Land cover identification using Pleiades satellite imagery by comparison of NDVI and BI method in Jatinangor, West Java

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Abstract. Land cover monitoring is important to maintaining human needs and ecological function balance that will be able to observe, analyse, and present land use form. Some methods that can be implemented to this case are Normalized Difference Vegetation Index (NDVI) and Bare soil Index (BI). Land cover identification is using Pleiades images in 2018 for Jatinangor area, with land cover classes were built in five class, divided by producer’s and user’s accuracy and validated with field survey results. Accuracy of NDVI method is 69.56% with kappa 0.57 also producer's accuracy is 73.94% water bodies, 84.88% built land, 67.37% open field, 98.79% crops field, and 98.79% vegetation. User's accuracy in a row for each class are 26.86% 82.78%, 20.01%, 76.15%, and 75.37%. The Accuracy of BI method is 69.17% with kappa 0.52. Producer's accuracy for each class is 73.28% water bodies, 70.71% land build, 52.83% open filed, 63,04% crop field, and vegetation with 81.29%. User's accuracy in a row for each class is 17.05%, 81.29%, 21.44%, 65.13%, and 88.54%. Validation of NDVI more fit in the field than BI that can be concluded NDVI has a good result than BI.

1. Introduction
Physically image of land cover is variety of vegetation, any nature and culture object without human activity intervention on it [1]. As time goes by, nature things and culture object that never touch by human activity has been changed to any multipurpose to fulfil any demand due to population increase. Population increase is add to demand for land made some changes, so it is needed to classify and analysis land cover continuously. Success image analysis and classification method is highly depends on human intervention in permanent or periodic that change identification of land use due to some purpose, also the abilities of sensing systems themselves and character of the phenomena being studied [1, 2].

Land cover that identically with vegetation can be classify by implemented Normalized Difference Vegetation Index (NDVI) and Bare soil Index (BI) method [3, 4] Classify and analysis that important for land cover has any purpose like monitoring loss and additional land use that it will always changes due to human activity. Any monitoring already well research by any researcher for using NDVI and BI method [4-7] but not for using Pleiades satellite imagery that this image has high resolution for the best results of classification [8].

West Java especially Jatinangor is currently known as educational region that has functional shift from agricultural land to educational land so it developed from few years before and this changes already planned since 1980 [9, 10]. Establishment of this planed has changes any live aspect of society in Jatinangor like economics, and increasing of human populations [11], that it has impact to demand of land for any purpose, so in this case monitoring of land cover must needed.

Satellite dataset has been utilized to monitor changes of any vegetation coverage. NDVI is calculates using visible and Near Infrared (NIR) bands to estimate changes in vegetation [5] from advanced
Pleiades images data. So do with BI that using Pleiades images data for detecting the land under dense spare vegetation that utilizes Red, Blue, NIR, and MIR wavelength in its formula [12]. Pleiades has optical consist in earth observation composed of 2.8 m nadir resolution for the four multi-spectral bands and 0.7m nadir resolution for panchromatic band. Its swath about 20 km that has delivers optical resolution product in a panchromatic images into multispectral band image, orthorectified on a Digital Terrain Model (DTM) [8].

2. Datasets and Methods

2.1. Study Area
Jatinangor is located in West Java between 107°46’52.9” E Longitude 6°56’13.62” S (Figure 1) Latitude that known as educational areas that developed well for any several higher education institution [13]. Jatinangor already become a small town that always growth by the time. Development of this region starts from trading activity along Raya Bandung Streets – Sumedang, habitation, any service for students and more [11].

![Figure 1](image.jpg)

**Figure 1.** Jatinangor area, blue line pointed out the study area and red line pointed out the administration border

2.2. Data

2.2.1. Pleiades
Pleiades has four spectral bands (blue, green, red and near-infrared) with 2.8 m resolution, with field of vier of 20km in vertical viewing, a panchromatic channel with a 70 cm vertical viewing resolution. Acquisition capacity, in a single pass, of a 100 x 100 km² mosaic images, virtually instantaneous acquisition capacity for stereoscopic pairs (and even triplets) of 20 km up to 300 km with cloud-free image coverage of 2,500,000 km² per year. In addition, it has very precise image location (<12 meters without ground control points) enabling optimal use of data in Geographic Information Systems (GISs) [8].

As time goes by, Pleiades has improved better. Pleiades satellite completed with sensor that can make some colour images with spatial resolution 50 cm. each satellite has two days temporal resolution with hellosynchronous quasi-circular orbit in 694 km altitude. Pleiades has 5 band with resolution band image detail as follows [14]:
- Blue, 0.43 – 0.550 μm, resolution 2 m
- Green, 0.500 – 0.620 μm, resolution 2 m
- Red, 0.590 – 0.710 μm, resolution 2 m
- NIR IR, 0.74 – 0.940 μm (middle IR), resolution 2 m
- PAN, 0.470 – 0.820 μm, resolution 50 cm.

Pleiades images will use in this study for detect NDVI and BI calculation by each formula with classification of maximum likelihood, and use value of kappa statistic (KHAT) with producer’s and user’s accuracy. Pleiades image that used in this study is 2018 data image.

2.2.2. Toponym survey data

Toponym survey data of Jatinangor used for validation suitability of maximum likelihood classification. Region of Interest (ROI) data in this case is needed for high confidence level classification. It must be fit well to the real field with 70% confidence interval [13, 14]. Toponym survey point in the field describe in figure 2 as follows.

![Figure 2. Field data survey with nine points of interest.](image)

2.2.3. Independent Control Point

Independent control point is important for geometric correction of image data. In this study we used eight points of ICP with acceptable RMS Error is < 1 m [10]. Eight point is describe in table 1 as follows.

| Points Name | Position in Meter |
|-------------|-------------------|
|             | X                 | Y                 |
| G001        | 805357,0897       | 9237584,145       |
| G002        | 804423,3177       | 9235203,9118      |
| G003        | 809046,5443       | 9229267,4403      |
| G004        | 803909,7392       | 9230319,6842      |
2.3. Methods
To complete classifies of land cover with NDVI and BI method, some of process needs to be done as follows.

- Geometric correction that calculate by ICP.
- NDVI and BI transformation for calculate process as formula of each method using formula as follows:

2.3.1. Normalized Difference Vegetation Index (NDVI)
NDVI is dimensionless quantity as an indicator of vegetation greenness in a scene, based on contrast between maximum reflection in a near infrared (NIR). That typically with range from -1 to 1, positive of NDVI values are associated with vegetated area, while zero and negative values correspond to bare soil and water bodies, snow, clouds, and non-vegetated areas [5] [15] [16]. Reflection in NIR caused by leaf cellular structure and the maximum absorption in the red (R) due to chlorophyll pigments[17]. It is express as a ratio of difference and the sum of NIR and R bands:

\[
NDVI = \frac{NIR - R}{NIR + R}
\]  

Commonly, NDVI is used indicator of vegetation parameters in remotely sensed data [10] [16] for global vegetation mapping. From using formula 1, transformation of NDVI describe with figure 3.

![Figure 3. NDVI Transformation, that blue in high state and orange in low state.](image)

Transformation process results a histogram to describe pixel intensity distribution, with minimum value is -0.73662 and maximum value is 0.683673.

| G005  | 807150,5708 | 9232691,7844 |
|-------|-------------|--------------|
| G006  | 806223,2654 | 9236494,0042 |
| G007  | 809601,315  | 9230961,3259 |
| G008  | 804237,6389 | 9232786,6299 |
2.3.2. Bare soil Index (BI)

Bare soil Index helps in observing vegetation gaps, providing information about dense and sparse vegetation areas and dry vegetation [3] [18]. Vegetation index value is not reliable in situations where the vegetation covers less than half of the area. For more reliable vegetation status estimation, a new method formulated with medium infrared information. In calculation of this index, we use Rikimaru's approach based on the high reciprocity between bare soil status and vegetation status. It is expressed from $BI = \text{Bare soil Index} (0 < BI < 200)$, $B_1 = \text{blue band}$, $B_3 = \text{red band}$, $B_4 = \text{band NIR}$, $B_5 = \text{SWIR band}$.

$$BI = \frac{(B_5 + B_5) - (B_4 + B_1)}{(B_5 + B_3) + (B_4 + B_1)} \times 100 + 100 \quad (2)$$

$(0 < BI < 200)$

Figure 4 below is describe transformation of BI after implemented the Pleiades image that already processed by geometric correction.

![Figure 4](image)

**Figure 4.** BSI transformation, that blue indicates high states and orange in low states.

Histogram value for BI transformation with minimum value is 42.0315 and maximum value 163.08.

- **NDVI and BI classification**
  Purpose of land cover classification in this study uses 5 samples. They are water bodies, built land, open field, crops field, and vegetation. We are using a threshold of index value in NDVI and BI from each land cover class.

- **NDVI and BI land cover**
  This step is used for comparing the NDVI and BI method to get the accuracy. Comparing of these methods using maximum likelihood with confusion matrix which produce Kappa Statistic (KHAT) with accuracy are 0-4 for low, 0.4 -0.8 for moderate, 0.8 -1 for high [19]. Basic accuracy measure is overall accuracy, which calculate by dividing correctly classified pixel by total number of pixel checked. Two approaches are possible producer’s and user’s accuracy [9].

The producer’s accuracy measures how well a certain area has been classified. The more errors of omission exist, the lower producer’s accuracy.

$$\text{producer's accuracy} \% = 100\% - \text{error of omission} \% \quad (3)$$
User’s accuracy is, if the correct classified pixels in a class are divided by the total number of pixels that were classified in that class. One class in the map can have two types of classes on the ground. The ‘right’ class, which refers to the same land-cover on the ground, and which show a different land cover on the ground than predicted on the map then the classes is ‘wrong’. The more errors of omission exist, the lower user’s accuracy.

\[
\text{user’s accuracy} (\%) = 100\% - \text{error of omission} (\%)
\]  

(4)

Kappa coefficient is a measure of overall agreement of a matrix. Kappa coefficient takes also non-diagonal elements into account. With classification algorithm of supervised classification that used in this study for overall accuracy is 84% and Kappa coefficient is 0.768 for 95% confidence level [9].

3. Results and Discussions

3.1. Geometric Correction results

The results of Geometric correction in this study are good results not greater than 1 m that RMSE value for X is 0.73 and Y is 0.35 with average of RMSE is 0.81.

3.2. Maximum likelihood

Supervised classification use 5 samples in the image as figure 4 follows. In this results accuracy value is 85.9452% and kappa coefficient is 0.8007 that will be used for reference to compare the NDVI and BI method.

![Supervised classification (maximum likelihood) result](image)

**Figure 5.** Supervised classification (maximum likelihood) result, blue region is water bodies, red region is built land, topaz sand region is open field, orange is crops, and green is for vegetation.

3.3. NDVI and BI Land cover classification
As figure 6 follows, built land wider than another class that it approve Jatinangor has land cover changes from vegetation to build land for NDVI classification. BI land cover classification has result for crops is wider than other class as figure 7.

**Figure 6.** NDVI classification result

**Figure 7.** BI classification result

Compare results of NDVI and BI method is well describe by table 2 - 4 for accuracy with maximum likelihood as the reference to compare two method.
Table 2. Accuracy level of Maximum Likelihood

| Classification   | Producer’s Accuracy | User’s Accuracy | Kappa | Overall Accuracy |
|------------------|---------------------|-----------------|-------|------------------|
| Water Bodies     | 75,35 %             | 37,93 %         | 0.80  | 85,94 %          |
| Built land       | 71,15 %             | 93,75 %         |       |                  |
| Open field       | 92,33 %             | 60,74 %         |       |                  |
| Crops            | 89,42 %             | 86,67 %         |       |                  |
| Vegetation       | 96,26 %             | 93,38 %         |       |                  |

Table 3. Accuracy level of NDVI Method

| Classification   | Producer’s Accuracy | User’s Accuracy | Kappa | Overall Accuracy |
|------------------|---------------------|-----------------|-------|------------------|
| Water Bodies     | 73,94 %             | 26,86 %         | 0,57  | 69.56 %          |
| Built land       | 84,88 %             | 82,78 %         |       |                  |
| Open field       | 67,37 %             | 20,01 %         |       |                  |
| Crops            | 32,86 %             | 76,15 %         |       |                  |
| Vegetation       | 98,79 %             | 75,37 %         |       |                  |

Table 4. Accuracy level of BI Method

| Classification   | Producer’s Accuracy | User’s Accuracy | Kappa | Overall Accuracy |
|------------------|---------------------|-----------------|-------|------------------|
| Water Bodies     | 73,28 %             | 17,05 %         | 0,52  | 69.17%           |
| Built land       | 70,71 %             | 81,03 %         |       |                  |
| Open field       | 52,83 %             | 21,44 %         |       |                  |
| Crops            | 63,04 %             | 65,13 %         |       |                  |
| Vegetation       | 81,29 %             | 88,54 %         |       |                  |

Accuracy level that produce by maximum likelihood has overall accuracy is 85.94 that means it’s a good result as requirement. Total for NDVI has overall accuracy in moderate 69.56% and also for BI in moderate is 69.17%.

3.4. Comparison of land cover area classification

Result of land cover area classification describe in table 5 and figure 8 as follows.

Table 5. Land cover area classification

| Land cover class | Maximum Likelihood (Ha) | NDVI (Ha) | BSI (Ha) |
|------------------|-------------------------|-----------|----------|
| Water Bodies     | 162,19981               | 100,92425 | 122,4148 |
### Table 1. Area of Classification (Ha)

| Category     | Maximum Likelihood | NDVI Classification | BI Classification | Total   |
|--------------|--------------------|---------------------|-------------------|---------|
| Open Field   | 241,409525         | 586,7817            | 669,5127          | 2591,4618 |
| Built land   | 409,937675         | 804,954175          | 623,0900          | 2591,4618 |
| Crops        | 1188,29205         | 546,304             | 938,7947          | 2591,4618 |
| Vegetation   | 589,6227           | 552,497625          | 237,6497          | 2591,4618 |

**Figure 8.** Area of classification chart

3.5. **Study area validation**
Validation data is used toponym data survey that has nine points. These points will suit by the result of classification for each method. For maximum likelihood has final result for 8 out of 9 is fit well by the field, in NDVI has 4 points that fit well and 5 not fit at all. For BI has 3 fit well to the field and 6 not fit. For the clear describe for this explanation it can be seen at figure 9 as follows.
4. Conclusion
The final results of NDVI and BI classification method has 5 sample of class. They are water bodies, built land, open field, crops, and vegetation. Accuracy test that using maximum likelihood as reference has good accuracy level approximate to 85.94% with kappa coefficient is 0.8.

Accuracy of NDVI method is 69.56% with kappa 0.57 also producer's accuracy is 73.94% water bodies, 84.88% built land, 67.37% open field, 98.79% crops field, and 98.79% vegetation. User's accuracy in a row for each class are 73.94% water bodies, 84.88% built land, 67.37% open field, 98.79% crops field, and 98.79% vegetation.

From that result can be conclude that NDVI is more better than BSI because of validation of BSI not has many fit well to the field in validation data process.

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