



Analysis of Land Erosion Hazard Level in the Babak Watershed Using the USLE Method

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ARTICLE INFO	ABSTRACT
Published: Keywords: Babak Watershed, Erosion, Erosion Hazard Level, USLE Method.	<i>The Babak Watershed is considered an area that has high utility value and strategic functions. With various existing functions, this watershed faces various problems, such as changes in land function that trigger the emergence of critical land, Narrowing of river paths and sediment accumulation problems. Land quality decline caused by erosion plays a major role in triggering the amount of sedimentation. The existence of this article is intended to calculate erosion and identify the dominant erosion hazard classes occurring in the Babak watershed. In this study, the empirical method used to predict the amount of erosion is the Universal Soil Loss Equation (USLE) method. Erosion in the Babak watershed is calculated by calculating erosion in nine weirs in the area. The analysis carried out shows that the level of erosion that occurs in each weir is as follows: 92.40 tons/ha/year for the Jenguar weir, 86.83 tons/ha/year for the Babak weir, 87.19 tons/ha/year for the Gde Bongoh weir, 72.07 tons/ha/year for the Keru weir, 55.53 tons/ha/year for the Simbe weir, 112.12 tons/ha/year for the Jurang Sate weir, 33.76 tons/ha/year for the Gebong weir, 32.94 tons/ha/year for the Datar weir, and 34.07 tons/ha/year for the Baturiti weir. The results of erosion classification show that the Babak Watershed is dominated by the level of mild erosion hazard (II), which is 37.97% of the watershed area. The erosion hazard level that dominates each weir is as follows: the weirs dominated by very light erosion hazard levels (I) are Gebong, Datar, and Baturiti, with an area of 56.89%, 59.72%, and 67.13%, respectively. Meanwhile, weirs dominated by the level of mild erosion hazard (II) were found in the Jenguar, Gde Bongoh, Keru, and Simbe weirs, with an area of 41.45%, 42.27%, 45.68%, and 49.47%, respectively. On the other hand, the Babak and Jurang Sate dams are dominated by moderate erosion hazard levels (III), with an area of 51.08% and 37.21%, respectively.</i>

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INTRODUCTION

The Babak Watershed is located in the Lombok River Region. This watershed is considered an area that has high use value and strategic function, because it is a watershed that remains wet throughout the year. The utilization of water resources in this watershed is very complex, including water sources from regional drinking water companies, interconnection networks with several irrigation weirs and reservoirs. (Balai Wilayah Sungai Nusa Tenggara 1, 2014).

With its various functions, the Babak watershed is inseparable from watershed problems in general. Starting from 1999/2000, protected forests in the Babak Watershed were massively damaged and became open land of more than 1500 ha (Idris et al., 2015). Illegal logging and land conversion resulting in the occurrence of critical land. According to (Sulistiyono, 2023), Hilly areas affected by extreme rain are very detrimental, because the high intensity of rainfall can

trigger ground collapses surrounding the hilly area. (Humaidi, 2010) stated that the Babak watershed experienced relatively large channel narrowing problems (sedimentation/gradation), among others, in Jereneng Hamlet, Bagikpolak Village, Labuapi District. Erosion that causes land degradation has an important role in accelerating the sedimentation process. The narrowing of the river channel is caused by large sedimentation in the deep bend due to the meandering of the river channel. Based on research by (Fathoni, 2012), the total sediment contained in the babak river is 424,928.88 tons/year. Soil erosion around the Babak watershed is one of the main factors that cause sediment deposits in the river. These sediment deposits reduce the cross-sectional capacity of the river to accommodate flood discharge, and trigger river water overflows that can cause flooding. Not only that, (Setiawan, 2018) states that sediment ultimately results in a significant decrease in reservoir capacity due to sedimentation and deposition processes.

The USLE method designed by Wischmeir and Smith in 1978 is the most widely employed method for estimating the magnitude of erosion (Pamungkas, 2020). The USLE method is employed to estimate soil erosion and is also developed to estimate the average soil loss from a specific land area, considering slope characteristics, rainfall patterns, soil types, and land management practices. Given the lack of information about the potential for erosion that can occur in the Babak watershed in the form of data or maps and it is known that the role and function of the Babak watershed is very important for the lives of the surrounding community, this study was conducted with the aim of identifying the magnitude of erosion and determining the level of erosion hazard that is dominant in the Babak watershed. The results of this erosion rate analysis can be used as a reference for related agencies in an effort to maintain the sustainability of the Babak watershed.

METHOD

The location of this research was carried out in the Babak Watershed. According to Balai Wilayah Sungai Nusa Tenggara data, the area of the Babak Watershed is 259.17 Km² with a river length of 54.89 Km. Administratively, the Babak watershed is located in West Lombok Regency (42.26% of the watershed area), Central Lombok (55.76%) and a small part (1.98%) in East Lombok Regency.

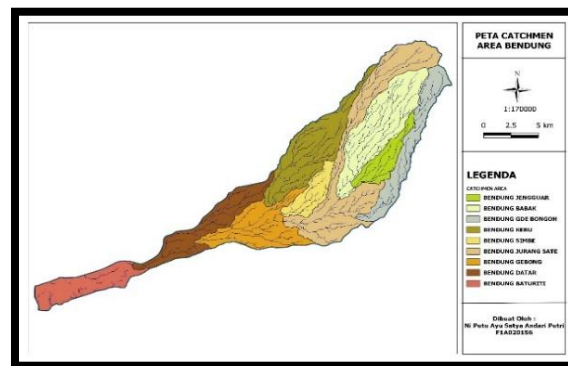


Figure 1. Map of the Babak Watershed

The empirical model used to predict soil erosion in this study is the USLE (Universal Soil Loss Equation) method, which was proposed by Wischmeier and Smith in 1978. The common formulas used are:

$$A = R \times K \times LS \times C \times P$$

Where A refers to the amount of land erosion (tons/ha/year), R is a factor that indicates rainfall erosivity, K is a factor that describes soil erosion, LS is a factor related to the length and slope of the land, C is a factor related to land cover, and P is a factor related to land management.

The R factor of rain erosivity is the driving force that causes the peeling and transport of soil particles to a lower place, this occurs due to the influence of the fall of rain particles directly on the ground and partly due to the flow of water above the ground surface. According to Sarief (1985), the erosion factor of rain is used to assess the potential ability of rain to erode the soil. The mathematical formula used by Lenvain to determine the R factor is based on the study of rainfall erosion using rainfall data from several places in Java (Asdak, 2010).

$$R = 2.21 \times P_m^{1.36}$$

With:

R = Erosivity index

P_m = Monthly rainfall (cm)

The K-factor, or soil erodibility factor, quantifies how well soil particles resist being dislodged and moved by the impact of raindrops. The texture of the soil plays a major role in the small erodibility of the soil. Soils with large aggregate particles have a large resistance to the carrying capacity of surface flow because it requires considerable energy to transport these soil particles, while soils with fine aggregate particles are resistant to peeling because the cohesion properties of the soil are also large. Table 1 shows the K factor values for the Babak Watershed. In this study, the K factor's value was established using guidelines and publications from the Soil Research Institute (BPT, 1985) regarding soil conservation practices in Indonesia. Table 1 shows the value of factor K for the Babak Watershed.

Table 1. K factor value of some soils in Indonesia (BPT, 1985)

Number	Soil Type	K Value
1	Regosol Grey Chocolate & Litosol Complex	0.172
2	Chocolate Litosol & Mediterranean Complex	0.273
3	Gray Regosol & Litosol Complex	0.172
4	Mediterranean Brown	0.323
5	Mediterranean Reddish Brown	0.323

The topographic factors L (length) and S (slope) respectively describe the Impact of length and slope on erosion rates. In its application, the values of L and S are calculated simultaneously as the LS factor. The LS factor is the ratio between the erosion rate on a land with a certain length and slope compared to the total soil erosion.

Table 2. The value of the K factor of some soils in Indonesia (Kironoto et al., 2021)

Slope Class	Slope	LS Value
I	0-8	0.40
II	8-15	1.40
III	15-25	3.10
IV	25-40	6.80
V	> 40	9.50

Factors C and P are two important components of soil erosion analysis, where Factor C describes the influence of vegetation integration, soil surface conditions, and land management practices on the rate of soil loss, by calculating the ratio between the level of erosion on konsevation land with certain management versus uncultivated and clean land, while Factor P measures the ratio between the level of erosion on the land and certain conservation actions on the land which is processed in the direction of the slope. The values for these two factors, which can be seen in Tables 3 and 4, are determined based on specific criteria – for Factor C based on land use patterns, while for Factor P they are based on conservation measures adjusted for slope, which together provide a comprehensive picture of an area's vulnerability to soil erosion.

Table 3. The value of factor C based on land use (Kodoatie and Sjarief, 2005)

Number	Types of Land Use	Grade C
1	Secondary Dryland Forest	0.03
2	Shrub	0.07
3	Primary Forest	0.02
4	Industrial Plantation Forest	0.05
5	Secondary Swamp Forest	0.15
6	Plantation	0.4
7	Dryland Agriculture	0.1
8	Dry Land Agriculture Mixed With Shrubs	0.1
9	Settlement	0.6
10	Paddy	0.15
11	Pond	0.05
12	Open Ground	1

Table 4. P factor values for various special soil conservation actions (Arsyad, 2010)

Number	Special Soil Conservation Measures	P value
1	No erosion control action	1
2	Bench Terrace:	
	- Good construction	0,04
	- Medium construction	0,15
	- Poor construction	0,35
	- Traditional terrace	0,4

3	Plant strips	
	- Bahlia grass	0,4
	- Clotararia	0,64
	- With Contours	0,2
4	Soil management and planting according to contour lines:	
	- Slope 0 – 8 %	0,5
	- Slope 8 – 20 %	0,75
	- Tilt >20%	0,9

The amount of land loss in each unit of land obtained through the USLE equation is used as a basis for determining the level of erosion hazard that occurs. Furthermore, to find out the distribution of each class of erosion hazards, grouping and analysis of the distribution on each land unit were carried out. Table 5 shows the distribution table of the Erosion Hazard Level:

Table 5. Erosion Hazard Class (Kironoto et al 2021)

Number	Class	Total Erosion (tons/ha/year)	Information
1	I	<15	Very Light
2	II	15-60	Light
3	III	60-180	Keep
4	IV	180-480	Heavy
5	V	>480	Very Heavy

RESULT AND DISCUSSION

Analysis of Average Rainfall of the Area

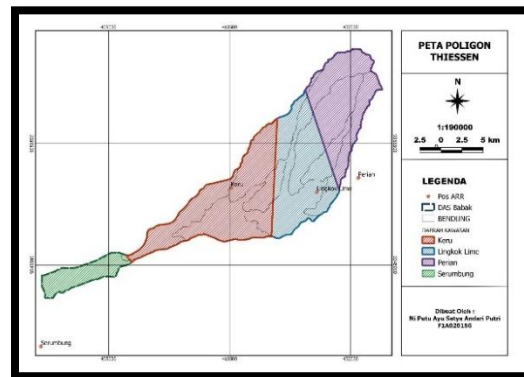


Figure 2. Thiessen Polygons Babak Watershed

The Thiessen polygon method is used to determine the influence of the area of the rainfall station by dividing the Watershed into several regions using polygons. The analysis of the Thiessen polygons for the Babak watershed is shown in Figure 2, which involves four rainfall stations. From the Thiessen polygon map that has been compiled, a percentage of area for each influential rainfall

station will be obtained. These values will be used to calculate the average monthly rainfall in the Babak watershed. The percentage area for each rainfall station can be seen in the following table.

Table 6. Area of each rain station

Weir	Rain Station	Area (Ha)	Area (km)
Jenguar	Lingkok Lime	681.68	6.82
	Perian	553.88	5.54
Babak	Lingkok Lime	1,691.97	16.92
	Perian	2,390.21	23.90
GDE Bongoh	Lingkok Lime	685.17	6.85
	Perian	1717.82	17.18
Keru	Lingkok Lime	1170.64	11.71
	Keru	2397.17	23.97
	Perian	113.31	1.13
Simbe	Lingkok Lime	374.39	3.74
	Keru	778.32	7.78
Jurang Sate	Lingkok Lime	3140.71	31.41
	Keru	592.01	5.92
	Perian	1991.31	19.91
Gebong	Keru	2896.20	28.96
Datar	Serumbung	42.05	0.42
	Keru	2598.22	25.98
Baturiti	Serumbung	2089.97	20.90
	Keru	11.56	0.12
Total		25,916.58	259.17

Rainfall data testing using the RAPS (*Rescaled Adjusted Partial Sums*) method

The RAPS test is used to test the accuracy of data between rainfall stations by detecting shifts in the mean value. The following table shows the results of the RAPS test at four rainfall stations that affect the Babak watershed.

Table 7. Comparison of calculated $\frac{Q}{\sqrt{n}}$ values and $\frac{Q}{\sqrt{n}}$ table values for each station.

No	Station	Q count	Q table	Information
1	Perian	0.559	1.226	Consistent
2	Lingkok Lime	1.010	1.226	Consistent
3	Serumbung	0.768	1.226	Consistent
4	Keru	1.325	1.432	Consistent

Table 8. Comparison of calculated $\frac{R}{\sqrt{n}}$ values and $\frac{R}{\sqrt{n}}$ table values for each station.

No	Station	R count	R table	Information
1	Perian	1.058	1.451	Consistent
2	Lingkok Lime	1.186	1.451	Consistent
3	Serumbung	1.006	1.451	Consistent
4	Keru	1.384	1.451	Consistent

USLE Method Erosion Calculation

Rain Erosivity Factor (R)

In the USLE method, the R parameter is calculated based on monthly rainfall data. The average monthly rainfall in the Watershed is determined using the percentage area of each rainfall station obtained through the analysis of the Thiesen Polygon.

Table 9. Average Rainfall Erosion Value of Babak Watershed

Number	Weir	Rain Erosivity (R)
		(cm/year)
1	Jenguar	1,815.98
2	Babak	1,735.62
3	Gde Bongoh	1,665.74
4	Keru	1,520.14
5	Simbe	1,521.09
6	Jurang Sate	1,782.41
7	Gebong	1,304.12
8	Datar	1,293.49
9	Baturiti	833.387

Soil Erodibility Factor (K)

Based on the map of soil types in the Babak watershed, it is known that the area consists of six types of soil, namely gray brown and lithosol complex, brown lithosol & Mediterranean complex, gray and lithosol complex, brown and brown brown and brown Mediterranean complex

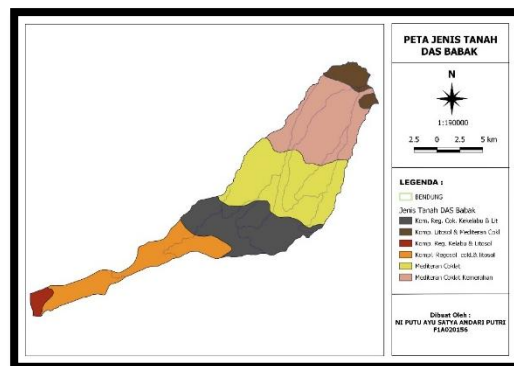


Figure 3. Map of the Babak watershed soil type

Table 10. Babak Watershed K Values

Number	Soil Type	Area (ha)	K Value
1	Mediterranean Reddish Brown	6,503.78	0,323
2	Mediterranean Brown	7,685.71	0,323
3	Comp. Litosol & Mediterranean Cokl	1,224.36	0,273
4	Kom. Reg. Cok. Gray & Lit	6,134.99	0,172
5	Kompl. Regosol cokl. & lithosol	4,367.74	0,172

Slope Length and Slope Factor (LS)

The length factor (L) and slope (S) were analyzed using Digital Elevation Model (DEM) data through QGIS software, so that information was obtained about the percentage of length and slope in the Babak Watershed.

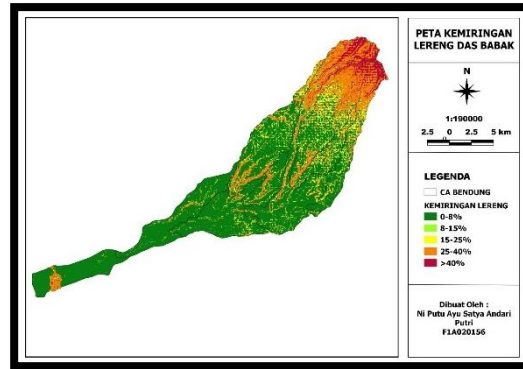


Figure 4. Map of Length and Slope of the Babak Watershed

Table 11. LS Value of the Babak Watershed

Number	Slope (%)	Broad (ha)	Value LS
1	0 - 8	11,831.17	0,4
2	15-15	6,328.1	1,4
3	15-25	3,508.23	3,1
4	25-40	1,880.11	6,8
5	>40	2,369.05	9,5

Land cover factors (C) and land conservation measures (P)

To obtain the value of the land cover factor (C), land cover map data was used, while for the land conservation value (P) it was assumed that no conservation action was taken in the Babak watershed, so that the land conservation value (P) was categorized without conservation action the value $P = 1$.

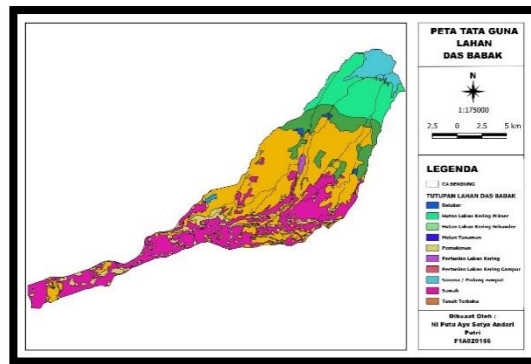


Figure 5. Land Use Map of the Babak Watershed

Table 12. Babak Watershed CP Values

Number	Land Cover	Area (Ha)	CP Value
1	Mixed Dryland Agriculture	10,379.27	0.1
2	Paddy	6,962.42	0.15
3	Secondary Dryland Forest	2,240.53	0.03
4	Shrub	109.49	0.07
5	Primary Dryland Forests	3,362.59	0.02
6	Settlement	1,610.34	0.6
7	Savannah / Grassland	1,140.86	0.04
8	Open Ground	55.93	1
9	Plantation Forest	55.15	0.05

Land Erosion Calculation

After various values of factors that affect the erosion rate analysis process using the USLE method, namely R, K, LS, CP values have been obtained, the erosion rate can be calculated. The following is presented a table of the results of erosion calculations in the Babak watershed.

Table 11. Erosion in the Babak Watershed

Weir	Area (ha)	A (tons/year)	Average (tons/ha/year)
Jenguar	1.235,56	114,164.78	92.40
Babak	4.082,18	354,445.99	86.83
Gde Bongoh	2.402,98	209,523.20	87.19
Keru	3.681,12	265,315.33	72.07
Simbe	1.152,70	64,014.2	55.53
Jurang Sate	5.724,03	641,796.98	112.12
Gebong	2.896,19	97,763.95	33.76
Datar	2.640,27	86,956.54	32.94
Baturiti	2.101,53	71,606.38	34.07
Average		211,731.93	51.17

Based on the table above, the rate of erosion that occurred in the Babak Watershed was recorded at 211,731.93 tons per year. The analysis showed that all factors were positively associated with the increase in the rate of erosion. However, factors that have a significant influence on the increase in erosion hazard values are the LS factor and the C factor. The flatter the ground surface and the tighter the vegetation cover, the lower the erosion rate that occurs.

Erosion Hazard Level

Table 12. Recap of the distribution of erosion hazard levels in the Babak Watershed

No	Erosion Hazard Class	Erosion Hazard Level	Area (Ha)	%
1	I	Very Light	6,019.05	23.22
2	II	Mild	9,829.54	37.97
3	III	Moderate	7,744.49	29.87
4	IV	Severe	2,155.10	8.30
5	V	Very Heavy	168.39	0.64
			25,916.58	100

Based on the results of the analysis that has been carried out, it can be seen that most of the watershed area which amounts to about 37.97% or 9,829.54 hectares is classified as a "mild" erosion hazard level (Class II) with an erosion rate of between 15 to 60 tons/ha/year. followed by the "Medium" category (Class III), which covers 29.87% of the total watershed area, or 7,744.49 hectares, with an erosion rate of 60 to 180 tons/ha/year. The "Very Light" category (Class I) with an erosion rate of less than 15 tons/ha/year covers 23.22% or 6,019.05 hectares. Meanwhile, the "Heavy" category (Class IV) covers an area of 2,155.10 hectares or approximately 8.30% of the total watershed area, with a significant erosion rate of 180 to 480 tons/ha/year. The most critical area is the "Very Heavy" category (Class V), although the smallest percentage is 0.64% or 168.39 hectares, but has a very high erosion rate, exceeding 480 tons/ha/year. This data shows that most of the Babak watershed has a mild to moderate level of erosion. However, the existence of areas with severe and very severe erosion rates, even if a small percentage, requires serious attention in land conservation efforts.

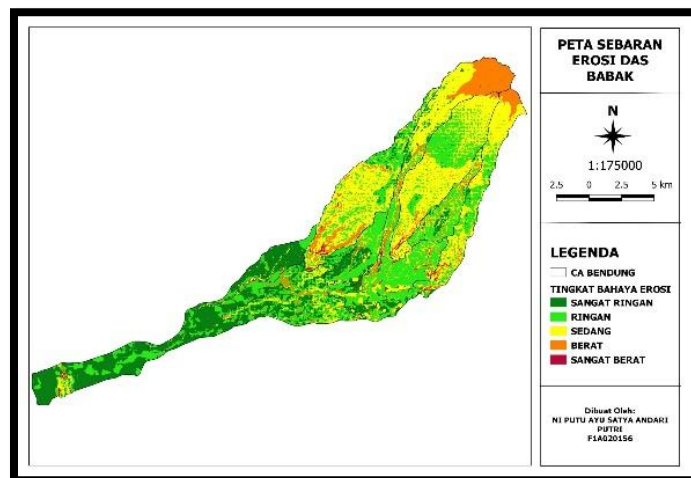


Figure 6. Map of erosion distribution in the Babak watershed

CONCLUSION

Based on the results of erosion calculations that have been carried out using the Universal Soil Loss Equation (USLE) method, erosion results were obtained in 9 weirs reviewed in the Babak watershed, namely, Jenguar Weir of 92.40 tons/ha/year, Babak Weir 86.83 tons/ha/year, Gde Bongoh Weir 87.19 tons/ha/year, Keru Weir 72.07 tons/ha/year, Simbe Weir 55.53 tons/ha/year, Jurang Sate Weir 112.12 tons/ha/year, Gebong Weir 33.76 tons/ha/year, Datar Weir 32.93 tons/ha/year, Baturiti Weir 34.073 tons/ha/year. The level of erosion hazard occurring in the nine Weirs reviewed resulted in a distribution ranging from very light to very heavy (I-V). The Gebong Weir, the Datar Weir and the Baturiti Weir are dominated by grade I (very light) with a distribution area of 56.89%, 59.71% and 67.13% respectively. The Jenguar Weir, Gde Bongoh Weir, Keru Weir, and Simbe Weir are dominated by grade II (light) with a distribution area of 41.45%, 42.27%, 45.68% and 49.47% respectively. The Babak Weir and the Jurang Sate Weir are dominated by grade III (medium) with a distribution area of 37.21% and 51.08% respectively.

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