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RESEARCH ARTICLE

FLOOD DISASTER INVESTIGATION BASED ON CORRELATION OF QUANTITATIVE GEOMORPHOLOGY AND GROUNDWATER LEVEL IN CINTARATU VILLAGE, PANGANDARAN REGENCY, WEST JAVA PROVINCE, INDONESIA

M Faisal Abda Hasan[1*], Nana Sulaksana[3], Boy Yoseph Cahya Sunnan Sakti Syah Alam[3], Mi'raj Maulana[1], Aldo Prayoga[1], and Muhammad Arif[2]

[1]Undergraduate Faculty of Geological Engineering, University of Padjadjaran, Jalan Raya Bandung-Sumedang KM. 21, Jatinangor, West Java, Indonesia
[2]Postgraduate Faculty of Geological Engineering, University of Padjadjaran, Jalan Raya Bandung-Sumedang KM. 21, Jatinangor, West Java, Indonesia
[3]Faculty of Geological Engineering, University of Padjadjaran, Jalan Raya Bandung-Sumedang KM. 21, Jatinangor, West Java, Indonesia
**Corresponding Author Email: mfaisalabdahasan28@gmail.com*

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ABSTRACT

Recently, a flood disaster is occurred in Cintaratu Village, Parigi Sub-district, Pangandaran Regency of West Java Province. Geomorphologically, the watershed systems of this area consist of Cintaratu, Selasari dan Cintakarya. Geologically, the study area is composed by calcarenite, reef limestone, and clastic limestone which is susceptible to dissolution when contact with the water. This research was conducted to investigate the causes of flood disaster based on the correlation between quantitative geomorphology and groundwater level analysis. The methods for this research are field observation and studio analysis. Field observation were conducted by hydro-geological mapping to determine the groundwater level and, also, the lithology of the surrounded area. Studio analyses include the calculation of Bifurcation Ratio (Rb), Drainage Density (Dd), and Fault Fracture Density (FFD). Based on Bifurcation Ratio calculation, the value of Rb_{1-2} of Cintaratu, Selasari, and Cintakarya Watershed respectively are 2.8, 6, and 3.5. Generally, Cintaratu Watershed has the lowest Rb value, and thus has the highest potential to be flooded. Groundwater flow map shows that the stream accumulation zone is located at the center due to topography controlled, thus allows water to accumulate. The average elevation of groundwater is is 111.3871 masl, however, the the average elevation of the ground is 117.4706 masl. The difference of both value is 6.083529 m. This shows that undersaturated area between groundwater elevation and ground elevation is low. So it can be concluded that, the main causes of flood disaster either from above or underground can be investigated by the correlation between quantitative geomorphology analysis and groundwater level.

KEYWORDS

Quantitative Geomorphology, Groundwater level, Flood Disaster Investigation.

1. INTRODUCTION

Cintaratu Village, Parigi subdistrict, Pangandaran Regency is one of region in the south of West Java Province, Indonesia, phisiographically include in the southern mountain zone [1]. Geomorphologically, this area mostly consists of hills and plain landform. The watershed systems of this area consist of Cintaratu Watershed, Selasari Watershed dan Cintakarya Watershed. Geologically, the study area is composed by calcarenite, reef limestone, and clastic limestone which is susceptible to dissolution when contact with the water.

In October 2017, flood disaster struck Pangandaran Regency which cause some regions such as Sukaresik, Cikembulan, Cikalong, Cikangkung, Kalipucang, Cijalu, Bojong,, Pamotan and Cintaratu Village were drowned. Most of these regions are located near the shoreline and the river with lowland topography and flat slope. Long period and high intensity of rainfall in the upstream made the river disabled to contain the water flow from both upstream and seawater simultaneously, resulting flood disaster on several place in Pangandaran. One of them, Cintaratu Village where located at high elevation (approx. 100 to 120 masl) and far from the shoreline was also struck by flood.

According to a researcher, the flood is occurred when large volumes of runoff flow quickly into streams and rivers [2]. The peak discharge of a flood is influenced by many factors, including the intensity and duration of storms and snowmelt, the topography and geology of stream basins, vegetation, and the hydrologic conditions preceding storm and snowmelt events.

Thus, this research was conducted to investigate the cause of flood disaster in Cintaratu Village based on quantitative geomorphology analysis correlating with groundwater level as surface and undersurface analysis.

2. EXPERIMENTAL DETAILS

The methods of this research are quantitative geomorphology as surface water analysis and hydrogeological mapping as undersurface water analysis. Quantitative geomorphology analysis consists of:

Morphography analysis was conducted to know type of landform or topography that caused flood in the study area. Morphometry analysis was conducted to calculate degree of slope of study area by creating some cell grid 2 cm x 2 cm on topography map. Then each grid was drawn perpendicular to the contour and the slope can be calculated using the following formula [3]:

$$S = \frac{(n-1)\ Ic\ x\ 100\%}{d\ x\ Sp} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

S : Degree of slope (%) Ic : Countur interval (m)
n : Number of contour cut by the line d : Horizontal distance on the map (m)
Sp : Maps Scale

These analysis and calculation using software Mapinfo 10.5

Calculation of Bifurcation Ratio (Rb) and Drainage Density (Dd) value were conducted to know the correlation between stream order and density value with the characteristic of rock in study area which caused flood in study area. The stream order is the level of a river segment in a flow pattern. Systematic distribution of stream order in this calculation based on a study [4].

Bifurcation Ratio is the ratio between the total of segments in an stream order with the next order higher by using the formula:

$$Rb = N_i / N_{i+1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

Rb : Bifurcation Ratio value N_i : Total of segments an stream order (m)
N_{i+1} : Total of segments the the next order higher (m)

Drainage density is the value of total length of a catchment area is divided by total area of drainage by using this formula:

$$Dd = \frac{L_S}{A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

Dd : Drainage Density value (Km/Km^2) Ls : Total length of a catchment area (Km)
A : Total area of drainage (Km^2)

Making the straightness of valley from Shuttle Radar Topographic Model (SRTM) image by divide it into several grid with 4 cm x 4 cm in length. This to show the fracture density of study area, relating with surface water absorption rate in study area.

Groundwater level analysis was conducted by hydrogeological mapping in 17 hydro observation wells in the study area to find out groundwater level. Afterwards groundwater flow model and cross section is made to determine the effect of underground water level on the occurrence of floods.

3. RESULTS AND DISCUSSION

3.1 Quantitative Geomorphology analysis

According to morphography analysis of study area it shows that flooded area included in flat landform relatively on 108-119 masl and surrounded by the hills around it. Based on morphometry analysis, it proofs that the flooded area includes have value of slope 0% - 2% or 0^0 - 2^0 or according to a researcher include in flat or almost flat slope, with moderately denudational process and non-intensive surface erosion during dry conditions.

Bifurcation ratio calculation of Cintaratu, Cintakraya, and Selasari Watershed in the catchment area map (Figure 1) shows that the lowest value of Rb_{1-2} is 2.8 in Cintaratu watershed. According to bifurcation ratio classification it takes effect to the flood happened if Rb<3 Water level has a fast increase but slow decrease. Drainage density calculation of Cintakarya, Cintaratu and selasari watershed it shows that Dd value of the watersheds in study area < 0.4 Km/km2 [5]. According to Drainage density classification the value is included in moderately grade [6]. Lynsley also stated if the drainage density is smaller than 0.62 per kilometres square, then a watershed will have a pooling. And if the drainage density is larger than 3.1/kilometres square, then a watershed will have a drought (Table 1).

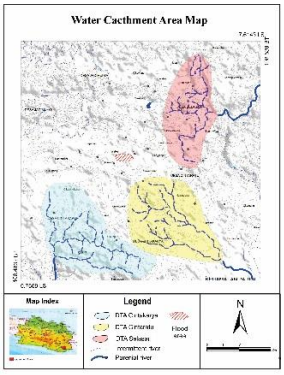

Figure 1: Water catchment Area Map

Another supporting data based on density of the straightness of the valley from Digital Elevation Model SRTM Image shows that density of fracture surrounding the flood area relatively rare. We can interpret that the absorption grade of surface water there is lower than the surrounding.

Table 1: Calculation of Rb and Dd value of Cintakarya, Cintaratu and Selasari watershed

Watershed	River Orde			Rb value		Length of Segment (km)	Area (km^2)	Dd Value
	1st	2nd	3rd	Rb 1/2	Rb 2/3			
Cintakarya	12	2	1	6	2	10.4	3.9	0.38
Cintaratu	14	5	1	2.8	5	12.1	3.8	0.31
Selasari	14	4	1	3.5	4	8.87	2.77	0.31

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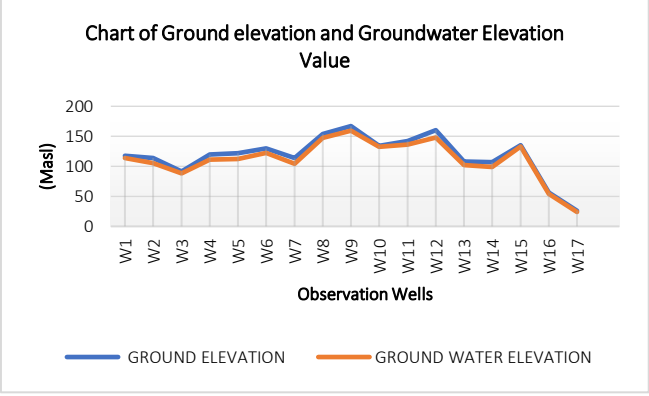
3.2 Groundwater Level Analysis

Based on analysis of groundwater level (Table 2) the average groundwater elevation is 111.3871 masl. However, the average of ground elevation value is 117.4706 masl. The difference of both value is 6.083529 m. This shows that undersaturated area between groundwater elevation and ground elevation is low. Hight intensity of rainfall in long period will cause flooded in this area.

Table 2: The value and Chart of Ground Elevation and Groundwater Elevation

Well observation	Ground Elevation (masl)	Groundwater Elevation(masl)
W1	117.3	114
W2	113.7	105.2
W3	91.5	88.5
W4	119.5	111.3
W5	122	112
W6	130	122.6
W7	114	104.4
W8	154	147.66
W9	167	159.35
W10	134	132.45
W11	142	136.18
W12	160	148.04
W13	108	101.85
W14	107	98.85
W15	135	133.17
W16	56	54.05
W17	26	23.98
Average	**117.4706**	**111.3871**



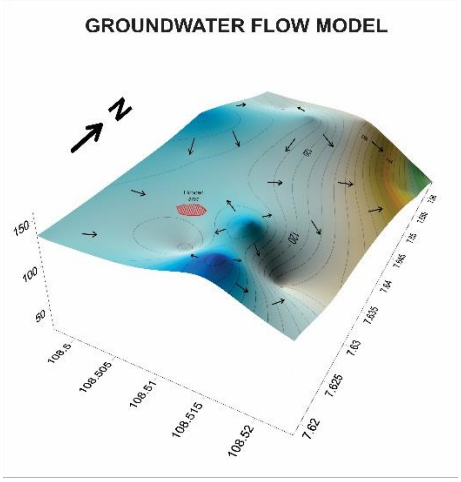


Figure 2: Groundwater Flow Model

3D groundwater flow contour map (Figure 2) shows that the flow accumulation zone is located at the center of study area due to the difference and the change of groundwater elevation becomes lower resulting a basin shape. This condition makes groundwater flow surrounding higher, flowing into and pooling there, so the lithology in area becomes saturated first than surrounding.

4. CONCLUSION

In conclusion, this study proofs that correlation between quantitative geomorphology analysis and groundwater level analysis show us the causes of flood disaster from surface and undersurface aspect. Based on quantitative as surface analysis, it shows that the flooded area is a plain landform with flat slope. Calculation of bifurcation ratio and drainage density also proofs that the value of Rb Cintaratu Watershed is less than 3, and Dd less than 0.4. its mean that water level in flooded area has fast increase but slow decrease and trend to have a pool. Density the straightness of valley as fracture representation show that the flooded area has relatively rare fracture which influence to absorption grade of surface water there. The Groundwater analysis shows that differences between ground elevation and groundwater elevation is low and there is a flow accumulation of groundwater in the flood area thus the waters accumulate, and the lithology becomes saturated earlier than surrounding.

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