TRMM 3B43 RAIN DATA INFORMATION IN DETERMINING LONG WET AND DRY PERIODS IN FARMING BUSINESS IN MOONSON AREA

Rusmayadi GUSTI*
Faculty of Agriculture, Banjarbaru Lambung Mangkurat University, Indonesia

Noor Riza Arian
Syamsuddin Noor Banjarbaru Airport Meteorological, Climatology, and Geophysical Agency, Indonesia

Ruslan Muhammad
Facult of Forestry, Banjarbaru Lambung Mangkurat University, Indonesia

*E-mail: gustirusmayadi@gmail.com

ABSTRACT
Based on the observation towards climate station in several agriculture production centers, there is an increase temperature. Temperature rise due to greenhouse effect is very clearly visible, e.g., in Banjarbaru Indonesian Agency of Meteorological, Climatology, and Geophysics (BMKG), misai di stasiun BMKG Banjarbaru, Banjarmasin Sei Tabuk Special Farm Meteorology Station (SMPK), and South Kalimantan Kotabaru BMKG. This temperature rise impacted to plant’s respiration increase that led to the reduction of photosynthesis result. Adaptation strategy with plants water balance analysis to determine the correct planting time and surplus period and water deficit, in various growth phases, is one of water permanent strategic measures to know water sufficiency in the field. Material used in this research is TRMM from 3B43 type in the form of grid with monthly temporal resolution and spatial resolution 0.25° x 0.25° with data from 1998 – 2015 period. Data format in the form of binary from ftp://disc2.nascom.nasa.gov/data/TRMM/Gridded/3B43_V7. Reanalysis surface temperature data is grid data from European Centre for Middle-Range Weather Forecasts (ECMWF) from 1998 -2015 period in netcdf format. Water balance analysis used Thornthwaite and Mather (1957) method. Water balance analysis shown groundwater in sufficient category (>60%) happens during November – July period, meanwhile water surplus happens during December – June period. Whereas during August – October period is in less period (<40%). This information can be used in the formulation of one season planting pattern both in wet or dry field.

KEY WORDS
TRMM, water balance analysis, surplus, deficit, rainy season, dry season.

Since 1980s, it is predicted that the global warming has become reality, like what happened to several research results related directly with global and local climate change or climate aberrations. Based on the observation towards severa climate stations in several agriculture centers, it shows that there is temperature rise. Temperature rise due to greenhouse effect is very clearly visible, e.g., in Banjarbaru BMKG, Banjarmasin Sei Tabuk SMPK, and South Kalimantan Kotabaru BMKG. This temperature rise resulted in the increase of plant’s respiration that led to photosynthesis result reduction.

Yonny et al. (1999) who stated that the most important impact of climate change is not in gradual warming but instead in the occurrence of extreme, e.g., long drought, thunder storm, flood, or landslide with rising frequency and magnitude. The meteorology researchers in CNRM believe that the rising rainfall quantity is the impact of temperature rise that will trigger water loss in the form of evaporation.

Anticipative measure towards climate change and its impact, analysis towards climate parameter in various observation scales must be improved, especially the one related with
the ability of weather forecast. The ability upgrade for accurate weather forecast can be conducted up to the poured water volume and availability and storing in ground for certain length of countable time. Therefore correct planting time can be predicted to anticipate extreme climate change, and able to give information or early warning to farmer communities on drought and flood. If rain characteristics or rainfall in certain place in the future is unknown, then the conducted analysis can only be rain evaluation.

Technology development in remote sensing, e.g., satellite and radar, rainfall measuring conducted by that technology until enabling it for rainfall observation in large areas even area that unreachable by conventional equipment. The advantages of remote sensing should be utilized further to learn weather and climate in an area for the interest of water resource management and it’s utilization for society welfare (Syaifullah, 2014). Especially for tropical area, at the moment there is remote sensing equipment that able to conduct rainfall measurement mission in tropical area by Tropical Rainfall Measurement Mission (TRMM) satellite. TRRM satellite can measure rainfall intensity from three hours, daily, to monthly scale.

Climate information is highly needed in disaster mitigation as a reference in policy making. Climate information advantages in agriculture are the availability of ground water for plants. Based on the capability to conduct climate analysis both in macro or micro scale able to generate product that can be used to support prospective farming and highly competitive farming, e.g., through plants water balance analysis to determine the correct planting time and water surplus and deficit period in various growth phase.

Based on the explained background, the formulation of the research problem is how to utilize TRMM satellite for agroclimate zonation based on water balance analysis? The scope of problem are (1) Research study area is South Kalimantan, (2) TRMM Satellite data used is TRMM 3b43 data which is monthly rainfall estimation data with spatial resolution 0.25 x 0.25 degree, and (3) field water balance calculation based on Thornthwaite and Mather method. Field Capacity Value (KL) and Permanent Wilting Point (TLP) based on field water balance technical guide from BMKG. This research purpose is to make agroclimate zonation based on field water balance based on TRMM satellite data in South Kalimantan.

**METHODS OF RESEARCH**

This research is conducted in South Kalimantan Province which is located between 1°20' S – 4°10' S and 114°19'E - 116°33'E. The research is conducted in six months from March to August 2016. For research location and rain observation post in South Kalimantan can be viewed in detail in Graphic 1.


Research Procedure. The stages in this research are:


2. TRMM Satellite Data Extraction. Binary format of TRMM Satellite Data extracted to certain grid (research domain area) by using GRADS software. Next data binary converted into numerical data with Matlab software. Data from conversion result compiled as monthly data serios from 1998 to 2015.

3. TRRM Satellite Rainfall Data and Surface Rainfall Data Validation. TRRM rainfall data and surface rainfall data validation applied correlation analysis (r). Correlation coefficient calculated by using equation (Wilks, 1995):

\[
\hat{r}_{\hat{Y}} = \frac{\sum_{i=1}^{n}(Y_i - \bar{Y})(\hat{Y}_i - \hat{\bar{Y}})}{\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2 \sum_{i=1}^{n}(\hat{Y}_i - \hat{\bar{Y}})^2}}
\]
Where: \( r_{\hat{Y}, \hat{Y}} \) = correlation coefficient between TRMM satellite data with surface observation rainfall data; \( Y_i \) = TRMM satellite data in data satelit TRMM in \( i \) period with \( i = 1, 2, \ldots, n \); \( \bar{Y} \) = average TRMM satellite data values; \( \hat{Y}_i \) = observation rainfall data in \( i \) period with \( i = 1, 2, \ldots, n \); \( \bar{Y} \) = observation rainfall average value; \( n \) = period length.

Water balance analysis stages are:

- ECMWF reanalysis surface temperature data extraction on set grid.
- Calculating Potential Evapotranspiration (ETP) value by using Thornthwaite and Mather method (1957).
- Calculating ground water availability with this equation:

\[
\text{Ground water availability (ATI)} = \frac{K\text{AT} - TLP}{KL - TLP} \times 100\%
\]

Where: KAT= ground water level; TLP = permanent wilting point; KL = field capacity and available water.

What categorized into three parts are:
- Lack, if ground water availability < 40%;
- Medium, if ground water availability 40% - 60%;
- Sufficient, if ground water availability > 60%.

A month experience rainy season rainfall ratio (CH) and ETP of related month has value > 0.75. Dry season happen when the ratio of Deficit (D) and ETP of related month has value > 0.5, meanwhile if the ratio is between 0 – 0.5 then it is called transition season or time.

This research procedure flow is presented in Graphic 2.
RESULTS AND DISCUSSION

**TRRM Satellite Data Validation and Surface Rainfall Data.** TRRM data and surface rainfall data validation in this research is conducted by taking 13 rainfall observation spots sample and the distribution of data representing all research areas. Rainfall data samples taken are adjusted with TRRM grid data. Relation level of those two data is analysed with (r) correlation value.

<table>
<thead>
<tr>
<th>No</th>
<th>Observation Spots</th>
<th>f_count</th>
<th>Monthly Series</th>
<th>P_value</th>
<th>f_count</th>
<th>Monthly Average</th>
<th>RMSE</th>
<th>P_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Banjarbaru</td>
<td>0.86</td>
<td>67.70</td>
<td>0.00</td>
<td>0.99</td>
<td>19.46</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Muara Uya</td>
<td>0.79</td>
<td>86.70</td>
<td>0.00</td>
<td>0.97</td>
<td>43.78</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sei. Pandan</td>
<td>0.75</td>
<td>93.60</td>
<td>0.00</td>
<td>0.99</td>
<td>41.90</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Marabahan</td>
<td>0.78</td>
<td>115.20</td>
<td>0.00</td>
<td>0.99</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Stagen</td>
<td>0.80</td>
<td>86.10</td>
<td>0.00</td>
<td>0.94</td>
<td>21.35</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sei Raya SMPK</td>
<td>0.79</td>
<td>77.90</td>
<td>0.00</td>
<td>0.97</td>
<td>23.17</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Batu Mandi</td>
<td>0.74</td>
<td>80.08</td>
<td>0.00</td>
<td>0.97</td>
<td>27.68</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Hambawang Beach</td>
<td>0.80</td>
<td>84.40</td>
<td>0.00</td>
<td>0.98</td>
<td>22.08</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Simpur</td>
<td>0.73</td>
<td>77.60</td>
<td>0.00</td>
<td>0.97</td>
<td>19.49</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Simpang Empat</td>
<td>0.82</td>
<td>94.20</td>
<td>0.00</td>
<td>0.97</td>
<td>26.29</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Sungai Tabuk</td>
<td>0.81</td>
<td>84.30</td>
<td>0.00</td>
<td>0.98</td>
<td>30.22</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Tambang Ulang</td>
<td>0.85</td>
<td>86.90</td>
<td>0.00</td>
<td>0.99</td>
<td>23.95</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Cindai Alas Selatan</td>
<td>0.80</td>
<td>100.30</td>
<td>0.00</td>
<td>0.92</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.79</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TRRM satellite monthly data and surface rainfall data series \((r)\) correlation value has good correlation between 0.73 - 0.86 with sample overall correlation average value as much as 0.78. Calculation Result of correlation value and TRRM satellite rainfall and surface rainfall pattern comparison shows that TRMM highly capable to be used as surface rainfall data which is indicated by strong correlation value. \(r\) Value in calculation result table can also be viewed in the following graphic:

Graphic 3 – TRRM Satellite Data Series and Sei Tabuk SMPK Surface Rainfall Graphic

**South Kalimantan Area Water Balance Analysis.** Based on TRRM 3B43 satellite data and reanalysis temperature data on every set grid spot analysis and field water balance calculation as illustrated by Graphic 4 is conducted. The graphic shows water surplus and deficit grid spot 92 (Sei Tabuk, Banjar Regency 3.33 °S and 114.68°E). Water surplus period happen during five months, i.e., December to April, meanwhile water deficit period happen during six months, i.e., May to September.

Since November \(CH > ETP\) but water surplus or deficit condition is the same with 0 (zero), this shows that rain water surplus condition is utilized to fill groundwater availability through infiltration and the rest of it released in the surface. Water surplus condition happened if ground water condition has become saturated or reached field capacity. Water surplus period can be optimized for rain fed agriculture and stock water storage in the form of irrigation making or retention basin building for dry season period. In wet field, last month surplus, April started rice seedlings plantation in the field (transplanting).

Field Water Balance in December, January, and February (DJF). Ground water availability level analysis in South Kalimantan in December, January, and February, shows
general sufficient condition. The area in less and medium water availability consisted of Kotabaru regency’s Laut Island. Water balance analysis in this month shows general water sufficiency except some areas of Laut Island (Kotabaru Regency) which still suffer from water deficit. Water surplus area with 50 – 100 mm value consisted of Tabalong Regency Tabalong, Balangan, Hulu Sungai Utara, Hulu Sungai Tengah, Hulu Sungai Selatan, Tapin, Northern Barito Kuala and Northern part of Banjar Regency. Water surplus with 25 – 50 mm values consisted of Tanah Laut regency, Tanah Bumbu and northern part of Kotabaru.

Ground water availability level analysis in South Kalimantan in July has started to varied from less to sufficient category. Water availability in less category shown with red colored legend with percentage < 40% consisted of Barito Kuala regency, Banjarmasin, western part of Banjarbaru, western part of Banjar Regency, western part of Tapin Regency, nad western part of Hulu Sungai Selatan. The variety of ground water availability in July shown from "less" category to highly varied from West to East. Areas with sufficient ground water consisted of Tabalong regency, Tanah Bumbu, Kotabaru, some parts of eastern part of Tanah Laut and some parts of eastern side of Banjar.  

Field water balance analysis in June, July, and August (JJA). Water deficit has extended to almost to entire areas of South Kalimantan with values around 1 – 25 mm. Water deficit is around 50 – 100 mm comprised of southern part of Barito Kuala and Banjarmasin. Water deficit with values of 20 – 50 mm comprised of Hulu Sungai Utara, western part of Hulu Sungai Selatan, western part of Tapin, western part of Banjar regency, western part of Tanah Laut coast, Banjarbaru and Barito Kuala. Groundwater availability and water balance volume is varied from west to east.

Based on South Kalimantan area water balance spatial analysis the groundwater availability period is in sufficient category (> 60%) berkisar 5 – 9 bulan, meanwhile water surplus period is around 4 – 7 months. In detail, ground water availability level period is in sufficient period and water surplus period in South Kalimantan in tabulation for each regency shown in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>Regency / City</th>
<th>Water Availability (&gt;60%)</th>
<th>Water Surplus</th>
<th>Rainy Season Period (CH/ETP)</th>
<th>Dry Season Period (D/ETP)</th>
<th>Transition Period (D/ETP) &lt;0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tabalong Regency</td>
<td>8 – 9 months</td>
<td>6 months</td>
<td>Nov-Jun</td>
<td>0</td>
<td>Jun-Oct</td>
</tr>
</tbody>
</table>

376
Water balance analysis above is early information that can be used as advice in agricultural activity planning in South Kalimantan. Generally ground water availability period with sufficient category happen in November-May, meanwhile water surplus period also happen during November-May period. Water balance analysis result in South Kalimantan also gives early information on the potential of drought or drought-prone areas. From water balance analysis, the level of ground water availability is in less category (< 40%) and water deficit happen during August to September (two months).

Period information of drought-prone area can be suggestion to anticipate and solve drought disaster. South Kalimantan almost every year in dry season suffers from smoke disaster due to field fire. Climate resource utilization has important role as one of useful information in planning and managing natural resources and as basic reference in policy planning and policy making.

Local agribusiness that sensitive to photo periodism in South Kalimantan generally started on October, both direct planning in dry field or stages planning in wet field as explained as following:

<table>
<thead>
<tr>
<th>Activity</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Seeding (dry field)</td>
<td>SW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Seeding (wet field)</td>
<td></td>
<td></td>
<td></td>
<td>TP1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd Seeding (wet field)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Rice (wet field)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TP2</td>
<td>TP3</td>
</tr>
</tbody>
</table>

SW = sowing, TP=transplanting


Based on Table 2, month amounts to conduct planting pattern business above still possible, but based on Graphic 6 there is a shift in rainy season that previously in April shifted to May. That time shift affected to result reduction because vegetative time around one month in April (above graphic). Meanwhile, local rice planted is photo-periodism sensitive which affected to flowering in June. This will reduce the time for carbohydrate accumulation which left around one month (May). Rainy season end time shift become more regressed, and this is almost spread evenly in South Kalimantan Monsoon area. This is need to be anticipated, one of it is by looking for short time varieties, therefore after the transplanted rice has enough time for active vegetative and seedlings. Some varieties with shorter age from the elders have been assembled like what have been done by Wahdah, Rusmayadi and Zulhidiani (2016) towards photo-periodism sensitive local variety Siam Unus mutant M6 with 111 – 115 days age after transplanting.
CONCLUSION

Field water balance analysis mapping based on TRMM satellite data shows ground water availability with sufficient category happen during November – July period, meanwhile water surplus period happen during December – June period. Water balance analysis gave more detail information to determine agriculture planting pattern. Water balance analysis gave information on planting potential time available and gave information on drought-prone areas which is very useful to be used for the basis of planting planning and management.

REFERENCES

7. Thornthwaite. 1957. Instruction and tables for computing potential evapotranspiration and the water balance. Drexel Institute of Technology. Laboratory of Climatology. USA.