Akas Pinaringan Sujalu

by Akas Pinaringan Sujalu Akas Pinaringan Sujalu

Submission date: 09-Jun-2021 11:26PM (UTC-0400)
Submission ID: 1603826389
File name: y_and_Food_Safety_for_the_Twenty-first_Century-137-146-SPLIT.pdf (150.93K)
Word count: 2738
Character count: 12459

Chapter 12
Water Balance Analysis for the Determination of Available Growing Season at Sub-Watershed, Loa Janan, East Kalimantan

Akas Pinaringan Sujalu and Ismail

Abstract This geographic sub-watershed is in Loa Janan, position 116°49′ EL–117°08′ EL and 0°34′ SL–0°45′ SL, with an extent of 644.2 km^2 that includes eight villages. Characteristics of rain in this area are included in the area class III (1,500–2,000 mm/year), with a bimodal or double wave rainfall model with C pattern. The highest rainfall period is in December and April, and the lowest rainfall in September and November. The sub-watershed has level Q (±9.8 %), or rainfall type A (very wet area with tropical wet vegetation), and an E1 agroclimate zone.

Monthly water balance indicated that this area has a potential growing season available all year round (12 months), a water surplus for 8 months (478.8 mm/year), and a water deficit for about 3 months (44.5 mm/year).

Keywords Water balance • Growing season

12.1 Introduction

Water is a natural resource that is renewable and can be found everywhere, although still limited in quantity and quality and availability, both geographically and according to the season. Therefore, increased use will result in human intervention against the greater water resources; this will cause change in order and the hydrological cycle as more and more territory is used, and an uneven distribution of water, both spatially and temporally, as well as decreasing water quality. At the same time, the utilization efficiency and lower water use often ignore areas from which the water flow is derived.

Along with the development of the city, most of the upstream regions of sub-watersheds have experienced pressure that caused degradation of the River Loa Janan, mainly because of logging, housing needs, and changes in regional function.

A.P. Sujalu (✉) • Ismail
Faculty of Agriculture, The 17th of August 1945 University, Samarinda,
Jl. Ir. H. Juanda 80, Samarinda 75124, Indonesia
e-mail: pinaringan_b@yahoo.co.id; ismail.6913@yahoo.co.id

S. Hongladarom (ed.), *Food Security and Food Safety for the Twenty-first Century*, DOI 10.1007/978-981-287-417-7_12

Conditions are very obvious on a swamp area that stretches along the banks of the Mahakam River downstream and especially the watershed in Loa Janan of other rivers, of which a large part has been transformed into economic zones and settlements.

Management of a sub-watershed with good manners and rights is an attempt at controlling the reciprocal relationship between natural resources such as vegetation, soil, and water by humans and all their activities so that the watershed management objectives to ensure sustainability and harmony of the ecosystem and increase the benefits of natural resources contained therein for human life can be achieved. It is intended as an effort to maintain the Mahakam River water discharge in the dry season, which can prevent the intrusion of seawater. It also avoids increasing the flow rate of surface water in the rainy season, which can lead to high frequency of flooding in the cities of Samarinda and Tenggarong (Trisusanto 2002).

The direct impact that is felt as the change in the water balance of watershed Loa Janan is tangible, with the occurrence of droughts and floods that are more widespread and more frequent disturbances in various aspects of life.

12.2 Research Methods

12.2.1 Time and Place of Research

The study was conducted for approximately 6 months (July–December 2011) in watershed Loa Janan, covering an area of approximately 644.2 km^2.

12.2.2 Data Collection

Data were collected from both primary and secondary sources related to the research:

(a) Climate, particularly rainfall and evaporation
(b) Physiographic characteristics, particularly land slope
(c) Soil conditions, especially those related to water status in soil

12.2.3 Water Balance Analysis

Analysis of the water balance of land is expressed in the form of integral equations by simplifying some similarities, so that the water balance of a land area can be expressed in the form of the equation:

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

where:

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})

12.2.3.1 Analysis of Potential Evapotranspiration (ETP)

Calculation of potential evapotranspiration (ETP) using equations from Buckman and Braddy, quoted by Sujalu (1997) and Ismail (2009), is as follows:

$$\mathrm{EPTi} = 616 \times \left(10 \times \frac{\mathrm{Ti}}{\mathrm{I}}\right)^{a1}$$

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

$$\mathrm{a} = 6.75 \times 10^{-7}\,\mathrm{I}^3 - 7.71 \times 10^{-5} 1^2 + 1.792 \times 10^{-2} 1 + 0.492$$

where;

ETP = evapotranspiration
Ti = temperature of the month to the first month
I = index monthly heat
a = constant

12.2.3.2 Analysis of Soil Water Content (WCS)

Changes in water content of soil (WCS) is the difference in soil moisture content in a period relative to earlier periods between sequences. Each change in soil water content can be calculated with the formula R − ETP. If that is a negative value, there will be a deficit (lack of) water (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 exponentially and is expressed by the equation:

$$\mathrm{ASW} = \mathrm{WHC} \times \mathrm{k}^{\mathrm{a}},$$
$$\mathrm{WHC} = \mathrm{FC} - \mathrm{PWP},$$
$$\mathrm{WCS} = \mathrm{PWP} + \mathrm{ASW}$$

where

WCS = actual soil water content (mm)
ASW = availability of soil water actual (mm)
WHC = water-holding capacity or availability of maximum soil water (mm)
FC = field capacity (mm)
PWP = permanent wilt point (mm)
k = constant [obtained $k = ((Po + P_1)/WHC)$]

with

$Po = 1.000412351$ and $P_1 = -1.073807306$
a = accumulation of potentially lost water (accumulated potential water loss, APWL), which represents the accumulated value (R − ETP) when the value of R < ETP

12.3 Results and Discussion

12.3.1 Preview Area Sub-Watersheds Loa Janan

Sub-watershed Loa Janan is part of the Mahakam River watershed, located at coordinates between 116°49–117°08′ EL and 0°34′–0°45′ SL, with a total area of 644.2 km^2, divided into five districts, namely, sub-districts of Bakungan, Batuah, Loa Duri Ilir, Loa Duri Ulu, Loa Janan Ulu, Purwajaya, Tani Bhakti, and Tani Harapan. The sub-watershed area in Loa Janan has varied topography, with elevation ranging from 10–120 m above sea level with a diverse variety of heights (Table 12.1).

12.3.2 Condition Elements of the Climate in the Sub-Watershed Loa Janan

Rainfall data (2001–2010) from three climate observation stations in the sub-watershed area Loa Janan for the year showed that monthly average rainfall ranged from 104 to 214 mm month^{-1} or an average of 168 mm month^{-1}, whereas the average rainfall ranged from 1,500 to 2,850 mm/year or an average of 2,018 mm/year. Rainfall occurred on rainy days (rd) with monthly rates ranging from 9 to 14 rd with on average rainfall occurring 11 rd month^{-1}.

Analysis of rainfall characterization includes four main components, namely:

1. Annual rainfall spread of this area falls within class region III (rainfall between 1,500 and 2,000 mm/year).
2. Spread type rainfall in Loa Janan sub-watershed area has no period of dry months (months with rainfall <100 mm month^{-1}). Thus, the obtained value of Q = ±9.8 %,

Table 12.1 The area land use type at sub-watershed area Loa Janan (116°49′–117°08′ EL dan 0°34′–0°45′ SL)

No.	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: Anonymous (2001)

or rain type A (which may imply that the watershed area Loa Janan is very wet areas with dense vegetation of tropical rainforest).

3. Rainfall patterns are bimodal or dual (double wave) with the notation pattern C; periods of high rainfall occurred in December and April and periods of low rainfall occurred in September and November.
4. For agro-climate zones, the watershed has no dry months, 8 humid months (HM), and 3 wet months (WM), including agro-climate zones E1 (Table 12.2).

12.3.3 Calculation of Potential Evapotranspiration (ETP)

Calculation of potential evapotranspiration (ETP) conducted monthly by using equations from Buckman and Braddy, quoted by Sujalu (1997) and Ismail (2009) in the watershed area Loa Janan ranged from 137.2 to 140.2 mm or an average of 138.8 mm month^{-1}; the highest point in April was 140.2 mm and the lowest point in July was 137.2 mm.

12.3.4 Water Balance

The calculation results in soil water status as obtained from analysis of soil physical properties in the laboratory soil of AATA (Agency of Agriculture Technology Assessment) of Province of East Kalimantan from Heriansyah (2004) showed that soil available water content (WCS) was in the range between 244 and 299 mm or an of average 268 mm.

Table 12.2 Climate data average monthly Loa Janan sub-watershed area 116°49′ EL–117°08′ EL dan 0°34′ SL–0°45′ SL

	Month											
Climate elements	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 (°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

Water balance implies the details of the input and output of water in one area 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, as can be seen in Appendix Table 12.4.

Monthly water balance analysis of the results mentioned here shows that these areas have a surplus during the 8 months from January to May and in November–December. The monthly water surplus in overall water surplus reached 478.8 mm/year. In addition to having monthly water surpluses, the region normally has a monthly cumulative water deficit in the period from July to October of as much as 44.5 mm/year as a whole.

As has been previously communicated, in its position the Loa Janan River divides the city of Tenggarong, and considering the amount of potential runoff that occurred in the region and also by considering the conditions of Loa Janan area topography, the watershed area in Loa Janan is very possibly suitable to build dams or reservoirs, which have various functions. Although the main function is to accommodate the construction of the dam, monthly surplus water runoff results in a potential that is large enough in this area, as well as water reserves in the period of the months of water deficit that can be utilized by a variety of purposes including drinking water.

12.3.5 Analysis of Cropping Periods (Growing Season)

Determining the length of the cropping period (growing season) can be based on the ratio P/PE (ratio between precipitation and potential evapotranspiration), defined as the time interval in a year that has a ratio P/PE > 0.5 plus the time needed for evapotranspiration of 100 mm of groundwater considered available in the soil (FAO). Results of analysis of the ratio P/PE can be seen in Table 12.3.

Based on this analysis, the P/PE ratio of the foregoing shows that the P/PE in rainfall average monthly cumulative throughout the year (12 months) is always >0.5. Therefore, according to the restrictions provided by FAO, the sub-watershed Loa Janan has a planting period (length of growing season) of 12 months or all year round.

12.4 Conclusion

Based on the description as a whole, it can be concluded that sub-WBA Loa Janan area has a all-year-round (12-month) potential planting period (growing season), which is supported by the surplus water during 8 months or cumulatively amounting to 478.8 mm/year and a deficit of water for 3 months or cumulative of 44.5 mm/year.

Table 12.3 Ratio rainfall (R) and potential evapotranspiration (EP) monthly

	Months											
Climate elements	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
Evapotranspiration. 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

Appendix

Table 12.4 Monthly water balance in the Loa Janan sub-watershed area

	Bulan											
Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall (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
Potential Evapotr/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
R – 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
Water content of soil / WCS (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
Actual evapotran/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
Deficit (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

116°49′ EL–117°08′ EL dan 0°34′ SL–0°45′ SL

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.

At the time of surplus (R > ETP) the amount was equal to ETP

References

Anonymous. (2001). *Inventory and identification of areas prone environment in sub-watershed Loa Janan Samarinda* (Mapping erosion hazard level). BAPEDALDA. East Kalimanatan.

Asdak, C. (1995). *Hydrology and watershed management*. Yogyakarta: Gadjah Mada University Press.

Ismail. (2009). Water balance analysis at Karangmumus River Watershed Area (RBA) Samarinda City. *Journal MAKARA-SAINS, 13*(2), 151–156. Universitas Indonesia.

Seyhan, E. (1990). *Hydrology basics*. Yogyakarta: Gadjah Mada University Press.

Sosrodarsono, S., & Takeda. (1983). *Hydrology for water resources*. Jakarta: PT Pradnya Paramitha.

Sujalu, A. P. (1997). *Climate resources utilization for agriculture and water management planning*. Seminar Papers. LPTP-East Kalimantan.

Trisusanto, A. (2002). *Protected area management plan for the upper rock watershed mumus samarinda through local community approach*. Thesis. Graduate Program. Faculty of Civil Engineering. Surabaya Institute of Technology (Unpublished)

Akas Pinaringan Sujalu

ORIGINALITY REPORT

9%	7%	5%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

3%

★ Laode Sabaruddin, Nur Arafah, Hasbullah Syaf, Sitti Leomo, Tresjia Corina Rak, Jumarddin La Fua. "Analysis of Soil Water Balance to Determine Planting Time of Crops on Dryland, Indonesia", Pakistan Journal of Biological Sciences, 2021

Publication

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		