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ANALYSIS OF WATER BALANCE FOR DETERMINE CROPPING PATTERNS FOR FOOD CROPS IN WATERSHED KARANGMUMUS-THE PROVINCE OF EAST KALIMANTAN

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Abstract

The experiment objectives was to determine cropping patterns of food crop in watershed Karangmumus. The geographical position 116°49' EL – 117°08' EL dan 0°34' SL – 0°45' SL, with extent of the 644.2 km^2 whereas covers 8 village or 38.58% of total Samarinda City. Have the Area Class III (1500 – 2000 mm/ year,. with the Bimodel or Double Wave rainfall models with C patern. The hight rainfall depth periode at December and April, therefore the low rainfall depth at September and November. Have a value Q = ± 9.9%, or rainfall tipe A (very wet area with tropical wet vegetation) and E1 agroclimtic zone. Modified method of Thornthwaite and Mather of bookkeeping system of water balance was used based on monthly data. Water Balance monthly indicated that this area have potential growing season about 9 months, have to water surplus 7 month (478, 8 mm year^{-1}) and water deficits about 4 months (44.5 mm/year). In these area rice could be planted twice a year without irrigation. Futher for non-irrigation land with monthly high rainfall, the result showed that the area had potency of growing periods of 182 days through the year. Planting dates might be started from October 1 until December 1, with sequence of rice-rice or rice-rice-other food crops.

***Key words**: water balanced, growing season, cropping patterns.*

INTRODUCTION

Considering that the East Kalimantan Province having the wet tropical climate, generally it can be said that the rainfall in the entire region is sufficient for agriculture. Even, in the dry land, where the distribution of rainfall throughout the year in many areas is uneven, the production could be comparable with those in the irrigated land, if it is managed properly.

Therefore, the principal constraint of agriculture in Watershed Karangmumus areas is the water distribution. This is due to the existing irrigation facilities are inadequate, both in terms of technology and limited irrigation canals.

Although there are a lot of rains, plants can not directly utilize it from the river or the rain, but it should first be transformed so that it can be used by plants. By considering that the availability of water is very essential for agricultural planning, therefore, the success of farming will also be determined by how much we can expect the availability of water for plants. Various attempts were made to reduce the risk of crop failure is to compile information about potential the time of planting, especially for crops. Method of Thornthwaite and Mather (1957) is one approach that is commonly used to determine the level of availability of water to determine the potential growing season and croping patterns.

Water balance iss simply a statement of the details of the law of energy conservation, which applies also to the water issue. Knowledge of the water balance is the basis for the development of agricultural production, crop selection, and determination of cropping pattern (Oldeman and Frere, 1982 in Sujalu, 2000). Preparation of the water balance is the basis of the development potential of climate, soil, and plants that are very useful for planning the development of agricultural production. It is intended to provide important information on the net amount of water that can be obtained, the value of the surplus water which can not be accommodated, and when the water balance occur. Therefore, these data can be used as a basis for planning and management of various activities, such as making a water dam (for water storage and distribution), and the possibility of natural water utilization for a variety of other activities.

MATERIALS AND METHODS

A. Time and Place Research

The study was conducted at Watershed Karangmumus for approximately 6 (six) months (July-December 2012) in an area of approximately ± 64 420 hectares.

B. Data Collection

Data collected from both primary and secondary data related to the research, include:

a. Climate, particularly rainfall and evaporation
b. Physiographic, particularly land slope
c. Soil Conditions, those related to soil water status
d. The vegetation, especially the dominance of vegetation, land cover

C. Water Balance Analysis

Analysis of water balance the form of integral equations by simplifying some similarities, method of Thornthwaite and Mather of bookkeeping system (1957). So that the water balance of a land area can be expressed in the form of the equation:

$$CH = ETA \pm \Delta\ WCS \pm Li$$

Whereas:

CH = rainfall (mm $months^{-1}$)

ETA = actual evapotranspiration (≤ETP)

Δ WCS = soil water content changes (mm $months^{-1}$)

Li = runoff (surplus or deficit depending on its value) (mm $months^{-1}$)

C.2. Analysis of Soil Water Content (WCS)

Changes in Water Content of Soil (WCS) is the difference in soil moisture content on a period to prior periods between sequential. For each change in soil water content, can be calculated with the formula R-ETP that if a negative value, there will be a deficit (lack of) water for (ETp=ETa). Conversely, if (R-ETP) is positive, then there will be a surplus/excess of water (R-ETp-ΔWCS), so that soil water availability decreases water exponentially and expressed by the equation:

$$ASW = WHC \text{ X } k^a,$$
$$WHC = FC - PWP,$$
$$WCS = PWP + ASW$$
$$K = ((Po + P_1) / WHC$$

Whereas:

ASW = Availability of Soil Water (mm)

WHC= water holding capacity or availability of Maximum Soil Water (mm)

WCS = Actual Soil Water Content (mm)

FC = Field Capacity (mm)

PWP = Permanent Wilt Point (mm)

a = Accumulate Potential Water Loss (APWL)

Po = 1.000412351 (constant)

P_I = -1.07380730 (Constant)

C.1. Analysis of Evapotranspiration Potential

Calculation the potential evapotranspiration (ETp) using equation from Buckman and Braddy (1969) quoted bay Sujalu (2002, 2011, 2013) as follow:

$$EPTi = 616 \text{ X } \left(10 \text{ x } \frac{Ti}{I}\right)^{a1}$$

$$\mathbf{I} = \sum_{jan}^{des} \left(\frac{Ti}{5}\right)^{1.514}$$

whereas;

ETP = Potential Evapotranspiration

Ti = Temperature of the month to the first monthly

I = Index monthly heat

a = $6.75 \times 10^{-7} I^3 - 7.71 \times 10^{-5} I^2 + 1.792 \times 10^{-2} I + 0.492$

RESULTS AND DISCUSSIONS

A. Preview Area Watershed Karangmumus

Geographically located of the region Watershed of Karangmumus is part of the Mahakam river basin is located at coordinates 116°49' EL – 117°08' EL dan 0°34' SL – 0°45' SL, with extent of the 644.2 km^2 whereas covers 8 sub-district or 38.58% of total Samarinda City, i.e. Samarinda Utara, Samarinda Ilir, Samarinda Ulu, Lempake, Sungai Pinang, Mugirejo, Gunung Kapur, and Muara Badak.

Watershed Karangmumus divided into 9 (nine) sub-watershed (river), namely Karangmumus, Lantung, Pampang, Muang, Karangasam, Bayur, Jayamulya, Siring and Betapus as well as several other small rivers. This area has varied topography, with elevation ranging topographic region from 1-120 m above sea level with a diverse variety of heights.

Table 1. The Area Land Use Type

No.	The Area Land Use Type	Area	
		(ha)	(%)
01.	Farm (dry land farming)	403.13	0,65
02.	Forest	292.15	0,46
03.	Shrub	13.996.25	22,23
04.	Mixed Garden	8.473.44	14,21
05.	Bush	29.501.36	46,07
06.	Wetland	1.248.99	2,06
07.	Garden	2.106.64	3,52
08.	Settlements	4.267.78	7,21
09.	Settlement expansion (Pp)	415.61	0,69
10.	Slough/swamp area	1.815.63	2,91
Amount		64.420, 98	100

Source: Anonim (2001), Trisusanto (2002)

B. Condition Elements the Climate

Based on rainfall data from 3 (three) climate observation station in the basin area Watershed Karangmumus year period from 2001 to 2010 showed that rainfall monthly average ranged from 101-220 mm month^{-1} or an average of 168 mm month^{-1}, whereas the average rainfall ranging from 1500-2850 mm year^{-1} or average of 2018 mmyear^{-1}. Rainfall occurred on rainy days (rd) monthly rates ranging from 9-14 rd with an average rainfall occurred 11 rd month^{-1} (Table 2).

Analysis of rainfall characterization includes four main components, namely:

1. Annual Rainfall spread of this area falls within Class Region III (rainfall between 1500-2000 mm year^{-1}).
2. Type Rainfall has a period of dry months (months with rainfall of <100 mm month^{-1}). Thus obtained value of Q = ±9.8%, or rain type A (which may imply that the Watershed Karangmumus is very wet areas with dense vegetation of tropical rain forest).
3. Rainfall patterns or Bimodel Dual (Double Wave) with the notation Pattern C, periods of high rainfall occurred in December and April, while periods of low rainfall occurred in September and November.
4. Agro-climate zones, this area has a dry month (DM), 8 months humid (HM) and 3 wet months (WM), including agro-climate zones E1.

C. Water Balance

Watershed Karangmumus in general has not been irrigated that is highly dependent on rain water. Table 1 was the result of water balance analysis was used as a reference in determining the initial forecasts of alternative commodities and time of planting on land that does not have a irrigation.

The calculation result in soil water status were obtained from analysis of soil physical properties in the laboratory soil Assessment Institute for Agricultural Technology (BPTP) East Kalimantan Province from Heriansyah (2004) quoted by Ismail (2005) showed that soil available water content (WCS) in the range 244-299 mm or average 268 mm

The analysis of water balanced implies about the details of the input and outputs of water in one place at a certain time period, compiled in the form of quantitative equations, which provide information in the form of quantitative values of each component of input and output water, can be seen in Table 1.

Tabel 1. Monthly Water balance Analysis at Watershed Karangmumus
(116°49' EL – 117°08' EL dan 0°34' SL – 0°45' SL)

Elements	Month											
	Jan.	Feb.	Mar	Apr.	May	June	July	Agst	Sept	Oct.	Nov.	Des.
Rain fall/CH (mm)	194.0	143.0	233.0	333.0	183.0	113.0	178.0	121.0	104.0	134.0	198.0	214.0
Evapotr.Pot. /ETP (mm)	139.0	138.7	139.6	140.2	139.6	138.4	137.2	138.1	138.4	139.3	139.3	138.7
CH – ETP (mm)	55.0	4.3	94.4	192.8	42.4	-25.4	40.8	- 17.1	- 34.4	- 5.3	58.7	75.3
APWL (mm)	0	0	0	0	0	0	0	-17.1	-51.5	-61.8	0	0
Soil Water available/SWC (mm)[1]	268	268	268	268	268	242,6	268	250.9	198.5	136.7	185.4	260.7
Δ WCS	0	0	0	0	0	-25.8	0	- 17.1	- 58.0	- 62.0	- 3.3	0
Evapotr. Akt./ETA (mm)[2]	139.0	138.7	139.6	140.2	139.6	138.4	136.9	142.0	152.0	196.0	139.3	138.7
Defisit (mm)	0	0	0	0	0	0	0.3	3.9	13.6	26.7	0	0
Surplus (mm)	55.0	4.3	94.4	192.8	42.4	0	0	0	0	0	58.7	75.3

Note : [1]. Water Content of Soil (WCS) at Field Capacity (FC)
[2]. Actual evapotranspiration (ETA) in the period of time deficit (R<ETP) was obtained from R (mm) + Δ WCS. While at the time of surplus (R> ETP) the amount equal to ETP

Table 2. Climate Data Average Monthly at Watershed Karangmumus
(116°49' EL – 117°08' EL dan 0°34' SL – 0°45' SL)

Climate Elements	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Rainfall (mm month^{-1})	194	123	233	333	183	113	178	121	104	134	198	214
Rainy Days (days)	12	11	12	14	12	11	9	10	9	11	11	12
Temperature (^{0}C)	26.8	26.7	27.0	27.2	27.0	26.6	26.2	26.5	26.6	26.9	26.9	26.9
Humidity (%)	87.2	86.3	89.2	90.2	88.6	86.5	85.6	86.2	83.4	85.9	87.1	86.3
Sun Radiation (Kkal cm-^{2})	0.55	0.48	0.51	0.53	0.53	0.51	0.51	0.49	0.41	0.44	0.44	0.52

Monthly Water Equilibrium analysis of the results mentioned above can be seen that these areas have a surplus during the eight months that occurred in a period of months from January to June and in November-December. The monthly water surplus in detail is in January amounted to 27.0 mm, 57.3 mm in February amounted, in March amounted 119.7 mm (the highest monthly surplus), in April amounted to 72.8 mm, 48.4 mm in May, months of June amounted to 19.6 mm (the lowest monthly surplus), the month of November amounted to 58.7 months in December and amounted to 75.3 mm in overall water surplus reached 478.8 mmyear^{-1}.

In addition to having monthly water surpluses, the region normally monthly cumulative water deficit in a period of months from June to October as a whole as much as 44.5 mm year^{-1}, with details of the deficit in June amounted to 0.4 mm month^{-1}, July amount 0.3 mm month^{-1}, the month of August amounted to 3.9 mm month^{-1}, the month of September amounted to 13.6 mm month^{-1} and in October of 26.7 mm month^{-1}.

As has been previously communicated its position Karangmumus river divides the city of Samarinda especially Watershed of Karangmumus, and considering the amount of potential run-off that occurred in the region and also by considering the conditions Karangmumus area topography, the watershed Karangmumus very possible to build dams or reservoirs, which have various functions.

Although the main function is to accommodate the construction of the dam monthly surplus water run off resulting in the potential is big enough in this area, as well as water reserves in the period in the months of water deficit that can be utilized by a variety of purposes including drinking water

E. Analysis of Cropping Periods (Growing Season)

To determine the length of cropping period (the length of growing season) can be done based on the ratio P/PE (ratio precipitation and potential evapotranspiration), defined as the time interval in a year that have a ratio P/PE>0.5 plus the time needed for PE 100 mm of ground water is considered available in the soil (FAO, 1978). Results of analysis ratio P/PE can be seen in Table 3 below.

Table 3. Ratio rainfall (R) and potential evapotranspiration (EP) monthly

Climate Elements	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Rainfall (mm / month)	194	123	233	333	183	113	178	121	104	134	198	214
Evapotr.Pot. / ETP (mm)	139.0	138.7	139.6	140.2	139.6	138.4	137.2	138.1	138.4	139.3	139.3	138.7
Ratio P/PE	1.4	0.9	1.7	2.4	1.3	0.8	1.3	0.9	0.8	0.9	1.4	1.5

Based on this analysis the ratio P / PE ratio of the above in mind that the P / PE in the rain fall average monthly cumulative throughout 12 months is always>0.5. Therefore, according to the restrictions provided FAO (1978), the Watershed of Karangmumus areas have planting period (the length of growing season) for 12 months or all year round.

F. Cropping Patterns for Food Crops

Table 1 shows that in this type of land use, have the potential for considerable length of time of planting is about 270-330 days as paddy fields will be planted with rice twice a year. The results of the water balance analysis showed that both the use of land for irrigated land and non-irrigated land at watershed Karangmumus (generally) in East Kalimantan Province still has the potential to grow rice at least once a year.

In watershed Karangmumus, the area of irrigated rice can be planted with rice twice a year. So for the region can be planted rice twice a year if just relying rainfall. Thus as long as farmers can grow rice twice a year because of the additional water from rain. This region does not have irrigation but can still grow rice twice a year (Table 4), due to adequate rainfall with the potential for 293 days of planting time and planting time beginning November 1. Whereas during the dry season still has the potential to grow rice at least once a year

Based on conditions the elements of the climate and the results of analysis of water balance, Watershed Karangmumus at least once a year. In rainy season (wet season) can be used 2 periods cultivation of rice and second crop by 1 periods for a year. Whereas during the dry season can be used 1 periods cultivation of rice and second crop by 1 periods for a year, with one priods (July-September) fallowed land.

CONCLUSIONS

Based on the description as a whole can be concluded that Watershed of Karangmumus at irrigated or non-irrigated land area has a all year round (12 month) potential planting period (growing season).

Table 4. Pattern of Cropping

Subject	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Ratio P/PE	1.4	0.9	1.7	2.4	1.3	0.8	1.3	0.9	0.8	0.9	1.4	1.5
Pattern of Cropping[1]	**Rice II**		**Second Crop**				**Rice I**				**Rice II**	
Pattern of Cropping[2]	**Rice I**		**Second Crop**				**fallowed**				**Rice I**	

Note: [1] Pattern of Cropping at Wet season
[2] Pattern of Cropping at Dry Season

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