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Extreme flood event analysis in Indonesia based on rainfall intensity and recharge capacity

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Abstract. Indonesia is very vulnerable to flood disaster because it has high rainfall events throughout the year. Flood is categorized as the most important hazard disaster because it is causing social, economic and human losses. The purpose of this study is to analyze extreme flood event based on satellite rainfall dataset to understand the rainfall characteristic (rainfall intensity, rainfall pattern, etc.) that happened before flood disaster in the area for monsoonal, equatorial and local rainfall types. Recharge capacity will be analyzed using land cover and soil distribution. The data used in this study are CHIRPS rainfall satellite data on 0.05 ^{0} spatial resolution and daily temporal resolution, and GSMap satellite rainfall dataset operated by JAXA on 1-hour temporal resolution and 0.1 ^{0} spatial resolution, land use and soil distribution map for recharge capacity analysis. The rainfall characteristic before flooding, and recharge capacity analysis are expected to become the important information for flood mitigation in Indonesia.

1. Introduction

The characteristics of rainfall in Indonesia are high throughout the year. Thus Indonesia is vulnerable to flood disaster. Most intense convective activity occurs in the Indonesian archipelago that it produces frequent heavy rainfall [1]. The large amount of rainfall in Indonesia plays an important role as central atmospheric heat sources of the Earth's climate system throughout the year [2]. The existence of such natural conditions resulted in Indonesia very vulnerable to disasters associated with rainfall, one of which is the flood disaster. Flood disaster is hydrometeorological disaster that is frequent in Indonesia. The frequency of the flood disaster is increasing from year to year with increasing rainfall intensity.

Rainfall variability in Indonesia is influenced by oceans, islands, monsoon and topography. Based on these factors, Indonesia has three rainfall patterns: monsoonal, equatorial and local [3]. Understanding the rainfall characteristic for each pattern of rainfall that causes the flooding disaster is important.

The rain gauge network in Indonesia is sparse, poorly distributed, and shows gaps in observations. Thus, it is not sufficient to describe spatially and temporally rainfall for the area. The rainfall satellite data may be the best solution for rainfall estimation where there is no rain gauge station [4]. Here, we describe extreme flood event analysis in Indonesia based on rainfall intensity and recharge capacity.

2. The Extreme Flood Analysis

The rainfall data used in this study are CHIRPS rainfall satellite dataset with 0.05 ^{0} spatial resolution and daily temporal resolution developed by U.S. Geological Survey (USGS) and CHG scientists (Figure 1), and GSMap rainfall satellite dataset operated by JAXA with 1-hour temporal resolution and 0.1 ^{0} spatial resolution (Figure 2). Previous research based on analysis of GSMap satellite rainfall dataset showed that in general Indonesia has two characteristics of rainfall pattern before floods; they are short-

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term rainfall period and long-term rainfall period [5]. Java Island has a short-term rainfall period more than long-term period before the flood because it has high population density around 1000 people/km^2 [6]**.** The CHIRPS rainfall satellite data set is highly correlated with daily rainfall observational data. The mean of daily rainfall values of the CHIRPS data correlated very well spatially with observational station data [7]. The CHIRPS satellite dataset has more detailed spatial resolution, and GSMap data have a more detailed temporal resolution. An understanding of the strengths and weaknesses of different rainfall satellite data products is valuable to know a better rainfall characteristic before flooding. The combination of these two satellite dataset will hopefully obtain better understanding of the nature of the rainfall characteristic that occurred before great flooding.

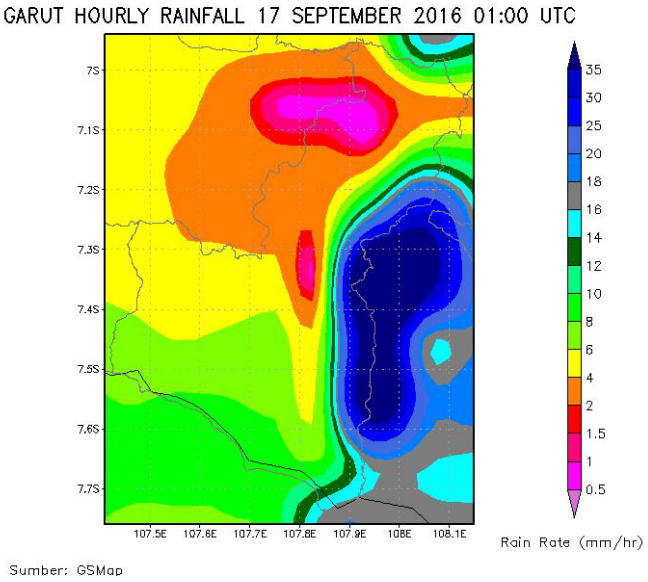


Figure 1. GSMap satellite dataset of Garut, West Java.

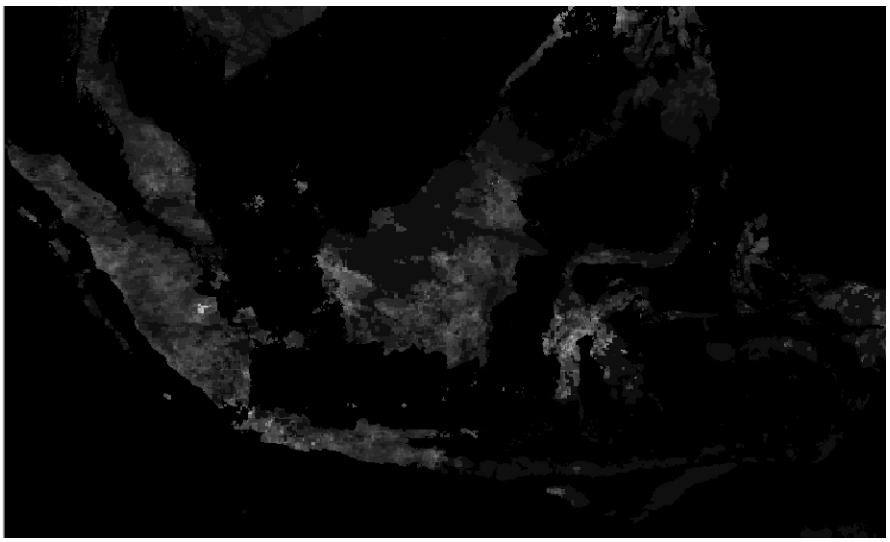


Figure 2. CHIRPS satellite data of Indonesia.

Several previous studies have suggested that increased flood frequency was a result of heavy rainfall and uncontrolled land cover changes [8–10]. Increasing urbanization promotes flooding with excess rainfall due to increasing of the total impervious area [11]. The intensity of the peak floods has increased

which is the direct effect of the land use/cover changes [11]. Land use changes affect the capacity of water recharge [12]. Land use changes are associated with urban development and contribute to the peak discharge, volume and frequency of floods [13,14]. The heavy rainfall, land use changes and decrease of recharge capacity may lead to extreme flooding events. The land use changes have impacted the CN number. If the CN number increased, it caused the decrease of moisture retention capacity of the soil. This condition resulted, despite the equal rainfall, a larger discharge rate than before. The direct effect of the land use/cover change both soil moisture retention capacity and run-off rate [15]. The previous study showed the land use changes, soil moisture retention capacity and run-off rate are the very important factors that have to be identified besides the rainfall characteristic for flooding disaster mitigation. The main cause of flooding has not been determined yet, whether poor management impact or natural rainfall character changes. So it is important to study both flood causes to gain a clear view the main cause of flooding. The purpose of this research is to obtain the characteristic of rainfall before flooding occur for the 3 rainfall types, land use and recharge capacity analysis to know their impact on flooding. Two sources of rainfall satellite datasets will be used are CHIRPS and GSMap; land cover and soil distribution map of the study area that caused flooding disaster will be analyzed.

The study will be conducted in some areas in Indonesia that have different rainfall types, land-use and soil distribution map. The study areas are Belitung Island, Java Island and Maluku Island. Heavy rainfall triggered a flash flooding that occurred in Belitung Island inundated numerous villages in the districts of Belitung and East Belitung in July 2017. Wu, P., et al., have studied that the trans-equatorial monsoon flow plays a principal role in the formation of the repeated heavy rains [16]. In Way Ela River, Ambon Island, Maluku Province Landslide Dam Outburst Flood disasters occurred that was caused by heavy rainfall [17].

The methodology used in this study is as follow:

- Rainfall observation data analysis
- Flood events data collecting and analysis
- Data processing and statistical analysis of CHIRPS rainfall satellite dataset with 0.05^{0} spatial resolution and daily temporal resolution, and rainfall satellite dataset GSMap with 1 hour temporal resolution and 0.1^{0} spatial resolution
- Land cover and soil distribution analysis

The rainfall characteristic before flood event will be obtained using GSMap and CHIRPS satellite data processing. The recharge capacity will be obtained using land use types and soil distribution analysis.

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