Identification of Flood Distribution Per District Based on GIS in Palembang City

Rahmad Hidayat Saputra[1], Indrayani[2], Ahmad Mirza[3], Ahmad Najib[4], M Agung Prakoso[5], Wenda Latifah Anjani[6]

[1-6]Civil Engineering Department, State Polytechnic of Sriwijaya, Palembang, Indonesia
indrayani@polsri.ac.id

Abstract. Palembang City is one of the largest and most populous cities on the island of Sumatra, Indonesia. The topography of the Palembang City area is mostly lowland, which is one of the causes of frequent flooding, especially when rainfall is high, so the potential for hydrometeorological disasters in the Palembang City area cannot be avoided. In this research, the distribution of floods per sub-district in Palembang City was identified as an effort to anticipate and minimize risks and losses resulting from flood disasters. Flood distribution points are mapped using GIS. From the map of the distribution of flood points, there are 196 flood inundation points with variations in height of 5–50 cm totaling 51 points, 20–50 cm totaling 93 points, and more than 50 cm totaling 52 points spread across all sub-districts in Palembang City. Flood points occur with quite high rainfall intensity, on average reaching 10-15 times a year with a frequent frequency category (> 5 a year), an average height of 20–50 cm, and a receding duration for the flood point of 2–4 hours or even more at several points in the sub-districts in Palembang City.

Keywords: Flood Map, Palembang City, District, GIS

1 Introduction

Palembang City is one of the largest and second-most populous cities in Sumatra after Medan City. Currently, the Palembang City area is divided into 18 sub-districts and 107 sub-districts. Based on data from the Meteorology, Climatology, and Geophysics Agency (BMKG) station and rainfall analysis results for October 2022, rainfall in the South Sumatra region is dominated by high-criterion rainfall (301–500 mm) with rain characteristics in the normal to above-normal range. Very high rainfall (>500 mm) occurred in small parts of Musi Banyuasin, Palembang, and Muara Enim. This high rainfall is a rare event experienced over the last 30 years in Palembang City.

The cause of this rainfall is the continued strengthening of La Nina and negative IOD, which is driving an increase in rainfall during the rainy season, which will take place from 2022 to 2023. With increasing rainfall in the Palembang City area, the potential for hydrometeorological disasters cannot be avoided. This condition has the potential to increase the risk of hydrometeorological disasters in areas in Palembang City that receive very heavy to extreme rainfall, causing flooding. With the geography of

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Palembang City being predominantly lowland, it is not surprising that Palembang City is often surrounded by floods when it rains with high intensity.
Based on a report from the Regional Disaster Management Agency (BPBD) of Palembang City, flooding will occur in the Palembang City area if there is high-intensity rain, which causes the water discharge of the Musi River to overflow, and this condition is made worse by less than optimal city drainage factors. The worst flooding in Palembang City occurred in December 2021, when the water level at that time was around 50–100 cm. There are hundreds of flood points that occur in Palembang City, where flooding in residential areas is almost evenly distributed in every sub-district that is flooded, starting from Sukarami, Kemuning, Kalidoni, Alang-Alang Lebar, Ilir Timur II, Ilir Timur I, Ilir Timur I, Sako, Seberang Ulu I, Seberang Ulu II, and surrounding areas.
To overcome this problem, it is necessary to map the distribution of floods in each sub-district in the Palembang City area. By mapping the distribution of floods, we can anticipate and minimize the risks and losses resulting from flood disasters that occur.

2 Literature Review

2.1 Theoretical Studies

5.2.1 Flood

According to Law No. 24 of 2007, a flood is an event or situation where an area or land is submerged due to the increasing volume of water. Lapan distinguishes between floods and inundations, where the category of flood is if the water level exceeds 40 cm, covers a large area, and usually has a radius of more than 100 m, while for inundation, the spatial scale is when the water level is less than 40 cm, with the area only concentrated in one section and usually covering an area of less than 100 m. There are three factors that greatly influence flooding, namely:

1. Meteorological elements (intensity, distribution, frequency, and duration of rain).
2. Watershed characteristics (watershed area, land slope, height, and soil water content)
3. Human factors that have an influence on the conversion of a conservation area can reduce the soil's ability to absorb and retain water, which ultimately increases the opportunity for surface runoff to occur also erosion.

5.2.2 Flood Control

Flood control needs to be done to prevent and reduce losses caused by flooding. The main components of flood control efforts are water resource management, spatial planning, disaster threats, and coastal area management.
In general, there are two types of control, namely structural flood control (land reforestation, construction of building infrastructure to control flow, canalization and others) and non-structural flood control including spatial control, increasing public awareness, mapping flood-prone areas and so on.

5.2.3 Flood Category

Based on the location of the surface flow source, floods are divided into two categories: flash floods and local floods. Meanwhile, based on the mechanism, floods are divided into two types: regular floods, namely floods caused by rain, and irregular floods, namely floods caused by something other than rain (tsunami, etc.).

2.2 Identify Inundation or Flooding in Palembang City

The rapid development in the city of Palembang has resulted in an increasing shortage of land for development. This has an impact on landfills in swampy areas so that development can be carried out on them. The reduction in water catchment areas can, of course, cause the spread of flooding to become wider because rainwater, which should be directly absorbed in swamp areas, can no longer be accommodated in swamp areas due to the backfilling carried out in swamp areas, causing water to stagnate on the ground surface.

Inundation or flooding in Palembang City is not only caused by a reduction in land area but also due to inadequate river capacity or drainage, as well as the presence of retention ponds that do not function properly and river shallowing. The heavy rain that fell on the city of Palembang on October 5 and 6, 2022, reached 188.7 mm. This rainfall was the highest extreme rainfall in October during the last 30 years (https://iklim.sumsel.bmkg.go.id), which caused most of the city of Palembang to be flooded.

Fig. 1. Flood conditions in front of the Herper Hotel and the surrounding area on October 6, 2022.

Some of the main roads that frequently flood are as follows:

1. RE Road. Martadinata in front of BNI Lemabang with flooding or flooding at a height of 50 cm in Ilir Timur Dua District.
2. Jalan Sergeant KKO Badaruddin to SMA N 5 Palembang with flooding or flooding at a height of 70 cm to 1 meter in Ilir Timur Dua District.
3. Foundation 1, with flooding/flooding at a height of 50 cm, in Ilir Timur Dua District.

4. Jalan Arafuru with flooding at a height of 70 cm in Ilir Timur Dua District.
5. in front of the Ajendem Mosque to the Ayam Sekojo Church with flooding or flooding at a height of 1 meter in Ilir Timur Dua District.
6. Jalan RW. Mangonsidi with flooding/flooding at a height of 80 cm, Kalidoni District.
7. Resident Abdul Rozak with flooding or flooding at a height of between 50 cm and 1 meter, Kalidoni District.
8. Demang Lebar Daun 9, Jalan Jenderal Sudirman, Ilir Timur I District.
9. Sekip, Kemuning District.
10. Jalan Sukabangun II, Sukarami District.
11. Jalan Ratu Prawira Negara, Ilir Barat Satu District.
12. Jalan Simpang Patal, Ilir Timur III District.
13. Jalan Kemang Manis Bukit Besar, Ilir Barat Dua District.

2.3 Research Roadmap

This research is a continuation of previous research on evaluating the distribution of floods in the city of Palembang using remote sensing technology (Indrayani et al., 2021). In this research, flood distribution mapping is carried out through field investigations, and the results will be analyzed using GIS so that we can get a database to identify the condition of retention ponds as flood control structures.

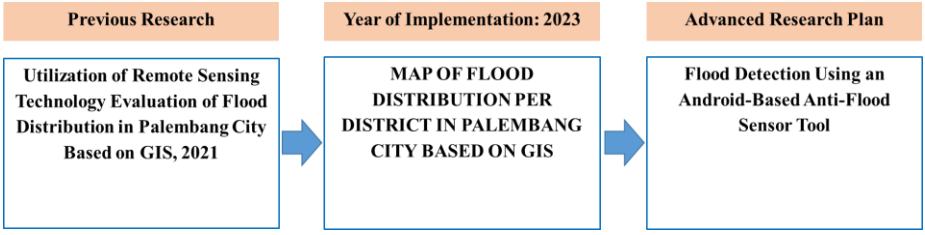

Fig. 2. Research Roadmap.

2.4 State of the Art

This research uses theoretical studies, data, formulas, and methods from previous studies. The essence of several previous research studies is used to support the arguments that will be prepared, so that this research is more complete and useful. Several studies have been carried out related to flood analysis, including Indrayani et al. (2023), conducting research on the distribution of floods in Palembang City using remote sensing technology. Furthermore, in 2020, Utomo et al. also researched the distribution of floods in DKI Jakarta using Setelit Sentinel-1 imagery, with the title: Utilization of Remote Sensing in Palembang City. From the research results, it was found that the flood distribution area in Palembang City will increase in 2022. And several other researchers also researched the distribution of floods using remote sensing and GIS technology (Utomo et al., 2020; Muamanah, 2019; Laurensz et al., 2019; Ariyora et al., 2015).

Some literature discusses more than one theme. The section that describes the relationship between the themes discussed in previous research, which have a direct connection with this research, is explained in Figure 3.

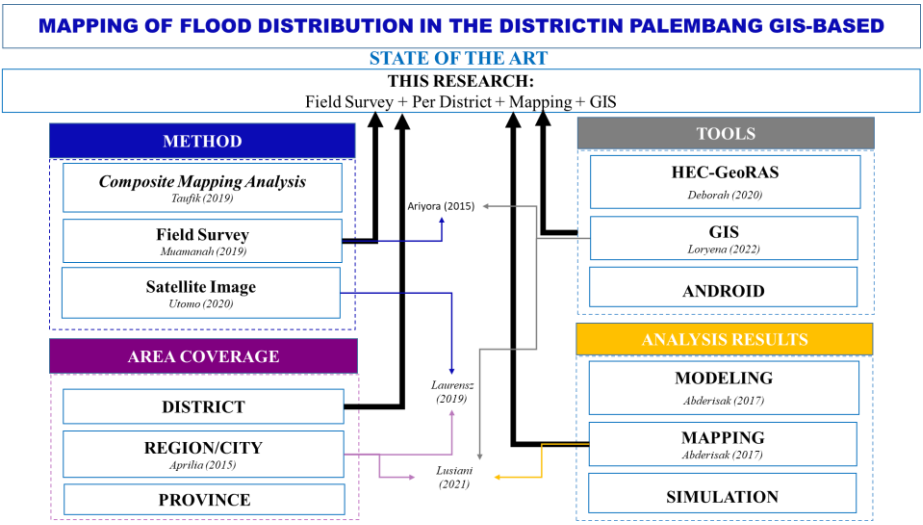

Fig. 3. Previous Research Gaps.

2.5 Conceptual Framework of Thinking

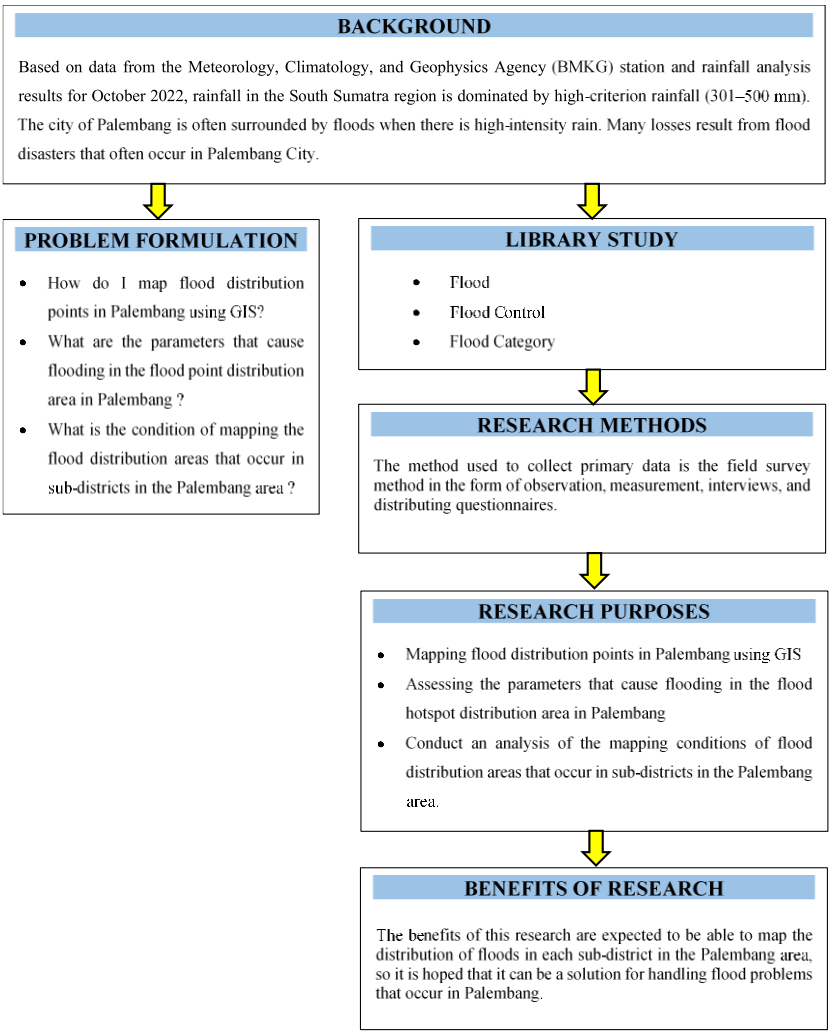

Fig. 4. Conceptual Framework of Thinking.

3 Research Objectives and Benefits

The aim of this research is to map flood distribution points in Palembang City using GIS. The benefits of this research are expected to be able to map the distribution of floods in each sub-district in the Palembang City area, so it is hoped that it can be a solution for handling flood problems that occur in Palembang City.

4 Research Methodology

4.1 Study Region

The study area covers 107 sub-districts and 18 sub-districts within the Palembang City area. The study area can be seen in Figure 5.

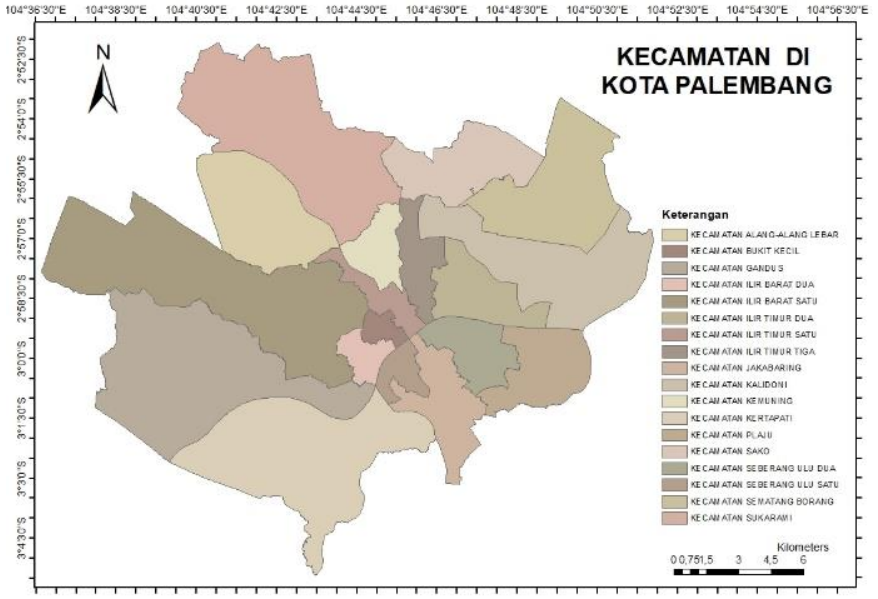

Fig. 5. Palembang City Inundation or Flooding Study Area.

4.2 Method of Collecting Data

The method used to collect primary data is the field survey method in the form of observation, measurement, interviews, and distribution of questionnaires, which is explained in Table 1. The secondary data collected and the agencies involved in collecting this data are explained in Table 2.

Table 1. Type And Location of Primary Data Collection.

Data Primer	Data Collection Locations
Area data, coordinates, sub-district, swamp sub-district	Results of Google Earth interpretation and GIS data processing
Data on length, sub-districts, and sub-districts through which rivers and tributaries pass	Sub-districts and sub-districts in the city of Palembang and GIS data processing
The distribution of inundation and flooding includes the location of inundation and flooding points, coordinates, duration of inundation and flooding, intensity of	Interviews and distribution of questionnaires to all people who live in the city of Palembang, sub-districts, and sub-districts within the city of Palembang

inundation and flooding, and height of inundation and flooding	
Description of inundation or flooding	Interviews and distribution of questionnaires to related parties in sub-districts and sub-districts in the city of Palembang, which are included in the study area

Table 2. Types And Agencies Related to Secondary Data Collection.

Data Seconds	Institution
• Data on the distribution of inundation and flooding in Palembang City • Map of the river network in Palembang City • Palembang area data • Palembang City population data • Related maps	• Palembang City PUPR Department • Palembang City, Bapeda • Palembang City Geoportal • USGS Earth Explorer • RBI

4.3 Research Stages

The stages carried out in this activity include:

1. A preliminary survey was carried out to obtain initial data, which is an important part of the technical study materials and materials for further work.
2. Manufacturing through interviews and surveys to obtain information on the distribution of the area of inundation or flooding, the intensity of inundation or flooding, the height of inundation or flooding, the duration of inundation or flooding, and efforts made to prevent and control inundation or flooding in sub-districts and sub-districts in Palembang City.
3. Collection of secondary data in the form of:
   a. Number of residents in Palembang City
   b. The area of sub-districts and wards in Palembang City
   c. Maps related to the required data
4. Distributing questionnaires and interviews to related parties, including the community and community leaders, as well as sub-district and sub-district parties in the Palembang City area. The distribution of the questionnaire was carried out in two stages, namely:
   a. The first stage is distributing the questionnaire via social media (WhatsApp, Facebook, and Instagram) to people who live in Palembang City. The number of sample respondents was taken using the equation Slovin:

$$n = N / [1 + (N \times e2)] \quad (1)$$

Where:
n = number of samples
N = total population of Palembang City aged 20–64 years (± 800,000 people)
e = standard error (5%)

So that,

$$n = 800.000/[1 + (800.000 \times 0{,}052)]$$
$$= 800.000/2001$$
$$= 399{,}8 \approx 400 \text{ respondents}$$

b. The second stage involves distributing questionnaires and conducting interviews directly to the field (sub-districts and sub-districts in Palembang City) to obtain the existing conditions of inundation and flooding that occur in sub-district and sub-district areas in Palembang City and carrying out cross-checks on the results of distributing the questionnaire in the first stage to the field to obtain the coordinates and description of the location of the flood point.

4.4 Data Analysis Method

The results of the questionnaire data collection are then processed using Microsoft Excel so that the locations of flood points can be obtained both from the results of questionnaires and interviews. Investigation results from location photos that have ordinates, tracking location points plotted on Google Earth, and digitizing the ordinate points. The results of digitizing flood points are plotted into GIS to assign attributes to each point. The final result of data processing is a thematic map mapping the distribution of flood/inundation points per sub-district in Palembang City, and then an analysis of the existing mapping results is carried out.

5 Research Results and Discussion

5.1 Geographical Conditions of Palembang City

Palembang City consists of 18 sub-districts and 107 sub-districts, with an area of 400.6 km2. Administratively, the territorial boundaries of Palembang City are where the north borders Banyuasin Regency, the south borders Ogan Komering Ilir Regency and Banyuasin Regency, the east borders Banyuasin Regency, and the west borders Banyuasin Regency, Muara Enim Regency, and Ogan Komering Ilir Regency.

5.2 Distribution of Inundation and Flood Points in Palembang City

Based on the results of investigations carried out in October 2022 in 18 sub-districts in Palembang City, there were 196 points of inundation or flooding, with variations in height from 5 cm to more than 50 cm. The distribution of flood points resulting from the investigation is shown in Figure 6.

Fig. 6. Distribution of inundation and flood points in Palembang City.

5.2.1 Distribution of Inundation/Flood Points Based on Flood Height

The distribution of inundation and flood points based on the height of the standing water is divided into 3 levels, namely those with a height of 5–20 cm, a height of 20–50 cm, and a height of >50 cm. The number of inundation or flood points at each height can be seen in Table 3 and Figure 7.

Table 3. Number of Inundation/Flood Points Based on Height.

No	Flood Height	Number of Flood Points (Points)	Percentage (%)
1	5 - 20 cm	51	26 %
2	20 - 50 cm	93	47 %
3	> 50 cm	52	27 %
	TOTAL	196	

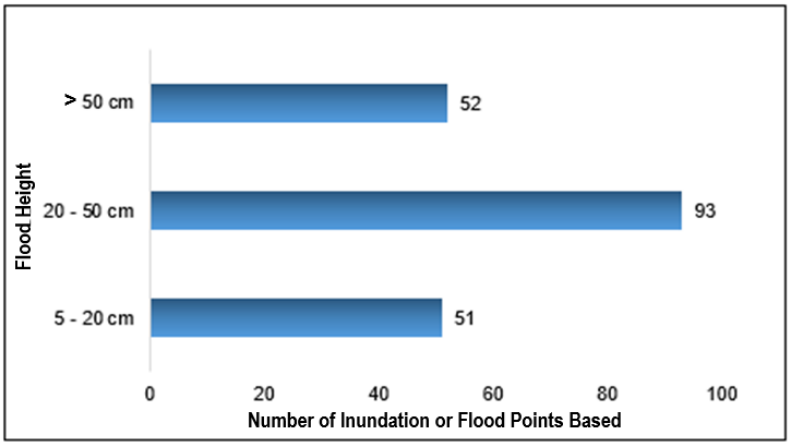

Fig. 7. Graph of the Number of Inundation or Flood Points Based on Height.

From Table 3 above, it can be seen that the highest percentage of flooding occurs at a water level of 20–50 cm, namely 93 points, or 47% of the total points of inundation and flooding. This shows that inundation and flooding in Palembang City still require serious attention in their handling.

5.2.2 Distribution of Inundation/Flood Points Based on Frequency of Occurrence

The distribution of inundation/flood points based on the frequency of flood occurrence is divided into 4 groups, namely: < 5 times; 5–10 times; 10–15 times; and > 15 times. The number of flood points in each group can be seen in Table 4 and Figure 8.

Table 4. Number of Inundation/Flood Points Based on Flood Frequency.

No	Flood Frequency	Number of Flood Points (Points)	Percentage (%)
1	< 5 kali	61	31 %
2	5 - 10 kali	57	29 %
3	10 - 15 kali	36	18 %
	TOTAL	196	

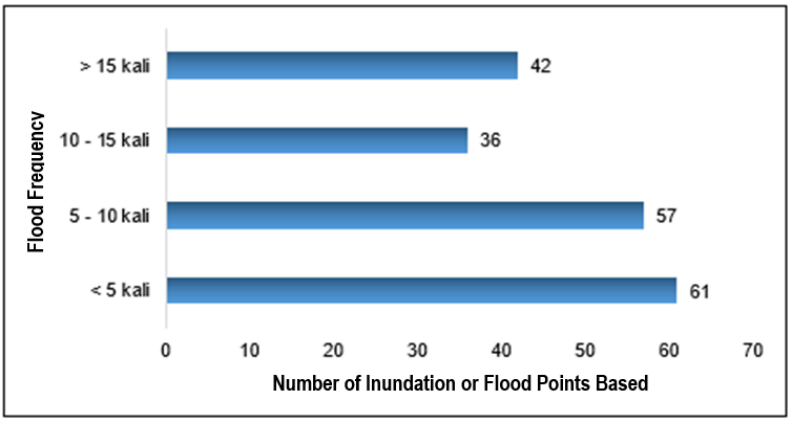

Fig. 8. Graph of the Number of Inundation or Flood Points Based on Frequency.

From Table 4 above, it can be seen that the highest percentage of inundation/flood frequency is less than 5 times, namely 61 points, or 31% of the total inundation/flood points, and the lowest flood frequency is 10–15 times, which is 18%, or 36 points.

5.2.3 Distribution of Inundation/Flood Points Based on the Duration of Water Flooding

The distribution of flood points based on standing water is divided into 4 groups, namely: < 1 hour; 12 hours; 2–3 hours; 3–4 hours; and > 4 hours. The number of inundation or flood points can be seen in Table 5 and Figure 9.

Table 5. Number of Inundation/Flood Points Based on Inundation Duration.

No	Flood Duration (Hour)	Number of Flood Points (Points)	Percentage (%)
1	< 1	25	13 %
2	1 – 2	48	24 %
3	2 – 3	27	14 %
4	3 – 4	21	11 %
5	> 4	75	38 %
	TOTAL	196	100

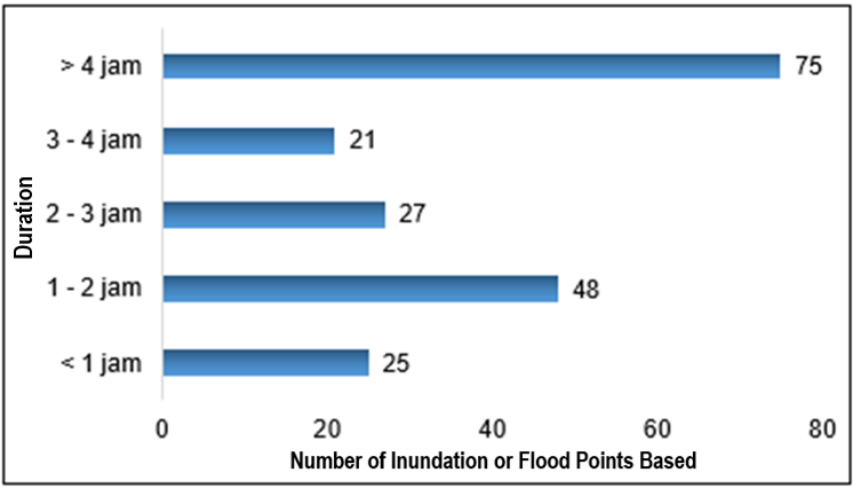

Fig. 9. Graph of the Number of Inundation or Flood Points Based on the Duration of the Water Inundation.

From Table 5 above, it can be seen that the highest duration of inundation was more than 4 hours, namely 75 points, or 38% of the total inundation/flood points. This shows that stagnant water still takes a long time to reach the water source or water catchment area.

6 Conclusion

Based on this research, we identified the distribution of inundation and flooding points that occurred in each sub-district in Palembang City. From the analysis carried out, there were many factors that caused inundation and flooding points to occur in the area. After mapping the flood distribution points using GIS, we obtained a map of the distribution of flood points in each sub-district in Palembang City. From the map of the distribution of flood points, it can be seen that there are 196 flood inundation points with height variations of 5–50 cm totaling 51 points, 20–50 cm totaling 93 points, and >50 cm totaling 52 points spread across all sub-districts in Palembang City. Where inundation or flood points occur with fairly high rainfall intensity, on average reaching 10-15 times a year, which has a frequent frequency category of 5 per year, resulting in inundation or flood points occurring up to the average height. 20–50 cm with a receding duration for the inundation/flood point of 2-4 hours; even the duration of the receding point for the inundation point is up to > 4 hours at several points in the sub-districts in Palembang City.

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