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THE LAND CONSERVATION EFFORTS FOR WATERSHED'S HYDROLOGICAL FUNCTION

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ABSTRACT

The conversion of land-use gives a dominant influence to the watershed's hyodrological functions. The relationship between land-cover and hydrological function can be seen by the watershed's total produced water and resistance against the peak debit at various timescales. The aims of this study was to simulate the peak discharge in some scenarios of land conservation in Awo Watershed, South Sulawesi. This study was done by rainfall frequency analysis and peak discharge predict by using the Watershed Modelling System TR 55. Input data of the model consists of: watershed area, time consentration and SCS Curve Number of land hydrological group data, land cover specification and soil moisture condition. Simulation of land use and land conservation scenarios are done on this model. The peak-disharge simulation result with 2, 5 and 10 years return period rainfall were 240.72, 804.41, and 1387.68 m^3/sec. Conservation efforts by contour and terraced planting can reduce the Awo watershed's peak discharge up to 13.50%.

Keywords : peak discharge, land conservation, watershed modelling system.

I. INTRODUCTION

Watershed is important as a rain catchment area that serves as a provider of water and flood control. Hydrologically watershed management seeks to manage the Earth's surface biophysical conditions, in such a way as to obtain a maximum water yield and has an optimum flow regime, which is distributed evenly throughout the year.

Along with the increase in human numbers and activities, the need for land has also increased. As a result, people tend to use the land towards more potential. Efforts to increase the utilization causes the change of land use, especially forests.

Land use change has a dominant influence on the hydrological functions of watersheds (Verrina et al., 20130; (Pratama and Yowono, 2016) (de la Cretaz & Barten, 2007). The relationship of land cover to hydrological function can be seen from the aspect of total water yield and buffer power watershed to peak discharge at various time scale (Noordwijk et al., 2002). Land use change without the application of land conservation principles, causing most of the rainfall to be a direct runoff, thus increasing the potential for flooding due to the loss of soil ability to absorb rain water (Lipu 2010).

Land conservation is defined as the effort to utilize the land in accordance with its capability and provide treatment in accordance with the conditions required to avoid damage (Arsyad, 2006).

The hydrological model is designed to study the functions and responses of a watershed from various inputs of the watershed. The hydrological model is a simple illustration of an actual hydrological system. One of the hydrological models of river flow prediction, developed to simulate watershed conditions is Watershed Modeling System (WMS). WMS is a graphical modeling software for all hydrologic and hydraulic phases of a watershed. WMS can perform an automatic depiction of watersheds, geometry parameter calculations, curve number calculations which are soil type parameters (Sadrolashrafi et al., 2008); (Sharkh, 2009). Technical Release (TR 55) WMS, is a flood hydrograph used to model rainfall processes. With the use of TR 55, the model can be built with triangulated irregular network (TIN) used to describe the river and its boundaries and calculate geometric data or watershed characteristics. This aims of this study was do simulate peak discharge of the watershed, for some forms of land conservation using Watersheed Modeling System TR 55, in an effort to maintain the hydrological function of Awo Watershed, South Sulawesi.

II. MATERIALS AND METHODS

This study was do at the DAS Awo in the district of Sidenreng Rappang in the Indonesian province of South Sulawesi. The research location can be found at 3o 54'S latitude, 119o 48' longitude, with the watershed area 343,49 km^2

A. Analysis Rainfall Frequency

Analysis rainfall frequency was done as follows:

1. Calculates the distribution with the Gumbel distribution model and the Pearson Type III Log based on the calculated statistical parameters.
2. Selecting a distribution model appropriate to the Chi-Square method.
3. Calculates design rainfall with 2, 5 and 10 return period based on the appropriate distribution model.

B. Calculate Maximum peak discharge

Calculation of peak discharge is done by using Watershed Modeling System Model Technical Releases 55. Data input of WMS TR 55 consists of:

1. Watershed area , calculated using the facilities contained in the WMS
2. SCS Curve Number, determined by considering 3 factors is land hydrological group, land cover classification and soil moisture condition. The hydrological group of land in this study, determined based on soil texture
3. The concentration time (Tc), calculated in WMS by using the Kerby equation.

III. RESULTS AND DISCUSSION

A. Analysis Rainfall

Based on the interpretation of chi-squared test results on distribution calculations of Gumbel and Log Pearson Type III, the most appropriate rainfall distribution for the Awo Watershed region is the Pearson Log distribution III. So that the rainfall of design with the 2, 5 and 10 years return period based on the Log Pearson III of distribution , is presented in Table 1.

Table 1. Rainfall design with Method Log Pearson Type III

Return period (years)	rainfall of design daily (mm/day)
2	42,69
5	73,52
10	99,40

B. Parameters watershed

Input the WMS model of the TR-55 method is a watershed parameter consisting of area, curve number (CN) and time of concentration. CN values are based on land use and hydrological groups of land. The hydrological group of land is determined based on soil texture. The following are presented of land uses, land hydrological groups and CN values on the Awo Watershed.

Land use and land hydrological groups that the potential to cause surface runoff are areas of high CN value. The dryland farming on litosol soil has the highest CN value of 89, with the land hydrological group D having infiltration rate 0 - 1 mm / sec (Asdak, 2010). Soil lithosol is type of soil a rocky with a layer of soil that is not so heavy and very little nutrients, so have the capacity and rate of small infiltration, resulting in the availability of water in the dry season a little.

Table 2. Parameters model WMS Awo Watershed

No	Land use	Type of soil	Area (km^2)	Land hydrological groups	CN
1	Forest	Laterit	196,73	C	77
2	Forest	Podsolik	2,96	D	79
3	Dryland farming	Laterit	72,87	C	85
4	Dryland farming	Litosol	39,48	D	89
5	Dryland farming	Podsolik	1,75	D	88
6	Bush	Laterit	12,19	C	71
7	Bush	Podsolik	2,26	D	79
8	paddy	Litosol	15,25	D	84

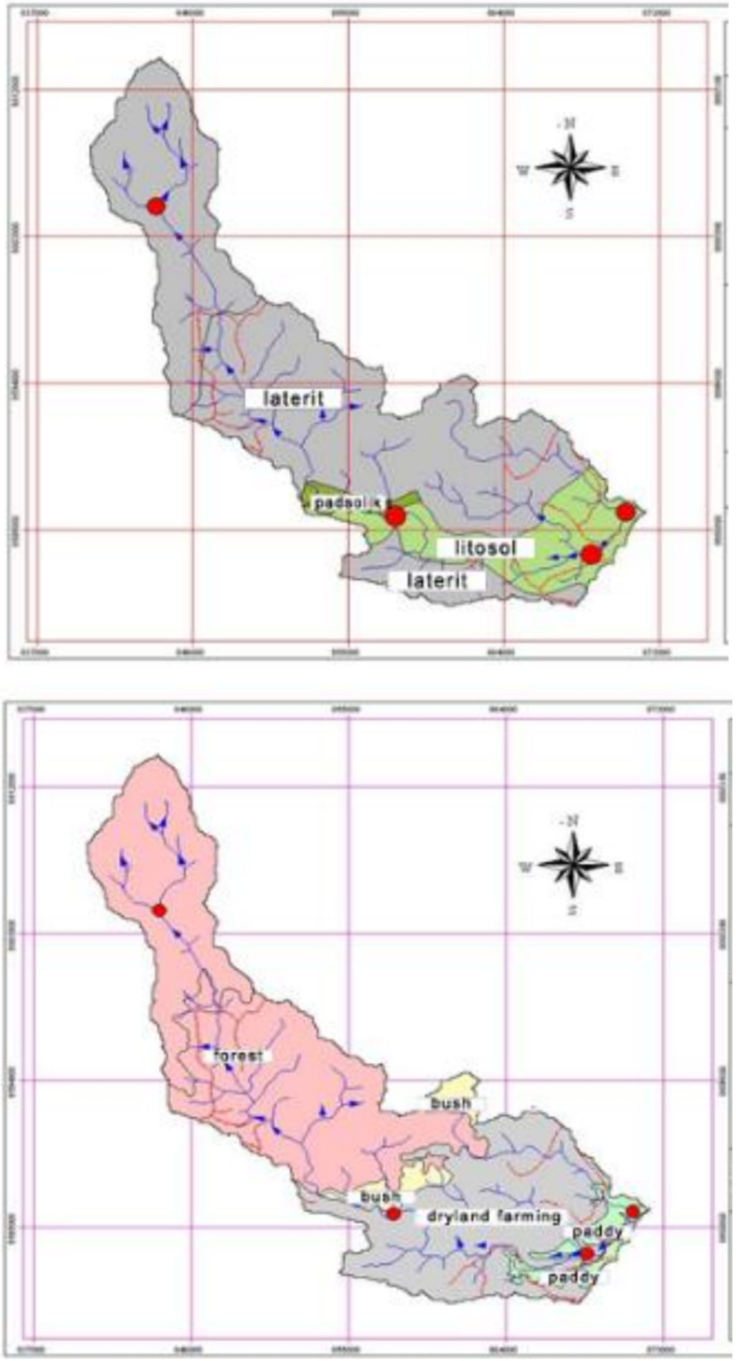


Fig. 1. Map type of soil and land use of Awo Watershed

C. Hydrograph Peak discharge

The flow discharge represents the response of the DAS system to the overall rainfall input. The amount of flow discharge in a watershed, in addition influenced by watershed characteristics, also by rainfall. The results of the peak discharge calculations with the WMS model, based on the design rainfall from the Log Pearson III distribution are presented in Fig. 2, each with a return period of 2, 5 and 10 years.

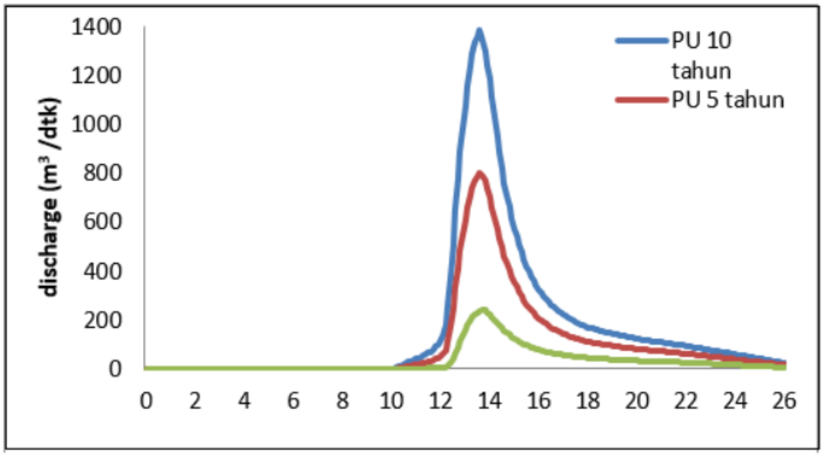


Fig. 2. The peak discharge hydrograph on the Awo Watershed

In Fig. 2., the above shows the peak discharge in Awo Watershed, for the 10th return period of 1387.68 m3 / sec. The Awo watershed is dominated by type of laterite soil (82%). laterite soil or often called to as red soil, formed in humid, cold, and possibly waterlogged environments. This soil has a permeable profile and easy to absorb water (Mustapha et al., 2014). So, indicate the existence of forest damage to the watershed.

The Awo Watershed has 114.1 km2 (33%) of dryland farming, so the conversion of land from forests to dryland farming negatively impacts the function of forests as a regulator of water systems in watershed ecosystems. Forest conversion and land-use change result in land degradation in the form of loss of soil's ability to retain rainwater, thus increasing surface runoff and flood potential (Lipu, 2010).

D. Improvement hydrological condition of the Awo Watershed

Land conservation is basically an effort to maintain the watershed hydrology function. Land use change with minimal soil and water conservation measures can affect flow volume and peak discharge. The rain is more flowing on the surface than it infiltrate into the soil (Baniva et al., 2013).

Simulation of land conservation to improve hydrological function of Awo Watershed is done with several scenarios:

Scenario 1 improvement the management of dryland farming into a good straight-line up land

Scenario 2: practice of contour planting.

Scenario 3: practice of planting by a good contour and terraced

Simulation of land conservation efforts to peak discharge on Awo Sub Watershed is presented in Fig. 3 and Fig. 4.

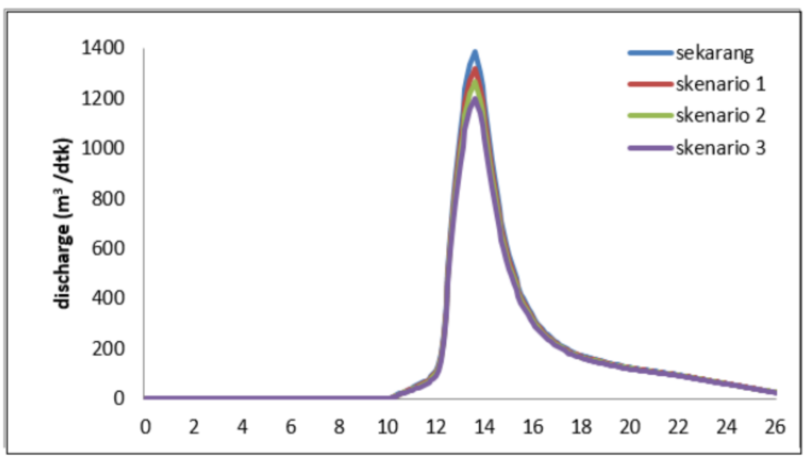
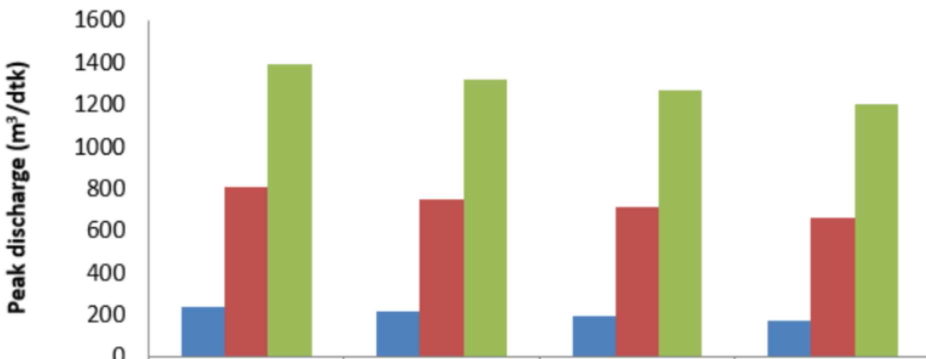


Fig. 3. Hydrograph peak discharge on some land use

The effort of land conservation decreases the peak discharge of Awo watershed, from the existing condition 1.387,68 m^3/ sec to the ideal condition that is practice of contour and terrace 1.200,69 m^3 /sec. Such conservation efforts affect CN value and peak discharge of Awo Watershed. A low CN value indicates an increase in watershed capability in regulating the water system, the amount of infiltration is greater so reducing surface runoff and flood potential.



	sekarang	1	2	3
PU 2 thn	240,72	214,48	193,43	170,69
PU 5 thn	804,41	751,55	708,72	661,08
PU 10 thn	1387,68	1319,43	1264,11	1200,69

Fig 4. Peak discharge on the various return periods

The decrease in peak discharge for scenario 1 with conservation of good straight-line up land was 4.9%. For scenario 2 with contour practice was 8.9%. The main advantages of contour system planting are the occurrence of temporary water reservoirs allowing water absorption, so can reduce of surface runoff (Suripin, 2001); (Marhendi, 2014).

While scenario 3 with conservation practice of contour and terrace is 13,5%.The terrace function to reduce the length of the slope and retain water so as to reduce the velocity and the amount of surface runoff, and allow increase the amount of water infiltre into the soil (Marhendi, 2014). In addition to land conservation efforts, physical conditions and watershed characteristics also affect the discharge produced (Asdak, 2010); (Maria and Lestiana, 2014).

IV. CONCLUSION

The Awo watershed is dominated by laterite soil (82%) with forest (58%) and dryland farming (33%). The peak discharge of the Awo watershed based on the Watershed Modeling System (WMS) for a 10-year return period is 1387.68 m^3/sec. Efforts to conserve land with the practice of contours and terraces on dryland farms can reduce peak discharge by 13.5%.

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