RESEARCH ARTICLE OPEN ACCESS

Drought Analysis Using the Palmer Drought Severity Index (PDSI) Method in the Reak Watershedon the Lombok River Basin

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ABSTRACT:
The Reak watershed is one of the 52 Utility Watershed ini Lombok River Basin. The level of Water users in Reak Watershed is quite large, aside from the use of irrigation, drinking water, and the need for non-consumtive use. The Reak watershed has a watershed area of 37.81 km$^{2.}$ Thies type of river is Intermitten. Hydrological analysis is used to select influential rainfall stations using the Thiesen polygon. Then collect rain station data that has influenced the last 20 years. Calculate the generation of discharge data using average.Potential daily month evapotranspiration analysis was obtained from the evaporation data of the ishoyet area from the evaporation data for each climate station.Drought analysis uses average data with the method Palmer Drought Severity Index (PDSI).
Based on the results of the Thiessen polygon, it is found that the Rainfall in the Reak Watershed is Influenced by the Santong Rainfall Station which is also located in North Lombok Regency.At the Water Holding Capacity (WHC), it is found that the Sto in the Reak River Basin is 156 mm. In the Palmer Drought Severity Index Analysis, it is found that Jan to May is a wet month, June is a dry month, July to October is extreme dry, November is dry and December is wet.
Keyword: Bera Watershed, Water Available, Water Balance

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I. INTRODUCTION

Drought is one of the problems arising from lack of water reserves at the surface of the land. Besides the drought is also caused by the dry season. This dry season has an impact on the severity of the drought if it lasts longer. Drought that occurs during the dry season regularly occurs in Indonesia and prevention is so slow that it becomes a prolonged problem that cannot be resolved (Pratama, 2014).

The parameter of drought is very closely related to El Nino, El nino is one indicator of drought that is used in assessing the level of drought itself.

West Nusa Tenggara is one of Indonesia's provinces which often experiences high drought. According to BMKG this drought is caused because NTB itself is located just north of the australia country which climate causes drought because it carries with a relatively dry and cold air mass.

Besides the drought that hit Indonesia is also caused by reduced rainfall during the rainy season so that water reserves in the soil surface are reduced.

II. STUDY AREA

This research was conducted at the Reak River Basin (DAS) of the Lombok River Region. The Reak Watershed is one of the 52 Utility Watershedsin Lombok River Basin. The level of water users in the Reak watershed is quite large, aside from the use of irrigation, drinking water, and the need for non-consumtive use. The Reak watershed has a watershed area of 37.81 km^2. This type of river is Intemitten.

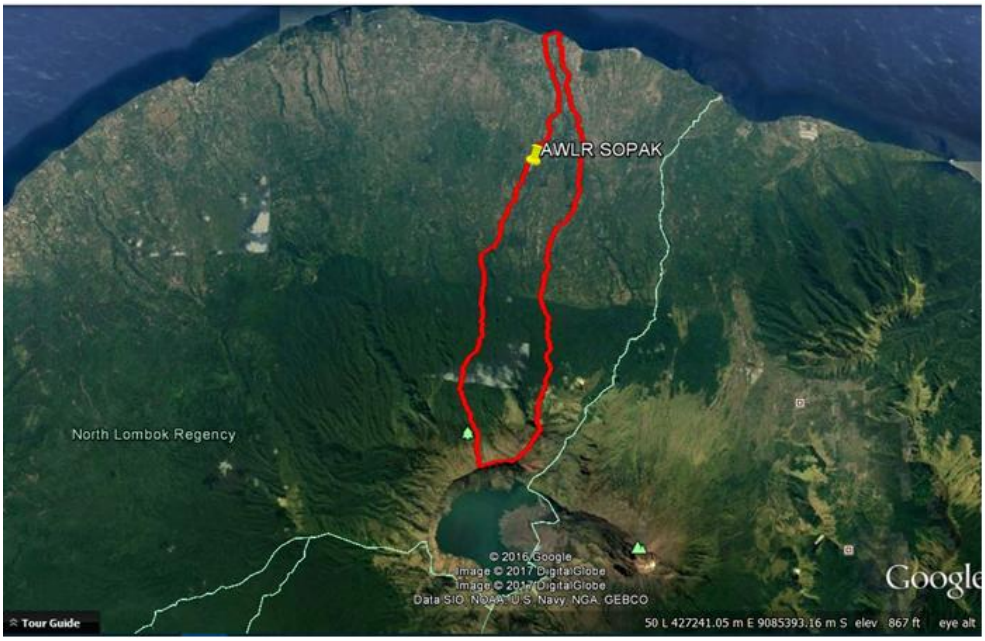

Figure2.1 Maps of the Reak Watershed of the Lombok River Basin

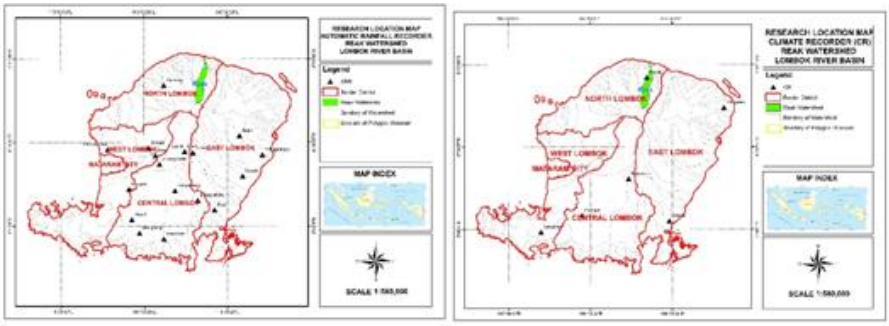

Figure 2.2 Research Location Maps ARR and CR inReak Watershed of the Lombok River Basin

III. METHOD

3.1 Rainfall Analysis

Hydrological analysis is used to select influential rainfall stations using the Thiesen polygon. Then collect rain station data that has influenced the last 20 years. Calculate the generation of discharge data using average.

3.2 Evapotranspiration Analysis

Potential daily month evapotranspiration analysis was obtained from the evaporation data of the ishoyet area from the evaporation data for each climate station.

3.3 Calculating Drought Analysis

Drought analysis uses average data with the method Palmer Drought Severity Index (PDSI) .The steps in calculating the Palmer Drought Severity Index Method are as follows:

a. Calculate water storage capacity (Water Holding Capacity)

b. Calculates the difference between P and ET

- If (P-ET)>0, there is a surplus of rainfall (wet month period)
- If (P-ET)<0, there is a rainfall deficit (dry period)

c. Calculates the amount of cumulative rainfall deficit rainfall APWL (Accumulated potential Water Loss)

By adding up the numbers (P-ET) for the dasarians that have a potential eapotranspiration more than the negative rainfall (P-ET).

$APWL = -\sum_1^n (P - ET)neg$

$APWL_i = APWL_{i-1} + (P\text{-}ET)_{neg}$

If P>ET, This data series is interrupted APWL = 0

d. Calculate soil moisture

- In wet months (P> ET), value ST=Sto (WHC)
- In dry dasarians (P <ET), this month ST every month is calculated by formula:

$ST = Sto \times e^{-(\frac{APWL}{STo})}$

With:
ST = The moisture content of the soil in the rooting area (mm)
STo = The soil moisture content in field conditions (mm), the Sto referred to in this formula is the value = WHC
e = Navier's number(e=2.718)
AWL = Cumulative amount of rainfall deficit (mm)

e. Calculate the change in soil moisture content
Changes in soil moisture content(ΔST)each dasarian can be obtained by reducing soil moisture (ΔST)each dasarian can be obtained by reducing soil moisture (ST) in the previous dasarian($\Delta ST=ST_i - ST_{i-1}$) then the negative value causes the soil to become dry.

f. Calculating Actual Evapotranspiration (ETa)
- On a wet month (P>ET), Value ETa = ET
- On a dry month (P>ET), Value ETa = P – ΔST

Calculating Deficits (Moisture Deficiency)
D = ET – ETa

With:
D = Deficit (mm/month)
ET =PotentialEvapotranspiration (mm/month)
ETa =Actual evapotranspiration (mm/month)

g. Calculating Surplus (Moisture Strength)

S = (P-ET) – ΔST
With:
S = Surplus (mm/month)
P = Rainfall (mm/month)
ET = Potential Evapotranspiration (mm/month)
ΔST = Change of soil moisture (mm/month)

h. Calculating Runoff (Ro)
Shows the amount of water flowing at the ground surface. Calculate it 50% multiplied by the surplus value.

i. Menghitung pengisian lengas tanah potensial (PR)
PR = WHC – ST
j. Calculates potential soil moisture replenishment(R)
Filling of soil soil occurs if the ST in the previous month is smaller than the ST in the month, adding the ST value becomes the soil moisture filling.
$R = ST - ST_{j-1}$
With:
R =Moist soil filling
ST = The moisture content of the soil in the month of the month
ST_{j-1}= The moisture content of the soil in the previous month's case.

k. Calculate potential soil moisture loss(PL)

PL = ET – ΔST

l. Calculate soil moisture loss (L)

$L = ST_{j-1} - ST$

m. Determination of the coefficient
The coefficient in question is to determine the value CAFEC (Climatically Appropriate for Exiting Condition).The values of the coefficients above are determined by the formula:
- Evapotranspiration coefficient
$\alpha = \frac{AE}{ET}$
- Moisture filling coefficient into the soil
$\beta = \frac{R}{PR}$
- Runoff coefficient
$\gamma = \frac{Ro}{S}$
- The coefficient of soil moisture loss
$\delta = \frac{L}{PL}$
- Approaches to climate weighting
$K = \frac{(ET+R)}{(P+L)}$

n. Determination of value CAFEC (Climatically Approprite for Existing Condition)

- Determine the value of evapotranspiration CAFEC
ET = α x ET
- Determine the moisture content in the soil CAFEC
R = β x PR
- Determine runoff values CAFEC
Ro = γ x Ro
- Determine the loss of soil moisture CAFEC
L = δ x PL
- Determine loss of presipiration CAFEC
P = ET + R + Ro – L

o. Determination of periods of lack or excess rain (d)
p.
d = P - P
q. Determination of absolute value (D)
D = Average value d
The second approach to the value of factor K
$K' = 1.5 \log 10 ((\frac{PE+R+Ro}{P+L} + 2.80) : \frac{25.4}{D} + 0.5$
DK' = D x k

r. Climate character as a weighting factor (K)

$K = \frac{DxK'}{\sum_1^{12} DxK} xK'$

s. Moisture anomaly index (Z)

Z = d x K

t. Drought IndexPalmer

IV. RESULT AND DISCUSSION

Rainfall analysis uses the Thiesen Polygon method because there are no ARR stations in the Reak River Basin. Here are the results of the analysis of the Polygon Thiesen.

$X = (\frac{Z}{3})_{j-1} + \Delta X$

$AX = (\frac{Z}{3})_j - 0.103\ (\frac{Z}{3})_{j-1}$

4.1 Rainfall

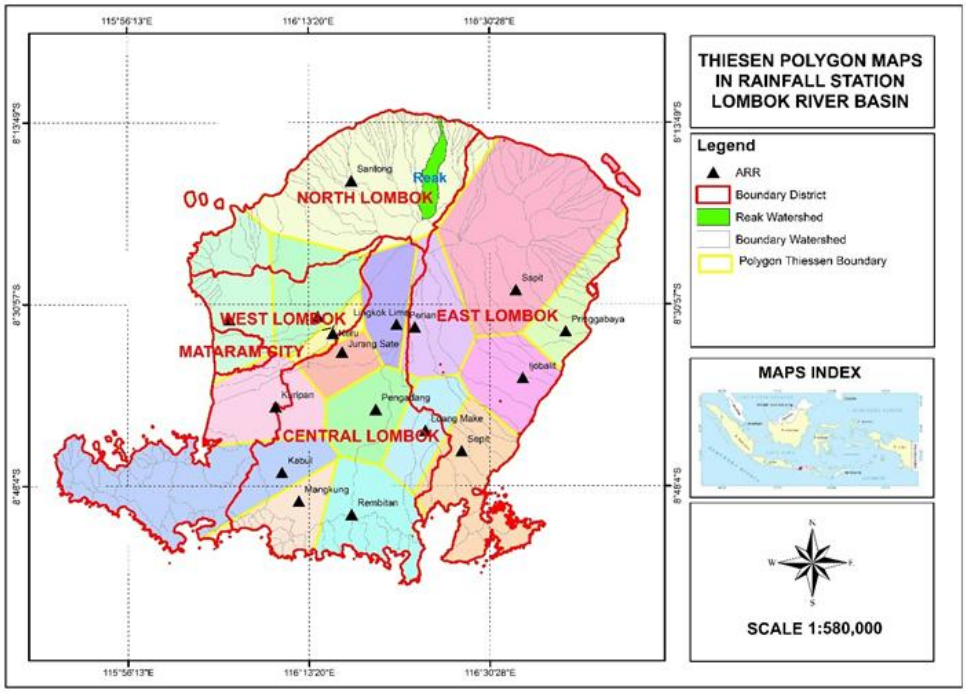

Figure 4.1 Thiessen Polygon in Rainfall Station on Lombok River Basin

Based on the analysis of the data above it was found that the rainfall in the Reak watershed was influenced by Santong ARR Station. The rainfall data in ARR Reak is as follows:

Table 4.1 Average Rainfall Data Table, Probability of 80%, 50% and 20% at Santong ARR Station

Prob	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des
Average	294	353	309	173	86	36	29	8	17	49	157	242
R - 80%	153	182	140	90	6	1	0	0	0	5	76	18
R - 50%	295	371	316	152	60	25	9	0	8	49	127	241
R - 20%	431	460	386	269	129	42	31	11	23	72	220	360

Source: BWS NT-I

4.2 Climate

Analysis of climate data using the Sopak climate station (CR) which is located right in the Reak Watershed in Lombok River Basin.

The following climate parameters in the Sopak CR Reak River Lombok River Basin:

Table 4.2 Table Parameter Data Table in CR Sopak

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des
Relative Humidity(%)	87.10	87.34	85.09	84.77	75.31	84.18	85.57	82.96	78.66	79.98	81.99	86.66
Temperature (°C)	25.62	25.56	26.01	26.39	26.54	26.83	26.74	26.81	27.07	27.57	27.19	26.46
Wind velocity(km/day)	39.80	37.31	27.84	26.19	28.40	25.31	31.19	35.06	35.57	35.26	30.79	32.97
Wind velocity(m/s)	0.46	0.43	0.32	0.30	0.33	0.29	0.36	0.41	0.41	0.41	0.36	0.38
Solar radiation(%)	34.78	38.61	48.24	55.02	59.78	59.07	70.45	70.79	72.39	68.17	50.61	36.50
Solar radiation(Cal/cm^2/day)	217.52	244.14	243.82	214.90	193.63	233.06	304.96	384.82	427.63	113.59	309.31	46.17
Pan Evaporation (mm/hr)	3.54	3.46	4.52	4.81	5.60	5.27	5.66	5.99	6.26	6.02	4.96	3.63

Source: BWS NT-I

4.3 Analisis Water Holding Capacity

The value of retained excess soil or soil moisture at the Field capacity (Sto) is equal toWater Holding Capacity (WHC) (Janna, 2015).

Table 4.3 Field capacity calculation (Sto) in ARR Santong

No	Vegetation Type	Texture	Area (Km^2)	WHC (mm)
1	Rice Fileds	Fine Sand	4	222
		Dusty Clay	41	5074
		Clay	19	1528
2	Agriculture	Dusty Clay	22	4251
		Clay	1	118
3	Settlement	Fine Sand	1	0
		Dusty Clay	1	0
		Clay	0	0
4	Plantation crops	Fine Sand	2	314
		Dusty Clay	11	3309
		Clay	4	775
Total			106.501	15592
Value Sto				156

4.4 Drought Analysis in Lombok River Basin Reak Watershed

After getting the value of water storage capacity in each rain station, the drought index calculation is then performed, where drought occurs in June (Dry Status), July-October (Dry Extreme Status), November (Dry Status). The index value obtained from June-November is around -2.1 to -18.61. The results of the drought index value then the drought distribution map is drawn.

Table 4.5 Calculation of Drought with the Palmer Drought Severity Index Method

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	294	353	309	173	86	36	29	8	17	49	157	242
Evaporation	110	97	140	144	173	158	175	186	188	187	149	112
P-ET	184	256	169	29	-87	-123	-146	-178	-170	-137	8	130
Ro	92	128	85	14	0	0	0	0	0	0	0	0
Palmer Value	13.5	15.4	15.4	10.2	2.7	-3.6	-7.8	-14.8	-18.6	-13.1	-2.1	8.9
Status	W	W	W	W	W	D	ED	ED	ED	ED	D	W

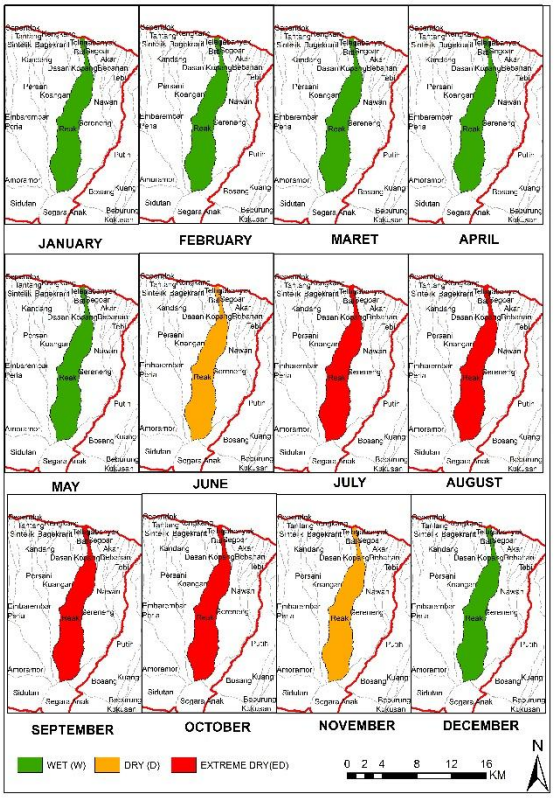

Figure 4.2 Map of Palmer Drought Severity Index (PDSI) Analysis Result

Figure 4.2 shows that the Reak watershed experienced a drought in June-November (6 months), which included extreme drought in July-October. This was caused by the low rainfall during the month and high evaporation. This analysis also looks at land use and soil types. To reduce the extreme level of drought, it is necessary to reforest the upstream area of the Reak River Basin. Efforts are also needed to overcome the effects of further drought if they occur.

Whereas in the wet month, efforts are needed to maintain water by building reservoirs such as reservoirs and dams.

Efforts to use excessive water are also not recommended considering the drought can also get worse. Besides this the El nino factor can also exacerbate the level of drought. Eastern Indonesia is very vulnerable to being influenced by the Sea Surface Temperature (SST) of Nino.

Drought can also lead to forest fires if it is not well anticipated by the government or the local community.

V. CONCLUSION

Based on the results of the analysis of the Palmer Drought Severity Index (PDSI) above, it was found that:

1. Reak watershed has a watershed area of 37.81 km2, and has an intermittent river type.
2. Reak River Basin is located in North Lombok Regency, West Nusa Tenggara Province
3. Based on the results of the Thiessen polygon, it is found that the Rainfall in the Reak Watershed is Influenced by the Santong Rainfall Station which is also located in North Lombok Regency.
4. At the Water Holding Capacity (WHC), it is found that the Sto in the Reak River Basin is 156 mm.
5. In the Palmer Drought Severity Index Analysis, it is found that Jan to May is a wet month, June is a dry month, July to October is extreme dry, November is dry and December is wet.
6. Based on the results of Palmer Drough Severity, the need for handling dry conditions with efficient water use, as well as conservation efforts in the upstream watershed in order to reduce the effects of drought. Besides that, it can also be done by building reservoirs such as reservoirs and dams that accommodate and reduce the impact of flooding in the rainy season and use storage water during the dry season.

REFERENCE

[1]. BWS NT-I. 2018. Rencana Alokasi Air Tahun 2018/2019 Wilayah Sungai Sumbawa. Mataram: Balai Wilayah Sungai Nusa Tenggara –I.
[2]. Febrianti R, dkk, 2016. Analisis Kekeringan Menggunakan Metode Palmer Drought Index (PDSI) di Sub DAS Babak Kabupaten Lombok Tengah Provinsi Nusa Tenggara Barat.
[3]. Kodoatie, R. & Syarief, R. 2010. Tata Ruang Air. Yogyakarta: Andi.
[4]. Rahmawati, RW, dkk. 2018. Analisis Kekeringan Hidrologi berdasarkan Metode Moisture Adequacy Index (MAI) di Daerah Aliran Sungai Temon Kabupaten Wonogiri.
[5]. Ahsanita, D, Analisa Kekeringan Menggunakan Metode Palmer Drought Severity Index (PDSI) dan Thornthwaite-Matter di Kecamatan Praya timur Kabupaten Lombok Tengah.

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