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Study Of Water Resources Management For River Area Of MSBL

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Abstract—In accordance with the mandate of the Water Resources Law, after the Water Resources Management Pattern in the River Basin is completed, the next step is to draw up a Water Resources Management Plan whose preparation must be in accordance with the Water Resources Management Pattern in the River Basin. The Water Resources Management Plan is the result of a comprehensive and integrated planning that is needed to carry out water resource management and serves as a guide and direction in the implementation of water resource conservation, utilization of water resources, and control of the destructive power of water in river areas.As described above, one of the contents in the design of the water resources management pattern is the alternative choice of water resources management strategies for each scenario. The water resources management strategy is a series of efforts or water resources management activities to achieve the objectives of water resource management in accordance with the scenario of the condition of the river area. According to PP 42 of 2008, it is stated that the Water Resources Management Plan is prepared based on a Water Resources management strategy that is selected from the alternative strategies contained in the Water Resources Management Pattern by the Water Resources Management Coordination Center in the relevant River Basin. The purpose of this research is to formulate a Water Resources Management Plan for the Musi Sugihan Banyuasin Lemau River Basin (MSBL) set by the Minister of Public Works which is a comprehensive and integrated plan between related sectors in water resource management and is used as a guideline and basis/foundation preparation of programs and activity plans for each related sector in the implementation of water resources management. The results are a discussion of strategic issues in the management of MSBL along with mapping the area of the PSDA pattern starting from conservation of natural resources, utilization of natural resources, prevention of water damage, availability of data and information, economic conditions along with maps of flood areas, water absorption and maps of water demand in MSBL.

Keywords—water resources management ; MSBL; river basin

I. INTRODUCTION

Law of the Republic of Indonesia number 7 of 2004 concerning Water Resources (SDA), article 11, paragraph (1), paragraph (2) and (3) mandates that in order to ensure that water resources can provide the maximum benefit to the interests of the community in In all areas of life, in every River Basin (WS) a Water Resources Management Pattern is needed.

The Water Resources Management Pattern is the basic framework for planning, implementing, monitoring, and evaluating water resources conservation, water resource utilization, and water damage control, with the principle of integration between surface water and ground water and involving the role of the community and the business world. . According to PP 42 of 2008 concerning Water Resources Management, Presidential Decree no. 12 of 2012 concerning the Determination of River Basin. The design of the water resources management pattern must include:

The purpose of water resource management in the relevant river area.

1. Basic considerations used in managing water resources.
2. Several scenarios of river basin conditions.
3. Alternative options for water resources management strategies for each scenario.
4. Operational policies to implement water resources management strategies.

In accordance with the mandate of the Water Resources Law, after the Water Resources Management Pattern in the River Basin is completed, the next step is to draw up a Water Resources Management Plan whose preparation must be in accordance with the Water Resources Management Pattern in the River Basin. The Water Resources Management Plan is the result of a comprehensive and integrated planning that is needed to carry out water resource management and serves as a guide and direction in the implementation of water resource conservation, utilization of water resources, and control of the destructive power of water in river areas

Most of the Musi river area is located in South Sumatra Province (95.3% of the total area of the Musi River Basin in accordance with Ministerial Regulation 11a/PRT/M/2006), so reviews and issues in South Sumatra Province are used as strategic issues as follows:

1. Musi River Area
    a. Aspect of Space Utilization
    b. Social Population
    c. Economy
    d. Transportation System
    e. Regional Infrastructure
    f. Institutional and development financing
2. Banyuasin River Area
    a. Rainfed Rice Fields and Rice Fields
    b. DMI Water Needs
    c. Level of Sedimentation and Water Pollution
    d. Upstream Land as Water Catchment
    e. Independent Integrated City
    f. Tanjung Api-Api Harbor
    g. Residential Settlement Within the National Park Area
3. Sugihan River Area
4. Lemau River Area

II. Location of Study Area

The research location is planned to be in the MSBL WS as shown in the following picture Figure 1.

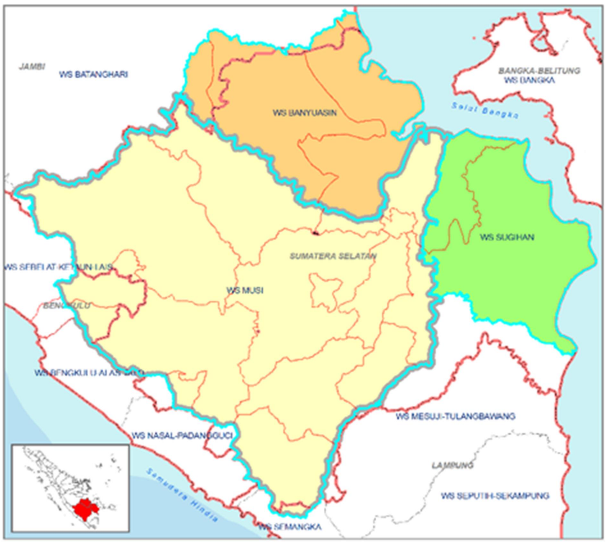

Figure 1. Research Location

III. MATERIAL AND METHODS

3.1. Watershed Critical Analysis

One of the land resource problems that need special attention is the problem of damage to the watershed ecosystem (DAS), which is caused by the decreasing environmental carrying capacity due to the increasing pressure on land use and the lack of conservation efforts by the community. Furthermore, this condition can increase erosion problems, which have an impact not only on decreasing land productivity in the on site area, but also increasing sedimentation in the off site area.

The problem of damage to watershed ecosystems as described above has occurred in many watersheds in Indonesia over the past few years, where there has been a significant change in land use function, from forest land to plantation land, cultivated land/agricultural land turned into residential land, industrial land , etc. To prevent further damage to the watershed ecosystem, it is necessary to carry out more integrated watershed control/management efforts.

There are several parameters that can be used as a basis for assessing watershed damage/criticality, such as parameters of rainfall, erosion rate, percentage of flood inundation area, percentage of open land, dominance of land cover, percentage of forest cover, permanent vegetation, variations in flow discharge, balance of availability. and water requirements, and runoff. The number of indicators/parameters used here is intended to be able to assess the criticality of a land from various aspects.

Among several critical watershed parameters as mentioned above, the erosion rate parameter is often associated with conservation direction activities, therefore it will be analyzed in more detail as follows.

3.2. Soil Erosion Analysis

Land use and poor soil management, can cause accelerated erosion, and will directly lead to increased soil criticality. The problem of erosion is closely related to water resource planning, where erosion will cause an increase in the sediment load in the river system and result in changes in hydro-morphological conditions (sediment deposition in reservoirs, lakes, and channels which results in the rise of the river bed surface, especially in downstream rivers). If this erosion occurs quickly, it will spur changes in the hydrological elements of the river; namely increasing surface flow and decreasing base flow. Therefore, critical areas with high erosion rates need to be identified, and soil conservation programs need to be considered, with the hope of achieving an erosion rate at a reasonable level.

Of the many formulas that can be used to predict the magnitude of erosion, the model developed by Wischmeier and Smith (1978) - commonly known as the Universal Soil Loss Equation (USLE) - is considered the most popular and widely used method for predicting the magnitude of erosion. USLE is an erosion model designed to predict the long-term average of sheet erosion, including rill erosion, under certain conditions. It should be explained here that the USLE formula was developed for a plot of land with a small size/area, so that if you want to apply it to a watershed (DAS) or river area (WS) with a large size/area, the watershed/WS needs to be divided into a number of small areas, which are referred to as land units. Erosion that occurs is then calculated for each land unit, and the amount of total erosion in the watershed/WS can be obtained by adding up the erosion that occurs in all land units.

By using the USLE equation, it is possible to predict the average rate of erosion of a certain plot of land, on a steep slope and with a certain rainfall pattern, for each type of cropping and management actions (soil conservation actions) that are or may be carried out. The equations used group the various physical (and management) parameters that affect the rate of erosion into six main parameters.

The proposed USLE equation is as follows:

$$A = R\,K\,L\,S\,C\,P \qquad (1)$$

Where:

A = is the amount of soil eroded in [tonnes per hectare per year].

R = is a factor of rainfall and surface runoff (rain erosivity), namely the number of units of the rain erosion index, which is the product of the total rain energy (E) with a maximum rainfall intensity of 30 minutes (I30) per year.

K = is the soil erodibility factor, namely the erosion rate per rain erosion index (R) for a soil obtained from the standard experimental plot, namely the experimental plot which is 72.6 ft (22.1 m) long and is located on a 9% slope without plants

L = is the slope length factor, i.e. the ratio between the magnitude of erosion from soil with a certain slope length to erosion from soil with a slope length of 72.6 ft (22.1 m) under identical conditions.

S = is the slope steepness factor, namely the ratio between the amount of erosion that occurs from a plot of land with the steepness of a certain slope, to the amount of erosion from soil with a slope of 9% under identical conditions.

C = is the factor of ground cover vegetation and plant management, namely the ratio between the amount of erosion from a plot of land with vegetation cover and certain plant management to the amount of erosion from identical soil without plants.

P = is a factor of special soil conservation measures, namely the ratio between the amount of erosion from soil that is treated with special conservation measures (such as tillage according to contours, planting in stripping or terraces), to the amount of erosion from soil that is cultivated in the direction of the slopes under conditions that identical.

Schematically the USLE equation can be explained in Figure 2 below.

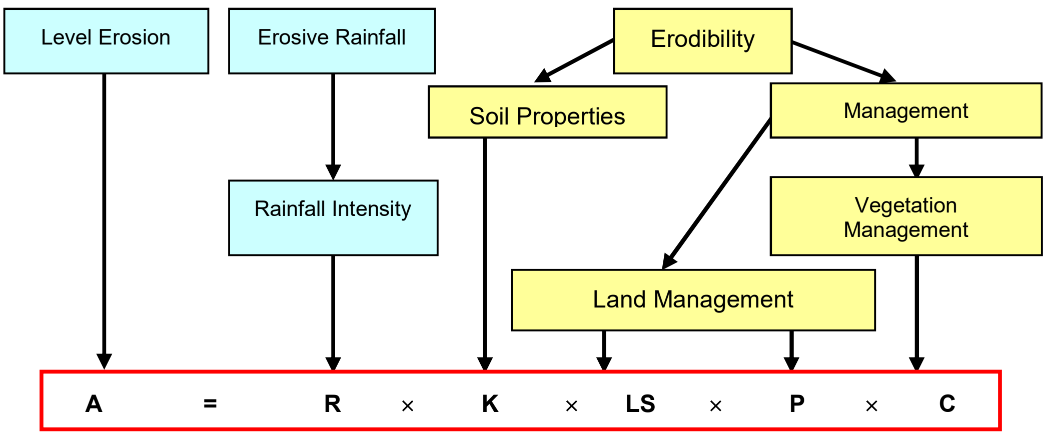

Figure 2. Schematic of the USLE erosion estimator equation

Often the parameters C and P are expressed as CP parameters, which describe the parameters of land use and its management. By entering the parameters R, K, LS, and CP in the USLE formula, the magnitude of soil erosion that occurs can be predicted; these parameters can be obtained from the literature (Kirby, 1984). The following is the process of calculating erosion in the study area

3.3. Analysis of Potential Availability of Water Resources

The availability of water in terms of water resources basically comes from rainwater (atmospheric), surface water, and ground water. Rain that falls on the surface in a watershed or river basin partly evaporates again according to the climatic process, some flows through the surface and sub-surface into channels, rivers or lakes, and partly seeps down to the ground as a recharge. on the soil water content. The measured flow in rivers or channels or lakes is a potential surface water discharge, as well as water flowing into the ground, the water content stored in the soil is a potential groundwater discharge.

Of the three water sources, those that have the greatest potential to be utilized are surface water sources in the form of water in rivers, canals, lakes/reservoirs and others. The use of ground water is very helpful in meeting the needs of raw water and irrigation water in areas where it is difficult to get surface water, but the use of ground water requires very expensive pump operating costs.

3.3.1. Water Availability Variability

To be able to state the availability of water perfectly, the flow rate data must be time series. This time series data is the main input in the river basin simulation model, which fully describes the variability of the flow discharge data.

The simplest way to express water availability is to use a number that is the average of the existing discharge data. This method does not provide information about the variability of the data. While a number that can show the variability of water availability is the mainstay discharge.

3.3.2. Mainstay of Surface Flow

Reliable discharge is a reliable discharge for a certain reliability. For irrigation purposes, a reliable discharge is used with 80% reliability. This means that with an 80% possibility the discharge that occurs is greater than or equal to the discharge. For drinking water and industrial purposes, higher reliability is required, which is around 90% to 95%. If river water is to be used for hydroelectric power generation, a very high reliability is required, which is between 95% to 99%.

The average discharge value, as well as the mainstay discharge, can be calculated from the observational discharge data which is quite long. The problem that often occurs is that the measured discharge data is incomplete, i.e. many observations are empty or incorrect, for this reason, hydrological data analysis is needed to complete the blank data and extend the time series data that is not long enough.

Surface water potential is usually indicated by a reliable discharge of 80% with a half-month time period which is analyzed by frequency analysis using the empirical normal distribution equation as follows.

$$\mathbf{Q80 = Q + k \cdot S} \qquad (2)$$

With:

Q80 = discharge with an 80% probability of occurrence

Q = average discharge

K = frequency factor (Gauss reduction variable = - 0.84)

S = standard deviation

In the condition that the availability of discharge data is low, it is necessary to find a correlation between rain and flow; One of the rain-flow methods that can be used is the Mock Model.

3.3.3. Groundwater Potential and Recharge

Data on groundwater potential information depends on the condition of the aquifer in each area (major aquifer, minor aquifer, or non aquifer). Groundwater filling is influenced by several factors, including soil texture and structure, initial moisture, type and depth of litter, and vegetation. Theoretically, if it rains, some of the rainwater will seep into the soil, some will be retained in the basins of the ground surface, some will be retained on the vegetation canopy and some will be as surface run off. On this basis it can be concluded that the amount of groundwater infiltration is a function of rainfall, the area of the catchment, and the characteristics of the catchment area.

The following describes the magnitude of groundwater recharge caused by rainwater. Groundwater recharge is the replenishment of water into the ground to fill the groundwater zone. Illustration of this filling. While the calculation steps for groundwater recharge can be seen in Figure 3.

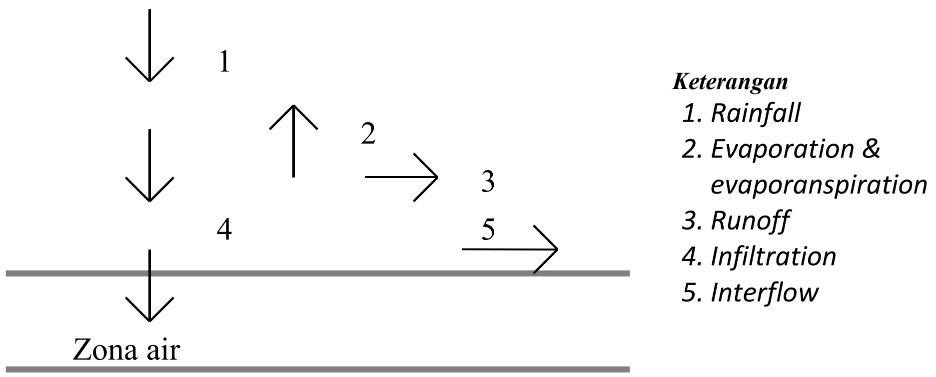

Figure 3. Groundwater Recharge Illustration

To determine the amount of recharge water, the data needed are monthly rain data and land use data. Rain data is used to determine the amount of mainstay rain. The mainstay rain is taken as 80% exceeded (R80) which means that rain is expected to occur 1 in 5 dry years. Land use data is used to estimate the average run off coefficient in the study area.

From the analysis of the rain data, then an analysis of the monthly average rainfall was carried out. The analysis of the regional mean rain was carried out using the algebraic mean with the assumption that the rain conditions that fell in the study area were homogeneous.

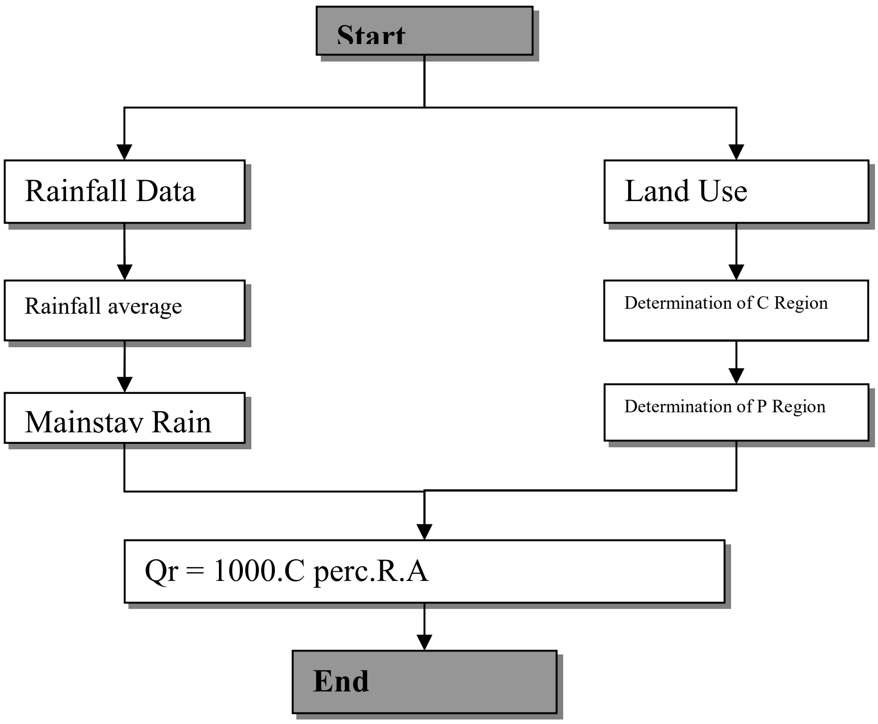

Figure 4. Groundwater Recharge Analysis Step

IV. RESULTS AND DISCUSSION

Flood is a natural phenomenon that often occurs, especially those whose location is included in the category of low elevation. Floods cannot be avoided absolutely, but can be controlled to a certain degree. There are many ways and methods that can be used to find out how the characteristics or character of the flood of a river and how to solve it. From the conventional way to the present which has entered the era of computerization. Many mathematical models that can be used and have been made in the form of software packages that are very easy to use.

Mathematical model software that is currently very well known is Duflow, HEC RAS, MIKE 11, SOBEK and others. Each software has its own advantages and disadvantages. SOBEK has an advantage that similar software does not have, which is that it can display floods in two dimensions by utilizing DEM (Digital Elevation Model) data. In this study, related activities have been carried out in an effort to solve problems, as described below :

1. Surveys, inventory and identification of problems will be carried out through field checks, secondary data collection, established policies related to flood control efforts and collection of previous studies.
2. Hydrological analysis and river basin analysis.
3. Policy analysis to be formulated in flood management in river areas.
4. Flood analysis and strategy formulation in handling river basin floods using SOBEK software.

In addition, in the modeling it is necessary to make assumptions to simplify the problem without affecting the results of the modeling on the description of the characteristics of events in the field.

River cross sections in several places for which there is no data will be determined using a visualization approach from the DEM map and the distance between calculation points is not determined, depending on the node that is agreed to be used as a reference.

Coefficient of roughness, using the Manning method with a coefficient of 0.04 applies in all cross sections. The simulation time period is set according to the length of the discharge data. The simulation time step is set to 1 hour. The simulation is carried out using the unsteady flow method.

Tidal data is data that will be used in flood analysis at the study site. As stated earlier, flooding is a natural phenomenon whose occurrence is caused by the interaction of several factors, including tidal factors.

Therefore, these variables are included in the model used to fill in the boundary condition data. The data to be used is observational data on sea level which is installed at the mouth of the river. From this data obtained tidal hydrograph data that occurred at the study site.

Before the data is used, the analysis stage must first be carried out to determine whether the data already represents the tidal characteristics that occur in the study location or not. If the data obtained already represents the tidal characteristics at the study site, then the next step can be determined parameters Highest High Water Level (HHWL), Mean High Water Level (MHWL), Mean Water Level (MSL), Mean Low Water Level (MLWL) , Lowest Low Water Level (LLWL) which will be used in the flood control simulation. Below are the tidal parameter values for the study location, as follows:

- Mean High Water Level (MHWL): 1.08 m
- Mean Water Level (MSL) : 1.03 m
- Mean Low Water Level (MLWL): 0.96 m

To determine the pattern of water resources management, especially in the preparation of scenarios, strategies and evaluation of the implementation of water resources management, several analyzes are needed that have dependencies and are interrelated with one another.

The data that has been inventoried is then carried out by data management, and analyzed using a predetermined methodology in the form of the Indonesian National Standard (SNI) or certain applicable standards and criteria.

The pattern of water resource management is a framework for developing water resources in the future (20 years) so that the results of the analysis must be in the form of assumptions to estimate the condition of water resources in the future and are directed at aspects of water resource management in river areas, namely the conservation of water resources, utilization of water resources, control of the destructive power of water, information systems for water resources as well as empowerment and enhancement of the role of the community and the business world.

Some of the analyzes used as a basis for consideration in determining water resources management scenarios are described in Table 1.

Table 1. Data, Analysis and Output

No.	DATA	ANALYSIS	OUTPUT
1.	Water Resources Conservation		
	RTRW Topographic maps Land Use Map DEM (Digital Elevation Mode) Watershed and WS . Map Government Administration Area Map	Watershed and WS Thematic Map Analysis Method : GIS	Map of watershed boundaries, in the WS and in the Administration Areas of the Prov, Regency/City Government, Districts in the DAS/WS along with the percentage of the area
	BPDAS Reports & Maps Rainfall RTRW Land Use Map DEM (Digital Elevation Mode) Watershed boundary map on WS and Wil. Government Admin	Analysis of Land Cover Areas in Watersheds and River Borders Method : GIS	% of land cover area in the watershed and % of land cover area on river borders in the initial (current) condition and the assumption of % land cover area in the next 5, 10, 15 and 20 years. The dynamics of past land use changes and the trend of its changes in the future
	Rainfall Sediment and Erosion Land Use Map DEM (Digital Elevation Mode)	Analysis of Land Erosion Potential	Land sedimentation in initial conditions (current) and the assumption of land sedimentation in the next 5, 10, 15 and 20 years.
	Rainfall debit Soil sample, Mektan Lab Tested, soil grain diameter	Method : Universal Soil Loss Equation (USLE)	River sedimentation in initial conditions (current) and river sedimentation assumptions in the 5, 10, 15 and 20 years to come.
	Maximum debit Minimum debit Watershed Map on WS	River Sedimentation Transport Analysis	Qmax/Qmin on initial conditions (currently) and assuming Qmax/Qmin on 5, 10, 15 and 20 years to come.

	Location Data for Natural Resources Facilities (SDA Assets)	Method : Suspended Load and Bed Load	Percentage of functioning or damaged natural resource conservation assets
	National Policy, Provincial Government, Regency/City Government Concerning Water Resources Management Laws and PPs and related regional regulations, such as Law no. 41 Year 1999 Concerning Forestry	Overview of policies, laws, regulations and regulations Qmax/Qmin Analysis of water resources conservation assets	Policies, Laws, Government Regulations and Regional Regulations that are not appropriate and which are still relevant to the scenario and strategy of water resources conservation.
2.	Use of Water Resources		
	Rainfall (daily maximum and average rain) debit	Surface Water Availability Analysis Method : Rainfall-Roverflow Model using the tank/box model Standard : Procedure for Calculation of Mainstay River Water Discharge with Curve Analysis of Frequency Revision of SNI 19-6738-2002, published by BSN	Availability of Surface Water to date, Surface water availability in the next 5, 10, 15 and 20 years.
	Groundwater Basin Map MapGeology/ Permeability Groundwater Potential Map DEM (Digital Elevation Mode)	Groundwater Availability Analysis Method : GIS	Groundwater Availability to date, Assumption of Groundwater Availability in the next 5, 10, 15 and 20 years.
	Population data for the last year Population growth rate Standard requirements for raw water Climate-evapotranspiration Industrial Development Plan Topographic maps Land Use Map Tidal data Salinity on the River Irrigation Development Plan	Water Needs Analysis: - DMI Water Needs per district Irrigation Water Needs per district Other Water Needs (Agriculture, Plantations, Fisheries, Tourism per district	sumptions of water needs per district in the next 5, 10, 15 and 20 years, equipped with a map

	Location Data for Natural Resources Facilities (SDA Assets) DEM (Digital Elevation Mode)		
	User data and the amount of ground water use in the last 3 years. Groundwater Basin Map DEM (Digital Elevation Mode)	Groundwater Needs Analysis The analysis is based on the current use of groundwater and the forecasted increase in use in the next 5, 10, 15 and 20 years.	ssumptions of Groundwater Use in the next 5, 10, 15 and 20 years. And Map of Groundwater Basin along with the location of its users.
	Availability of surface water in the next 5, 10, 15 and 20 years Groundwater Availability in the next 5, 10, 15 and 20 years Estimated water demand per district in the next 5, 10, 15 and 20 years with a map Estimated Groundwater Use in the next 5, 10, 15 and 20 years Water Drought Map Water Storage (Reservoir, Reservoir)	Water Balance per district Water allocation by simulating the availability of surface water and ground water with water demand per district. In the simulation priority is taken from surface water. For groundwater, it can be taken for existing (existing) use and use if there is insufficient surface water.	Water Balance per district in 5, 10, 15 and 20 Locations of areas/districts that experience water shortages during the dry season Locations of areas/districts that experience water shortages throughout the year
	Location Data for Natural Resources Facilities (SDA Assets) National Policy, Provincial Government, Regency/City Government	Analysis of water resource utilization assets	Percentage of functioning or damage to natural resource utilization asset
	Regarding Water Resources Management Laws and PPs and related Regional Regulations	Overview of policies, laws, regulations and regulations	Inappropriate policies, laws, regulations and regulations that are still relevant to the scenario and strategy for utilizing water resources
3.	WATER DAMAGE RESPONSIBILITY		
	Flood Inundation Map Disaster map Land use map DEM (Digital Elevation Mode) Data on the frequency of disasters (floods, landslides, earthquakes and tsunamis, coastal abrasion) in	Disaster Thematic Map Analysis (floods, landslides, earthquakes and tsunamis, coastal abrasion, estuary closures) Method : GIS	Maps of annual inundation areas, prone to landslides, prone to earthquakes and tsunamis, prone to coastal abrasion, estuary closures

	the last 10 years Damage control efforts that have been carried out		
	Location Data for Natural Resources Facilities (SDA Assets)	Analysis of water damage control assets	Disaster prone area category Percentage of functioning or damage to water damage control assets
	Data on the frequency of flood events in the last 10 years	Analysis of the flood return period that always occurs in the WS every year	Assumed frequency of flood events
	Rainfall (daily maximum and average rain) debit	Analysis of the flood return period that always occurs in the WS every year Method : Statistics and Regression Flood Discharge Analysis	The assumption of flood events that will occur every year, 5, 10, 15, 20 years to come along with the inundation area.
	Water quality Amount and location of waste dumped into the river during the last 3 years. Number and location of water quality monitoring stations for sources and water bodies	Standard: Procedure for Calculation of Flood Discharge Revision of SNI 03-2415-1991. Analysis of River Water Quality, River Pollution, Amount and location of RT & Industrial waste disposal with population and industry growth	The level of pollution that occurs in rivers and groups of water bodies
	National Policy, Provincial Government, Regency/City Government Concerning Water Resources Management Laws and Government Regulations and related Regional Regulations, such as Law No. 24 of 2007 concerning Disaster Management, Law No. 23 of 1997 concerning Environmental Management, Regional Regulation on Quality Standards for River Bodies, Thresholds for river water classes/classes and Waste Quality Requirements	Overview of policies, laws, regulations and regulations	Inappropriate policies, laws, regulations and regulations that are still relevant to the scenario and strategy for controlling the destructive power of water
4.	AVAILABILITY OF DATA & INFORMATION SYSTEM SDA		
	Location data and condition of SDA facilities	Analysis of network density of rain stations, water level/discharge, climatology of	Rain Station Network Density, Water Level/Discharge and Climatology

	Number, location and condition of sta. rain, water level/discharge and climatology Number, location and condition of source water quality monitoring stations and water bodies DEM (Digital Elevation Mode) Existence of Natural Resources Information System Disaster prone map The existence of a disaster early warning system Availability and completeness of data	water quality monitoring stations for sources and water bodies Review of the availability and completeness of the data. A review of the condition of the stations mentioned above, their operating and maintenance systems. Overview of the existence of the Natural Resources Information System	O&P Recommended Map of the location of the rain station network, water level/discharge, climatology and water quality monitoring stations for sources and water bodies Recommendations for the existence of a natural resource information system Recommendations for the existence of disaster early warning
5.	PEMBERDAYAAN & PENINGKATAN PERAN MASY & DUNIA USAHA		
	Existence and Number of Water User Organizations Organizational Independence (self-help) Presence and Number of Businesses Related to Natural Resources The Role of the Business World	A review is carried out on the quantity and role of community organizations and the business world related to natural resource management	Recommendations for developing and increasing the role of community organizations and the business world related to natural resource management
	Stakeholders who are related and have an interest in Water Resources Management, Institution : Water Resources Manager	Stakeholder analysis was carried out by reviewing the main tasks and functions of institutions related to the management of WAS natural resources.	Working relations and coordination between institutions in carrying out their main tasks and functions as well as the composition or list of Stakeholders invited to PKM 1 and PKM 2.
6.	Economical Condition		
	District/City in numbers Regional Socio-Economic Aspects	regional economic growth, dominant sector in economic growth,regional balance sheet.	The level of regional economic conditions (strong, moderate, mild).

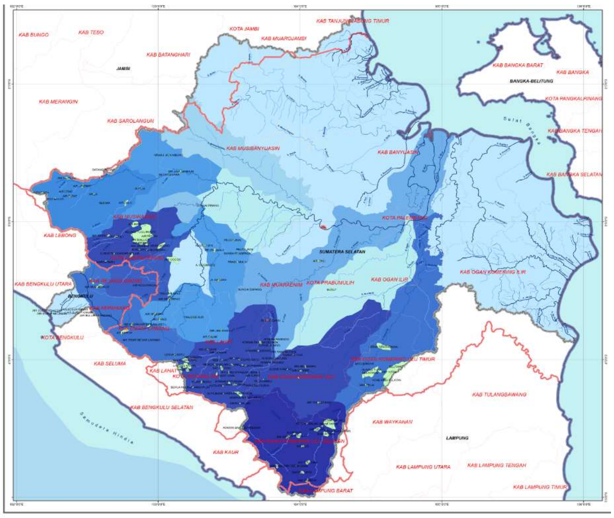

Figure 5. MSBL Area Water Demand

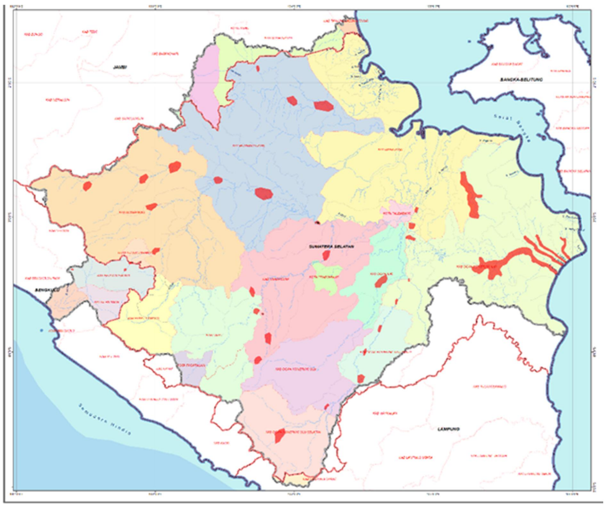

Figure 6. Flood prone map

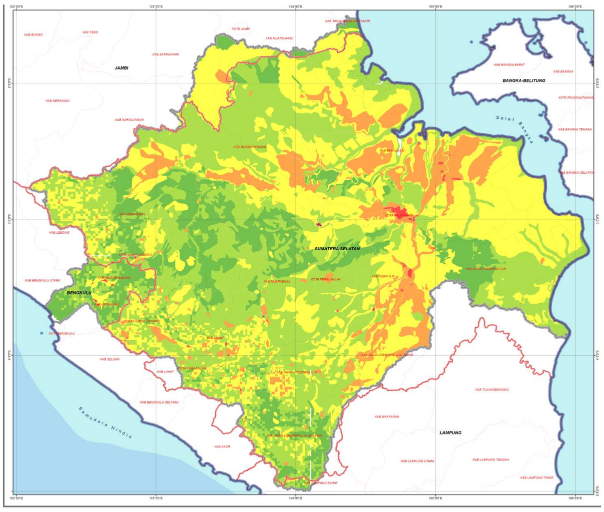

Figure 7. Map of the MSBL Watershed

V. Conclusion

To determine the criticality level of a watershed, one of the indicators is the amount of erosion that occurs in the watershed. Of the many formulas that can be used to predict the magnitude of erosion, the model developed by Wischmeier and Smith (1978) – commonly known as the Universal Soil Loss Equation (USLE) – is considered the most popular and widely used method for predicting the average Long-term erosion from sheet erosion includes rill erosion under certain conditions. It should be explained here that the ESLE formula was developed for a plot of land with a small size/area, so that if you want to apply it to a watershed with a large size/area, the watershed needs to be divided into a number of small areas, which are referred to as land units. Erosion that occurs is then calculated for each land unit, and the amount of total erosion in the watershed can be obtained by adding up the erosion that occurs in all land units.

The problems along S.Musi are as follows:

1. Erosion of riverbanks that threatens infrastructure buildings along river bends. This cliff erosion occurs along the river from upstream to downstream.
2. Flash floods, especially in the upper reaches of the river
3. Rise of the riverbed due to sedimentation which reduces the carrying capacity of the river
4. The discharge of the Musi River in the lower reaches of the Musi River (from the confluence of the Komering River to the estuary) ranges from 1,400 to 4,200 m/sec (average 2,500 m^3/sec). In the rainy season, the water level in the Musi river rises to + 1.8 m above sea level.
5. The riverbed downstream has been filled with sediment carried by the river from upstream as a result of erosion upstream. Rising riverbeds result in reduced flow capacity and flooding as well as an increase in the extent of swamps downstream of the river. The landslide on the river bank at the bend of the river caused damage to roads and houses on the banks of the river. River banks are usually reinforced with concrete retaining walls or gabions.
6. The main problem in the upstream part of S.Musi is inundation due to flood waters and cliff erosion.

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