Study Water Availability of Malino River to Meet the Need of Water Requirement in District Ongka Malino, Central Sulawesi of Indonesia

I Wayan Sutapa[#1]

[#1] Department of Civil Engineering, Faculty of Engineering, University of Tadulako, Palu, Central Sulawesi, JL. Sukarno – Hatta Km. 8 Palu, Central Sulawesi, Indonesia
Email: wsutapa@yahoo.com

Abstract: Global climate change is marked by changes in weather patterns and climate patterns result in increased or reduced rainfall in some areas. Decreased rainfall as input variables watershed due to irregularities global climate will affect the flow of the river, both annual river flow and seasonal dynamics. One of the basic human needs are affected by global warming is the water. The importance of adequate water supply for the community public hearings mandated by the declaration of the United Nations in 2000 which set the year 2015 as the horizon for achieving the Millennium Development Goal's (MDG's). This is confirmed again at the Earth Summit in Johannesburg in September 2002 on the preparation of programs and strategies in 2015 for water supply and sanitation. In this study, the availability of water is analyzed by the FJ. Mock model and water needs were analyzed based on the guidelines for water needs. The analysis showed that there is excess water in January and May to August and the lack of water in the Month of February and the month of September to December. To overcome the shortage of water is necessary to change the cropping pattern and prioritize water for the needs of the population and livestock.

Keywords: water availability, water requirement, water balance.

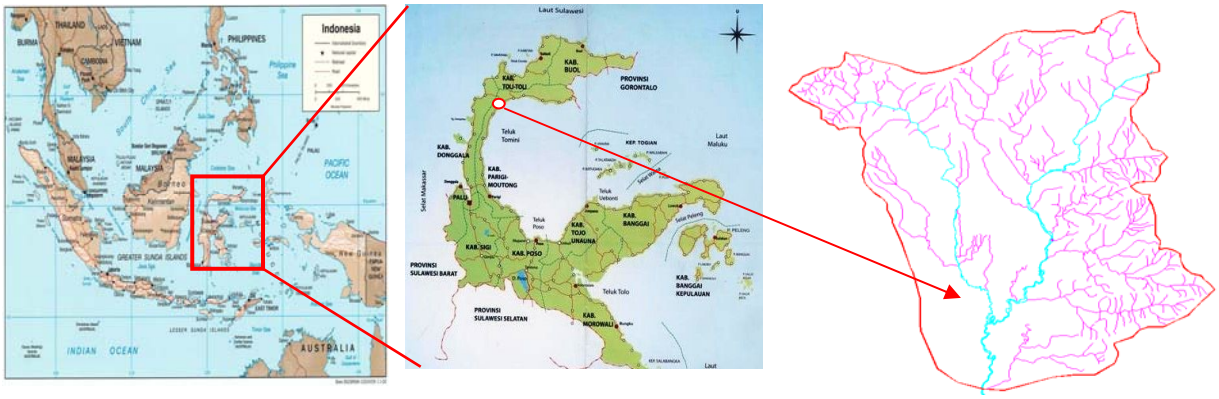
I. INTRODUCTION

Global climate change is characterized by changes in weather patterns and climate patterns result in increased or reduced rainfall in some areas. Decreased rainfall as input variables watershed due to irregularities global climate will affect the flow of the river, both annual river flow and seasonal dynamics. In general, the impact of global climate change is that the higher rainfall will result in larger streams and declining rainfall will reduce the flow of the river. One of the basic human needs are affected by global warming is the water. The importance of adequate water supply for the community public hearings mandated by the declaration of the United Nations in 2000 which sets 2015 as the horizon for achieving the Millennium Development Goal's (MDG's). This is confirmed again at the Earth Summit in Johannesburg in September 2002 on the preparation of programs and strategies in 2015 for water supply and sanitation.

The development of the region in an area caused water demand continues to increase in line with population growth. Food needs and population activity is closely associated with the need for water. It cannot be avoided, but it must be predictable and planned to use as possible. A common trend is an imbalance between supply and demand of water. To achieve a balance between water demand and water availability in the future, efforts are needed to study the components of water demand and water use efficiency. From this study are expected to know the amount of water available, the amount of water needs and the solutions needed to address the problem.

II. MATERIALS AND METHODS

This research was conducted in watershed Malino, Moutong Parigi Regency, Central Sulawesi Province, Indonesia. Geographically located at $00^0$55'54" south latitude and 120^0 46' 27.7" east longitude. Location of the research is presented in Figure 1.



Indonesia Map | Central Sulawesi Province | Malino Watershed

Source: Google maps and results analysis

Fig. 1. Location of Research

The data used in this study is secondary data consisting of: 1) daily rainfall data from station Ongka Persatuan and Kayu Agung (2002-2013); 2) Data from the station climatology Kayu Agung (2002-2013); 3) Topographic map scale of 1: 25,000 sheets Malino (2116-23, Lambunu (2116-24), Tomini (2116-51), Tinombala (2116-52).

To assess water availability and water needs watershed Malino required method and the following steps:

1. Rain watershed mean analyzed by Thiessen method [1] after it first looks for the value of statistics and graphs FDC annual precipitation of both rain station (Ongka Persatuan and Kayu Agung).

$$P = \frac{P1.A1 + P2.A2 + P3.A3 + ...Pn.An}{A1 + A2 + A3 + ... + An}$$

2. Potential evapotranspiration calculated by Penman Monteith [1-4] method according to the recommendations of the Food and Agriculture Association with the help of software CropWat 8 for Windows.

$$ET_0 = \frac{0{,}408\Delta Rn + \gamma \frac{900}{(T+273)} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0{,}34U_2)}$$

3. The availability of water is calculated by the method of FJ. Mock [1,4,5]:

a. Evapotranspiration

$$E = ETo^* \times \frac{d}{30}.m$$

d = 3/2 (18 – h) atau d = 27 – 3/2 h

ET = ETo* – E

b. Water balance in the soil surface

ΔS = P – ET

WS = ΔS – SS dan WS = 0 jika ΔS < SS

WS = 0 jika ΔS < SS

c. Ground water storage

In = WS x I

$Vn = k \cdot V_{n-1} + 0{,}5\ (1 + k).\ In$

$\Delta Vn = Vn - V_{n-1}$

d. River flow

Base Flow (BF) = Infiltration (I) - changes in the volume of ground water (ΔVn)

Direct Run Off (DR) = Excess water (WS) - Infiltration (I)

Flow = Base Flow (BF) + Direct Run Off (DR)

4. Dependable of Flow

   Dependable of flow is calculated based on the basic design year [1,6]

   $Q_{80}= \frac{n}{5}+1$

5. Water Requirement

   a. Domestic water requirement / household [7]

TABLE I. Standard Domestic Water Requirement

No.	Total Population	Type of City	Water Requirement (litre/day)
1	< 2,000,000	Metropolitan	➢ 210
2.	1,000,000 – 2,000,000	Metropolitan	150 – 210
3.	500,000 – 1,000,000	Big	120 – 150
4.	100,000 – 500,000	Big	100 – 120
5.	20,000 – 100,000	Medium	90 – 100
6.	3,000 – 20,000	Small	60 - 90

   b. Non domestic water requirement

      Non-domestic water requirement is calculated at 15-30% of the domestic water requirements.

   c. Water Requirement to Rice [8]

      1. The period of land preparation:

         $NFR = IR - R_e$

      2. The period of growth

         $NFR = ET_c + P + WLR - R_e$

         $R_e = 0,7x\frac{1}{15}R_{80}$

         $ET_c = K_c.ET_o$

         $IR = \frac{M.e^k}{e^k - 1}$

         $M = E_o + P$

         $E_o = 1,1\ ET_o$

   d. Water requirement for Livestock [9]

TABLE II. Water Requirement for Livestock

No.	Kinds of Livestock	Water Requirement (litre/head/day)
1.	cow / buffalo / horse	40.0
2.	goat / sheep	5.0
3.	pig	6.0
4.	fowl	0.6

6. Water balance

   Comparison between water availability and water requirements

III. RESULTS AND DISCUSSION

Population data from the Central Bureau of Statistics, Central Sulawesi form Ongka Malino District in numbers 2012 and 2013, the average population growth rate Watershed Malino 0.55% per year. The population who lived in watershed Malino now is 20045 people and spirit will increase to 20267 in 2 years, 20606 people in the next 5 years, 21183 people in the next 10 years and 22386 people in the next 20 years. Thus, when viewed from the parameters of the population of the watershed Malino include the category of village, where the water requirements the population ranged from 40-60 litre / person / day. Thus it can be determined water requirements of the population / domestic whereas for non-domestic water requirements the planned 15% of

domestic water requirements / household. Loss of water due to leaks in distribution pipes, illegal connections, damage or inaccuracies meter readings taken 20% of the new system and 30 to 50% for the old system of domestic water requirements and non-domestic. Water requirement for the planned peak hours 1.75 of domestic water requirements, non-domestic and water loss. So a requirement of water for population in Watershed Malino is:

TABLE III. Total Water Requirement Population

No.	Year	Water requirement (m^3/sec)
1.	2013	0.050
2.	2015	0.051
3.	2018	0.061
4.	2023	0.061
5.	2033	0.075

Source: Results of the analysis

Cropping patterns in Watershed Malino currently is the planting season 1: February / March and season 2: September / October. Based on this cropping pattern and rain and climatological data analysis, are used to determine water requirements in the intake / weir. Rice area in Watershed Malino currently is 3512.4 ha. Thus it can be counted on the rice crop water requirements Watershed Malino.

TABLE IV. Water Requirement for Rice

No.	Months	Water requirement (m^3/sec)
1	January	0.850
2	February	5.830
3	March	5.553
4	April	3.140
5	May	0.000
6	June	0.457
7	July	0.000
8	August	0.576
9	September	6.185
10	October	5.578
11	November	3.864
12	December	2.750

Source: Results of the analysis

Data on the number of livestock from the Central Statistics Agency Central Sulawesi form Ongka District of Malino in numbers 2012 and 2013, where a large number of livestock four feet = 6762 tails, four small feet = 1713 tails, pig = 1508 tails and fowl 29820 tail. Livestock water needs in Watershed Malino is 305.98 m^3 / day or 0.004 m^3 / sec.

Malino River water availability is calculated by the method of FJ. Mock. The results of the calculations are presented in Table 5.

TABLE V. Calculation Results Malino River Water Availability (m^3 / s)

Nr.	Year	Jan	Feb	March	April	May	June	July	Augst	Sep	Oct	Nov	Dec	Sum
1	2002	3.834	2.451	1.550	1.994	0.975	0.705	0.478	0.334	0.242	0.164	0.119	0.080	12.926
2	2003	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536	34.504
3	2004	4.623	2.674	1.691	7.352	2.341	1.693	4.626	1.690	1.222	0.828	1.106	0.531	30.376
4	2005	0.372	0.288	0.182	3.979	7.981	8.649	6.693	3.757	2.975	11.164	4.411	2.518	52.968
5	2006	1.940	2.894	1.188	2.323	6.370	6.649	3.405	1.858	1.344	0.911	8.026	5.765	42.672
6	2007	7.126	14.916	5.324	5.883	5.057	3.869	8.026	10.250	7.722	3.371	2.438	5.926	79.907
7	2008	8.228	3.134	10.610	7.567	5.044	7.417	11.167	11.942	4.636	12.605	10.645	5.252	98.247
8	2009	3.240	5.744	5.401	4.290	4.653	6.611	4.777	2.223	1.608	1.089	0.788	0.534	40.958
9	2010	3.671	1.781	6.870	4.916	19.475	15.559	19.844	13.901	14.580	9.500	10.174	5.286	125.556
10	2011	4.453	6.273	9.001	3.941	8.400	6.663	5.788	6.954	5.693	9.464	6.150	2.910	75.690
11	2012	3.000	3.554	6.568	6.002	2.345	1.687	8.851	3.582	2.061	8.369	11.475	11.376	68.869
12	2013	4.740	9.498	3.383	9.404	10.976	4.072	11.080	8.425	4.659	2.757	1.994	14.115	85.103

Source: Results of the analysis

Dependable of flow Malino River based on the basic year of planning, the result is:

TABLE VI. Calculation of Basic Year Planning

Nr.	Year	Discharge (m^3/sec)	Rank	Year	Basic year
1	2002	12.926	12.926	2002	
2	2003	34.504	30.376	2004	
3	2004	30.376	34.504	2003	Q_{80} = n/5 + 1
4	2005	52.968	40.958	2009	= 12/5 + 1 = 3,4
5	2006	42.672	42.672	2006	
6	2007	79.907	52.968	2005	
7	2008	98.247	68.869	2012	
8	2009	40.958	75.690	2011	
9	2010	125.556	79.907	2007	
10	2011	75.690	85.103	2013	
11	2012	68.869	98.247	2008	
12	2013	85.103	125.556	2010	

Source: Results of the analysis

The basic year is 2003 as a planning rank 3 with dependable of flow is;

TABLE VII. Dependable of Flow Malino River

Month	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Discharge (m^3/sec)	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536

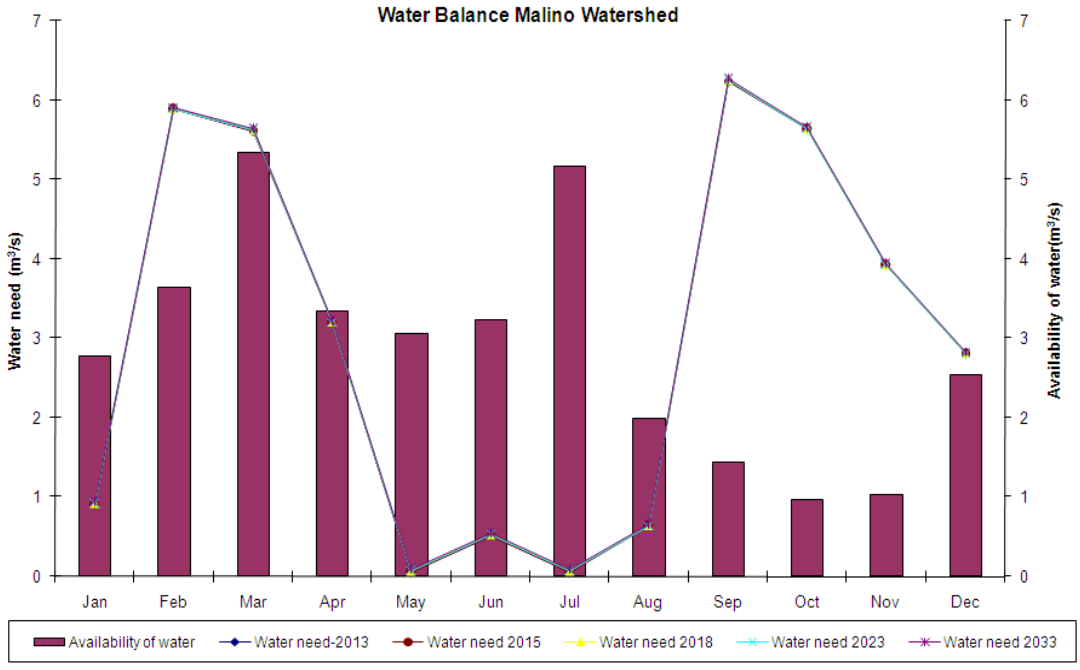
Source: Results of the analysis

To determine the ratio between the availability of water in the River Malino (dependable of flow) and water requirements in watershed Malino, then made a table and figure water balance following:

TABLE VIII. Water Balance Watershed Malino

Month Year	Jan	Feb	March	April	May	June	July	Augst	Sep	Oct	Nov	Dec
2013												
Rice crop water requirement (m^3/s)	0.850	5.831	5.553	3.140	0.000	0.457	0.000	0.576	6.185	5.578	3.864	2.750
Water requirement the population (m^3/s)	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Livestock water requirement (m^3/s)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Total water requirement (m^3/s)	0.904	5.885	5.607	3.194	0.054	0.511	0.054	0.630	6.239	5.632	3.918	2.804
Availability of water (m^3/s)	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536
2015												
Rice crop water requirement (m^3/s)	0.850	5.831	5.553	3.140	0.000	0.457	0.000	0.576	6.185	5.578	3.864	2.750
Water requirement the population (m^3/s)	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
Livestock water requirement (m^3/s)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Total water requirement (m^3/s)	0.905	5.886	5.608	3.195	0.055	0.512	0.055	0.631	6.240	5.633	3.919	2.805
Availability of water (m^3/s)	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536
2018												
Rice crop water requirement (m^3/s)	0.850	5.831	5.553	3.140	0.000	0.457	0.000	0.576	6.185	5.578	3.864	2.750
Water requirement the population (m^3/s)	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
Livestock water requirement (m^3/s)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Total water requirement (m^3/s)	0.915	5.896	5.618	3.205	0.065	0.522	0.065	0.641	6.250	5.643	3.929	2.815
Availability of water (m^3/s)	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536
2023												
Rice crop water requirement (m^3/s)	0.850	5.831	5.553	3.140	0.000	0.457	0.000	0.576	6.185	5.578	3.864	2.750
Water requirement the population (m^3/s)	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
Livestock water requirement (m^3/s)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Total water requirement (m^3/s)	0.915	5.896	5.618	3.205	0.065	0.522	0.065	0.641	6.250	5.643	3.929	2.815
Availability of water (m^3/s)	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536
2033												
Rice crop water requirement (m^3/s)	0.850	5.831	5.553	3.140	0.000	0.457	0.000	0.576	6.185	5.578	3.864	2.750
Water requirement the population (m^3/s)	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Livestock water requirement (m^3/s)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Total water requirement (m^3/s)	0.929	5.910	5.632	3.219	0.079	0.536	0.079	0.655	6.264	5.657	3.943	2.829
Availability of water (m^3/s)	2.778	3.640	5.338	3.344	3.053	3.225	5.171	1.983	1.434	0.972	1.032	2.536

Source: Results of the analysis



Source: Results of the analysis

Fig. 2. Water Balance Watershed Malino

IV. CONCLUSION

The results of the analysis hydrology of the Watershed Malino can be concluded as follows:

1. The need for water in the Watershed Malino for 2, 5 and 20 years 10 relative not change significantly. Needs sufficient water occurred in the period February-March and September-October. This happens because in this period is a time of preparing land for rice plants that require more water.
2. Availability of water occurs Malino River upward trend from January, February and a peak in March. In April, May and June relatively stable and rose to a peak in July. In August, September, October and November decreased and rose again in December.
3. By considering the water balance of the graph, then the month of February and the month of September to December shortage of water. Sufficient water shortage occurred in September, October and November. Excess water occurs in January and May to August.

To overcome the shortage of water in the watershed Malino needs to be done the following steps:

1. Cropping pattern needs to be reviewed to become season 1: December / January and season 2: July / August
2. At the time of shortage of water, the water available for the priority needs of the population and livestock
3. Keep in preserve existing forests in Watershed Malino.

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AUTHOR PROFILE

I Wayan Sutapa, graduating Water Engineering Brawijaya University Malang in 1990, the graduate program IHE-Delft the Netherlands for Master of Engineering in 2001 and a Doctoral Program in Civil Engineering at the University of Brawijaya, 2013. It publishes the International Journal of 4 pieces and already several times following the International Seminar. Now as a lecturer in the Faculty of Civil Engineering Tadulako and as a Researcher in the field of water resources.