MORPHOMETRIC CHARACTERISTICS OF CIPATUJAH WATERSHED TO DETERMINE THE LEVEL OF VULNERABILITY OF FLOOD IN SOUTH TASIKMALAYA, WEST JAVA, INDONESIA

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ABSTRACT: Flood is a natural phenomenon that often occurs in a region that is fed by many streams. The flood disaster stems from the flow of water from a higher surface and can be no longer accommodated by a drainage canal or river. This study aims to determine vulnerability level of the flood basin in the area surrounding Cipatujah river. There are three methods used in this study, namely methods studio with Rb, Dd, Fs, field methods by means of geological mapping, description of outcrop, image capture, laboratory methods by analyzing verification of field data with the data studio and the relationship between morphological diversity and slope in the research area. This research was conducted using spatial data obtained from the GIS. Morphometric parameters used in this study include linear aspect and relief from the watersheds in Cipatujah area. The results of morphometry analysis showed that the DAS Cipatujah has a river system ordered by the largest to 4 (according to the Stahler's classification). This is related by water flow and also a higher speed of the river flow, so it can be said that DAS Cipatujah has a high level of flood vulnerability during rainy seasons.

1. INTRODUCTION

A watershed is a complex megasystem built by physical systems, biological systems, and human systems. Watershed is often defined as an area of land which is a unity with the river and its tributaries. Its functions are to accommodate, to store, and to drain water from rainfall to the lake or into the sea naturally. Watershed has limits; in land, it is divided by topographical divider meanwhile in the sea, it is up to water area that is still affected by land activities (UU No. 7 Tahun 2004).

A watershed morphometry study involves analyzing the area, linear, and dimension parameters of the watershed. This helps us understanding watershed's natural environment and also summarizes spatial characteristics of the watershed. Morphometry is a measurement and mathematical analysis of the configuration of earth surface, shape, and dimension of its landforms. As the time goes by, a watershed morphometry is started being used not only to get regular math numbers but also as to relate it with geological disasters. The characterizations of a watershed morphometry can be a reference to get to know the vulnerability of geological disasters in the basin and surrounding area. Karnawati (2005) stated that geological disasters happen as a result of natural geological processes that its cycle of events ranging from the scale of a few years to a few hundred, even millions of years. The characterization of geological disasters includes earthquake, tsunami, volcanic eruption, land and rock masses movement or erosion, and flood. Flood is the water flow of a river in high quantities. The water flow in the river is relatively larger than normal condition due to the rainfall in upstream or in certain places that occurs continuously, so the water can no longer be accommodated by the existing rivers. Consequently, the large quantity of water overflows and floods the land (Peraturan Dirjen RLPS No. 04 Tahun 2009). According to Ligal (2008), floods can happen because of the water level raising caused by unusual amount of rainfall, temperature changing, broken levee or dam, rapid snowmelt, or an obstruction of water flow in another area. The study of morphometric Cipatujah watershed basin will provide a very good alternative to know the underlying factors controlling the hydrological behavior as well as providing the necessary data and information that will enhance better understanding about potential basins and consequent implication of hydro-related disasters. This study attempts to examine the basin morphometry of Cipatujah's river basin and evaluate its hydrological implication related to flood. The study uses geospatial techniques integrated with achieved analogue data. The main object of this research is to examine the drainage morphometric characteristics of the Cipatujah watersheds and to evaluate the implication of morphometric characteristics on potential flood basin in the research area.

2. MATERIAL AND METHODS

2.1 STUDY AREA

Cipatujah river is part of rivers that flows through southern mountain region of western Java. The research take place in Cipatujah district, South Tasikmalaya, West Java. The location of this river is very near with the Indian Ocean. The geographical location of the Cipatujah tiver is between 107° 55' 59,99" N, 07° 28' 00" E and 108° 04' 00" N, 07° 46' 00" E. Research area covers the entire Cipatujah watershed amounting to 151.911 km^2.

According to Alzwar, dkk (1992) and Supriatna, dkk (1992), this research area is divided into three rock formations and one sediment surface.

2.2 METHODS

This research uses spatial and non-spatial data. The first step in this research started with collecting the data in the form of regional geological map of the research area, topographic map with scale 1:25000 (there are five topographic maps, Cipatujah map, Ciandum map, Parabon map, Taraju map, and Simpang map), and a satellite image of Cipatujah watershed area. Then, a topographical map digitation was done including digitation of contour, watershed, river, road, and settlement with a help from Map Info software (Version 11.5). After done doing inventory and map digitation, the next step was distributing the Cipatujah watershed into 27 sub-watersheds (Fig 1). Next, writer did an analysis of morphometric characteristics. In this study, quantitative morphometric analysis of the characteristics was carried out in Cipatujah river and the 27 sub-watersheds were also analyzed using the mathematical formula given in Table 1. Those characteristics are perimeter, basin length, number of stream order, mean stream length, stream length, bifurcation ratio, stream length ratio, drainage density, elongation ratio, relief ratio, and stream frequency.

Table 1. Summary of Morphometric Characteristics Determined in the Study Area and Their Methods

Category	Parameter	Derivation Procedure
Area	Basin Area	Area = Map scale x counted squares
	Drainage Density (Dd)	Dd = ΣL/A ; where ΣL = Sum of all stream lengths and A = Basin Area
	Length of Stream (Nu)	ΣNu
	Basin Length	This is the straight line from the mouth of the basin to the farthest point on the basin perimeter
Linear	Total Stream Length	This is the total of all the tributes and the principal drainage
	Average stream length	Total stream length is divided by total number of streams
	Main stream length (Lb)	This is the length of the principal drainage line
	Bifurcation Ratio (Rb)	Rb = $\frac{Nu}{Nu+1}$
Relief	Texture Ratio (Rt)	Rt = ΣN/p ; ΣN is the amount of river segment in a watershed and p is the perimeter of the watershed.

3. RESULTS AND DISCUSSION

3.1 MORPHOMETRIC CHARACTERISTICS OF CIPATUJAH RIVER

The linear, areal, and relief morphometric of Cipatujah River are given in Tabel 2. Those three aspects made based on topographical condition and the river system contained in Cipatujah watershed. The sub-watershed distribution and river's segment can be seen in the picture 1. Cipatujah watersheds have order 4 as its biggest order. (Fig 1). The fourth order of drainage segment has the highest amount of water and sediment flow. This research shows that the stream order one has the highest number of stream segments which is 756 while the total number of stream order in the river is 1.467. Stream order one has the highest number of stream segments with a sum of stream length 323,028 km for the first order stream. Cipatujah river has 505,58 km as its total stream length. The highest Rb (6,25) is found between the first and second stream order of Cipatujah river. Cipatujah watershed has an average value of Rb (bifurcation ratio) of 2,35455. According to Schumm (1956), the Rb that is below 3 means that the watershed causes flood water level rises fast but its shrinkage is slow. So, it can be concluded that Cipatujah's watersheds have a quite high vulnerability level of flood.

The Cipatujah watershed that is being the main source of this research has an area of 151,911 km^2 and a circumference of 3,541 km/km^2. The Dd value belongs to the moderate category (Soewarno, 1991) and to the rough until moderate category of landscape texture classification (Sukiyah, 2009). Montogomery and Dietrich (1989) in Samson, dkk (2015) also state that if the Dd value is categorized as a moderate one, it means that the area is covered by plentiful plants vegetation and moderate category of landscape relief. The calculation result of texture ratio (Rt) is 4,067. Texture ratio (Rt) is an important factor because it is related to rock constituent lithology, infiltration capacity, and aspects of terrain relief (Nugraha, dkk, 2012). High *texture ratio* (T) indicates potential erosions and also a high runoff. *Texture ratio* of all watersheds in Cipatujah can be categorized as moderate-high because it has a value more than 1. Based on this factor, it means that the amount of erosion and runoff will be quite much. The result of slope analysis is classified into some range values: below 5%, 5 – 20%, 21 – 50%, and more than 60%. Besides that, observation in the research field also showed that the use of land in Cipatujah is still dominated by forestry. Recapitulation of calculation of the Cipatujah watershed morphometry can be seen in Table 2.

Table 2. Result of Morphometric Characteristics of Cipatujah River

Area (km^2)	151,911
Perimeter (km)	75
Total Stream Length	505,58 km
Bifurcation Ratio (Rb)	2,35455
Drainage Density (Dd)	3,541 km/km^2
Texture Ratio (Rt)	4,067

3.2 FLOOD VULNERABILITY IN CIPATUJAH WATERSHED

After done analyzing morphometry characteristics of the Cipatujah watershed, the writer did delineation of flood vulnerability level to the watershed. It is divided into three vulnerability categories: highly vulnerable, moderately vulnerable, and less vulnerable. Moderately vulnerable area of the watershed is commonly found in the north side until the middle side of Cipatujah watershed. This is in accordance with the watershed's topographical condition because it is located in highland (with an elevation of 700 to 900 meters above sea level) with steep slope and land use dominated by forestry so that it still has a lot of water infiltration. Meanwhile, the less vulnerable area is located in the southeast, south, and southwest side of the watershed. This can be seen from the Rb value that is relatively small (below 3). This is also caused by its geographical location. In the south side of the research area has a very low altitude (0 – 12.5 mapl) and low level of water infiltration. It is also so close to the Indian Ocean. This is caused by parties who change land into tourist spots. Fig 2 shows the vulnerability map of the Cipatujah river applied on a terrain model of geographical visualized areas that are susceptive toward flood.

4. CONCLUSION

The use of geospatial techniques, remote-sensing derived data and integrated analogue, is done to make topographic maps for mapping and measuring morphometric characteristics of Cipatujah river. It is proven competent with reliable accuracy in morphometric studies. The flood potential area map revels vulnerability levels of the river, which mere categorized into highly, moderate, and less vulnerable. This division is based on morphometric characteristics analysis approach and is strongly supported with geomorphological condition in the Cipatujah watershed area. Less vulnerable flood area has generally has Rb value with a range of 3 to more than 5. It is commonly found in highland with steep slopes. Meanwhile, highly vulnerable flood area generally has a smaller Rb value which is less than 3. It is commonly found in lower highland and placed near the sea. Moreover, land use analysis also supports the delineation of flood vulnerability level in Cipatujah watershed. Highly vulnerable flood area has a low water infiltration. This can be seen from the conversion of forestry land into tourist spots and settlements. This research is expected to be a government's guideline in the future, especially in disaster mitigation management development in Cipatujah watershed, Tasikmalaya and its surrounding area. So, if someday when flood is coming, we can do a fast and right respond to prevent numbers of casualties and other losses.

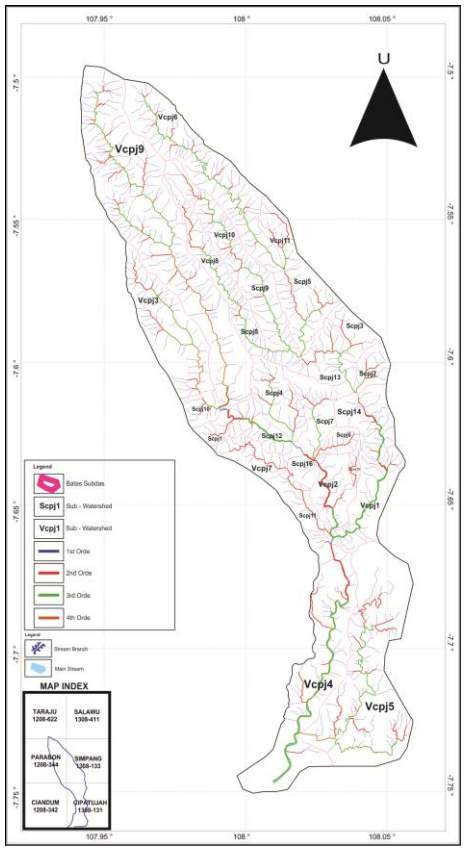

Fig 1. Drainage Network

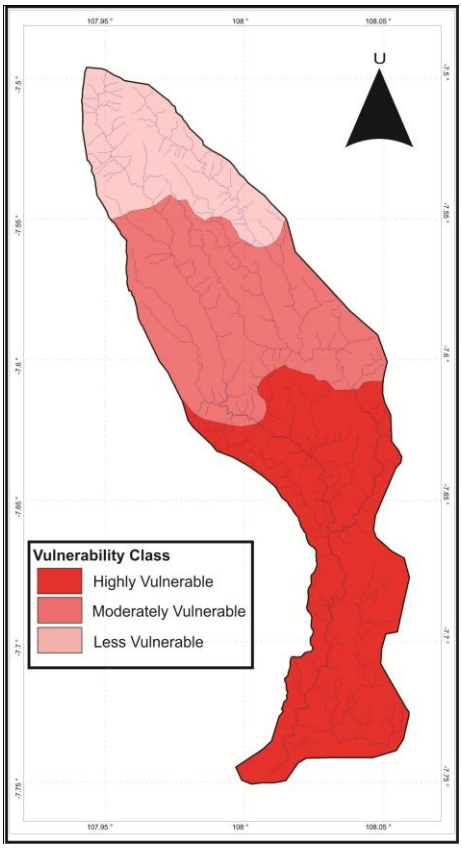

Fig 2. Cipatujah Watershed Potential Flood

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