

Water Balance Analysis in Bera Watershed Sumbawa River Basin

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ABSTRACT:

Bera Watershed is one of the watersheds located in 555 Watershed of Sumbawa River Basin. Bera Watershed has an area of 164.6 km² (effective area of 148.39 km²). Bera watershed is one of the important things because it is one of the utility watersheds in Sumbawa River Basin. Bera Watershed consists 1 of reservoir, 4 of small reservoirs, dan 20 of weirs.

Calculation steps in this study: 1) Calculation of regional rainfall using 11 ARR (Automatic Rainfall Recorder) with Isohyet Method and IDW Analysis (Inverse Distance Weighted) Using software ArcGIS 10.4, 2) Evaporation using data from climate station located in Plampang, 3) Water available is calculated using the NFR (Net Field Requirement) method, and 5) Water Balance is calculated using excel by comparing the demand and supply of water that can be provided based on water available.

In this study the results are as follows: 1) Rainfall region in Bera watershed, which range from 0 -124.3 mm (10 days), b) Evaporation in Bera watershed which ranges from 3.94-7.92 mm (10 days), c) Availability of water in Bera watershed calculated using the Mock method with a range of discharge of 0.315 liters/second to 1221.6 liters/second, d) The water requirements in Bera watershed are calculated using the NFR (Net Field Requirement) method with a discharge range of 0.145 liters/second to 2036.3 liters/second, e) Based on the calculation of the water balance it is found that the average water supply is 60%. This indicates that there is a need for better arrangements, both in water collection buildings and in irrigation networks.

Keyword: Bera Watershed, Water Available, Water Balance

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I. INTRODUCTION

West Nusa Tenggara is one of the national rice barns in Indonesia. This has an impact on the importance of management in the utilization of existing water resources. The government through the ministry of public works and public housing has made development efforts in the form of water resources infrastructure as a step in optimally using water. West Nusa Tenggara has 2 River Areas, namely the Lombok River Basin and the Sumbawa River Basin. Based on the PERMEN PUPR No. 4 of 2015 concerning the Criteria and Determination of River Areas states that the two river basin are nationally strategic river areas. The importance of conducting an analysis of the needs and availability of water to find out the balance of water in the Utilities so that operational patterns can be more optimal. This water balance will also become a reference in the development of the watershed in the future, whether or not water resources infrastructure can be built or not.

Based on data from the Regional Office of the Nusa Tenggara I River, the Sumbawa River

Basin has an area of 15,416 km² River Basin consisting of 555 Watersheds that have been used for water use through water collection buildings in 103 Utility Watersheds. Bera Watershed is one of the Utilities Watersheds in Sumbawa River Basin which is used as Sampling Watershed. This is because the watershed is vital considering that it is one of the Watersheds (DAS) that have Dams in it, in addition to the Moyo, Boal, Pelaparado and Cabang Watersheds.

II. STUDY AREA

This research will be carried out in Bera Watersheds in the Sumbawa River Basin. The Bera watershed has an area of 164.6 km² with an effective watershed area of 148.39 km². Bera Watershed consists of 1 Dam, Tiu Kulit Dam, 4 Embung, and 20 Weirs. Tiu Kulit Dam is a dam built to irrigate agricultural land with an area of 1800 ha with the following technical data: a) Reservoir total 11 million m³, b) Effective Reserves 10 million m³, and c) Dead storage 1 million m³.

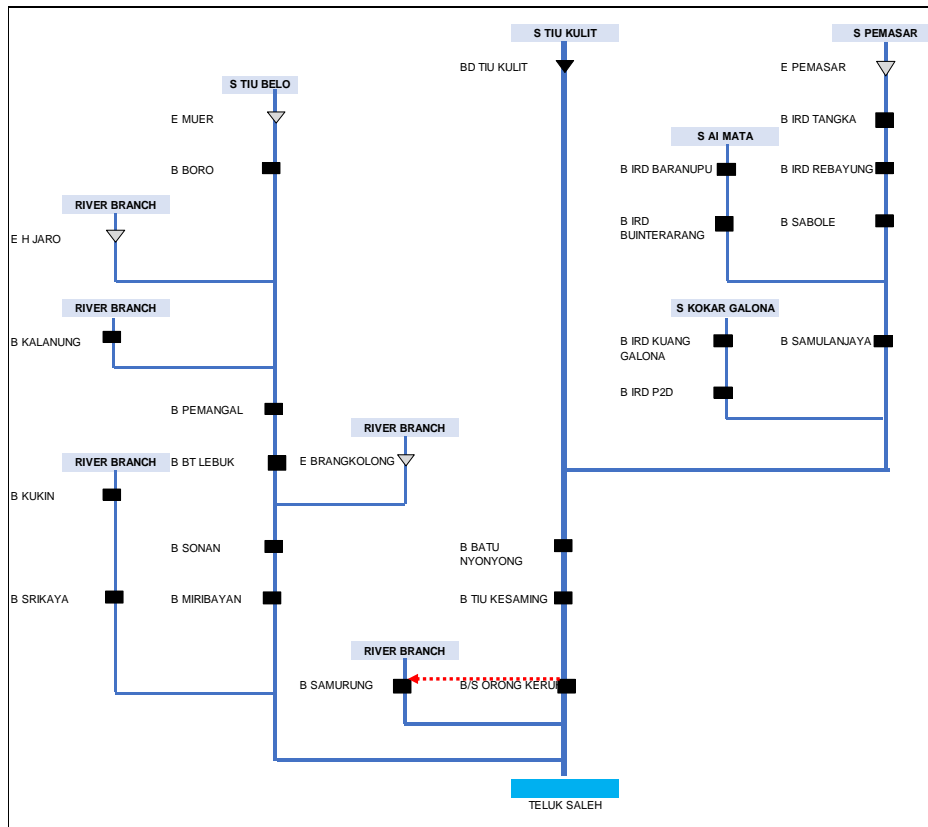


Figure 2.1 Schematic of the Bera Watershed of the Sumbawa River Basin

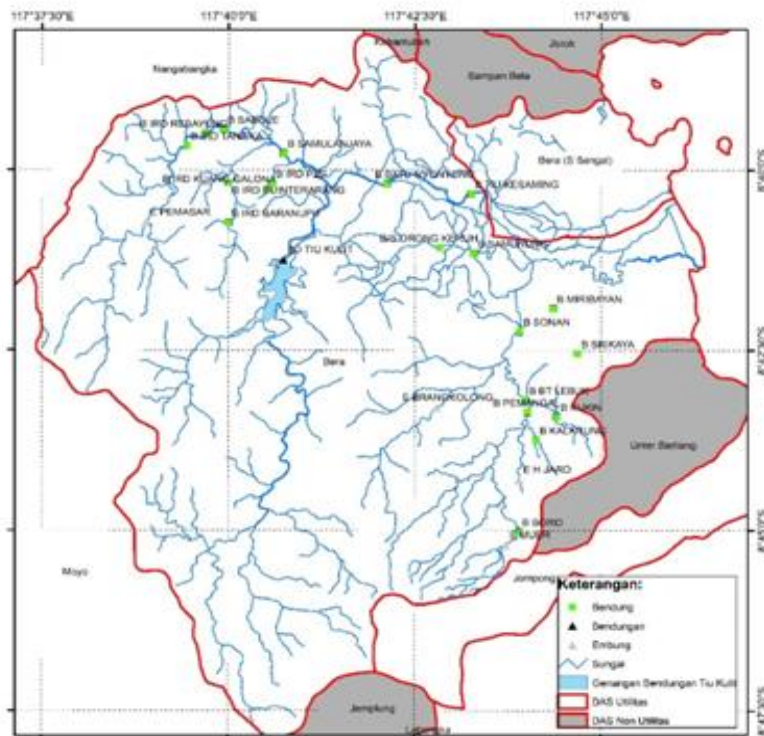


Figure 2.2 Map of Bera Watershed Infrastructure of the Sumbawa River Basin

The following is a list of water resources infrastructure in Bera Watershed Sumbawa River Basin:

Table 2.1 Infrastructure of Water Resources in Bera Watershed Sumbawa River Basin

No	Headwork	Irrigaton Area (Ha)	Authority	Start Planting	Cropping Pattern
1	BD Tiu Kulit	1800	Government	Dec I	Paddy-Paddy-Pal
2	E Pemasar	620	Government	Dec I	Paddy-Paddy-Pal
3	B Ird Tangka	30	Village	Dec I	Paddy-Paddy-Pal
4	B Ird Rebayung	200	Village	Dec I	Paddy-Paddy-Pal
5	B Sabole	30	Districts	Dec I	Paddy-Paddy-Pal
6	B Ird Baranupu	75	Village	Dec I	Paddy-Paddy-Pal
7	B Ird Bunterarang	25	Village	Dec I	Paddy-Paddy-Pal
8	B Samulanjaya	100	Districts	Dec I	Paddy-Paddy-Pal
9	B Ird Kuang Galona	5	Village	Dec I	Paddy-Paddy-Pal
10	B Ird P2D	5	Village	Dec I	Paddy-Paddy-Pal
11	B Batu Nyonyong	100	Districts	Dec I	Paddy-Paddy-Pal
12	B Tiu Kesaming	150	Districts	Dec I	Paddy-Paddy-Pal
13	B/S Orong Keruh	50	Districts	Dec I	Paddy-Paddy-Pal
14	B Samurung	169	Districts	Dec I	Paddy-Paddy-Pal
15	E Muer	286	Government	Dec I	Paddy-Paddy-Pal
16	B Boro	100	Districts	Dec I	Paddy-Paddy-Pal
17	E H Jaro	50	Village	Dec I	Paddy-Paddy-Pal
18	B Kalanung	50	Districts	Dec I	Paddy-Paddy-Pal
19	B Pemanggal	90	Districts	Dec I	Paddy-Paddy-Pal
20	B Batu Lebuk	150	Districts	Dec I	Paddy-Paddy-Pal
21	E Brangkolong	500	Government	Dec I	Paddy-Paddy-Pal
22	B Sonan	80	Districts	Dec I	Paddy-Paddy-Pal
23	B Miribayan	130	Districts	Dec I	Paddy-Paddy-Pal
24	B Kukin	50	Districts	Dec I	Paddy-Paddy-Pal
25	B Srikaya	75	Districts	Dec I	Paddy-Paddy-Pal

III. METHOD

3.1 Rainfall

Calculation of rainfall uses 11 ARR (Automatic Rainfall Recorder) located in Sumbawa River Basin. The method used is isohyet with interpolation analysis, namely Inverse Distance Weighted (IDW) with the help of ArcGIS 10.4 software. The rain that is used is 80 percent probability of dry from each ARR station.

3.2 Evaporation

Calculation of pan evaporation using the climate record of Plampang.

3.3 Water Available

Calculation of water availability uses the FJ Mock model. FJ Mock is an analysis that calculates the amount of water availability (QA) from rain data, for example isohyet.

3.4 Water Demand

The equation is used to determine the maximum irrigation water requirements (QD max) and Net Field requirements (NFR), according to KP-02 (2013: 123).

$$QD \text{ max} = NFR \times AC / (8.64 \times e) \dots \dots \dots (1)$$

With:

$$QD \text{ max} = \text{Irrigation water needs (lt/dt)}$$

- AC = Cropping Area (m²)
- NFR = Net Filed Requirement (mm/day)
- Etc = Plant water needs (comsumtife use), mm/day
- WLR = Replacing the water layer (mm/day)
- P = Percolate (mm/day)
- Re = Curah Hujan Efektif (mm/day)

3.5 Water Balance

The preparation of water balance in a place and in an area is intended to find out the net amount of water obtained so that it can be used as best as possible (Gede, 2009). In this calculation, the water balance is obtained from the difference between water availability and water needs. If the result is positive then the status of the surplus water balance and if the result is negative then the status of the water balance is deficit.

IV. RESULT AND DISCUSSION

4.1 Rainfall

The following data on rainfall results in the Headwork area in Bera Watershed:

Table 4.1 Regional Rainfall Calculation Results (Samples Jan I - Feb III)

No	Headwork	Rainfall (mm)					
		JAN I	JAN II	JAN III	FEB I	FEB II	FEB III
1	BD Tiu Kulit	68.2	69.1	106.0	67.6	93.8	85.8
2	E Pemasar	84.9	59.8	93.5	75.4	96.5	65.8
3	B Ird Tangka	84.8	59.3	92.8	75.9	96.2	64.7
4	B Ird Rebayung	81.9	60.3	94.1	75.1	95.0	66.6
5	B Sabole	80.8	60.7	94.6	74.8	94.6	67.4
6	B Ird Baranupu	77.3	63.2	98.1	72.7	94.5	72.8
7	B Ird Bunterarang	77.0	63.0	97.8	72.9	94.2	72.4
8	B Samulanjaya	78.3	62.0	96.3	73.8	94.1	70.1
9	B Ird Kuang Galona	75.9	63.5	98.3	72.5	93.5	73.1
10	B Ird P2D	75.9	63.5	98.2	72.5	93.5	73.0
11	B Batu Nyonyong	72.2	65.1	100.4	71.5	92.8	76.5
12	B Tiu Kesaming	67.8	66.9	102.7	70.4	91.5	80.1
13	B/S Orong Keruh	62.3	70.6	107.8	67.5	91.5	88.6
14	B Samurung	65.0	69.8	106.8	67.8	92.6	87.1
15	E Muer	50.9	81.6	122.6	57.5	95.1	114.7
16	B Boro	49.4	82.9	124.3	56.5	95.5	117.7
17	E H Jaro	49.7	82.4	123.7	57.0	95.1	116.5
18	B Kalanung	50.0	81.8	122.9	57.7	94.7	115.1
19	B Pemanggal	53.6	79.1	119.3	59.8	94.3	108.7
20	B Batu Lebuk	53.2	78.6	118.7	60.6	93.5	107.6
21	E Brangkolong	59.3	74.8	113.5	63.3	93.5	98.7
22	B Sonan	58.7	74.6	113.2	63.9	93.1	98.0
23	B Miribayan	56.3	75.5	114.4	63.5	92.6	100.0
24	B Kukin	49.4	82.0	123.2	57.7	94.7	115.5
25	B Srikaya	51.8	79.4	119.7	60.2	93.6	109.2

4.2 Evaporation

The following data on rainfall results in the headwork area in Bera Watershed:

Table 4.2 Results of Evaporation Calculations (Samples Jan I - Feb III)

No	Headwork	Evaporation (mm)					
		JAN I	JAN II	JAN III	FEB I	FEB II	FEB III
1	BD Tiu Kulit	4.08	4.55	3.94	4.33	5.18	5.39
2	E Pemasar	4.08	4.55	3.94	4.33	5.18	5.39
3	B Ird Tangka	4.08	4.55	3.94	4.33	5.18	5.39
4	B Ird Rebayung	4.08	4.55	3.94	4.33	5.18	5.39
5	B Sabole	4.08	4.55	3.94	4.33	5.18	5.39
6	B Ird Baranupu	4.08	4.55	3.94	4.33	5.18	5.39
7	B Ird Bunterarang	4.08	4.55	3.94	4.33	5.18	5.39
8	B Samulanjaya	4.08	4.55	3.94	4.33	5.18	5.39
9	B Ird Kuang Galona	4.08	4.55	3.94	4.33	5.18	5.39
10	B Ird P2D	4.08	4.55	3.94	4.33	5.18	5.39
11	B Batu Nyonyong	4.08	4.55	3.94	4.33	5.18	5.39
12	B Tiu Kesaming	4.08	4.55	3.94	4.33	5.18	5.39
13	B/S Orong Keruh	4.08	4.55	3.94	4.33	5.18	5.39
14	B Samurung	4.08	4.55	3.94	4.33	5.18	5.39
15	E Muer	4.08	4.55	3.94	4.33	5.18	5.39
16	B Boro	4.08	4.55	3.94	4.33	5.18	5.39
17	E H Jaro	4.08	4.55	3.94	4.33	5.18	5.39
18	B Kalanung	4.08	4.55	3.94	4.33	5.18	5.39
19	B Pemanggal	4.08	4.55	3.94	4.33	5.18	5.39
20	B Batu Lebuk	4.08	4.55	3.94	4.33	5.18	5.39
21	E Brangkolong	4.08	4.55	3.94	4.33	5.18	5.39
22	B Sonan	4.08	4.55	3.94	4.33	5.18	5.39

23	B Miribayan	4.08	4.55	3.94	4.33	5.18	5.39
24	B Kukin	4.08	4.55	3.94	4.33	5.18	5.39
25	B Srikaya	4.08	4.55	3.94	4.33	5.18	5.39

4.3 Water available

The following are the results of the calculation of water requirements with Early Planting Dec. based on the results of the survey and 3 Cropping rotation groups.

Table 4.3 Water Availability Calculation Results (Samples Jan I - Feb III)

No	Headwork	Water Available (liters/Second)					
		JAN I	JAN II	JAN III	FEB I	FEB II	FEB III
1	BD Tiu Kulit	575	546	788	844	1039	1222
2	E Pemasar	149	177	232	252	297	300
3	B Ird Tangka	64	75	98	108	126	127
4	B Ird Rebayung	10	11	16	17	20	20
5	B Sabole	7	8	11	12	14	15
6	B Ird Baranupu	31	30	47	50	59	63
7	B Ird Bunterarang	15	14	23	24	28	30
8	B Samulanjaya	51	48	77	81	96	100
9	B Ird Kuang Galona	2	2	3	3	3	3
10	B Ird P2D	1	1	1	1	2	2
11	B Batu Nyonyong	114	108	164	176	210	232
12	B Tiu Kesaming	93	88	124	139	166	190
13	B/S Orong Keruh	16	15	20	22	27	33
14	B Samurung	102	97	134	148	181	217
15	E Muer	16	15	22	22	29	40
16	B Boro	4	4	6	5	7	10
17	E H Jaro	11	10	15	15	20	28
18	B Kalanung	11	10	15	15	19	27
19	B Pemanggal	111	106	152	151	197	268
20	B Batu Lebuk	8	7	10	10	13	18
21	E Brangkolong	61	58	79	84	107	137
22	B Sonan	119	113	154	165	208	267
23	B Miribayan	21	20	28	30	37	49
24	B Kukin	17	16	24	23	31	43
25	B Srikaya	16	15	22	22	28	39

4.4 Water Demand Irrigation

The following are the results of the calculation of water requirements with Start Planting Des I on the results of the survey and 3 Cropping rotation groups.

Table 4.4 Results of Calculation of Water Needs (Samples Dec I - Jan III)

No	Headwork	Water Demand (liters/Second)					
		JAN I	JAN II	JAN III	FEB I	FEB II	FEB III
1	BD Tiu Kulit	1121.1	820.9	144.9	761.8	554.1	1121.1
2	E Pemasar	302.1	329.9	87.0	223.4	176.9	302.1
3	B Ird Tangka	14.6	16.1	4.4	10.7	8.6	14.6
4	B Ird Rebayung	102.4	105.5	27.2	72.5	59.5	102.4
5	B Sabole	15.6	15.7	4.0	11.0	9.0	15.6
6	B Ird Baranupu	41.2	37.8	8.0	28.7	22.7	41.2
7	B Ird Bunterarang	13.8	12.6	2.7	9.5	7.6	13.8
8	B Samulanjaya	54.1	51.4	12.0	37.3	30.5	54.1
9	B Ird Kuang Galona	2.8	2.5	0.5	1.9	1.5	2.8
10	B Ird P2D	2.8	2.5	0.5	1.9	1.5	2.8
11	B Batu Nyonyong	59.0	48.9	9.4	39.2	31.5	59.0
12	B Tiu Kesaming	94.0	71.2	13.3	60.1	48.9	94.0
13	B/S Orong Keruh	33.5	22.2	3.8	21.2	16.3	33.5
14	B Samurung	109.6	76.1	13.3	71.3	53.6	109.6
15	E Muer	218.1	101.5	11.3	144.5	84.9	218.1
16	B Boro	77.5	34.4	3.5	51.3	29.4	77.5
17	E H Jaro	38.6	17.4	1.9	25.4	14.9	38.6

18	B Kalanung	38.5	17.7	1.9	25.2	15.0	38.5
19	B Pemanggal	66.7	33.8	4.3	43.8	27.3	66.7
20	B Batu Lebuk	111.6	56.9	7.4	72.0	46.4	111.6
21	E Brangkolong	347.7	205.0	31.0	229.1	154.9	347.7
22	B Sonan	56.0	33.0	5.0	36.3	25.0	56.0
23	B Miribayan	93.5	52.6	7.8	59.3	41.3	93.5
24	B Kukin	38.8	17.6	1.9	25.2	15.0	38.8
25	B Srikaya	56.7	28.0	3.5	36.3	23.2	56.7

4.5 Water Balance

The following are the results of the water balance where it is calculated by the discharge of water supply divided by the discharge of water requirements:

Table 4.5 Results of Calculation of Water Balance (Samples Dec I - Jan III)

No	Headwork	Fulfillment of water (%)						
		JAN I	JAN II	JAN III	FEB I	FEB II	FEB III	Total
1	BD Tiu Kulit	51%	67%	100%	100%	100%	100%	56%
2	E Pemasar	49%	54%	100%	100%	100%	100%	47%
3	B Ird Tangka	100%	100%	100%	100%	100%	100%	100%
4	B Ird Rebayung	58%	66%	100%	100%	100%	100%	48%
5	B Sabole	47%	50%	100%	100%	100%	100%	47%
6	B Ird Baranupu	75%	79%	100%	100%	100%	100%	63%
7	B Ird Bunterarang	100%	100%	100%	100%	100%	100%	75%
8	B Samulanjaya	96%	97%	100%	100%	100%	100%	69%
9	B Ird Kuang Galona	61%	65%	100%	100%	100%	100%	56%
10	B Ird P2D	31%	33%	100%	100%	100%	100%	41%
11	B Batu Nyonyong	100%	100%	100%	100%	100%	100%	94%
12	B Tiu Kesaming	100%	100%	100%	100%	100%	100%	82%
13	B/S Orong Keruh	46%	100%	100%	100%	100%	100%	57%
14	B Samurung	93%	100%	100%	100%	100%	100%	78%
15	E Muer	7%	15%	100%	15%	34%	100%	19%
16	B Boro	5%	11%	100%	11%	25%	100%	15%
17	E H Jaro	28%	60%	100%	58%	100%	100%	48%
18	B Kalanung	28%	58%	100%	58%	100%	100%	47%
19	B Pemanggal	100%	100%	100%	100%	100%	100%	98%
20	B Batu Lebuk	47%	100%	100%	100%	100%	100%	59%
21	E Brangkolong	17%	28%	100%	37%	69%	100%	30%
22	B Sonan	100%	100%	100%	100%	100%	100%	99%
23	B Miribayan	90%	100%	100%	100%	100%	100%	73%
24	B Kukin	44%	92%	100%	92%	100%	100%	62%
25	B Srikaya	29%	55%	100%	61%	100%	100%	47%
Average Bera Watershed		60%	73%	100%	85%	93%	100%	60%

Based on the above results it was found that some Water Buildings on average a year can meet nya 70% of their water needs consisting of B Tangka Ird, B Ird Bunterarang, B Ird Batu Nyonyong, B Ird Tiu Kesaming, B Samurung, B Pemanggal, B Sonan, B Miribayan. Whereas the average water building can only meet $\leq 30\%$ consisting of E Muer, B Boro, and E Brangkolong.

V. CONCLUSION

Based on the results above, the conclusions are as follows:

1. Bera watershed with an area of 164.6 km², and has infrastructure for 1 dam, 4 embungs and 20 weirs,
2. Regional Rainfall in Bera Watershed, which ranges from 0 - 124.3 mm (10 days),

3. Evaporation in Bera watershed, which ranges from 3.94-7.92 mm (10 days),
4. The availability of water in the Bera watershed is calculated using the Mock method with a range of debits of 0.315 liters/second to 1221.6 liters/second,
5. The water requirements in Bera Watershed are calculated using the Net Field Requirement (NFR) method with a discharge range of 0.145 liters/second to 2036.3 liters/second, and
6. Based on the calculation of the water balance there is an average water supply of 60%. This indicates that there is a need for better arrangements, both in water collection buildings and in irrigation networks.

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