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Track and Record Flood Disasters through Modeling Disaster

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Abstract. Protection of human life sources is the main goal of disaster management. This paper examines the importance of modeling disasters in a mitigation perspective by tracking and recording flood occurrence. Mitigation is a benchmark for the success of a disaster information. Flood disaster modeling is one form of spatial-based disaster information. This study uses a hydrological approach as a flood analysis, the development of flood analysis in the form of a pool area calculation. The results of the study show that the characteristics of the area that are prone to flood disasters are strongly influenced by the watershed hirological conditions. Hydrological parameters have different influences in an area to form a flood-prone zone. The flood-prone area based on the return period of 1, 2, 5, 10, 20, 50 and 100 years has different zones. Spatial distribution of flood-prone areas is spread in most Cibeurem watersheds, especially located in Sidareja, Gandrungmangu, Kawunganten and Cipari districts.

1. Introduction

Flood disaster is an annual disaster that occurs in most of Cilacap District [1]. The Cibeurem watershed is one of the alluvial landscapes that form the Cilacap Regency land unit [2]. In 2012, 2013, 2014, 2015 and 2016 the flood disaster still affected Cipari, Kawunganten, Sidareja, and Gandrungmangu Districts. Based on BNPB data in 2016, the floods that occurred in these regions had an ever-increasing impact. Victims of property up to thousands of families (heads of households) must evacuate. In 2012 the flood disaster even affected the loss of the human life. The 2013 to 2016 flood disaster still occurred in most of the Cibeurem watershed and resulted in an increase in the number of refugees and affected families.

Table 1. Flood Event Data in the Cibeureum Watershed

2012	2013	2014	2016
08 March	**10 April**	**19 December**	**08 June**
6 families were displaced and 172 houses were submerged in Sidareja District	12 families fled in Sidareja Subdistrict, inundating Gandrungmangu District	154 residents served inpatients, 580 families sought refuge in Kedungreja, Kawunganten, Gadrungmangu and Sidareja Districts	28 residents were hospitalized, 560 families were affected, 268 people were displaced

22 November	**10 July**	**22 December**	**29 July**
1 person died, 985 families fled in Sidareja and Kedungreja districts.	2177 families were displaced, 8050 people were inundated in Sidareja District, Gandrungmangu	119 families / 834 inhabitants, 1313 submerged housing units in Kedungreja, Kawunganten, Gadrungmangu and Sidareja Districts	12 families were displaced in Sidareja Subdistrict
	16 December		**10 July**
	677 families were displaced in Sidareja and Kedungreja districts		935 residents were displaced

Source: 2016 Flood Disaster Data (geospasial.bnpb.co.id)

Disasters occurring in the Cibeurem watershed are influenced by most of the watershed physical factors. Sidareja, Gandrungmangu, Kawunganten and Cipari sub-districts are areas that have high to very high classes against flood vulnerability. The condition of the region which is mostly in the form of lowlands with fine texture and infiltration ability is very slow [3]. These conditions encourage some areas in the Cibeurem watershed to be very vulnerable to floods.

Rescue of human life sources is a top priority in disaster management. Floods often occur in important areas such as built areas and some floodplain areas[4], [5]. Disasters on a national scale, such as floods and volcanic eruptions require comprehensive disaster management measures. Measurement of possible risks that can occur needs to be done. Measuring risk, planning and developing controllers, regulating physical factors to planning early warnings for the community, government and other NGO institutions to prepare for possible flood disasters [6].

The study of flood-prone areas using a hydrological modeling approach is a research that aims to create flood-prone zones based on hydrological parameters. The calculation of flood plans is used as a reference to find out areas that are prone to flooding.[7], determined the tidal flood-prone area by developing a GIS-assisted river flood model. Land use parameters are the control parameters for the model produced. GIS can be used to develop spatial modeling, one of which is by analyzing flood numerical models [8]. [9]modeling flood disasters by compiling flood inundation maps aided by HEC-RAS softwere. Modeling of flood disasters can be carried out by numerical calculations and assisted by GIS analysis tools.

Disaster modeling can provide additional knowledge, input and scientific development for applications in natural disasters, which are expected to be used as a fast, precise and accurate step to take a policy to minimize or reduce the impact of disaster risk[10]. Preparation of flood maps, vulnerability maps, and maps of the extent of damage caused by flooding can be used to determine the economic risks due to flood disasters[11]. Minimizing losses caused by flooding is the goal of a flood warning system. Estimating the magnitude of flooding that might occur in the future and the inundation area is the main basic concept of flood warning[12]. Knowing flood modeling information can be used to track what impacts will occur from a flood disaster.

Based on the preliminary findings, two research objectives can be formulated. The first objective is to compile a flood modeling in the Cibeurem watershed. The second objective is to analyze flood prone areas in the Cibeurem watershed.

2. Research and Data Areas

Cibeurem watershed is located in Cilacap Regency, west of the Citanduy River Basin and east of the Serayu River Basin. The total area of the Cibeurem watershed is around 255.50 km2 which includes Wanareja, Cipari, Sidareja, Gandrungmangu, Kedungreja, Patimuan and Kawunganten Districts.

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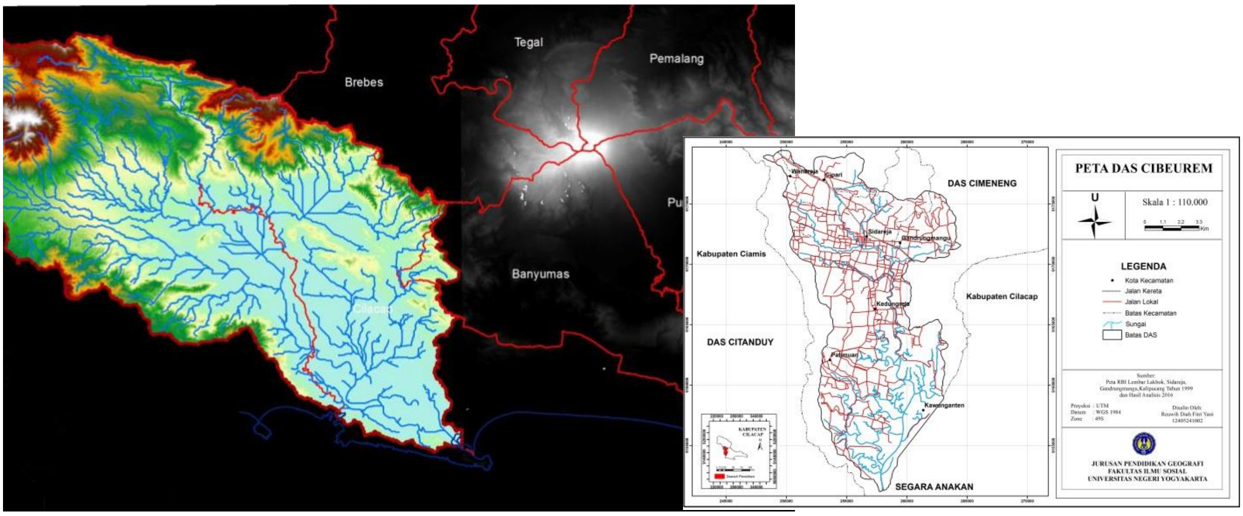

Figure 1. Research Area

This study uses hydrological data to make flood disaster modeling. Rainfall data and the estimated flow coefficient of Cook's method. This study uses data on physical characteristics of watersheds such as slope, land use, surface water deposits, soil infiltration and cross-sectional area. The physical characteristics of the watershed and the cross-sectional area become the main input for compiling flood modeling in the Cibeurem watershed. Following are some of the data used in this study:

Table 2. Research Data

Data	Resource	Year
Rainfall data	Dinas Bina Marga Kabupaten Cilacap	2005-2015
Thematic map • Map of RBI Sidareja, Gandrungmangu, Kalipucang, and Lakbok sheet • Topographic map • Land use map • Geological map • Land map	Badan Informasi Geospasial (BIG) BAKOSURTANAL (Badan Koordinasi Survey dan Pemetaan Nasional)	• 1999 • 2014 • 2014 • 2014 • 2014

3. Research Methods

The method used in this research is hydrological analysis to compile modeling of flood disasters in the Cibeurem watershed. Determination of the model of flood disaster in this study uses several parameters, including rainfall, flow coefficient and cross-sectional area of the Cibeurem river flow. The data in the study were obtained by observation and interpretation of several thematic maps such as, Land Use Maps, Slope Maps, Hold Maps and River Network Maps.

The process of modeling flood disasters through the calculation of each parameter. The analysis used in this study includes: a) rainfall analysis using Polygon Thissen and rain plans. b) estimation of the flow coefficient using the Cook method. Estimation of coefficients using the Cook method includes four parameters, namely, slope, land cover, surface water deposits and soil infiltration. c) analysis of flood inundation.

The data that has been collected is then processed and analyzed using several analytical techniques above. Rainfall analysis will produce maximum rainfall and rainfall plans in the study area. Determination of Cook parameter values is used to determine the magnitude of the coefficient of flow in the Cibeurem watershed so that it can be estimated the amount of runoff generated by the rain plan. The results of the plan rain calculation and flow coefficient value are used to calculate the maximum discharge of the Cibeurem watershed. Maximum discharge is overlaid with maximum channel capacity in the study area. Debits that are not able to be accommodated in the analysis using inundation analysis. Flood flooding in the study area was determined based on the flood return period.

4. Results and Discussion

4.1 Hydrological Conditions of the Cibeureum Watershed

Floods that occur in an area cannot be separated from the watershed hydrological conditions in the region. Factors that cause flooding can be in the form of climatological conditions, changes in land cover and population growth, decrease in ground water level [13]. Hydrological processes that occur in a watershed consist of assessing rain behavior, the relationship of rainfall with runoff, and peak discharge [14]. Assessing rainfall, run-off water and peak discharge of the watershed are things that need to be done to track floods in the study area.

4.1.1. Rainfall

[15] explains that rain is a number of water that can be either solid or liquid that falls from the atmosphere and reaches the earth's surface. Rain is the main parameter that provides a very potential possibility for calculation. Determining the method for measuring rainfall is very important to do. Mathematical calculations (statistics) are very good to calculate rain data especially to determine the probability of rain distribution. Using rain probability can be a support for analyzing water loss due to runoff [16]. Assessment of rainfall in the watershed can be done by estimating the distribution of rainfall, the process of rain into river flow and effective rain.

Cibeurem watershed rainfall is calculated based on rainfall data recorded at the rain station that represents the study area. The maximum daily rainfall is calculated based on the Polygon Thissen method. Based on the calculation of maximum daily average rainfall, the Cibeurem watershed area has the highest average daily rainfall of 57.11 mm and the lowest average daily rainfall of 22.63 mm.

Planned rain is also called the maximum daily rain probability is the maximum amount of daily rainfall that may occur in a certain return period [17]. Rainfall plans in the study area were determined using Log Pearson Type III distribution.

Table 3. Rainfall of the Cibeureum Watershed Plan

Return period (years)	Probability (%)	Rainfall Plan (mm)
1	100	16,431
2	50	33,178
5	20	44,757
10	10	52,217
25	4	61,292
50	2	67,788
100	1	74,071
200	0,5	80,18

4.1.2. Flow Coefficient

Overland is all water flowing through a moving river leaving the catchment area (DAS), without regard to the origin / path taken before reaching the channel (surface or subsurface) because this runoff is a combination of surface flow and groundwater flow at high groundwater level or a combination of surface water flow and flow that subsurface flow at low groundwater [18].

The Cibeurem watershed coefficient value is calculated based on the mapping unit in the Cibeurem watershed. The land mapping unit in the Cibeurem watershed is based on a data base obtained by hitching up slope maps, land use maps, surface waterfill maps and soil infiltration maps. The results of the overlapping of the four maps resulted in a map of the Cibeurem watershed flow coefficient. The calculation of the total coefficient value of the Cibeurem watershed is done by adding up all the scores of the flow coefficient values in each land unit.

The results of the calculation of the flow coefficient in the Cibeurem watershed based on Cook's method, the study area has a flow coefficient of 0.6684 or 66%. This value shows that 66% of the rain that falls in the Cibeurem watershed will become runaway water.

4.1.3. Peak discharge

The maximum discharge of a watershed indicates the ability of a watershed to accommodate the maximum amount of rainfall that falls in the region. The maximum discharge of the Cibeurem watershed is calculated using the rational formula method. The parameters of the flow coefficient, rainfall intensity and the area of the water tank are the input parameters to calculate the maximum discharge of the watershed. The maximum discharge of the Cibeurem watershed is calculated based on the return period of 1, 2, 5, 10, 25, 50, 100 and 200 years. The following is the calculation of the maximum discharge of the Cibeurem watershed.

Table 4. Peak Discharge of Cibeureum Watershed

Return period (years)	**R (maks)**	**I (mm/hour)**	**C**	**A (km^2)**	**Q (m^3/dtk)**
1	16,431	1,517	0,668	225,25	63,410
2	33,178	3,067	0,668	225,25	128,199
5	44,757	4,138	0,668	225,25	172,967
10	52,217	4,827	0,668	225,25	201,767
25	61,292	5,666	0,668	225,25	236,837
50	67,788	6,212	0,668	225,25	259,659
100	74,071	6,848	0,668	225,25	286,244
200	80,18	7,413	0,668	225,25	309,861

4.2 Modeling of Cibeureum Watershed Floods

Modeling of floods in the Cibeurem watershed was prepared based on rainfall analysis, flow coefficient analysis and inundation analysis.

4.2.1. Rainfall Analysis

Rainfall analysis is used to determine the tendency of rainfall data in the study area. Rainfall parameters used in making the model are rainfall intensity. Rainfall intensity is calculated based on hourly rainfall data. Calculation of rainfall intensity affects the amount of maximum discharge in the study area. Calculation of rainfall intensity in the study area was carried out using the maximum daily rainfall that was applied by the Mononobe method.

Table 5. Rainfall of the Cibeureum Watershed Plan

T (minute)	**Return Period (years)**							
	1	**2**	**5**	**10**	**25**	**50**	**100**	**200**
5	30,480	61,584	83,063	96,921	113,765	124,727	137,517	148,835
10	19,157	1724,791	52,205	60,916	71,502	78,392	86,430	93,544
15	14,561	29,419	39,680	46,300	54,347	59,583	65,693	71,100
30	9,151	18,490	24,939	29,100	34,157	37,449	41,288	44,687
60	5,752	11,621	15,674	18,289	21,468	23,537	25,950	28,086
120	3,615	7,304	9,851	11,495	13,493	14,793	16,310	17,652
180	2,755	5,566	7,508	8,761	10,283	11,274	12,430	13,453
240	2,272	4,591	6,192	7,225	8,480	9,297	10,251	11,095

360	1,732	3,499	4,719	5,506	6,463	7,086	7,812	8,455
480	1,428	2,885	3,892	4,541	5,330	5,844	6,443	6,973
720	1,088	2,199	2,966	3,461	4,062	4,453	4,910	5,314

4.2.2. Estimating Flow Coefficient

Estimation of the flow coefficient in the Cibeurem watershed using the Cook method. The parameters used in estimating the flow coefficient using the Cook method are slope parameters, land use, surface water deposits and soil infiltration. The slope of the slope is a major factor in the surface hydrology process. The greater the slope, the greater the flow. Following are the results of the calculation of slope in the study area.

Table 6. Slope Class of Cibeureum Watershed

Class	**Slope (%)**	**Area (km^2)**	**Percentage (%)**	**Weight**
1	< 5	212,2	91,07	10
2	5 – 10	5,0	2,14	20
3	10 – 30	14,7	6,32	30
4	>30	1,0	0,47	40

Calculation of surface water deposits is carried out using a flow density approach. Quantitative surface water deposits can be carried out by referring to flow density [19]. Linsley suggested that the relationship between flow density and drainage conditions assumes that the lower the flow density, the greater the surface flow which is retained in several places before heading to the river. Flow density parameters include river length and watershed area. The results of the classification of surface water deposits in the study area are as follows:

Table 7. Density Class of Cibeureum Watershed

Class	**Flow Density (mil/mil^2)**	**Area (km^2)**	**Percentage (%)**	**Weight**
1	< 1	41,4	18,29	5
2	1 – 2	40,9	18,09	10
3	2 – 5	80,4	35,52	15
4	>5	63,6	28,10	20

Land cover in the study area is in the form of land use and other land cover vegetation. Land cover affects the retained process or the release of surface flow or water that seeps into the soil. The forms of land use in the study area are classified by adjusting the Cook method and further scoring is carried out in accordance with the magnitude of the influence of each land use in influencing the amount of surface runoff. Land use classification uses the Meijerink classification (1970) and is converted into the land use method of Cook. The results of land use classification in the study area are as follows:

Table 8. Landuse of Cibeureum Watershed Class

Vegetation class in Cook Method	**Area (km^2)**	**Percentage (%)**	**Weight**
There are no effective cover crops or the like	54,3	23,31	20
The cover crops are small to moderate, there are no agricultural crops and the natural cover is small, less than 10% of the watershed	6,7	2,87	15

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50% covered by trees and grass	142,8	61,31	10
90% of the watershed is covered either by woody grass or the like	29,1	12,51	5

Ground infiltration is the last parameter used to estimate flow coefficient. Soil infiltration in this study was carried out using a soil texture approach. The more rough the soil is in an area, the faster the infiltration in the region. Soil qualitative infiltration needs to be changed to land infiltration classes. The map of soil infiltration classes is obtained by riding a soil texture map with a land use map. Soil texture and land use greatly influence the rate of infiltration in the study area. The following are the results of the interpretation of soil infiltration in the Cibeurem watershed.

Table 9. Cibeureum Watershed Infiltration Class

Class	**Infiltration rate**	**Area (km^2)**	**Percentage (%)**	**Weight**
1	High	46,1	16,07	5
2	Normal	33,95	11,82	10
3	Slow	162,5	56,59	15
4	Very Slow	44,58	15,52	20

4.2.3. Inundation Analysis

Inundation in the Cibeurem watershed was obtained based on analysis of maximum discharge, maximum channel capacity, inundation volume and inundation area. Maximum channel capacity indicates there is no flood in the study area. River crossings are expressed in channel capacity. The maximum capacity of the channel in this study was measured in the area of Sidareja District which is part of the Cibeurem watershed. Based on the calculation of the channel capacity of 50 m2 with a maximum discharge of 58.716 m3 / sec.

Puddle discharge is obtained from riding the maximum capacity data channel with maximum discharge data in the Cibeurem watershed. The amount of debit that exceeds the water level or storage will become a flood or inundation. Discharge overflow in the study area was calculated based on return periods of 1, 2, 5, 10, 25, 50, 100 and 200 years. The following is the result of calculation of overflow discharge.

Table 10. Characteristics of Cibeureum Watershed Discharge

Return period (years)	**Probability (%)**	**Maximum Discharge (m^3/dtk)**	**Channel Capacity (m^3/dtk)**	**Inundation Discharge (m^3/dtk)**
1	100	63,410	58,716	4,694
2	50	128,199	58,716	69,483
5	20	172,967	58,716	114,251
10	10	201,767	58,716	143,051
25	4	236,837	58,716	178,121
50	2	259,659	58,716	200,943
100	1	286,244	58,716	227,529
200	0,5	309,861	58,716	251,145

The results of the calculation of flood discharge need to be converted into volume and area of inundation. Calculation of flood overflow volume is done by multiplying the inundation debit with the time period which is hours. The area of the inundation calculation is done to determine the spatial

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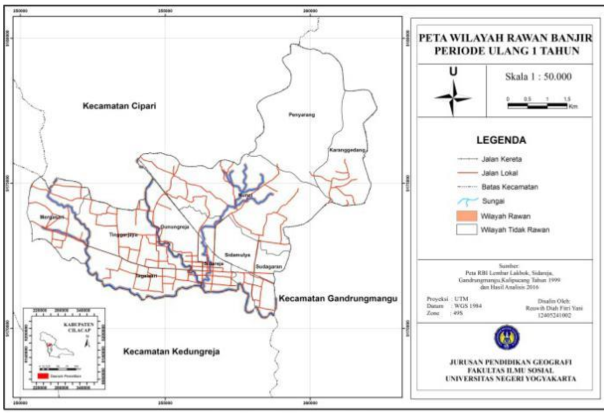
distribution of inundation. Calculation of inundation area in the study area is done by converting overflow discharge in each return period. The following is the area of inundation in the flood target area.

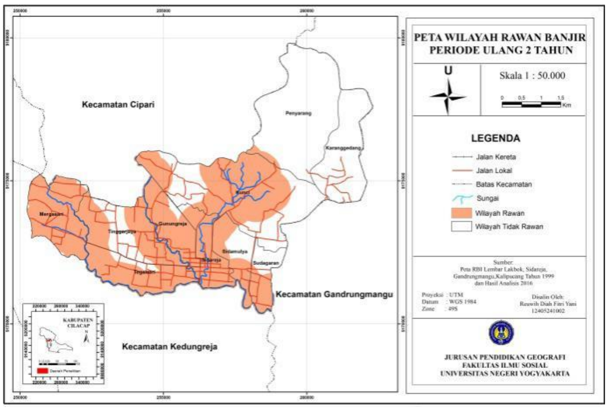
Table 11. Area of Cibeurem Watershed

Return period (years)	**Inundation Area (km^2)**
1	0,05
2	0,75
5	1,23
10	1,54
25	1,92
50	2,17
100	2,45
200	2,71

4.3 Flooding in Cibuerem watershed

Flooding in the Cibeurem watershed is determined from the results of modeling floods. Using rainfall parameters, flow coefficient and area of flood inundation in the Cibeurem watershed can be modeled. Disasters are events or series of events that threaten and disrupt people's lives and livelihoods caused by both natural factors and / or non-natural factors as well as human factors resulting in human casualties, environmental damage, property losses and psychological impacts (Law Act Number 24 of 2007). Disaster models resulting from flood calculations in the Cibeurem watershed require spatial distribution information to find out which areas were affected by floods. Based on the results of the modeling of flood disasters in the Cibeurem watershed, it is known that the areas prone to flooding are as follows:





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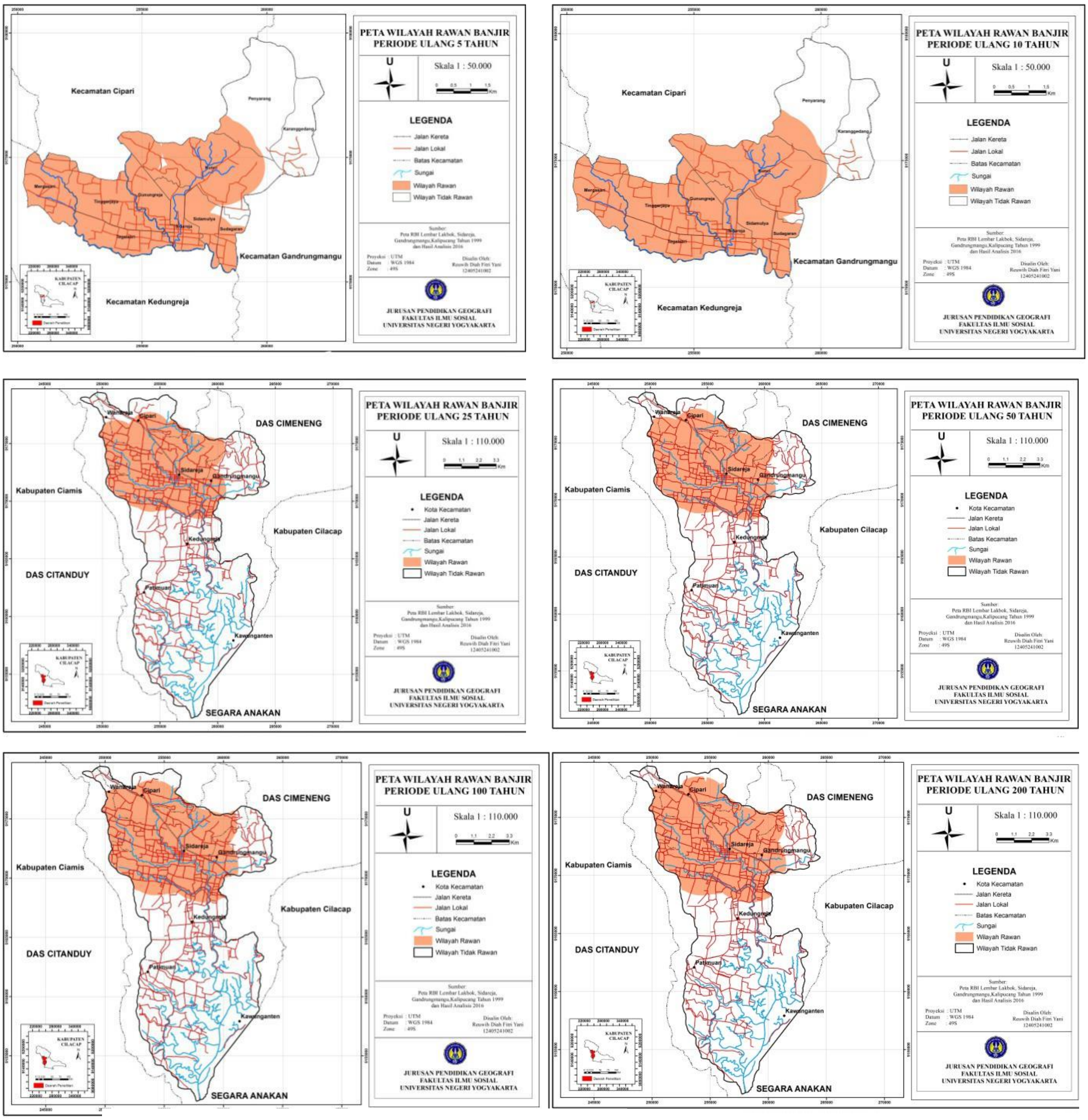

Figure 2. Maps of Various Periodic Flood Prone Areas in The Cibeurem Watershed

Based on a map of flood-prone areas in the Cibeurem watershed for several periods of flood return, it can be seen that flooding is a disaster that threatens the region. The one-year flood return period in Sidareja Subdistrict becomes an area prone to flood disasters. Flood return period 2, 5 10 floods began to affect other sub-districts, such as Cipari, Kedungreja, and Gandrungmangu. The 50, 100 and 200 year flood return periods are estimates of floods with long periods of vulnerable periods. In this period, floods threaten most of the sub-districts in the Cibeurem watershed.

5. Conclusions and Recommendations

Flood disaster can be mitigated by predicting flood events in the future. Modeling disasters can be used to track and record disaster events using hydrological parameters and physical parameters of the watershed. Flood disasters in the Cibeurem watershed can be modeled for a certain period of time.

Rainfall and flow coefficient in the Cibeurem watershed are controlling factors for flood disaster modeling. The area of flood inundation made based on the results of the flood disaster modeling, which is stacked up with the maximum capacity of the channel can be used to determine the flood area. In general, it appears on the map of flood warrants in the 1, 2 and 5 year periods that floods impact on several districts such as Sidareja District. Flood periods of 10, 25, 50, 100 and 200 years, flood disasters impacted most areas in the Cibeurem watershed.

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