



Community Based Inundation and Flood Mitigation in Palembang City, Indonesia

Indrayani¹, Rahmad Hidayat Saputra^{1,*}, Anna Elvaria¹, Akhmad Mirza¹, Ahmad Najib¹,
Agung Prakoso¹, Wenda Latifah Anjani¹

¹ Civil Engineering Department, State Polytechnic of Sriwijaya, Jl. Sriwijaya Negara Bukit Besar Palembang 30139, South Sumatra - Indonesia

* Corresponding author : rahmad.hidayat.saputra@polsri.ac.id

Tel.: +81-812-8288-0400

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Abstract

The increasing intensity of rainfall in Palembang City has heightened the risk of hydrometeorological disasters, particularly flooding and inundation. Despite various efforts by the municipal government to mitigate these events, flooding continues to occur following episodes of high or prolonged moderate rainfall. This study analyzes flood mitigation strategies with focus on community participation in addressing recurring inundation. Data from a flood distribution map reveal 196 flood points across the city, with flood heights ranging from 20 to 50 cm, occurring on average 10-15 times annually and typically receding within 2 to 4 hours though longer durations are observed in several sub-districts. Surveys and interviews conducted in 18 sub-districts identified key contributing factors, including drainage obstruction due to waste, sedimentation, vegetation, unauthorized construction, limited catchment areas, and inadequate drainage connectivity. Additional challenges include diminished retention pond capacity caused by vegetation overgrowth, functional conversion, embankment erosion, and topographical disadvantages such as low-lying terrain. The study proposes the optimization and restoration of drainage infrastructure, community empowerment in catchment area management, and the installation of additional pumps and automated sluice gates as integrated solutions. These measures aim to enhance water flow and reduce the frequency and impact of flooding in Palembang City.

Keywords: Mitigation, Flood, Community Participation, Palembang.

1. Introduction

Indonesia is classified as a high-risk region for various types of disasters, encompassing both natural and non-natural hazards. A disaster can be defined as an event or a series of events that pose threats and disruptions to the lives and livelihoods of communities, triggered by natural, non-natural, or human-induced factors, resulting in loss of life, environmental degradation, property damage, and psychological impact (Chandra and Supriharjo, 2013; Ferianto and Hidayati, 2019). Indonesia is among the countries most vulnerable, to both natural and anthropogenic disasters. In February 2024 alone, 173 disaster events were recorded, of which 99,42% were hydrometeorological in nature. Wet hydrometeorological events constituted 91,28% of the disaster, while 8,72% were classified as dry hydrometeorology. Floods were the most frequent events, accounting for 109 incidents, followed by extreme weather (35 events), forest and land fires (15 events), landslides (13 events), and a single earthquakes (BNPB, 2024)

Flooding is one of the most frequent natural disasters, causing significant socio-economic impacts, yet many people in flood-prone areas remain unaware of indifferent to the risks (Zal, 2018; Laurensz *et al.*, 2019). Flooding typically occurs when the volume of water in a river, lake, or channel exceeds its capacity, resulting in overflow, and flooding is significantly influenced by changes in land use patterns. Additionally, floods may arise from surface runoff that surpasses the drainage capacity of an area. The

presence of stagnant water and flooding in certain areas can significantly hinder land utilization activities (Rosyidie, 2013; Indrayani *et al.*, 2018). Land use changes within watershed areas, combined with rapid urban development, significantly contribute to increase surface runoff and water discharge, particularly during the rainy season (Jafar, Mapa and Sakke, 2016; Qalbi, Abdullah and Ismail, 2024; Ramsaf *et al.*, 2025). Community activities can trigger three types of flooding: upstream discharge-induced river flooding, localized flooding, and tidal flooding caused by sea level rise (Setiawan *et al.*, 2020).

Flooding frequently occurs when continuous rainfall persist over an extended period, leading to river overflow. Community preparedness over time is essential to ensure that the level of risk and the impacts of flood disasters can be effectively reduced (Annisa Temrin and Awang, 2017; Briantama, Suhartanto and Sajali, 2024). Flood disasters in Indonesia have shown a continuous annual increase, primarily driven by high rainfall intensity and insufficient infiltration areas in urban regions. Additionally, five key contributing factors include excessive precipitation, the degradation of watershed retention capacity, poor river channel planning, river sedimentation, and improper spatial planning and infrastructure development all of which adversely affect both communities and governmental operations (Findayani, 2015; Arifin *et al.*, 2021).

Flood preparedness requires enhancing public awareness and understanding through media-based education, the application of the 3R principles (Reduce, Reuse, Recycle), and participation in waste bank programs.

An integrated flood control plain is essential, involving the expansion of green open spaces to 30% improvement of drainage systems, construction of stormwater drainage infrastructure, and restoration of the natural functions of rivers and wetlands. Emergency response efforts should include logistics management, identification of evacuation sites, implementation of preparedness policies, deployment of early warning systems such as J-FEWS, and strengthening of resources mobilization capabilities (Taryana, El Mahmudi and Bekti, 2022; Kamil, Asyasyauki and Diem, 2023; Lestari, Suhartanto and Andawayanti, 2024).

Palembang City, as defined by Government Regulation No. 23 of 1988, spans 400,62 km² and is home to over 1,6 million residents. Administratively, it comprises 18 sub-districts and 107 urban villages, with Gandus Sub-district being the largest (68,78 km²) and Ilir Barat II the smallest (6,22 km²) (Saputra *et al.*, 2024). The South Sumatera region is predominantly characterized by high rainfall intensity (301-500 mm) with normal to above-normal precipitation patterns. Extremely high rainfall levels (>500 mm) were recorded in limited areas of Musi Banyuasin, Palembang, and Muara Enim. In Palembang, such rainfall intensity is considered a rare -events over the past 30 years. Flooding in the city frequently occurs during heavy rainfall events that cause the tributaries of the Musi River to overflow, a condition exacerbated by suboptimal urban drainage systems. The most severe flooding occurred in December 2021, with water depth ranging from 50 to 100 cm. An extreme rainfall event of 188,7 mm on October 5-6, 2022, marked the highest recorded October precipitation in the past three decades, inundating large parts of Palembang (BPS, 2021; Idrat *et al.*, 2024). Flood vulnerability in Palembang City is divided into five categories; very high vulnerability (16,88 km²), high vulnerability (888,53 km²), moderate vulnerability (110,03 km²), low vulnerability (92,73 km²), and areas classified as not vulnerable, covering 58,39 km² (Indrayani *et al.*, 2022).

Flood mitigation can be achieved through the application of flood risk management methods, biopore-based water management technologies, the construction of retention ponds, and early preventive measures (Sebastian, 2008; Rahmawati, Nurhapsa and Fahmi, 2024; Sudarmadjii

et al., 2024). Disaster mitigation and emergency response must be tailored to the specific characteristics of each hazard, such as flash floods in Indonesia, which are driven by factors including high rainfall intensity, slope gradients, soil type and elevation, land cover, and river network density (Sadisun, 2008; Seno, 2013; Anjarwati, Ery Suhartanto and Linda Prasetyorini, 2024). Geographic Information System (GIS) technology can be utilized to map flood-prone locations, while remote sensing supports flood disaster mitigation efforts. Flood risk assessment can also be conducted using standardized risk assessment methodologies (Muhammad Yusoff and Thomas, 2021; Putra *et al.*, 2022; Prasasti, Suhartanto and Prasetyorini, 2024).

Although the Palembang City Government has implemented various measures to address flooding, inundation still occurs during high or prolonged moderate rainfall. Therefore, this study aims to develop a community-based flood mitigation system that actively involves residents, in order to enhance the effectiveness of flood management decisions in Palembang.

2. Methods

This study employed a qualitative research methodology, which involved direct field investigations and the distribution of questionnaires to 800 residents across all sub-districts in Palembang City. The investigation was conducted in two phases: first, through the administration of questionnaires, followed by interviews with key stakeholders, including staff from village and sub-district offices across the 18 sub-districts of Palembang City, as well as residents who had lived in flood-prone areas for over ten years. The locations of inundation and flooding were subsequently mapped using Geographic Information System (GIS), resulting in the creation of thematic flood distribution maps for Palembang City (Indrayani *et al.*, 2016).

The findings from the interviews contributed to the development of a community-based flood mitigation strategy for the city. The study area for flood distribution is illustrated in Figure 1.

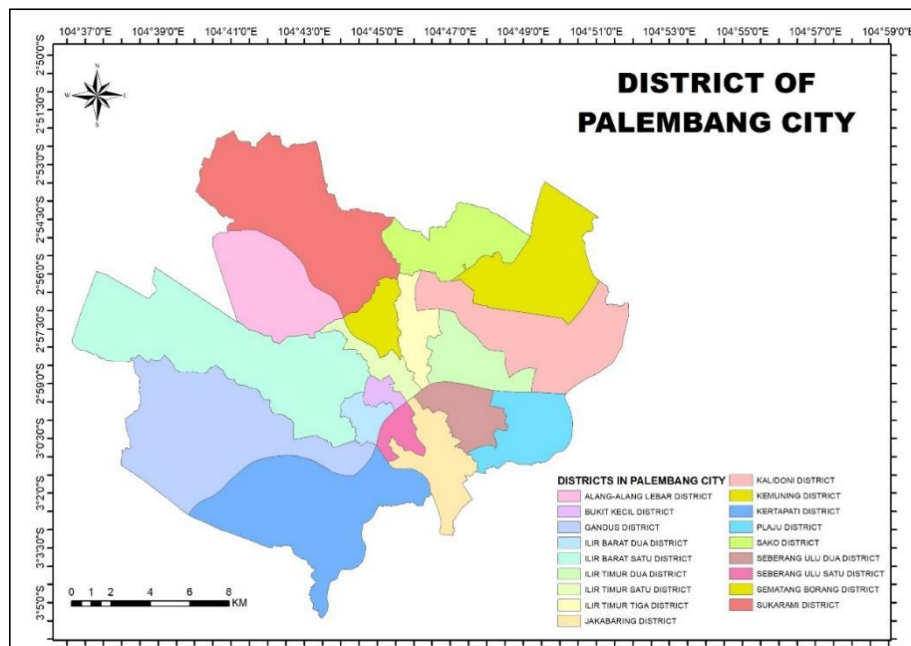


Fig 1. Inundation and Flood Study Area of Palembang City.

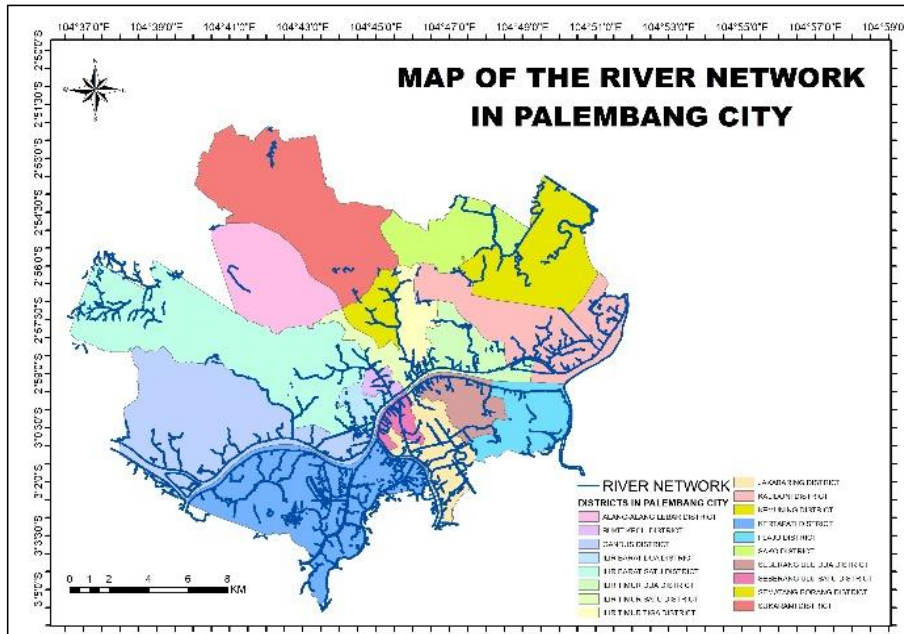


Fig 2. Map of The River Network in Palembang City.

Table 1. Administrative Area of Palembang City

No	District	Village
1	Alang-alang Lebar	Srijaya, Karya Baru, Talang Kelapa, and Alang-alang Lebar Village
2	Sukarami	Sukabangun, Sukajaya, Sukarami, Kebun Bunga, Talang Betutu, Sukodadi, and Talang Jambi Village
3	Sematang Borang	Lebong Gajah, Srimulya, Sukamulya, and Karya Mulya Village
4	Sako	Sukamaju, Sialang, Sako, and Sako Baru Village
5	Ilir Timur Tiga	Sepuluh Ilir, Sebelas Ilir, Kuto Batu, Duku Enam, Sembilan Ilir, and Delapan Ilir Village
6	Kalidoni	Sei Lais, Sei Selincah, Sei Selayur, Kalidoni, and Bukit Village
7	Ilir Timur Dua	Lawang Kidul, Tiga Ilir, Satu Ilir, Sungai Buah, and Lima Ilir Village
8	Kemuning	Sekip Jaya, Pahlawan, Dua puluh Ilir, Pipareja, Talang Aman, and Ario Kemuning Village
9	Ilir Timur Satu	Tiga Belas Ilir, Empat Belas Ilir, Lima Belas Ilir, Enam Belas Ilir, Tujuh Belas Ilir, Delapan Belas Ilir, Kepandean Baru, Sei Pangeran, Dua Puluh Ilir Satu, Dua Puluh Ilir Tiga, and Dua Puluh Empat Village
10	Bukit Kecil	Talang Semut, Dua Puluh Dua Ilir, Sembilan Belas Ilir, Dua Puluh Tiga Ilir, Dua Puluh Enam Ilir, and Dua Puluh Empat Ilir Village
11	Ilir Barat Satu	Bukit Lama, Dua Puluh Enam Ilir D Satu, Lorok Pakjo, Demang Lebar Daun, Bukit Baru, and Siring Agung Village
12	Plaju	Plaju Darat, Talang Putri, Komperta, Plaju Ilir, Talang Bubuk, Plaju Ulu, and Bagus Kuning Village
13	Seberang Ulu Dua	Sebelas Ulu, Dua Belas Ulu, Tiga Belas Ulu, Empat Belas Ulu, Tangga Takat, Enam Belas Ulu, and Sentosa Village
14	Jakabaring	Lima Ulu, Tuan Kentang, Delapan Ulu, Silaberanti, and Sembilan/Sepuluh Ulu Village
15	Kertapati	Karya Jaya, Keramasan, Kemang Agung, and Kemas Rindo Village
16	Seberang Ulu Satu	Satu Ulu, Dua Ulu, Tiga-Empat Ulu, Lima Ulu, and Tujuh Ulu Villages
17	Gandus	Pulo Kerto, Gandus, Karang Jaya, Karang Anyar, and Tiga Puluh Enam Ilir Village
18	Ilir Barat Dua	Kelurahan Tiga Puluh Lima Ilir, Tiga Puluh Dua Ilir, Kemang Manis, Dua Puluh Sembilan Ilir, Dua Puluh Delapan Ilir, and Dua Puluh Tujuh Ilir Village

3. Geographical Conditions

Palembang City consists of 18 sub-districts and 107 villages. Administratively, the boundaries of Palembang City are as follows: the north, it borders Banyuasin Regency; to the south, it borders Ogan Komering Ilir Regency and Banyuasin Regency; to the east, it borders Banyuasin Regency; and to the west, it borders Banyuasin Regency, Muara Enim Regency, and Ogan Komering Ilir Regency. The majority of the sub-districts are situated adjacent to the rivers within the city.

4. Results

4.1 Distribution of Floods and Inundation Per District in Palembang City

The investigation conducted in October 2022 across 18 sub-districts in Palembang City identified 196 flood points, with flood heights ranging from 5 cm to over 50 cm. The distribution of flood points was categorized into three levels based on the height of inundation: 5-20 cm, 20-50 cm, and > 50 cm. The majority of flood points, accounting for 93 points (47% of the total), experienced water levels in the 20-50 cm range. The distribution of flood points based on the frequency of flooding is classified into four categories: < 5 times; 5-10 times, 10-15 times, and > 15 times. The highest percentage of flood occurrences is observed in the category of less than five times, accounting for 61 points, or 31% of the total flood points. The lowest flood frequency, 10-15 times, represents 18% or 36 points.

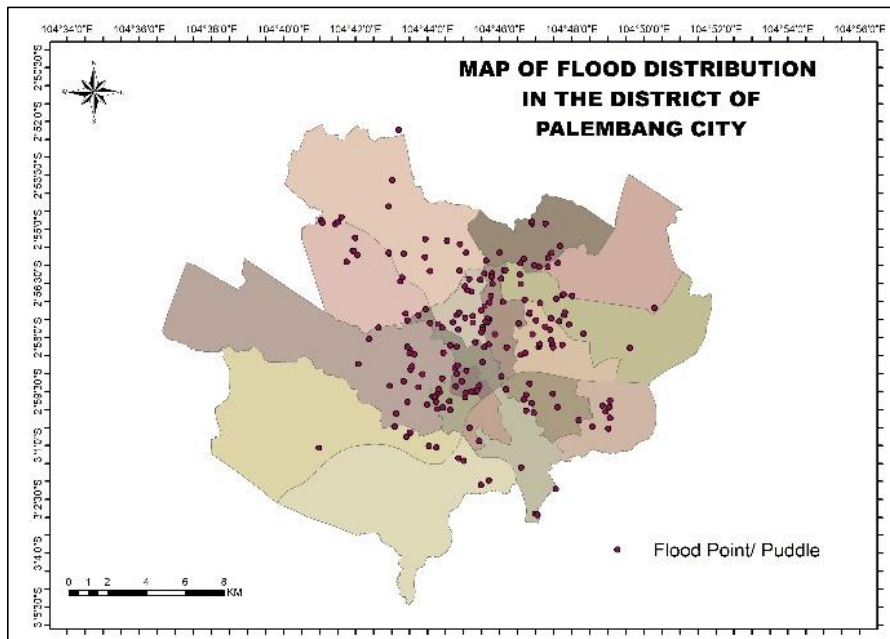


Fig 3. Distribution of Flood Points in Palembang City.

Table 2. Number of Flood Point Distribution per District in Palembang City.

No	District	Number of Flood Points
1	Alang-alang Lebar	13
2	Bukit Kecil	10
3	Gandus	7
4	Iilir Barat Satu	17
5	Iilir Barat Dua	11
6	Iilir Timur Satu	8
7	Iilir Timur Dua	18
8	Iilir Timur Tiga	16
9	Jakabaring	10
10	Kalidoni	12
11	Kemuning	19
12	Kertapati	4
13	Plaju	7
14	Sako	13
15	Seberang Ulu Satu	2
16	Seberang Ulu Dua	7
17	Sematang Borang	6
18	Sukarami	16
Total Flood Points		196

The distribution of flood points based on waterlogging duration is divided into five categories: < 1 hour, 1–2 hours, 2–3 hours, 3–4 hours, and > 4 hours. The longest waterlogging duration, exceeding 4 hours, was observed in 75 points, or 38% of the total flood points. The findings of the research revealed the distribution of flood inundation points across the sub-districts of in Palembang City.

The analysis indicates that a total of 196 flood points are distributed across the 18 sub-districts of Palembang City. The sub-district with the highest number of flood points is Kemuning, with 19 points, whereas the sub-district with the fewest flood points is Seberang Ulu Satu, with only 2 points.

4.2 Flood Analysis in Kemuning District

Following the identification of flood locations across the sub-district, it was found that Kemuning District has highest number of flood points, with 19 locations spread throughout the sub-district. Subsequently, an analysis was conducted to determine the causes of flooding and potential mitigation strategies for the flood-prone areas within Kemuning District.

Table 3. Flood Frequency Analysis (3 to 5 Times Per Year) in Kemuning District.

No	Flood Point	Analysis
1	Jl. Pipareja. Height : 5–20 cm, Receding duration: 2–3 hours	The channels surrounding Jl. Pipareja need to be reconditioned to anticipate the occurrence of flooding and waterlogging in the area.
2	Jl. Mayor Sabara, Secir Sekip Tengah (Sp. Gersik) Height : 5–20 cm Receding duration: 2–3 hours	It is necessary to recondition the channels leading to the watershed around Sp. Gersik, and subsequently, conduct watershed conservation in the surrounding area to anticipate flooding and waterlogging.
3	Jl. Mayor Sabara, Around Sekip Tengah (In front of SDN 156) Height : 5–20 cm Receding duration: 2–3 hours	It is necessary to recondition the channels leading to the watershed around SDN 156. Additionally, watershed conservation efforts in the surrounding area should be implemented to mitigate the risk of flooding.
4	Jl. May Sabara, Around Sekip Tengah (Sp. Lorong Hanan) Height : 5–20 cm Receding duration: 2–3 hours	It is necessary to recondition the channels leading to the watershed around Sp. Lorong Hanan, and subsequently carry out watershed conservation around the area to better anticipate flooding.
5	Sekip Bendung Height : 20–50 cm Receding duration: > 4 hours	The flooding in Sekip Bandung is in close proximity to the watershed, it is essential to conserve the watershed around the area to prevent future flooding events.
6	Simpang POLDA. Height : 20–50 cm Receding duration: 1–2 hours	It is essential to recondition the channels around the Sp. POLDA to mitigate the risk of flooding.
7	Jl. May Sabara, Around Sekip Tengah (In front of Mammee Bakery) Height : 5–20 cm Receding duration: 2–3 hours	It is necessary to recondition the channels leading to the watershed around Jl. May Sabara. Additionally, watershed conservation efforts in the surrounding area should be implemented to mitigate the risk of flooding.

Table 4. Flood Frequency Analysis (5-10 Times Per Year) in Kemuning District.

No	Flood Point	Analysis
1	Jl. Rawa Jaya Height : 20–50 cm Receding duration: > 4 hours	It is necessary to recondition the channels leading to the watershed around Jl. Rawa Jaya in order to effectively anticipate and mitigate flooding.
2	Jl. Tombak Height : 20–50 cm Receding duration: > 4 hours	It is necessary to recondition the channels around Jl. Tombak to effectively anticipate flooding. Additionally, it is important to reassess the rain discharge conditions in the area.
3	Jl. AKBP H. Umar, Lorong Harapan Jaya/Waras Jaya 1 Height : > 50 cm Receding duration: 2–3 hours	It is necessary to recondition the channels around Jl. AKBP H. Umar, and carry out watershed conservation around the area to prevent flooding. Additionally, it is essential to recalculate the rain discharge conditions in the area. Following this, a design review of the water channels around Jl. AKBP H. Umar should be conducted to assess whether they are still accommodate the rainwater runoff and channel it effectively into the watershed.
4	Jl. Lieutenant Simanjuntak Height : 20–50 cm Receding duration: > 4 hours	It is necessary to recondition the channels leading to the watershed around Jl. Lieutenant Simanjuntak to prevent flooding and inundation in the area. This will help improve the flow of water and reduce the likelihood of flooding during heavy rainfall events.

Table 5. Flood Frequency Analysis (15 Times Per Year) in Kemuning District.

No	Flood Point	Analysis
1	Jl. Sirna Raga Height : > 50 cm Receding duration: 3–4 hours	It is necessary to recalculate the condition of rain discharge in the area. Subsequently, a design review of the water channels around Jl. Sirna Raga should be conducted to assess whether they can still accommodate the rain discharge and effectively channel it into the watershed. This will help ensure that the infrastructure can handle future rainfall events and prevents flooding.
2	Jl. Rawasari Height : > 50 cm Receding duration: 3–4 hours	It is necessary to recondition the channels leading to the watershed around Jl. Rawasari, followed by conservation efforts for the watershed in the surrounding area to anticipate flooding and inundation. Additionally, it is crucial to recalculate the rain discharge conditions in the area and conduct a design review of the water channels around Jl. Rawasari to determine if they can still effectively accommodate the rain discharge and channel it into the watershed. This will help mitigate the risk of flooding and ensure the proper management of stormwater.
3	Jl. Angkatan 66 Height : > 50 cm Receding duration: 3–4 hours	It is essential to recalculate the rain discharge conditions in the area and conduct a design review of the water channels around Jl. Angkatan 66 to determine whether they are still capable of accommodating the rainwater discharge and effectively channeling in into the watershed.
4	Jl. Cambai Height : > 50 cm Receding duration: 3–4 hours	The flooding on Jl. Cambai is in close proximity to the watershed, it is essential to conserve the watershed around the area to prevent future flooding events.
5	Jl. Super Semar Height : > 50 cm Receding duration: > 4 hours	It is essential to recalculate the rain discharge conditions in the area and conduct a design review of the water channels around Jl. Super Semar to determine whether they are still capable of accommodating the rainwater discharge and effectively channeling in into the watershed.
6	Lr. Kalpataru Height : > 50 cm Receding duration: > 4 hours	It is essential to recalculate the rain discharge conditions in the area and conduct a design review of the water channels around Lr. Kalpataru to determine whether they are still capable of accommodating the rainwater discharge and effectively channeling in into the watershed.
7	Jl. Basuki Rahmat Height : > 50 cm Receding duration: > 4 hours	Due to the proximity of flooding on Jl. Basuki Rahmat to the watershed, it is essential to implement watershed conservation measures in the area to mitigate the risk of flooding and inundation.
8	Pasar Sekip Ujung Height : > 50 cm Receding duration: > 4 hours	It is necessary to recondition the channels leading to the watershed around Pasar Sekip Ujung, followed by conservation efforts for the watershed in the surrounding area to anticipate flooding and inundation. Additionally, it is crucial to recalculate the rain discharge conditions in the area and conduct a design review of the water channels around Pasar Sekip Ujung to determine if they can still effectively accommodate the rain discharge and channel it into the watershed. This will help mitigate the risk of flooding and ensure the proper management of stormwater.

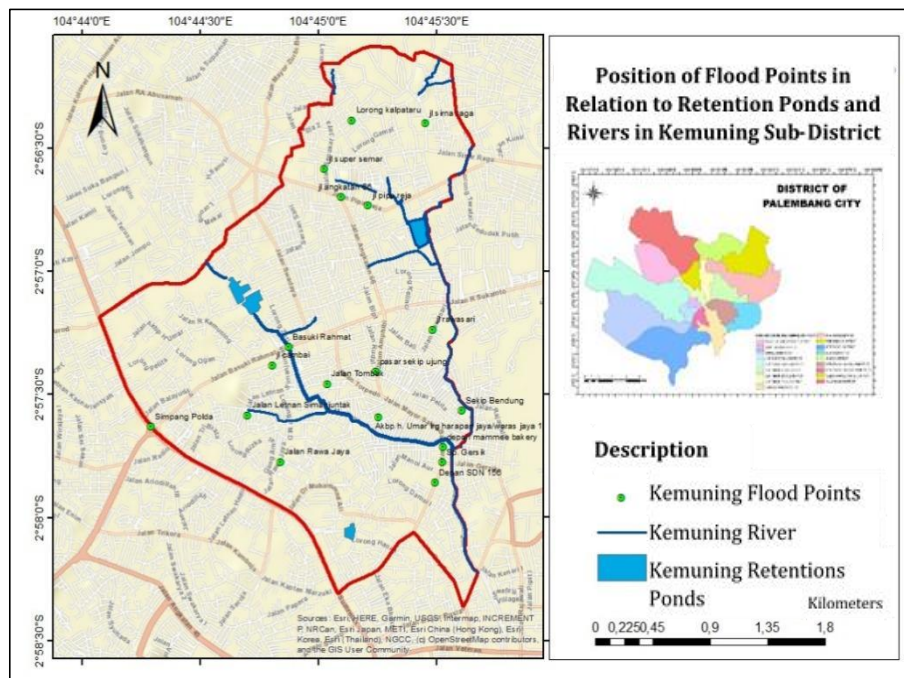


Fig 4. Distribution of Flood Points in Kemuning District.

4.3 Causes of Flooding in Palembang City

Based on the investigation, the causes of flooding in Palembang City can be attributed to the following factors:

1. Inadequate Drainage System: Waterways and drainage system often fail to drain effectively due to various reasons, including:
 - Accumulation of garbage in the drainage system.
 - Siltation of waterways due to sedimentation and sludge deposits.
 - Obstruction of drainage systems by buildings, such as sidewalks or other structures, making the channels difficult to clean and maintain.
 - Vegetation or plant growth obstructing the flow of water in the drainage systems.
 - The capacity of the drainage system is insufficient to accommodate the volume of surface water entering the channels.
2. Distance from Catchment Area: The distance from rivers, retention ponds, or swamps delays the flow of rainwater into these catchment areas. This problem is exacerbated when the condition of the drainage system is poor, as mentioned in point 1. In some areas, the water takes over four hours to recede, prolonging flooding.
3. Poor Maintenance of Retention Ponds: Retention ponds that are not properly maintained, such as those overgrown with water hyacinth, inhibit water flow and reduce the storage capacity of the ponds, exacerbating flooding.
4. Improper Construction of Retention Ponds: Some retention ponds have soil-based pavement structures, which may cause landslides along the pond's walls, leading to soil erosion that enters the pond, resulting in sedimentation and reduced pond capacity.
5. Misuse of Retention Ponds: Activities such as fish farming in retention ponds can significantly reduce their capacity to manage water.
6. Loss of Tributaries: Accumulation of garbage or the conversion of tributaries into residential or other

built-up areas contributes to the loss of natural drainage channels, aggravating flooding.

7. Reclamation of Swamps Area: The reduction of rainwater catchment areas due to the reclamation of swamps of residential or commercial development disrupts the natural water flow, contributing to flooding.
8. Low-lying Areas: Some flood-prone areas, even near rivers or retention ponds, continue to experience flooding due to inadequate capacity in the surrounding water bodies, compounded by the issues previously discussed.
9. Excessive Rainfall: High or prolonged rainfall can overwhelm the drainage and retention systems, leading to flooding.

5. Discussion

Mitigation measures based on investigation by relevant authorities and the local community include:

1. Dredging and Maintenance of Retention Ponds: Siltation in retention ponds should be addressed through dredging, garbage removal, and regular maintenance. Additionally, sluice gate networks should be improved to prevent waste from entering the ponds. These efforts should be conducted by the government in collaboration with the local community.
2. Construction of New Retention Ponds: New retention ponds should be established in flood-prone areas to enhance water management.
3. River Normalization and Restoration: The normalization of rivers through the removal of obstructions such as building, construction of retaining walls, and cleaning of river channels is necessary to improve water flow.
4. Improvement of Drainage Systems: New drainage systems should be constructed, considering the existing water discharge in the area to ensure proper capacity and functionally.

- Implementation of Flood Control Systems: The development of the Palembang City Flood Control System, which incorporates retention ponds with a storage capacity of 50.000 m³ and automatic sluice gates, is a critical component in managing flooding in Palembang. The system features submersible drainage pumps with a capacity of 6.000 liters per second, designed to mitigate inundation over an area of 245 hectares. A total of six pump units have been installed, positioned along the Bendung River, and are situated the following retention ponds: Seduduk Putih, IBA, POLDA, Sekip, and Talang Aman. It is anticipated that these pumps will reduce flooding across 240 hectares. Furthermore, one mobile pump unit, along with equipment such as gabions and sandbags, managed by the Balai Besar Wilayah Sungai (BBWS VIII), is on standby to address emergent flooding situations. However, the construction of the flood control pump and retention ponds has led to new flooding problems in the 9 Ilir and 10 Ilir areas, which were previously unaffected. This highlights the need for careful consideration of the impacts of such flood control measures on surrounding areas. The pumps are intended to accelerate the flow of water to the nearest river while considering the highest water levels during floods.

6. Conclusion

Based on the analysis conducted, several strategic measures are proposed to mitigate flooding in Palembang City:

- Normalization and construction of retention ponds should be implemented to enhance water retention capacity. This included the rehabilitation of existing retention ponds and the development of new ones, with active involvement from the surrounding communities.
- River normalization and restoration are essential to ensure the efficient flow of water. These activities should include removing obstructions and rehabilitating degraded riverbanks, also with the participation of local communities.
- Redesigning of drainage systems must be undertaken with careful consideration of current and projected surface water discharge to ensure they can adequately accommodate stormwater flows.
- Construction of flood control infrastructure, such as pumps and automatic sluice gates within retention ponds, should be prioritized to expedite water discharge during heavy rainfall events and to minimize flood inundation.

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