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# Determination of Flood Distribution using Post-Flood Event Measurement

**Muhammad Adib Irsyad Zamri, Muhammad Afiq Syakirin A Halim, Muhammad Aiman Muhhafiz Idris, Muhammad Azraie Abdul Kadir***

*Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA*

*Corresponding Author: mazraie@uthm.edu.my
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**Abstract**

The determination of flood distribution is essential for understanding the extent and impact of flooding events. This study aims to determine the flood level in the Sri Medan, Johor area and develop a flood distribution map using post-flood event measurements. Additionally, this study also to analyze the causes of the flood in Sri Medan, Johor. A point measurement method was employed to gather data on flood levels in the Sri Medan area following a flood event. This involved collecting measurements at various locations within the affected region. Through the implementation of point measurement methods, the flood levels and distribution map in the Sri Medan area were successfully determined. The result shows several potential causes of the flood in Sri Medan which were also successfully determined.

## 1. Background Study

Flooding is a severe natural risk that may severely impact ecological and social systems [1]. Extreme rainfall events of high intensity have been a problem in Malaysian major centers since the 2000s, especially along the West Coast. Convection is the primary process by which this phenomenon is created. As a result, flooding is one of the main natural disasters that affects Malaysian communities and results in yearly losses of millions of moneys. Compared to the RM 1000 million necessary for flood mitigation projects during the 7th Malaysian Plan, the required allocation for the 8th Malaysian Plan has increased by over 600% (RM 6000 million) [2]. The presence of floods will lead to numerous challenges with human activity, health, and the economy. In addition, it causes structure damage, slope instability, and fatalities. Disaster management is viewed to reduce the danger of disasters, such as floods. To arrange relief efforts effectively, it is essential to promptly and accurately map the extent of flood areas in order to give a comprehensive picture of the flood situation. However, data on flood map extent increasingly difficult to acquire due to the data is expensive and time-consuming. The available data also limited to several area only [3]. This study aims to propose flood distribution using post flood event measurement which is point measurement methods to gather data on flood levels in the Sri Medan area following a flood event. This involved collecting measurements at various locations within the affected region.

## 2. Materials and Methods

The methodology of the investigation is described in this subtopic. This chapter includes a case study, data collection, GIS application, and analysis of flood measurement.

## 2.1 Case study: Sri Medan

The total population in Sri Medan is 36,145 people and the population density is 119 (per km2). One of the areas in Sri Medan, specifically Kg Sejagong, is an *Orang Asli* settlement [4]. Kg Sejagong serves as a community where indigenous Orang Asli people reside and is recognized as an important location within Sri Medan, contributing to the cultural diversity and heritage of the region [4]. The land in Sri Medan is mostly used for crops such as oil palm trees. Around the 60s, Sri Medan was often hit by floods for a long period of time. This is due to its location and the lack of an effective drainage system, and the recent flood occurred in Mac 2023. Fig. 1 shows the location of Sri Medan, Johor.

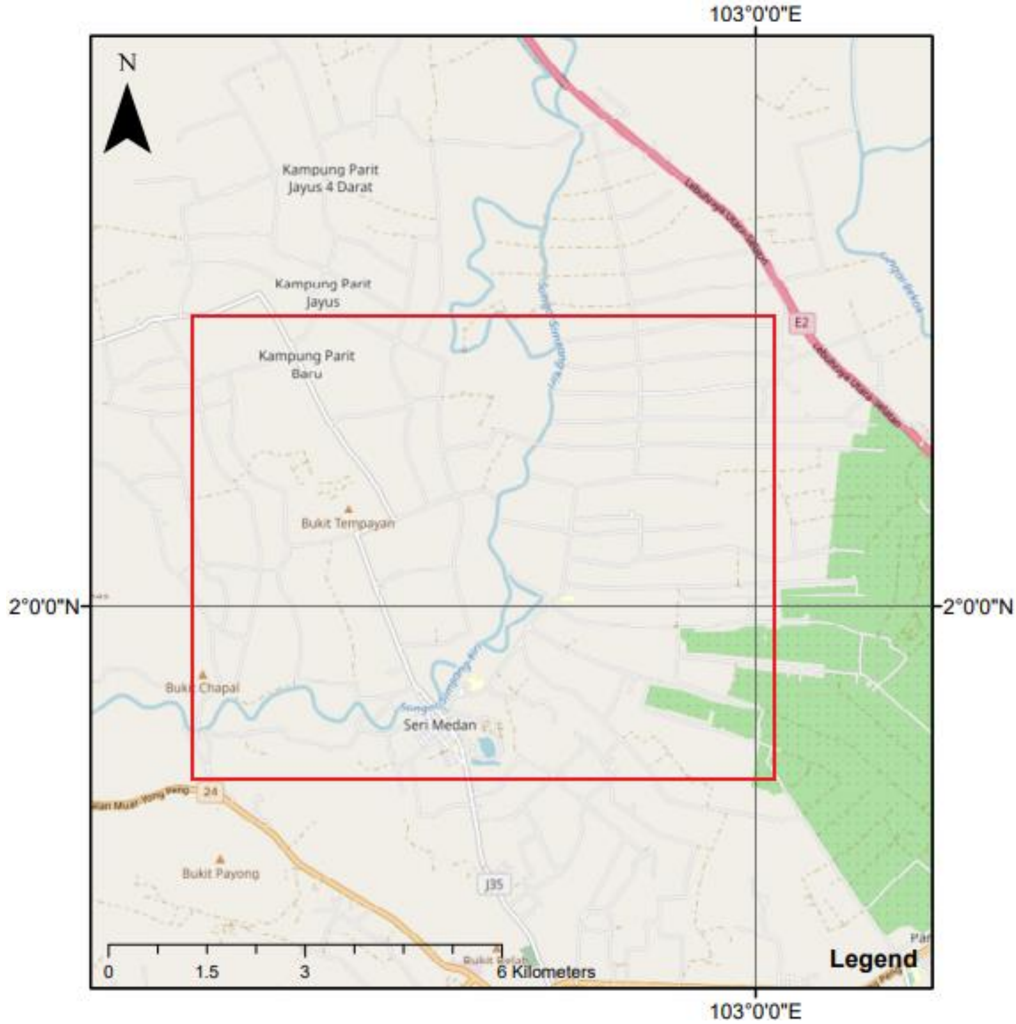



**Fig. 1** *Location of Sri Medan.*

## 2.2 Methods

The first step in the flood analysis process involves data collection, which is carried out using the point measurement method to identify the flood levels. This study made point in 22 different locations. Multi-location measurements provide a more comprehensive and reliable understanding of the target parameter [5]. This typically entails taking measurements at various locations within the affected area to determine the extent of flooding. Once the data has been collected, it serves as the foundation for the next step. In the second step, a flood distribution map is developed using ArcGIS software. ArcGIS can quantify impact crater diameters regardless of the specific map projection used as the image's foundation [6]. This mapping programme enables visualization and analysis of spatial data, enabling the creation of a comprehensive map illustrating the areas impacted by flooding. With the flood distribution map in hand, the third step involves analyzing the flood distribution. Analyzing the flood distribution involves studying the patterns, severity, and spatial extent of the flood. This analysis helps to identify how the floodwaters are distributed across the affected area, assess the level of damage caused, and understand the geographical area impacted by the flood [7]. By examining these characteristics, this study can gain a deeper understanding of the flood event, enabling the development of effective mitigation measures and emergency response plans. Finally, based on the findings from the previous steps, the fourth step involves proposing the likely cause or causes of the flood. This could involve considering various factors such as heavy rainfall, river overflow, inadequate drainage systems, or other contributing elements [8]. By following these steps, a systematic and detailed assessment of a flood event can be conducted, aiding in future planning and mitigation efforts.

## 3. Equations

In this equation, Inverse Distance Weighting interpolation (IDW) interpolation, is a spatial interpolation technique commonly used in (GIS) and geostatistics. In accordance with known values from adjacent sites, it is used to make estimates for values in unknown locations. Zi is the value that is known at each sample point i, while Z(x) is the value that is estimated at the target position x. Wi is the weight applied for each sample point i, calculated based on the distance between the target location and each sample point. IDW interpolation is a simple and intuitive method but can be sensitive to outliers and irregular data points [9]. The formula for IDW interpolation is as follows:

$$Z(x) = \sum(wi * Zi) / \sum wi \quad (1)$$

## 4. Results and Discussion

In this study, a total of 22 locations were taken in the Sri Medan area for data. Each location has a 3-point water level taken from the flood mark at the same structure after the flood event. The average of the 3-point water level value was taken as the water level for the location. The method used is to use a measuring tape and leveling staff to measure the water level for each location. Detailed location measurements are shown in Fig. 2 and Table 1.

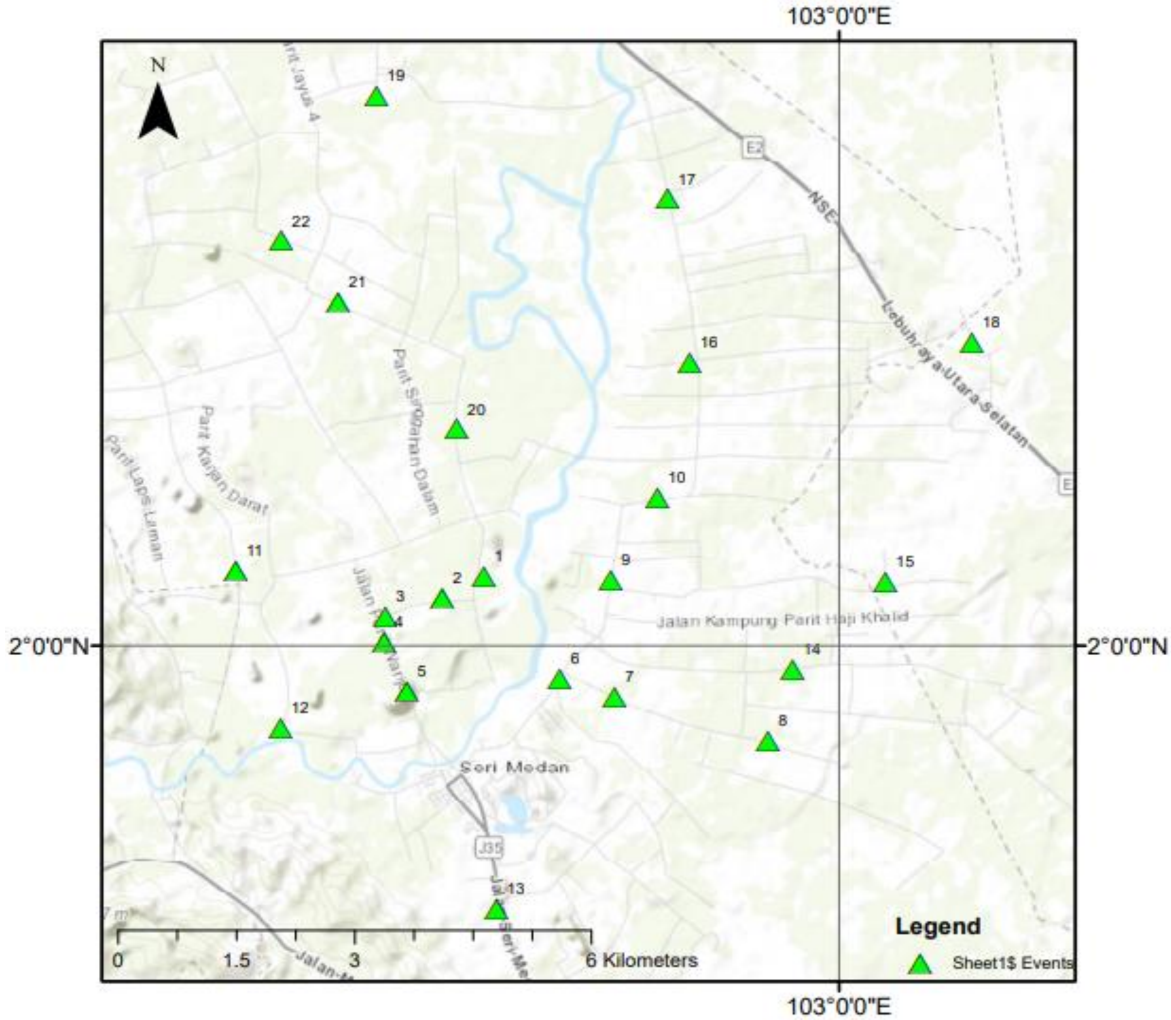
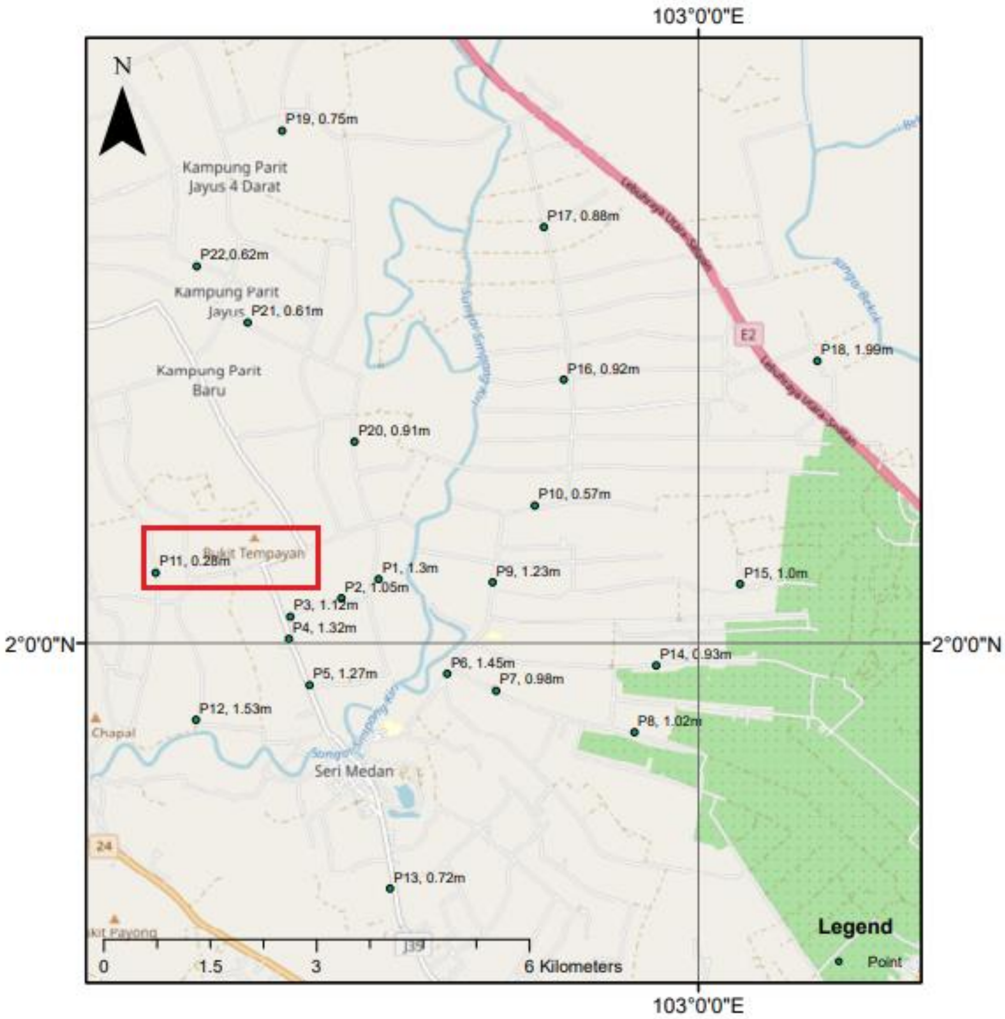



**Fig. 2** Number of points observed in Sri Medan

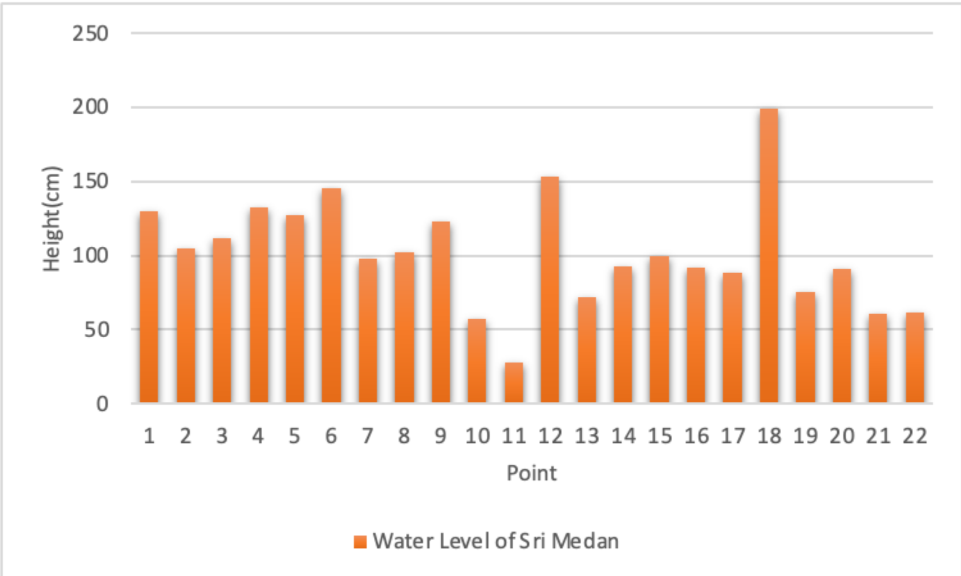
**Table 1** Data of flood area in Sri Medan

| No. | Water Level | Latitude | Longitude |
|---|---|---|---|
| 1. | 130cm | 2.008085 | 102.959469 |
| 2. | 105cm | 2.00566 | 102.954745 |
| 3. | 112 cm | 2.003319 | 102.948269 |
| 4. | 132 cm | 2.000489 | 102.948082 |
| 5. | 127 cm | 1.994651 | 102.950701 |
| 6. | 145 cm | 1.996073 | 102.96817 |
| 7. | 98 cm | 1.993919 | 102.974379 |
| 8. | 102 cm | 1.988679 | 102.991895 |
| 9. | 123 cm | 2.007689 | 102.973925 |
| 10. | 57 cm | 2.017382 | 102.979282 |
| 11. | 28 cm | 2.008878 | 102.931199 |
| 12. | 153 cm | 1.990258 | 102.936296 |
| 13. | 72 cm | 1.968867 | 102.960916 |
| 14. | 93 cm | 1.997137 | 102.99466 |
| 15. | 100 cm | 2.007463 | 103.005307 |
| 16. | 92 cm | 2.033375 | 102.982942 |
| 17. | 88cm | 2.052712 | 102.980429 |
| 18. | 199cm | 2.035727 | 103.015094 |
| 19. | 75cm | 2.064909 | 102.947231 |
| 20. | 91 cm | 2.025519 | 102.956412 |
| 21. | 61 cm | 2.040607 | 102.942862 |
| 22. | 62 cm | 2.047735 | 102.93641 |

The highest flood water level area in Sri Medan is at point 18, which is 199cm deep. This is due to the proximity to the primary water supply, flat topography, and natural drainage systems for water runoff from adjacent areas. The average flood water level in the area is 102cm deep, meaning it shows that the average area in Sri Medan has a low topographic structure and is easily flooded. The lowest flood water level in the Bukit Tempayan region is 28 cm deep due to its proximity to the steep Bukit Tempayan region and its distance from the river. The river's water-carrying capacity increases as floodwaters move downriver, and the time and distance taken for water to spread out affect the intensity and height of floodwaters. Fig. 3(a) and Fig. 3(b) shows the water level result of this study.



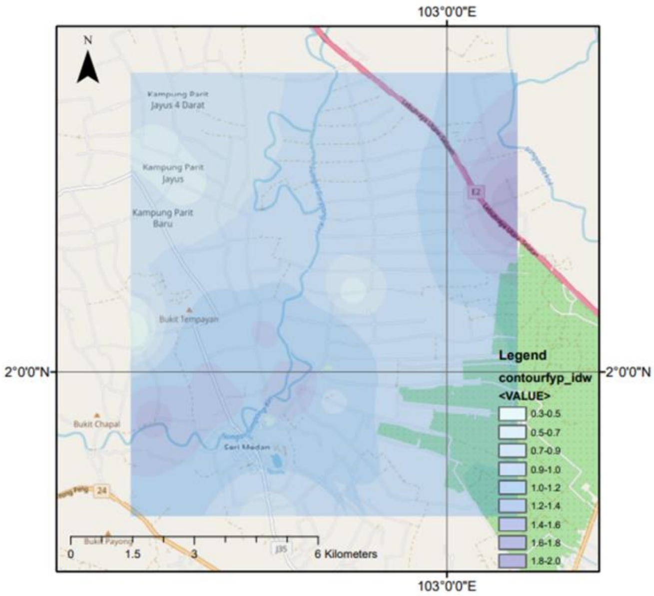

(a)



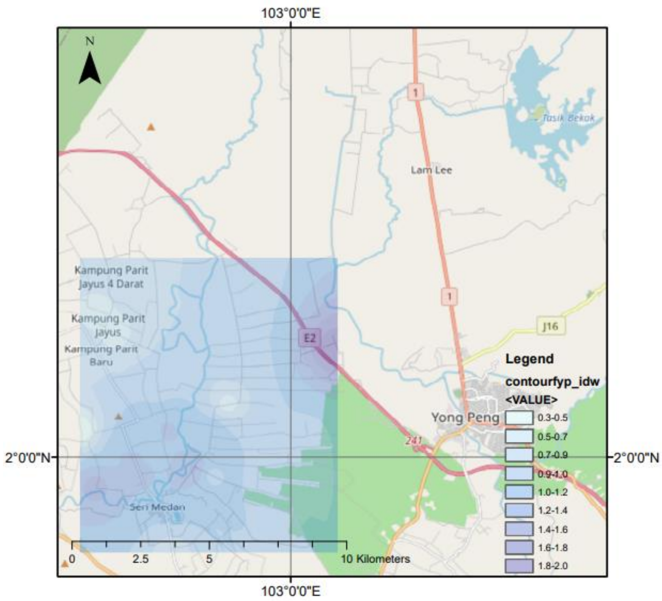

(b)

**Fig. 3** (a) Flood Distribution Water Level Map at Sri Medan, (b) Water Level of Sri Medan

The increasing flood water levels in a particular area in Sri Medan have become a growing concern due to their detrimental impacts on communities and infrastructure. This report presents the results of an analysis conducted on post-flood event measurements to investigate the rising flood water levels. The Sri Medan area, specifically around Sungai Bekok, Sungai Simpang Kiri near the North-South Highway, Sungai Simpang Kiri near Bukit Chapal, and Kampung Parit Jayus, experiences varying flood water levels. Flood water levels in Sungai Bekok, Sungai Simpang Kiri near the North-South Highway, Sungai Simpang Kiri near Bukit Chapal, and Kampung Parit Jayus all have varying levels of flood risk. Sungai Bekok has the highest recorded flood water level at 1.99 meters, Sungai Simpang Kiri near Bukit Chapal can be considered a moderate to moderately high flood risk, and Kampung Parit Jayus can be considered a lower flood risk. Fig. 4(a) shows the flood distribution in Sri Medan area, with some areas being flooded and some not. Most affected areas are close to rivers, but one area recorded high values.




(a)

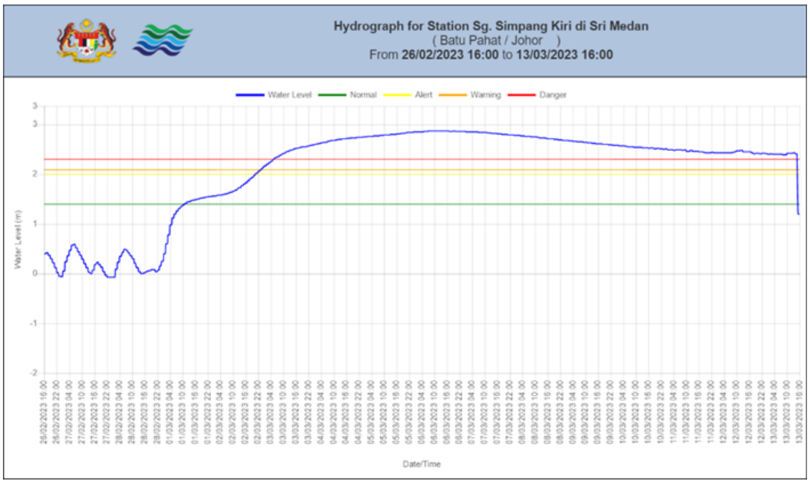



(b)

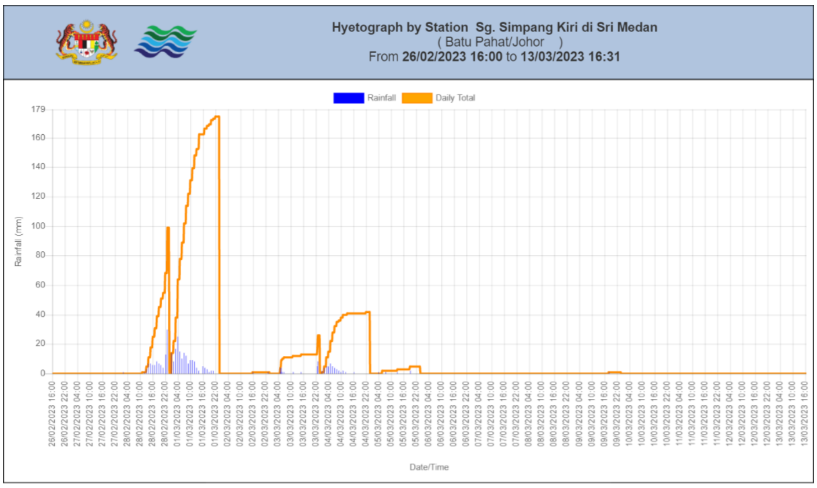
**Fig. 4** (a) Flood distribution in Sri Medan, and (b) Flood level in Sri Medan

The course of a flood is determined by terrain, amount and speed of water, and presence of barriers. The cause of a flood can be divided into three stages: Rising stage, Crest stage, and Fall stage. Rising stage occurs when water levels rise as rainfall increases the volume of water in rivers or other bodies of water. Crest stage occurs when the flood reaches its peak height and spreads to the low-lying area of Sri Medan. Fall stage occurs when the water level gradually recedes. Floods can take days or weeks to recede, depending on the amount of water involved and terrain of the affected area. Sea tides do not have a major impact on the severity of floods in low-lying areas, but high tides can have an adverse effect. Fig. 4(b) shows the flood level in Sri Medan. Floods can occur in a variety of ways, such as when a river or stream breaches its banks, inundating storms, collapsed levees or dams, or unprotected beaver dams.

The Sri Medan area is located 23.37 km from the nearest beach, so sea tides do not have a major impact on the severity of floods in low-lying areas. However, high tides can have an adverse effect on flooding by causing the water level to rise higher and cause large waves in nearby areas. Additionally, when high tide occurs, the natural flow of rivers and water bodies can be blocked, leading to rising water levels and potential flooding upstream. It is important to remember that depending on the local circumstances, the effect of sea tides on floods might change. Additionally, tidal flooding threats may become even more severe because of climate change consequences. Flooding can occur in a variety of ways, such as when a river or stream breaches its banks. Inundating storms collapsed levees or dams, or unprotected beaver dams can also cause flooding. Floods usually occur when it rains for several days, when heavy rain falls in a short period of time. For example, on 1/3/2023 until 6/3/2023, the Bekok river overflowed and filled the Simpang Kiri river, leading to flooding in the Sri Medan area. Fig. 5 and Fig. 6 shows the water level and rainfall that related to flood in Sri Medan taken online from JPS [10].

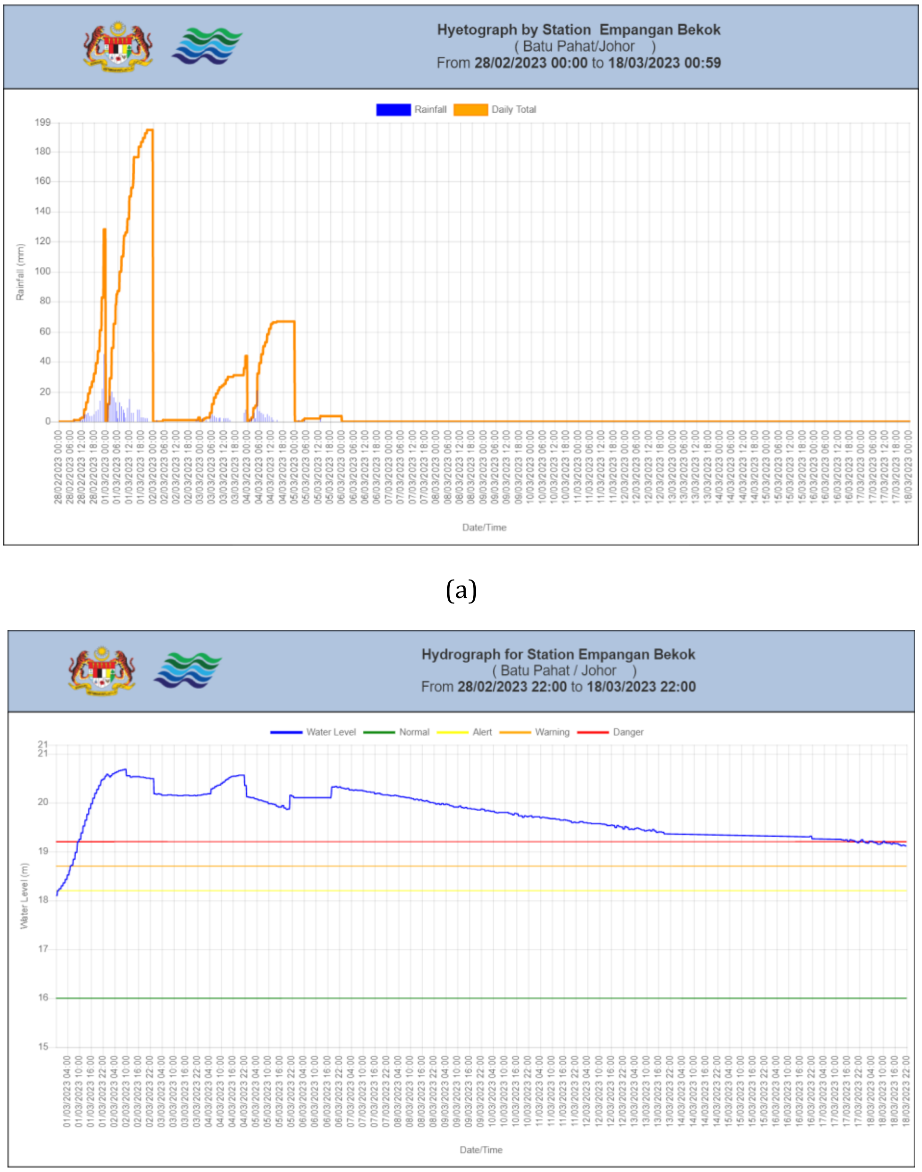



(a)




(b)

**Fig. 5** (a) Water level of Simpang Kiri river at Sri Medan, and (b) Rainfall data of Simpang Kiri river at Sri Medan




(a)

(b)

**Fig. 6** (a) Rainfall data of Bekok dam, and (b) Water level of Bekok dam

## 5. Conclusion

The flood water level data collected in Sri Medan shows that the region near the river has a higher flood water level than the area far from the river. The effectiveness of the drainage system in the affected region can have an impact on the time it takes for the flood water to recede. It is important to keep the drainage system in excellent working order and community awareness of the importance of maintaining a healthy drainage system is also important. Flooding is caused by heavy rainfall and water discharge from the Bekok dam, and low-lying areas are also a factor. This knowledge can be used to design effective flood prevention, mitigation, readiness, and response measures. To get more interesting data, the observation area must have a certain distance. By expanding the observation area, this study can capture a wider range of spatial variability and potentially identify different patterns or trends.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design, data collection, analysis and interpretation of results, draft manuscript preparation:*** *Muhammad Adib Irsyad Zamri, Muhammad Afiq Syakirin A Halim, Muhammad Aiman Muhhafiz Idris, Muhammad Azraie Abdul Kadir. All authors reviewed the results and approved the final version of the manuscript.*

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