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Impact Of Agroforestry On Hydrological Functions In The Batang Merao Hulu (Micro Watershed) Bremas District, Jambi Province

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ABSTRACT

Land as a limited natural resource can suffer damage and decrease productivity if it is not managed wisely. Land use of an area affects the hydrology of the area, changing land use meanschanging the type and proportion of land cover which in turn affects its hydrological response.Incompatibility of land use can have an impact on decreasing land quality, so that it often results in floods, droughts, erosion which will reduce land productivity and community welfare. The equipment used in this research are: (1) Computer with ArcGIS¬ 10.4 software, ArcSWAT version 2012.1_8 Microsoft Office 2013, SWAT Plot for calculating R2 and NS values; (2) Global Positioning System (GPS); (3) Digital camera, stationery and external hard disk to store data. Planting with agroforestry patterns and the application of conservation techniques in the Batang Merao Hulu sub-watershed have an effect on hydrological characteristics, this is indicated by the reduced runoff coefficient value before planting agrofrestry with the application of conservation techniques from 0.4 to 0.09 and the flow regime coefficient from 48.49 m3/s to 17.18 m3/s. The best land management scenario is to carry out planting with agroforestry patterns and the application of conservation techniques in the form of mound terraces. This agroforestry pattern not only emphasizes the types of woody plants and MPTs butalso prioritizes local local plants which are the prima donna of the people of Kerinci Regency, namely coffee and cinnamon, so that ecologically, the hydrological function of the watershed ismaintained.

Keywords: Agroforestry; land; watershed; SWAT Model

INTRODUCTION

Land as a limited natural resource can suffer damage and decrease productivity if it is not managed wisely. Land use of an area affects the hydrology of the area, changing land use means changing the type and proportion of land cover which in turn affects its hydrological response. Incompatibility of land use can have an impact on decreasing land quality, so that it often resultsin floods, droughts, erosion which will reduce land productivity and community welfare. Intensive use of natural resources results in land conversion in the upstream which has a negative impact on the balance and quality of water resources. Land conversion generally occursin the use of forest land into plantation and agricultural areas, plantation areas into agriculturalland and settlements, agricultural areas into settlements and industry. Not infrequently there are forest areas and plantations that turn into empty, neglected and barren land which later becomes critical land. Physically, the causes of watershed damage that are highlighted are changes in land use, especially reduced forest cover in a watershed. Forest conversion for various uses occurs in almost all watersheds, in line with increasing population and development. BASED ON Law No. 41/1999 on Forestry in article 18 paragraph 2 it has been stipulated that theminimum proportion of forest area in a watershed is 30% and spread proportionally.

Agroforestry is a land use system that combines trees with agricultural crops (annual/seasonal)with spatial and temporal arrangement of plants to improve the ecological and economic functions of the land so as to create plant diversity within an area of land in order to reduce therisk of farming failure while reducing soil erosion and improve the sustainability of land resources and the environment. Agroforestry can also be used as an approach to community empowerment programs at restoring environmental conditions (land cover, soil fertility, water management) on community-owned land which is also at increasing community income and welfare. Land cover improvement/improvement and application of technical civil soil and water conservation techniques (terrace gulud) as well as the application of conservation/environmentally friendly farming practices are expected to increase infiltration of water into the soil, reduce surface runoff, and control soil erosion on land. - developed land. Fluctuation of flow rate is one of the indicators to assess the biophysical aspects of a watershed or environmental damage. From the physical aspect, it is necessary to monitor changes in land use so that it can control changes in water flow and minimize soil damage (Pawitan 2006). Good watershed management is management that pays attention to various aspects related to it, both social, economic and physical aspects.

Watersheds have complex hydrological components and may be difficult to understand in theirentirety. The use of the hydrological model as a simplification of the actual reality is needed tohelp predict the processes that occur in the watershed. The SWAT (Soil and Water Assessment Tool) hydrological model is one model that can estimate the hydrological conditions based on physical processes (physical based model), thus allowing a number of different physical processes to be simulated in a watershed. The SWAT hydrological model can be used to assess land use changes on hydrological characteristics. SWAT is a hydrological model that was developed to predict the effect of land management on water yields, sediments, pesticide loads and agricultural chemicals that enter rivers or water bodies in a complex watershed with soil, land use and management varying over a long period of time. (Neitsch et al. 2005). This study tries to apply the SWAT model to determine the impact of land management with an agroforestry system on the hydrological function of the Batang Merao watershed by simulating the extent of agroforestry activities from the first year to the third year of planting.

METHODOLOGY

The research was carried out in the Batang Merao Hulu sub-watershed which is the upstreampart of the Batanghari watershed, geographically located at 1056'6" – 2000'00" South Latitude and 101017'10" - 101018'58' ' East Longitude. Topographically, it is bordered to the north by Mount Tigajerai and Mount Rinting, to the south by Mount Tengah Leras, to the west by Bukit Barisanand Mount Kerinci, and to the east by the Berhala Strait (Husni, 2012). The total area of the Batang Merao Hulu sub-watershed is around 1,237 ha with a main river flow of 4,544 m. The Batang Merao Hulu sub-watershed is included in the very small watershed category according to the Ministry of Forestry (2013), the watershed which is included in the very small watershed category has a total area of less.

MATERIALS

The equipment used in this research are: (1) Computer with ArcGIS¬ 10.4 software, ArcSWAT version 2012.1_8 Microsoft Office 2013, SWAT Plot for calculating R2 and NS values; (2) Global Positioning System (GPS); (3) Digital camera, stationery and external hard disk to store data. The materials used in this study include Spatial Data, Land cover maps with a scale of 1: 50,000resulting from the interpretation of recorded Landsat images in 2020, a Soil Classification Mapof a scale of 1: 250,000 from the Bogor Soil and Agroclimate Research Center (Puslitanak), and a National Digital Elvasion Model (DEM) Map. with a resolution of 30 m, Slope map generatedfrom DEM. Average daily rainfall data (mm) from 2017 to 2020 from the Regional VI Sumatra River Basin. Daily average discharge data from the 2016 to 2020 water level measurements fromthe Regional VI Sumatra River Basin. Climatic data includes maximum and minimum temperature (0C), humidity (RH) and wind speed (m/s) for 2000 – 2020 from the Jambi Meteorology, Climatology and Geophysics Center (BMKG). Soil characteristics data are effective depth (mm) and soil infiltration (mm/hour), in each horizon including horizon thickness (mm), soil texture, bulk density (g/cm3), water holding capacity (mm H2O/mm soil), Saturated hydraulic conductivity (mm/hour), rock fraction content (%), soil erodibility value and soil organic matter content (%). River characteristics data is the characteristics of the existing riverchannels in the research area.

DATA ANALYSIS PROCEDURE

The annual flow coefficient is commonly known as the surface runoff coefficient (C). The analysis in this study uses the Annual Flow Coefficient (KAT) because it refers to Government Regulation number 37 of 2014 concerning Watershed Management (DAS) that theannual flow coefficient is one of the indicators used to determine the condition of a watershed.The annual flow coefficient is the ratio between direct runoff (thick annual flow minus base flow) and annual rainfall thickness (mm) in a watershed to determine the percentage of rainfallthat becomes runoff. Technically it is also explained in the Minister of Forestry Regulation Number: P.61/Menhut-II/2014 concerning monitoring and evaluation of watershed management, that the value of the annual flow coefficient is one of the indicators used to determine whether a watershed is experiencing (physical) disturbances. the value of the annual flow coefficient indicates the condition of the watershed is in good condition (Kemenhut 2014).The annual flow coefficient uses equation (3):

$$Koefisien\ aliran\ tahunan = \frac{Direct\ run\ off\ /_{DRO}\ (mm)}{Direct\ rainfall\ (mm)} \qquad (3)$$

Where Direct runoff (DRO) is the real runoff water value, namely the total annual flow minus the base flow value, or in the form of the equation

$$DRO = Q - BF \quad (4)$$

Table 1. Classification of Annual Flow Coefficient Value (KAT)

Nilai KAT	Kategori
KAT ≤ 0,2	Sangat rendah
0,2 < KAT ≤ 0,3	Rendah
0,3 < KAT ≤ 0,4	Sedang
0,4 < KAT ≤ 0,5	Tinggi
KAT > 0.5	Sangat tinggi

Impact Analysis of Agroforestry and Application of Soil and Water Conservation Techniques on Hydrological Functions of the Upper Batang Merao Sub watershed

Research flow chart in analyzing hydrological function Batang Merao Hulu sub-watershed as in Figure 5 and a description of the stages are as follows: The data that must be prepared includes: Soil classification map with database information, namely effective depth (mm) and soil infiltration, each horizon includes horizon thickness (mm), soil texture, bulk density (g/cm3), water holding capacity (mm H2O/mm soil), Saturated hydraulic conductivity (mm/hour), rock fraction content (%), soil erodibility value and soil organic matter content (%). Conducted a field survey (ground check) to take some soil samples. Land use map with data base information is the type of land cover and plant management. This map was created based on the interpretation of Landsat TM imagery andIf necessary, a survey can be carried outin the field (ground check). DEM map from the Shuttle Radar Topography Mission (SRTM) image with a resolution of 30 x 30 m. Climate data includes maximum and minimum temperature (oC), solar radiation (MJ/m2/day) and wind speed (m/s) for 2000-2020 from the Jambi Meteorology, Climatology and Geophysics

Center (BMKG). Hydrological data in the formof daily rainfall and daily discharge in 2011-2020 obtained from Sumatra Region VI River Basin. River characteristics data is the characteristics of the existing river channels in the research area.

Watershed delineation

The watershed that will be used as the research area will be delineated based on DEM automatically by the SWAT Model according to its natural topographic boundaries, as well as the hydrological network. For simulation purposes, the SWAT Model divides the watershed into several subbasins where each subbasin has one main river network.The SWAT model provides a choice of thresholds for the formation of subbasins in the watershed. The size of the threshold used will determine the formation of the main river network and tributaries. The river network will determine the number of subbasins formed in the watershed. The number of subbasin

<u>ValiDASi</u>

The validation step aims to prove that a process/method can provide consistent results in accordance with established specifications. Validation is carried out on discharge data by entering calibrated parameters. The consistency of the validated SWAT model is indicated by the values of R2 and NSE. The SWAT model is then used to perform ssimulation in the scenario to determine the effect of land cover in the form of agroforestry hydrological function of the watershed. The application of this simulation was carried out on dry land agricultural land cover and mixed dry land agriculture on flat sloping and slightly steepslope classes. Parameters that are considered constant are soil data, climate data and rainfall data.

The results of this simulation are expected to be used as a consideration in making the best land use planning in the Batang Merao Hulu sub-watershed. SThe simulation is carried out based on several scenarios as follows: Land cover in 2018, Simulation of planting with agroforestry pattern, Simulation of increasing the area of agroforestry planting with the application of conservation techniques The prediction simulation uses rainfall with the sameassumption as the rainfall in 2020. The Batang Merao Hulu sub-watershed (upstream of the Batanghari watershed) is geographically located at 1º56'6"-2º00'00" South Latitude and 101º17'10"-101º18'58"BT. The total area of the Batang Merao Hulu sub-watershed is around 1,237 ha with a main river flow of 4,544 m. The Batang Merao Hulu sub-watershed is includedin the very small watershed category because according to the Ministry of Forestry (2013), thewatershed included in the very small watershed category has a total area of less than 10,000 ha. The boundaries of the Batang Merao Hulu sub-watershed are as follows: To the north it is bordered by Mount Tigajerai and Mount Rinting, To the south, it is bordered by Gunung Tengah Leras, In the west it is bordered by Bukit Barisan and Mount Kerinci, To the east it is bordered by the Idol Strait.

Results and Discussion

Slope Classification and Topography

Land characteristics in a watershed vary greatly depending on topography, climate, geology, soil, and the vegetation that covers it. The slope of the slope is one of the parametersof the topographical aspects that affect the state of a watershed. In addition to increasing the amount of runoff, the steeper the slope also increases the water carrying energy as a result of the increasing speed of water moving down the slope. This is due to the greater gravity in linewith the slope of the soil surface from the horizontal plane, which will result in more eroded topsoil. Slope class spatial data is generated automatically by the SWAT model from DEM according to the 5 class interval set. The slope class used based on the Ministry of Forestry consists of 0-8% (flat), 8-15% (sloping), 15-25% (slightly steep), 25-40% (steep), and >40% (very steep) . The slope class of the Upper Batang Merao Sub-watershed varies from flat (0- 8%) covering an area of 168.83 ha (13.27%), gentle (8-15%) covering an area of 348.17 ha (27.36%), slightly steep (15-25%) covering an area of 475.20 ha (37.35%), steep (25-40%) covering 254.36 ha (19.9%) very steep (>40%) covering 25.81 ha (2.03%). The topographic class in the Batang Merao Hulu sub-watershed is dominated by a rather steep slope class (15- 25%). The distribution of slope classes in the Batang Merao Hulu sub-watershed is presented in Figure below this

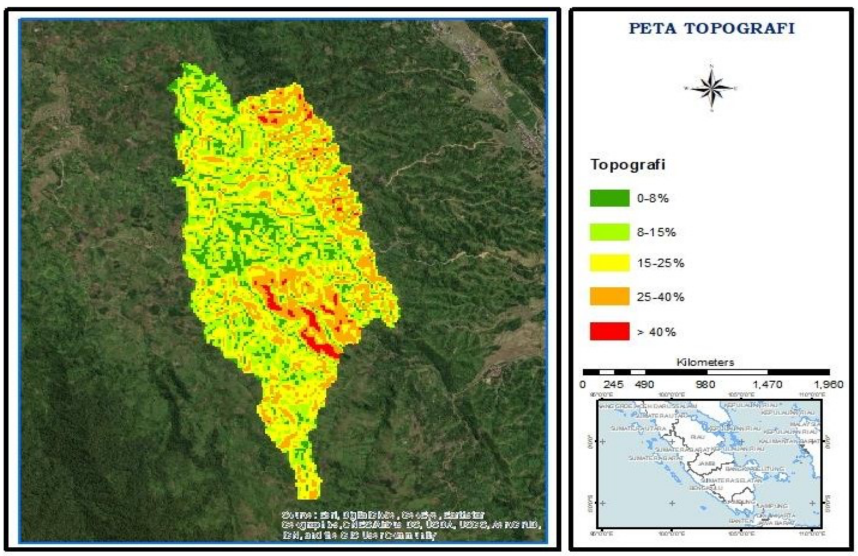

Figure 1. Distribution of slope classes in the Batang Merao Hulu sub-watershed

Type of soil

A watershed (DAS) is a physically complete and clearly defined land system in which various combinations of topography, soil, vegetation, and climate can be found. The watershedis a hydrological unit which is the source of water for the river regime. Watershed is also a unitary landscape (soilscape), namely the association of land in a certain landscape.Soil is oneof the most important parts of the hydrological cycle. Rainwater that falls will pass through theground and various kinds of hydrological processes will occur that will occur above the ground,in the soil, or in deeper layers.

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The distribution of soil types in the Merangin Tembesi sub-watershed is classified according to USDA (United States Department of Agriculture) criteria. Soil types in the study area were obtained from a map of soil units with a scale of 1: 250 000. Based on this classification, there are 3 types of soil, namelyHapludox area of 440.58 ha (34.62%), Humitropepts area of 136.86 Ha (10.76%) and Troporthents area of 694.99 Ha (54.62%). Troporthents soil type (order Entisol) has a fairly large area with an area of 694.99 ha or reaches 54.62% of the total area.Batang Merao Hulu sub-watershed. Entisol soil type is known as a young soil in terms of development. The common unique properties of Entisols are the dominant mineral soil material and the absence of a clear horizon/layer, although it can sometimes have a stratified layer. It contains very few signs indicating the process of pedogenesis (soil development). In other words, Entisol soil layers are quite difficult to distinguish in terms of color. The absence of a pedogenic horizon can be caused by an inert parent material, such as quartz sand, v ... t enough time for horiz ... specially for the lower ... ayer (top soil).Batang N...

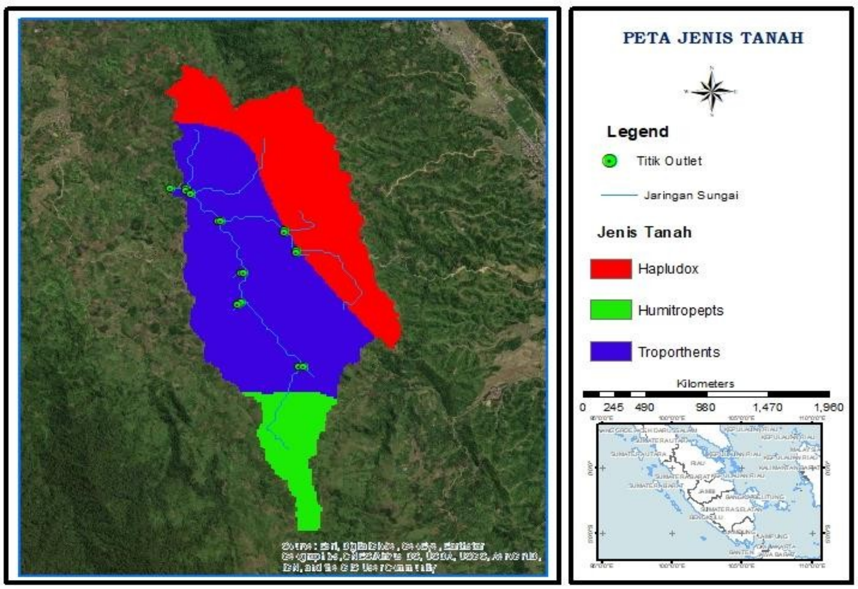

Figure 2. Distribution of soil types in the Batang Merao Hulu sub-watershed

The results of testing the initial discharge model before calibration are compared with the discharge results from observations in the field for two months, namely September and October 2020 manually, the R2 value is 0.84 and the NS is 0.76. As for the validation process for two months, namely November and December 2020, the R2 value of 0.73 and NS of 0.43 were obtained. Based on the calibration results, it is included in the good class according to the efficiency classification of the Nash-Sutcliffe model, the value of NS 0.75. As for the calibration, it is included in the Satisfactory class

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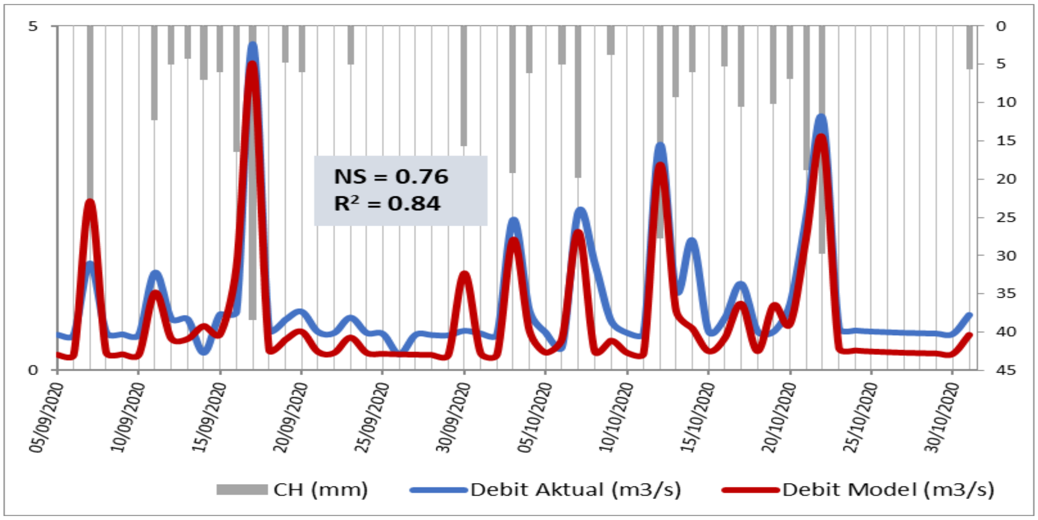
according to the efficiency classification of the Nash-Sutcliffe model, the value of0.75 > NS > 0.36The graph of the validation and calibration results model is presented in Fig. .



Land Cover Simulation in 2018 (scenario 0)

In 2018, agroforestry planting activities have not been carried out at the research location, and land use in the Batang Merao Hulu sub-watershed dominated by dry land agriculture with an area of1,204.87 Ha (94.69 %) and mixed dry land agriculture covering an area of 67.51 Ha (5.31 %). Dry land agriculture is the cultivation of agricultural crops on landthat lacks water and less fertile soil. The characteristics of dry land are characterized by low rainfall (< 250 - 300 mm/year), drought index (ratio)/ratio between rainfall and evapotranspiration less than 0.2), very limited plant variety (only shrubs, grasses and small trees). in certain areas), very high temperatures (+49oC in summer), the soil texture is sandy and has high salination in the soil and groundwater due to high evaporation and infiltration (IM. Kurnia, 2013). Based on the results of aIn the analysis, the hydrological function of the Batang Merao Hulu Sub-watershed in 2018 was in the form of a surface run off of 753.31 mm,an interflow of 835.53 mm, a run-off coefficient of 0.4, and a flow regime coefficient of 48.49m3/s. The run off coefficient value shows a moderate value, this is because the flow of water on the surface of the soil is still high so that it exceeds the rate of water infiltration into the soil.Based on these conditions, it can be concluded that the condition of the watershed based on itshydrological function is in the poor category and this can be the cause of floods and landslides.

Simulation of Planting with Agroforestry Patterns (scenario 1)

The simulation of agroforestry planting is carried out using parameters in the form ofsecondary data such as soil, climate and rainfall data derived from the Agroforestry Impact Study Report compiled by LPPM Unja in collaboration with BPDASHL Batanghari in 2020 with an agroforestry planting area of 30% of the Batang sub-watershed area. Merao Hulu. Thetypes of plants used in the agroforestry pattern consist of:types of woody plants (sembulun, sengon), MPTs (Multy purpose tree species), such as rubber, avocado, jengkol, farmers, cinnamon, and intercropping plants (generally coffee).Analysis of the hydrological function ofthe Batang Merao Hulu sub-watershed set shows a surface run off of 746.45 mm, an interflowof 839.43 mm, a run off coefficient of 0.4, and a flow regime coefficient of 44.87 m3/s. Surfacerun off has decreased, this shows that land cover in the form of woody plants and MPTS can increase water infiltration into the soil. While the value of the run off coefficient did not change,this could be due to the small area being planted with an agroforestry pattern, and the lack of implementation of conservation techniques on the land.

Conclusion

Planting with agroforestry patterns and the application of conservation techniques in the Batang Merao Hulu sub-watershed have an effect on hydrological characteristics, this is indicated by the reduced runoff coefficient value before planting agrofrestry with the application of conservation techniques from 0.4 to 0.09 and the flow regime coefficient from 48.49 m3/s to 17.18 m3/s. The best land management scenario is to carry out planting with agroforestry patterns and the application of conservation techniques in the form of mound terraces. This agroforestry pattern not only emphasizes the types of woody plants and MPTs but also prioritizes local local plants which are the prima donna of the people of Kerinci Regency, namely coffee and cinnamon, so that ecologically, the hydrological function of the watershed is maintained,

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