SINEKTIKA Jurnal Arsitektur

p-ISSN: 1411-8912
e-ISSN: 2714-6251
http://journals.ums.ac.id/index.php/sinektika

ANALYSIS OF THE IMPACT OF FLOOD ON RESIDENTIAL BUILDING DAMAGE IN RAWANG SPREAD DISTRICT, SUNGAI PENUH CITY, JAMBI

Mella Anggina Riskyani
Architecture
Faculty of Engineering
Universitas Sriwijaya
mellaanggina@gmail.com

Miftahul Akbar Ramadhan
Physics Education
Faculty of Mathematics and Natural Sciences Education
Universitas Pendidikan Indonesia
miftahul.akbar.2001@gmail.com

Muhammad Ridho Fajri
Computer Science Education,
Faculty of Mathematics and Natural Sciences Education
Universitas Pendidikan Indonesia
mridhofajri@gmail.com

Manuscript submitted: May 8, 2024
Manuscript accepted: June 13, 2025

ABSTRACT

Indonesia is known for being prone to disasters, and over the past decade, they have impacted 942,697 houses. Among these disasters, floods rank as the second most impactful in the country. In Sungai Penuh City, flooding occurs annually and has become the primary concern for the local government. Since the start of 2024, three of Sungai Penuh's eight sub-districts have endured prolonged floods due to heavy rainfall in the Batang Merao Watershed, leading to water overflow and settlements along the riverbank. This research analyses the damage inflicted by the Batang Merao River floods between December 2023 and April 2024 on house buildings in the Hamparan Rawang District. The data collection method employed was qualitative, involving observation and interviews. Subsequently, the data underwent quantitative analysis to derive a building damage index. The study focused on three categories of building components: structural, architectural, and utility. Among the 86 respondents, the structural damage index was 16.76 (light), architectural damage was 16.76 (light), and utility damage was 16.90 (light). The overall building damage index, calculated from these results, is 12.58 (light).

KEYWORDS: building, damage, disaster, flood, residential house

Indonesia dikenal sebagai negara yang rentan terhadap bencana, dan selama satu dekade terakhir, bencana tersebut telah berdampak pada 942.697 rumah. Diantara bencana-bencana tersebut, banjir menempati urutan kedua yang paling berdampak di Indonesia. Di Kota Sungai Penuh, banjir terjadi setiap tahun dan telah menjadi perhatian utama pemerintah setempat. Sejak awal tahun 2024, tiga dari delapan kecamatan di Sungai Penuh mengalami banjir berkepanjangan akibat curah hujan yang tinggi di Daerah Aliran Sungai (DAS) Batang Merao, yang menyebabkan meluapnya air dan menggenangi permukiman di sepanjang bantaran sungai. Penelitian ini menganalisis kerusakan yang ditimbulkan oleh banjir Sungai Batang Merao antara Desember 2023 dan April 2024 terhadap bangunan rumah di Kecamatan Hamparan Rawang. Metode pengumpulan data yang digunakan adalah kualitatif, yang melibatkan observasi dan wawancara. Kemudian, data tersebut dianalisis secara kuantitatif untuk mendapatkan indeks kerusakan bangunan. Penelitian ini berfokus pada tiga kategori komponen bangunan: struktur, arsitektur, dan utilitas. Dari 86 responden, indeks kerusakan struktural adalah 16,76 (ringan), kerusakan arsitektural 16,76 (ringan), dan kerusakan utilitas 16,90 (ringan). Indeks kerusakan bangunan secara keseluruhan, yang dihitung dari hasil ini, adalah 12,58 (ringan).

KATA KUNCI: *bangunan, kerusakan, bencana, banjir, rumah tinggal*

INTRODUCTION

The World Risk Report 2023, published by Bündnis Entwicklung Hilft and the Institute for International Law of Peace and Armed Conflict (IFHV) of Ruhr-University Bochum, ranks Indonesia as the second most disaster-prone country in the world, with a Global Risk Index score of 43.50. Based on data from National Disaster Management Authority (BNPB, 2024), among 2015 to 2024, disasters have impacted 942,697 residential buildings, including heavily, moderately and lightly damaged buildings. Floods ranked second as the most impactful disaster after tornadoes, with a total of 7,894 incidents and 236,331 houses affected during the same period (BNPB, 2024).

Flooding has been a priority issue for the Sungai Penuh City government since early 2024. At least three out of eight districts in the city—Hamparan Rawang, Tanah Kampung, and Koto Baru—have been flooded since the beginning of the year. During the flood period, around 5,000 hectares of land were inundated, including residential areas, agricultural land, and roads. The distribution of flooding in Sungai Penuh City and Kerinci can be observed through the Sentinel satellite imagery shown in Figure 1.

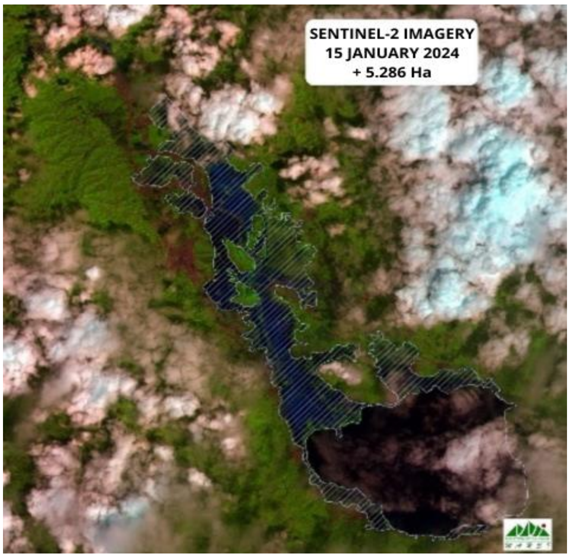

Figure 1. Sentinel-2 Imagery Map Flood Distribution
(Source: KKI Warsi, 2024)

According to Aminudin (2013), flooding is a disaster caused by high levels of rainfall in an area that is not supported by adequate drainage infrastructure, which can lead to waterlogging in areas that are not desired by the people living there. In the Pocket Book: Quick, Agile, and Resilient in Facing Disasters by BNPB (2012), floods are divided into three categories: river floods, flash floods, and tidal floods. The floods in Sungai Penuh and Kerinci are classified as river floods, which are caused by high rainfall intensity that occurs continuously in a river watershed (DAS) on a large scale (Mandasari, 2020). Flooding in these two areas occurs due to the overflow of the Batang Merao River and the inability of Lake Kerinci to accommodate the rainfall runoff (Mandasari, 2020). According to the Batang Merao River watershed map (Endriani, 2011), more than 30% of the Sungai Penuh City area is part of the lower watershed of the Batang Merao River, so when the Batang Merao River overflows, some settlements along the river will experience flooding. In addition, land use changes in the upstream area of Batang Merao can lead to erosion, changes in water storage capacity, and uncontrolled water discharge in the downstream area of Batang Merao, resulting in flooding (Ningsih et al., 2020).

Flood disasters generally cause significant losses and have a real impact on the social and economic conditions of the community. One of the most visible impacts is the damage to residential buildings and public facilities due to prolonged flooding. The effect of flooding on building materials can be a serious problem, as prolonged exposure to water can cause damage to floors, walls or other building structures. In some cases, floods with high discharge can affect the structural integrity of building, even leading to the collapse of the structures.

(a) (b)

Figure 2. Flood Conditions, (a) Outdoor, (b) Indoor
(Source: Author Observation, 2024)

This study aims to examine the impact of the Batang Merao River flood from December 2023 to April 2024 on the damage to residential buildings in the Hamparan Rawang District. The purpose of this research is to encourage the community to more carefully consider the selection of building locations in flood-prone areas in the future. Additionally, it is hoped that the community will be more prudent in choosing building materials based on their strength and durability.

METHODS

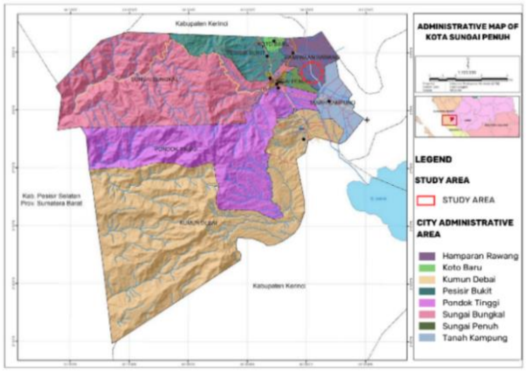

Figure 3. Administrative Map of Sungai Penuh City
(Source: BPPD Sungai Penuh City)

This research was conducted in the Hamparan Rawang District, which is the area most frequently affected by floods in Sungai Penuh City. The focus of this study is on the affected settlements located along the Batang Merao River, specifically in Tanjung Village and Tanjung Muda Village, which were completely affected by the flood (100%). The research was conducted during April 2024.

Data Collection Method

The method used in this study is a mix method. The mix method is a research method that involves the collection, analysis, and integration of quantitative and qualitative research results in a single study (Ulfa et al., 2021). Quantitative data collection is conducted through interviews and field observations to obtain measurable data on building damage, while qualitative data collection is done through literature studies and interviews with respondents. The use of this method aims to obtain valid, comprehensive, reliable, and objective data. This mix method research employs a sequential explanatory design, where quantitative data is collected first, followed by the collection of qualitative data to validate and support the previously obtained quantitative data (Sugiyono, 2014). The data used in drawing conclusions are supported by primary and secondary data. Primary data is obtained from: (1) Field observations, conducted by directly observing the condition of buildings affected by the flood, (2) Interviews with the community, aimed at gaining deeper insight into the condition of buildings when the flood occurred. Interviews were conducted in Tanjung Village and Tanjung Muda Village with 86 families out of approximately 4,100 families affected by the flood in Hamparan Rawang District.

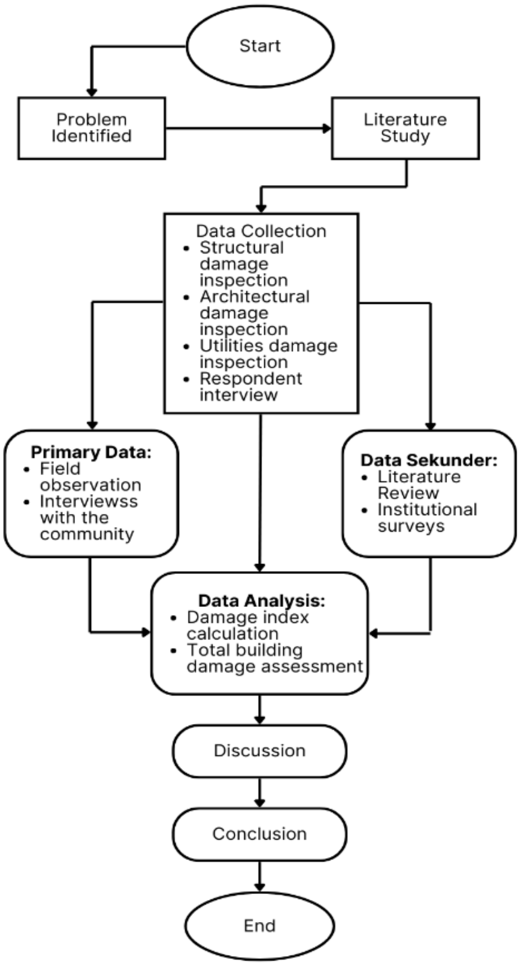

Figure 4. Research Flowchart
(Source: Author Observation, 2024)

Secondary data is supporting data obtained from: (1) Document review, which includes reviewing regulations, journal articles with a similar focus, news from online media sources, maps, and others, (2) Data from relevant agencies, such as the RTRW map from the BPPD of Sungai Penuh City, elevation data from BPS Sungai Penuh, data on the number of affected victims from Tanjung and Tanjung Muda Villages, and others. The research flow has been illustrated in Figure 4.

Guidelines for Assessment and Weighting of Building Damage

The definition of building damage refers to the dysfunction of a building or its components caused by the end of its service life, human actions, or natural causes such as excessive functional loads, fires, or natural disasters (Directorate General of Cipta Karya, 2007). The assessment of building damage is determined by the quantitative measure of the extent of damage to each building component. The level of building damage is determined through visual observation and indications of the impact of the damage on the safety of building use, comfort, and the aesthetics of the room or building form. The types of damage to building components observed are classified into four conditions based on the Ministry of Public Works and Housing (PUPR) (2020), which are: no damage, minor damage, moderate damage, and severe damage, with each identification having percentages of 0%, 10%, 25%, and 50%, respectively (Sunarna et al., 2023). The condition of the building is determined based on several criteria outlined in Table 1.

Table 1. Building Damage Criteria
(Source: Rahmaddi, 2021)

Identification of Physical Damage		
Structural Aspect	Minor Damage	**Damage Percentage:** 10% Criteria for Minor Damage: a. Uneven settlement of the foundation b. Cracks in column plaster < 1 mm on less than 30% of total columns c. Cracks in beams < 1 mm d. Cracks at joints < 1 mm e. Roof structure damage < 30% of total roof area
	Moderate Damage	**Damage Percentage:** 25% Criteria for Moderate Damage: a. Uneven foundation settlement causing damage to the upper structure b. Surface cracks in columns > 1 mm on more than 30% of total columns c. Beams sagging, crack width > 1 mm d. Cracked, loose, or displaced joints e. Sagging roof structure affecting > 30% of total roof area
	Severe Damage	**Damage Percentage: 50%** Criteria for Severe Damage: a. Building visibly tilting and floor bulging

		b. Tilted column position, crushed concrete core, collapsed columns c. Broken or collapsed beams d. Detached, damaged, or decayed joints e. Wood/plate/bolt connections bent or extensively cracked, or collapsed roof
Architectural Aspect	Minor Damage	**Damage Percentage: 10%** Criteria for Minor Damage: a. Wall paint appears dull, eroded, blistered, wrinkled, with hairline cracks < 0.3 mm b. Discoloration of paint on openings, damaged accessories, difficulty in opening/closing c. Stained, rusty, or hairline-cracked floor d. Indications of dampness or leakage on the ceiling, marked by stains
	Moderate Damage	**Damage Percentage: 25%** Criteria for Moderate Damage (Architectural Aspect): a. Large cracks on plaster > 0.3 mm, peeling paint or skim coat, cracks exposing bricks b. Wide cracks on frames/panels, gaps between frame and wall c. Floor tiles detached, broken, or chipped d. Ceiling covering partially detached or sagging in several areas
	Severe Damage	**Damage Percentage 50%** Severe Damage Criteria: a. Pest damage, cracks in the bricks, shifted bricks. b. Decay on the opening door/frame, decaying door/frame, broken frame/glass. c. Broken ceramics, destroyed, floor sunken. d. Ceiling sagging extensively with indications of collapse, ceiling collapsed.
Aspek Utilitas	Minor Damage	Damage Percentage 10% Minor Damage Criteria: a. Pipe leakage in easily accessible areas, broken faucet. b. Pump motor burned but not severely. c. Dirty water pipes damaged or clogged.
	Moderate Damage	**Damage Percentage 25%** **Moderate Damage Criteria:** a. Pipe leakage in many places or most of the pipes are damaged. b. Pipes to the drainage system are clogged, broken, or cracked. c. Pump motor burned severely.
	Severe Damage	**Damage Percentage 50%** Severe Damage Criteria: a. Pump completely damaged. b. Motor completely burned. c. Pipes leaking in many places. d. Faucet not functioning. e. Sanitation area collapsed.

RESULTS AND DISCUSSION

Area Conditions and Building Characteristics
The selection of the research focus area is based on the regions most affected by severe flooding, namely the residential areas of Tanjung Village and Tanjung Muda, located on the banks of the Batang Merao River, where all the houses in both villages were 100% submerged by the flood. Data from BPBD as of January 17th reports that the number of houses affected by the flood in Tanjung Muda Village and Tanjung Village are 322 units and 275 units, respectively. The affected families in both villages are 425 families or 1,285 people in Tanjung Muda Village, and 360 families or 1,038 people in Tanjung Village. The mapping of the research area can be seen in Figure 5.

Figure 5. Existing Bench Condition
(Source: Author Document, 2022)

❖ Type of Buildings

Residential buildings in Tanjung Village and Tanjung Muda Village are divided into two types based on building materials: permanent buildings and semi-permanent buildings. The difference between permanent and semi-permanent houses can be distinguished by the type and material of the foundation, walls, structural form, and roof (Supriani, 2011). Permanent houses are built with strong, high-durability materials, such as bricks, concrete, wood that has undergone preservation treatment, or metal, while semi-permanent houses are generally built with simpler materials, such as untreated wood or bamboo. Some semi-permanent houses are usually modified from stilt houses, where the walls of the lower floor are renovated using bricks and cement plaster on the columns, while the upper part retains the use of untreated wood.

Based on observations conducted on 86 house units, 31 units are permanent houses and 55 units are semi-permanent houses. According to the observations, the majority of permanent buildings in the research area are made from brick and concrete materials, while semi-permanent houses are of the modified stilt house type, with half walls, unplastered bricks, and the upper walls made of untreated wood.

❖ **Building Age**

Based on the survey results, the buildings in Tanjung Village and Tanjung Muda Village that were affected have varying ages, with the youngest building being 6 months old and the oldest building being 80 years old. The variation in age is classified into four categories: buildings aged 0-5 years, 6-10 years, 11-20 years, 20-50 years, and >50 years. The percentage of building ages is detailed in the graph in Figure 6.

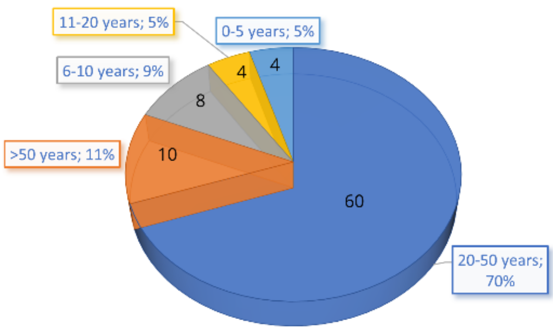

Figure 6. Building Age Diagram
(Source: Author's Observation, 2024)

Flooding Condition

Table 2. Flood Condition in the Research Area

Desa	RT	Ketinggian Banjir	Durasi	Periode
Tanjung	6	0.8 Meter	45 days	30 December – February
	8, 10	1-1.5 Meter		
Tanjung Muda	3, 4	1-1.5 Meter	45 days	30 December – February

Based on observations and information obtained from the local government, the type of flood occurring in Hamparan Rawang District and parts of Sungai Penuh City is river overflow flooding, which is caused by continuous rainfall in the Batang Merao watershed and the inability of the water to be channeled into drainage systems (Hasddin & Tamburaka, 2020). In addition, flooding in Hamparan Rawang occurs because it is an area with one of the lowest land elevations in Sungai Penuh (BPS Sungai Penuh, 2023). The flooding in Hamparan Rawang has lasted an average of 1.5 months, starting from December 31, 2023. The flood height varies from 80 cm to 1.5 meters for buildings lower than the river water surface level. Among all the respondents, 17.4% of the total buildings were still flooded as of April 13, 2024.

Analysis of the Impact of Flooding on the Physical Condition of Buildings

- **Building Damage Level**

The flood disaster lasting approximately 1.5 months caused various degrees of damage to the majority of residential buildings in Tanjung Village and Tanjung Muda Village. According to PERMEN PU No 24 (2008), the intensity of building damage is classified into three levels: light damage, moderate damage, and severe damage. Based on the Technical Guidelines from the Directorate General of Human Settlements (1998), the assessment of the damage level of buildings is conducted in three aspects: structural physical aspect, architectural physical aspect, and utility aspect.

The weighting of building components uses a method developed by Uzarski in 2007. Each component in different aspects will be assigned a functional weight based on the building hierarchy. The calculation is based on the following criteria: affecting the safety level of the users, affecting the comfort level, and affecting the aesthetics. The building components and their weightings can be seen in Figure 7.

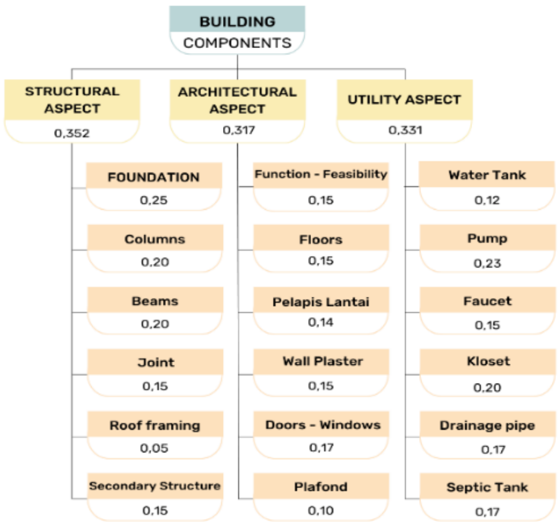

Figure 7. Building Component Weights
(Source: Author's Analysis, 2024)

- **Structural Aspect**

Based on observations and interviews, the most common structural damage complaints experienced by residential buildings are damage to the columns, such as rotting/cracking, experienced by 46% of respondents. Additionally, there are many damages to the beams, such as rotting/cracking, affecting 36% of the buildings. The flood height of less than 1.5 meters did not affect the roof frame. More detailed data on structural damage complaints can be seen in the following data.

Each structural component that experienced damage is assigned a damage weight and classified into light, moderate, and severe damage. The total damage weight for each component can be seen in Table 3.

Table 3. Structural Damage Weight Table

Aspect	Building Component	Damage Weight (%)
Structure	Foundation	1,17
	Column	8,95
	Beam	7,96
	Joint	2,27
	Roof Frame	0,58
	Secondary Structure	3,54

- **Architectural Aspect**

Based on observations and interviews, the majority of visible architectural damage includes damage to doors and windows, affecting 81%, damage to plaster and wall paint, affecting 25%, and finishing appearance that is deemed unfit, affecting 36%. More detailed data on architectural damage complaints can be seen in figure 8.

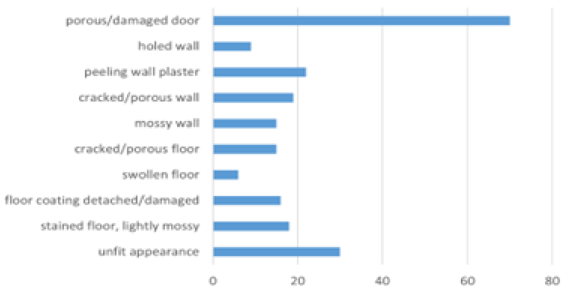

Figure 8. Architectural Damage Types Data
(Source: Field Observation, 2024)

Each component of the architectural aspect that experienced damage is assigned a damage weight and classified into light, moderate, and severe damage. The total damage weight for each component can be seen in Table 4.

Table 4. Architectural Damage Weight

Aspect	Building Component	Damage Weight (%)
Architectural	Functionality for Livebility	12,38
	Floor	18,60
	Floor Covering	24,76
	Wall Plaster	28,66
	Doors and Windows	25,63
	Ceiling	0,00

- **Utility Aspect**

The villages of Tanjung and Tanjung Muda, which are the focus of the study, mostly still lack access to proper sanitation. Proper sanitation access has criteria: (1) using a household toilet with a squat toilet or pedestal toilet, (2) using a septic tank or a pit latrine as a place for waste disposal (Ministry of Health, Republic of Indonesia, 2023). As many as 22% of respondents still do not have a private toilet and use communal MCK facilities or carry out the sanitation process directly in the river.

The assessment of utility damage was conducted on buildings that had proper sanitation access, totaling 67 respondents. Out of 86 buildings, 8 buildings experienced total collapse in the bathroom/toilet area. Based on observations and interviews, the most common utility damage complaint experienced by residential buildings was clogged toilets, reported by 51% of respondents. The toilet clogs lasted for several days after the flood. Detailed data on utility damage complaints can be seen in figure 9.

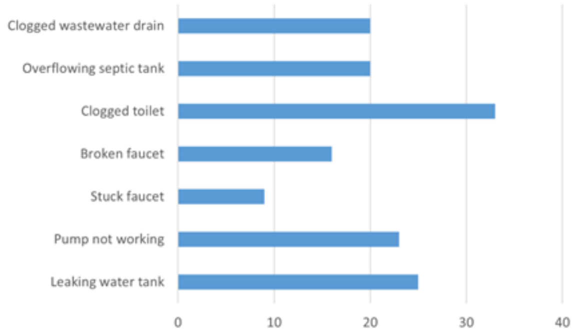

Figure 9. Utility Damage Types Data
(Source: Field Observation, 2024)

The weight of damage for each architectural component that has sustained damage is calculated and classified as minor damage, moderate damage, or severe damage. The total damage weight for each component can be seen in Table 5.

Table 5. The damage weight of utilities.

Aspect	Building Component	Damage Weight (%)
Utility	Tank/Reservoir	16,79
	Water Pump	15,54
	Water Faucet	17,61
	Toilet	19,60
	Septic tank	13,98
	Sewage System	13,98

- **Building Damage Index**

The building damage index is the combination of two or more component damage values, each with its respective component weight. The damage index calculation for each aspect and the overall building damage index has been made using the following formulas (Suparjo, 2006):

$$C_I = W_1 \times C_1 + W_2 \times C_2 + W_3 \times C_3 \quad (1)$$

Alternatively, it can be written as:

$$C_I \sum_{i=1}^{n} = (W_1 \times C_1) \quad (2)$$

Description:
CI = Combined Damage Index
W = Component Weight
C = Component Damage Value
i = 1 = Component 1
n = Number of Components

From the formula above, the damage index for each aspect can be calculated as follows:

Structural Aspect Damage Index
= (1,167 x 0,25) + (8,95 x 0,20) + (7,95 x 0,2) + (2,27 x 0,15) + (0.58 x 0,05) + (3,54 x 0,15)
= 4.75175 (Minor damage category)

Architectural Aspect Damage Index
= (12,383 x 0,15) + (18,60 x 0,15) + (24,76 x 0,14) + (28,66 x 0,15) + (25,63 x 0,17) + (0,0 x 0,10)
= 16,76995 (Minor damage category)

Utility Damage Index
= (16,79 x 0,12) + (15,54 x 0,23) + (17,61 x 0,15) + (19,60 x 0,20) + (13,98 x 0,17) + (13,98 x 0,17)
= 16,9037 (Minor damage category)

Therefore, the calculation of the overall combined building damage index is as follows:

Building Damage Index
= (4.75175 x 0,352) + (16,76995 x 0,317) + (16,9037 x 0,331)
= 12,58381485 (Minor damage category)

CONCLUSION

Based on the analysis results regarding the types of damage, damage weighting assessment, and damage index calculation, the following conclusions can be drawn:

- From the damage analysis and calculation of damage weights, the structural damage is 4.75175 (minor damage), architectural aspect damage is 16.76995 (minor damage), and utility aspect damage is 16.9037 (minor damage).
- The overall building damage index, based on the calculation results, is 12.58381485 (minor damage), meaning that, in general, the buildings affected by the flood are still able to serve their functions.

From the flood disaster impact analysis on residential buildings, it is expected that:

- It will assist the local government of Sungai Penuh in planning appropriate actions for improving the quality of residential areas.
- In the future, the community can consider the location of house construction in flood-prone areas. Additionally, people can be more mindful when choosing building materials based on their strength and durability.

Based on the research conducted on the impact of flooding on residential building damage in Hamparan Rawang District, it was found that the level of damage in the structural, architectural, and utility aspects was classified as minor. However, to minimize similar impacts in the future, the following improvements and preventive measures are recommended:

- **Structural Aspect**: It is recommended to use water-resistant materials such as reinforced concrete with a protective layer (waterproofing) on the foundation and lower walls. Additionally, consider elevating the ground floor of the house (stilts or split-level) to reduce structural damage from flooding.
- **Architectural Aspect**: Future house designs should be adjusted to flood potential, such as by raising doors and ventilation above ground level. It is also recommended to use finishing materials that are easy to clean and resistant to moisture, such as ceramic tiles or ACP (Aluminum Composite Panel) on the lower walls.
- **Utility Aspect**: Electrical and water installations should be elevated at least 1 meter above the floor surface to avoid flooding. Use waterproof pipes and cables, and ensure that an automatic circuit breaker system is in place to prevent electrical short circuits during flooding.

REFERENCES

Aminudin. (2013). Mitigasi dan Kesiapsiagaan Bencana Alam. Bandung: Angkasa Bandung.

BPS Kota Sungai Penuh. (2023).Kota Sungai Penuh Dalam Angka. Sungai Penuh: Badan Pusat Statistik Kota Sungai Penu

Bündnis Entwicklung Hilft / IFHV. (2023). *WeltRisikoBericht* 2023. Berlin: Bündnis *Entwicklung Hilft.*

Direktorat Jenderal Pencegahan dan Pengendalian Penyakit, Kementerian Kesehatan RI. (2023). Laporan Tahunan 2022 Stop Buang Air Besar Sembarangan di Indonesia. Jakarta: Kemenkes

Endriani. (2010). Studi Kepadatan, Erodibilitas dan Kemantapan Agregat Tanah Andisol Akibat Perubahan Tataguna Lahan di Hulu Das Batang Merao. Jurnal Hidrolitan, 2(1), 40 – 47. ISSN 2086 - 4825

Hasddin & Tamburaka, N. (2020). "Studi Karakteristik dan Wilayah Terdampak Banjir di Kecamatan Mandonga, Kota Kendari." Jurnal Pembangunan

Wilayah dan Kota, 17(4), 420 – 427. Doi: 10.14710/pwk.v17i4.32391

Kementerian PUPR. (2020). Tata Cara Identifikasi dan Verifikasi Kerusakan. Jakarta: Ditjen. Perumahan, Kementerian Pekerjaan Umum dan Perumahan Rakyat.

Mandasari, N. (2020). Penanggulangan Bencana Banjir Di Sungai Batang Merao Pada Badan Penanggulangan Bencana Daerah Kota Sungai Penuh Tahun 2019. Jurnal Administrasi Nusantara (Jan), 3(2), 45-51. doi: 10.51279/jan.v3i2.344

Ningsih, S. N., Putra, E. G., & Goembira, F. (2020). Analisis Ketersediaan, Kebutuhan dan Kualitas Air Pada DAS Batang Merao. Jurnal Ilmu Lingkungan, 18(3), 545-555. doi: 10.14710/jil.18.3.545-555

Pusat Data Informasi dan Humas BNPB. (2012). Buku Saku: Tanggap Tangkas Tangguh Menghadapi Bencana Dari Badan Nasional Penanggulangan Bencana Edisi Tahun 2012. Jakata : Pusdatinmas BNPB.

Rahmaddi, P. N. (2021). Buku Pedoman Survei Kerusakan Bangunan. Jakarta: Ditjen. Perumahan, Kementerian Pekerjaan Umum dan Perumahan Rakyat.

Sugiyono. (2014). Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D. Bandung : Alfabeta

Sunarna, Adi H.P., & Ni'am, M.F. (2023). Analisis Dampak Banjir Rob terhadap Kerusakan di Kelurahan Bandengan Kecamatan Kabupaten Kendal. Rang Teknik Jurnal, 6(1). doi: 10.31869.rtj.v6il.3443

Suparjo, I., dkk. (2006). Perhitungan Indeks Kondisi Bangunan dan Analisis Biaya Perbaikan Gedung Akademi Keperawatan Panti Rapih Pasca gempa. Forum Teknik Sipil No. XIX/1-Januari 2009

Supriani, F. (2019). Analisis Tipikal Rumah di Kota Bengkulu dan Kesesuaian Dengan Rumah Tahan Gempa. Jurnal Inersia, 2(2), 19–26. doi: 10.33369/ijts.2.2.19-26

Ulfa, A., dkk. (2021). Desain Penelitian Mixed Method. Pidie: Yayasan Penerbit Muhammad Zaini.