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Comparative Study on NDVI with RVI for Estimated Area and Class Distribution

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RVI;

Abstract

This study aims to determine the differences and comparison of the results of the estimated area, the distribution of clove vegetation using the *Normalized Difference Vegetation Index (NDVI)* and *Ratio Vegetation Index (RVI)* and to choose a vegetation index that is more suitable for clove vegetation analysis in Buleleng district, Bali. The method used is to compare statistically descriptive area and distribution class produced by the NDVI and RVI models with area data from the Forestry and Plantation Service (FPS), Buleleng regency, Bali in 2014, amounting to 7622.32 ha. The estimated area of clove vegetation by the NDVI model was 7852.68 ha and the RVI model was 7669.44 ha. There is an estimated difference in the area of clove vegetation of 183.24 ha and a difference in the broad class category of 2453.85 ha for the Rare class (NDVI > RVI) category, for the Medium class of 1611.45 ha (RVI > NDVI), and for the Dense class of 659.16 ha (RVI > NDVI). Comparison of the area with FPS data obtained 97.07% for the NDVI model and 99.39% for the RVI model. This shows that the RVI model vegetation index is more suitable for use in the estimation of the area and class of clove vegetation distribution in Buleleng regency, Bali.

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1. Introduction

The slow supply of information on an agricultural commodity in a broad sense requires attention. This is inseparable from the conventional methods that are still used in the data collection process, such as the clove production data in Buleleng regency, Bali. Clove production for 4 quarters of 2014 averaged 745 kg/ha with an area of 7622.32 ha and in 2015 an average of 694 kg/ha with an average area of 7723.91 ha (Dinas Kehutanan dan Perkebunan Pemkab Buleleng, 2014; Dinas Kehutanan dan Perkebunan Pemkab Buleleng, 2015). The application of remote sensing satellite technology has become an alternative and even the main choice for vegetation analysis studies.

Vegetation index calculation is one of the simplest types of band transformations (Rees, 2013). Some vegetation index models extracted from remote sensing satellite imagery have been widely used in various global scale vegetation studies. Remote sensing satellite technology can effectively monitor plant biomass, map land drought, *Leaf Area Index (LAI),* chlorophyll concentration to estimated productivity (Adams & Gillespie, 2006; Beeri *et al.,* 2007; Gu Wanhua *et al.,* 2011; Xie *et al.,* 2008). Comparative research and estimation using vegetation index in remote sensing have been carried out, both comparison between vegetation index models and index comparison of various sensors (SPOT, Landsat 7, Landsat 8) to vegetation cover (Brian *et al.,* 2007; Dandan Xu & Xulin Guo, 2014; GuoLin Gao & ShiYing Wang, 2012; Hongxia Luo *et al.,* 2014; LI Hongjun *et al.,* 2007).

These studies analyze many index correlations with the distribution of vegetation cover, differences in sensitivity of the spectral reflectance response of vegetation and the methods used in the comparison.

Normalized Difference Vegetation Index (NDVI) and *Ratio Vegetation Index (RVI)* vegetation index models are the two most frequent index algorithms and are widely used in remote sensing satellite image processing. Mathematically, these two models have different shapes. The NDVI and RVI index formula involves a spectral radial two-way reflectance factor at near-infrared wavelengths (Near Infrared, usually λ = 0.8 to 1.0 μm) and red wavelengths (Red, usually λ = 0.6 to 0.7 μm) (Rees, 2013).

The use of Landsat 8 satellite imagery as an instrument in monitoring and mapping the utilization of natural resources and the environment is quite good results. This is inseparable from the characteristics of Landsat 8 such as having good enough spatial and temporal resolution and quite a large number of spectral resolutions, thus increasing the accuracy of data in estimating and inventorying natural resources in a large area. This study aims to determine the differences and comparison of the results of the estimated area, the distribution of clove vegetation using NDVI and RVI and to choose a vegetation index that is more suitable for clove vegetation analysis in Buleleng district, Bali.

2. Materials and Methods

The materials used were Landsat 8, 1G level, May 5, 2014, for scene 1, Path 117, Row 66 and May 30, 2014, for scene 2, Path 116, Row 66. The study area is presented in Figure 1 and astronomically located in coordinates 8°03'40'' – 8°23'00'' South Latitude and 114°25'55'' – 15°27'28'' East Longitude.

The steps taken in this study were (1) coordinate measurements in the field (2) image data processing and analysis. At step (1), the coordinates of the sample of clove vegetation in the field are measured by selecting location points that are quite homogeneous using the Global Positioning System (GPS) Smartphone. This coordinate is used as an indicator of the position of clove vegetation at coordinates on Landsat 8 imagery.

In step (2), it begins with making the study area image by mosaicing 2 scenes of Landsat 8 imagery, then overlaid with a digital map of the study area boundaries. Reflect correction on Top Of Atmosphere (TOA) using a formula from the U.S. Geological Survey (USGS, 2019). Geometric correction refers to 9 allied control points (Ground Control Point, GCPs) performed by the nearest neighbor method. To clarify visual interpretation and highlight aspects of vegetation, stretching using the Linear with Saturation method and building a composite image with a band combination, namely Red = band 6, Green = band 5 and Blue = band 4.

Figure 1. The regional research area of Buleleng regency, Bali

Classification of clove and no clove vegetation objects using the maximum method likelihood. The entire image data processing uses TerrSet Version 18.21 software. Two vegetation index images are built using the formula (Rees, 2013):

$$NDVI = \frac{r_i - r_r}{r_i + r_r} \quad (1)$$

$$RVI = \frac{r_i}{r_r} \quad (2)$$

Where r_i = reflectance in the NIR band (band 5)
r_r = reflectance in the Red band (band 4)

Identification of clove vegetation index in the image is obtained by adjusting the measurement results of clove vegetation coordinates in the field with pixel coordinates in the image (Yuliara *et al.*, 2017). Comparison and area analysis of the distribution of clove vegetation was done statistically descriptive with average area data from Plantation and Forestry Service of Buleleng regency in 2014 as a reference. More, processing and analyzing image data is presented in Figure 2.

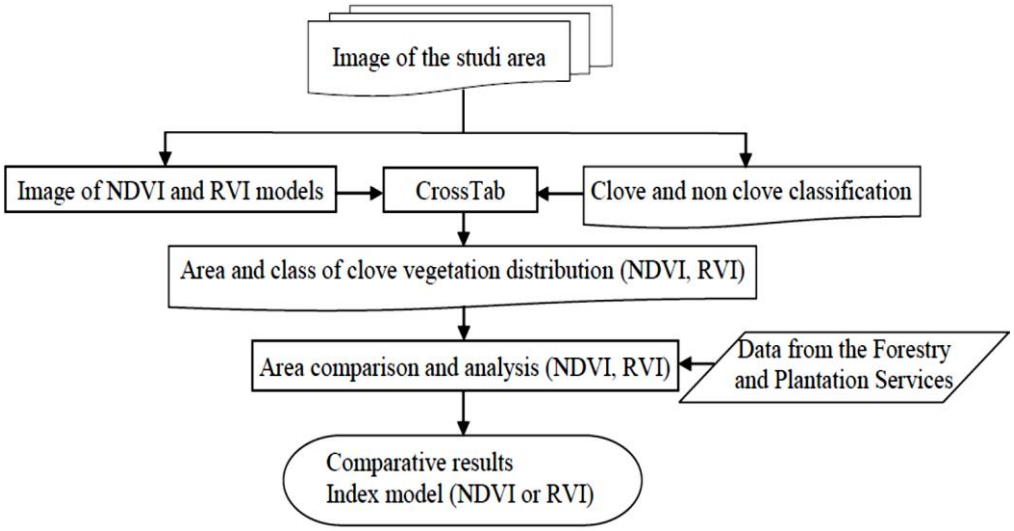

Figure 2. Research flow chart

3. Results and Discussions

The image of the study area was obtained by mosaicing 2 scenes on Path 117, Row 66 and Path 116, Row 66 Landsat 8 image data for the Bali region which was then overlaid with a digital map of the boundaries of the study area. Geometric Correction and Resample using 9 Ground Control Points (GCPs) resulted in a total value of Root Mean Square (RMS) of 12.73 which is smaller than 1/2 the pixel dimension (Lillesand *et al.,* 2015). Processing stretching contrast using the Linear with Saturation method and the formation of composite images with the composition of the RGB band = 654.

The classification process to distinguish clove and non-clove objects using the type of hard classification and the calculation of its accuracy with the confusion matrix produces an overall accuracy of 89.16%. The distribution of vegetation index values for NDVI and RVI models is calculated using the vegetation index algorithm according to Equation (1) and Equation (2). The results of the NDVI vegetation index image model with Quant palette and RVI with QualW1 palette are presented in Figure 3 and Figure 4.

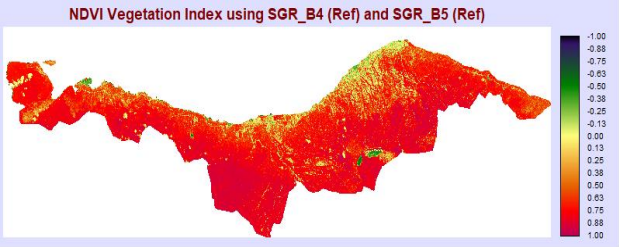

Figure 3. Distribution image of NDVI vegetation index model

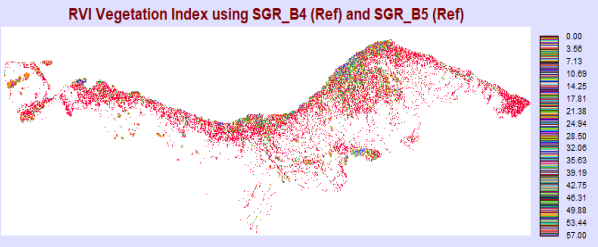

Figure 4. Distribution image of NDVI vegetation index model

The measurement results of pixel values in the study area images for NDVI and RVI vegetation index model images at 10 observation points (OP) are presented in Table 1.

Table 1
NDVI And RVI vegetation index values in the OP

OP	Geographical coordinates		Vegetation index model	
	Latitude (X)	Longitude (Y)	NDVI	RVI
1	295080	9092700	0.84810	0.08219
2	295140	9092876	0.83582	0.08943
3	294840	9093986	0.85714	0.07692
4	295050	9093055	0.80132	0.11029
5	284370	9083666	0.76543	0.13287
6	295260	9092336	0.82474	0.09605
7	307110	9098875	0.83226	0.09155
8	306240	9099837	0.79762	0.11258
9	306420	9099475	0.80800	0.10619
10	307590	9097255	0.81905	0.09948
Average			0.10017	0.81895

Comparison of vegetation index values of NDVI models with RVI at each OP graphically (histogram) is presented in Figure 5. The minimum and maximum values of the vegetation index model indicated as clove vegetation in the image are presented in Table 2. The results of processing the vegetation index image where the pixels are indicated as clove vegetation from NDVI are presented in Figure 6, while for RVI are presented in Figure 7.

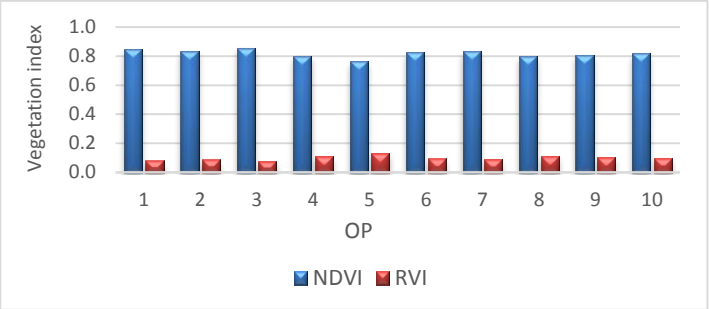

Figure 5. Histograms of NDVI and RVI index models in OP

Table 2
Minimum and maximum vegetation index values

Vegetation index model	Index values	
	Minimum	Maximum
NDVI	0.76543	0.85714
RVI	0.07692	0.13287

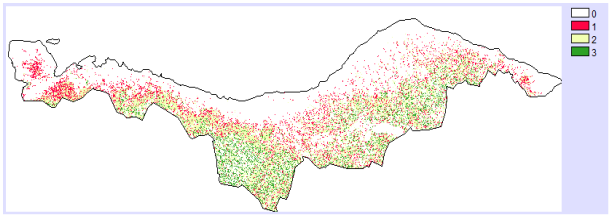

Figure 6. Class image distribution of NDVI model clove vegetation index

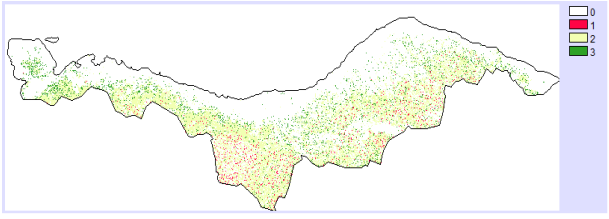

Figure 7. Class image distribution of NDVI model clove vegetation index

The results of the calculation of the accuracy-test (Overall accuracy) for the classification of clove and non-clove objects using a confusion matrix, obtained 91.64% for NDVI and RVI of 89.16%. The process of identifying images to estimate the extent and class of clove vegetation distribution is done through the CROSSTAB (Cross Tabulation) module available in the TerrSet image processing module version 18.21. The results of this processing are in the form of clove vegetation distribution based on NDVI and RVI vegetation index models along with their density classes or distribution which are categorized into Rare, Medium and Dense classes. The results of statistical data processing obtained an estimate of the area of clove vegetation and the category of clove vegetation distribution are presented in Table 3.

Spatial information (map) of the distribution of clove vegetation in Buleleng regency, Bali, the NDVI vegetation index model is presented in Figure 8 and the RVI model is presented in Figure 9.

Table 3
Estimation of clove vegetation area and distribution class based on vegetation index model

Vegetation index model	Area estimate (ha)	Area of distribution classes (ha)		
		Rarely	Medium	Dense
NDVI	7852.68	2731.77	4096.08	1024.83
RVI	7669.44	277.92	5707.53	1683.99
Difference	183.24	2453.85	1611.45	659.16
Average	7761.06	1504.85	4901.81	1354.41

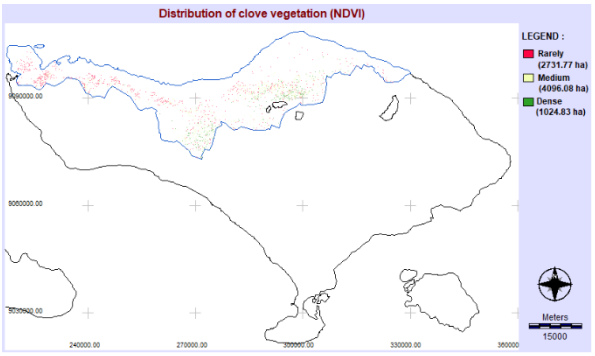

Figure 8. Distribution of clove vegetation model NDVI, Buleleng regency

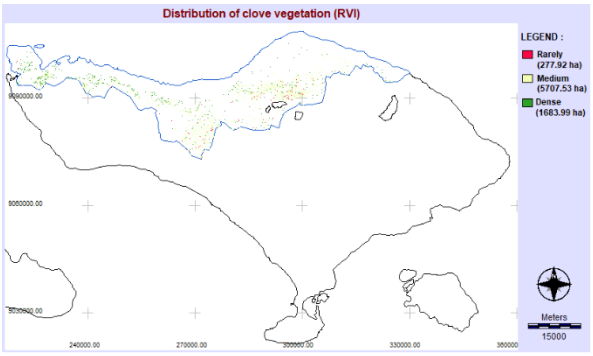

Figure 9. Distribution of clove vegetation model RVI, Buleleng regency

A complete comparison of estimated clove vegetation area based on NDVI and RVI vegetation index models with clove vegetation area data in 2014 from FPS of Buleleng regency is presented in Table 4.

Table 4
Comparison of NDVI and RVI area with FPS area Buleleng regency

Vegetation index model	Area (ha)	Average area of FPS Buleleng regency (ha)	Percentage (%)
NDVI	7852,68	7622,32	97,07
RVI	7669,44	7622,32	99.39

Image processing in this study generally meets the Standard Operational Procedure (Lillesand *et al.*, 2014). In terms of quality and quantity giving good results, such as the results of geometric corrections and resample, the total value of Root Mean Square (RMS) is 12.73. This result is very good in providing certainty of the position of objects in the image and making the image already has a reference (registration) at the 50N zone UTM coordinates (Mather, 2011). Processing stretching contrast using the Linear with Saturation method and the formation of composite images with the composition of the band RGB = 654 produces better visualization compared to single-band images and visually different objects appear to be seen more clearly (Lillesand *et al.*, 2015; Mather, 2011). The pixel values of NDVI and RVI images as presented in Table 1 represent and indicate clove vegetation objects in the OP in the field.

From Figure 5 it can be seen that, in general, the NDVI vegetation index model gives a greater vegetation index value than the RVI vegetation index model. For each OP, NDVI and RVI values appear to be opposite. That is, if an NDVI value increases, the RVI value will decrease (Purevdorj, 1998). From Table 2, it can generally be interpreted that, the minimum vegetation index value indicates the unhealthy or sparse density of clove vegetation at the location concerned, or it can be said that clove vegetation does not cover the entire soil surface. The higher the value of the vegetation index indicates the condition of clove vegetation the more healthy or fertile and dense and active in the process of photosynthesis.

4. Conclusion

The difference in the estimated area of the clove vegetation area between the NDVI and RVI models is 183.24 ha. The differences in the categories of sparse class areas are 2453.85 ha, Medium classes 1611.45 ha and Dense classes 659.16 ha. The results of the comparative area with FPS data are 97.07% for the NDVI model and 99.39% for the RVI model. These results indicate that the RVI model is an index model that is more suitable for estimation of the area and class of clove vegetation distribution.

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