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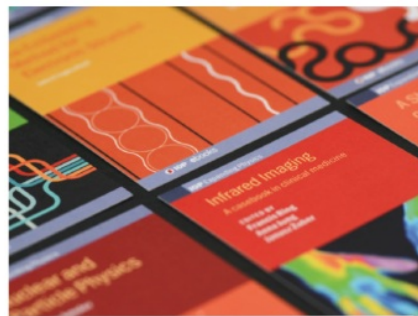
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## Design and Development of Calculation System for <sup>1</sup>Normalized Difference in Vegetation Index (NDVI) Using Landsat 8 Satellite Image

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# Design and Development of Calculation System for Normalized Difference in Vegetation Index (NDVI) Using Landsat 8 Satellite Image

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**Abstract.** The satellite image is a Earth's surface image recorder that is performed without physical contact with the object. Satellite imagery can also be used as a solution to get the information of a wide area that is covered by vegetation. Normalized Difference Vegetation Index (NDVI) is an index depicting the level of a green plant with a combined tally of the Visible Red Band and the Near Infrared Band. Visible Red Band is the band of Landsat satellite image 8 whereas Near Infrared Band is a band 5 of Landsat satellite image 8. This research intends to build a system of counting of NDVI data by making use of satellite images Landsat 8 on the special region of Yogyakarta. The equation used in this study is the equation correction between Visible Red Band and Near Infrared Band from Landsat 8 satellite imagery and NDVI equation. Zoom functions and masking is also built into the system so it can be more focused on the area that wants to the canvas. The results of this research are in the form of value and a map of the NDVI that have been colors segmented in the Province of Yogyakarta.

## 1. Introduction

The rising temperature of the Earth's surface caused climate changing. Because of that technology that can quickly figure out and gives information regarding temperature changes are needed. Remote sensing is the science to manage and interpret an image that can be utilized in many different types of applications. Remote sensing has been recognized as a tool that is able to detect accurately land closure [1]. Remote sensing is carried out to obtain information by analyzing the data without direct interaction with the objects that will be examined [2].

The vegetation index is one of the parameters that are used to analyze the State of the vegetation of a region. Vegetation index has a range of variation of the algorithm. The decline and alternative Normalized Difference Vegetation Index (NDVI) has been proposed by various researchers to refine parameters, such as the Soil-Adjusted Vegetation Index (SAVI), the Perpendicular Vegetation Index (PVI), the Enhanced Vegetation Index (EVI), the Global Environment Monitoring Index (GEMI), and



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the Atmospherically Resistant Vegetation Index (ARVI). Each index is calculated by the correction factor one or some factor which becomes deficient NDVI [3]. The vegetation index is a method of transformation spectral data based images that may be used also as observation of forest and soil background effects purposes also in the analysis of vegetation [3].

Remote sensing satellite NASA spearheaded by the United States by launching the first satellite for natural resources on 23 July 1972 called the ERTS-1 (Earth Resources Technology Satellite). The second satellite was launched in 1975 named ERTS-2, the satellite carries sensors RBV (Return Beam Vidcon) and MSS (Multi-Spectral Scanner) that have a spatial resolution 80 x 80 m. After satellite launched, ERTS-1 and ERTS-2 were renamed Landsat 1 and Landsat 2 continues with the next Landsat series type 3, 4, 5, 6, 7 and later Landsat 8.

Landsat 8 is more commonly referred to as a satellite with the resume mission Landsat 7 rather than being referred to as a satellite with new specifications. Seen from characteristics Landsat 8 similar to Landsat 7, good the resolution (spatial, temporal, spectral), flying height as well as the characteristics of the sensor is brought. There are few additions that become a refinement point from Landsat 7 such as the number of more channels Landsat 8 channels than Landsat 7, the correction method, the lowest spectrum of electromagnetic waves that the sensor can capture and can see the values bit (Digital Number value ranges) of each image pixel.

Research in advance already doing research on NDVI [1][3][4][5]. But earlier studies only conduct analysis using software or existing application. In this case, the researchers will build and design a system for estimating vegetation coverage on the special region of Yogyakarta using calculation NDVI on Landsat satellite image 8. Additional features such as zoom and masking will be made on the application.

## **2. Methods**

This research will be focused on the making of the application system of calculating the NDVI using satellite images Landsat 8 on the Yogyakarta with add mask and zoom within the application so it can ease the process of calculation.

### *2.1. Remote Sensing*

There are a variety of definitions of remote sensing. The following definition of remote sensing, according to some experts:

- Remote sensing used to get information such as the object area by way of analyzing the data obtained using the tool without having to direct interaction on the object or area that wants to canvas [2].
- Remote sensing uses electromagnetic sensors to get images of the earth that analyzed so that useful information can be obtained [6].

Image is a continuous function of a two-dimensional image's intensity [7]. The image is obtained from the capture of the reflected signal object. The image is the output of recording devices such as cameras analog or digital. The analog or digital image is an image of a real object, while the image of the processed results of radiate heat that produces certain colors in accordance with the heat emitted is called image-based thermal [8].

The value of pixels from each gray image is at 0-255 intervals, while on the colored image there are three different values in the interval 0-255. A grayscale image is an image that only uses gray levels. Gray is the only color in RGB space with red, green and blue components which each have the same intensity value [9]. Image processing function to improve the quality of the images through some of the processes to be easy-to-read or presented [10].

The image is a picture or record object. Increasing the use of remote sensing data based on factors, such as the following [10]:

1. Get a complete overview and image information such as the object of the Earth.
2. Observations with the stereoscope can produce a three-dimensional image.
3. Produce a better and quicker image of remote area.

The characteristics of the object on the image recognition are as follows[11]:

- 1) Image color has a level of brightness and darkness of the object, a dark color concluded with low spectral reflection, while the high-spectral reflection symbolized by bright colors.
- 2) Shadows located in dark areas that hide object details.
- 3) The pattern is a characteristic of the mark form between human and nature.
- 4) The similarity of the objects to each other is called Association.
- 5) The form of the attribute that is clearly visible and easily recognizable.
- 6) The site, which is the location of the object one with other objects.
- 7) Size, in the form of height, breadth, distance, and volume.

The main function of image interpretation, namely tapping data taken from the image and used for certain purposes. Data capture from images presented in the form of graphs, tables, or thematic maps. The process of its performance begins by elaborate or separating different objects than for the same objects will be given withdrawal limit line. The recognized object type classified and illustrated with maps[12].

## 2.2. Satellite Landsat8

Landsat 8 OLI and TIRS are American earth observation satellites released on 11 February 2013. Landsat 8 is a development from Landsat 7. Initially, Landsat 8 was the Landsat Data Sustainability Mission (LDCM) which was a combination of NASA and the United States Geological Survey (USGS). Landsat 8 OLI and TIRS are equipped with 2 sensors namely sensors Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). Landsat 8 provides global coverage of seasonal from the Mainland at any resolution. 30-meter resolution is Visible (Band 1, Band 2, Band 3, Band 4 and Band 9), NIR (Band 5) and SWIR (Band 6 and Band 7). Resolution of 100 meters, namely Thermal (Band 10 and 11 Bands), and a resolution of 15 meters is Panchromatic (Band 8). Landsat 8 can be seen in Figure 1[13].



**Figure 1.** Landsat 8

**Table 1.** Landsat7

Band	Wavelength (nm)	Name	Resolution (m)
1	0.450-0.515	Blue	30
2	0.525-0.605	Green	30
3	0.630-0.690	Red	30
4	0.775-0.900	Near-IR	30
5	1.550-1.750	SWIR-1	30
6	10.00-12.50	LWIR	60
7	2.090-2.350	SWIR-2	30
8	0.520-0.900	Pan	15

Landsat types are as follows:

1. Landsat 1 was released on 23 July 1972 used until 6 January 1978.
2. Landsat 2 was released on 22 January 1975 used until 22 January 1981.
3. Landsat 3 was released on 5 March 1978 used until 31 March 1983.
4. Landsat 4 was released on 16 July 1982 used until 1993.
5. Landsat 5 was released on 1 March 1984 are experiencing a major disruption in November 2011 and deactivated on 26 December 2012.
6. Landsat 6 was published on 5 October 1993 but the Landsat 6 failed to orbit.
7. Landsat 7 was released on 15 December 1999, suffered damage since May 2003.
8. Landsat 8 has an Onboard Operational Land Imager (OLI) sensor and a Thermal Infrared Sensor (TIRS) with 11 canals. OLI is on channels 1-9 while TIRS is on canals 10-11.

Types and comparison of the Canal and the Band on the Landsat 7 and Landsat 8 can be seen in Table 1 and Table 2.

**Table 2.** Landsat8

Band	Wavelength (nm)	Name	Resolution (m)
1	0.433-0.453	Coastal/Aerosol	30
2	0.450-0.15	Blue	30
3	0.525-0.600	Green	30
4	0.630-0.680	Red	30
5	0.845-0.885	Near-IR	30
6	1.560-1.660	SWIR-1	30
7	2.100-2.300	SWIR-2	30
8	0.500-0.680	Pan	15
9	1.360-1.390	Cirrus	30
10	10.30-11.30	LWIR-1	100
11	11.50-12.50	LWIR-2	100

Landsat 8 has a new specification in the Band 1, 9, 10 and 11 which served to capture the electromagnetic waves are lower compared to Landsat 7. The Band is superior in identifying characteristics of seawater at different depths. There is a one Thermal Infrared Band Satellite in the Landsat 7 Satellite, whereas in Landsat 8 has two Thermal Infrared Band. In addition to the difference in the amount of Thermal Infrared Band, a spatial resolution from both satellites was also different 60 meters on the Satellite Landsat 7 and 100 meters on the satellite Landsat 8. Satellite Landsat 8 there are two new Band is Coastal/Aerosol and Cirrus Band that doesn't exist on a Landsat 7 Satellite.

### 2.3. Reflectance Correction

The value of the pixels on the satellite image shows the exposure from the Earth's surface in the form of a Digital Number (DN) that is calibrated to a range of values. DN conversion into real exposure needs to be done for the comparative analysis of some of the images. Calculation Reflection Correction for satellite imagery can be seen in equation (1)[13].

$$\rho\lambda = \frac{M_p Q_{cat} + A_p}{\sin(\theta_{SE})} \quad (1)$$

where:

- $\rho\lambda$ : TOA planetary reflectance
- $M_p$ : Band-specific multiplicative rescaling factor of metadata (REFLECTANCE\_MULT\_x, where x is number band)
- $A_p$ : Band-specific additive rescaling factor of metadata (REFLECTANCE\_ADD\_BAND\_x, where x is number band)
- $Q_{cat}$ : Quantized and calibrated standard product pixel values (DN)
- $\theta_{SE}$ : Local sun elevation angle (SUN\_ELEVATION)



Value  $M_p$  and  $A_p$  different in each Band of imagery acquired by each sensor. Satellite Landsat 8 has 2 sensors namely Sensors Operational Land Imager (OLI) and Thermal Infrared Sensors Sensor (TIRS). Value  $M_p$  dan  $A_p$  obtained from the file metadata on Landsat 8, whereas the value of the  $M_p$  dan  $A_p$  used in this study was obtained from the sensor OLI that is the Band 4 and the Band 5.

$Q_{cal}$  is the value of the DN of the band 4 and band 5 on satellite images Landsat 8.  $\theta_{SE}$  the angle of the Sun is the value obtained from Landsat satellite imagery metadata file 8. There is only one value of the angle of the Sun on a satellite image.

#### 2.4. Index Vegetation

The vegetation index is an index which describes the level of a greenish plant. Vegetation index usually uses a simple algebraic calculation. Vegetation indexes are designed to amplify the signal of the vegetation on the data obtained by remote sensing. Vegetation index providing the size estimates of the amount of vegetation that is green and healthy [16].

Vegetation index was used in research is the NDVI which can be seen in the equation (2). The green vegetation index is a healthy size.

$$NDVI = \frac{Band\ 5 - Band\ 4}{Band\ 5 + Band\ 4} \quad (2)$$

Where:

Band 4: Visible Red Band of image satellite Landsat 8

Band 5: Near Infrared Band 5 of image satellite Landsat 8

NDVI calculation requires two inputs i.e. the **Near Infrared Band (Band 5 Landsat 8)** and the **Visible Red Band (Landsat 4 Band 8)**. The use of two inputs based on the theory that the plants are healthy to tend to give a lot of reflection on wave Near Infrared and a bit of reflection (the more absorbing). Table 2.3 is a table of the values of NDVI object against the Earth's surface [17].

**Table 3.** NDVI Values Against the Object Surface

Band	Wavelength (nm)
<0.1	Snow, Rocks, Badlands, Sand
0.2 – 0.5	Bushes, Grasslands, Crops Ripen.
0.6 – 0.9	Temperate Forests, Tropical Forests, Healthy Herbs

NDVI values less than 0.1 are included in the category of non-vegetation objects in the form of rocks, barren land, sand, and snow. NDVI values between 0.2 to 0.5 are included in the category of vegetation cover that is not so thick as bushes, grasslands, and aging plants. NDVI values between 0.6 to 0.9 are included in the category of tight vegetation covers such as temperate forests, tropical forests and healthy plants.



### 3. Proposed System

This section will discuss some of the processes that are needed to build an application system of counting of NDVI data on satellite images Landsat 8.

#### 3.1. Data Source

Source data obtained from the official website and the source of the study of literature. In this study used satellite imagery data is a satellite image of Landsat 8 OLI and TIRS that are retrieved from the official website (<https://earthexplorer.usgs.gov/>). The USGS website look can be seen in Figure 2.

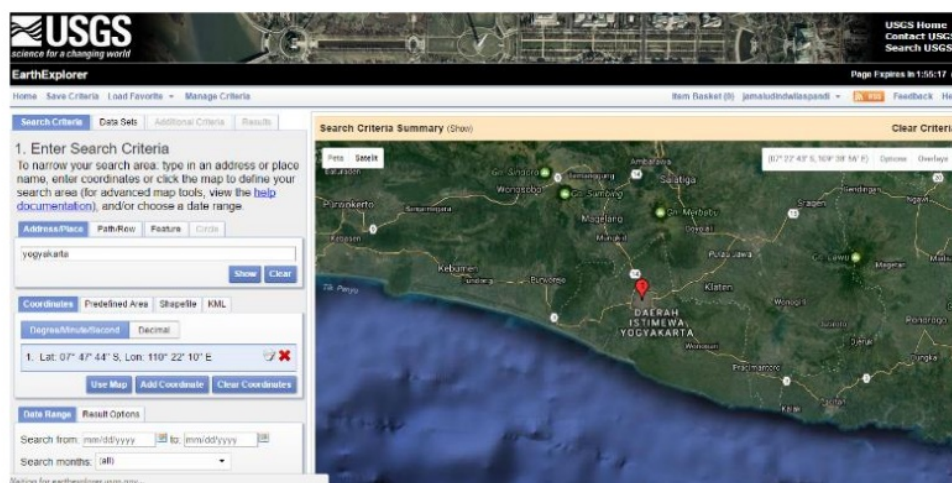
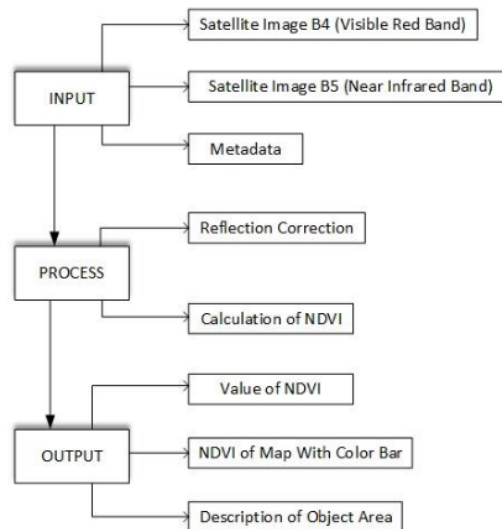


Figure 2. Search Image USGS

Fig 2 is the search function on the image data on province Yogyakarta. In the column address/place name input area is required, or by entering values for the Path/Row corresponds to the value of each region. The value Path/Row province D.I.Y is 120/65. Satellite image of the data used in this research was grouped into two with a different period of time. Satellite image data were taken during the period of 1 December 2011 to 1 December 2016 (Period A). Satellite image data within the period of 1 January 2012 to 31 December 2017 (Period B).

#### 3.2. System Design Process

The general description of the system that describes the application flow from input to output can be seen in Figure 3.



**Figure 3.** Application Work Process

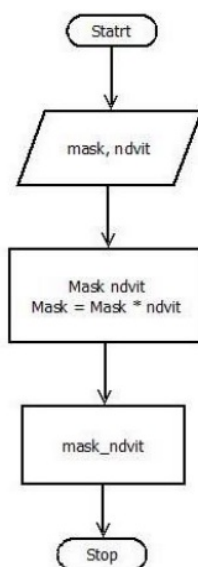
Figure 3 is a process of the system to be built. The following of explanation application process from input to output:

1. The system that was built had 2 types of input<sup>8</sup>, the image input, and file metadata input. The input image is a satellite image Landsat 8 Band 4 (Visible Red Band) and Band 5 (Near Infrared Band). The format of satellite images Landsat 8 is GeoTIFF. The input metadata file is input the number of variables. The value of the<sup>7</sup> variable metadata that is used is the value of Multiplicative Rescaling Factor from<sup>7</sup> Visible Red Band and Near Infrared Band, the value of Additive Rescaling Factor Visible Red Band and the Near Infrared Band as well as the value of the sun's elevation (height of the Sun). The metadata file is a text file that has an a.TXT format.
2. There are two processes in the system, namely the process of correction of reflectance and the process of counting of the NDVI. Reflectance correction process performed of input satellite images Landsat 8 band 4 and Band 5. NDVI calculation requires the input of Visible Red Band image and image of Near Infrared Band from Landsat 8.
3. The resulting output is the NDVI values and maps that segmented by color as well as a description of the object

### 3.3. Masking Image

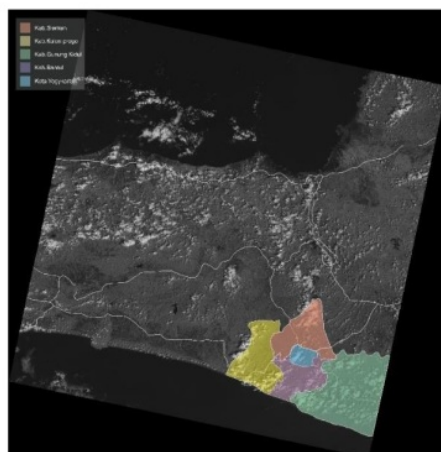
Masking process aimed to separate the region that is going to be checked with areas that do not want to be checked. The process of masking is performed on the input image.

NDVI masking process conducted by using polygon on the image. Polygon acts as masking to cut the area that you want to use for research. Flowchart masking stages can be seen in Figure 4.



**Figure 4.** Flowchart Process Masking

The process of masking NDVI requires two input i.e. input image Visible <sup>1</sup>Red Band (Band 4) and the Near Infrared Band (Band 5). Masking process performed on the NDVI image axes threshold in the GUI. Masking process function use implies (). The process of masking is done on a satellite image which had been modified. Image masking can be seen in Figure 5.



**Figure 5.** Image of Masking

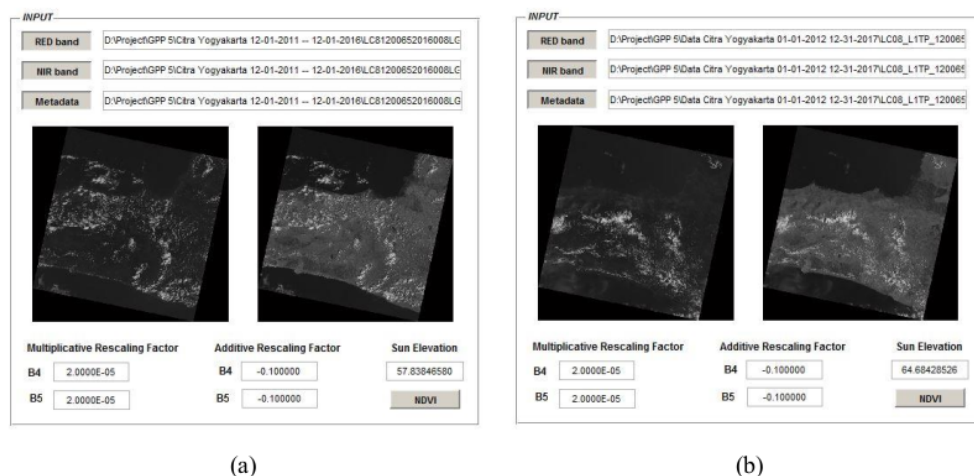
Figure 5 is a satellite image which had been modified used in the process of masking. Image masking is given color areas and lines to the Yogyakarta which aims to ease the process of masking in accordance with the area that wants to the canvas. The colors in the image masking show each district in the Yogyakarta. There are 5 colors in image masking, color red indicates regions of Sleman, the yellow color indicates the area of Kulon Progo, purple color indicates counties Bantul, blue shows areas of the city of Yogyakarta and the green color indicates the area of Kulon Progo.

#### 4. Result

##### 4.1. Process Input

The application created is a GUI (Graphical User Interface). The application is made as simple as possible so that the user can operate the application easily.

The image is used in the process of counting of the GPP is a satellite image Landsat 8. Satellite images Landsat 8 TIFF format which has a size of pixel 7731X7591 and data type uint16. The result of the input image Visible Red Band and the Near Infrared Band can be seen in Figure 6.



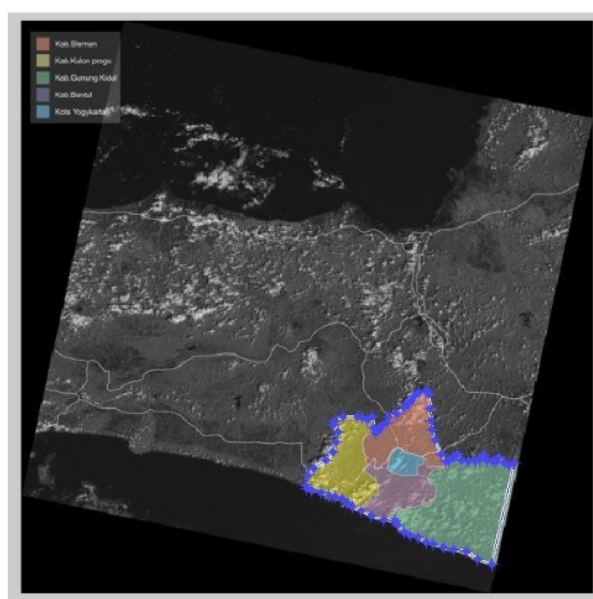
**Figure 6.** (a) Input of Image (Period A), (b) Input of Image (Period B)

Figure 6 (a) is a satellite image input by the Date 1 December 2011 until 1 December 2016. Figure 6 (b) is the input of the satellite image of B with the date of the 1 January 2012 until 31 December 2017. The image displayed on a panel namely satellite imagery that is already subset 512x512 pixel. The left image is the input of the Visible Red Band. The left image is the result of input from the Visible Red Band while the right Image is the result of input from the image the Near Infrared Band. Multiplicative Rescaling Factor value for the image of the Visible Red Band is 2.0000-05 and image the Near Infrared Band has Multiplicative Rescaling Factor is 2.0000-05. Sun Elevation function to display the value of the angle of the Sun. The value of the variable the height of the Sun in Figure 6 (a) that is 57.83846580 whereas in Figure 6 (b) that is 64.68428526. The function used to display the variable value from the metadata file input is "set()".

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

#### 4.2. *Process Masking*

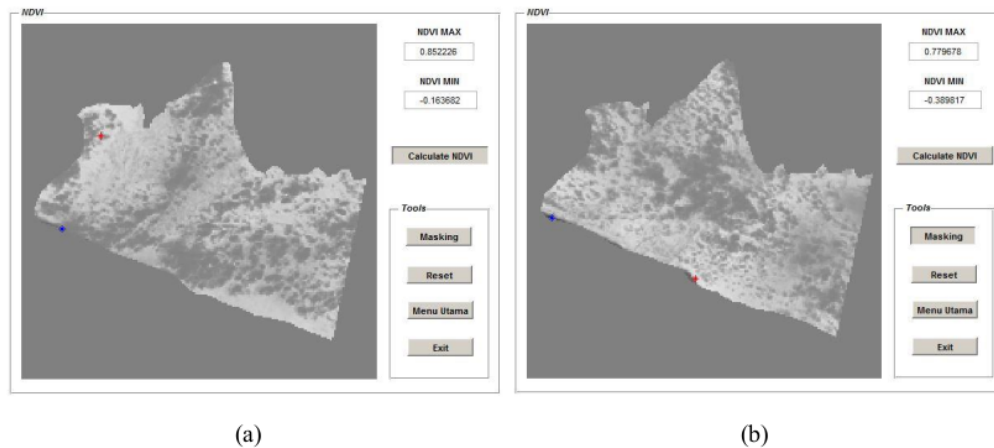
The process of masking is done manually by the user. Masking is performed on the input image and results masking in the form of image NDVI. Masking function to determine the area that wants. The display masking can be seen in Figure 7.



**Figure 7.** Process Masking

Figure 8 is the process of masking on the input image. Masking is performed on the Yogyakarta (the research areas) are marked with a red circle in Figure 8. The process of masking is only performed on an image that has been modified (Figure 5) to avoid the occurrence of errors or differences in the pixel of the image. The image of the Visible Red Band and the Near Infrared Band will be truncated automatically according to form that has been cut off earlier on image masking process. The results of the process of masking can be seen in Figure 8.





**Figure 8.** (a) Result of Masking Process (Period A), (b) Result of Masking Process (Period B)

Figure 8 (a) is a result of the masking process on first research (period A). The results of the masking on the B can be seen in Figure 8 (b). Figure 8 (b) is the result of the process of masking on the period B.

#### 4.3. Calculation of NDVI Output

Code program from equation 1 can be seen in Figure 9. Figure 9 is a function of the correction process reflection satellite image of the Visible Red Band and the Near Infrared Band. The variable "RED\_ref" is the variable to store the results of the final calculation of the correction of reflection of the Visible Red Band. The value of the Digital image of the Visible Red Band Number multiplied by the variable "nmb4" which is the value of a Multiplicative Rescaling Factor to the Visible Red Band, then the multiplication results in total with the variable "nab4" which is the value of the Additive Rescaling Factor for the Visible Red Band and the sum divided by the results of sin from the variable "SUN\_ELEVATION".

```
RED_ref = ((nmb4*REDt)+(nab4))/sind(SUN_ELEVATION);
assignin('base','RED_ref',RED_ref)
NIR_ref = ((nmb5*NIRt)+(nab5))/sind(SUN_ELEVATION);
assignin('base','NIR_ref',NIR_ref)
```

**Figure 9.** Code Program of Correction Reflektan in Matlab

The variable "NIR\_ref" i.e. a variable to store the value end of the correction process reflection on the ideals of the Near Infrared Band. The variable "NIRt" Digital value is Number of input satellite imagery of Near Infrared Band. The value of Digital Number from Near Infrared Bands multiplied by the variable "nmb5" which is the value of the Multiplicative Rescaling Factor for the Near Infrared Band. The results of the multiplication combined with the variable "nab5" which is the value of the Additive Rescaling Factor for the Near Infrared Band and the result of the sum divided by the sin of the angle of the Sun value "SUN\_ELEVATION".

The input image has been corrected using reflection then processed into the counting process of the NDVI vegetation cover to get value as in formula 2. Program code for the counting of the NDVI can be seen in Figure 10.

```
ndvi = (NIR_ref-RED_ref) ./ (NIR_ref+RED_ref);
```

**Figure 10.** Code Program of NDVI Calculation in Matlab

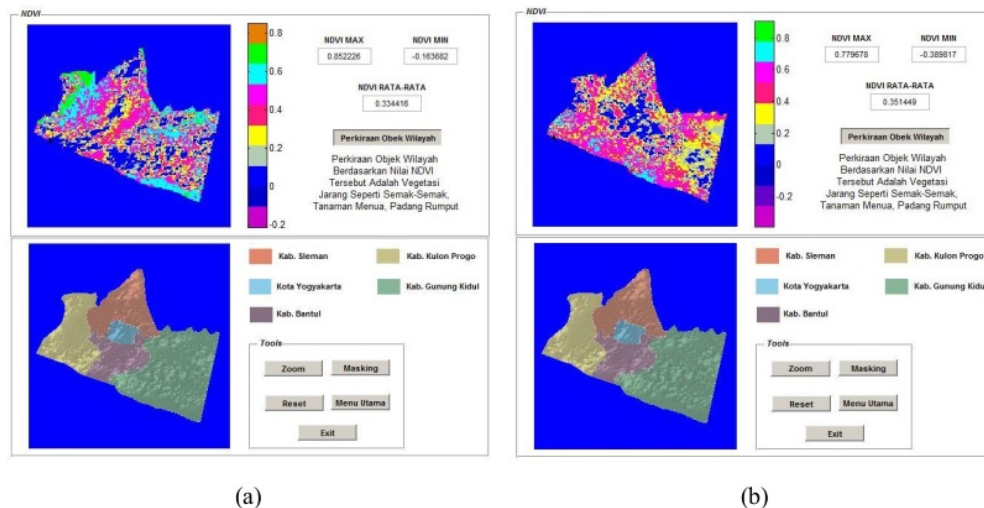
The variable "ndvi" is the variable to hold the value NDVI calculation result image. The variable "NIR\_ref" is the value of the matrix image of Near Infrared Band that has corrected the previous process on reflection. Variable "RED\_ref" is the value of the matrix image of the Visible Red Band that has corrected the previous process on reflection. Next image of NDVI will be shown on the GUI with the Code in Figure 11.

```
axes(handles.ndvi);  
imshow(ndvi, []);
```

**Figure 11.** NDVI of Print Image

Figure 11 function to display images NDVI into GUI. Axes used to accommodate the image you want to display. Images NDVI displayed using function handles so that the image can be called from the variable "ndvi" into axes on the GUI. The name of the axes to accommodate the image of NDVI which is "ndv1". Imshow () function to display the image of the NDVI.

The result of the calculation NDVI on the Yogyakarta can be seen in Figure 12.



**Figure 12.** (a) Calculation of Result NDVI (Period A), (b) Calculation of Result NDVI (Period B)

Figure 12 (a) shows the result of the NDVI calculating process from Period A (1 December 2011 until 1 December 2016). The maximum NDVI is 0.852226 values at period A is at coordinates 293/373 located in Kulon Progo Regency. The value of NDVI minimum is -0.163682 at coordinates 271/425 located in Kulon Progo Regency. The average value of NDVI is 0.334416 which included in the vegetation cover that is not so thick such as shrubs, pasture and crops ripen. Value counting of NDVI in the second study (period B) can be seen in Figure 15.



Figure 12 (b) is the result of a process of counting NDVI in period B (1 January 2012 until 31 December 2017). The maximum NDVI value at period B is 0.779678 at coordinates 343/454 in Gunung Kidul Regency. The value of NDVI minimum is -0.389817 there are at coordinates 262/420 located in Kulon Progo Regency. The average value of NDVI is 0.351449 which include the category vegetation cover that is not so thick such as shrubs, pasture and crops ripen.

## 5. Conclusion

Image processing of satellite imagery, correction reflectance and counting of the NDVI was successfully implemented in the application. Average NDVI values in the Yogyakarta with a period of 1 December 2011 until 1 December 2016 (Period A) is range 0.334416 and the average value of NDVI with a period of 1 January 2012 to 31 December 2017 (Period B) is 0.351449. The value of NDVI with period B is better than period A, with this it can be concluded that the NDVI value is getting higher from year to year.

An experiment using two satellite imagery with period A and period B show that there are great differences in the maximum NDVI value. The maximum NDVI values in the span of period A is 0.852226 located at Kulon Progo Regency while the maximum NDVI value at period B is located at Gunung Kidul Regency with 0.779678 NDVI values. The maximum value on the period A and B period are not so different. However, the biggest difference can be seen in its territory. The maximum NDVI value period A lies at Kulon Progo Regency while the maximum NDVI value at period B is located at Gunung Kidul Regency. It is hoped the research could help in the search for information on vegetation cover.

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