Identification of paddy field using Landsat image in Karawang Regency, West Java

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Abstract. The Government of the Republic of Indonesia has a mission to achieve food self-sufficiency in 2017; therefore it is necessary efforts to the stability of food needs. Karawang Regency as a granary states have a vital role in maintaining the national rice self-sufficiency, so indispensable information paddy field area. Paddy field accurate mapping can be done with a fast and efficient method of using remote sensing technology. This study aims to identify the paddy field using remote sensing technology. The data used is Landsat TM 2002 and Landsat-8 2015. The classification method using an approach Normalized Difference Vegetation Index (NDVI) and the Tasseled Cap Transformation (TCT). This method can be implemented to identify the fields that are still green or in the growing season. TCT produces three images of the six combinations, namely Brightness (BRT), greenness (GRN), and wetness (WET). BRT provides graytone gradation of non-vegetation to water. GRN is indicated the gradation of vegetation cover, begin from densely vegetated until the most rare or non-vegetated areas. While wetness (WET) indicates the area associated with the presence of water. The main results of the classification is not a wetland and paddy. Based on existing data paddy land area of research area is ± 57% of the area of Karawang Regency.

1. Introduction
Food is a basic human need for survival and life, food is a central issue for people around the world, including Indonesia. So the human needs to food is a top priority the fulfillment of which cannot be postponed. The government is targeting self-sufficiency in the next two years, there is the possibility of constraints in achieving food sovereignty in the form of climate change, namely the existence of extreme weather such as droughts, floods, landslides, pest / disease with serious consequences to the decline in agricultural production, especially food crops. The conversion of agricultural land into non-agricultural land is currently increasing, and many factors influence the occurrence of land use both internally and externally.

Population growth and increasing infrastructure needs cause the needs of the land will increase also, over the function of agricultural land is the impact of the transformation of economic structures (agriculture to industrial) and demographics (rural to urban areas) which encourage land use change from agriculture to non-farm. In the last ten years, the conversion of the rice fields in central home rice-producing Indonesia i.e. Java Island, an average of more than 22,000 hectares/year [1]. Karawang as one of the highest rice contributor region especially in West Java until the currently still experiencing over the function of agricultural land especially the rice fields. The negative impact of the conversion of the rice fields is declining support national food resilience. Agricultural earnings decline and increasing poverty [2]. To know the over the function of agricultural land is to identify the widespread use of land of each type of land use on a particular year and then compared the next year.
The mapping of agricultural land in this research using the image Landsat TM 2002 and image Landsat-8 2015 using technology Remote Sensing.

Remote sensing is the science of obtaining information about an object, area, or symptoms by analysis of data obtained by using the tool without direct contact to the object, area, or symptoms [3]. Remote sensing data can be obtained through the recording sensors mounted either on aircraft, satellites, space shuttle, or other vehicle. The sensor will produce data that vary according to the location of the height sensor and the characteristics of the object being studied [4]. Remote sensing analysis based on the method of distinguishing an object to other objects using the properties of electromagnetic waves emitted. Sensing for agriculture generally uses light waves visible, near infrared (NIR), and thermal infrared spectral approach to the character of the different vegetation cover which can indicate the condition of land and crops.

Information needs in food security programs associated with the conversion of land need to support rapid technological, informative and inexpensive. Remote sensing technology is a technology that can be utilized in monitoring changes in the use of agricultural land to non-agricultural with basic data with satellite imagery. Landsat image is one type of remote sensing imagery generated from passive systems remote sensing. Landsat TM imageries are widely used for mapping land cover, land use mapping, soil mapping, geological mapping, and mapping of sea surface temperatures. The accuracy of the land cover information will provide convenience in analysing the planning and development of a region. Landsat 8, 2015 in this study is used to identify the current condition of land cover that has a resolution of 30 m and 12 bit pixel, image data can be accessed free of charge, and is an opportunity for utilization as possible.

2. Method

Stage of growth and the size of agricultural land becomes very important for horticultural crops, because the vast canopy of leaves is the variable that is relatively easy to measure that became an indicator of light absorption in plants. In the studies linking the use of the leaf canopy to the need for watering the plants in agricultural areas [5]. Spectral vegetation index calculated from the data visible and near infrared reflectance (NIR), correlate linearly with the number of active radiation absorbed by the canopy of plants during photosynthesis [6].

2.1. Normalized Difference Vegetation Index (NDVI)

Vegetation index is a measure of vegetation greenness value obtained from the digital signal processing brightness value data (brightness) some channels satellite sensors. The absorption of red light by chlorophyll and reflectance of infrared light close by mesophyll tissue in the leaves will make brightness values received satellite sensors through the canals will be much different. On land without vegetation, including territorial waters and residential, vacant land is open or damaged vegetation conditions, cannot provide high-value ratio on a comparison of the value of these canals. And contrary to the mainland by dense vegetation and healthy conditions, comparisons of both channels provide a very high value (maximum). In mainland non-vegetation, including territorial waters, residential, vacant land is open, and areas with vegetation damaged condition, it will not show the value of a high ratio (minimum).

Vegetation index most commonly used is the Normalized Difference Vegetation Index (NDVI). The vegetation index value based on the difference between the maximum absorption of radiation in the red channel (red) as a result of the pigment chlorophyll and maximum reflectance in the near infrared spectral channels (near infra-red / NIR) as a result of the cellular structure of the leaves [7].

The NDVI formulation is as follows:

$$NDVI = (\rho_{NIR} - \rho_{Red}) : (\rho_{NIR} + \rho_{Red})$$  \hspace{1cm} (1)
Where:
\[ \rho_{NIR} = \text{reflectance value canal near infrared} \]
\[ \rho_{Red} = \text{reflectance value of the red channel} \]

2.2. Tasseled Cap Transformation (TCT)

Tasseled Cap Transformation (TCT) is a mathematical formula to calculate the brightness level (brightness), greenness (greenness), and moisture (wetness) of digital numbers in each band (band 1 to band 5 and band 7) on Landsat imagery. TCT was first introduced of the Landsat MSS, TCT subsequently refined using data from Landsat TM. That the values in the TCT ie Brightness, greenness, and wetness can be used to analyze the drought, and the bands that influence the growth phases of rice, among others, are blue, green, red, and Near-Infra Red (NON). The calculation of the level of greenness with TCT method can only be applied by the Landsat satellite data only. Vegetation index is a quantitative calculation that is used to calculate the biomass or vegetation conditions. Generally made by using a combination of several spectral bands.

Mathematical formulation third components TCT are expressed in the following three equations for Landsat 8:

\[
\text{Brightness} = B2 \times 0.3029 + B3 \times 0.2786 + B4 \times 0.4733 + B5 \times 0.5599 + B6 \times 0.508 + B7 \times 0.1872
\]

\[
\text{Greenness} = B2 \times 0.2941 + B3 \times -0.243 + B4 \times -0.5424 + B5 \times 0.7276 + B6 \times 0.0713 + B7 \times -0.1608
\]

\[
\text{Wetness} = B2 \times 0.1511 + B3 \times 0.1973 + B4 \times 0.3283 + B5 \times 0.3407 + B6 \times -0.7117 + B7 \times -0.4559
\]

where \( B1 = \text{Band1}, B2= \text{Band2}, B3= \text{Band3}, B4= \text{Band4}, B5= \text{Band5}, B6= \text{Band6}, B7= \text{Band7} \) [8].

Overhead perspective, using electromagnetic radiation in a few parts of the electromagnetic spectrum that is reflected or emitted from the earth’s surface, the technology is able to generate information on the growth stage of rice plants by reflectance (reflection) electromagnetic waves generated. The growth phase of rice based International Rice Research Institute (IRRI) is divided into nine phases, whose determination requires a model of appropriate classifier to produce a high degree of accuracy [9].

Satellite Landsat-8 has a sensor Onboard Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) with the number of channels as many as 11 pieces. Among these channels, 9 channels (bands 1-9) are in the OLI and the other 2 (bands 10 and 11) on TIRS. Most channels have specifications similar to Landsat-7 [10]. Date acquired October 18, 2015. Target_WRS_PATH 122 and target_WRS_ROW 64. Date acquired Landsat-7 December 22, 2001. Here’s the specs channels owned by the Landsat-8 are as follows table 1.

| Table 1. Specifications spectral sensor canals imagers LDCM (Landsat-8) |
|--------------------------|------------------|-----------------|-----------------|
| Sensor                  | Band             | Wavelength (µm) | Resolution (meter) | Sensor             |
| 1. Operational Land Imager (OLI) | Band 1           | 0.43 - 0.45     | 30               | Visible (Coastal aerosol) |
|                         | Band 2           | 0.45 - 0.51     | 30               | Visible (Blue)     |
|                         | Band 3           | 0.53 - 0.59     | 30               | Visible (Green)    |
|                         | Band 4           | 0.64 - 0.67     | 30               | Visible Red (Red)  |
|                         | Band 5           | 0.85 - 0.88     | 30               | Near Infrared      |
|                         | Band 6           | 1.57 - 1.65     | 30               | SWIR 1             |
|                         | Band 7           | 2.11 - 2.29     | 30               | SWIR 2             |
3. Result and discussion

Based on the results of this analysis also shows that the minimum and maximum values of NDVI in rice fields is lower than all the study sites. This is because the water will cover lowest NDVI values, whereas the vegetative phase in rice fields have NDVI values lower than the forest cover. Chlorophyll will absorb more light in the visible spectrum, especially the red spectrum (band 3) i.e. in a wavelength range of 0.63 to 0.690 microns. Therefore land with healthy plant will have a value of spectral band 3 which is lower than the land areas experiencing drought. In normal land spectral values that are in band 4 which has a wavelength range from 0.76 to 0.90 (near infrared) has a high sensitivity to the plant canopy, but not too sensitive to water. It is therefore more appropriate band 4 is used to identify vegetated land and open land and vegetation less able to reflect drought conditions. For dry land characterized by chlorophyll leaves dry and damaged / dead, were analyzed in band 5 (mid infra-red) wavelength range from 1.55 to 1.75 micron. Band 5 sensitive to the water content in the plant that will reflect the higher spectral dry plant (drought). Band 4 (near infra-red) has a high sensitivity to the plant canopy, but not too sensitive to water.

Colour composite composed of Landsat NDVI statistical value gives the appearance of a green color that contrasts indicating as paddy fields, paddy fields look very different than non paddy area. NDVI value in rice fields will follow a phase change (fallow, water and vegetation), wherein the water phase NDVI value would be very low, in the vegetative phase ranges from low to high. In the area of non-paddy changes in the value of NDVI is generally not too big, although NDVI vegetative be greater than NDVI vegetative rice. Cover water while the negative NDVI vegetation cover will reach its lowest NDVI if in an open condition.

| Band | Wavelength Range | Sensitivity |
|------|------------------|-------------|
| Band 3 | 0.63 - 0.690 | Spectral band 3 |
| Band 4 | 0.76 - 0.90 | Near infrared |
| Band 5 | 1.55 - 1.75 | Mid infra-red |

Table 2. NDVI Landsat-8

| NDVI value | Cover area |
|------------|------------|
| 23 – 57    | Wetland    |
| 99 – 124   | Settlement |
| 185 – 255  | Paddy filed|
| 230 – 237  | Forest     |

The research area is one of the districts in West Java who experienced conversion of agricultural land to non-agricultural (roads, settlements, industry, etc.). Since 1989 there were approximately 2,502 ha of land switch functions are 54% for industry and 36% for housing (Department of Agriculture). The results of the analysis of the largest agricultural land-use transitions occurred in the Cikampek District that many have compared to the industrial areas of agricultural land. Changes in land use may occur because of changes in spatial plans and change of policy direction and development as well as market mechanisms. The last two things happen more often in the past due to lack of understanding of the community and government officials regarding spatial. The transformation from agriculture to non-agriculture was widespread in line with the development policy that emphasizes the aspects of amenity growth through investment, both to local and overseas investors in the provision of land.
3.1. Land use in 2002
Land use types used consists of 5 that is wetlands, settlements, dry land, water bodies (swamp, pond), and paddy field. Total is the largest area are paddy fields. Dry land has an area of 28,704 hectares or 14.9% of the total land area. The land area that is both comprehensive settlement which has 7,504 hectares or 3.8% of the land area. Then the paddy fields with an area of 116,054 hectares, or 60.3%, while for the water bodies (pond) have extensive percentage 23,496 with 3.8%, other area 17,226 hectares of the total land area in the Landsat images have been classified.

3.2. Integration NDVI and TCT for identification of drought
Use of TCT and NDVI has been done in the later study applied to map drought in the Citarum River Basin and the northern coast of West Java Province [11]. In assessing the level of dryness, TCT analysis is divided into five classes humidity of land as presented in table 3 and analysis of NDVI which produces plant greenness level 5 class in table 4.

| Class | TCT value | water content % | moisture  |
|-------|-----------|-----------------|-----------|
| 1     | -295 - -30 | <5%             | very dry  |
| 2     | -30 - -13  | 5 - 20          | dry       |
| 3     | -13 - 10   | 20 - 70         | moist     |
| 4     | 10 - 35    | 70 - 100        | very moist|
| 5     | 35 -       | >100            | stagnant  |

Source: Wahyunto et al. (2003).

| Class | NDVI value | Level greenish / land cover conditions |
|-------|------------|---------------------------------------|
| 1     | < -0.03    | Land is not vegetated                 |
| 2     | -0.03 - 0.15 | The greenery is very low           |
| 3     | 0.15 - 0.25 | low greenish                         |
| 4     | 0.26 - 0.35 | The greenery was                     |
| 5     | 0.36 - 0.61 | high greenery                        |

Source: Wahyunto et al. (2003).

NDVI value analysis to identify plants experience drought conditions, in addition to visual analysis can use any combination of bands sensitive to vegetation and water. NDVI has a value of -1 to 1 whereas a negative value describes the conditions of open ground and greenery is low, the value of 1 is the high land with greenery. Use of the method of integration is the use of a single analysis using only the NDVI or TCT cannot be used to determine crop drought conditions. The results of the analysis of NDVI or TCT has the same appearance at a different plant drought conditions that need to be done integration by combining the value of greenness (NDVI) and surface moisture (TCT). Integration of greenness and moisture level of the land surface can be made that the land does not have a greenish vegetation and very low humidity that has a very low surface area categorized as experiencing severe drought. In contrast, no vegetated land but has a high moisture classified as land is not dry or watery (figure 1).

3.3. Spectral analysis of plant condition
Analysis of spectral patterns of soil conditions can be briefly described in figure 1. The analysis of Landsat satellite data Colour composite image with RGB composition TCB (Tasseled Cap Brightness) -NDVI (vegetation index) -TCW (Tasseled Cap Wetness), giving the appearance of the object is not vegetated red, green in areas with vegetation, and blue or dark the appearance of water or wet objects [11]. Gradation of redness depending on the level of vegetation and water shortages, more and more
red tone sparse vegetation, as well as in the more dense vegetation NDVI increasingly green, and for TCW getting increasingly wet blue or the deeper the colour.

**Figure 1.** Composite image Landsat-8

3.4. Land use in 2015

Land use types used consists of 5 land use that is that is wetlands, settlements, dry land, water bodies (swamp, pond), paddy field. Total is the largest area paddy fields. Dry land has an area of 30,934 hectares or 16.1% of the total land area. The land area that is both comprehensive settlement which has 4,241 hectares or 2.2% of the land area. Then the paddy fields with an area of 112,878 hectares, or 58.7%, while for the water bodies have extensive percented 25,180 with 13.1% and other area 19,051 hectares with 9.0% of the total land area in the Landsat 8 images have been classified figure.2.

**Figure 2.** Landuse image Landsat-8
4. Conclusions
Remote sensing data on wave spectrum of visible light, near infrared, and thermal can be used to identify, assess, and monitor wetland. Analysis of soil surface moisture (wetness) using TCT (Tasseled Cap Transformation) and analysis of the level of greenness of plants using NDVI (Normalized Difference Vegetation Index) can be used to map the condition of agricultural land. TCW (Tasseled Cap Wetness) effectively used for monitoring the condition of the paddy fields. To enhance the interpretation of the results, the identification and classification of wetland, carried out the integration of two or more methods of analysis, because it can complement the advantages and disadvantages of each.

Identification of wetland by using remote sensing technology can help provide a comprehensive picture of the condition and the spatial distribution of wetland in the region. Wetland of Landsat TM rice cultivation area covers 60.3% of Karawang Regency, Landsat 8 2015 showed a decrease of acreage of paddy be 58.7%. The information obtained can be used to determine management measures in keeping with the food security in the Karawang Regency.

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