Analysis of Rainfall Distribution and Climate Classification in Response to Flood Events in Lebong Regency, Indonesia

Rospita Naomi Limbong[1], Anang Anwar[2], Septi Johan[1] & Lizalidiawati*[1]
[1]Physics Department, Universitas of Bengkulu, Indonesia
[2]Meteorology, Climatology, and Geophysical Agency, Bengkulu, Indonesia
*Corresponding Author: lizalidiawati@unib.ac.id

Received: 12th March 2024; **Accepted**: 9th May 2025; **Published**: 16th May 2025
DOI: https://dx.doi.org/10.29303/jpft.v11i1.8740

Abstract *- This study aims to analyze the distribution and time series of rainfall in Lebong Regency, using a case study of the flood event on April 16, 2024, and to analyze the condition of climate change in Lebong Regency from 2014 to 2024. This research uses daily rainfall data to examine flood events and monthly data over 11 years from 2014 to 2024 for climate classification analysis with 10 rainfall observation stations using the Schmidt-Ferguson method. The results of the data processing were analyzed using descriptive and quantitative methods. Based on the research results, it was found that the distribution of rainfall before, during, and after the flood event experienced a significant change. Before the incident, the lowest rainfall in Lebong Regency was recorded at the Bungin, Gunung Alam, Rimbo Pengadang, and Semelako Atas Stations with a value of 0 mm/day (no rain). Rainfall increased on the day of the flood in several sub-districts, with the highest recorded at the Lemeu Station in Uram Jaya sub-district, reaching 101 mm/day. Meanwhile, after the day of the flood, the rainfall was 12 mm/day. Meanwhile, the climate classification based on the Schmidt-Ferguson method shows that the rainfall in Lebong Regency falls into the wet to very wet climate category. The very wet climate category in Lebong Regency is represented by the Bungin station, with rainfall amounting to 1166 mm/month in January 2020. Based on the 11-year average data, the highest rainfall occurs in November, amounting to 537.58 mm/year. The study also contributes to understanding local flood risk based on long-term rainfall classification, which has rarely been explored in the Bengkulu region.*

Keywords*: Flood; Rainfall; Climate*

INTRODUCTION

Indonesia is one of the tropical countries affected by weather anomalies. Of the various natural disasters that hit Indonesia, 95% are caused by climate change which is affected by various natural phenomena such as floods caused by high rainfall (Ismail et al., 2020). Changes in rainfall in Indonesia have seen a significant increase both spatially and temporally, originating from convection processes and the formation of convective rain clouds (Pabalik et al., 2015). In general, the variability of rainfall in Indonesia is influenced by seasonal and inter-seasonal rainfall affected by ENSO and IOD. ENSO, often known as El Niño, is the rise in sea surface temperatures above normal in the eastern part of the Pacific Ocean, while La Niña is the decrease in sea surface temperatures in the equatorial part of the Pacific Ocean (Narulita, 2020). This causes extreme climate changes in Indonesia, leading to many environmental problems (Ariska et al., 2022).

Climate Change is a weather condition that usually lasts for a long time. This climate change significantly affects weather phenomena such as heavy rainfalls (Miftahuddin, 2016). One of the consequences of this climate change is the increase in high rainfall, which leads to prolonged floods or droughts, subsequently causing a significant decline in the economy due to the damage to air regulation systems, agricultural crops, and/or infrastructure (Nurlatifah et al., 2023). Floods are a type of natural disaster associated with significant material and life damage. Floods are usually caused by heavy rainfall, land surfaces that are lower than sea level, settlements built on floodplains along rivers or streams, and debris that obstructs river flow. Floods occur almost every year, yet the problem remains unresolved. The frequency, extent, depth, and duration of floods continue to be an increasingly serious problem (Nurdin & Dinda A.G, 2020).

Understanding the rainfall characteristics of a region can determine potential problems or disasters that will occur. Rainfall characteristics that show wet, humid and dry months will be useful for regional management and can make the most of rain and reduce its negative effects (Arham et al., 2015). It is important to use long-term climate data in weather analysis and interpretation to be able to predict when climate extremes will occur, what the scale of change will be, and the impacts they will have on a region. The purpose of analyzing the climate of an area is to show the potential climate resources of that location (Laimeheriwa et al., 2020).

Lebong Regency is one of the regencies in Bengkulu Province which has an area of approximately 1,665.28 km2 with a tropical climate that gets high rainfall, so Lebong has mineral-rich and fertile soil. Based on information from the agency in charge, it states that the Lebong Regency area consists of hills whose altitude ranges from five hundred to one thousand (500 - 1000) meters above sea level. The average monthly temperature in Lebong reaches 28.66°C (Marcellina et al., 2024).

Although there are many studies on flooding caused by rainfall, there is limited research that links long-term climate classification with real-time flooding events in small hilly areas such as Lebong. Therefore, this study aims to analyze rainfall data from 2014 to 2024 to determine the climatic conditions in Lebong Regency and analyze the spatial temporal rainfall in flash flood cases in Lebong Regency due to high rainfall so that the water intensity of Ketahun River, Kelempian River, and Rimbo Kedui River has increased.

RESEARCH METHODS

The location of this research was conducted at 10 station points in Lebong Regency, as shown in Figure 1.

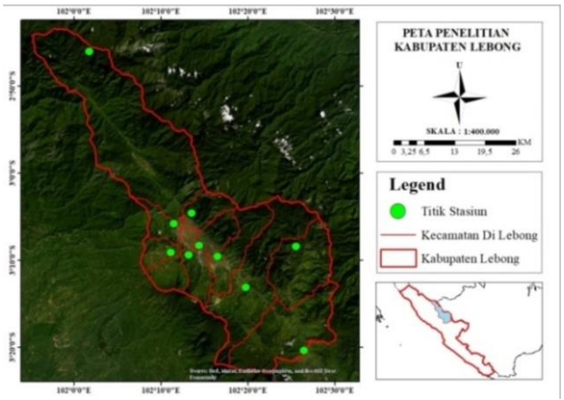


Figure 1. Location map and rainfall station points (green points) in Lebong Regency

Research Stages

The stages of the research conducted include data collection, mapping rainfall data using ArcGIS, and climate classification using the Schmidt-Ferguson method. The data needed consists of daily rainfall data obtained directly from the BMKG class 1 station in Bengkulu over a period of 11 years (2014-2024). Daily rainfall data is used to measure the highest rainfall intensity at each station during floods, and monthly rainfall data is used to determine its climate classification. The data analysis used is descriptive and quantitative analysis.

Schmidt-Ferguson Classification Method

The Schmidt-Ferguson classification has several climate categories: very wet, wet, somewhat wet, moderate, somewhat dry, dry, very dry, and extremely dry as shown in Table 1.

Table 1. Schmidt-Ferguson Climate Classification

Climate Type	Criteria	Explanation
A	0 < Q < 0.143	Extremely wet
B	0.143<Q< 0.333	Wet
C	0.333<Q< 0.600	Moderately wet
D	0.600<Q< 1.000	Moderate
E	1.000<Q< 1.670	Moderately dry
F	1.670<Q< 3.000	Dry
G	3.000<Q< 7.000	Very dry
H	7.000 < Q	Incredibly dry

Source : (Diah *et al*., 2023).

To find the Q value, you can use the following formula

$$Q = \frac{Average\ number\ BK}{Average\ number\ BB} \times 100\%$$

With Q being the Schmidt-Ferguson Coefficient, BK is a dry month, while BB is a wet month. Month criteria can be determined based on the following precipitation:

- Wet Month (WM): > 100 mm/month
- Wet Month (BL): 60 - 100 mm/month
- Dry Month (DM): < 60 mm/month

RESULTS AND DISCUSSION

Analysis of Rainfall Distribution and Time Series Related to the Flood Event on April 16, 2024

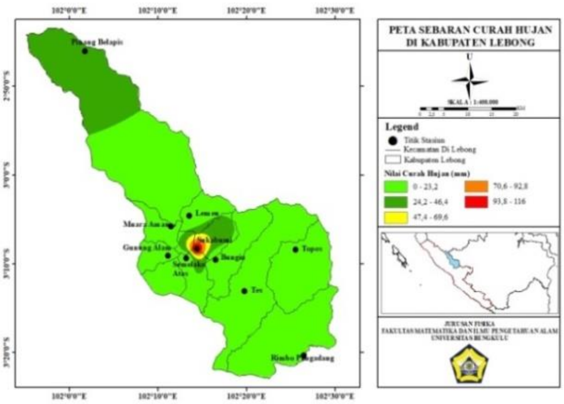
Rainfall intensity is the amount of rainwater that collects on a flat area without evaporation, absorption, or flow. It is measured in millimeters or inches, but in Indonesia, the commonly used unit is millimeters (mm) (Ajr & Dwirani, 2019). Whereas Flood is defined as water that inundates the land due to overflowing rivers, caused by heavy rain or flooding due to overflow of water from other higher areas (Findayani Aprilia, 2018).

The following is rainfall data for three consecutive days which can be viewed in Table 2.

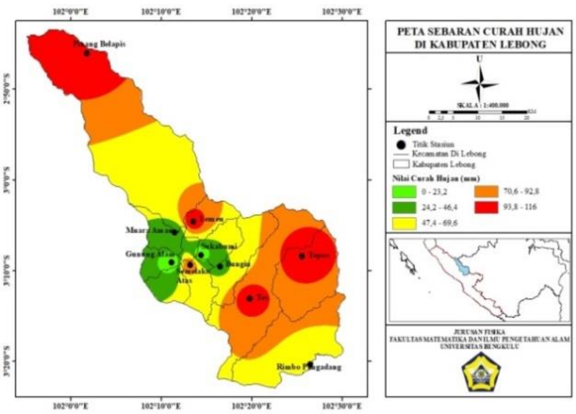
Table 2. Daily Rainfall Data

Station	15-Apr	16-Apr	17-Apr
Bungin	0	45	13
Gunung Alam	0	14	36
Lemeu	2	101	12
Muara Aman/Tungga	3	32	16
Pinang Belapis	20	96	34
Rimbo Pengadang	0	56	27
Simelako Atas	0	88	37
Sukabumi	60	13	45
Tes	2	95	23
Topos	5	96	23

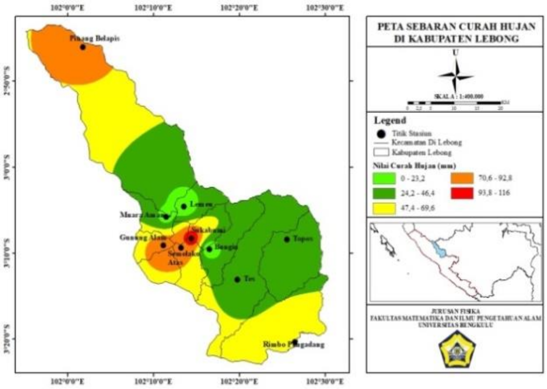
Table 2 above can see that the increases in rainfall experienced different increases, the highest rainfall occurred on 16 April 2024 where on that day there was a flood that caused rivers in Lebong District to overflow.



(a)



(b)



(c)

Figure 2. Map of Rainfall Distribution and Flood Occurrence in April 2024
(a) Before, (b) At the Moment, (c) After

Figure 2 above is the distribution of rainfall in the form of a map marked in red which describes areas that experience high rainfall ranging from values of 93.8 - 116 mm/day and light green color describes areas that experience very low rainfall or even no rain ranging from values 0 - 23.2 mm/day.

From the table, images and distribution map images above, it can be seen that Uram Jaya District, which was measured at the Lemeu station, experienced a fairly high increase. On April 15, 2024 before the flood event, the measured rainfall was 2 mm / day and increased on April 16, 2024 by 101 mm / day and rainfall decreased on the day after the event by 12 mm / day. Previously there has been no research on flood events in the area to be compared with the current research. However, there is information obtained by researchers from the BPBD in charge of reporting that the flood event on April 16, 2024 was said to be almost the same as the incident 29 years ago, in 1995. As a result of this flood event, several areas in Lebong Regency were flooded, such as Topos, Rimbo Pengadang, Bingin Kuning, Lebong Sakti, Uram Jaya, Amin, North Lebong. This flood event caused huge losses for local residents as seen in Table 3.

Table 3. List of Areas and Flood Damage on April 16, 2024

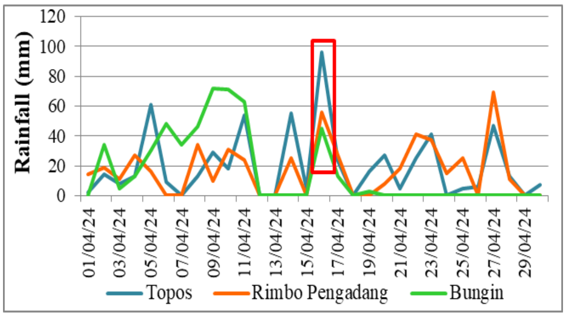
No	Category	Amount
1	People affected	2.712 people
2	Houses damaged	195 units
3	Suspension bridges damaged/broken	24 units
4	Roads damaged	-
5	Public facilities damaged	15 units
6	Business premises damaged	15 units
7	Agricultural areas damaged	Hundreds of hectares
8	Villages affected	29 villages
9	Sub-districts affected	7 sub-districts

Source : Antara, 2024 (https://www.antaranews.com/berita/4066917/bpbd-kabupaten-lebong-hitung- kerugian-akibat-banjir-bandang).

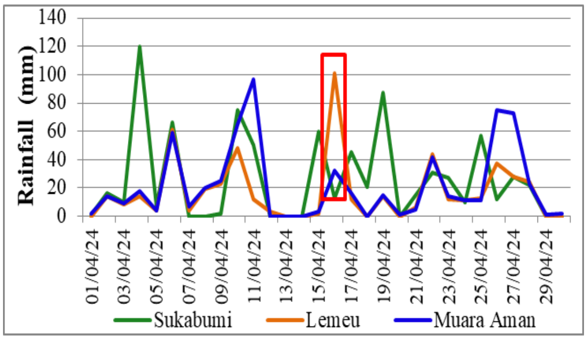
In an effort to reduce the damage caused by the above flood disasters, the participation of the government and the community is very important in prevention efforts. One of them is by carrying out disaster mitigation such as building and raising embankments to prevent river water from overflowing into settlements as well as providing flood-prone maps and building early warning systems.

The time series analysis of rainfall in the flood-affected area shows a significant increase in rainfall. It can be seen in Figures 3 (a) and (b).

In Figure 3 is a time series image of the rainfall height on the day of the event marked with a red box. In figure (a) it can be seen that the highest rainfall is at Topos station and figure (b) the highest rainfall is at Lemeu station. Overall, figures (a) and (b) have the highest rainfall at Lemeu Station around 101 mm/day.



(a)



(b)

Figure 3. Daily Rainfall Time Series in Lebong Regency (a) Topos, Rimbo Pengadang, and Bungin Stations; (b) Sukabumi, Lemeu, and Muara Aman Stations.

Analysis of Climate Classification Based on the Schmidt-Ferguson Method

The weather classification in Lebong Regency often changes according to changes in rainfall patterns. This affects the length of wet and dry months in the area. Based on observations of rainfall at each station, it is found that flooding events that have occurred in Lebong Regency are influenced by seasonal changes in rainfall in the area. Based on the Schmidt Ferguson classification, it is found that the Lebong Regency area has two types of climate, namely, very wet and wet. When viewed in the table below, it is found that the average number of dry months is mostly represented by Lemeu Station with a value of 19 dry months/11 years and the average number of wet months is represented by Rimbo Pengadang Station with a value of 123 wet months/11 years.

Table 4. The results of the division of climate types based on Schmidt- Ferguson at 10 rainfall stations in Lebong Regency from 2014 - 2024.

Stasiun	BK	BB	Q	Tipe Iklim
Bungin	8	117	0.0684	A
Gunung Alam	8	103	0.0777	A
Lemeu	19	102	0.1863	B
Muara Aman/Tungga	9	115	0.0783	A
Pinang Belapis	5	122	0.041	A
Rimbo Pengadang	5	123	0.0407	A
Semelako Atas	11	106	0.1038	A
Sukabumi	8	114	0.0702	A
Tes	6	120	0.05	A
Topos	15	106	0.1415	A

The value of Q obtained from the ratio of the number of Dry Months (BK) divided by the number of Wet Months (BB) (Pratama et al., 2023). Hasil analisis tipe iklim di Kabupaten Lebong, teridentifikasi memiliki dua (2) kriteria tipe iklimnya, yaitu sangat basah (A) hingga basah (B). Tipe A meliputi 9 Stasiun hujan yaitu: Bungin, Gunung Alam, Lemeu, Muara Aman, Pinang Belapis, Rimbo Pengadang, Semelako Atas, Sukabumi, dan Tes. Tipe B selanjutnya mencakup satu stasiun pengukuran curah hujan, yaitu: Stasiun Topos. Penurunan nilai Q mengindikasikan bahwa curah hujan di suatu daerah tinggi (lebih basah).

CONCLUSION

The research results indicate that the distribution of rainfall before, during, and after the flood event experienced a significant change. Before the incident, the rainfall in Lebong Regency was lowest at Bungin, Gunung Alam, Rimbo Pengadang, and Semelako Atas Stations with a value of 0 mm/day (no rain). Rainfall increased the following day, causing flooding in several sub-districts, namely, Lebong Sakti, Uram Jaya, Amen, Lebong Utara Topos, Rimbo Pengadang, Bingin Kuning. The highest rainfall measured at the Lemeu Station in Uram Jaya District reached 101 mm/day. Meanwhile, the climate classification based on Schmidt-Ferguson Lebong Regency falls into the category of wet to very wet climate. The very wet climate category in Lebong Regency is represented by the Bungin station, with rainfall in January 2020 amounting to 1166 mm/month. Based on the 11-year average data, the highest rainfall occurs in November, amounting to 537.58 mm/year.

ACKNOWLEDGMENT

The author expresses gratitude to the BMKG Bengkulu Climatology Station for providing invaluable data for this research. The data served as an important foundation in the preparation and analysis of this research. The author also expresses deep respect and gratitude to the supervising lecturer for the guidance, input, and support provided during the research process. The dedication and guidance provided were instrumental in enhancing the quality of this research. I hope the results of this research can benefit all parties in need.

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