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

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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), misal 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 $0.25^{\circ} \times 0.25^{\circ}$ 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 Medium-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 occurance 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 its utilization for society welfare (Syaifulah, 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. TRMM 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

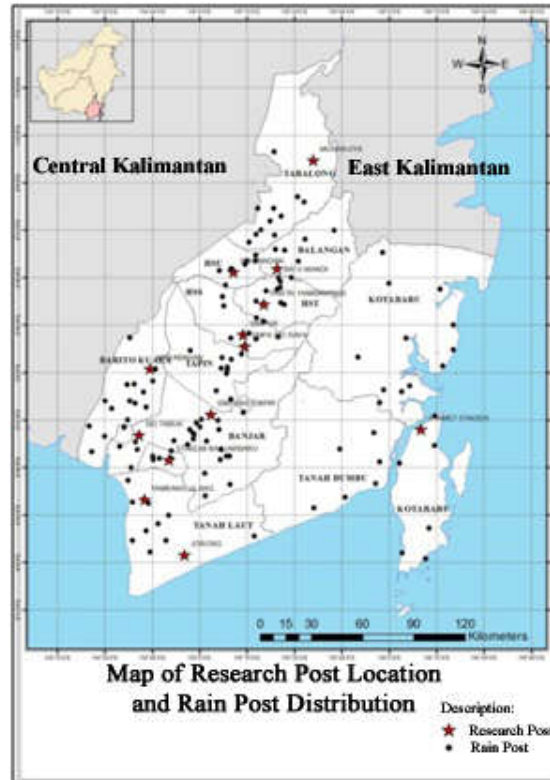
This research is conducted in South Kalimantan Province which is located between 1°20' S – 4°10' S and 114°19'E - 116°33'E. The research is conducted in six months from March to August 2016. For research location and rain observation post in South Kalimantan can be viewed in detail in

Graphic 1.

Research instrument consisted of computer, GrADS Open Software version 2.0, Matlab software version 7.8, Arc GIS 10.2, and Microsoft Excel for RMSE value and calculation and correlation. Material used is TRMM satellite type 3B43 in the form of grid data with monthly temporal resolution and spatial resolution 0.25° x 0.25° with 1998 – 2015 data period. Data format in the form of binary data and downloaded from ftp://disc2.nascom.nasa.gov/data/TRMM/Gridded/3B43_V7. Surface temperature data in the form of grid data from European Centre for Medium-Range Weather Forecasts (ECMWF) 1998-2015 periods in netcdf format downloaded from <http://www.ecmwf.int/en/research/climate-reanalysis/browse-reanalysis-datasets>.

Surface rainfall data 1998-2015 period from 13 observation spot locations sourced from South Kalimantan BMKG, i.e., (1) Muara Uya, Tabalong Regency 1.88°S and 115.60 °E, (2) Batu Mandi, Balangan Regency 2.45 °S and 115.41 °E, (3) Sei Pandan, Hulu Sungai Utara 2.47 °S and 115.18 °E, (3) Hambawang Beach, Hulu Sungai Tengah Regency 2.64°S and 115.34°E, (4) Simpung, Hulu Sungai Selatan 2.80 °S and 115.23 °E, (5) Sungai Raya SMPK, Hulu Sungai Selatan Regency 2.86 °S and 115.24 °E, (6) Banjarbaru, 3.46 °S and 114.84°E, (7) Simpang Empat, Banjar Regency 3.22 °S and 115.06 °E, (8) Sei Tabuk, Banjar Regency 3.33 °S and 114.68 °E, (9) Marabahan, Batola Regency 2.98 °S and 114.74°E, (10) Jorong, Tanah Laut Regency 3.96 °S and 114.92°E, (10) Tambang Ulang, Tanah Laut Regency

3.67°S and 114.71 °E, (11) Stagen Kotabaru Regency 3.30 °S and 116.17°E, (12) Tambang Ulang, Tanah Laut Regency 3.67 °S and 114.71 °E, and (13) Stagen Kotabaru Regency 3.30°S and 116.17°E.



Graphic 1 – Research location and rain post in South Kalimantan

Research Procedure. The stages in this research are:

1. Determining Input Data. Main data used is monthly rain data from TRMM satellite type 3B43 1998 - 2015 data period in the form of grid with spatial 0.25° x 0.25°. Data format in the form of binary data downloaded from ftp://disc2.nascom.nasa.gov/data/TRMM/Gridded/3B43_V7. Supporting data in the form of monthly surface rainfall data 1998 – 2015 period from BMKG observation spot in South Kalimantan for TRMM data validation. Monthly surface temperature data from ECMWF reanalysis data in netcdf format 1998 – 2015 periods.
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 series 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):

$$r_{\hat{Y}} = \frac{\sum_{i=1}^n (Y_i - \bar{Y})(\hat{Y}_i - \bar{\hat{Y}})}{\sqrt{\sum_{i=1}^n (Y_i - \bar{Y})^2} \sqrt{\sum_{i=1}^n (\hat{Y}_i - \bar{\hat{Y}})^2}}$$

Where: $r_{\hat{Y}Y}$ = correlation coefficient between TRMM satellite data with surface observation rainfall data; Y_i = TRMM satellite data in data satelit TRMM in i period with $i=1, 2, \dots, n$; \bar{Y} = average TRMM satellite data values; \hat{Y}_i = observation rainfall data in i period with $i=1, 2, \dots, n$; $\bar{\hat{Y}}$ = observation rainfall average value; n = period length.

Water balance analysis stages are:

- ECMWF reanalysis surface temperature data extraction on set grid.
- Calculating surface temperature value in 1998 – 2015 period for every set grid.
- Calculating Potential Evapotranspiration (ETP) value by using Thornthwaite and Mather method (1957).
- Calculating ground water avaibility with this equation:

$$\text{Ground water avaibility (ATI)} = \frac{KAT - TLP}{KL - TLP} \times 100\%$$

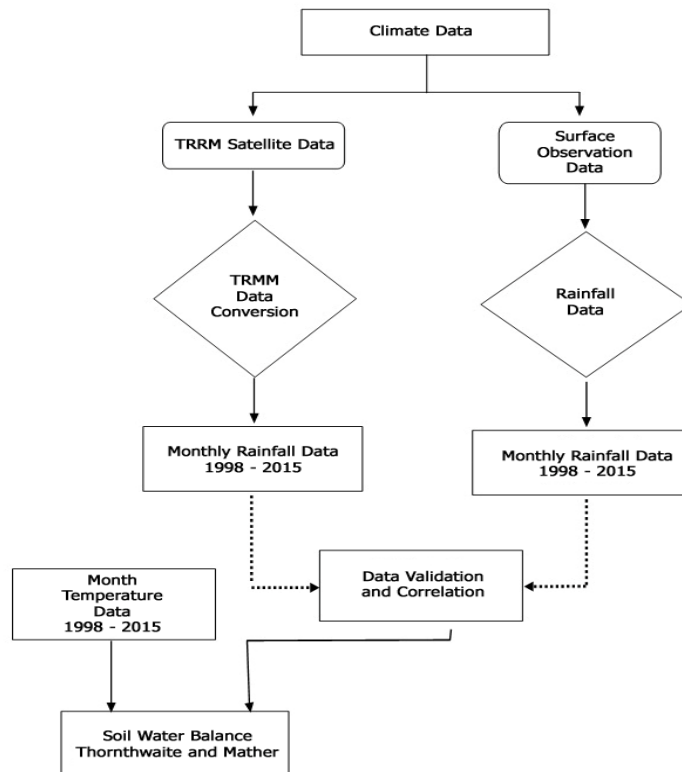
Where: KAT= ground water level; TLP = permanent wilting point; KL = field capacity and available water.

What categorized into three parts are:

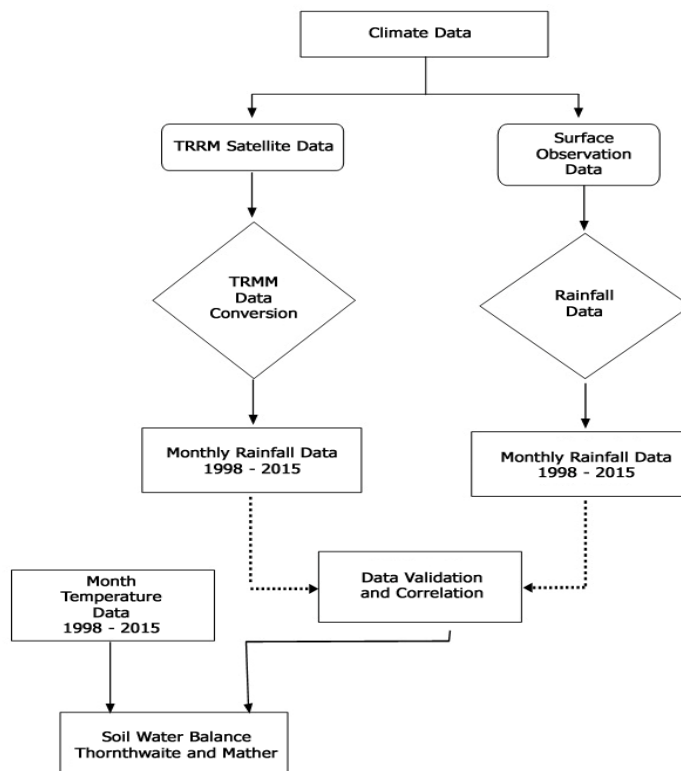
- Lack, if ground water avaibility < 40%;
- Medium, if ground water avaibility 40% - 60%;
- Sufficient, if ground water avaibility > 60%.

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.



Graphic 2 – Procedure Flow Diagram

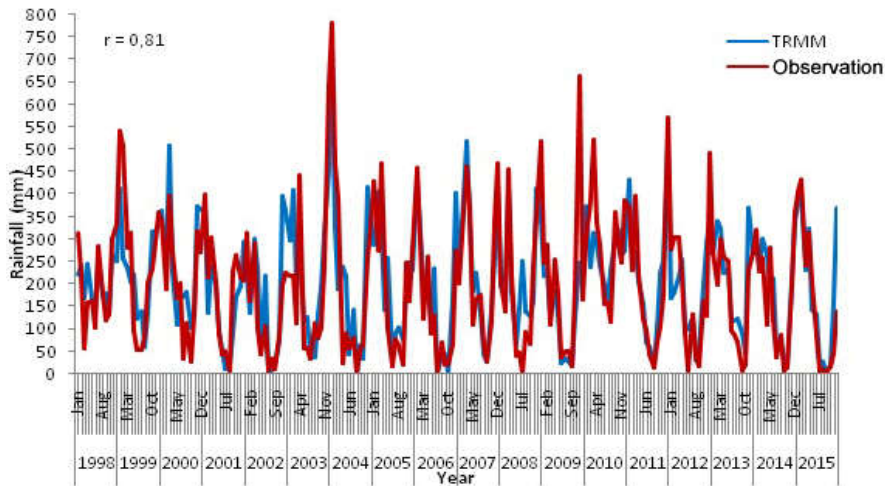
RESULTS AND DISCUSSION

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.

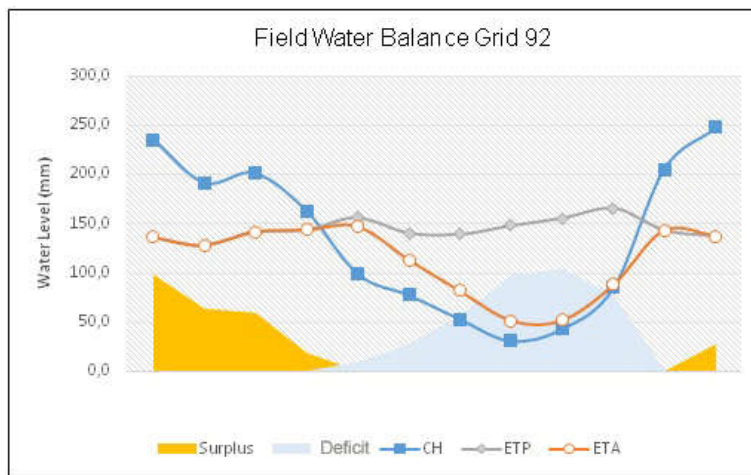
Table 1 – Correlation Value and TRMM Satellite RMSE and Surface Rainfall

No	Observation Spots	Monthly Series			Monthly Average		
		r _{count}	RMSE	P _{value}	r _{count}	RMSE	P _{value}
1	Banjarbaru	0.86	67.70	0.00	0.99	19.46	0.00
2	Muara Uya	0.79	86.70	0.00	0.97	43.78	0.00
3	Sei. Pandan	0.75	93.60	0.00	0.99	41.90	0.00
4	Marabahan	0.78	115.20	0.00	0.99	0.00	0.00
5	Stagen	0.80	86.10	0.00	0.94	21.35	0.00
6	Sei Raya SMPK	0.79	77.90	0.00	0.97	23.17	0.00
7	Batu Mandi	0.74	80.08	0.00	0.97	27.68	0.00
8	Hambawang Beach	0.80	84.40	0.00	0.98	22.08	0.00
9	Simpur	0.73	77.60	0.00	0.97	19.49	0.00
10	Simpang Empat	0.82	94.20	0.00	0.97	26.29	0.00
11	Sungai Tabuk	0.81	84.30	0.00	0.98	30.22	0.00
12	Tambang Ulang	0.85	86.90	0.00	0.99	23.92	0.00
13	Cindai Alas Selatan	0.80	100.30	0.00	0.92	0.00	0.00
	Average	0.79			0.97		

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 TRRM 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.

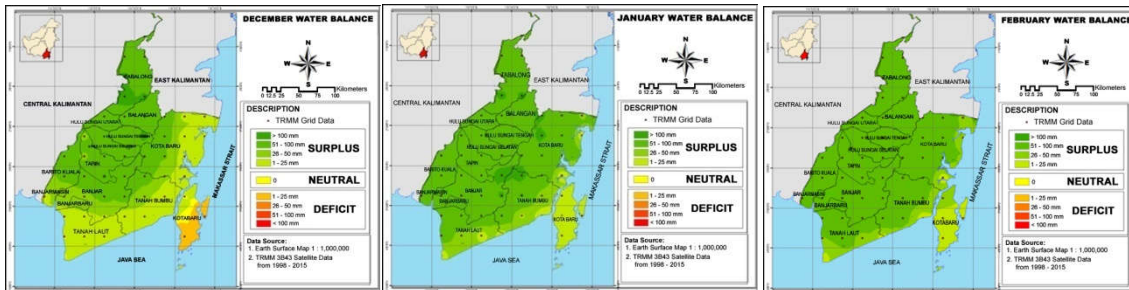


Graphic 4 – Field water balance graphic on grid 92 (Sei Tabuk, Banjar Regency 3.33°S and 114.68°E)

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

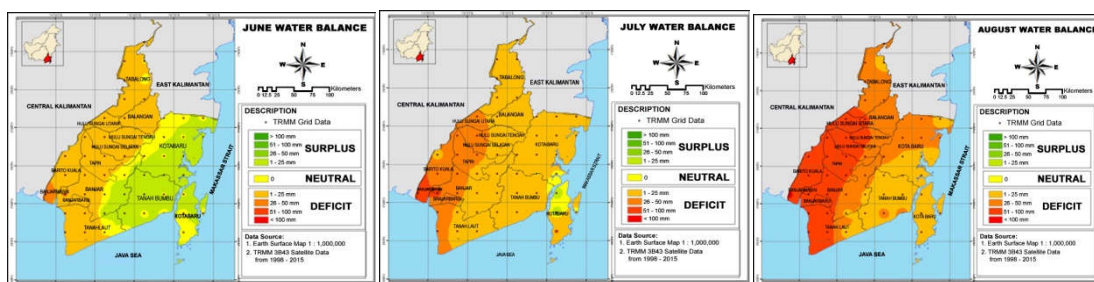
general sufficient condition. The area in less and medium water availability consisted of Kotabaru regency's Laut Island. Water balance analysis in this month shows general water sufficiency except some areas of Laut Island (Kotabaru Regency) which still suffer from water deficit. Water surplus area 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.



Graphic 5 – Surplus Map/December, January, and February Surplus

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.



Graphic 6 – Surplus/ Defisit Map in June, July, and August

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 2 – South Kalimantan area field water balance analysis

No	Regency / City	Water Availability (>60%)	Water Surplus	Rainy Season Period (CH/ETP)	Dry Season Period (D/ETP)	Transition Period (D/ETP) <0.5
1.	Tabalong Regency	8 – 9 months	6 months	Nov-Jun	0	Jun-Oct

2.	Balangan Regency	8 – 9 months	5 – 6 months	Nov-May	0	May-Oct
3.	Hulu Sungai Utara Regency	8 months	5 months	Oct-Jun	Sep	May-Agt and Oct
4.	Hulu Sungai Tengah Regency	8 – 9 months	5 months	Nov-Jun	0	May-Oct
5.	Hulu Sungai Selatan Regency	7 – 8 months	5 months	Nov-May	Agt-Sep	May-Jul and Oct
6.	Tapin Regency	7 – 8 months	5 – 6 months	Nov-Apr	Sep	May-Jul and Oct
7.	Banjar Regency	7 – 9 months	5 – 7 months	Nov-Apr	Agt-Sep	May-Jul and Oct
8.	Tanah Laut Regency	7 – 8 months	5 months	Nov-Apr	Agt-Sep	May-Jul and Oct
9.	Tanah Bumbu Regency	7 – 8 months	5 – 7 months	Nov-Jul	0	Jun-Oct
10.	Kota Baru Regency	6 – 7 months	5 – 7 months	Nov-Jul	0	Agt-Oct
11.	Barito Kuala Regency	6 months	5 months	Nov-Apr	Agt-Sep	May-Jul and Oct
12.	Banjarbaru City	5 – 7 months	5 months	Nov-May	Agt-Sep	May-Jul and Okt
13.	Banjarmasin City	6 months	5 months	Nov-Apr	Agt-Sep	May-Jul and Oct

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:

Activity	Month											
	10	11	12	1	2	3	4	5	6	7	8	9
1 st Seedling (dry field)	SW											
2 nd Seedling (wet field)		TP1										
3 rd Seedling (wet field)			TP2									
Main Rice (wet field)							TP3				Panen	

SW = sowing, TP=transplanting

Source: Hasegawa et al (2004).

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.

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