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Research article

Flood Vulnerability and Mapping of Flood Evacuation Point District in Gayungan District, Surabaya City Using a Geographic Information System

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Abstract

Gayungan District is one of the areas in Surabaya that frequently experiences flooding. Generally, flooding can be categorized into two types: first, flooding caused by dry land being submerged by increasing water levels. Second, flooding caused by overflowing rivers/irrigation channels caused by blockages, which increase the volume of water beyond the river's capacity. The objectives of this study are: 1) Identifying flood-prone areas in Gayungan District using GIS-based river buffer analysis. 2) Analyzing the distribution of evacuation points and their suitability for flood-affected settlements. Using quantitative descriptive methods. The results show a 300-meter flood coverage zone, with one shelter and worship facility within the flood-affected zone.

Keywords: Floods, Shelters, Mapping

1. Introduction

Indonesia is a tropical country with only two seasons: the rainy season and the dry season. During the rainy season, several regions in Indonesia frequently experience disasters, including flooding. These floods are caused by several factors, both natural and human-caused. These factors cause water levels to rise and rivers to overflow, ultimately leading to flooding. Surabaya, the capital of East Java Province and the country's second-largest city, is one of several Indonesian cities frequently hit by flooding. Surabaya is located in the north of Java Island and borders the Madura Strait.

Gayungan District is one of the administrative districts in Surabaya City with an area of 6.15 km². The largest village in Gayungan District is Ketintang Village with an area of 2.97 km². The average temperature in this district is around 28.3°C with a humidity of around 77.9%, and a wind speed of 2.7 knots (BPS Kota Surabaya, 2023). The Surabaya City Government has created policies and measures to address flooding in Surabaya City, but this problem cannot be fully resolved and continues to occur. This can occur because the existing drainage system is designed only for irrigation purposes, so the existing drainage is unable to accommodate the large volume of water caused by changes in land use (Saud, 2007).

Drainage is an important and crucial aspect in managing flooding in residential areas. The drainage system is designed to effectively direct water and reduce/eliminate puddles during rainfall. The drainage system also serves to minimize soil erosion and increase the soil's water absorption capacity (Aditiya & Soebagio, 2019). Despite its function, flooding in the residential area of Ketintang Village, Gayungan District, still frequently occurs due to inadequate drainage, sedimentation, and the accumulation of waste in the drainage. During high rainfall, this area can experience inundation reaching 19.83 cm for 76 minutes, with an inundated area of 19.78 hectares (Aditiya & Soebagio, 2019).

Floods occur when the water discharge/volume overflows and exceeds the capacity of the river channel due to rainfall, soil infiltration capacity, topographic conditions, and land cover type. Floods categorized as hydrometeorological hazards and disasters are floods that produce significant damage over a wide area (Sahid, 2024). Floods occur in almost every country in the world, most frequently in urban areas. This is due to rapid development and migration seeking decent living opportunities in urban areas (Rochman & Prasetya, 2019).

In general, flooding can be categorized into two types. First, flooding occurs because dry land is submerged by water that has increased in volume. Second, flooding occurs due to overflowing rivers/irrigation channels caused by blockages, causing an increase in water volume that cannot be accommodated by the river's capacity (Kodoatie & Sugiyanto, 2001). Flooding is a very serious issue because it directly affects people's lives, so serious efforts are needed to be planned to reduce or even eliminate the risk and impact of flooding (Priyana & Harsini, 2017).

In practice, the primary factor, or the factor that contributes most to flooding, is human activity. This is human activity that is not environmentally conscious, particularly in river basins (DAS) that are categorized as upstream, midstream, and downstream (Suharjo et al, 2015). This is reinforced by the abundant evidence related to human behavior towards the environment, which influences the frequency of flooding, with varying intensities (Priyana et al, 2014). Furthermore, flooding is also influenced by the duration and intensity of rainfall, as well as the ability of the river in the area to drain the water properly (Ulfiana et al, 2023).

Steps that can be taken to support flood disaster risk mitigation include the use of Geographic Information Systems (GIS). GIS is a computer-based system that functions to store, process, analyze, and display spatial data. GIS has experienced rapid development in recent years and can be applied in various fields, including disaster mitigation and evacuation planning. One of the main software that can be used is ArcView, developed by ESRI (Wibowo et al, 2015).

Structural disaster mitigation efforts require the strategic presence of mitigation shelters, which serve as temporary evacuation sites for affected communities. Ideally, shelters/evacuation sites are designed as multi-story buildings that are earthquake and tsunami resistant and serve dual functions, such as providing facilities that remain useful even when a disaster does not strike, such as community activity centers, educational facilities, places of worship, or other public facilities (Sipta, 2017). However, in reality, in some areas, evacuation sites are still underutilized and inadequate in terms of facilities and quality.

According to Law Number 24 of 2007 concerning Disaster Management, a disaster is an event that threatens and disrupts people's lives, caused by natural factors, non-natural factors, or human actions/behaviors. It also results in human, environmental, material, and psychological losses. Mapping, a branch of geography, plays a crucial role in disaster mitigation efforts because it can help identify the characteristics of the affected earth's surface (Ambarwati & Johan, 2016).

Gayungan District is one of the areas in Surabaya frequently hit by flooding. The resulting standing water, particularly along Jalan Ahmad Yani, often causes traffic jams, with water levels varying, even exceeding the height of minibuses.

To date, there has been no study or research specifically mapping the locations of evacuation shelters for flood disasters in Gayungan District. Therefore, a study that discusses and maps spatially using GIS is needed to identify and analyze the spatial distribution of shelters. This research is expected to provide information for the community and relevant local governments to improve disaster mitigation preparedness and minimize disaster risks, particularly flooding.

This research was able to take place because it was rooted in the problem formulations that the author had obtained, including: How are evacuation points (places of worship) distributed and effective in reaching flood-affected areas? And How can the use of Geographic Information Systems (GIS) support disaster planning? gas flood disaster in the area?. Furthermore, from the existing problem formulation, the research objectives emerged, this research has two objectives, namely firstly to identify flood-prone areas in Gayungan District using GIS-based river buffer analysis, and secondly the objective is to analyze the distribution of evacuation points and their suitability for settlements affected by flooding.

Furthermore, this research will be useful in the future if it is reviewed and can be read by the general public. For academics, there will be several uses of this research, including (1) providing information about the number, area coverage, and distribution pattern of evacuation points in Gayungan District, (2) becoming a guideline and reference for academics to conduct research on evacuation points, especially Gayungan District, (3) Providing analysis of the number, area coverage, and distribution pattern of evacuation points in Gayungan District. In addition to academics, this research also provides benefits to the general public, useful for providing information to the public about the location of evacuation points in Gayungan District, providing information on evacuation point patterns in various sub-districts, as well as the reach of evacuation

points in each residential area in the District. In addition, it provides information on evacuation points in Gayungan District. Making it easier for the Gayungan District community to choose which evacuation point will be used by each community. For the local government, this research is useful for providing information on the distribution pattern and reach of the Gayungan District area, so that it can be a recommendation for the government to establish or build evacuation points for areas in need. For example, the categories of areas that require development are areas with minimal evacuation points, residential locations that are far from evacuation points, or areas that are difficult to reach from evacuation points.

2. Research Methods

2.1. Research Area

This study selected the study location in Gayungan District, Surabaya City with the variable Evacuation Point (Educational facilities and places of worship) with. The method used in this study is a descriptive quantitative and qualitative approach. According to the Big Indonesian Dictionary (KBBI), quantitative refers to something based on quantity or amount, which is a part of energy that cannot be further divided. Quantitative data is data in the form of numbers or data converted into numbers (scoring). This type of data can usually be analyzed using statistical methods or techniques. This data can also be in the form of numbers or scores, which are often obtained through data collection tools with answers in the form of a score range or questions that are assigned specific values (Putri, 2024).

Population is a generalization area consisting of: objects or subjects that have certain qualities and characteristics that are determined by researchers to be studied and then conclusions drawn (Suriani et al, 2023). In conclusion, a population is a comprehensive collection of objects that are of interest to researchers. The object of this study is the shelter in Gayungan sub-district.

2.2. Data Colecction and Processing

This research uses secondary and primary data sources. Secondary data obtained from BPS and the Surabaya City website already provides the names of educational facilities, places of worship and locations of educational facilities and places of worship. so that researchers can access the location of these facilities using Google Earth to obtain coordinate points. The primary data used is buffer data obtained from processing carried out using Arcmap. The data is presented in part below:

Table 1. Data Source

Data	Source	Usability
SHP Settlement	INA Geoportal	Create a map of flood-prone areas
SHP Administrative Boundary	INA Geoportal	Making a map of regional administrative boundaries
SHP River, Gayungan District	INA Geoportal	Knoing how dense the settlement is
Coordinate points of places of worship	Google Earth	Knowing the number of shelter points distributed
Data on the distribution of flood impacts	Obtained from the results of management using Arcmap	To determine which parts are affected by the flood
Buffer 300 m	Reach points obtained from plotting the reach points of places of worship	Knowing the reach of shelters to flood-prone areas
Flood affected locations based on population	To determine the shelter capacity	To determine the shelter capacity

Data processing technique consist of several step as follow:
a. Import all shapefiles (rivers, admin boundaries, coordinate points of places of worship) into Arcmap

b. Performing the River Buffer Process (Opening Arctoolbox-Analysis Tool-Proximity-Buffer)
c. Displaying Places of Worship Points (Enter Excel data in cxv format - right click XY Data - Display XY Data - Export as shapefile - add different symbols)
d. Overlay settlement and buffer data (Arctoolbox-Analysis tool-Overlay-Intersect/identify-Input 1: Settlements, Input 2 River Buffer)
e. Adding Administrative Boundaries (Admin Boundary Shapefile - Different Line Symbolization (District Boundary: Thick Line, Village Boundary: Dotted Line))
f. Adding Location Labels (Right Click Layer-Properties-Labels)
g. Map Layout (Layout view-Map Title-Legend-North arrow-Scale-Inset Location map-Compiler's Name)

2.3. Data Analysis Method

The analytical method used is Buffer. Buffer in Geographic Information Systems refers to an area generated around a point, line, or polygon that encompasses the entire area within a certain distance from the element. This area is depicted by GIS as a new polygon. The term 'negative Buffer' can also be applied to polygons to measure the distance inward from the edge of a regional feature. Buffers can be applied to both raster and vector data model problems. A Buffer Zone is an area associated with a map object, be it a point, line, or area (polygon). By creating a buffer, a coverage area will be formed or protect spatial features on the map (buffer area objects) with a certain distance. Therefore, the area created from this graph is used to determine the spatial distance of the map object from other objects around it.

3. Results and Discussion

This research produced a map, namely the Flood Buffer Map and Evacuation Point Distribution in Gayungan District, Surabaya City. Based on GIS that provides spatial data and results by showing areas vulnerable to flooding and the distribution of evacuation locations in Gayungan District, Surabaya City. The map was created through a series of spatial data processing processes, which include buffer analysis, overlay, and visualization of evacuation locations focused on religious facilities in Gayungan District such as mosques and churches. The resulting map also aims to provide insight, information, and accurate notification of flood risk vulnerability in Gayungan with the readiness of facilities to evacuate in affected areas.

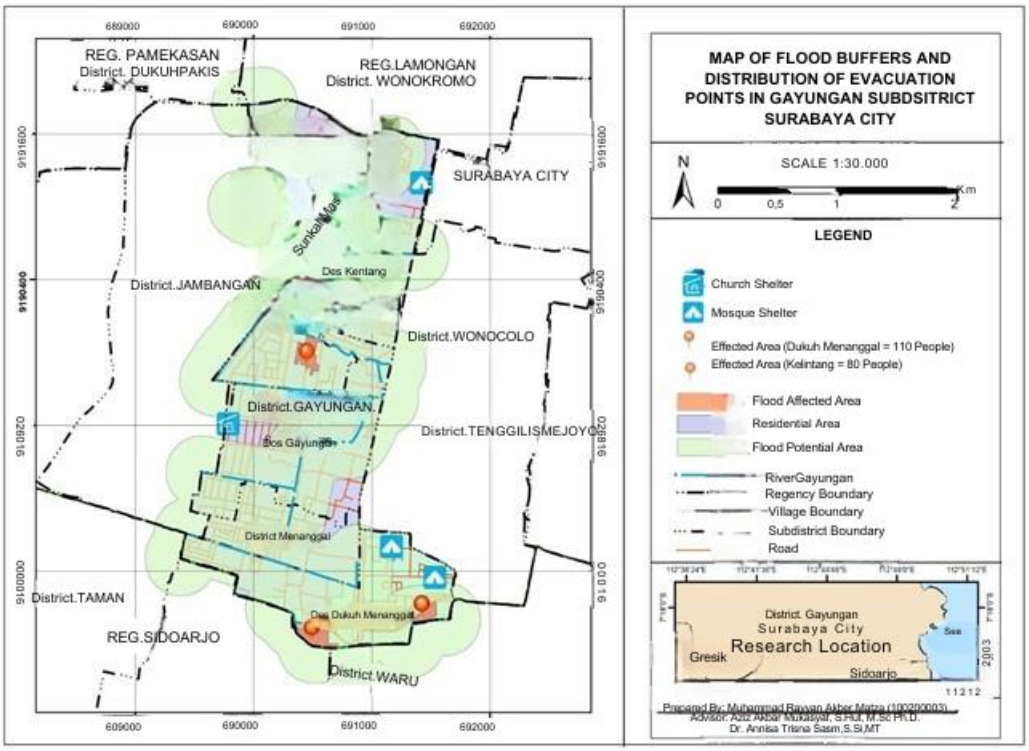

Figure 1. Feasibility Evaluation Map of Ngembak Landfill in Purwodadi Subdistrict, Grobogan Regency in 2024

One of the important things that needs to be considered in this study is the determination of areas at risk of flooding, the determination is done by analyzing the tampon zone which is 300 meters from the river network that passes through Gayungan District. The determination of this distance is based on the provisions recommended in the guidelines made by BNPB and research by JICA, which states that the range of 250-500 meters from the river is an alert area, therefore in lowland areas such as Surabaya is considered/categorized in the alert zone for flood disasters. The analysis findings represent residential areas within this 300-meter tampon zone as having a high level of vulnerability to flooding. Gayungan District is particularly vulnerable in Ketintang and Dukuh Manunggal Villages, both of these areas have high population densities, coupled with drainage infrastructure that is not yet fully ready to drain and accommodate high-intensity rainwater.

Next, a merger was performed to combine settlement data with river zones through an overlay. The results show that the majority of dense settlements in Gayungan District are located in areas potentially affected by flooding. This result emphasizes the importance of detailed, structured, and more systematic disaster mitigation planning in Gayungan District. Furthermore, historical data related to flooding incidents from the Surabaya City Regional Disaster Management Agency (BPBD) and information from various media, both online and conventional, can also be used as references to validate the existing results. This indicates a match between the mapped flood-prone areas and previously recorded flood incidents.

Regarding the provision of mitigation/evacuation locations, this study obtained results that can identify ideal locations for shelters, which in this study are based on places of worship. The distribution of shelters shows a strong concentration in the western area of Gayungan District, which is geographically safer because it is in a higher area than other areas and far from the river flow. This is also related to the density of settlements and existing facilities in the area. However, the results also show that there is one mosque shelter located within the 300-meter buffer range, which is interpreted as a high risk of flooding. This indicates the need for a re-evaluation of the shelter location, as well as the need for recommendations for alternatives that can be done, such as raising the shelter or relocating the location to a safer area.

To support research on the accessibility of shelters to affected areas, proximity analysis was used to measure the distance between settlements and the nearest evacuation site. This method allows for the identification of areas lacking adequate access to evacuation facilities, thus providing a basis for consideration in the addition or relocation of shelters in the future. However, this study did not include an analysis of shelter capacity due to limited non-spatial attribute data. Therefore, in the next development phase, it is recommended to align data on the physical capacity of shelters, supporting facilities, and the estimated number of affected residents, so that planning can be carried out more accurately and efficiently.

Overall, this study/research has had a significant impact on efforts to reduce the risk and impact of flooding in densely populated urban areas, such as Gayungan District. The resulting map serves not only as a means of representing and visualizing data, but also as a basis for providing insights for developing disaster mitigation policies and strategies by relevant parties. With this spatial information, stakeholders can conduct risk assessments and evaluations more systematically and with greater focus, and position points appropriately and according to community needs.

4. Conclusion

This research produced a map of the 300-meter flood buffer in Gayungan District, Surabaya City. Furthermore, evacuation shelters, including religious facilities like mosques and churches, were identified. However, one shelter in Gayungan District remains affected by the flooding. Therefore, an evaluation and relocation are necessary to maximize and optimize the provision of shelter services for evacuation.The resulting maps serve not only as a means of representing and visualizing data, but also as a basis for providing insights for relevant parties in developing disaster mitigation policies and strategies. With this spatial information, stakeholders can conduct risk assessments and evaluations more systematically and with greater focus, and position points appropriately and according to community needs.

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Author Contributions

Conceptualization: Muhammad Rayyan Akbar Mafaza, Annisa Trisnia Sasmi, Mohd Hairy Ibrahim; **methodology**: Muhammad Rayyan Akbar Mafaza, Aziz Akbar Mukasyaf; **investigation**: Muhammad Rayyan Akbar Mafaza; **writing—original draft preparation**: Muhammad Rayyan Akbar Mafaza; **writing—review and editing**: Annisa Tisnia Sasmi, Aziz Akbar Mukasyaf; **visualization**: Muhammad Rayyan Akbar Mafaza. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

References

Aditiya, R., & Soebagio. (2019). Kajian Banjir Di Wilayah Ketintang Surabaya. *(Study of Flooding in the Ketintang Area, Surabaya). Jurnal Rekayasa dan Manajemen Konstruksi*, 157-162.

Ambarwati, W., & Johan, Y. (2016). Sejarah Dan Perkembangan Ilmu Pemetaan. *(History and Development of Mapping Science) Jurnal Enggano*, 80 - 82.

BPS Kota Surabaya (2023). *Kecamatan Gayungan Dalam Angka 2023*. Surabaya: Badan Pusat Statistik Kota Surabaya.

Priyana, Y., & Harsini, S. (2017). Pemodelan Jalur Evakuasi Banjir Di Kampung Sewu Surakarta. *(Flood Evacuation Route Modeling in Kampung Sewu, Surakarta). Prosiding Seminar Nasional Pendidikan Geografi FKIP UMP*, 123.

Priyana, Y., Anna, A. N., & S, A. A. (2014). Model Simulasi Luapan Banjir Sungai Bengawan Solo Untuk Optimalisasi Kegiatan Tanggap Darurat Bencana Banjir. *(Flood Overflow Simulation Model of the Bengawan Solo River for Optimizing Flood Emergency Response Activities). Forum Geografi* , 22.

Putri, A. C. (2024). Metode Penelitian Kualitatif: Pengertian, Jenis, Kelebihan dan Kekurangannya. *(Qualitative Research Methods: Definition, Types, Advantages, and Disadvantages).* Retrieved from Telkom University: https://telkomuniversity.ac.id/metode-penelitian-kualitatif-pengertian-jenis-kelebihan-dan-kekurangannya/

Putri, A. C. (2024). Penelitian Kuantitatif: Penelitian, ciri - ciri, kelebihan dan kekurangan. *(Quantitative Research: Definition, Characteristics, Advantages, and Disadvantages).* Retrieved from Telkom University: https://telkomuniversity.ac.id/penelitian-kuantitatif-pengertian-ciri-ciri-kelebihan-dan-kekurangan/

Rochman, A., & Prasetya, D. B. (2019). Pemetaan Cepat untuk Mitigasi Banjir Sederhana Menggunakan Komersial Drone di Desa Way Galih, Lampung Indonesia. *(Rapid Mapping for Simple Flood Mitigation Using Commercial Drones in Way Galih Village, Lampung, Indonesia). Forum Geografi*, 103.

Sahid, S. (2024). Enhancing Digital Elevation Model Accuracy for Flood Modelling–A Case Study of the Ciberes River in Cirebon, Indonesia. *Forum Geografi*, 38(1), 40-56. https://www.doi.org/10.23917/forgeo.v38i1.1839

Saud, I. (2007). Kajian Penanggulangan Banjir di wilayah Pematusan Surabaya Barat. *(Study of Flood Mitigation in the Pematusan Area, West Surabaya). Jurnal APPLIKASI*, 1-10.

Sipta, Y. (2017). Shelter Mitigasi Bencana, Syiah Kuala. *(Disaster Mitigation Shelter, Syiah Kuala). Proyek Akhir Sarjana*, 1 - 117.

Suharjo, Anna, A. N., Cholil, M., & Rudiyanto. (2015). Analisis Morfologi Dan Morfostruktur Serta Pengaruhnya Terhadap Banjir Luapan Sungai Bengawan Solo Hulu Tengah. *(Morphological and Morphostructural Analysis and Their Influence on Flooding of the Upper-Middle Bengawan Solo River). University Research Coloquium*, 18.

Suriani, N., Risnita, & Juliani, M. S. (2023). Konsep Populasi dan Sampling, Serta Pemilihan Partisipan Ditinjau Dari Penelitian Ilmiah Pendidikan. *(The Concept of Population and Sampling, and the Selection of Participants from the Perspective of Educational Scientific Research). IHSAN: Jurnal Pendidikan Islam*, 24 - 36.

Ulfiana, A., Arsyad, M., & Palloan, P. (2023). The Atmospheric Dynamics Re-lated to Extreme Rainfall and Flood Events during September-October-November in South Sulawesi. *Forum Geografi* 37(2), 107-116. http://dx.doi.org/10.23917/forgeo.v37i2.22339

Wibowo, K. M., Kanedi, I., & Jumadi, J. (2015). Sistem Informasi Geografis (Sig) Menentukan Lokasi Pertambangan Batu Bara Di Provinsi Bengkulu Berbasis Website. *(Geographic Information System (GIS) for Determining Coal Mining Locations in Bengkulu Province Based on a Website). Jurnal Media Infotama*, 51 - 60