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Evaluation of Periodic Rainfall Data on the Potential for Recurring Flood Disasters in Padang City

Vrielsha Bana[1], Nofi Yendri Sudiar[1*], Harman Amir[1], Fadhila Ulfa Jhora[1]

[1] *Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
Corresponding author. Email: vrielsha@gmail.com

ABSTRACT

This study examines the characteristics of periodic rainfall and its relationship with flood occurrence in Padang City, Indonesia, during the period 2014–2023. A quantitative approach was employed, incorporating descriptive, spatial, and statistical analyses. Rainfall data were obtained from the Water Resources Management Agency (PSDA) and the Meteorological, Climatological, and Geophysical Agency (BMKG), while flood event data were sourced from the Regional Disaster Management Agency (BPBD) of West Sumatra Province.The results indicate a moderate positive correlation between rainfall intensity and flood frequency ($r = 0.619$). However, the relationship is not statistically significant ($p > 0.05$), suggesting that rainfall alone does not fully explain the occurrence of flood events. Additional factors, including topography, land use patterns, and drainage system capacity, play a substantial role in influencing flood dynamics.Spatial analysis further reveals that areas with high rainfall intensity do not always correspond to high flood frequency, highlighting the importance of non-climatic factors in flood risk assessment. These findings provide valuable insights for improving flood mitigation strategies and enhancing urban resilience in Padang City.

Keywords : Periodic rainfall; Flood occurrence; Spatial analysis; Padang City; Disaster mitigation.

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I. INTRODUCTION

Flooding is one of the most frequent natural disasters in Indonesia and has shown a significant increase in recent years. This trend is driven by multiple factors, including climate change, rapid urbanization, and insufficient water resource management systems.

Padang City, located on the western coast of Sumatra, is particularly vulnerable to flooding due to its geographical and hydrological characteristics. The city experiences high rainfall intensity, features low-lying areas, and is intersected by several major rivers, including the Batang Arau, Batang Kuranji, and Batang Anai. These conditions collectively increase the likelihood of flood events, particularly during the rainy season.

According to official data, Padang City covers an area of approximately 694.96 km² and has a population of around 900,000 inhabitants. The combination of high rainfall and uneven spatial distribution often results in water accumulation and flooding, especially in densely populated areas with inadequate drainage infrastructure.

Periodic rainfall refers to recurring rainfall patterns over a specific time interval, influenced by large-scale climatic factors such as monsoon circulation, solar position, and ocean–atmosphere interactions. Understanding these patterns is essential for evaluating flood risk and supporting effective disaster mitigation planning.

This study aims to (1) identify the characteristics of periodic rainfall in Padang City and (2) analyze its relationship with the frequency of flood events.

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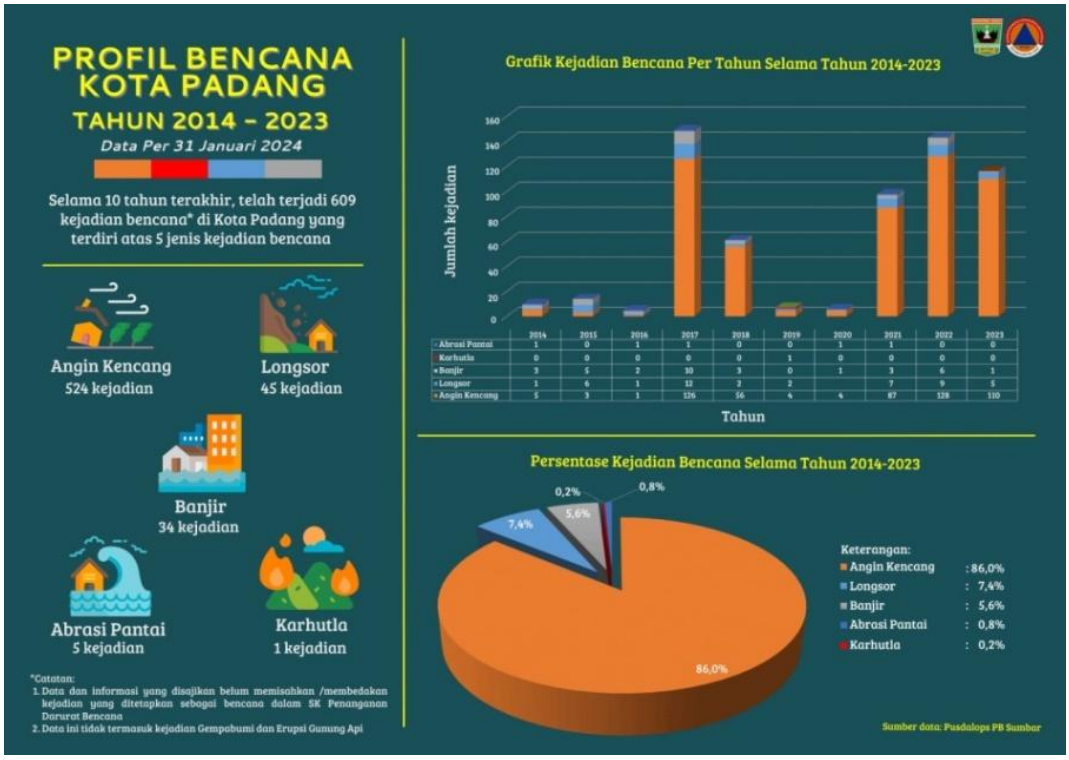
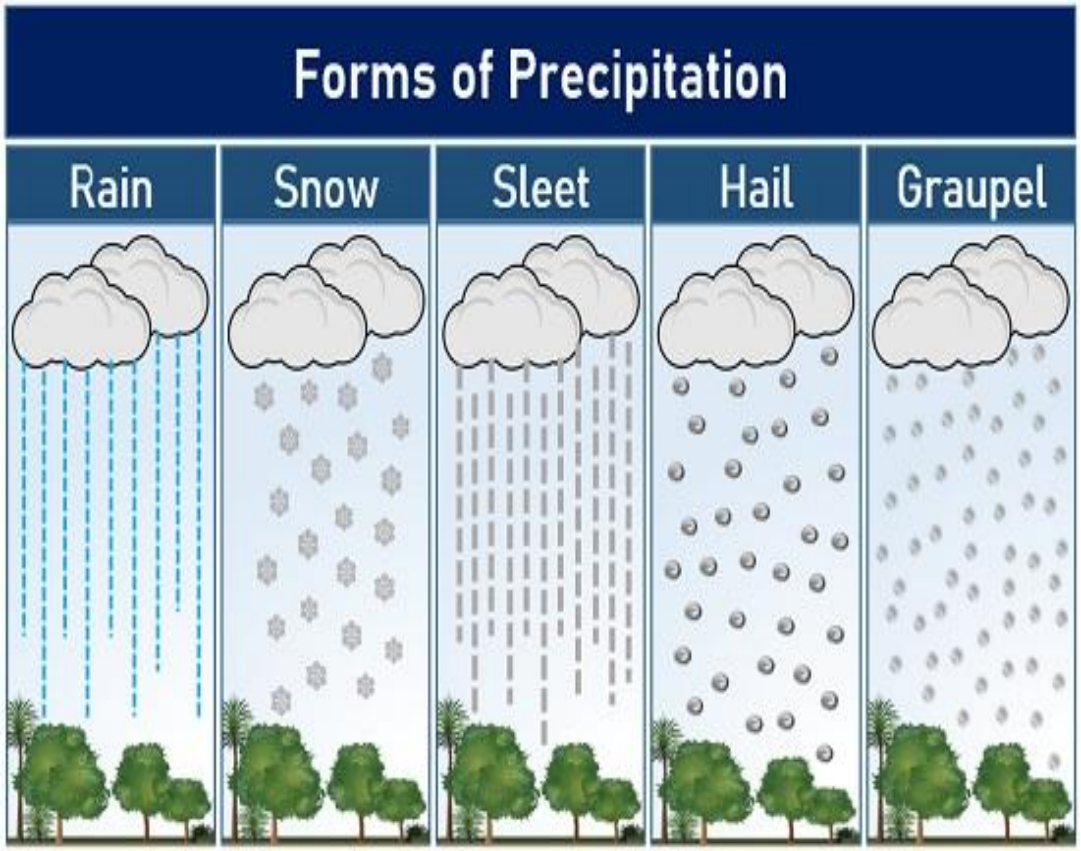


Ilustrating 1. Padang City Disaster Diagram BPBD Prov. WEST SUMATRA



Ilustrating 2. Types of Rain Illustrations

II. METHOD

2.1 Study Area and Data Sources

This study was conducted in Padang City, Indonesia, using data collected over a 10-year period (2014–2023). Rainfall data were obtained from PSDA and BMKG observation stations, while flood occurrence data were collected from BPBD West Sumatra.

2.2 Data Analysis

A quantitative approach was employed, consisting of :

- **Descriptive analysis** to characterize rainfall patterns
- **Spatial analysis** using ArcGIS to map rainfall distribution and flood occurrences
- **Statistical analysis** using Pearson correlation to examine the relationship between rainfall and flood frequency

2.3 Isohyet Method

The isohyet method was used to estimate spatial rainfall distribution. This method involves drawing contour lines connecting points with equal rainfall values to calculate the average rainfall over a given area.

Formula using the Isohyet Method:

$$P = (\sum(Pi \times Ai)) / A$$

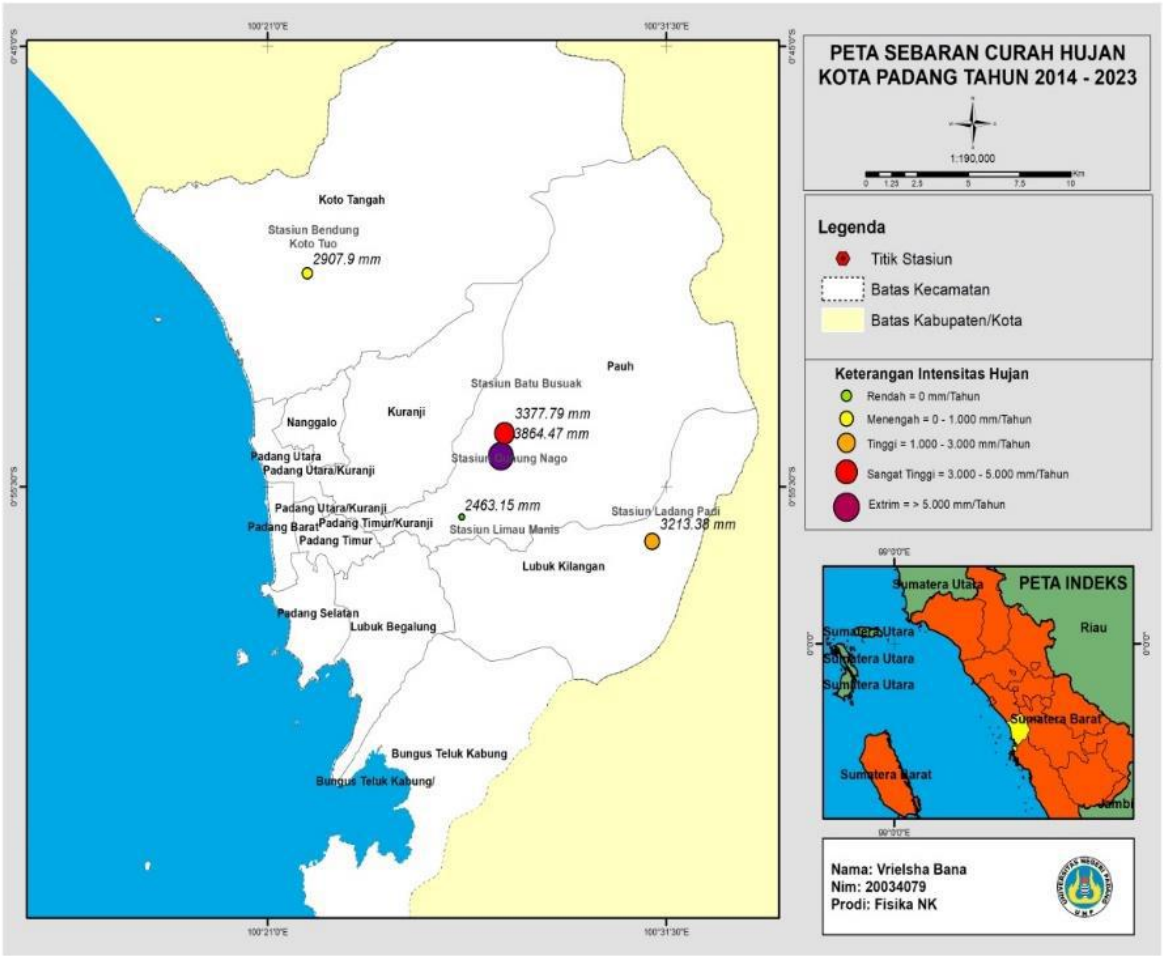
Where:
P = Average rainfall (mm/year)
Pi = Rainfall in each area (mm)
Ai = Area between isohyets (km^2)
A = Total area (km^2)

III. RESULTS AND DISCUSSION

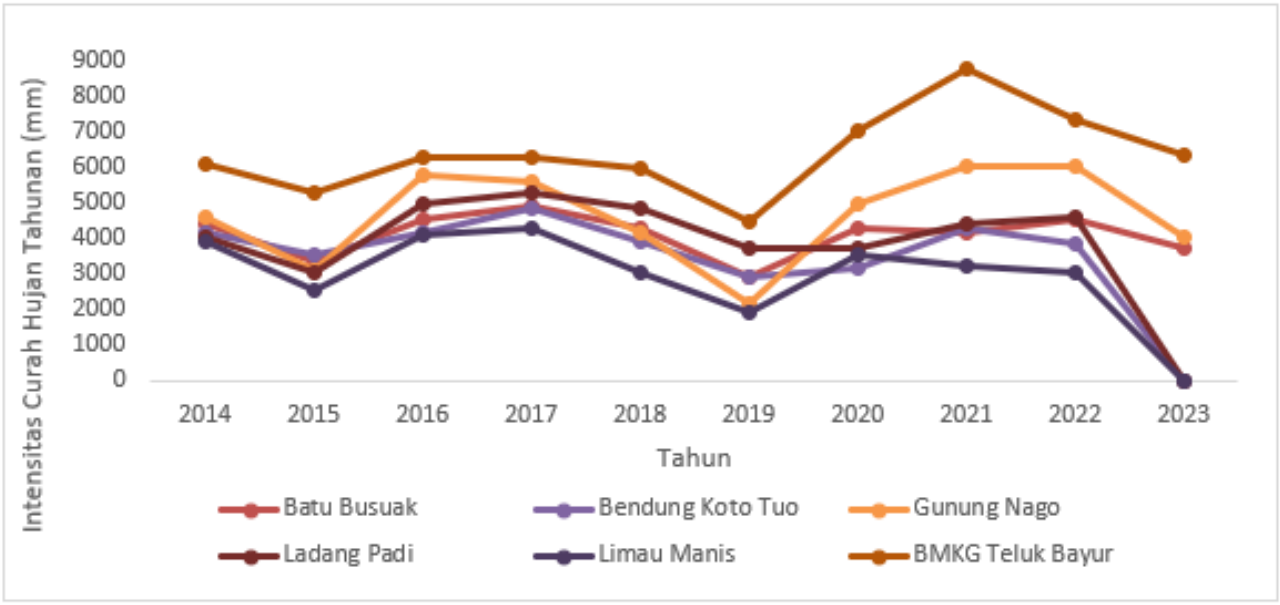
3.1 Rainfall Characteristics

Table 1. Annual Rainfall Intensity in Padang City (PSDA and BMKG TELUK BAYUR) Period 2014 – 2023

Rainfall Intensity of Rain Stations in Padang City (PSDA and BMKG TELUK BAYUR) Year 2014 - 2023 in Padang City												
No	Station Name	2014 (mm)	2015 (mm)	2016 (mm)	2017 (mm)	2018 (mm)	2019 (mm)	2020 (mm)	2021 (mm)	2022 (mm)	2023 (mm)	average
1	Batu Busuak	4400	3349	4549	4872	4282	2906	4306	4169	4536	3746	3426.25
2	Bendung Koto Tuo	4178	3506	4157	4847	3891	2879	3176	4254	3856	-	2895.33
3	Gunung Nago	4560	3078	5767	5604	4181	2144	4967	6003	6044	4026	3864.5
4	Ladang Padi	4042	3039	4951	5279	4862	3688	3739	4376	4585	-	3213.41
5	Limau Manis	3918	2541	4104	4290	3045	1915	3499	3208	3038	-	2463.16
6	BMKG Teluk Bayur	6057	5288	6281.2	6249	5946	4456	7045	8757	7354	6302	43550.2



Ilustrating. 3. Spatial distribution of rainfall in Padang City during 2014–2023, illustrating variation across observation stations.



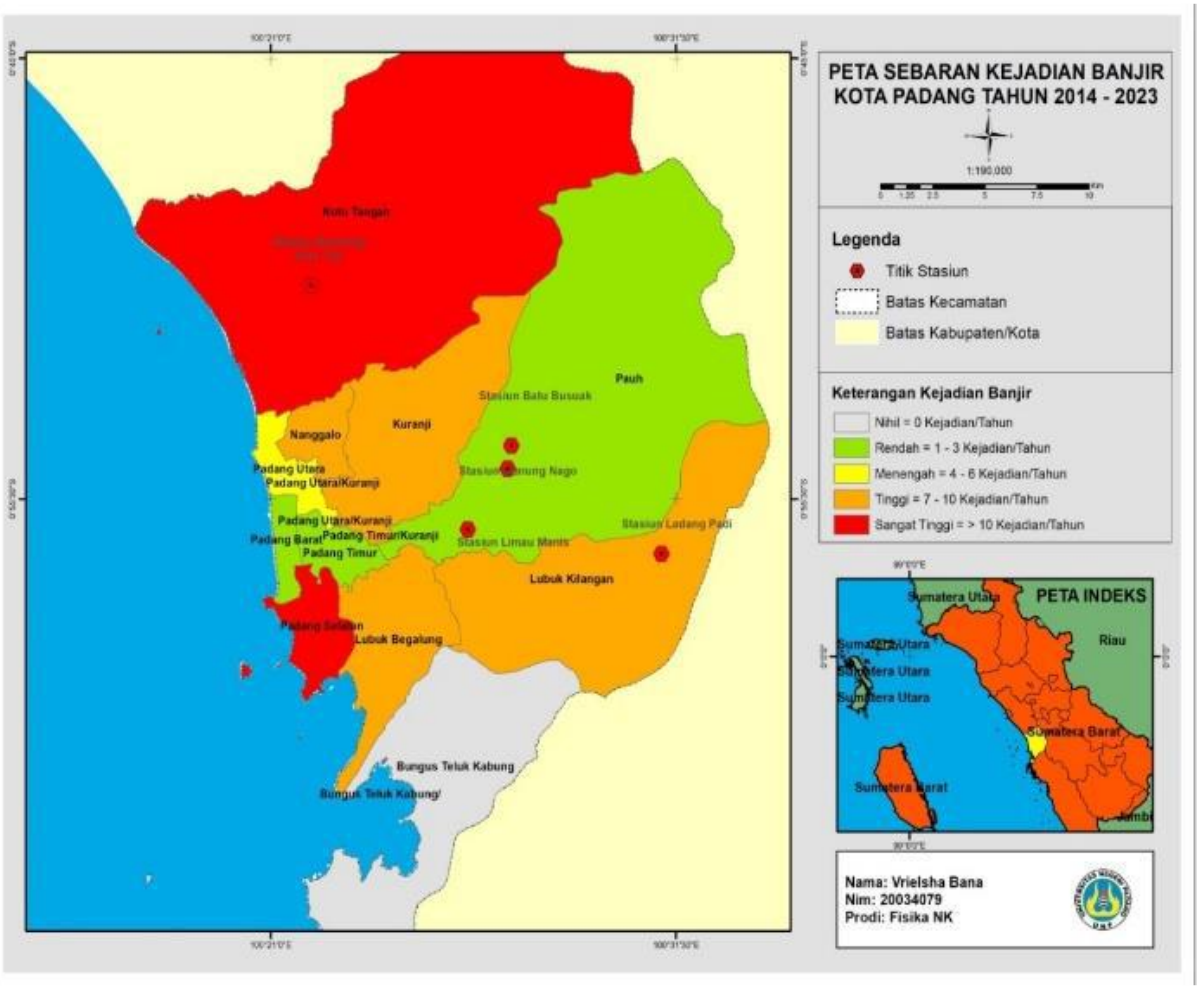
Ilustrating. 4. Annual Rainfall Intensity Graph (PSDA and BMKG TELUK BAYUR) in Padang City for the Period 2014 – 2023

The analysis shows considerable variation in rainfall intensity across observation stations. The BMKG Teluk Bayur station consistently records the highest rainfall, whereas the Limau Manis station exhibits the lowest values. These variations indicate the influence of geographical factors such as elevation, proximity to the coastline, and local climatic conditions.

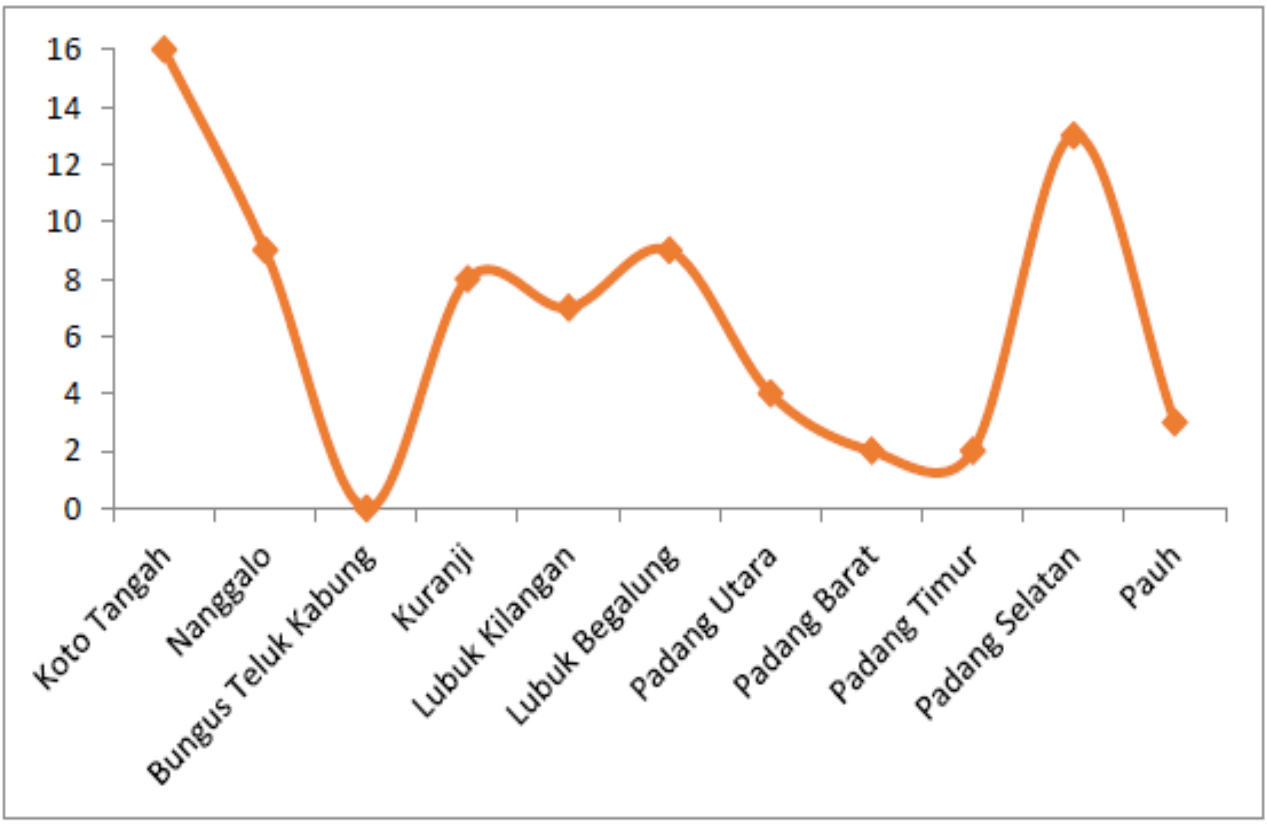
3.2 Flood Occurrence Distribution

Table 2. Number of Flood Frequency Events in Padang Padang City for the Period 2014 – 2023

Number of Flood Frequency Events in Padang City											
Area	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Amount
Koto Tangah	1	1	4	0	0	0	0	8	2	0	16
Nanggalo	2	1	2	0	0	0	1	1	1	1	9
Bungus Teluk Kabung	0	0	0	0	0	0	0	0	0	0	0
Kuranji	0	0	3	2	0	0	0	2	1	0	8
Lubuk Kilangan	0	1	2	2	0	0	0	1	1	0	7
Lubuk Begalung	0	5	0	1	0	0	0	2	1	0	9
Padang Utara	0	0	0	2	0	0	1	1	0	0	4
Padang Barat	0	0	0	2	0	0	0	0	0	0	2
Padang Timur	0	0	0	1	0	0	0	1	0	0	2
Padang Selatan	0	2	2	7	0	0	1	1	0	0	13
Pauh	0	1	0	0	0	0	1	0	0	1	3
Total	3	11	13	17	0	0	4	17	6	2	73



Ilustrating. 5. Flood Map from BPBD Prov. WEST SUMATRA



Ilustrating. 6. Graph of the Number of Flood Frequency Events in Padang City for the Period 2014 – 2023

Flood events are unevenly distributed across Padang City. The highest frequency of flood occurrences is observed in Koto Tangah District, which is characterized by low elevation and proximity to major river systems. In contrast, Bungus Teluk Kabung experiences relatively few flood events.

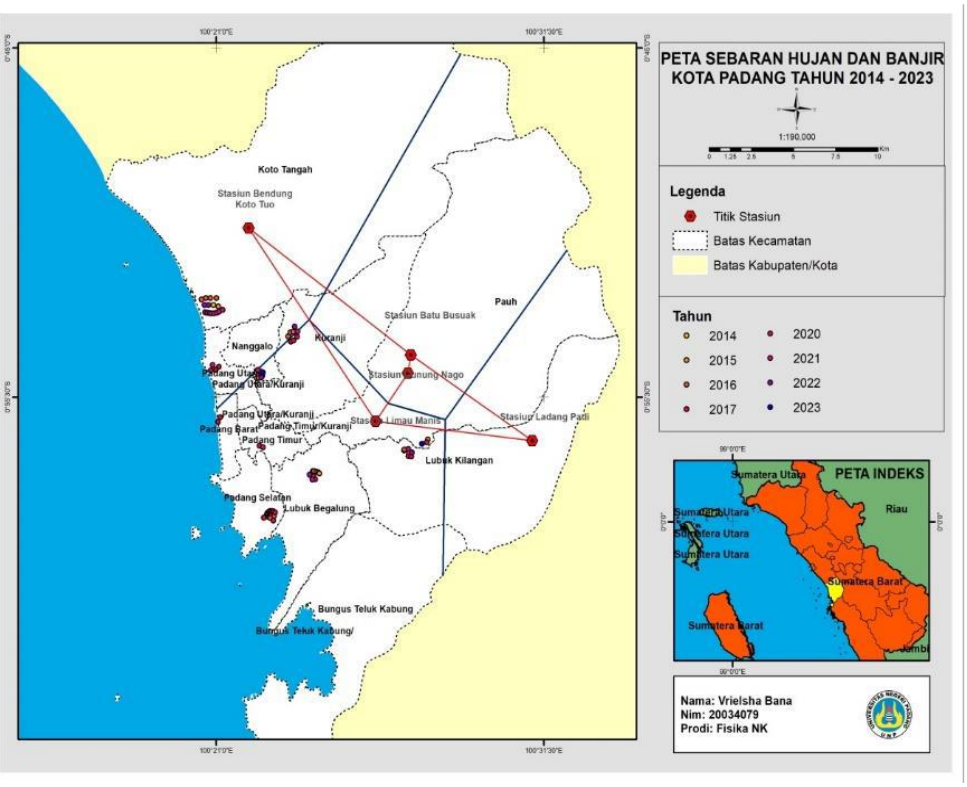
3.3 Relationship Between Rainfall and Flooding

These results indicate that flood occurrence is influenced by several factors, including drainage system capacity, land use changes, and topographical conditions ($r = 0.619$). However, this relationship is not statistically significant ($p > 0.05$), suggesting that rainfall alone is insufficient to explain the occurrence of floods.

This finding implies that additional factors play a critical role, including:

- Drainage system capacity
- Land use changes and urban development
- Topographical conditions

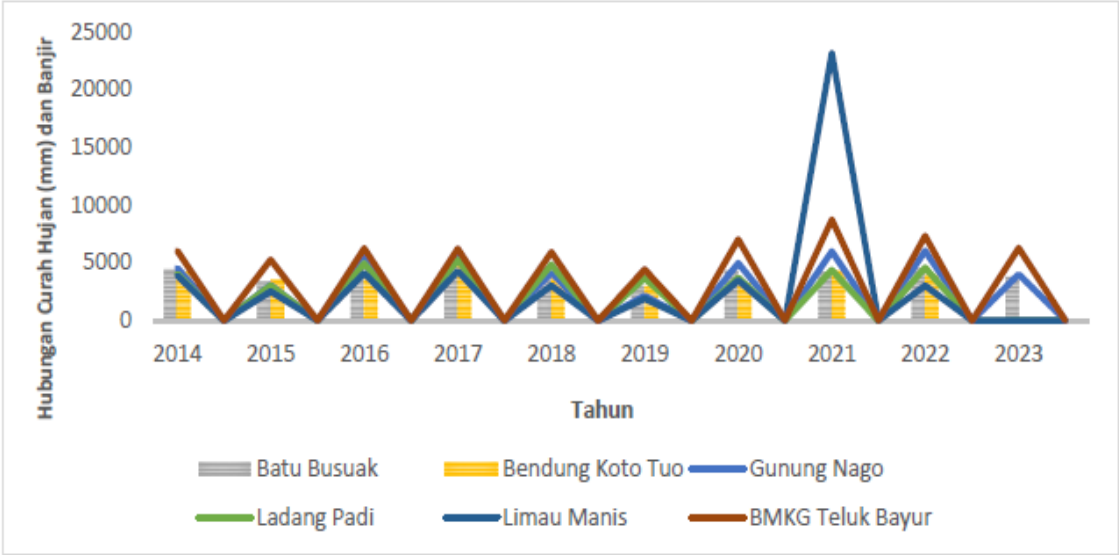
3.4 Spatial Analysis



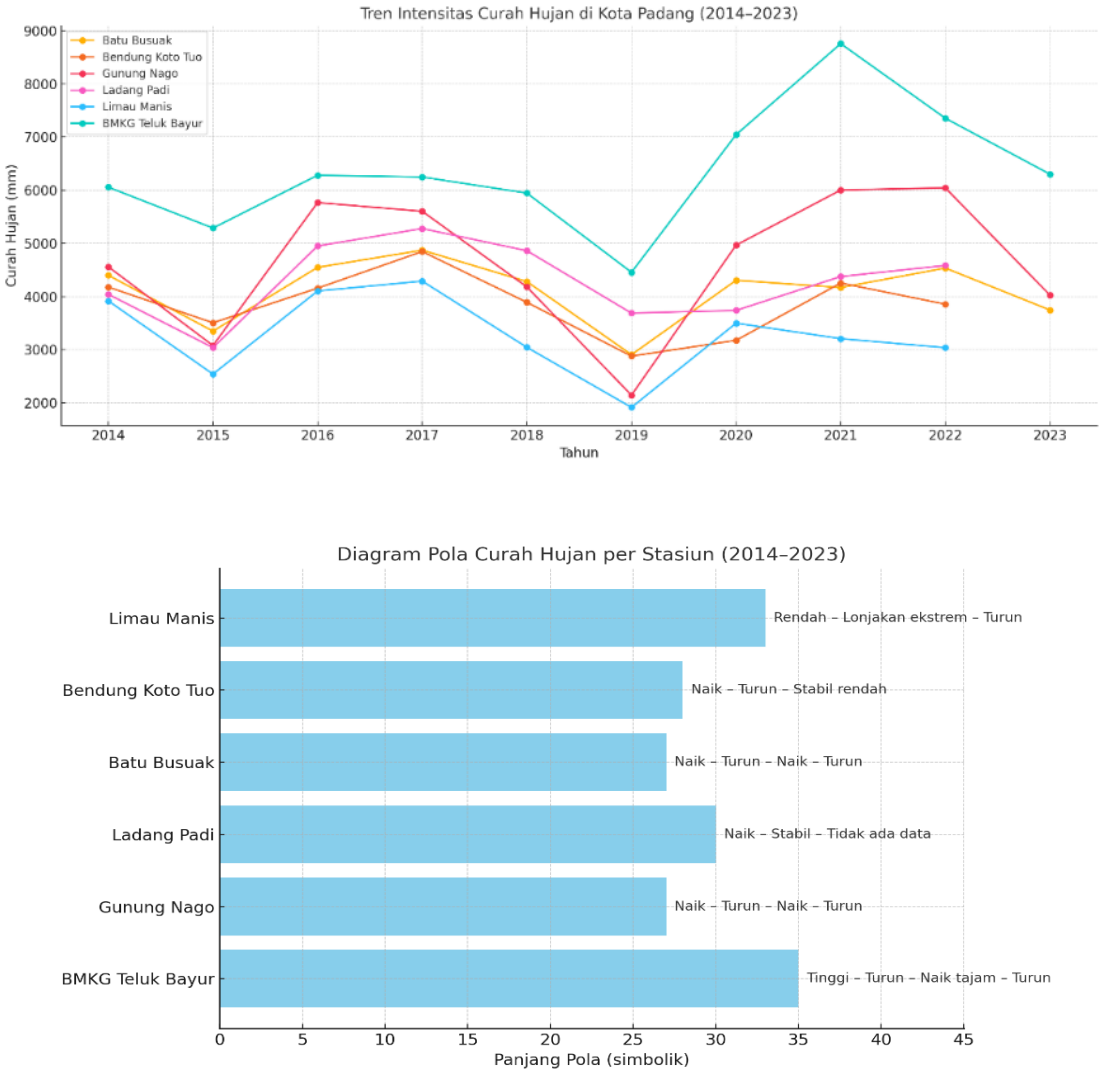
Ilustrating. 7. Combined Map of Rainfall and Flood Distribution of Padang City 2014 – 2023 using the Isohyet Method

Spatial overlay analysis reveals that areas with high rainfall intensity do not always correspond to areas with high flood frequency. This discrepancy highlights the importance of non-climatic factors in influencing flood risk.

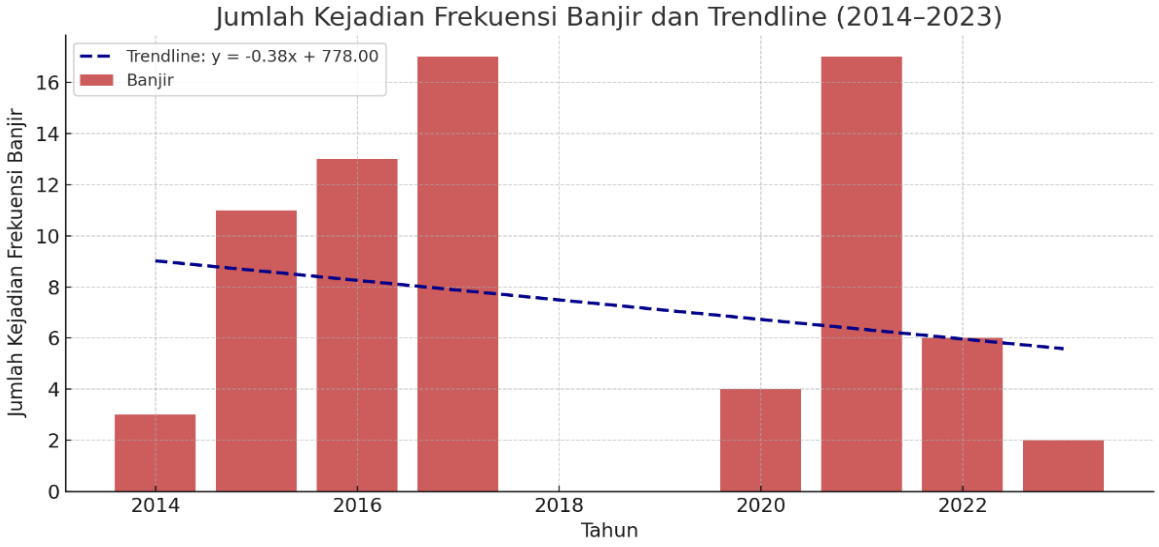
3.5 Temporal Trends



Ilustrating. 8. Graph of Rainfall and Flood Relationship Patterns in Padang City for the 2014-2023 Period



Ilustrating. 9. Annual Rainfall Patterns and Trends of PSDA and BMKG Teluk Bayur in Padang City for the 2014-2023 Period



Ilustrating. 10. Trend of the Number of Flood Occurrences in Padang City for the 2014-2023 Period

Flood occurrences exhibit a fluctuating pattern over time, with peaks observed in 2017 and 2021. This variability may be associated with climatic fluctuations as well as changes in local flood management practices.

IV. CONCLUSION

This study demonstrates that rainfall in Padang City exhibits fluctuating patterns over the period 2014–2023. While there is a moderate positive relationship between rainfall and flood occurrence, the relationship is not statistically significant.

These findings indicate that flood events are influenced by multiple interacting factors beyond rainfall, including topography, land use, and drainage infrastructure. Therefore, effective flood mitigation strategies should adopt an integrated approach that considers both climatic and non-climatic factors.

These findings highlight the importance of integrating climatic and non-climatic factors in flood risk management.

These findings reinforce the importance of integrating both climatic and non-climatic factors in flood risk management strategies.

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