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# Erosion Analysis in the Mrica Reservoir Catchment Area in Indonesia using the Soil Erosion Status Method

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**Abstract.** The reservoir catchment area (RCA) of Mrica in Banjarnegara district is a powerplant in Central Java with a capacity of 184.5 MW. Mrica Dam, is also called the dam of Great Commander General Sudirman, has seen a gradual decrease in its functions due to sedimentation from massive erosion, especially in the upland regions. RCA Mrica, with the upland area in Wonosobo district, has an area of 93,546.4 hectares, consisting of six sub-watersheds, Lumajang, Serayu upstream, Begaluh, Serayu, Tulis and Merawu. In 2017, sedimentation in the dam reached 238,236,588.20 m3/year, resulting from an erosion rate of 524,948.33 tons/year. Considering this serious erosion problem in the Mrica RCA, this study aims to estimate the distribution of the erosion level, categorised as slight, moderate and severe, using the SES (soil erosion status) formula. SES was calculated by mapping the level of each influential parameter: aspect, drainage, land cover, slope and soil texture. The calculation used SRTM (Shuttle Radar Topography Mission) satellite imagery and 2017 Landsat TM7 images. The results show slight erosion (<50 tons/ha/year) in 1,468.7 ha (1.6%); moderate erosion (50-100 tons/ha/yr) in 56,258.8 ha (60.1%); and severe erosion (> 100 tons/ha/year) in 35,818.9 ha (38.29%). Sampling in the field took into account the slope class of the nine classes and was repeated three times, so the number of samples taken in the field was 27. From field visits to the 27 location points, there was conformity in the results of the sensing analysis is much more than 85%". The results of the erosion calculation using the SES method showed severe erosion of 27.9% (26,137 ha); moderate erosion of 70.2% (65,679 ha); and slight erosion of 1.8% (1,731 ha). Further erosion calculation using the SES method needs to be compared with calculation using other methods.

**Keywords:** qualitative erosion, Mrica, Soil Erosion Status

## 1. Introduction

Mrica reservoir, located in Banjarnegara district, is the location of an electricity power station serving several regions in Central Java under PT. Indonesia Power management. The reservoir also functions as a tourist attraction and for irrigation of the downstream area. Considering the importance of the reservoir functions, the area upstream of the reservoir catchment area (RCA)of Mrica needs to be managed properly to avoid land degradation. The Mrica Dam only has a capacity of 101,990,000 $m^3$, so it can be said that it is in good condition, but the observation in the field shows that it is not able to accommodate the volume of sediment transportation that occurs annually.

According to Sunandar *et al.* (2013), the reservoir capacity was 101,990,000 $m^3$ and the sediment that entered the reservoir was 238,236,588 $m^3$/year, with an overflow sediment of 136,246,588 $m^3$/year. The severe sedimentation in Mrica has shortened the reservoir's lifetime, which was previously estimated to be up to 100 years (1988-2088) (Sunandar *et al.*, 2013).

Mrica reservoir is a dam for the hydropower electric company Perusahaan Listrik Tenaga Air (PLTA), commonly known as PLTA Panglima Besar Sudirman. The reservoir was built by damming the Serayu River and inundating 32 villages in seven sub-districts. It began to be inundated in April 1988. The reservoir collects rainfall from the area upstream of Serayu River and is located in Bawang sub-district, Banjarnegara, Central Java Province. The construction of the reservoir was allocated to PLTA, with a 180.93 MW capacity, and is used for the irrigation of an area of 6,550 ha, for the fisheries of the karamba system (bamboo cage), and as a tourism location (Wulandari, 2007). It is located at an elevation +231 m above sea level (a.s.l.), with an inundated area of 8.85 km$^2$. The reservoir can collect 140 million m$^3$ of water, with a flow of 11 m$^3$/second. Based on the results of a sedimentation analysis, it was estimated that reservoir age for sediment accumulation ranged from 38.5 to 46 years old (Hanafi, 2015). However, land use changes that occur in the reservoir catchment area will change reservoir capacity and affect the hydrology.

Land use changes and intensive cropping patterns sometimes generate benefits; however, they also put the area at risk due to intensive erosion, environmental damage and flash floods. The occurrence of massive erosion will lead to reservoir silting, decrease the volume capacity of the irrigation canals and disrupt the power plant system. Another negative impact of erosion is that it can also degrade the quality and quantity of natural resource conditions.

Erosion that occurs in the upstream area will have an impact downstream, such as on reservoir sustainability, human activity and the environment. The ongoing erosion process will also lead to changes in soil structure aggregate and fertility level, in turn affecting the productivity of agricultural land. An increase in erosion will increase sedimentation and affect electricity supply and irrigation water capacity. Erosion calculations using the MUSLE (Modification of the Universal Soil Loss Equation) method in Mrica showed 16,775,896 tons/year or 11,183,931 m$^3$/year, or a reduction in soil thickness of 16 mm/year (Hanafi, 2015). With the USLE (Universal Soil Loss Equation) method, the calculation of erosion is 524,948.33 tons/ha/year, with the sedimentation of 238236588.20 m$^3$/year (Sunandar *et al.*, 2013).

The process of erosion in the upstream area and the accompanying sedimentation in the downstream area will adversely affect the reservoir's lifetime. The process of erosion, therefore, needs to be studied to identify the distribution of the erosion level and to provide countermeasures. With the development of remote sensing technology, qualitative erosion can be calculated with satellite image analysis and radar imagery. Both imagery types can be calculated and analysed to obtain erosion distribution from slight to severe levels. The calculation results can help in the planning process before prevention steps and countermeasures are taken so that continuous erosion can be avoided. Satellite and radar imagery will reduce the time needed for surveys and field checks. On the other hand, if there is no satellite imagery, a census survey of the whole RCA/reservoir watershed area needs to be conducted.

Intensive land management, unsuitable land use in terms of land capability and unmatched site species will lead to land becoming infertile more quickly. To study land degradation levels in hilly and mountainous areas, erosion needs to be calculated. The objective of this research is to calculate and map the distribution of qualitative erosion classes using the SES method and satellite images of RCA Mrica. The SES method not only calculates the total erosion accumulated into the sediment in the reservoir but also calculates each unit of land in the field, so it is more detailed than the previous erosion calculation method. The advantage of calculating erosion using the SES method is that it can be done quickly and throughout the catchment area, while its weakness is that it only produces a qualitative calculation of erosion, but does not determine the amount of erosion that has occurred.

## 2. Research Method

The RCA Mrica research location is located at the latitude and longitude coordinates 7°09'-7°30' S and 109°36'-109°65' E. RCA Mrica is between Wonosobo and Temanggung regencies and is surrounded by four other regencies: to the west is Purbalingga regency; to the east Temanggung regency; to the north Pekalongan regency; and the south of Kebumen regency. The research site includes areas that often experience surface and landslide erosion, meaning the land easily experiences a degradation in soil fertility. This is due to the existing land use is not following the land use capability (LUC) class.

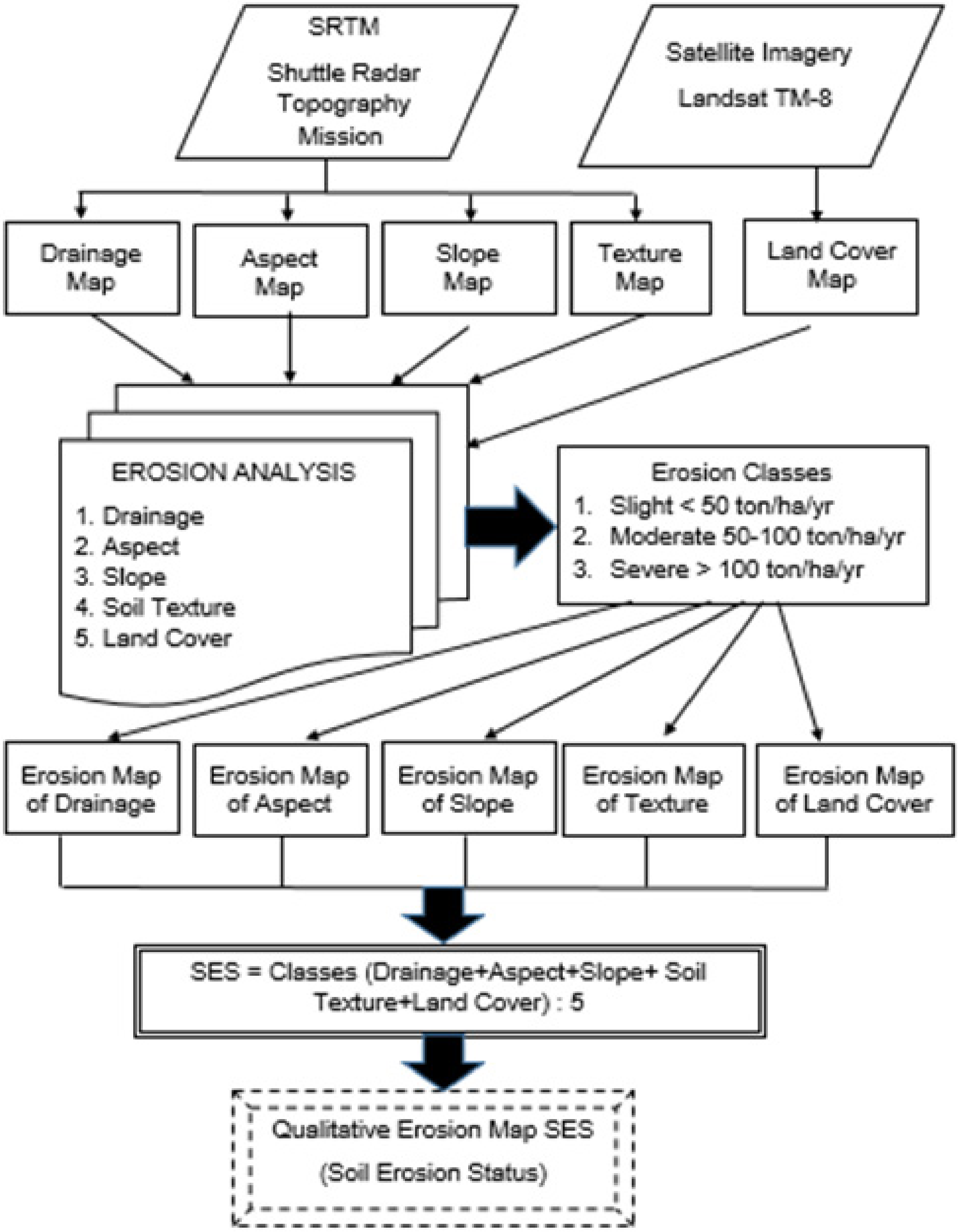


***Figure 1. Flow chart SES analysis in the catchment area of Mrica reservoir.***

The research method was based on qualitative calculations by conducting field surveys and also analysis of satellite image data. The field surveys involved collecting biophysical data from river conditions, slopes, slope direction, soil texture and land cover. To complete the erosion analysis, the primary data were supported by secondary data from the field. The field surveys were also intended to validate the results of the qualitative erosion analysis calculations using the soil erosion status (SES) method. According to Trisakti (2014), the qualitative erosion calculation method is very suitable for long-term planning, while quantitative erosion calculation for producing definite erosion figures is more for short-term planning.

Satellite images were taken in October 2014 including Shuttle Radar Topography Mission (SRTM) images and Landsat imagery 8. The SRTM images were employed for analysis of the drainage density, slope direction, slope and soil texture, while the Landsat 8 images were used for the analysis of land cover and use class distribution. Figure 1 shows a flow chart of the satellite image analysis methods, starting from radiometric and geometry correction to the qualitative erosion calculation SES results. Based on the SRTM imagery, maps were made, including drainage maps, slope direction maps, slope maps and texture maps. For the Landsat 8 images, classification of land cover and land use was made to produce a land cover map.

All five maps were further analysed by slicing or impact classification of the erosion. This resulted in the erosion class; i.e., (a) slight <50 tons/ha/yr, (b) moderate = 50-100 tons/ha/year and (c) severe > 100 tons/ha/yr. The results from the classification analysis of each parameter then generated an erosion map for each parameter. These comprised (a) a map of erosion caused by drainage, (b) a map of erosion due to differences in slope direction, (c) an erosion map due to slope, (d) an erosion map due to differences in soil texture and (e) erosion map based on land cover. Sampling in the field was distributed throughout the RCA Mrica area, representing nine different slope classes, each of which was repeated three times, meaning there were nine slopes x 3 three replications, equal to 27 samples. Validation of the accuracy level of the remote sensing analysis was made by comparing the erosion conditions in the field and the level of erosion on the map, which was expected to have an accuracy of more than 80%.

From the five erosion class maps, the average erosion that had occurred was then calculated, resulting in the qualitative SES erosion. Validation of the erosion calculation results was made by checking the location to compare the erosion class on the map with the actual conditions in the field. The provision for drainage maps referred to drainage speed, as shown in Table 1 (Harjadi, 2015).

**Table 1. Class provisions for drainage parameters.**

| No | Description | mm/hour | Class |
|---|---|---|---|
| 1 | Good | >125 | 3 |
| 2 | Very good | 65-125 | 3 |
| 3 | Moderate | 20-65 | 2 |
| 4 | Slightly slow | 5-20 | 2 |
| 5 | Slow | 1-5 | 1 |
| 6 | Very slow | <1 | 1 |

The aspect map, or the direction of the sunlight onto the slopes, was based on Table 2.

**Table 2. Class provisions for aspect parameters.**

| No | Symbol | Description | Degree | Class |
|---|---|---|---|---|
| 1 | N | North | 22.5 | 1 |
| 2 | NE | North-east | 67.5 | 1 |
| 3 | E | East | 112.5 | 2 |
| 4 | SE | South-east | 157.5 | 3 |
| 5 | S | South | 202.5 | 3 |
| 6 | SW | South-west | 247.5 | 3 |
| 7 | W | West | 292.5 | 2 |
| 8 | NW | North-west | 337.5 | 1 |

The slope Map, from flat class to slightly sloping up to precipitous, was based on Table 3. There were 12 classes for the texture map, from rough to fine texture, as shown in Table 4. The land cover map consisted of eight types of cover, using the criteria shown in Table 5.

**Table 3. Class provisions for slope parameters.**

| Slope | % | Description | Class |
|---|---|---|---|
| A | 0 - 4 | Flat to slightly sloping | 1 |
| B | 4 - 8 | Gently sloping | 1 |
| C | 8 - 15 | Moderately sloping | 1 |
| D | 15 - 25 | Strongly sloping | 2 |
| E | 25 - 35 | Moderately steep | 2 |
| F | 35 - 45 | Steep | 2 |
| G | 45 - 65 | Very steep | 3 |
| H | 65 - 85 | Extremely steep | 3 |
| I | > 85 | Precipitous | 3 |

**Table 4. Class provisions for texture parameters.**

| No | Symbol | Texture | Class |
|---|---|---|---|
| 1 | S | Sand | 3 |
| 2 | LS | Loamy Sand | 3 |
| 3 | L | Loam | 1 |
| 4 | SL | Sandy Loam | 1 |
| 5 | SiL | Silty Loam | 1 |
| 6 | Si | Silty | 3 |
| 7 | SCL | Sandy Clay Loam | 2 |
| 8 | SiCL | Silty Clay Loam | 1 |
| 9 | CL | Clay Loam | 2 |
| 10 | SC | Sandy Clay | 1 |
| 11 | SiC | Silty Clay | 1 |
| 12 | C | Clay | 2 |

**Table 5. Class terms for land cover parameters.**

| No | Land Cover | Class |
|---|---|---|
| 1 | Forest | 1 |
| 2 | Rice field | 1 |
| 3 | Open land | 2 |
| 4 | Vegetable garden | 2 |
| 5 | Village | 2 |
| 6 | Bush | 2 |
| 7 | Agroforestry | 2 |
| 8 | Wasteland | 3 |

## 3. Results and Discussion

### 3.1. Analysis of Erosion

a. Drainage

Light erosion occurred in areas with slow and very slow drainage, while severe erosion took place in areas with good or very good drainage. According to Tingsanchali (2012)high floods and high tides, etc., and human factors such as blocking of channels or aggravation of drainage channels, improper land use, deforestation in headwater regions, etc. Floods result in losses of life and damage properties. Population increase results in more urbanization, more impervious area and less infiltration and greater flood peak and runoff. Problems become more critical due to more severe and frequent flooding likely caused by climate change, socio-economic damage, population affected, public outcry and limited funds. Flood loss prevention and mitigation includes structural flood control measures such as construction of dams or river dikes and non-structural measures such as flood forecasting and warning, flood hazard and risk management, public participation and institutional arrangement, etc. This paper describes concepts, policy, plan and operation on integrated urban flood disaster and risk management. In most developing countries, flood disaster management activities are handled by government. Participation of nongovernmental agencies and private sectors are very limited. Activities are exercised rather independently without proper coordination or integration. Flood disaster management in developing countries is mostly reactive responding to prevailing disaster situations (emergency response and recovery, slow drainage due to closed channels can cause flooding.

**Table 6. Erosion classes of each level of drainage.**

| Class | Criterion | Drainage | % | Ha |
|---|---|---|---|---|
| 1 | Slight | Slow, Very slow | 1.6 | 1,468.7 |
| 2 | Moderate | Slight slow, Moderate | 60.1 | 56,258.8 |
| 3 | Severe | Good, Very good | 38.3 | 35,818.9 |
| | | | 100 | 93,546.4 |

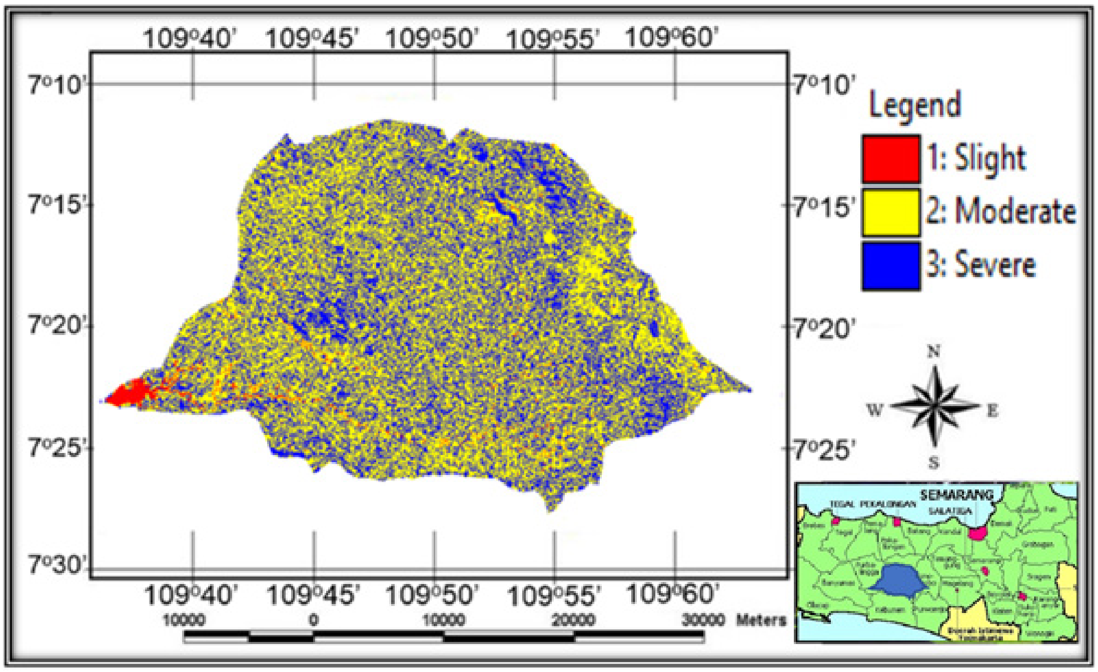


*Figure 2. Map of erosion class with different drainage.*

The most widespread erosion in areas with moderate drainage accounted for 56,258 ha, with light erosion-affected areas with slow drainage at 1,468 ha (Table 6). Prevention of erosion in areas with rapid drainage can be overcome using soil conservation constructions mechanically, vegetatively and biologically. The distribution of moderate erosion that dominates the area with medium drainage can be seen in Figure 2. The distribution of severe erosion of 38.3% or 35.818 ha is mostly spread over the upper (upstream) region and a small part of the central area.

**b. Aspect**

Slope directions affect the occurrence of erosion. The southward slope areas (SW = south west, S = south, and SE = south east) are the most prone to erosion, at a level of around 49.4%. According to Lee and Pradhan (2007)Malaysia, using Geographic Information System (GIS, aspect is one of the factors which causes landslides, together with other factors such as slope, lithology and land cover.

Severe erosion caused by the south facing area is 46,222 ha and is dominant in the RCA Mrica area (Table 7). As suggested, in the RCA Mrica for south facing land should be managed carefully, as this land is easily eroded. Figure 3 shows that the distribution of severe erosion due to the predominantly south-facing slope conditions is spread over 49%.

**Table 7. Erosion classes of each aspect level.**

| Class | Criterion | Aspect | % | Ha |
|---|---|---|---|---|
| 1 | Slight | NW,N,NE | 24.6 | 23,003.0 |
| 2 | Moderate | W,E | 26.0 | 24,322.1 |
| 3 | Severe | SW,S,SE | 49.4 | 46,221.3 |
| | | | 100 | 93,546.4 |

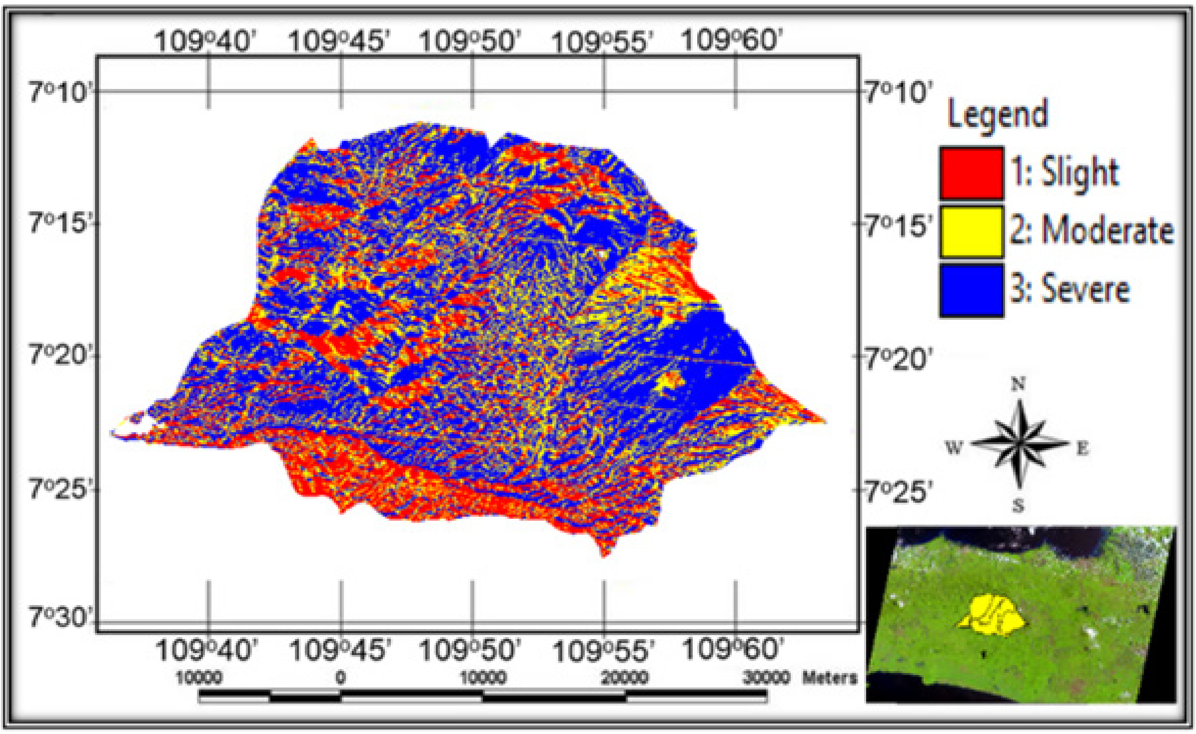


*Figure 3. Map of erosion class with different aspects.*

**c. Slope**

The steeper the slope, the greater the potential for erosion. The majority of the slopes (60.1%.) at RCA Mrica are moderate, comprising slope D (15-25%), E (25-35%) and F (35-45%). According to Trisakti (2014), the slope factor is one of the contributors to erosion speed and leads to the dredging of the RCA (watershed) below it.

From the slope factors, a medium erosion of 56.258.8 ha, or an area of 60.1% which dominates the RCA Mrica area, can be seen (Table 8). Figure 4 shows that in the RCA Mrica map, severe erosion is located in the upper (upstream) area, and light erosion is in the lower area, or near the river. Moderate erosion spread throughout the RCA Mrica area.

**Table 8. Erosion classes of each level of slope.**

| Class | Criterion | Slope | % | Ha |
|---|---|---|---|---|
| 1 | Slight | A,B,C | 1.57 | 1,468.7 |
| 2 | Moderate | D,E,F | 60.14 | 56,258.8 |
| 3 | Severe | G,H,I | 38.29 | 35,818.9 |
| | | | 100 | 93,546.4 |

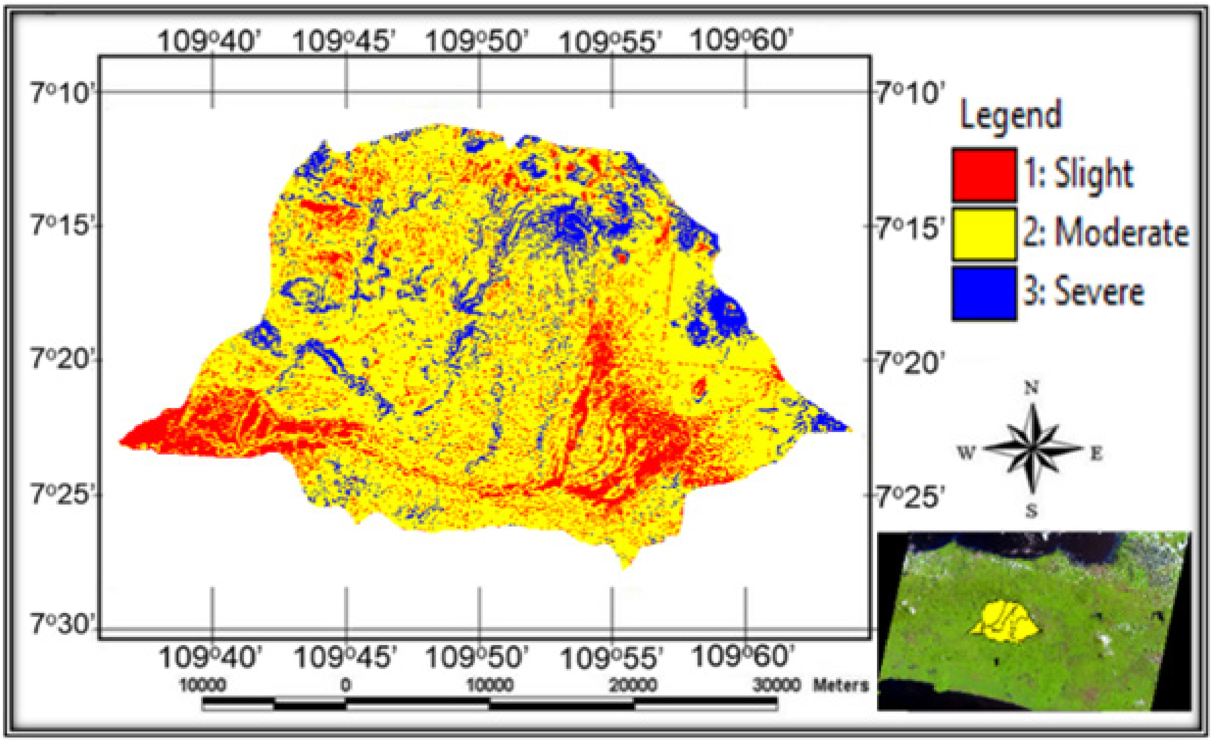


*Figure 4. Map of erosion class with different slopes.*

**d. Texture**

The softer the (clay) soil texture is, the more easily the land will be eroded, while the coarser texture (sand) will be resistant to erosion. Regarding the texture factor, most of the land in RCA Mrica is classified as moderate erosion, at around 66,034 ha (70.6%). According to the US Department of Agriculture (USDA) (2011), 12 texture classes affect soil sensitivity to erosion.

Table 9. Erosion classes for each level of texture.

| Class | Criterion | Texture | % | Ha |
|---|---|---|---|---|
| 1 | Slight | SiC, SC, SiCl, L, SiL, SL | 27.3 | 25,538.2 |
| 2 | Moderate | CL, C, SCL | 70.59 | 66,034.4 |
| 3 | Severe | S, LS, Si | 2.11 | 1,973.8 |
| | | | 100 | 93,546.4 |

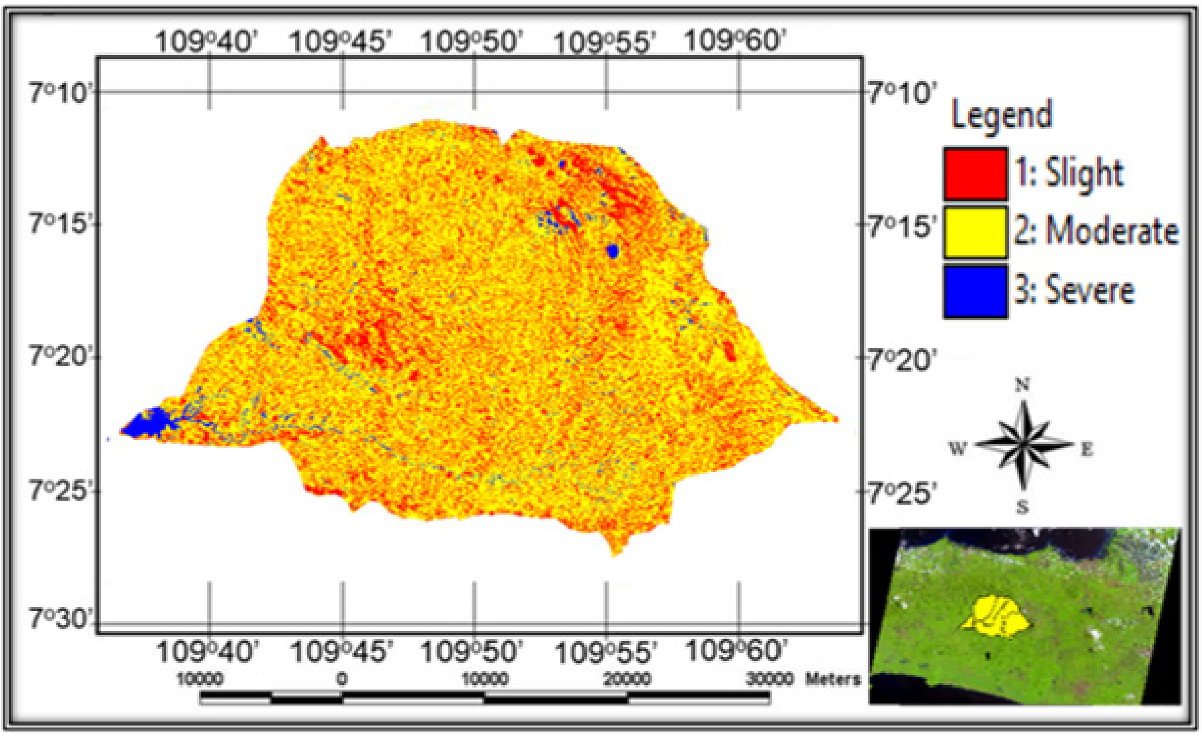


*Figure 5. Map of erosion class with different soil textures.*

Texture conditions in RCA Mrica are dominated by the moderate class, meaning they are not too subtle or too rugged and are included in the silt texture class (medium) (Table 9). There is very little heavy texture. only 1.973 ha (2.1%). Figure 5 shows a map of the distribution of moderate-dominated erosion, that spreads evenly from the top (upstream) to the bottom (downstream) of the area.

## e. Land Cover

From the existing land cover in RCA Mrica, there are medium and light erosion levels. Table 10 shows that erosion is dominated by 51.47% (48,148 ha) of moderate class and by light erosion at 47.98% (44,883 ha). Land cover conditions like this are sufficient to prevent erosion. According to Yan *et al.* (2016), more open land cover change will increase land degradation.

The erosion in the RCA Mrica area is predominantly at moderate and light levels, with slight erosion at a level of 0.55% (514 ha). Figure 6 shows the distribution of moderate (51%) and light (48%) erosions in the RCA Mrica area when calculated from the land cover factor. In areas with moderate erosion, reforestation is required to allow more land to be covered by vegetation, thus reducing the erosion rate.

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Table 10. Erosion classes for each level of land cover.

| Class | Criterion | Land Cover | % | Ha |
|---|---|---|---|---|
| 1 | Slight | Forest, Rice field | 47.98 | 44,883.5 |
| 2 | Moderate | Vegetable, Village, Bush, Agroforestry | 51.47 | 48,148.3 |
| 3 | Severe | Wasteland | 0.55 | 514.5 |
| | | | 100 | 93,546.4 |

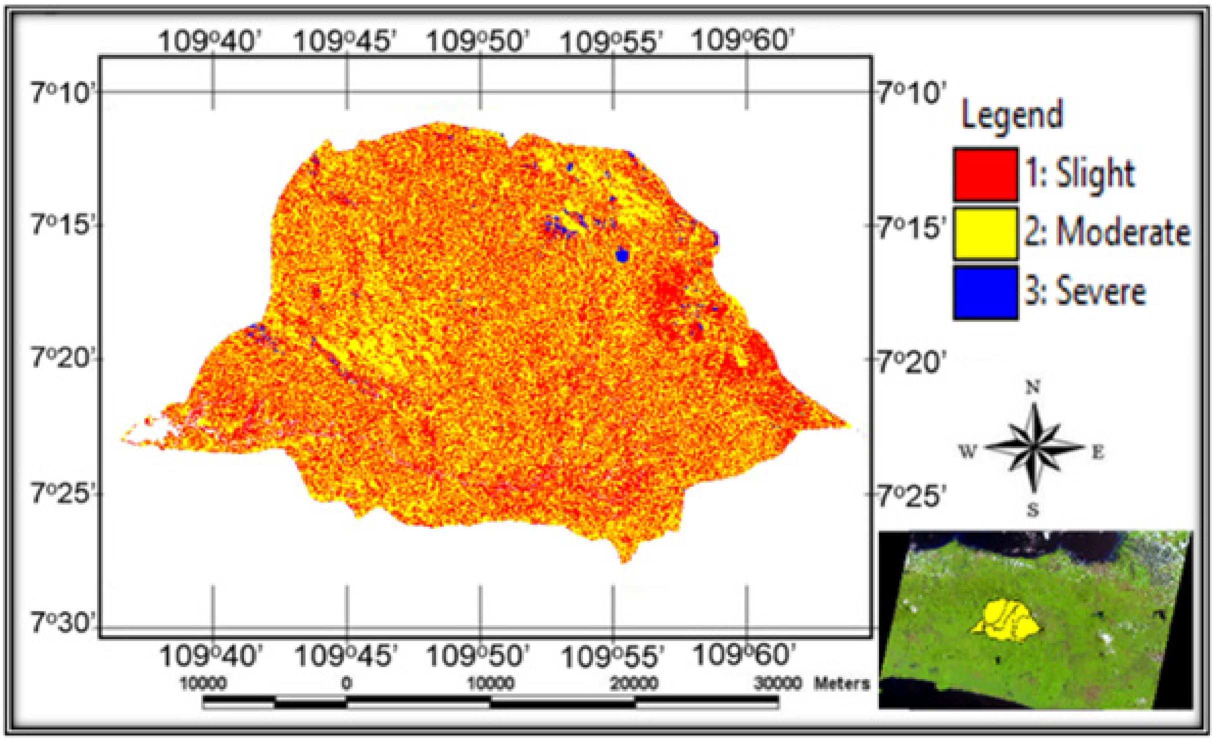


Figure 6. Map of erosion class with different land cover.

Table 11. Erosion classes of each factor.

| Percentage (%) | Aspect | Drainage | Land Cover | Slope | Texture |
|---|---|---|---|---|---|
| 1 | 24.6 | 1.6 | 48.0 | 1.6 | 27.3 |
| 2 | 26.0 | 60.1 | 51.5 | 60.1 | 70.59 |
| 3 | 49.4 | 38.3 | 0.6 | 38.3 | 2.11 |

| Area (ha) | Aspect | Drainage | Land Cover | Slope | Texture |
|---|---|---|---|---|---|
| 1 | 23,003 | 1,469 | 44,884 | 1,469 | 25,538 |
| 2 | 24,322 | 56,259 | 48,148 | 56,259 | 66,034 |
| 3 | 46,221 | 35,819 | 515 | 35,819 | 1,974 |

The results of the calculation for each parameter can be seen in Table 11; the five erosion factors resulted in almost equal erosion levels, all dominated by moderate erosion. Furthermore, severe erosion conditions are influenced by the aspect factor, drainage and slope.

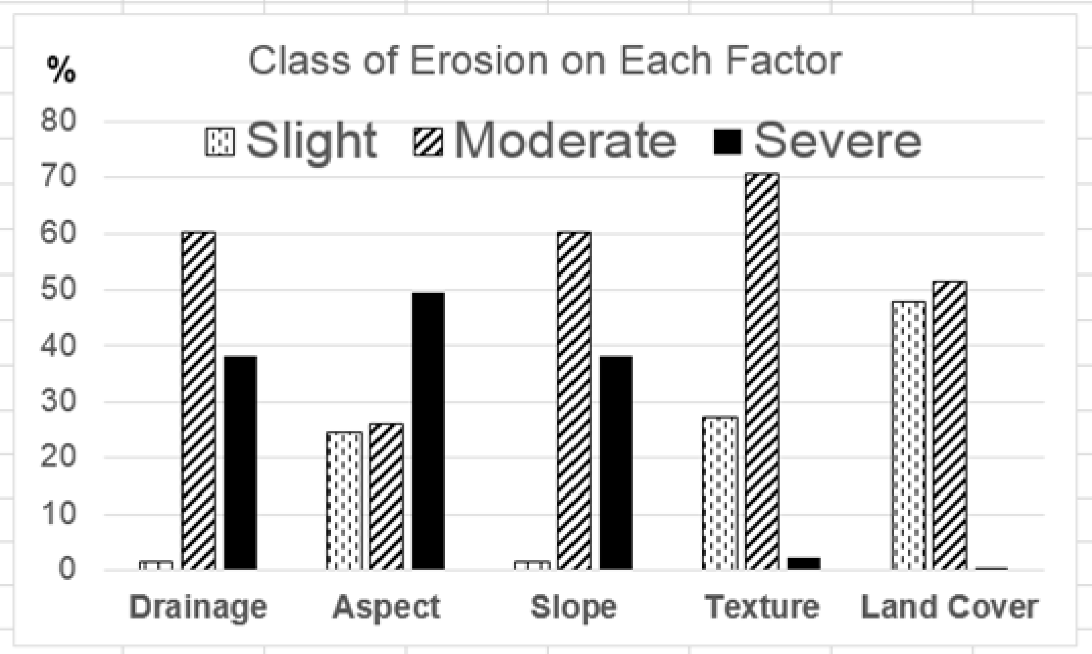


*Figure 7. Erosion class with different factors.*

**Table 12. Qualitative erosion with the SES method.**

| Class | Criterion | % | Ha |
|---|---|---|---|
| 1 | Slight | 1.85 | 1,730.6 |
| 2 | Moderate | 70.21 | 65,678.9 |
| 3 | Severe | 27.94 | 26,136.9 |
| | | 100 | 93,546.4 |

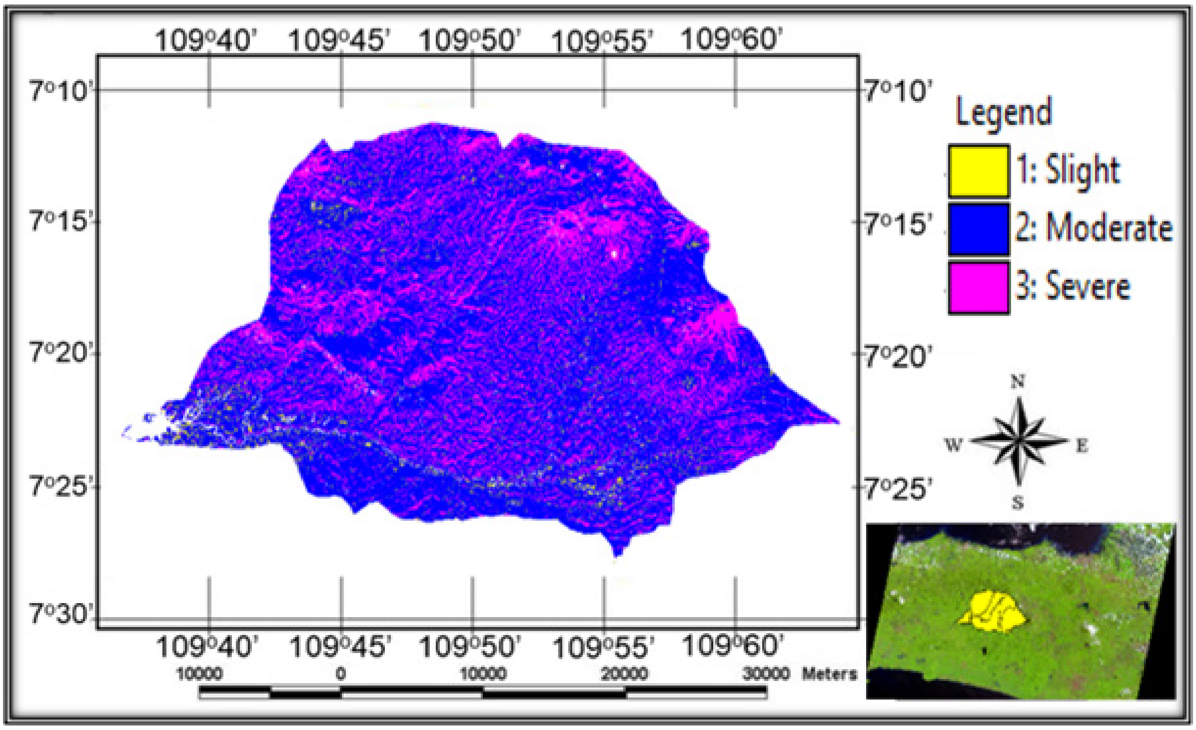


*Figure 8. Map of qualitative erosion at Mrica dam.*


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Figure 7 shows that the most predominant erosion is moderate; the exception for aspect factor and slope direction which are predominantly severe erosion. Soil texture and land cover factors make very little contribution to severe erosion.

The results of the erosion calculation using the SES method were moderate erosion 70% (65,678 ha), severe erosion 28% (26,137 ha) and 2% light erosion (1,731 ha) (Table 12).

Figure 8 shows a map of erosion distribution in the RCA Mrica area, which is dominated by moderate levels that are evenly distributed in the upper, middle and lower regions.

### 3.2. Discussion

From the five factors that influence erosion, aspect, drainage, land cover, slope and texture, average erosion can be calculated, meaning the results refer to qualitative erosion. According to Saiya, Dibyosaputro, and Santosa (2016), erosion calculations using USLE also consider the biophysical factors of soil, especially soil texture and slope. Different types of land use will also lose soil or erosion will occur (Martínez-Valderrama *et al*., 2016).

Erosion at RCA Mrica is dominated by moderate erosion, at 70.2%, or an area of 65,678.9 ha. Moderate and uniform erosion throughout the area is a serious problem that needs to be addressed immediately; for example, using soil and water conservation measures. Soil conservation can be performed mechanically as well as vegetatively; vegetative erosion control uses plants that can control erosion (Pasaribu, Rauf, & Slamet, 2018). Land use such as grasses and arid climatic conditions will increase the intensity of erosion (Jianga *et al*., 2018).

The conditions of erosion distribution in the RCA Mrica area are dominated by moderate erosion that is evenly distributed from the upper to the lower slopes, while the remaining instances include severe erosion and very little area that includes slight erosion. Severe erosion occurs in the upstream or mountainous areas and hills or on the RCA Mrica borders. The level of erosion that occurs is not only determined by the height of the location, but also by the K factor, soil erodibility, or the sensitivity of the soil to erosion (Sulistyo, 2015). Integration of soil erosion will be a consideration or have an impact on the occurrence of land degradation heterogeneity (Al Sayah *et al*., 2021).

Severe erosion is common in sloping to steep terrains on mountain ranges and hills with landslide and gully erosion. On the other hand, moderate erosion occurs in middle regions, such as alluvial-colluvial regions, with moderate slopes and is dominated by sheet and rill erosion. Light erosion on the lower basin that is not too steep is dominated by surface erosion due to open area conditions. This is in accordance with the conditions in the field, with the validation results obtaining an accuracy of more than 85%. Qualitative erosion calculations using the SES method in the Tulis sub-watershed also had an accuracy of more than 80% (Harjadi & Susanti, 2019)2016, and a radar image is SRTM (Shuttle Radar Topography Mission. The severity of erosion occurring in a certain location also indicates that land degradation has occurred on a massive scale (Tsymbarovich *et al*., 2020).

Furthermore, for light erosion, it is possible to conduct soil conservation measures mechanically, vegetatively and biologically, with limited use of chemical fertilizers, which tend to damage the land as they are unable to improve soil structure aggregation. The role of the government is also very important in helping to handle erosion so that it will not be a cause of flood disasters due to river shallowing (Hutauruk *et al*., 2020). In order to reduce the risk, mitigation must be made by understanding the signs of disaster due to mild or severe erosion (Shimizu *et al*., 2020).

## 4. Conclusion

Qualitative erosion analysis can be made using the SES (Soil Erosion Status) method. The defining parameters for such calculation are aspect, drainage, land cover, slope and soil texture. From the erosion calculation using the SES method, erosion at RCA Mrica was shown to comprise slight erosion 1.85% (1,730.6 ha), moderate erosion 70.21% (65,678.9 ha) and severe erosion 27.94% (26,136.9 ha). Light erosion is when the erosion value is <50 tons/ha/yr, with moderate erosion at 50-100 tons/ha/yr, and severe at > 100 tons/ha/yr.

In areas with severe erosion, integrated soil conservation using civil, technical, vegetative, chemical and biological methods needs to be undertaken. If such techniques are performed incorrectly, they can become a contributor to sedimentation in reservoirs and silting of rivers. Besides being a contributor to sedimentation, land that has experienced severe erosion will suffer rapid degradation and land can become marginal more quickly. Severe erosion occurs mostly in mountainous areas and hills, or at the top border of RCA Mrica.

The erosion conditions that dominate at RCA Mrica are moderate and uniform, so management of the upper land should be conducted carefully and appropriate land conservation rules followed. Suggestions for areas with severe erosion levels include civil and mechanical soil and water conservation measures; e.g., by repairing terraces, drainage and gully plugs or retaining dams. For medium erosion, soil and water conservation action with a combination of civil and vegetative measures, with an improvement of the grass, cropping patterns, and vegetation choices that are suitable for the condition of land should be taken.

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