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EFFECT OF CLIMATE CHANGE ON ANNUAL WATER ALLOCATION PLAN

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The most felt impact due to climate change in Indonesia is the climate anomaly. This condition will affect the planning of water allocation. The purpose of this study was to determine the impact of climate change on the annual water allocation plan. This research was conducted in the Bangga watershed, Indonesia. The methods used include climate change detection, irrigation water needs, domestic and non-domestic water needs, water availability, water balance, and an annual water allocation plan. The data used is daily rainfall data for 29 years (1993-2021) from Bangga Atas and Bangga Bawah stations and climate data from Bora station for the same period. The results of this study are: there has been a change in climate in the Bangga watershed and there has been an increase in rainfall in the last 10 years so the availability of water has also increased. Climate change has a very big influence on the availability of rivers, especially in the dry year, causing a water deficit. This condition applies to the period 1995-2021. In normal year conditions and wet year conditions, there is a change in the status of the water balance from deficit to surplus for the last 10 years. The annual water allocation plan based on the period 2012-2021 is proposed as an annual water allocation plan for the next five years and can be reviewed after three years. Meanwhile, the strategy to reduce the water shortage deficit is to make a priority scale for all water needs.

Keywords: climate change, water balance, water allocation annual plan, Bangga watershed

1 INTRODUCTION

The most felt impact due to climate change in Indonesia is the climate anomaly. This phenomenon causes the rainy season to last shorter with increasing intensity and the dry season to last longer than usual conditions. Rainwater that falls with high intensity cannot be accommodated by water bodies, causing flooding and a relatively long dry season resulting in drought.

The availability of water in a river area that is implemented in a watershed must be calculated for the discharge. This is very necessary to support the survival of humans and other living things in the area. From year to year the amount of water demand continues to increase in line with the increase in population, and the increase in living standards, while following the phenomenon of the hydrological cycle, it shows that the amount of water on land can be said to be constant and the volume of water is highly dependent on seasonal weather. To meet water needs for various types of purposes, such as for basic household needs, agriculture, fisheries and animal husbandry, industry, and power generation, water tends to be an object that is contested by its users. This is the beginning of the emergence of problems/disputes in the use of water.

Saving, protecting, and fulfilling water does not only concern current needs but must be able to ensure continuity of service in the future because this is directly related to human existence. Thus, the community must be ready to play an active role in planning and implementing a sustainable community water supply. The planning includes efforts to conserve water resources, and supply and allocate water following the order of priorities that have been set for each river area.

The phenomenon of the hydrological cycle provides an understanding that the availability of water on land is highly dependent on meteorological and geographical conditions of the region, the amount of water on land every year can be said to be constant, and the volume of water contained in a place is very dependent on the seasonal weather, namely rainy and dry.

Water allocation is a series of actions needed to regulate water quotas according to the type of water used, an effort to always be able to meet the quantity and quality of water following the rights guaranteed by the state. The basic needs of daily life and people's agricultural business in the irrigation system are the main priority, as well as the rights of other water users obtained based on water use permits, where the amount/volume of water that may be taken from a water source network for a business need has been determined. With the allocation of water, it is hoped that it will prevent violations that can result in disruption of the human rights of other people or parties [1]. To identify climate change, a composite analysis was carried out by classifying rainfall for 10 years, namely the period 1995 - 2011 as the baseline condition and the period 2012-2021 representing the current condition [2]. The purpose of this study was to determine the impact of climate change on the Annual Water Allocation Plan of Bangga river.

The Bangga River has a Bangga weir to irrigate the Bangga Irrigation area with a potential area of 416 ha. In addition, the water of the Bangga River is also used for raw water in the village of Bangga with a population of 2603 people in 2020, with an average annual population growth of 2.1% [3]. During the dry season, the water of the Bangga River is so reduced that it is unable to meet the water needs for irrigation and raw water for its residents. Therefore, we need effective and efficient water planning and regulation.

To preserve water in the Bangga River Basin, the existing forest land needs to be maintained. Based on data from the Palu-Poso Watershed Management Agency in 2021, the land cover of the Bangga watershed is 71.60 km^2 consisting of: forest 51.98 km^2 (72.6%), shrubs 13.43 km^2 (18.8%), settlements 0.13 km^2 (0.2%), open land 0.42 km^2 (0.6%), agriculture/paddy fields 5.64 km^2 (7.9%).

The importance of knowing the deficit of atmospheric vapor pressure (VPD) as a limiting factor for greening trends in dry areas. The effect of VPD on vegetation growth should be considered when evaluating the function of arid ecosystems under global warming [4].

By outlining the level of contribution of human activities and climate change to runoff, it is shown that the level of contribution of human activities to the reduction of runoff is greater than the contribution of climate change [5].

Increased temperature extremes and decreased soil water content (SWC) can result in severe yield reductions with negative impacts on growth stages for local crops such as wheat and canola [6].

2 MATERIAL AND METHODS

2.1 Description of study

The location of this research is in the Bangga watershed, Sigi Regency, Central Sulawesi, Indonesia with a watershed area of 65.90 km^2. Astronomically, Sigi Regency is located at the position of 119°38'45" - 120°21'24" East Longitude and 0°52'16" - 2°03'21" South Latitude. As with other regions in Indonesia, Sigi Regency has two seasons, namely the summer and rainy seasons. Summer occurs between April – September, while the rainy season occurs from October – March. The majority of the population's livelihood is as farmers and only a small part works as civil servants. Geographical conditions are at an altitude between 32 – 1350 m above sea level, most of the location is hilly. The research location is presented in the following figure:

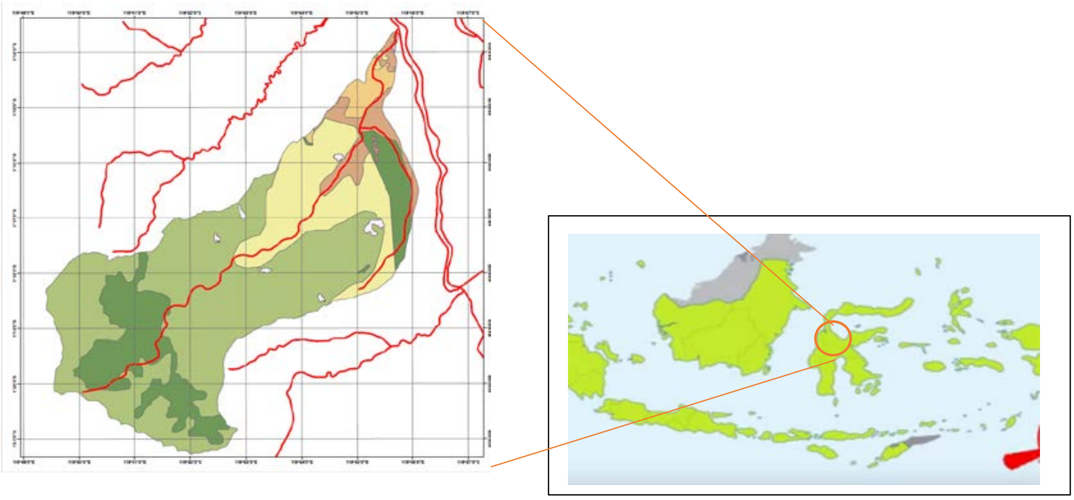

Fig.1. Location of research

2.2 Model description

2.2.1 Evapotranspiration

Evapotranspiration is the event of water loss from plant tissue and the soil surface used as a place to grow plants. Many methods can be used to calculate evapotranspiration. Potential evapotranspiration is calculated by the Penman Montheit. The input data is in the form of climatological data for Bora Station for 1995-2021 which was obtained from the Department of Human Settlements and Water Resources of Central Sulawesi.

2.2.2 Climate change

Detection of climate change uses the Mann-Kendall equation [7], [8], [9], [10]. The presence or absence of a trend is evaluated using the "Z" value. A positive/negative value of "Z" indicates an up/down trend. The "Z" statistic is a normal distribution to test the up and down trend at a certain level. If Z_{cal} is greater than Z then the trend is significant, and vice versa if Z_{cal} is smaller than Z then the trend is not significant. If the value of "Z" is equal to zero, it means that there is no trend. The value of Zα is obtained from the normal cumulative distribution table. In Mann-Kendall the level of significance tested is 0.001 ; 0.01 ; 0.05 and 0.1 with Zα = 3.292 ; 2,576 ; 1.96 and 1.645 respectively. In Mann Kendall's calculation results will appear several categories, namely NYS, NT, NNS, PNS. NYS stands for Negative Yes Significant, meaning the value of Z < 0 (declining trend), and significant (Z_{cal} > Zα). NT stands for No Trend, meaning that the value of Z = 0. NNS stands for Negative No Significant, meaning that the value of Z < 0 (declining trend) and not significant (Z_{cal} > Zα). PNS stands for Positive No Significant, meaning that the Z value > 0 but not significant (Z_{cal} > Zα). NYS stands for Negative Yes Significant, meaning the value of Z < 0 (declining trend) and significant (Z_{cal} > Zα). Input data in the form of monthly rainfall for Bangga Atas and Bangga Bawah stations from 1995-2021.

2.2.3 Drinking water needs (domestic and non-domestic)

The need for drinking water is increasing as the population increases in the future. This requires population projections for the planning year. There are several population projection methods used for planning, namely Arithmetic Method, Geometric Method, and Exponential Method [11]. Meanwhile, domestic and non-domestic water needs are calculated using population statistics [12].

a) Domestic water requirement/household.

Table 1. Standard domestic water requirement

No.	Total Population	Type of City	Water Requirement (liter/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.

2.2.4 Rice plant water needs

The water requirement of rice plants can be calculated by the following equation [12]:

1. The period of land preparation: NFR = IR - Re

2. The period of growth: NFR=ETc+P+WLR- Re

Input data in the form of semi-monthly rain data, evapotranspiration, percolation, and cropping patterns

2.2.5 Water availability

The availability of river water uses the empirical equation of the MockWyn-UB model, a model developed from the FJ model. Mock [13]. [14] which considers vegetation land cover and climate change factors [9], [15], [16].

Creating a model of MockWyn-UB is done following stages:

1. Rainfall

   Rainfall is calculated based on the area of land use.

   $P_{HT} = (L_{HT} / L_{DAS}) \times P_{DAS}$ (1)

   $P_{KC} = (L_{KC} / L_{DAS}) \times P_{DAS}$ (2)

   $P_{LT} = (L_{LT} / L_{DAS}) \times P_{DAS}$ (3)

2. The net rainfall (P_{NT})

   Net rainfall based on land cover and vegetation canopy interception by using the results of research by Dunne and Leopold (1978)

   $P_{NT}HT = 0.886\ P_{DAS} + 0.088$ (4)

   $P_{NT}KC = 0.925\ P_{DAS} + 0.333$ (5)

   $P_{NT}LT = P_{LT}$ (6)

   $T_{PN} = P_{NT}HT + P_{NT}KC + P_{NT}LT$ (7)

3. Potential evapotranspiration (ETo)

   Potential evapotranspiration for each month is calculated from the Penman-Monteith method [17], [18], [19]:

   $$ET_0 = \frac{0{,}408\Delta Rn + \gamma \dfrac{900}{(T+273)} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0{,}34 U_2)} \quad (8)$$

4. Actual evapotranspiration (ETa)

   Actual evapotranspiration is divided into two parts:

   If T_{PN} > ETo then the ETa = ETo (9)

If the $T_{PN} < ETo$,
then the $ETa = T_{PN} + \Delta SM$ (10)

5. Difference between T_{PN} with the monthly ETo,

$$S = T_{PN} - ETo \quad (11)$$

6. Accumulated potential water loss, APWL

   In the dry months or $T_{PN} < ETo$ is done by adding up the value difference (T_{PN} - ETo) each month with a value of (T_{PN} - ETo) the previous month. In the wet months or $T_{PN} > ETo$, then the value of APWL is equal to zero

7. Soil Moisture, SM

   In the wet months or $T_{PN} > ETo$, SM value for each month is equal to field capacity. In the dry months or $T_{PN} < ETo$, SM value is calculated by the equation:

$$SM = SMC.\ e^{-(APWL\ /\ SMC)} \quad (12)$$

8. Changes in monthly soil moisture (ΔSM)
9. *Water surplus* (WS)

   Water surplus occurs in wet months (TPN > ETo), obtained by If SM < SMC, then WS = 0 and if not then WS = S

10. Groundwater storage

    Value runoff and groundwater depend on the amount of water balance and soil conditions. The data required are:

    The coefficient of infiltration (In), the value 0.2 to 0.5. Groundwater flow recession factor (k), the value from 0.4 to 0.7

$$I = WS \times In \quad (13)$$

$$Vn = k\ .\ V_{n-1} + 0{,}5\ (1 + k).\ I \quad (14)$$

$$\Delta Vn = V_{n-1} - Vn \quad (15)$$

11. Factor heavy rain (FHR, Storm Run Off, SR)
12. Experience has shown that, although in certain months there is no water surplus (WS), some direct flow occurs during heavy rains. SR value was taken a few percent of the net rainfall.
13. Simulation WSα water surplus with the following provisions: 1). The highest value WS minus the value of the highest FHR
14. 2). The 2nd highest value WS minus the second highest value FHR. 3). Similarly, onwards. For outside of the above provisions, then the value WSα = WS
15. Heavy rain factor (FHR) = SR x TP
16. River flow

    Base Flow, $BF = I + \Delta Vn$ (16)

    Direct Run Off, $DR = WS\alpha - I + FHR$ (17)

    Run Off, $RO = BF + DR$ (18)

    River flow, $Q = RO \times$ watershed area (19)

Input data in the form of monthly rain, potential evapotranspiration, land cover vegetation area, and climate change scenarios.

2.2.6 Dependable flow

Dependable flow is a discharge that is expected to be available throughout the year with the smallest possible calculated failure risk. The input data is the result of calculating the availability of water which is ranked and the probability is calculated using the Weibull equation.

2.2.7 Water allocation

Water allocation is a series of actions needed to regulate water quotas according to the type of water used, an effort to always be able to meet the quantity and quality of water following the rights guaranteed by the state [1]. There are three scenarios applied, namely: wet conditions, normal conditions, and dry conditions. The annual water allocation plan (RAAT) for wet conditions uses the $Q\ A_{verage}$ dependable flow, normal conditions use the Q_{50} dependable flow and dry conditions use the Q_{80} dependable flow.

2.3 Methods

The complete research methodology is presented in Figure 2.

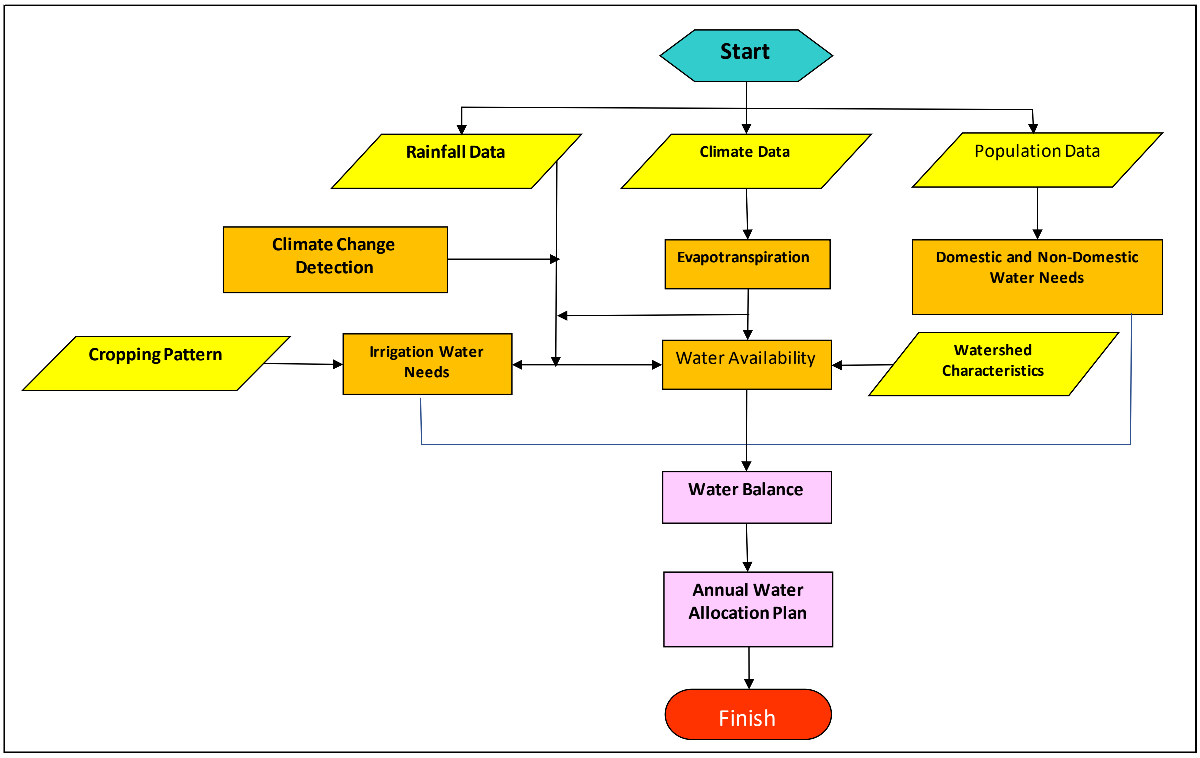

Fig. 2. Research flow chart

3 RESULTS AND DISCUSSION

3.1 Pattern of rainfall

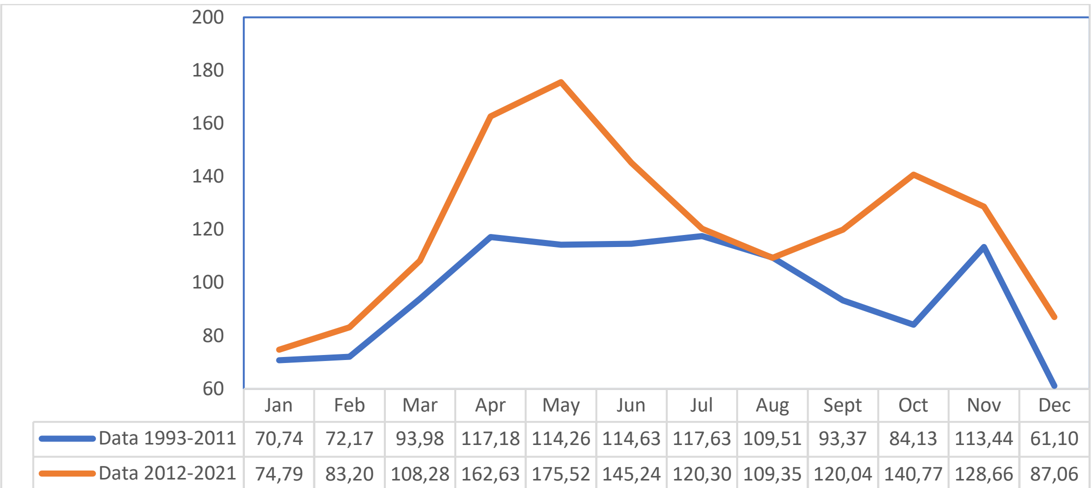

Fig. 3. The monthly average rainfall pattern for Bangga Atas & Bangga Bawah Stations

Based on Figure 3, it can be seen that the monthly average rain includes the equatorial rain pattern because the peak rain occurs around April and October. This condition occurs for rain data for the 1993-2011 period and the 2012-2021 period. But what distinguishes it is the rainfall for the 1993-2011 period is smaller than the 2012-2021 period. This also indicates that the average rainfall in the last 10 years is greater than in the previous decade.

Climate change detection

The results of the calculation of climate change detection using the Mann-Kendal Method are presented in Table 2.

Table 2. Climate change detection

Description	Month - Z value													
Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Yearly
1995-2011	0.00	-0.53	-0.42	-0.95	-0.77	-0.98	-0.42	0.14	-0.98	-2.31	-0.56	1.40	-1.02	-1.02
Significant	NT	NNS	NNS	NNS	NNS	NNS	NNS	PNS	NNS	NYS	NNS	PNS	NNS	NNS
2012-2021	1.07	0.89	1.43	0.54	1.07	1.61	1.25	0.54	1.25	1.43	0.00	-1.43	1.61	1.61
Significant	PNS	PNS	PNS	PNS	PNS	PNS	PNS	PNS	PNS	PNS	NT	NNS	PNS	PNS

Description	Month - Z value													
Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Yearly
1995-2021	0.62	0.98	1.18	0.19	0.77	0.96	-0.06	0.58	0.32	0.21	0.21	0.81	1.43	1.43
Significant	PNS	PNS	PNS	PNS	PNS	PNS	NNS	PNS	PNS	PNS	PNS	PNS	PNS	PNS

where:

NT = No Trend
NNS = Negative No Significant
NYS = Negative Yes Significant
PNS = Positive No Significant

Based on table 2 above, it can be explained that the value of Z > 0 and Z < 0 indicates climate change occurs except in January. The Z value in the period 1995-2011 is smaller than zero (Z < 0) which means that there is a decreasing trend of rain, while in the period 2012-2021 the Z value is greater than zero (Z > 0) which means that there is an increasing trend of rainfall. The same thing happened in the period 1995-2021 there was an upward trend except in July. This shows that in the last 10 years there has been an increase in rainfall compared to the previous decade.

3.2 Water balance

The results of the calculation of the water balance of the Bangga Watershed are presented in Table 3 below. Based on the table, it can be explained that in the dry year there was a water deficit for the period 1995-2011 and 2012-2021. In normal years there is a change in the status of the water balance to surplus except in January to May. The same thing happens in wet years except for January and February. This indicates that an increase in rainfall has resulted in an increase in the availability of river water in the last 10 years (2012-2021).

Climate change has a very big influence on the availability of river water, especially in the dry year (Q_{80}), causing a water deficit. This condition applies to the period 1995-2021. In normal year conditions (Q_{50}) and wet year conditions ($Q\ A_{verage}$), there is a change in the status of the water balance from deficit to surplus for the last 10 years decade (2012-2021).

Table 3. Recapitulation water balance

No.	Description	Month - m^3/sec																							
		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Ocr		Nov		Dec	
1	Dry year																								
	Period 1995-2011	-0,17	-0,16	-0,11	-0,08	-0,07	-0,07	-0,05	-0,06	-0,26	-0,25	-0,15	-0,17	-0,18	-0,17	-0,16	-0,09	-0,07	-0,08	-0,07	-0,07	-0,27	-0,27	-0,14	-0,16
	Water Balance Status	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	Period 2012-2021	-0,14	-0,15	-0,08	-0,05	-0,04	-0,04	-0,08	-0,07	-0,31	-0,32	-0,18	-0,23	-0,22	-0,22	-0,15	-0,09	-0,12	-0,12	-0,12	-0,11	-0,24	-0,22	-0,13	-0,16
	Water Balance Status	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
2	Normal year																								
	Period 1995-2011	-0,13	-0,12	-0,06	-0,03	-0,03	-0,03	0,07	0,06	-0,19	-0,18	-0,08	-0,11	-0,05	-0,04	-0,01	0,05	0,03	0,03	0,00	0,00	-0,21	-0,22	-0,10	-0,12
	Water Balance Status	D	D	D	D	D	D	S	S	D	D	D	D	D	D	D	S	S	S	S	S	D	D	D	D
	Period 2012-2021	-0,10	-0,10	-0,04	-0,02	-0,02	-0,02	0,10	-0,06	-0,07	-0,08	0,95	0,89	0,30	0,30	0,22	0,29	0,16	0,16	0,14	0,15	0,09	0,11	0,13	0,11
	Water Balance Status	D	D	D	D	D	D	S	D	D	D	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3	Wet year																								
	Period 1995-2011	-0,01	0,00	0,17	0,19	0,13	0,13	0,13	0,12	-0,10	-0,09	0,23	0,21	0,23	0,25	0,31	0,37	0,24	0,23	0,13	0,13	0,08	0,07	-0,02	-0,05
	Water Balance Status	D	D	S	S	S	S	S	S	D	D	S	S	S	S	S	S	S	S	S	S	S	S	D	D
	Period 2012-2021	-0,07	-0,08	-0,03	0,00	0,04	0,04	0,51	0,52	0,62	0,61	0,70	0,65	0,59	0,58	0,36	0,43	0,56	0,56	0,63	0,64	0,23	0,24	0,24	0,21
	Water Balance Status	D	D	D	D	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

Where:
- **D** = Defisit
- S = Surplus

3.3 The annual water allocation plan

By taking into account the water balance in the dry, normal and wet year conditions for the 1995-2011 and 2012-2021 periods, the annual water allocation plan based on the 2012-2021 period which is assumed to represent climate change is proposed as an annual water allocation plan for the Bangga watershed for five years. and will be reviewed after three years. Meanwhile, the strategy to reduce the water shortage deficit is to make a priority scale. The priority is to fulfill basic daily needs (worship, drinking water, cooking, washing, and lighting). If the water for basic needs is also not sufficient then it is done in turn. Likewise, for irrigation purposes, if the availability of water does not meet it, a shift system is treated. The annual water allocation plan for the Bangga watershed is presented in the following table.

Table 4. Annual water location plan for the Bangga watershed

Description	Discharge (m^3/s)																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov.		Dec	
A. Dry year																								
1. Water availability (Q_{80})	0,001	0,001	0,003	0,003	0,002	0,002	0,002	0,002	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,000	0,000	0,000	0,000	0,054	0,054	0,036	0,036
2. Water use																								
a. Consumtive use	0,135	0,143	0,073	0,051	0,033	0,034	0,021	0,017	0,216	0,229	0,089	0,141	0,140	0,143	0,102	0,039	0,049	0,050	0,046	0,036	0,237	0,224	0,129	0,157
1. Irrigation	0,127	0,135	0,065	0,043	0,025	0,026	0,013	0,009	0,208	0,221	0,081	0,133	0,132	0,135	0,094	0,031	0,041	0,042	0,038	0,028	0,229	0,216	0,121	0,150
2. Drinking water	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008
b. Non consumtive use																								
River maintenance (10% Q_{ave})	0,007	0,007	0,005	0,005	0,008	0,008	0,059	0,059	0,093	0,093	0,088	0,088	0,081	0,081	0,052	0,052	0,067	0,067	0,075	0,075	0,052	0,052	0,041	0,041
Total use (a+b)	0,142	0,150	0,079	0,056	0,041	0,041	0,081	0,076	0,309	0,323	0,178	0,229	0,220	0,224	0,154	0,091	0,116	0,117	0,121	0,111	0,289	0,276	0,171	0,199
3. Water balance	-0,141	-0,149	-0,075	-0,053	-0,039	-0,039	-0,079	-0,075	-0,308	-0,321	-0,177	-0,228	-0,220	-0,223	-0,153	-0,091	-0,115	-0,116	-0,121	-0,111	-0,235	-0,222	-0,134	-0,162
Water balance status	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
B. Normal year																								
1. Water availability (Q50)	0,047	0,047	0,036	0,036	0,023	0,023	0,181	0,018	0,238	0,238	1,123	1,123	0,521	0,521	0,379	0,379	0,274	0,274	0,261	0,261	0,384	0,384	0,305	0,305
2. Water use																								
a. Consumtive use	0,135	0,143	0,073	0,051	0,033	0,034	0,021	0,017	0,216	0,229	0,089	0,141	0,140	0,143	0,102	0,039	0,049	0,050	0,046	0,036	0,237	0,224	0,129	0,157
1. Irrigation	0,127	0,135	0,065	0,043	0,025	0,026	0,013	0,009	0,208	0,221	0,081	0,133	0,132	0,135	0,094	0,031	0,041	0,042	0,038	0,028	0,229	0,216	0,121	0,150
2. Drinking water	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008
b. Non consumtive use																								
River maintenance (10% Qave)	0,007	0,007	0,005	0,005	0,008	0,008	0,059	0,059	0,093	0,093	0,088	0,088	0,081	0,081	0,052	0,052	0,067	0,067	0,075	0,075	0,052	0,052	0,041	0,041
Total use (a+b)	0,142	0,150	0,079	0,056	0,041	0,041	0,081	0,076	0,309	0,323	0,178	0,229	0,220	0,224	0,154	0,091	0,116	0,117	0,121	0,111	0,289	0,276	0,171	0,199
3. Water balance	-0,096	-0,103	-0,042	-0,020	-0,018	-0,018	0,101	-0,058	-0,071	-0,084	0,945	0,893	0,300	0,297	0,225	0,288	0,158	0,157	0,140	0,150	0,095	0,108	0,135	0,107
Water balance status	D	D	D	D	D	D	S	D	D	D	S	S	S	S	S	S	S	S	S	S	S	S	S	S
C. Wet year																								
1. Water availability (Qave)	0,069	0,069	0,052	0,052	0,077	0,077	0,592	0,592	0,932	0,932	0,882	0,882	0,806	0,806	0,518	0,518	0,673	0,673	0,748	0,748	0,519	0,519	0,412	0,412
2. Water use																								
a. Consumtive use	0,135	0,143	0,073	0,051	0,033	0,034	0,021	0,017	0,216	0,229	0,089	0,141	0,140	0,143	0,102	0,039	0,049	0,050	0,046	0,036	0,237	0,224	0,129	0,157
1. Irrigation	0,127	0,135	0,065	0,043	0,025	0,026	0,013	0,009	0,208	0,221	0,081	0,133	0,132	0,135	0,094	0,031	0,041	0,042	0,038	0,028	0,229	0,216	0,121	0,150
2. Drinking water	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008	0,008
b. Non consumtive use																								
River maintenance (10% Qave)	0,007	0,007	0,005	0,005	0,008	0,008	0,059	0,059	0,093	0,093	0,088	0,088	0,081	0,081	0,052	0,052	0,067	0,067	0,075	0,075	0,052	0,052	0,041	0,041
Total use (a+b)	0,142	0,150	0,079	0,056	0,041	0,041	0,081	0,076	0,309	0,323	0,178	0,229	0,220	0,224	0,154	0,091	0,116	0,117	0,121	0,111	0,289	0,276	0,171	0,199
3. Water balance	-0,073	-0,081	-0,026	-0,004	0,036	0,036	0,511	0,516	0,623	0,610	0,705	0,653	0,585	0,582	0,364	0,427	0,557	0,556	0,627	0,637	0,230	0,243	0,241	0,213
Water balance status	D	D	D	D	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

4 CONCLUSIONS

Based on the results of the analysis and discussion, several conclusions can be drawn, namely:

1. There has been a change in climate in the Bangga watershed which is indicated by the value of Z≠0
2. There has been an increase in rainfall in the last 10 years so the availability of water has also increased.
3. Climate change has a very big influence on the availability of river water, especially in the dry year (Q_{80}), causing a water deficit. This condition applies to the period 1995-2021. In normal year conditions (Q_{50}) and wet year conditions (Q A_{verage}), there is a change in the status of the water balance from deficit to surplus for the last 10 years (2012-2021).
4. An annual water allocation plan based on the period 2012-2021 which is assumed to represent the occurrence of climate change is proposed as an annual water allocation plan for the Bangga watershed for the next five years and can be reviewed after three years.
5. The strategy to reduce the water shortage deficit is to make a priority scale for all water needs (basic needs, irrigation water, and river maintenance).

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