

# The potential of water availability in Maros Watershed using Thornthwaite-Mather water balance method

*by*

---

FILE	ROS_WATERSHED_USING_THORNTWHAITE-MATHER_WATER_BALANCE_METHOD.PDF (461.34K)		
TIME SUBMITTED	19-OCT-2020 09:46AM (UTC+0700)	WORD COUNT	2655
SUBMISSION ID	1419267426	CHARACTER COUNT	12926

PAPER • OPEN ACCESS

## The potential of water availability in Maros Watershed using Thornthwaite-Mather water balance method

4  
To cite this article: S A Lias *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **486** 012135

View the [article online](#) for updates and enhancements.

## The potential of water availability in Maros Watershed using Thornthwaite-Mather water balance method

S A Lias, Irmayani and S Laban

Department of Soil Science, Faculty of Agriculture, Universitas Hasanuddin, Jl. Perintis Kemerdekaan Km. 10, 90245, Makassar, South Sulawesi, Indonesia.

E-mail: syam\_lias@yahoo.com

**Abstract.** The consumption of water grows continuously along with the increasing the amount of population. The watershed as a reservoir is being the main hope for maintaining the availability of water sources. Estimating the potential of water availability can be done by using the Thornthwaite-Mather water balance method. This study was conducted to determine the potential of water availability in the Maros watershed. The Thornthwaite-Mather method uses a surplus and deficit approach through water balance equation. Potential evapotranspiration (E<sub>p</sub>) was calculated using daily temperature average data while we assumed that the actual evapotranspiration (E<sub>a</sub>) value is equal to E<sub>p</sub> value if wet month, and in dry month equal to rainfall minus  $\Delta$ ST. The water storage to the ground ( $\Delta$ ST) was computed from the value of water holding capacity (WHC) based on land area, vegetation type and soil type. The results of the analysis show that the average rainfall in the last five years (2014-2018) is 3005.7 mm year<sup>-1</sup>, while E<sub>p</sub>, E<sub>a</sub>, and  $\Delta$ ST are 1834.3 mm year<sup>-1</sup>, 1480.1 mm year<sup>-1</sup> and 360 mm year<sup>-1</sup>, respectively. The water surplus in the Maros watershed reached 1678.1 mm year<sup>-1</sup> with a deficit of 354.3 mm year<sup>-1</sup>.

### 1. Introduction

Water is an element that is widely used to meet human needs in various aspects of life such as daily needs (household), industry, and in agriculture. The many aspects that must be met become a problem for the availability of water resources [1]. The amount of water resources need is certainly seen from the number of consumers and the amount of consumption per consumer. Based on data from the Central Statistics Agency of Maros, the number of population every year continues to increase over the last ten years (in 2007-2017) with the lowest number of 3,231 people and the highest of 8,231 people with an average of 4,672 people per year. Humans is the main water users and from the population growth rate [1,2], it can be assumed that the need for water resources also increases .

One of the efforts in maintaining the availability of water is by using a reservoir known as a watershed. Meeting the water needs of an area utilizing water resources from the watershed. As stated in the Government Regulation of the Republic of Indonesia article 1 No. 37 of 2012 that the watershed functions to accommodate, store and drain water originating from rainwater. The main function of the watershed is to provide sufficient and sustainable water resources, reduce the amount of movement of soil particles and provide a high-quality drinking water supply. The watershed serves the water users both in the upstream and downstream areas [3]. However, the biophysical characteristics of the watershed as a processor in responding to the rainfall that falls in the watershed area has an influence on the size of evapotranspiration, infiltration, percolation and surface flow [4].



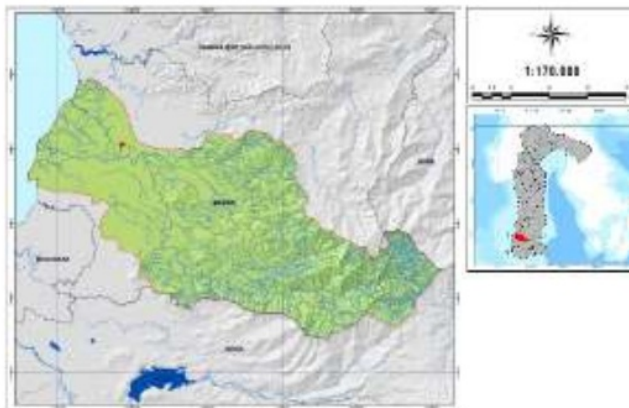
Water balance calculation is needed to give an idea actually regarding the availability of water in the watershed. As it is known that the water balance is the most important component in a hydrological system. Water balance is simply the amount of rainwater that falls into the ground minus evaporation and surface runoff [5]. The quantity or amount of water can be calculated with one simple model that estimates the monthly water potential by the Thornthwaite-Mather method. Estimation of monthly water potential by the Thornthwaite-Mather method has been studied in the Wuryanto Sub-watershed, Wonogiri and the results have a high correlation with the results of field measurements [6].

In addition, according to Tamba *et al* [6], Thornthwaite-Mather method is very easy because it only uses some data that is easily obtained, namely rainfall data as input, vegetation data as land cover, air temperature data, and soil physical properties data. From these data it can be seen the amount of water availability or shortages (deficits) without requiring water level data. In contrast to the Blaney-Criddle, Penman, Makkink and Priestly-Taylor methods, quite a lot of data such as temperature, radiation, wind speed, air humidity are quite difficult to apply in areas that do not have complete climate data.

Based on the description above, this study aims to determine monthly surplus and deficit in the Maros watershed and the potential availability of Maros watershed using the Thornthwaite-Mather method. The magnitude of the potential availability of water is a source of information and consideration for those who use water resources and / or policy makers in making decisions such as the amount of water flowed, flood estimation and prevention, agricultural potential and other problems, mainly for the availability of sustainable water sources. In addition, the usefulness of knowing water conditions in surpluses and deficits can anticipate possible disasters, and can also be used to utilize water as well as possible [7].

## 2. Methodology

This study was located in the Maros watershed where 93% of the area is in the Maros Regency (Figure 1). The total area of the Maros watershed is 73590 Ha. Geographically the Maros watershed is located at  $4^{\circ} 58'37''$  -  $5^{\circ} 12'4.16''$  LS and  $119^{\circ} 28'33.75''$  -  $119^{\circ} 54'53.40''$  East. The Erelembang River is the main river of the Maros watershed with its headwaters in the Buttono Pao District of Gowa Regency and the estuary in the Makassar Strait.



**Figure 1.** Maros watershed area

In this study using secondary data including rainfall and temperature (2014 - 2018) sourced from the Maros Climatology Station, BMKG, watershed administration map sourced from KMENLHK in 2013, Sulawesi soil type scale 1: 250,000 sourced from the Research Center Bogor Land in 2013, as well as a 1: 50,000 scale land use map sourced from the Ministry of Environment and Forestry

(KMENLHK) in 2013. The most important factor for calculating water balance is the availability of precipitation data besides air temperature, land cover and soil type and condition in the study area [8]. Potential water availability was calculated based on the Thornthwaite-Mather method using the surplus and deficit approach where:

2.1. Surplus (S)

The surplus was calculated using following equation:

$$S = (P - ETp) - \Delta ST \dots\dots (1)$$

Where S = surplus / excess (mm / month), P = rainfall (mm / month), ETp = potential evapotranspiration (mm / month), ΔST = Change in soil moisture (mm). The potential evapotranspiration value (ETp) is calculated using the Thornthwaite Mather (1957) method using the equation:

$$ETp = f \cdot 16 \left( \frac{10 \cdot T}{I} \right)^a \dots\dots (2)$$

Where: f = correction factor based on the location of latitude, T = Temperature (° C), a = constant value based on the value of I, I = The magnitude of the annual heat index calculated by:

$$I = \sum \left( \frac{T}{5} \right)^{1,514} \dots\dots (3)$$

Furthermore, the amount of change in soil moisture (ΔST) is calculated by reducing the value of soil moisture (Storage = ST) in the month concerned with the value of ST in the previous month. ST is determined based on wet and dry months. It says a wet month if P > ETp and a dry month if P < ETp. ST in the wet month is calculated using the equation:

In the dry months, the ST value for each month is calculated using the following formula:

$$ST = Sto \cdot e^{(APWL / -Sto)} \dots\dots (4)$$

Where, Sto = maximum water thickness that can be stored at each depth of soil layer (mm), e = navier number (e = 2.718), APWL = accumulation of potential groundwater loss (mm / month). APWL value is the monthly accumulation value of the difference in precipitation and potential evapotranspiration (P-ETp). Calculate APWL in the following way:

- APWL = (P-ETp)<sub>n</sub> - (P-ETp)<sub>n-1</sub> , If the dry month (P < ETp), where (P-ETp)<sub>n-1</sub> is the value (P-ETp) of the previous month
- APWL = 0, If the month is wet (P > ETp)

2.2. Deficit (D)

The deficit was obtained by calculating the difference between ETp and Eta:

$$D = ETp - Eta \dots\dots (5)$$

Where, Etp is potential evapotranspiration (mm/month), Eta is actual evapotranspiration (mm/month).

3. Results and discussion

Climatology conditions in the Maros watershed over the past five years (2014 - 2018) can be seen in Figure 2a and 2b. The highest average rainfall was in January, reaching 681.1 mm / month and the lowest average rainfall was in August which is 8.1 mm / month. Furthermore, the average monthly

temperature ranges from 26.6 °C to 28.3 °C. The highest temperature occurs in October while the lowest temperature occurs in January.

In this study, there are several components that must be available to obtain the results of the analysis. The overall components are presented in Table 1. This study uses the main data in the form of rainfall data (P), temperature (T), and land use. The important points in this study are the amount of incoming water (P) and the magnitude of the potential for water loss through evapotranspiration (ET) and changes in soil moisture ( $\Delta$ ST).

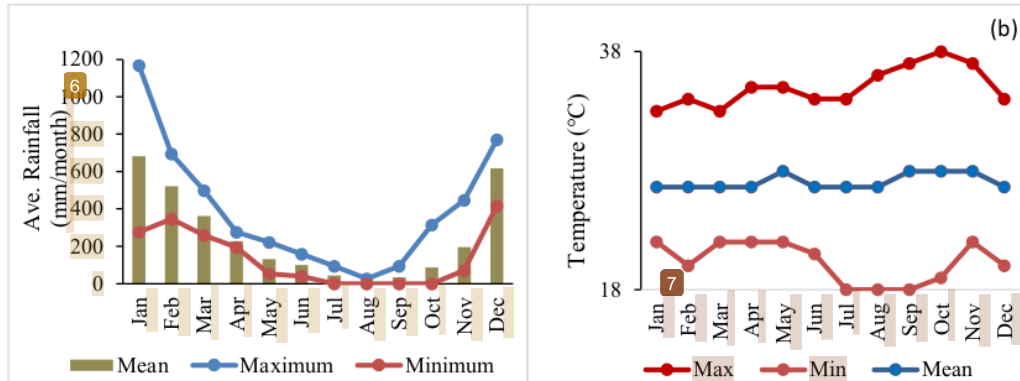


Figure 2. Climatology condition (a. Rainfall and b. Temperature) in Maros watershed during 2014 to 2018.

Figure 3 shows the potential for monthly water availability by the Thornwaite-Mather method. The potential yield of water in the Maros watershed is assumed to be a surplus and the deficit is a deficit. The diagram shows the amount of rainfall is directly proportional to the amount of potential water availability. However, it is inversely proportional to the deficit value. The smaller the rainfall falls, the smaller the water potential so that a deficit can occur. Rainfall that continues to decline will increase the deficit. Conversely, high rainfall will increase the amount of available water (surplus).

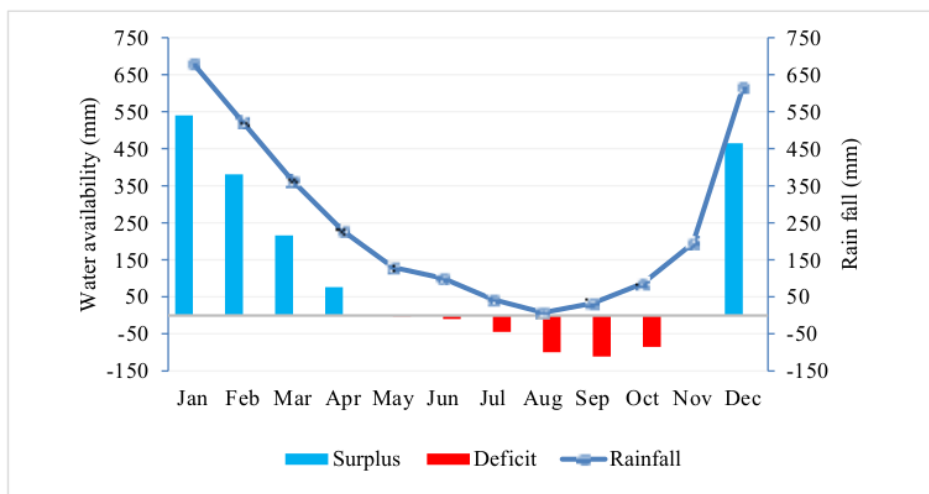


Figure 3. The water availability in Maros watershed

**Table 1.** the water balance that occurs in the Maros watershed is described in various components

Parameters	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
P (mm)	681.1	521.3	362.0	227.9	130.5	100.3	43.1	8.1	33.1	86.4	195.4	616.7
T (°C)	26.6	27.3	27.0	27.5	27.9	27.1	26.8	27.2	27.9	28.3	28.0	27.1
i	12.6	13.1	12.8	13.2	13.5	12.9	12.7	13.0	13.5	13.8	13.6	12.9
E <sub>tx</sub> (mm)	133.2	147.4	140.2	151.8	161.5	143.3	136.5	144.4	162.1	170.6	162.7	143.4
f	1.06	0.95	1.04	1.00	1.02	0.99	1.02	1.03	1.00	1.05	1.03	1.06
ET <sub>p</sub> (mm)	141.2	140.0	145.8	151.8	164.7	141.9	139.3	148.8	162.1	179.1	167.6	152.0
APWL (mm)	0	0	0	0	-34.3	-75.9	172.1	-312.8	-441.8	-534.5	0	0
ST (mm)	192.14	192.14	192.14	192.14	160.75	129.42	78.46	37.73	19.29	11.90	192.14	192.14
ΔST (mm)	0	0	0	0	-31.4	-31.3	-51.0	-40.7	-18.4	-7.4	180.2	0
ET <sub>a</sub> (mm)	141.2	140.0	145.8	151.8	161.9	131.6	94.1	48.8	51.5	93.8	167.6	152.0

The results of the analysis of potential water availability in the table of potential water availability in the Maros watershed show a surplus month in December with a surplus of 464.6 mm, January 539.9 mm, February 381.3 mm, March 216.2 mm and April 76.1 mm. In the following month there was a deficit in May 2.9 mm and continued to increase to 110.5 mm in June, 45.2 in July, 99.9 in August, and the highest deficit in September was 85.4 mm/month. Whereas for November there was no surplus or deficit. The deficit is the difference between potential evapotranspiration and actual evapotranspiration which applies only in the dry month or rainfall which is smaller than the potential evapotranspiration value plus changes in soil moisture [9].

#### 4. Conclusions

From the results of the analysis of the potential availability of water using the Thornthwaite-Mather method shows a surplus in the Maros watershed for five consecutive months namely December to April and a deficit for six months namely in May to October and one month of balance namely November. The surplus reached 1678.1 mm/year and a deficit of 354.3 mm/year. If accumulated, the potential for water availability reaches 1323.8 mm/year with a watershed area of 73,590 Ha.

#### References

- [1] Solle M S and Ahmad A 2016 Landslides Intensity on River Morphology of Jeneberang Watershed after Collapse of Caldera Wall at Mt. Bawakaraeng *Res. J. Appl. Sci.* **11** 874–8.
- [2] Barkey R, Nursaputra M, Mappiasse M F, Achmad M, Solle M and Dassir M 2019 Climate change impacts related flood hazard to communities around Bantimurung Bulusaraung National Park, Indonesia *IOP Conference Series: Earth and Environmental Science* **235**.
- [3] Suprayogo D, Hairiah K and Nita I 2017 *Manajemen Daerah Aliran Sungai (DAS): Tinjauan Hidrologi Akibat Perubahan Tutupan Lahan dalam Pembangunan* (Universitas Brawijaya Press).
- [4] Lihawa F 2017 Kajian bidang longsor di DAS Alo dengan metode geolistrik *Pros. Seminar Nasional Riset Inovatif* **2**.
- [5] Asdak C 2018 *Hidrologi dan pengelolaan daerah aliran sungai* (Yogyakarta: Gadjah Mada

- University Press).
- [6] Tamba C, Fauzi M and Suprayogi I 2016 Kajian Potensi Ketersediaan Air menggunakan Model Neraca Air Bulanan Thornthwaite-Mather (Studi Kasus: Sub Das Subayang Kampar Kiri Hulu) *J. Penelit. Jom FTEKNIK* **3** 1–8.
  - [7] Purnamawati H and Utami B 2014 Pemanfaatan Limbah Kulit Buah Kakao (*Theobroma Cocoa L.*) Sebagai Adsorben Zat Warna Rhodamin B *PROSIDING: Seminar Nasional Fisika dan Pendidikan Fisika* **5**.
  - [8] Hartanto P 2017 Perhitungan Neraca Air DAS Cidanau Menggunakan Metode Thornthwaite *Ris. Geol. dan Pertamb.* **27**.
  - [9] Fibriana R, Ginting Y S, Ferdiansyah E and Mubarak S 2018 Analisis Besar Atau Laju Evapotranspirasi pada Daerah Terbuka *Agrotekma J. Agroteknologi dan Ilmu Pertan.* **2** 130–7.

# The potential of water availability in Maros Watershed using Thornthwaite-Mather water balance method

## ORIGINALITY REPORT

% **15**  
SIMILARITY INDEX

% **10**  
INTERNET SOURCES

% **10**  
PUBLICATIONS

% **13**  
STUDENT PAPERS

## PRIMARY SOURCES

**1** Submitted to Universitas Hasanuddin  
Student Paper %**4**

**2** Submitted to Universitas Brawijaya  
Student Paper %**2**

**3** mafiadoc.com  
Internet Source %**2**

**4** S A Syaiful, M Riadi, F A Mustaman, A R Amin, M Farid, A Mollah, Makmur. " Growth and production of South Sulawesi local waxy corn genotypes ( L.) ", IOP Conference Series: Earth and Environmental Science, 2020  
Publication %**1**

**5** pertambangan.fst.uinjkt.ac.id  
Internet Source %**1**

**6** Submitted to UNESCO-IHE Institute for Water Education  
Student Paper %**1**

**7** Submitted to Wageningen University  
Student Paper

% 1

8

Submitted to University of Stellenbosch, South Africa

Student Paper

% 1

9

academicjournals.org

Internet Source

% 1

10

Submitted to Ritsumeikan University

Student Paper

<% 1

11

www.neliti.com

Internet Source

<% 1

12

orca.cf.ac.uk

Internet Source

<% 1

13

Yusran, A Sabar. "Mangrove management collaboration in the Marusu coastal region of Maros regency", IOP Conference Series: Earth and Environmental Science, 2020

Publication

<% 1

EXCLUDE QUOTES ON

EXCLUDE BIBLIOGRAPHY ON

EXCLUDE MATCHES

< 5 WORDS