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RESEARCH ARTICLE

RATE ANALYSIS OF SOIL EROSION USING UNIVERSAL SOIL LOSS EQUATION (USLE) METHOD IN JENEBERANG WATERSHED

Ruslinda Nur[1], Krisdayanti[2] and Rusnianti Nur[3]

1. Graphic Design Lecturer,The State Polytechnic of Creative Media. Makassar, Indonesia.
2. Geophysic Student, Hasanuddin University, Makassar, Indonesia.
3. Physics Student, GadjahMada University, Yogyakarta, Indonesia.

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Abstract

Erosion in a watershed is a complex phenomenon that affects the quality of land resources due to either natural or human influence. The purpose of this study to determine the rate of erosion in the Jeneberang watershed and produce a recommendation of soil conservation to reduce the rate of erosion. This study uses some parameter maps, such as Rain Erosivitas Index (R) map, Land Erodibility Index (K) map, Length and Slope's Declivity Factor (LS) map, and Plants Management Factor and Soil Conservation (CP). All parameters were analysed using USLE map to determine the rate of erosion. The analysis results the rate of erosion by USLE method indicates the hazard level of the erosion in the Jeneberang watershed are dominantly at the very low levels with an area 55.068,39 ha or 71.6% of the research area. However, the erosion in the study area can not be ignored because there is a very high level of danger to the extensive erosion 11.681,55 or 15% of the research area. Therefore, generated a recommendation of soil conservation by soil cover planting and terrace construction repairs. By this conservation recommendation, the area with a high level of the rate of erosion reduce in the amount of 10,6%.

Introduction:-

Erosion in a watershed (DAS) is a complex phenomenon that results in changes in the quality of land resources both naturally and due to human influence(Prayitno et al., 2015). Natural factors that affect erosion are climate, soil properties, land topography and ground cover (Asdak, 2018). Human influences in the process of increasing the rate of erosion such as mining for minerals, subsidence, clearing forests, clearing land for agriculture, clearing land for settlements and so on are predicted to predict a rate of soil erosion(Massinai, 2015).

One of the methods for estimating the magnitude of erosion, namely the Universal Soil Loss Equation (USLE) method developed by Wischmeir and Smith (Wischmeier & Smith, 1978) is the most commonly used method for estimating the magnitude of erosion. Geographic Information System (GIS) is a spatial-based technology that is very popular today. Erosion prediction using the USLE method can also use GIS in its calculations (Lorito et al., 2004).

Corresponding Author:- Ruslinda Nur
Address:- Faculty Graphic Design,The State Polytechnic of Creative Media. Makassar, Indonesia.

This study aims to apply GIS to predict the rate of erosion and the level of danger using the USLE method and provide recommendations for soil conservation as an effort to reduce the danger of erosion, especially in the Jeneberang watershed.

Research Method:-

The research location covers the entire Jeneberang Watershed which is geographically located at 119° 23' 50'' BT – 119° 56'10'' BT dan 05°10'00'' LS – 05°26'00'' LS. The data used are secondary data in the form of topographic maps sourced from DEM-SRTM, soil maps sourced from BAPPEDA of South Sulawesi Province, soil conservation maps sourced from Londongsalu research in 2008, vegetation cover maps sourced from Landsat Image 8 of 2016 and rainfall data sourced from BMKG Year 2012-2016. The analysis technique uses an overlay technique, which is to perform a spatial analysis by stacking thematic maps. Erosion estimation was carried out using the USLE method with the following equation(Bergsma et al., 1996):

$$\boldsymbol{A = R.K.L.S.C.P}$$

Notation,
A = amount of erosion (tons/ha/year),
K = soil erodibility value,
R = rain index,
L = slope length factor,
S = slope factor,
C = soil management factor,
P = soil conservation action factor.

Factors R, K, L and S mathematically can be categorized as variables that cannot be changed. In other words, to reduce erosion can only be done by manipulating the values of C and P. The magnitude of the erosion hazard is grouped as in table 1.

Table 1:- Erosion Hazard Class.

Class	Erosion Rate (tons/ha/year)
Very low	<5
Low	5 – 12
Medium	12 – 25
High	25 – 60
Very high	>60

(*Source : Bergsma et al. 1996*)

Result and Discussion:-

1. Prediction and Mapping of Erosion and Hazard Level

a. Rain Erosivity

Rainfall data was obtained from BMKG Station Region IV Makassar from 2012 to 2016 which consisted of 10 rain posts. Based on the data, it is known that the maximum average rainfall is 4,107.2 mm and the minimum average rainfall is 878.4 mm. It was also found that the highest rain erosivity index value occurred at the Malino rain post, which was 3,560.81 mm and the lowest was at the Pattalassang rain post at 662.84 mm (Table 2). The high erosivity index (R) value is caused by the high annual average rainfall and the amount of rain intensity which is reflected in the high maximum rainfall at the rain post.

Table 2:- Value of Rain Erosivity Index for Jeneberang Watershed.

No	Station name	X	Y	R
1.	Barombong	119,39	-5,208	1.113,37
2.	BMKG Makassar	119,45	-5,148	2.647,13
3.	BiringRomang	119,47	-5,175	2.466
4.	Barembeng	119,42	-5,353	2.049,41
5.	Malino	119,85	-5,253	3.560,81
6.	Limbung	119,43	-5,290	2.136,23
7.	Cakura	119,51	-5,425	2.112,14
8.	Mappakasunggu	119,41	-5,425	1.659,24

9.	Pattalassang	119,43	-5,425	662,84
10.	BMKG Gowa	119,47	-5,217	2.608,61

The R value obtained is the R value for each rain post. Therefore, to determine the R value for each pixel in the study area, interpolation was carried out using the Spline method. The map of the interpolation results can be seen in Figure 1.

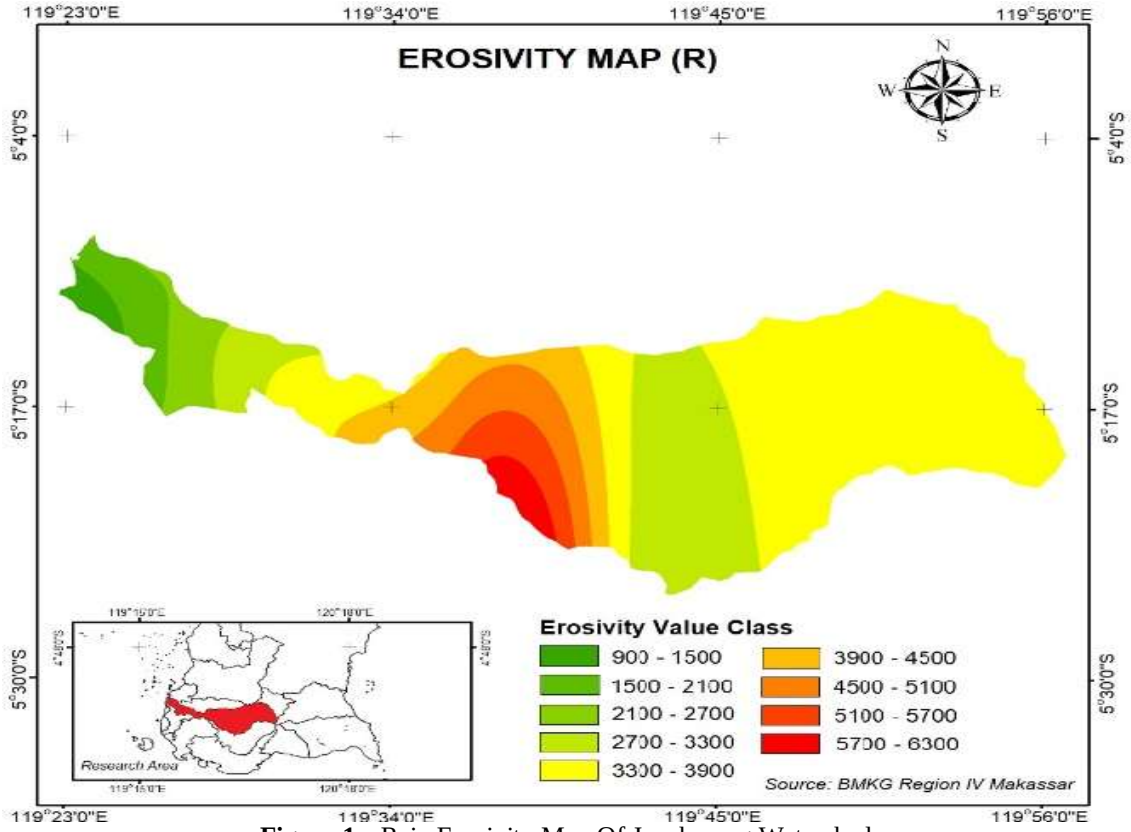

Figure 1:- Rain Erosivity Map Of Jeneberang Watershed.

b. Soil Erodibility

The soil type map in the research area consists of Andosol, Latosol, Mediterranean Reddish Brown, Reddish Brown Latosol Complex and Gray Brown Alluvial. The dominant soil type is the Reddish Brown Latosol Complex with an area of 42,000 ha (Table 3). Soil erodibility values in the Jeneberang watershed range from 0.09 to 0.28 which can be seen in Table 3 and Figure 2.

Table 3:- Soil Erodibility Value of Jeneberang Watershed.

Type of soil	K	Area (Ha)
Andosol	0,28	9.685
Latosol	0,09	7.298
Mediterranean Reddish	0,22	6.824
Sorrel Latosol Complex	0,23	42.000
Alluvial Gray Brown	0,20	11.030

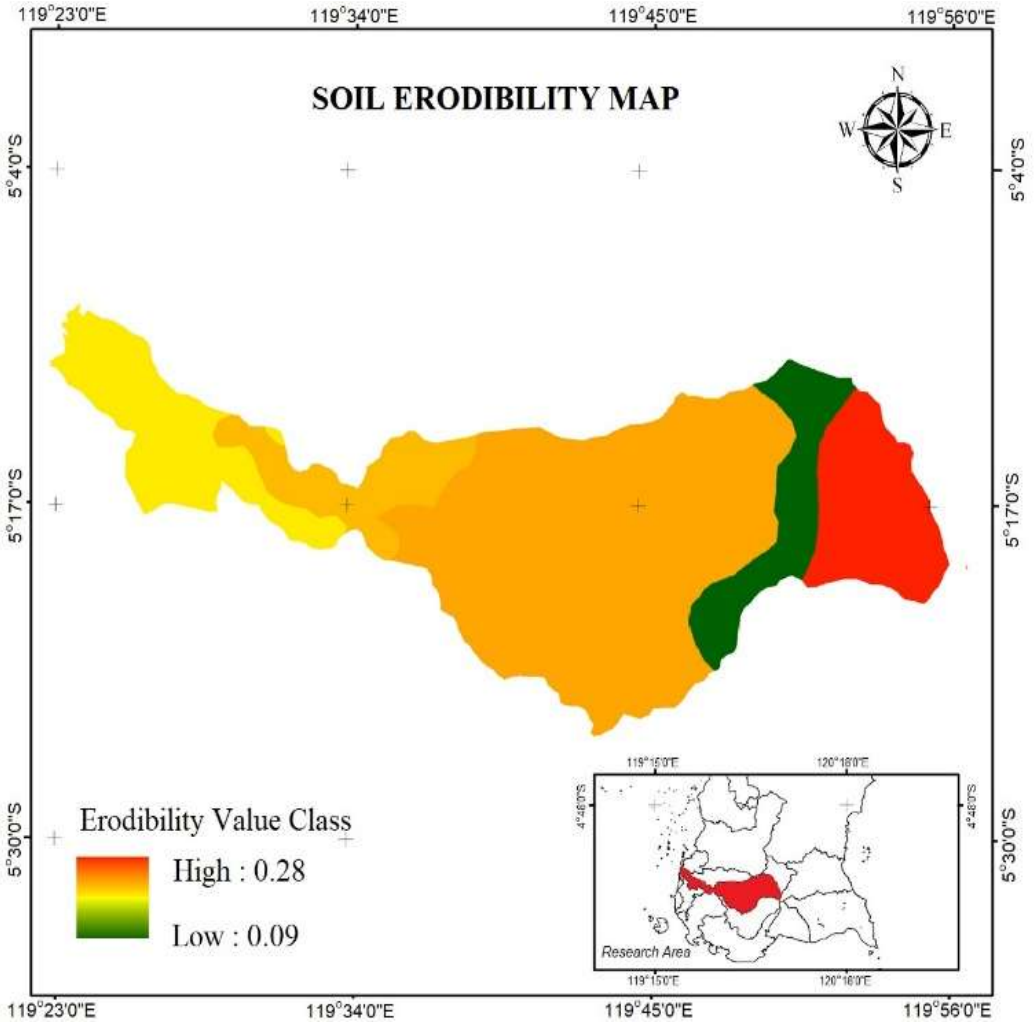

Figure 2:- Soil Erodibility Map of Jeneberang watershed.

c. Long and Slopes (LS)

In the study area, the domination of the slopes is 0-8% with an area of 63,460 ha. The largest LS index value is 9.50 with a slope of >40 has an area of 5,396 ha (Table 4) and the distribution of LS values can be seen in Figure 3.

Table 4:- LS Value of Jeneberang Watershed.

Slope Class	Slope (%)	Value LS	Area (Ha)
I	0 – 8	0,40	63.460
II	8 – 15	1,40	1.689
III	15 – 25	3,10	3.922
IV	25 – 40	6,80	2.362
V	>40	9,50	5.396

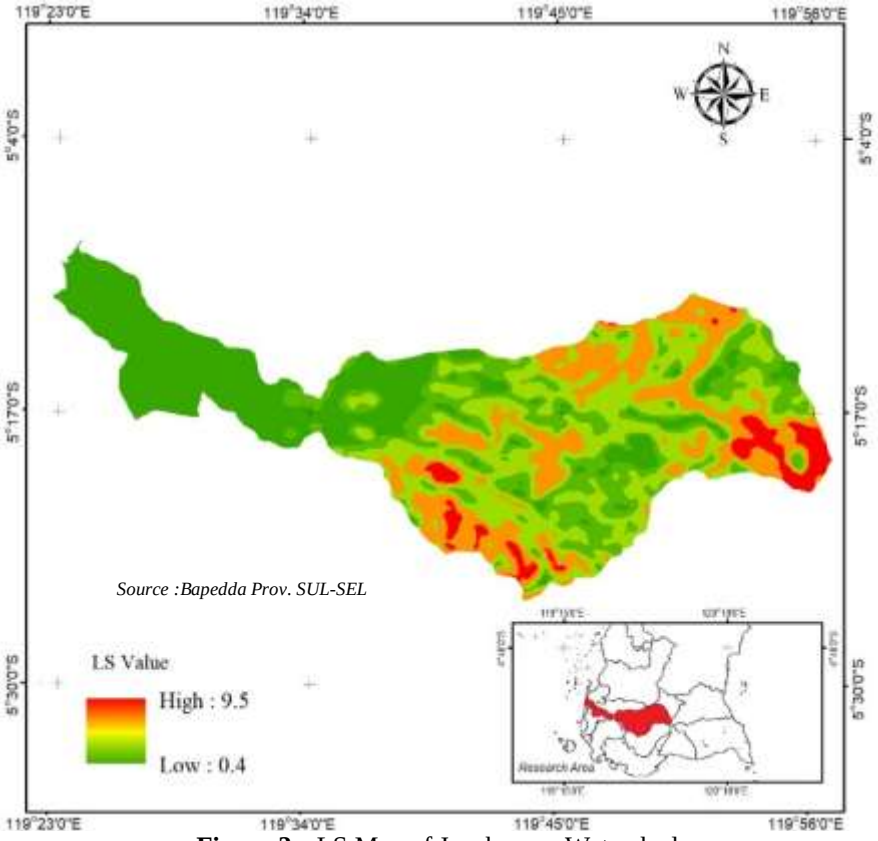

Figure 3:- LS Map of Jeneberang Watershed.

d. Plant Management and Soil Conservation

Land use and land conservation in the research area can be seen in table 5. Land use in the Jeneberang watershed is dominated by forest with an area of 24,830 ha with a C value (0.001) where the C value is classified as very good.

Table 5:- Land Use and Soil Conservation in the Jeneberang Watershed.

Land Use Name	C	P	Area (Ha)
Forest	0,001	1	24.830
Meadow	0,3	0,4	24
Plantation	0,1	0,1	1.168
Settlement	1	1	2.719
Ricefield	0,01	0,1	14.520
Rainfed ricefield	0,01	0,5	1.978
Shrubs	0,01	0,01	18.840
Empty Land	1	1	6,70
Farm	0,7	0,4	9.135

In the research area, the largest crop management value was on upland/field land use, namely 0.7 with a soil conservation value of 0.4 which has an area of 9,135 ha. The distribution of plant management values can be seen in Figure 4 and the distribution of soil conservation index values can be seen in Figure 5.

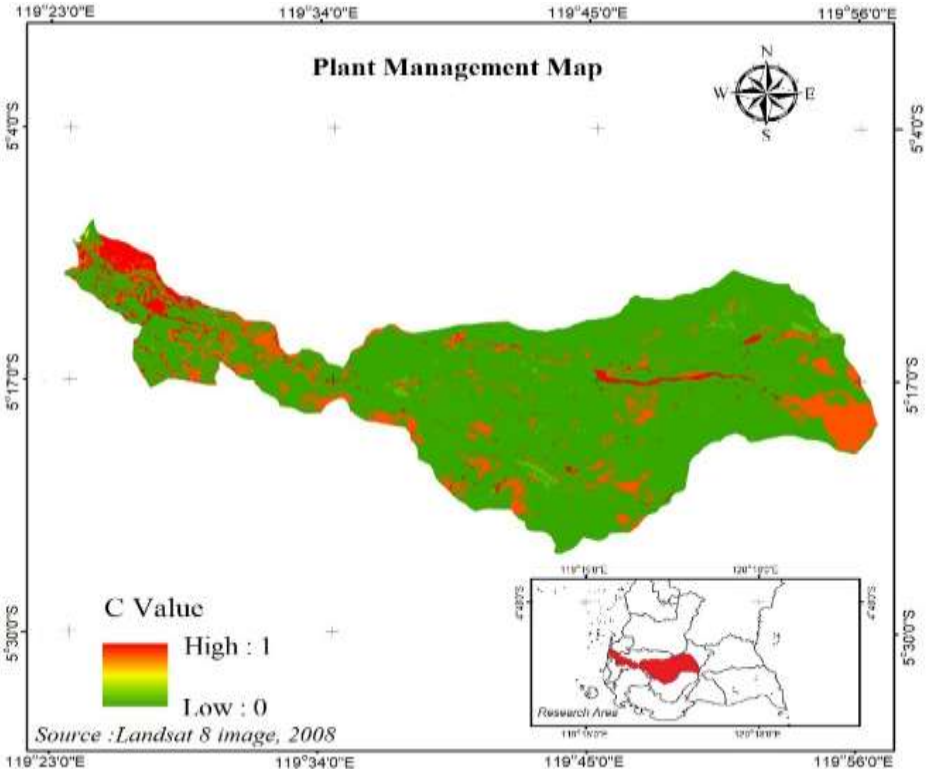

Figure 4:- Plant Management Map ofJeneberang Watershed.

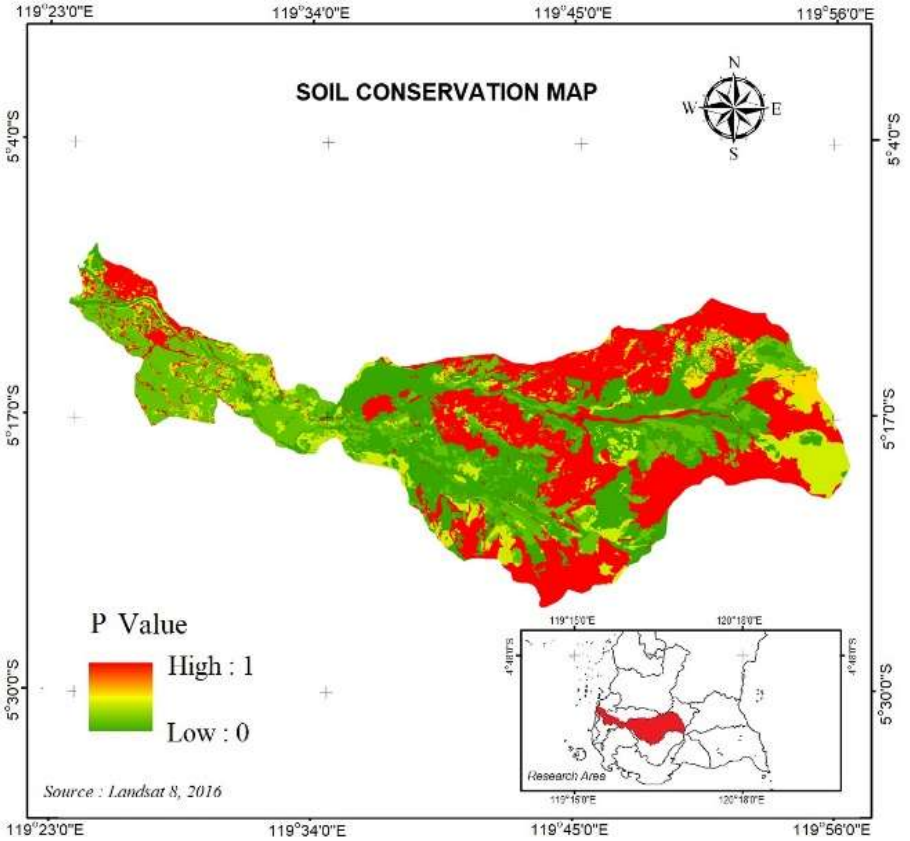

Figure 5:- Soil Conservation Map ofJeneberang Watershed.

e. Erosion Mapping and Its Hazards

The results of the analysis of the erosion hazard level of the Jeneberang watershed can be seen on the ErosionHazard Level (TBE) distribution map in Table 6 and Figure 6.

Table 6:- Hazard Level Erosion of Jeneberang Watershed.

Tingkat BahayaErosi	Ton/ha /tahun	Luas (Ha)	%
Very Low	<5	55.068,39	71,6
Low	5-15	7.727,94	10
Medium	15-25	1.073,25	1,4
High	25-60	1.278,54	2
Very High	>60	11.681,55	15

The table above shows that the erosion hazard level in the dominant Jeneberang watershed is still very low with an area of 55,068.39 ha or about 71.6% of the total area of the Jeneberang watershed. This shows that the erosion caused is not too large because the factor of plant cover and management is still quite good, but it cannot be ignored because it is also very high with an area of 11,681.55 ha. If plant management factors and conservation practices in the research area are not improved, the erosion rate that occurs in the future can become dominantly high or very high. Therefore, it is necessary to make recommendations for soil conservation that can reduce the rate of erosion that occurs so that the resulting erosion is not too large.

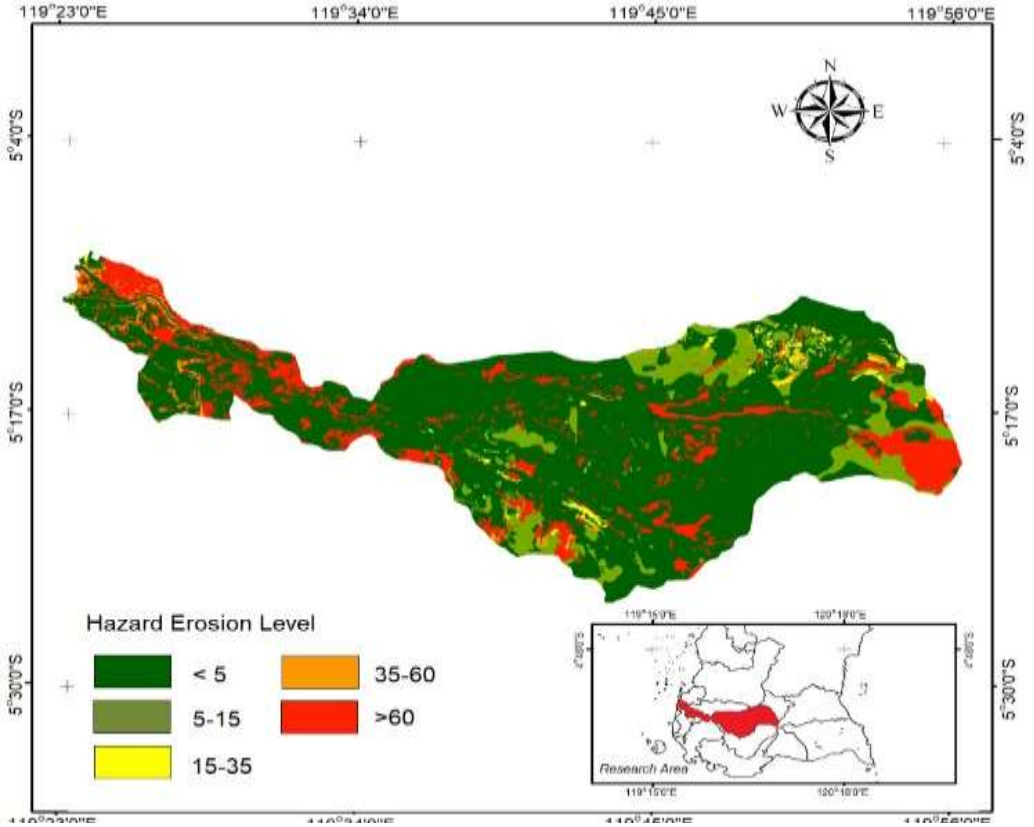

Figure 6:- Hazard Level Erosion Map of Jeneberang Watershed.

This is different from the results of research by Paharuddin(Paharuddina et al., 2014)which states that the level of erosion hazard that occurs in the upstream Jeneberang watershed area is above 60 tons/ha/year which is a very high class. The difference in the results obtained is due to the research area from Paharuddin (2012) which focuses on the upstream Jeneberang watershed area, where steep to very steep slopes occupy an area of 22,076 ha or 58.42% of the upstream Jeneberang watershed area. In this study, the area studied covers the entire Jeneberang watershed, where steep to very steep slopes only occupy an area of 7,758 ha or 10.1% of the Jeneberang watershed area.

2. Conservation Recommendations

In this study, soil conservation recommendations are focused on very high levels of erosion. The estimated C values and P values for the conservation recommendations used can be seen in table 7.

Table 7:- Land Use Recommendations.

No	Existing Land Use	C	Land Use Recommendation	C*
1.	Moor / field	0,7	Mixed Plantation	0,10

*: Land Use Recommendations

Table 8:- Recommendations for Soil Conservation.

No.	Existing Land Use	P	Soil Conservation Recommendations	P*
1.	Forests Without Soil Conservation Measures	1	Forest with dense cover	0,1
2.	Plantation	0,1	Mixed garden with bench terrace	0,04
3.	Ricefield	0,1	Rice field with bench terrace	0,04
4.	Moor / field	0,4	Mixed garden with bench terrace	0,04

*: Soil Conservation Recommendations

The recommended conservation recommendations to be applied to the Jeneberang watershed are forests that previously without conservation measures were converted into forests planted with plantation crops with a dense ground cover, and some land uses that previously had poor bench terrace construction became better bench terraces.

The existence of conservation recommendations in the research area, there is a decrease in the rate of erosion so that areas that previously had a very high level of erosion hazard became areas that had a low level of erosion hazard. It can be seen in table 9 that the percentage of areas that have high erosion experienced a change of 10.6%, namely the percentage before the recommendation was 15% and after the recommendation was 4.4%. The map after the conservation recommendations can be seen in Figure 8

Table 9:- Percentage Change in Area Before and After Conservation.

Erosion Hazard Level	Before (%)	after (%)	Change (%)
Very Low	71,6	87,9	16,3
Low	10	3,7	6,3
Medium	1,4	0,8	0,6
High	2	3,2	1,2
Very High	15	4,4	10,6

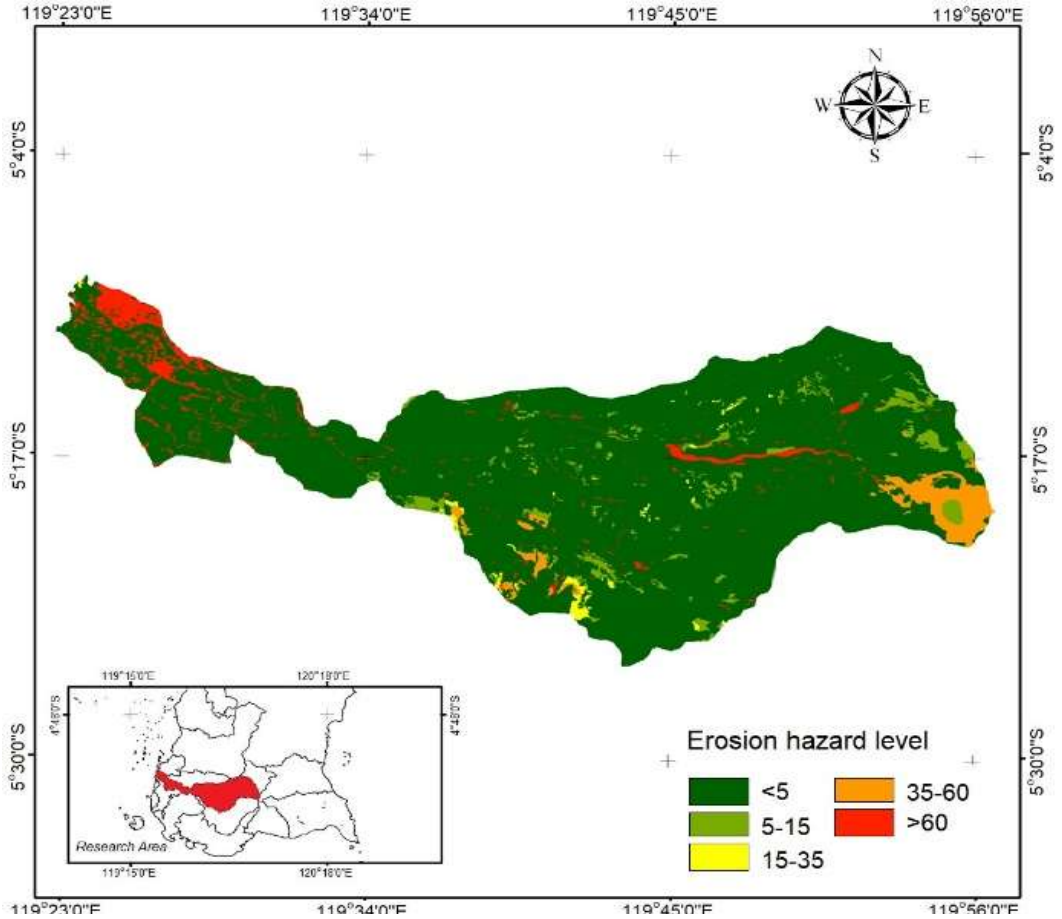

Figure7 :-Hazard Level MapBased on Conservation Recommendations.

Conclusion:-

The erosion rate using the Universal Soil Loss Equation (USLE) method shows the erosion hazard level that occurs in the dominant Jeneberang watershed is at a very low level with an area of 55,068.39 ha or 71.6% of the research area.

Recommended soil conservation, namely planting dense cover crops and improvement of terrace construction. With this conservation recommendation, areas with very high erosion rates experienced a change of 10.6%, from 15% to 4.4%.

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