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Analysis of Rainfall Characteristics using Hydrognomon v.4.0 in Karangploso, Malang

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Abstract
Rainfall is hydrology event that occurred seasonal in every year. There are two seasons occurred in Indonesia, dry season and rainy season. The analysis of rainfall characteristics plays a significant role to predict the rainfall occurrence and probability of flash flood. In this paper, rainfall analysis using Hydrognomon v.4.0 will provide hydrology data information, such as rainfall intensity and time series. The highest maximum rainfall of 526 mm (in 2010) has a return period of about 11 years. This means that rainfall of this magnitude can be expected to occur once every 11 years. The maximum rainfall of 425 mm (2013) has a return period of about 5.5 years, indicating a more frequent occurrence than the highest rainfall. Thus, it makes data trend rainfall with higher values tends to have longer return periods, indicating infrequent intensity. However, rainfall with lower intensity tends to have shorter return periods and occurring more frequently.

1. Introduction

Rainfall is one of the most significant hydrological phenomena, profoundly influencing both natural ecosystems and human activities (Sato & Shuin, 2024). In tropical countries like Indonesia, where the climate is characterized by a distinct division between the dry and rainy seasons, understanding rainfall characteristics is essential for effective water resource management, agricultural planning, and disaster mitigation. Karangploso, a subdistrict in Malang, East Java, is no exception, experiencing annual rainfall patterns that significantly affect local livelihoods. (Hakim & Kuncoro, 2024)

Analyzing rainfall characteristics provides critical insights into the intensity, frequency, and trends of rainfall events.(Chow et al., 1988) Such analysis not only helps in understanding the seasonal distribution of rainfall but also in assessing potential risks such as flash floods, which are often triggered by high-intensity rainfall.(Yuan et al., 2021) This study leverages Hydrognomon v.4.0, a hydrological data analysis tool, to examine rainfall patterns in Karangploso over a specific period, focusing on maximum rainfall intensities, return periods, and the implications for local hydrology. (Amri et al., 2024)

The findings of this study reveal that the highest recorded maximum rainfall in Karangploso was 526 mm in 2010, with a return period of approximately 11 years. Similarly, rainfall of 425 mm in 2013 exhibited a return period of about 5.5 years. (*No Title*, n.d.)These results indicate that while extreme rainfall events are infrequent, their impact can be significant, necessitating preparedness and mitigation strategies. Conversely, lower-intensity rainfall occurs more frequently and plays a crucial role in sustaining agricultural and ecological systems.

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By understanding these characteristics, this study aims to provide valuable data for stakeholders in water resource management, disaster risk reduction, and sustainable development planning in Karangploso and similar regions.(Yang & Liu, 2020)

2. Research Method

2.1. Rainfall Data Collection

The rainfall data for this study was collected from the Central Bureau of Statistics (BPS) website, covering the period from 2004 to 2013.(*No Title*, n.d.) This dataset provides historical rainfall records specific to Malang, including Karangploso subdistrict. The collected data was carefully curated and formatted to ensure compatibility with Hydrognomon v.4.0, a hydrological analysis software. The software facilitates the computation of rainfall return periods and trends in rainfall intensity, forming the basis for this study's analysis.

2.2. Rainfall Data Analysis

The way to get rainfall in Karangploso, Malang is to download data from the Central Bureau of Statistics. So as to obtain the rainfall needed for research. Frequency analysis can be calculated with Hydrognomon v.4.0 using Gumbel method, Normal method, Log Normal method, Log Pearson Type III method.

The analysis of rainfall data for Karangploso utilized Hydrognomon v.4.0, which provides advanced tools for frequency and trend analysis.(Bárdossy & Das, 2008) The methodology involved the application of several statistical distribution methods, including:

1. Gumbel Method: Used to predict extreme values, such as maximum rainfall.

2. Normal Method: Assumes rainfall data follows a normal distribution for baseline trend analysis.

3. Log-Normal Method: Suitable for skewed data distributions commonly seen in hydrology.

4. Log Pearson Type III Method: Widely used in hydrological studies for analyzing extreme events.

These methods enabled the calculation of return periods for various rainfall intensities, providing insights into the frequency and likelihood of specific rainfall events. The results from Hydrognomon v.4.0 were then interpreted to identify patterns and trends, ensuring a comprehensive understanding of the rainfall characteristics in Karangploso.(Pérez et al., 2021) This approach ensures robustness and reliability in the hydrological analysis, offering valuable data for regional water management and disaster risk planning.

3. Result and Discussion

3.1. Location of rainfall station in Karangploso, Malang

Figure 1. Location of rainfall station in Karangploso, Malang

Here is the location where the data is collected by BMKG Karangploso, Malang. It is located in the central city of Malang, thus the data can represent the rainfall data in Malang city.

3.2. Distribution Analysis

Based on rainfall data from 2004 to 2013, we can get other information with data analysis. Some of the analysis, such as the maximum mean, deviation standard and variation of coefficient.(Thangjai et al., 2020) The mean of rainfall data can be obtained from the formula:

$$Mean = \frac{Total\ of\ the\ rainfall\ data\ every\ year}{Total\ of\ the\ year} \quad \text{...}(1)$$

Here is the maximum rainfall data in Karangploso, Malang. From measurement data, we can obtain the mean value that represent most of rainfall occured.

Table 1. Rainfall data

Tahun	Max rainfall data (mm)
2004	230
2005	331
2006	405
2007	397
2008	235
2009	189
2010	526
2011	339
2012	406

2013	425

From the data provided the mean maximum is 348.3mm, the deviation standard is 104.87mm, and variation coefficient is 30. 11% which it means varied enough. Based on the data provided, the frequency analysis can be obtained as the table shown below and we can conclude that the highest maximum rainfall of 526 mm in 2010 has a return period of about 11 years. This means that rainfall of this magnitude can be expected to occur once every 11 years. The maximum rainfall of 425 mm in 2013 has a return period of about 5.5 years, indicating a more frequent occurrence than the highest rainfall. Rainfall with higher values tend to have longer return periods, indicating less frequent intensity. Conversely, rainfall with lower intensity tends to have shorter return periods, making it more frequent. Higher rainfall has a smaller probability of occurrence, for example rainfall of 526 mm has a probability of only 9.09% in a given year. Lower rainfall, such as 406 mm (in 2012), has a greater probability of about 27.27%. The larger the maximum rainfall, the longer the return period, indicating that high-intensity events are rare. Conversely, rainfall with smaller intensity has a shorter return period, meaning it occurs more frequently.

Table 2. Analysis frequency

Tahun	Curah hujan maksimum	Probabilitas	Periode ulang (Tahun)
2010	526	0.09	11.0
2013	425	0.18	5.5
2012	406	0.27	3.67
2006	405	0.36	2.75
2007	397	0.45	2.2
2011	339	0.54	1.83
2005	331	0.63	1.57
2008	235	0.72	1.37
2004	230	0.81	1.22
2009	189	0.90	1.10

The graph illustrates the annual rainfall trends from 2004 to 2013 for Karangploso station.

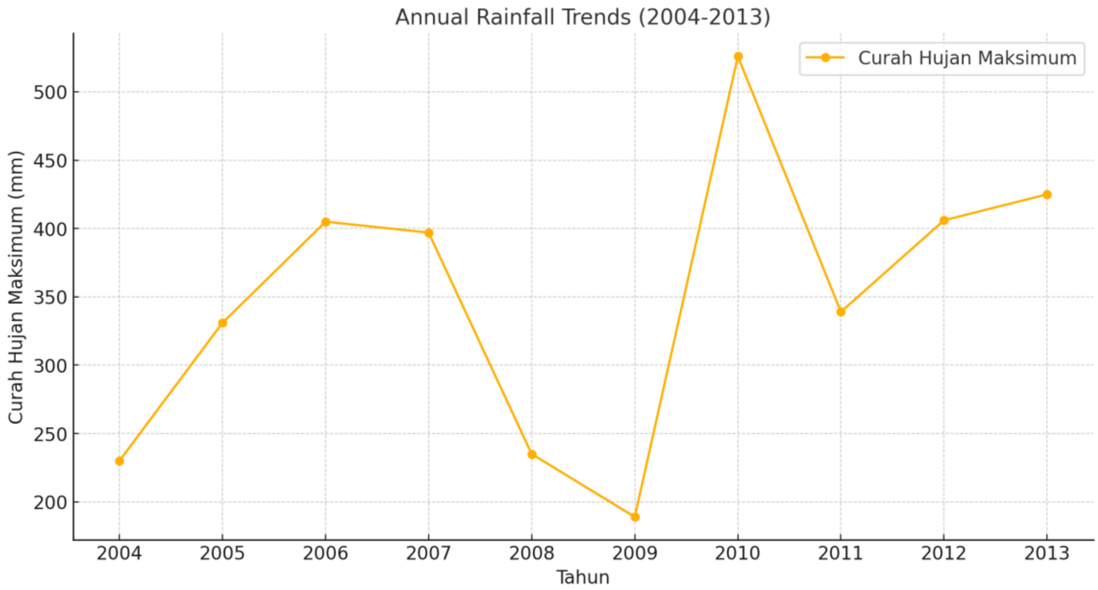

Figure 1. Annual rainfall trends from 2004 to 2013

The graph above describes the highest rainfall occurred in 2010 with 526 mm. The lowest rainfall occurred in 2009 with 189 mm and there is significant variability in annual maximum rainfall, with noticeable spikes and dips.

3.3. Hydrognomon v.4.0 analysis

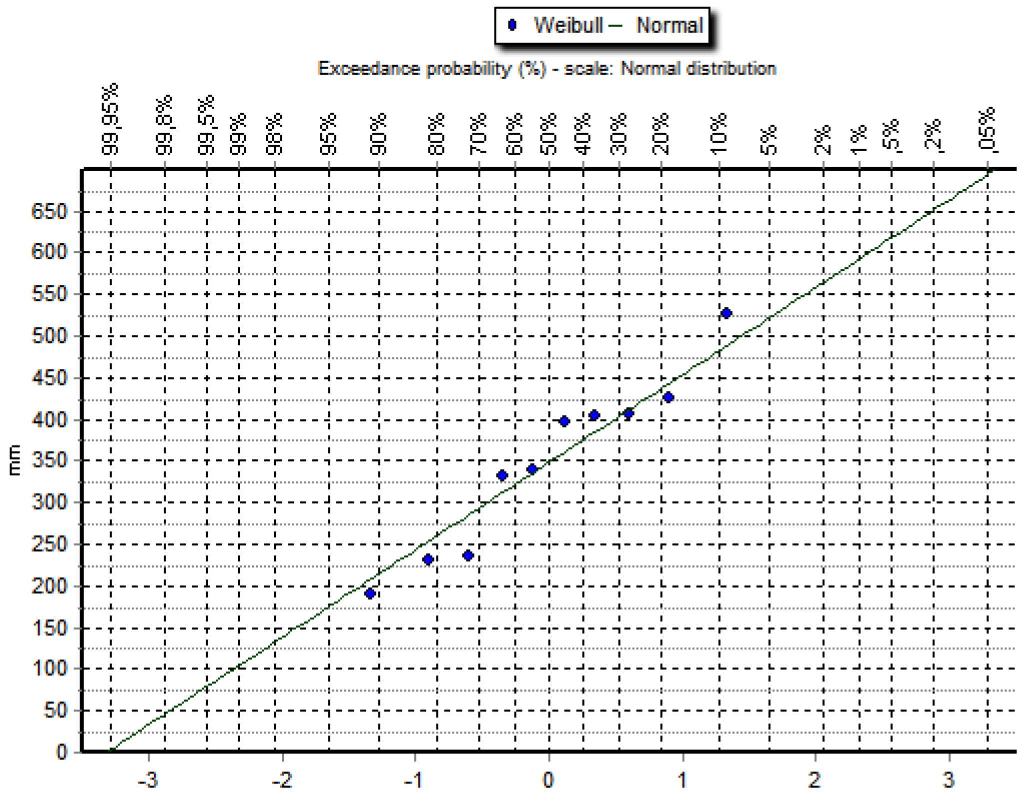

Figure 2. Exceedance probability - Normal distribution

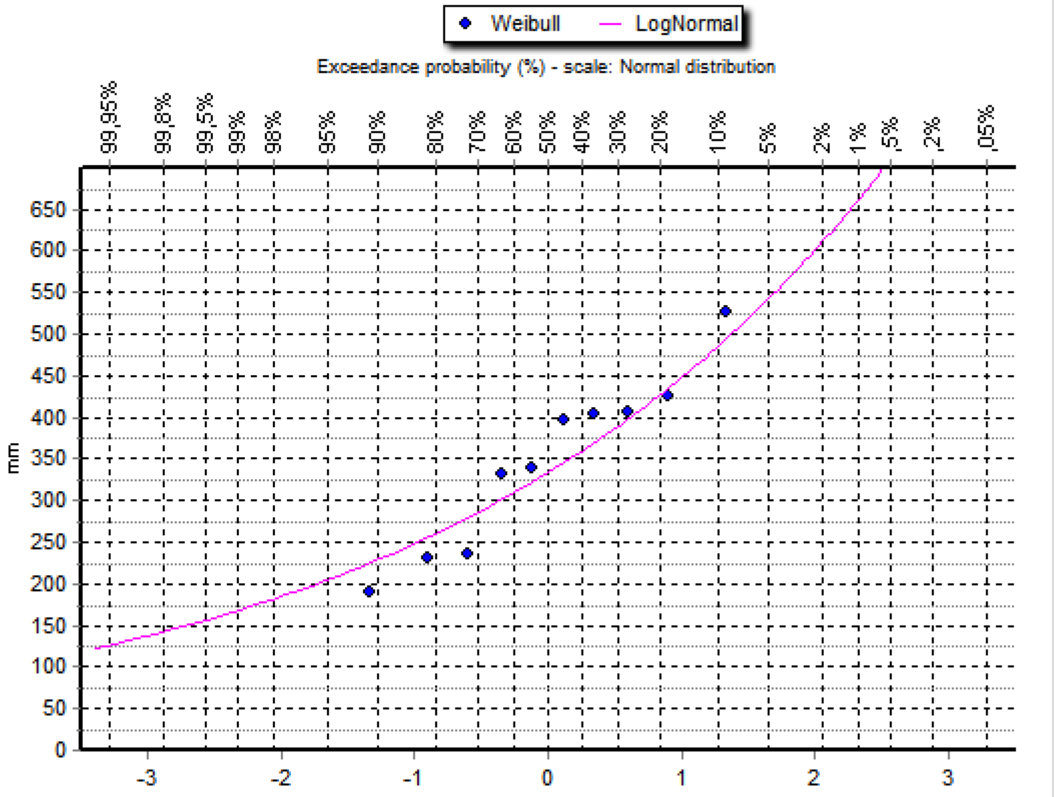

Figure 3. Exceedance probability - Log Normal

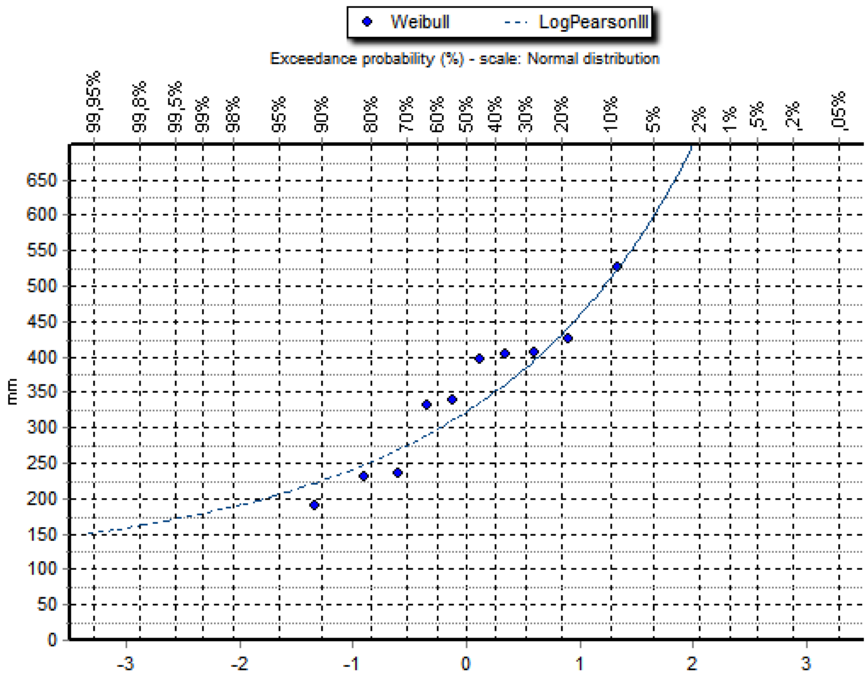

Figure 3. Exceedance probability - Log Pearson III

From the distribution graph shows that the higher rainfall intensity the exceedance probability will be smaller and the smaller rainfall intensity the exceedance probability will be higher. In addition, when the rainfall intensity range between almost 250 mm to 400 mm the exceedance probability probability range between 30 to 80 percent.

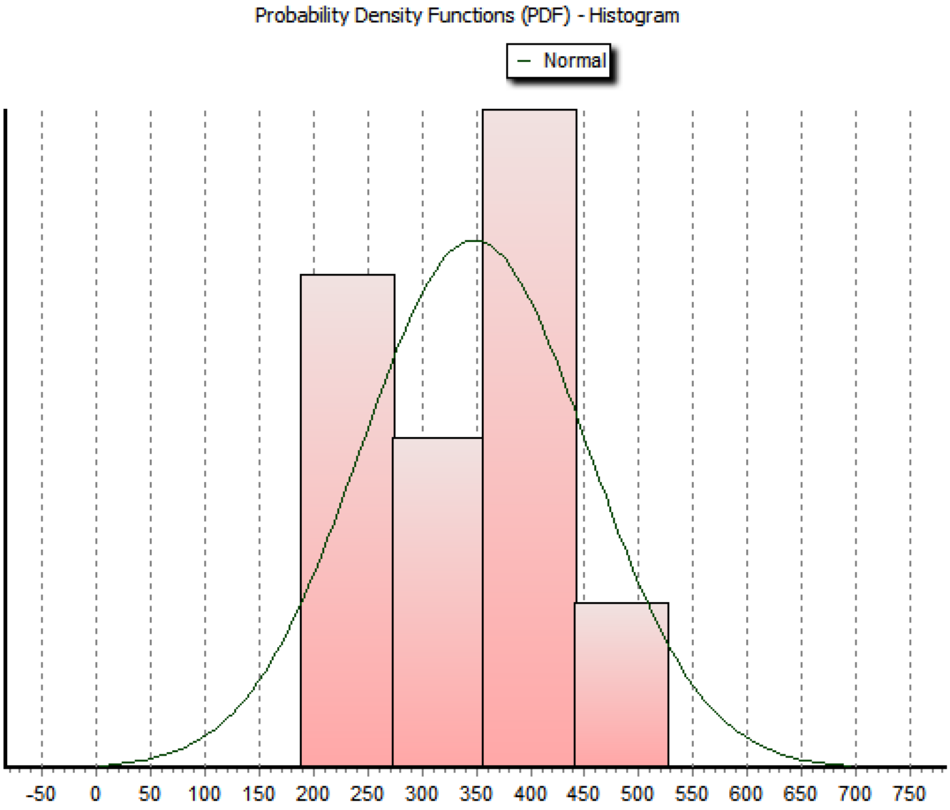

Figure 4. Histogram - Normal

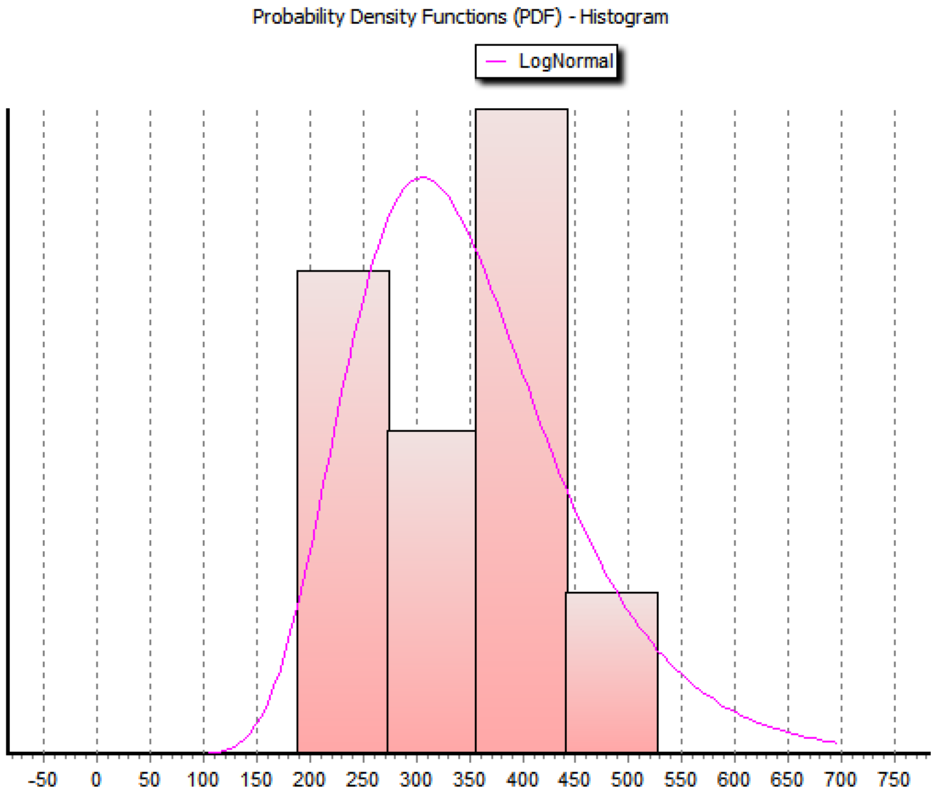

Figure 5. Histogram - Log Normal

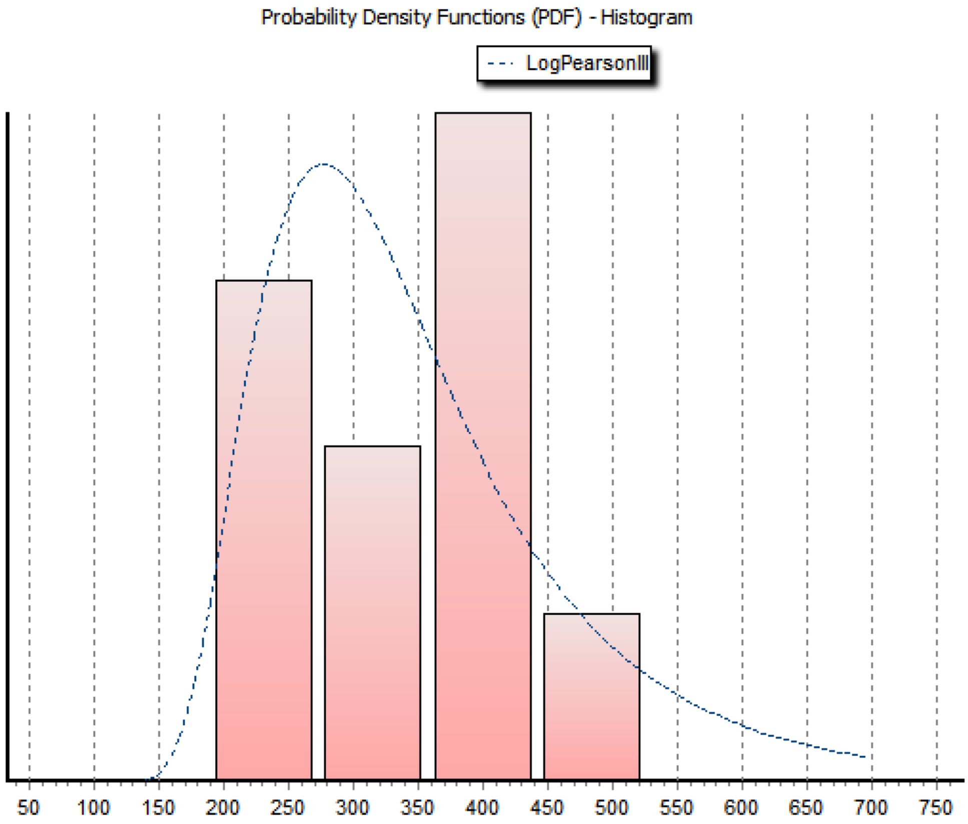

Figure 5. Histogram - Log Pearson III

4. Conclusion

This study analyzed rainfall characteristics in Karangploso, Malang. The average rainfall intensity that occured in Malang is 348.3mm. The analysis using hydrognomon v.4.0 shows that the higher rainfall intensity, the less frequent it is occured. Annual rainfall trends from 2004 to 2013 describes that the highest rainfall occured in 2010 with intensity 526 mm. The longest return period for the highest rainfall is 11 years. The long return periods for extreme rainfall, such as 11 years for 526 mm of rainfall, indicate that although rare, the risk of damage from this rainfall should be considered in disaster mitigation planning.

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