the mangrove ecosystem area in the Lembar bay area, West Lombok.

Based on Figure 2 and Table 1, in general, the mangrove ecosystem area in the Lembar bay area, West Lombok, is mostly categorized in good condition, which is around 45. 27% of the total area of the mangrove ecosystem. Most of the mangrove ecosystem areas with dense conditions are areas that are far from settlements and fishponds, dominated by natural mangroves which are very rarely visited by both local communities and outside communities so that the utilization rate is relatively low. The geomorphological condition in this area is the type of substrate that is owned in the form of muddy sand and is strongly affected by tidal conditions directly because it is facing the sea.

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