Correlation analysis of satellite-based mangrove index and mangrove forest health at Segara Anakan Cilacap, Central Java, Indonesia

Gathot Winarso¹, Muhammad Kamal², Syamsu Rosid², Wikanti Asriningrum¹, and Jatna Supriyatna³

¹Remote Sensing App Center LAPAN Jl. Kalisari No. 8 Jakarta Timur
²Faculty of Geography, Universitas Gadjah MadaBulaksumur, Yogyakarta, Indonesia
³Faculty of Math and Science, University of IndonesiaDepok, Indonesia

e-mail: gathot_winarso@lapan.go.id

Abstract: This study aims to introduce satellite-based Mangrove Index to substitute mangrove health indicator based on Normalized Difference Vegetation Index (NDVI) when it was failed to represent mangrove health at Segara Anakan mangrove area, Cilacap, Central Java, Indonesia. The Mangrove Index has potential to be implemented as indicator of mangrove health because it is deduced from two main characteristics of mangrove forest, which are vegetation condition and hydro-period parameters. Previous mangrove health identification was mainly conducted using visual analysis during the field check and used previous reports that could not be statistically analyzed. The correlation between Mangrove Index and mangrove health condition was analyzed to measure the degree and form of relationship between them as a basis for mangrove health modellng. We conducted paper review to synthesize the mangrove health condition and enriched our analysis by incorporating as many field data as possible related to canopy cover, stand density, seedling density, stake density, biodiversity index, soil moisture, pH, soil temperature, air temperature and air humidity. Our finding shows that the degree of correlation for each parameter were low. The maximum coefficient of determination ($R^2$) of 0.5 was found for combination between stand and sapling density divided by soil moisture. The combination these parameters was selected because Mangrove Index was produced from image bands that has high spectral reflectance response to vegetation (NIR) and soil moisture (SWIR). This result is not a final because limited parameters were incorporated in the analysis. Further deeper analysis to simulate all field parameters need to be done in the future.

1. Introduction
The mangrove area of the world has been decreasing and Indonesia has lost 1.6 million ha of mangrove during the period 1980-20051 [1]. In 2015 the status of Indonesia's mangroves was 3.5 million ha with 48% in good condition and 52% in degraded conditions. Therefore, mangrove forests should be conserved properly and utilized sustainably. Assessment of the status of mangrove conditions is essential in conservation planning and management so that it can be done better (Schmitt and Duke 2016). Mangrove condition could be estimated from canopy cover that able to calculate from satellite using vegetation index such as NDVI. NDVI, the satellite-based vegetation index was one of some health indicator [2]. However, mangrove condition from canopy cover was only derived from single parameter that is vegetation condition. [3] developed new index that called Mangrove Index. Mangrove index is potentially being developed as health indicator because deduced from two parameter of mangrove health that is vegetation and hydro-period. The correlation between mangrove index with some part of health indicator was analyzed in this paper.
2. Material and Method

2.1. Location
This research area was located at Segara Anakan Cilacap Central Java. Segara Anakan was recently largest mangrove area on Central Java Province, another mangrove area already disappeared and damaged during the extensive shrimp development along Northern Central Java. However, this area was categorized as degraded mangrove area by [4].

2.2. Data
Landsat 8 path/row 121/65 that acquired from LAPAN ground station on April 10, 2018 was used. Landsat 8 has seven band lied on visible and infra-red spectrum.

2.3. Field Data
The mangrove health indicator which is collected from literature review and possible to collect during field survey were canopy cover, tree density, sampling density, seedling density, species density, water/soil temperature, water/soli salinity, soil moisture and pH. Field data were collected from 44 station for each station. The field station was spread along mangrove area as shown on Figure 1.

![Figure 1. The distribution of sampling location to collect field data.](image)

2.4. Method
Mangrove vegetation are easy to interpret visually on RGB 564 composite image of Landsat-8, then the new-proposed index derived from 2 band that could differentiate mangrove vegetation that are band 6 and band 5. The different of digital number between band 6 and band 5 is large in the mangrove area and smaller in non-mangrove vegetation. This condition is caused absorption of electromagnetic wave on short wave infrared (SWIR) by tidal-caused wet soil on mangrove area band the reflectance on NIR
band is not different. Tidal effect at intertidal area generated specific soil character that influenced on vegetation community reflectance [5].

The formulation of mangrove index is:

\[ MI = (NIR - SWIR / NIR \times SWIR) \times 10000 \] [3]

Where IM is proposed mangrove index, NIR is near infrared band that is band 5 on Landsat-8 and SWIR is shot wave infrared band that is band 6 on landsat-8. The value of 10.000 is multiplication factor to derive index on between value -1 and 1 and 10.000 used because the radiometric resolution of Landsat-8 1T level data is 12 bit with grey level or digital number between 0 - 4096. The formula transferable able to apply on other data such as Landsat ETM+ by different multiplication factor that is modified to radiometric resolution of the data.

3. Result and Discussion

The correlation analysis was done between each indicator and mangrove index value and resulted low \( R^2 \) that means there is no significant correlation. Then, some indicator combined using simple formula such as multiplication, addition, division to get higher \( R^2 \). The better correlation we got was correlation between number of tree and sapling divided by soil moisture by \( R^2 = 0.259 \) as shown on figure 2. below. This result was still low and could be caused by some factor.

![The Correlation between Mangrove Index with Health Indicator](image)

**Figure 2.** The result of correlation between mangrove index and some of health indicator from all field station.

Mangrove index calculate from NIR that responds to vegetation and SWIR that responds to soil moisture. Soil moisture at mangrove area controlled by hydro-period that important parameter for growing of mangrove tree [6]. Suspected factor that caused low correlation was measurement of field...
soil moisture. The measurement was done at mangrove area that frequently inundated by tidal and resulted soil moisture very wet until medium wet. The problem was measurement instrument has wide range between dry until wet. It will get low resolution of measurement resulted same value between small difference soil moisture.

![The Correlation between Mangrove Index with Health Indicator only east part](image)

**Figure 3.** The result of correlation between mangrove index and some of health indicator only from field station at east part.

The other suspected factor that generate low correlation mangrove area with significant different situation. At Segara Anakan there are two different area, one with moderate condition at eastern part and one more is worse condition at western part. Then we analyzed only eastern area with good mangrove condition and $R^2$ was increasing significantly reach until 0.5.

4. **Conclusion**

Positive indication that there is correlation between mangrove index and vegetation/soil moisture. Vegetation is represented with number of tree and sapling however seedling does not have indication to correlate with mangrove index, the contribution of seedling into vegetation response was low. This is not final result the extension of analysis will be done exploring all health indicator that already measured at field.

5. **References**

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