The prediction of sediment yield at mouth of je’ne rakikang catchment area

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Abstract. Sedimentation caused by the occurrence of erosion processes is one of the issues that is often discussed because the impacts have an adverse effect on the condition of a land. This research aims to determine the total erosion by using the Universal Soil Loss Equation-based on Geographic Information System and predict the sediment yield using Sediment Delivery Ratio methods. This research was expected to provide information material for relevant agencies in planning watershed management in land rehabilitation and conservation of soil and water particularly Jeneberang Watershed Je’ne Rakikang catchment area. This research was conducted in Je'ne Rakikang catchment area, Parangloe districts, Gowa. This research approach the land unit as the unit of analysis. The results showed that the amount of erosion in the research area was classified as very heavy but the calculation results of the sediment at 1: 17 of the total value erosion. The value of total erosion was strongly influenced by the slope and soil types, while the value of the sediment was influenced by the characteristics of the Watershed.

1. Introduction
Sedimentation is part of the erosion process and is one of the issues that is often discussed because the impacts have an adverse effect on the condition of a land. The sedimentation problem that occurs in several regions around the world is very important, so it needs serious attention [1].

One of the provinces in Indonesia with increasing levels of erosion and sedimentation from year to year is South Sulawesi. The increase in erosion and sedimentation has taken place in three priority watersheds (Watershed of Saddang, Watershed of Jeneberang, Watershed of Walanae). These problems have had a serious impact, such as the erosion of nutrients on the soil surface, the increase in critical land and climbing in rivers and dams. This is due to the occurrence of sedimentation which has been triggered by the erosion process in the upper watershed [2].

One of the damaged watersheds in South Sulawesi is the Jeneberang [2]. Jeneberang Watershed is a priority watershed, as stated in the Decree of the Minister of Forestry and Plantation Number 328 / Menhut-II / 2009 dated 12 June 2009 concerning the Determination of Priority Watersheds for the Medium Term Development Plan (RPJM) 2010 - 2014) [3]. Therefore, the management of the Jeneberang watershed needs special attention, especially in the field of soil and water conservation to control erosion and sedimentation that occurs in the Bili-Bili Dam.

The impact that will be caused by sedimentation in the Jeneberang watershed, especially on the sustainability of the Bili-Bili dam is very large. In 1993, the amount of sediment entering the Bili-Bili reservoir reached 1794 m³/km²/year, and in 1999 it had increased to 2100 m³/km²/yr. Figures 1794
m³/km²/yr and 2100 m³/km²/yr, respectively equal to 21.53 tonnes/ha/yr and 25.2 tonnes/ha/yr. This figure has exceeded the erosion rate in the initial design of the dam, which is 18 tonnes/ha/year, which means that the effective life of the dam is set at 50 years, even when the Bawakaraeng volcano landslide occurred in 2004, the age of the dam is estimated to be 15 years old [4].

The Je'ne Rakikang Watershed (DTA) is one of the catchments geographically very close to the Bili-Bili dam which is in increasingly poor condition. Based on the results of the field orientation, it shows that the upstream part of the Jene 'Rakikang catchment area has land cover in the form of forest vegetation which is only found at the top of the hill, while the land cover on the riverbank is on average dominated by salain scrub, in the upstream part of the Jene'Rakikang catchment area slope class <40%. Baver, 1956; Zigg, 1940 in Seta (1987) [5] and Arsyad (2010) [6] show the results of research that the tendency of increasing erosion and sedimentation is exponentially due to the increasing slope of a slope.

Sediment yield prediction based on the Sediment Delevery Ratio (SDR) has been widely studied. However, research on sediment prediction based on micro SDR is still very limited. In the Je'neberang River Basin, there are many catchment areas, one of which is the Je'ne Rakikang watershed, where data on sediment is still very limited and even unavailable.

Based on data released by the Ministry of Forestry (2012) that the sediment for rivers in the Je'neberang watershed in 2008 such as the Je'neberang River, as much as 0.0138 mg of mud and 55.20 mg / liter of mud / water, the Jenelata river contains 0.0030 mg of mud. mg and mud / water 15.20 mg / liter, Jeneberang Kampili River, the content of mud is 0.0084 mg and mud / water is 33.60 mg / liter [7]. For Je'ne Rakikang, no data on silt content is available, so it is deemed necessary to conduct research on sediment content. This research is intended to predict the total erosion value in the Je'ne Rakikang catchment and to predict the sediment yield in the Jene 'Rakikang catchment.

2. Research methods

This research was conducted in the Jene 'Rakikang Catchment Area, which is located in the upper reaches of the Je'neberang Watershed. This research took place from January 2015 to March 2015. Determination of the research location was carried out by delineating the boundaries of the Jene' Rakikang Catchment, then overlaying it using slope maps, soil type maps, and land cover maps to determine land units in the Jene' Rakikang Catchment Area.

2.1. Observations in the laboratory

Observations in the laboratory begin by determining the land units to be observed through an overlay of land cover maps, soil type maps, and slope maps after which 34 land units are obtained. Next, determine the observation points on all land units that have been obtained in the map overlay results.

2.2. Direct observation in the field (survey)

Field observations began by inputting the coordinates of all land units into the GPS receiver then observing each land unit for erosion factors as follows:

- Soil Erodibility factor (K) for soil type was obtained from the RePPProt landsystem map, then to get the K value it was obtained through the K factor value table according to Arsyad (2010) and Asdak (2010) [1].
- Slope length factor (L) and slope steepness (S) were obtained based on the slope map and direct observation in the field, namely by measuring the length of the slope using a roll meter and the steepness of the slope was measured using a tool that resembles the Abney level work system then adjusted to the value table LS factor index according to Kiranoto (2003).
- Land Use Factor (C) was obtained by direct observation in the field of land cover vegetation and then matched with the C value in the crop management index table for single cropping and the crop management index table for intercropping and crop rotation according to the Ministry of Forestry in 2009 [8].
Soil Conservation Factor (P) was obtained by direct observation in the field of the applied soil conservation techniques and then matched with the values found in the soil conservation index table according to the Ministry of Forestry (2009) [8].

- Taking pictures/photos of research activities from each unit of land in the research location.

Secondary data in this study is data that can support research obtained from government agencies and related agencies. Secondary data includes the general condition of the research location obtained from the BPS of Gowa Regency, rainfall data, 1999 RBI maps, administrative maps, slope class maps, soil type maps, and land cover maps.

2.3. Data analysis

2.3.1. Erosion prediction. The amount of erosion was determined using the USLE (Universal Soil Loss Equation) Method Wischmeier and Smith (1987) where the value of A (amount of erosion) is obtained from the multiplication of R (Erosivity), K (Erodibility), LS (Length and Slope of the slope), C (Land use factor), and P (Soil Conservation Factor) [9].

2.3.2. Rain erosion factor (R). Rain erosivity factor in USLE was obtained from analysis of rainfall data for the last 10 years (2004-2013). The value of R (erosivity) is obtained by Lenvain's formula, namely the erosivity index is equal to 2.21 multiplied by the monthly rainfall in centimeters.

2.3.3. Analysis of sediment results. For sediment yields, it can be determined using the equation [1,10], namely the resulting unitary sediment area was obtained from total erosion times the ratio of sediment release times the area of the watershed. The amount of SDR in erosion calculations or to predict sediment yields for river basins generally uses an equation based on the formula proposed by Roehl in Lias (2002) [11], namely the Sediment Delivery Ratio equal to 36 times the area of the watershed/sub-watershed to the power of minus 0.20. Furthermore, to find out the total erosion that occurs in each land unit in the Jene'Rakikang catchment, the total erosion that occurs in the I land unit was equal to the area of the first land unit times the erosion that occurs in the I land unit [12].

3. Results and discussion

3.1. Land unit

The resulting land unit map used in this study is an overlay map of soil type maps, slope maps, and land cover maps. The number of land units from the overlay results is 233 land units grouped into 34 land units that have the same characteristics, and a map of the survey locations conducted on the 34 land units can be seen in Figure 1. Based on the results of field checks on all representative land units, it was found that there were differences between the land cover map and field conditions. The land unit 6 which is based on the land cover map is secondary forest which turns out to be based on the results of field checks in the form of plantation forest. The land unit 7 which is based on the map of land cover with secondary forest cover which turns out to be based on the results of field checking in the form of plantation forest. Land units 30 are based on a map of land cover in the form of shrubs which are based on the results of field checks in the form of plantations. Therefore, the land use used is the result of field checks.
3.2. Erosion
The erosion that occurs is very diverse due to different values of all factors that cause erosion, namely the values of R, K, LS, C and P. Based on the results of this formula, it can be explained that the erosion that occurs in the study area varies from very mild to very severe. Very heavy erosion is found in the 11th land unit (3030.99 tons/ha/year) with land cover in the form of dry land agriculture. The smallest erosion occurs in the 18th land unit (0.12 tonnes/ha/year) with land cover in the form of rice fields. This is in line with what was stated by Van Oost et al., (2012) in Wahyuningrum et al., (2014) that land management for seasonal crops also has a large effect on erosion [13].

3.3. Secondary forest and plantation forest
Secondary Forest and Plantation Forest are the largest land uses in the Je'ne Rakikang watershed with a total area of 2,656.07 ha with a percentage of 62.82%. Secondary forests are located in land units 1, 2, 3, 4, 5, 8, and 9, while plantation forests are on land units 6, 7, and 30. The plantations in the research location belong to INHUTANI, in the form of acacia plantations (Acacia Sp.). From the observation, secondary forest and plantation forest consist of 2 to 3 strata with medium crown density. Based on the crop management index table, the value of the crop management factor (C) for the land use is 0.005.

Among these two forested areas, the greatest erosion occurred in land unit 1, which was 23.68 tonnes / ha / year which covered land in the form of secondary forest, slope class > 45% (very steep), and an erodibility value of 0.23 (moderate). The smallest erosion value occurs in land unit 6, namely 0.43 tonnes / ha / year, which covers land in the form of plantations, slopes 0-8% (flat), and an erodibility value of 0.10 (very low). The difference in the value of erosion in forested areas is caused by two factors, namely the difference in the value of the slope and the difference in the value of soil erodibility.

According to Lal (1976) in Triwanto (2012), the degree of slope and the difference in soil erodibility will affect erosion because the degree of slope of the slope will affect surface tension so that the surface flow velocity increases, thus the water damage capacity will be large [14]. Soil with a high erodibility
index is soil that is sensitive or easily eroded, while soil with a low erodibility index always means that the soil is resistant or resistant to erosion.

3.4. Mining

The area of land use in the form of mining in the Je'ne Rakikang DTA is 14.25 ha or 0.34% of the area of the Je'ne Rakikang catchment area. Based on the results of field checks, the 10 land units based on the results of the image interpretation are mining, but based on the results of field checks, this mining area is in a dormant state so that the land cover is equated with open land. Open land has a relatively high amount of erosion (74.13 tons/ha/year) after dry land farming. This is because the vegetation cover is almost non-existent, so the raindrops fall directly on the soil surface and cause the destruction of soil particles and erosion of the soil layer. This is in line with Arsyad (2010), that the amount of soil erosion that occurs is the result of cooperation between various factors, namely rainfall, vegetation (plants) growing on the land, topographical conditions, namely steepness and slope length, characteristics the land, and the treatment or action given by humans to the land [15].

3.5. Dryland shrubs farming

The total area of land use in the form of dry land mixed with shrubs is 153.15 ha or 3.62% of the area of the Je'ne Rakikang catchment area. Mixed dry land farming in the Je'ne Rakikang watershed is found in land units 11, 12, 13, and 14. The greatest value of erosion in dry land agriculture is found in land units 11, namely 3030.99 tons/ha/year. Even though it has the same slope (> 45%) with land units 13, namely slope class 5 with LS value (9.5), but because of the different land cover, the C value is also different. In land units 11 and 12, the land cover is corn with a C value (0.64), and land units 13 and 14 are elephant grass with a C value (0.50).

Hairah et al (2004) stated that the type of land cover affects the amount of erosion [16]. Another factor that causes the high value of erosion in dry land agriculture is that soil conservation techniques have not been applied, such as crop management by applying agroforestry patterns [17–19], and making swales so that their erosion value can be reduced.

3.6. Savana

The total area of land use in the form of savanna in the Je'ne Rakikang catchment area is 77.54 ha or 1.83% of the area of the Je'ne Rakikang catchment area. Land use in the form of savanna is divided into 4 land units. Savannas are located in land units 15, 16, and 17. The greatest erosion value in savanna is in land unit 17, which is 58.96 tons / ha / year which is caused by differences in cover crop cover in the form of grass. The 17 land units have <50% cover, while the land units are 15 and 16 levels density > 70%. This difference in the level of cover causes erosion that occurs in land units 17 to be much greater than in other land units. Gunawan and Kusminingrum (2008) state that the level of erosion will decrease with increasing levels of plant dense, and cover crop cover> 70% of the soil is eroded close to zero [20].

3.7. Rice fields

The total area of land use in the form of paddy/rice fields in the Je'ne Rakikang DTA is 261.76 ha or 6.19% of the area of the research location which is divided into 9 characteristics of land units. Rice fields are located in land units 18, 19, 20, 21, 22, 23, 24, 25, and 26. The erosion values of these land uses vary widely. The variation in erosion value is influenced by the difference in erodibility (K). The K value on land unit 18 is 0.09 which belongs to the very low erodibility class. The value of K in land units 23, 24, 25 and 26 is 0.10 which is classified as a very low erodibility class. The value of K in land units 19, 20, 21, and 22 is 0, 23 belonging to the medium erodibility class. Hardjoamidjojo and Sukartaatmajaya (2008) suggest that the greater the erodibility of a soil, the more sensitive the soil is to erosion [21]. This is what causes the erosion that occurs in land units 19, 20, 21, and 22 to be larger than the other land units.
3.8. Shrubs
The total area of shrubs in the Je'ne Rakikang catchment area is 1,065.29 ha with a percentage of 25.20% which is divided into 7 characteristics of land units. These land units include land units 27, 28, 29, 31, 32, 33, and 34. Even though they have the same land cover, namely shrubs with a plant management factor (C) of 0.01, there are variations in the erosion value. The variation in the value of erosion in land cover in the form of shrubs is caused by differences in the value of length and slope (LS) and soil erodibility value (K).

The difference in the slope of this slope causes the erosion value to increase 17-fold and the difference in the erodibility value causes the erosion value to increase 2-fold. Arsyad (2010) states that a soil that has low sensitivity may experience heavy erosion if the soil is located on a long and steep slope and the rainfall is always high [6]. On the other hand, a soil that has a high erosion sensitivity, may show mild erosion symptoms or show no erosion if it is located on a gentle slope, with good soil cover and low intensity rain. In terms of soil conservation, shrubs are effective for soil protection from erosion, especially if they are supported by a tight ground cover. However, shallow roots are not good in terms of soil infiltration.

3.9. Sediment Delivery Ratio (SDR)
The Jene'rakikang DTA has an area of 4228.06 ha or 42.28 km² so that the sediment release ratio in the Je'ne Rakikang catchment area is 17% or 0.17, the calculation of the SDR value. Suripin (2004) stated that the amount of SDR tends to be inversely proportional to the area of the watershed [22]. The wider the watershed, the smaller the SDR value.

3.10. Sediment yield
In estimating the value of sediment yield in the Je'ne Rakikang watershed, the sediment release ratio (SDR) is calculated. Based on the Universal Soil Loss Equation (USLE) method, the estimated total erosion value (A) is 78.93 tonnes/km²/year. The area of the Je'ne Rakikang catchment area is 42.28 km². The calculation results of the estimated amount of sediment show that the value of the sediment yield in the Je'ne Rakikang catchment area is 4.69 tonnes/year and the contribution of sediment from each land unit.

The sediment yield value ranges from 1:17 to the total erosion value, this is influenced by the elongated shape of the watershed so that the sediment concentration time to the outlet is longer. In addition, the small value of sediment yield is also influenced by the extent of land cover in the form of forest in the research location, which is 62.82% considered capable of holding sediment.

Asdak (2010) states that not all of the land that is eroded on the surface of the catchment area reaches the river. Some of the eroded soil will be deposited in the ground surface depressions, at the legs of the slopes and other forms of sedimentary cross sections [1]. Therefore, the amount of sediment yield usually varies according to the physical characteristics of the watershed. This is in line with what Wahyuningsrum, et al. (2014) stated that permanent vegetation has a rough surface so that it can slow down overland flow and sediment flow [13].

4. Conclusion
Based on the results of this study, the following conclusions can be drawn:
1. The predicted total erosion value that occurs in the Je'ne Rakikang catchment area is very large. The amount of erosion value generated is strongly influenced by the slope and soil type.
2. Prediction of the value of sediment yield that occurs in the Je'ne Rakikang watershed based on the calculation of sediment yield (Y) is classified as small.

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