The potential of agricultural drought according to brightness and wetness index on Kebumen district

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Abstract. Drought is a phenomenon resulting irrelevancy or climate in General as a lack of rainfall in the area. Droughts also impact on the surface layer of the soil where the moisture content required to balance organic matter, soil biota, as well as the survival of vegetation. Its categorized by NOAA as drought farms/land. This research is finding potentially soil drought spatially and measured trough index algorithm with wetness and brightness index made by Jensen in Chen (2014) in the District of Kebumen, to see the condition of the organic matter and soil moisture as well as indicators of soil drought by 2015, as well as linked with meteorological drought by the method of standardized precipitation index (SPI) (30 years of rainfall data) statistically. Both the index (wetness and brightness) are calculated on the data of satellite imagery. The results say rain-fed rice land, pasture and moorland is tend to drier that average on months (February, June and December 2015). Those land use become vulnerable to agricultural drought when dry season occur.

Keywords: Wetness index, brightness index, Kebumen district, agricultural drought

1. Introduction
Indonesia is located in tropical zone and lie between Pacific Ocean and Indian Ocean, which is allows to be impacted either by positive Indian Ocean Dipole (IOD +) or La Nina. Both of them will make distortion on climate in Indonesia, particularly on amount of rainfall and duration of rainy season because of high temperature wind is carried from east Pacific Ocean [1]. Those distortion eventually cause drought, both IOD + and La Nina will increase duration of dry season or drought. Drought generally interpreted as a condition where a lack of rainfall in some area. Drought always gives negative impact to human activity such as water availability either for crops or other water usage [2].

The impact of drought becomes important thing in Kebumen district, because Kebumen have more than 60 % area is used as crops and affected by drought every year in 20 % of Kebumen area affected by drought. Drought gives impact to crop from depression on crop production to crop failure. Furthermore, crop itself giving an impact to soil organic matter because it consumes a lot of organic matter on top of soil. Organic matter is increasing infiltration rate, soil moisture capacity, and water binding capacity on the top of soil, which is helping soil to maintain amount of water [3]. Otherwise, in the crop field the organic matter will consumed and decrease. On that condition soil will risky to loss amount of water and vegetation on top of soil will stress, like agricultural drought that described by National Oceanic and Atmospheric Administration (NOAA) [4]. That condition make Kebumen District need to spatially detect through the organic matter and soil moisture to see actual agricultural drought.
Furthermore, the tendency of agricultural drought by the land use classification will show which land use is potentially having agricultural drought in the future. The result will give an insight about which land use needs some intervention when dry season come in terms of organic matter. In addition, it will give some unique viewpoint to drought topic in scientific research.

2. Method
Agricultural drought is traced through soil organic matter and soil moisture. Both of that variable try to be looked through image data processing or algorithm. Jensen on Chen [5] have made a calculation for organic matter and soil moisture by utilizing image using remote sensing. It interpreted by its color and will show the soil organic matter and soil moisture condition from brightness index and wetness index. Jensen on Chen [5] said that brightness index calculation will give a image result which contain organic matter value. The higher the brightness index means soil get brighter color and the less organic matter there. Wetness index will give a image result contain soil moisture value. The higher the wetness index means the more amount of water on soil. In this research image processed by using Landsat OLI on multi-temporal that is on February, June and December 2015.

Image data processing on this research using Landsat OLI calculation of it spectral values from brightness index and wetness index algorithms that made by Jensen and modified by Chen:

\[
\text{wetness index} = (0.1509 \text{ Band2}) + (0.1973 \text{ Band3}) + (0.3279 \text{ Band4}) + (0.3406 \text{ Band5}) \\
- (0.07112 \text{ Band6}) - (0.4572 \text{ Band7})
\]

\[
\text{brightness Index} = 0.3037 \text{ Band2} + (0.2793 \text{ Band3}) + (0.4743 \text{ Band4}) + (0.5585 \text{ Band5}) \\
+ (0.5082 \text{ Band6}) + (0.1863 \text{ Band7})
\]

Spectral values (index) are classified by unsupervised method on remote sensing application become five class of each index. The result is raster (image) data will transform into vector to simplify the next process, that is overlay method. And then, the result of wetness index and brightness index are overlaid to generate agricultural drought condition in vector (shapefile) data, in the same time satellite image shooting. The map of agricultural drought will be classified in five class, that is wet, mild drought, moderate drought, severe drought and extreme drought.

Agricultural drought conditions seen by it tendency on each unit land use to see which land use is risk. The process will generate land use what potentially agricultural drought. The output of this research is actual condition of agricultural drought on each month (February, June and December) and kind of land use potential that agricultural drought occurs.

3. Results and discussion
3.1. Agricultural drought
Based on the results of image processing Landsat OLI February, June and December of 2015 by applying wetness index and brightness index, spectral values derived or digital number with the value of the standard deviation that is quite large, ranging from 6.884 to 1.259 on DN dimension (digital number) (table 1). This shows that the average distance deviation of each data value against its average variation is large enough. In a nutshell is the spectral value data or vary widely. The average value of each index variation with time also has a brief overview of the indicators are represented. The average value of lowest wetness index is in June, representing the lowest level of soil moisture in between months. In a nutshell is the spectral value data or vary widely. The average value of each index variation with time also has a brief overview of the indicators are represented. The average value of lowest wetness index is in June, representing the lowest level of soil moisture in between months. The average value of most high brightness index there in December, representing the highest brightness level ground there in December, or organic content of low, but get the higher wetness index value.
The condition of the surface of the ground (agricultural drought) in all of three month has a pattern spreading from central to north, on the west and from central to south with moderate and severe drought classes there (figure 1). The central area is the most wet area with mild drought and wet class is the most there. The map below is the example of agricultural drought condition on December for an image of explanation above.

3.2. Agricultural drought on land use units
The results of overlaid between agricultural drought and land use map from the third month above can be drawn the conclusion against the pattern tendency of soil drought conditions each unit land use. There are three different conditions if seen from the viewpoint of the difference of the general condition of soil drought area of research. The first is a condition that is likely to be the same as the general condition, second wetter, and third drier. The conditions that tend to be the same as the general condition (pattern) of the research area is found on forest land use, horticulture and shrubs. Because the condition is dominate by moderate drought and followed with mild drought (green and yellow highlight) (table 2, table 3 and table 4) just like the domination of Kebumen district on February by moderate drought and mild drought (figure 2). Agricultural drought conditions are wetter than the general conditions contained on the rice paddy irrigation land use, cause its dominated by mild drought (table 2, table 3 and table 4).

Table 1. Digital number of wetness and brightness index on District of Kebumen 2015.

| Digital number | Min     | Max     | Average | Standard deviation |
|----------------|---------|---------|---------|--------------------|
| February (Wetness) | -31.034 | 14.005  | 275     | 1.259              |
| February (Brightness) | 14.142  | 99.514  | 24.921  | 3.929              |
| June (Wetness)      | -24.214 | 17.539  | -120    | 1.365              |
| June (Brightness)   | 14.193  | 104.690 | 23.477  | 5.862              |
| December (Wetness)  | -22.123 | 15.561  | 909     | 1436               |
| December (Brightness)| 14.919  | 113.003 | 26.119  | 6.884              |

Figure 1. Agricultural drought map in December 2015 on Kebumen district.
The last kind of the land use that has agricultural drought conditions tends to be drier than the general condition is meadow, moorland, rain-fed rice field cause its dominated by severe drought and moderate drought (table 2, table 3 and table 4). In this case when we go back to the theory then it can be said that each land use has different response against external conditions, such as rainfall and provide and giving different respond.

Table 2. Area of agricultural drought by land use unit February 2015 Kebumen district (km²).

| Land use   | Wet | Mild drought | Moderate drought | Severe drought | Extreme drought | Total |
|------------|-----|--------------|------------------|---------------|----------------|-------|
| Forest     | 0.02| 3.42         | 3.45             | 1.32          | 0.13           | 8.35  |
| Meadow     | 0.11| 0.99         | 2.46             | 2.89          | 0.34           | 6.79  |
| Horticulture | 2.30| 116.75       | 170.57           | 55.24         | 3.65           | 348.50|
| Irrigated Rice Field | 2.21| 226.72       | 105.45           | 24.19         | 4.84           | 363.41|
| Rain-fed Rice Field | 0.87| 19.33        | 50.74            | 28.61         | 2.56           | 102.11|
| Shrubs     | 0.37| 11.53        | 21.41            | 9.55          | 0.51           | 43.38 |
| Moorland   | 0.94| 21.33        | 57.62            | 51.60         | 4.62           | 136.11|
| Total      | 6.83| 400.07       | 411.70           | 173.41        | 16.64          | 1008.65|

Table 3. Area of agricultural drought by land use unit June 2015 Kebumen district (km²).

| Land use   | Wet | Mild drought | Moderate drought | Severe drought | Extreme drought | Total |
|------------|-----|--------------|------------------|---------------|----------------|-------|
| Forest     | 0.53| 5.23         | 2.14             | 0.42          | 0.03           | 8.35  |
| Meadow     | 0.25| 0.91         | 2.64             | 2.95          | 0.04           | 6.79  |
| Horticulture | 17.47| 147.87      | 136.86           | 40.96         | 5.34           | 348.50|
| Irrigated Rice Field | 11.01| 165.39      | 137.70           | 45.34         | 3.98           | 363.41|
| Rain-fed Rice Field | 1.53| 9.22         | 31.92            | 57.38         | 2.08           | 102.11|
| Shrubs     | 3.15| 13.67        | 15.76            | 8.74          | 2.06           | 43.38 |
| Moorland   | 4.17| 27.23        | 54.84            | 48.45         | 1.42           | 136.11|
| Total      | 38.11| 369.51       | 381.85           | 204.24        | 14.95          | 1008.65|

Table 4. Area of agricultural drought by land use unit December 2015 Kebumen district (km²).

| Land use   | Wet | Mild drought | Moderate drought | Severe drought | Extreme drought | Total |
|------------|-----|--------------|------------------|---------------|----------------|-------|
| Forest     | 0.53| 5.23         | 2.14             | 0.42          | 0.03           | 8.35  |
| Meadow     | 0.25| 0.91         | 2.64             | 2.95          | 0.04           | 6.79  |
| Horticulture | 17.47| 147.87      | 136.86           | 40.96         | 5.34           | 348.50|
| Irrigated Rice Field | 11.01| 165.39      | 137.70           | 45.34         | 3.98           | 363.41|
| Rain-fed Rice Field | 1.53| 9.22         | 31.92            | 57.38         | 2.08           | 102.11|
| Shrubs     | 3.15| 13.67        | 15.76            | 8.74          | 2.06           | 43.38 |
| Moorland   | 4.17| 27.23        | 54.84            | 48.45         | 1.42           | 136.11|
| Total      | 38.11| 369.51       | 381.85           | 204.24        | 14.95          | 1008.65|
Land use or vegetation above the soil have a role to absorb the rain fall, if it’s not the water become a runoff. The more wasted rainfall because of runoff will make soil surface become easily saturated, and then will hard to keep balance of mass of water [3]. On grassland, moor land and rain-fed rice field which is drier than the general condition is because lack of soil organic matter that have a role to maintain the water on the surface. Furthermore, for moorland and rain-fed rice field the activity of vegetation is consume a lot of soil organic matter.

On the other hand, on both of condition that is more likely and wetter than general condition, like forest, the soil is gets a steady supply of good primary sources or secondary sources. Primary source is a network of organic crops, such as leaves, twigs, branches, stem, root and fruit falling straight down the ground and decomposes organic elements that can stabilize the soil. Organic sources of supply on the use of land above can maintain the stability of organic items when affected by external factors such as a lack of rainfall. In other case, on irrigated rice field, the soil is always irrigated, and it maintain the mass of water on the surface of soil. That make the organic matter and soil biota can sustain their existing. Because Sanchez [6] said organic matter in tropical regions play a role it provides nutrient elements are released slowly, increasing the cation exchange capacity, lower fixation P because the diffraction by fixation side of organic radicals, helps solidify the soil aggregate, modify the retention of water and forms a complex with the micro elements. That’s why irrigated rice field have a wet topsoil condition, which is sustainable too.

4. Conclusion
Agricultural drought conditions are found on the highest ground on land use rain-fed rice fields, meadow and moorland. Forest, horticulture and shrubs is at a normal level or equal to soil drought conditions in Kebumen district. Agricultural drought conditions the lowest land is found in the irrigated rice field land use. The third of these conditions has the distinction of the influence of each land use against organic content of soil moisture and water resistance. The tendency of conditions in February, June and December, said the use of land that could potentially experience dryness of land is rain-fed rice field, meadow and moorland/fields. Thus, those land use need some intervention in terms of soil matter to mitigate rainfall deficit. Especially for rain-fed rice field and moorland that consume organic matter itself and will affect regional income.

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