ISSN: 2754-4982

Journal of Civil Engineering Research & Technology

SCIENTIFIC Research and Community

Review Article

Open Access

Analysis of Risk Level Mapping of Flash Flood in the Air Betung Sub-Watershed, Pagar Alam City, Indonesia

Achmad Syarifudin[1]* and Henggar Risa Destania[2]

[1]Department of Civil Engineering, Universitas Bina Darma, Indonesia

[2]Department of Civil Engineering, Indo Global Mandiri University, Indonesia

ABSTRACT

This research aimed to obtain a map of flood and inundation distribution in the Air Betung Sub-watershed of Pagar Alam City at an altitude of 200-1500 meters above sea level. Moreover, the city consists of mountainous and hilly areas, wavy and steep relief, forest areas, and plantations, including settlements and sub-watershed (DAS), characterized by an average annual rainfall of 234.50 mm, with air temperature between 140C-350C. Based on Indonesian Disaster Information Data (DIBI) from National Disaster Management Agency (BNPB) from 2014 to 2019, the Air Betung Sub-watershed has experienced 5 flash flood disasters. These incidents resulted in damage to 1 house unit, irrigation channels ± 50 m, retaining walls ± 25 m, and ± 30 hectares of agricultural land damaged. The method used in this research included Risk Index Mapping to determine the level of flash flood risk by analyzing hazard, vulnerability, and capacity indices. The hazard index was analyzed using Flash Flood Potential Index (FFPI) method, while the vulnerability and capacity indices were evaluated through equations in accordance with Perka BNPP No. 2 of 2012, as processed in the Arc-GIS version 10.4 program. Generally, risk index map research was classified into three classes, namely low, moderate, and high. The results showed that the Pagar Alam Selatan Sub-district had a high index value compared to others in the Air Betung Sub-watershed, Pagar Alam City.

***Corresponding author**

Achmad Syarifudin, Department of Civil Engineering, Universitas Bina Darma, Indonesia.

Received: January 12, 2024; **Accepted:** January 22, 2024; **Published:** January 29, 2024

Keywords: Risk Level Mapping, Flash Flood, The Air Betung Sub-Watershed

Introduction

Pagar Alam City, located in South Sumatra, is a disaster-prone area, covering 633.7 km^2 and divided into 5, consisting of 35 sub-districts. Geographically, Pagar Alam City is located at 4° South Latitude (SL) and 103.15° East Longitude (EL). The city is also characterized by hilly area with an altitude of 200-1500 meters above sea level, consisting of mountains, wavy and steep relief, forest, plantations, settlements, and river watersheds [1].

The climatic conditions in Pagar Alam City show an average annual rainfall of 234.50 mm, with air temperature ranging from 140°C to 350°C. Based on Indonesian Disaster Information Data (DIBI) from National Disaster Management Agency (BNPB) from 2014 to 2019, the Air Betung Sub-watershed has experienced 5 flash flood disasters. These incidents resulted in damage to 1 house unit, irrigation channels ± 50 m, retaining walls ± 25 m of land, and ± 30 ha of agricultural land [2].

Watershed is a catchment area for rainwater flowing into the respective river. Furthermore, it functions to accommodate, store, and naturally channel water from rainfall to lakes or the sea. In this context, land boundary is a topographical divider, where several boundaries at sea extend to water areas influenced by land activities [3]. Based on these conditions, Pagar Alam has the potential for a flash flood disaster, as shown by DIBI (Indonesian Disaster Information Data) data for the last 10 years. The recent advances in information technology have been proven effective in mapping disaster-prone areas and community capacity using Geographic Information System (GIS). Moreover, GIS can be applied to obtain, store, analyze, and manage spatial data [4].

Disasters are a series of events that threaten and disrupt lives and livelihoods caused by both natural and human factors. These incidents often lead to human casualties, environmental damage, property loss, and psychological impacts [4].

Flash Flood Potential Index (FFPI) method was designed by Greg Smith and the team at Coraldo Basin River Forecast Center (CBRFC) [5]. FFPI was created to complement existing conventional methods for detecting flash flood, such as Flash Flood Monitoring and Prediction System (FFMPS) [6]. Furthermore, it emphasizes the analysis of physiographic factors that answer the causes of flash flood.

Vulnerability is the disruption of environmental condition, community, structure, and service resulting from the impact of certain hazards, resulting in losses. The level of vulnerability is divided into social, economic, physical, and ecological/environmental. Meanwhile, capacity is the ability of areas and community to develop structured, planned, and integrated strategies for reducing threats and potential losses due to disasters [7].

Make sure to format your manuscript in double space format, use 12-point Times New Roman font, and insert line number.

Theory and Formula

Experimental Setup

This research was conducted in the Air Betung Sub-watershed, Pagar Alam City, consisting of 5 sub-districts, namely Pagar Alam Selatan, Pagar Alam Utara, Dempo Tengah, Pajar Bulan, and Sukamerindu Sub-districts [8].

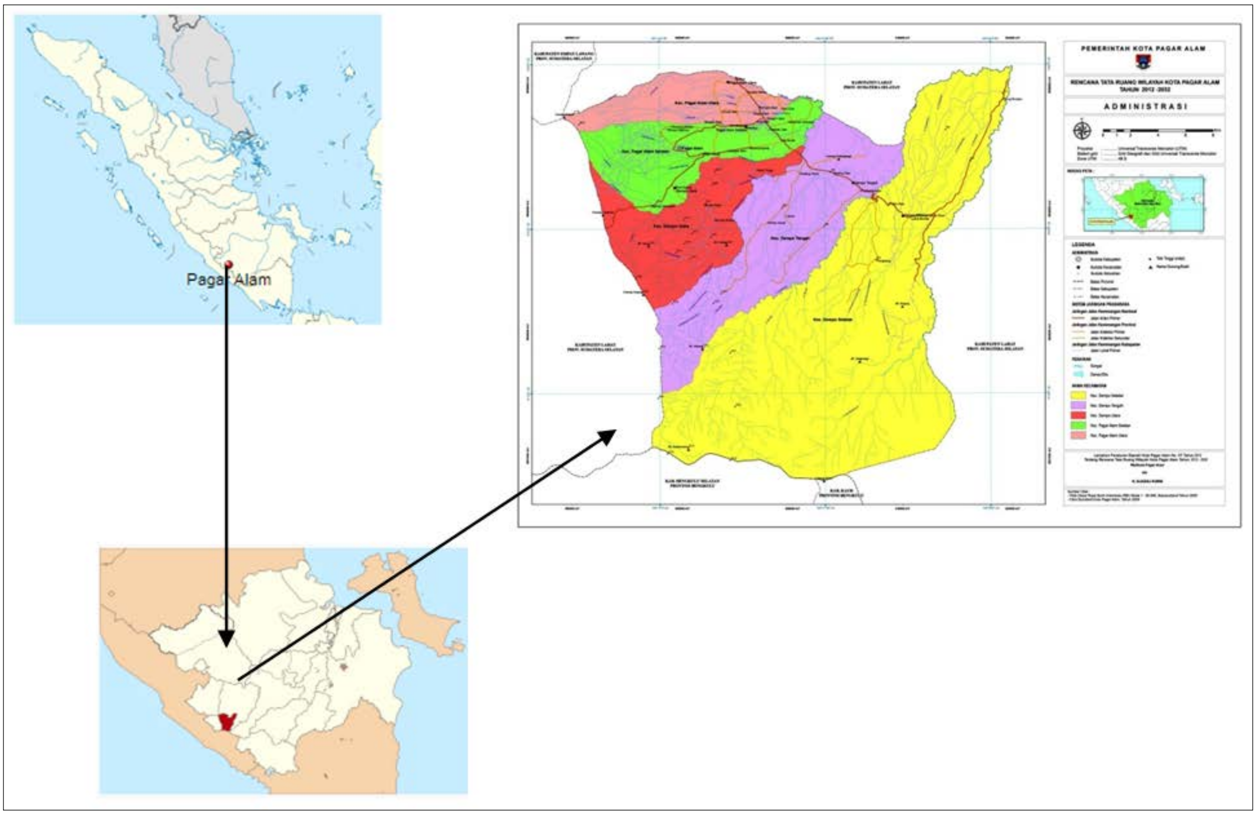


Figure 1: Map of Pagar Alam City

Data Collection Sources and Methods

Table 1: Data Requirement

Data type	Source	Year
Flash Flood Disaster Event	DIBI and BPBD	Until 2020
Population and Statistic Facility	BPS of Pagar Alam City	Until 2020
Base of Map	PUPR of Pagar Alam City	2020
Supporting Information Data	Sub-district of Pagar Alam	2020

Data Analysis Method

The analysis methods included in this research were:

1. Analyzing flash flood hazard in the Air Betung Sub-watershed in Pagar Alam City, using FFPI method.
2. Raster data processing.
3. Overlay flash flood hazard map for the Air Betung Sub-watershed using Arc-GIS 10.4 software to obtain a hazard map.
4. Analyze vulnerability index maps.
5. Analyze capacity index.
6. The final stage is to combine the maps of hazard, vulnerability, and capacity indices to obtain a flash flood potential map.
   Risk = Threat x (Vulnerability)/(Capacity) (1)
7. Overlay of flash flood risk map for the Air Betung Sub-watershed Arc-GIS software vers. 10.4 to obtain a risk map.

Result Discussions

Flash Flood Hazard Index Analysis

Flash flood hazard in the Air Betung Sub-watershed was determined based on slope, land use, soil texture, and canopy cover data. Scoring was carried out to assign scores to each class for individual disaster parameters.

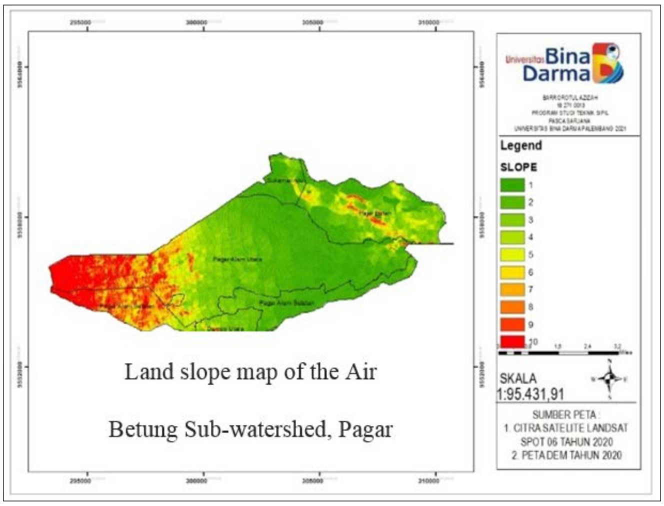


Figure 2: Land Slope Map

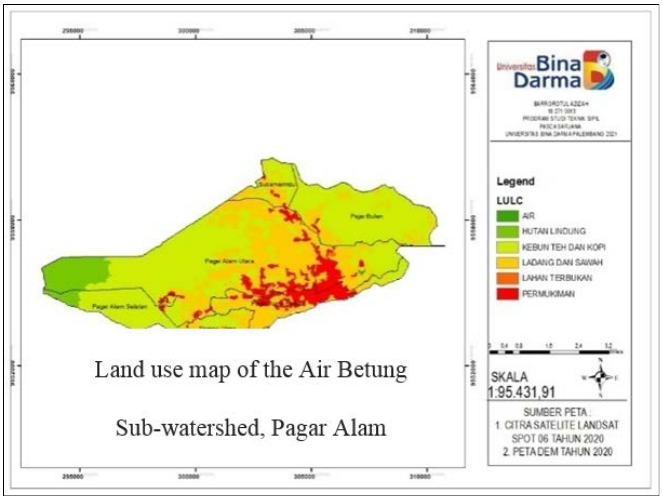


Figure 3: Land use Map

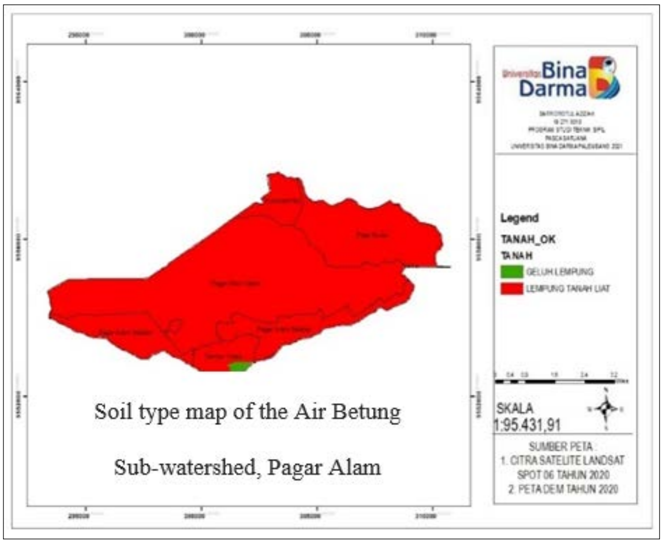


Figure 4: Soil type map

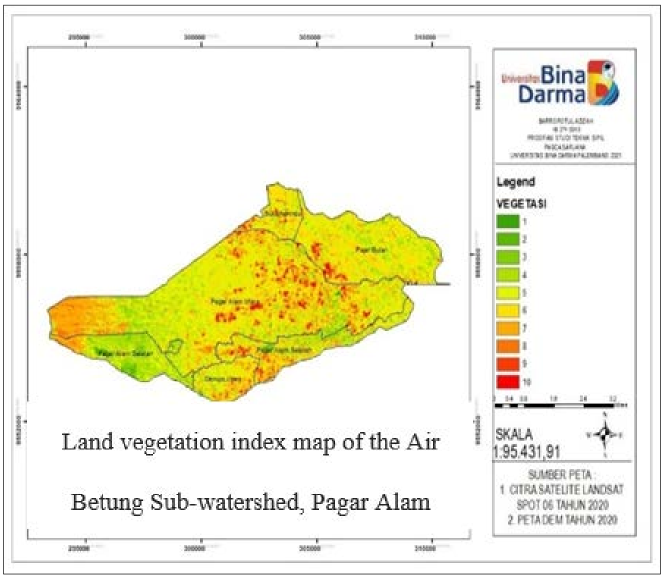


Figure 5: Canopy cover map

Areas prone to flash flood disasters in the Air Betung Sub-watershed were determined using FFPI is processed based on raster image processing (Raster Image Processing). The index values for each parameter were combined to calculate the average index.

FFPI =(M+L+S+V)/N (2)

Where:

M = Slope Slope

L = Land Use

S = Soil Texture

V = Land cover (Canopy)

N = Number of weightings

Based on Figure 6, the highest and lowest flash flood hazard index value is in Pagar Alam Selatan and Pajar Bulan, respectively.

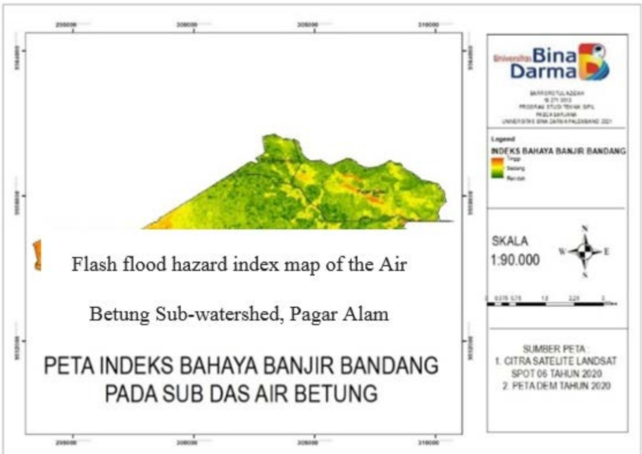


Figure 6: Flash Flood Hazard Index Map

Vulnerability Analysis

The total vulnerability index for flash flood disasters was calculated through the addition of several parameters, including the social (40%), economic (25%), physical (25%), and environmental (10%), as shown in Equation 1. The sum of the four vulnerability parameters is presented in the table below.

No	Sub-District	Social (40%)	Economic (25%)	Physic (25%)	Environment (10%)	Flash Flood Hazard Index	Class of Index
1	Pajar Bulan	0.431	0.468	1	0	0.53472	Moderate
2	Sukamerindu	0.431	0.468	0.901	0	0.50997	Moderate
3	Pagar Alam Utara	0.635	0.468	1	1.7	0.78632	High
4	Pagar Alam Selatan	0.635	0.468	1	1.7	0.78632	High
5	Dempo Utara	0.431	0.468	1	0	0.53472	Moderate

For greater clarity, the level of flash flood vulnerability is presented in the form of a map as follows:

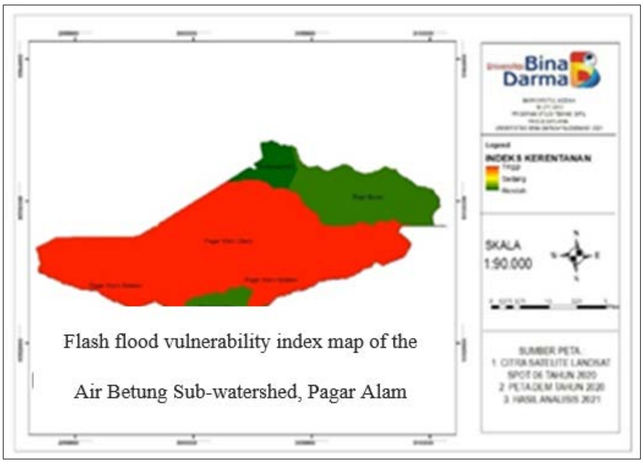
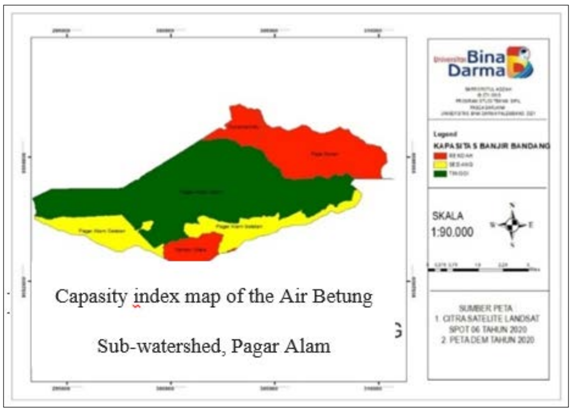


Figure 7: Vulnerability index map

Community Capacity Index Analysis

Each indicator was added to determine Community Capacity Index for addressing flash flood disasters at sub-district level. Based on the calculation results of the questionnaire assessment and capacity index class, Pagar Alam Utara, Pajar Bulan Dempo Utara, and Sukamerindu were at the highest level.



Flash Flood Risk Analysis

Flash flood risk index was analyzed based on the results of the hazard, vulnerability, and capacity indices using Equation 1. The risk index results were classified into three classes, namely medium, and high, as shown in Fig. 8. Pagar Alam Selatan is an area with a high risk of flash flood, while Sukamerindu has the lowest risk [9-17].

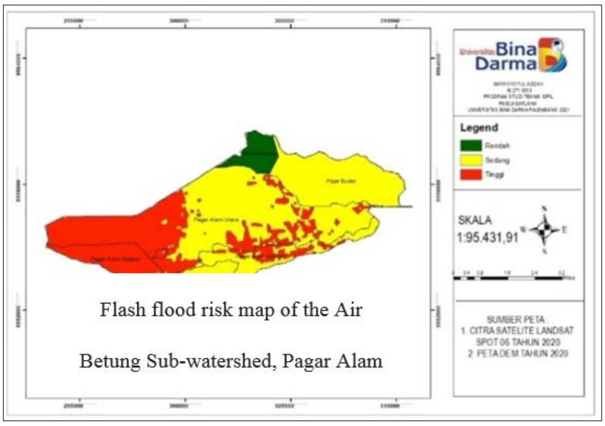


Figure 8: Flash flood risk map

Conclusion

In conclusion, this research successfully used FFPI method to assess flash flood hazard index.

1. The results showed that Pagar Alam Selatan was characterized by a high level of hazard, while Pajar Bulan was found in the low category.
2. The vulnerability index using the equation of Perkan BNPB No. 02 of 2012, showed that Pagar Alam Utara and Pagar Alam Selatan were in the moderate category with an index value of 0.7. Furthermore, three sub-districts were found in the moderate class, namely Pajar Bulan, Sukamerindu, and Dempo Utara, with an index value of 0.53.
3. The results of the capacity index showed that Pagar Alam Utara, Pajar Bulan Dempo UtaraUtara, and Sukamerindu were at the highest level. Flash flood risk index in the Air Betung Sub-watershed showed that Pagar Alam Selatan had a high risk, while Sukamerindu showed lower risk.

References

1. BPS-Statistics of Pagar Alam Manicipelity (2023) Pagar Alam Municipelity in Figues 2023.
2. DIBI (Data Informasi Bencana Indonesia) https://dibi.bnpb.go.id/.
3. Syarifudin A, Satyanaga A, Destania HR (2022) Application of the HEC-RAS Program in the Simulation of the Streamflow Hydrograph for Air Lakitan Watershed, Water (Switzerland) 14: 4094.
4. Elza Dewi, Alharia Dinata (2018) Analisis Perubahan Tata guna Lahan terhadap Debit Limpasan pada Sub-DAS Air Betung 5.
5. Jeff Lukas, Stephanie McAfee, Andy Wood, Connie Woodhouse, Ben Harding, et al. (2020) Colorado River Basin Climate and Hydrology, State of the Science, Chapter 8.
6. Stephan B Smith, Thomas Filiaggi M (2023) Flash Flood Monitoring and Prediction in Awips build 5 and Beyond, Meteorological Development Laboratory, NOAA'S National Weather Services.
7. Badan Nasional Penanggulangan Bencana (BNPB) (2012) Peraturan Kepala Badan Nasional Penanggulangan Bencana Nomor. 02 tahun 2012, tentang Pedoman Umum Pengkajian Risiko Bencana file:///C:/Users/User/Downloads/Peraturan%20Kepala%20BNPB%20No%2002%20Tahun%202012%20Tentang%20Pedoman%20Umum%20Pengkajian%20Risiko%20Bencana.pdf.
8. Alhaira Dinata, Lily Endah Diansari (2021) Optimasi Sumaber Daya Air di Sub-DAS Air Betung, Kota Pagar Alam, Sumatera Selatan 19.
9. Achmad Syarifudin, Henggar Risa D (2023) Sistem Drainase Perkotaan Berwawasan Lingkungan 1.
10. Syarifudin A, Destania HR (2020) IDF Curve Patterns for Flood Control of Air Lakitan river of Musi Rawas Regency, in IOP Conference Series: Earth and Environmental Science, Institute of Physics Publishing 448.
11. Achmad Syarifuldin, Hidrologi Terapan (2018) 1st ed, Yogyakarta: CV. Andi Offset 1.
12. Muhammad RZ, Mary Selintung, Rita Lopa (2023) Analysis of the Effect of Land Use on Flood Discharge in the Pangkajene River Basin, Pangkajene Regency and the Islands, International Journal of Engineering Business and Social Science 1: 331-339.
13. I Gede Tunas (2019) Performance of Flood Prediction Model in Tropical River Basin, Indonesia: A Synthetic Unit Hydrograph-Based Evaluation, Disaster Advances 12: 26-37.
14. Dai Agus Muttaqin, Entin Hidayat, dan Gusfan Halik (2023) Penilaian Risiko Banjir dengan Pendekatan Rasio Frekuensi dan AHP di Sub-DAS Jompo, Jember, Jawa Timur, Jurnal Aplikasi Teknik Sipil 21.
15. Fameira Dhiniati, Alharia Dinata (2022) Identification of Flash Flood Vulnerability using GIS-Based AHP (Analytical Hierarchy Process) Method in Air Mulak Sub-Watershed, Lahat Regency 6.
16. A Dinata, F Dhiniati, L E Diansari (2021) Delineation of flash flood hazard zones based on morphometric parameters using GIS technique in upper Lematang sub-watershed, IOP Conference Series: Earth and Environmental Science 708.
17. Komal Vashist, Singh K K (2023) HEC-RAS 2D modeling for flood inundation mapping: a case study of the Krishna River Basin, Water Practice and Technology, Water Practice & Technology 18: 831-844.