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Geographic Information System in Determining Flood and Safe Zone for Flood Mitigation

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Abstract
Computer-based technology has pervaded practically every aspect of human life in the modern era. Through diverse information systems, various fields have employed computer-based technology to build theories and their applications. Geographic Information System (GIS) technology is one type of computer-based system that is widely employed. Various disciplines can use Geographic Information System (GIS) technology to research and map flood zones. The research approach employed is the employment of ARC GIS 10.5 system technology to determine the flood zone's features. Pampang, Tamamaung, Sinri Jala, and Karuwisi Utara are four villages that are flood-prone locations that are included in the warning zone, according to the results of data processing using GIS software and data analysis illustrated from mapping the flood area in Panakkukang District. There are 1,985 hectares in the Rappocini sub-district, which is included in a vulnerable region, namely Bantabantaeng Village, and 145,709 hectares in Karunrung Village, Gunung Sari, Bontomakkio, Tidung, Kassi-Kassi, Mappala. Parts of the Manggala, Bangkala, and Borong regions, as well as sub-districts of Manggala, are included in the vulnerable areas. Tamalanrea Indah, Tamalanrea Jaya, and Tamalanrea sub-districts are the Tamalanrea sub-districts that have been designated as vulnerable zones.

Keywords: GIS; Flood; Mitigation; Zona; Mapping

Introduction

Flooding is a prevalent concern in several large cities, including Makassar City, the provincial capital of South Sulawesi. The tragedy of the flood disaster on January 21, 2019, which struck much of South Sulawesi Province, particularly Makassar City and Gowa Regency, continues to cause great pain and enormous losses for the flood victims [5]. Losses incurred as a result of the flood disaster could have been caused by the community's lack of responsiveness in the face of the impending flood disaster, causing many people to be unsure of where to move or evacuate, and eventually taking the risk of living in a house that was prone to flooding. Inundation in normally dry or non-swampy zones, and flooding as a result of runoff from river channels caused by flow in the river exceeding its drainage capacity, are two common types of floods. Siswoko,[17]. Puddles have diverse features depending on the size of the puddle, the depth of the puddle, the length of the puddle, and the regularity with which they appear. If not dealt with quickly, puddles will bring more harm to the community. [2] Wilhelmus Bunganean et al. Evita Flood Mitigation at Nusukan Sub-district, Banjarsari Sub-district, Surakarta City, Lylyana Dewi,[5], Drainages, such as sewers and culverts, are still not broad enough, and siltation develops, causing the water volume to rise, affecting the quick flow of water in these waterways and causing water to overflow to the surface. Use of Geographic Information Systems and Simple Additive Weighting Methods in Determining Flood Evacuation Locations in Surakarta City, Juliana and Charitas,[7]. There are six excellent spots to choose from. The six places all have the same criterion and sub-criteria for determining the evacuation location to serve as a temporary shelter in the event of flooding in Surakarta.

Because it is vital to have a design or plan in place ahead of time to minimize potential losses. Operations to mitigate this impact can be made in a variety of ways, including socializing disaster-prone areas with the community, replicating disaster response efforts for people of disaster-prone areas, and incorporating existing technological breakthroughs into the planning process. Catastrophe mitigation is a set of activities aimed at lowering disaster risk, either through physical development or greater awareness and preparedness for disasters (Article 1 paragraph 6 PP No. 21 of 2008 concerning Disaster Management Implementation) [3].

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Mitigation is a set of attempts to reduce catastrophe risk, both through physical development and greater knowledge, as well as increased capacity to address disaster risks. (PP No. 21 the Year 2008, Chapter I General Provisions, Article 1 point 6) (Law No. 24 of 2007[6], Chapter I General Provisions, Article 1 point 9 and Law No. 24 of 2007[6], Chapter I General Provisions, Article 1 point 9) [12]. Mitigation, as defined in Article 44 letter c, is done to lessen catastrophe risk for communities living in disaster-prone locations (Article 47 paragraph of Law Number 24 of 2007). (1) [6]. Disaster mitigation, as defined in Article 15 letter c, is done to lessen the risks and consequences of disasters. Natural disasters, man-made disasters, or a mix of the two in a country or community create disasters to communities in disaster-prone areas (PP No. 21 of 2008 Article 20 paragraph (1) [11]. 1) Natural disasters are a group of disasters brought on by natural forces, such as earthquakes, tsunamis, volcanic eruptions, floods, droughts, landslides, and so on. (2) A social disaster is brought about by humans, such as social conflict, community disease, or terror. Mitigation is the most effective way to lessen the damage of a disaster. [13].

Computer-based technology now pervades practically every aspect of human life. Through various information systems, various scientific disciplines have employed computer-based technology to build theories and applications. Geographical Information System (GIS) technology is one type of computer-based system that is widely used. A geographic information system (GIS) is a type of information system that manages data with spatial information (spatial reference). In a more limited sense, it's a computer system that can create, store, manage, and display geographically referenced data in a database, such as data identifiable by location. Scientific research, resource management, development planning, cartography, and route planning can all benefit from Geographical Information Systems technology. GIS, for example, can assist planners in swiftly calculating emergency response timelines in the event of a natural disaster, or it can be used to locate wetlands that require pollution protection. The following are the precise objectives to be met in this study: Identifying the inundation zone, the safe zone, and the location of the flood evacuation shelter. [7] Juliana and Charitas Determining Flood Evacuation Locations in Surakarta City Using Geographic Information Systems and Simple Additive Weighting Methods There are six excellent spots to choose from. The six places all have the same criterion and sub-criteria for determining the evacuation location to serve as a temporary shelter in the event of flooding in Surakarta.

Method

The research method used to achieve the proposed research's objectives has been compiled in the form of a flow chart that describes, in general, the systematic and rare implementation in coherent stages so that data is found to become material in the application of the ARC GIS 10.5 system technology. in determining flood zones and safe zones for flood mitigation in flood-affected areas, namely Manggala and Tamalanrea districts. According to Nico Nathanael (2019)[8, a geographic information system (GIS) is an information system that uses spatial data based on the geographic location of a region for analysis, storage, and display. GIS or Geographic Information System (GIS) is a special information system that manages data with spatial information (spatial reference), or in a narrower sense, a computer system that can build, store, manage and display geographically referenced information, such as data identified by location, in a database. Scientific research, resource management, development planning, cartography, and route planning can all benefit from Geographical Information Systems technology. GIS, for example, can assist planners in swiftly calculating emergency response timelines in the event of a natural disaster, or it can be used to locate wetlands that require pollution protection.

The following are primary data: 1) Ground-level elevation 2) Point of Evacuation Shelter The third option is to use a geometric path. The following data were obtained from several agencies, including Makassar City Disaster Management Agency (BPBD)[9], South Sulawesi Meteorological Agency, Makassar City Samsat, Makassar City LLAJR, Makassar City Transportation Service, Makassar City Spatial Planning Service, and Central Statistics Agency (BPS) Makassar City (2017-2018) Makassar in figures [1]: Total Population, Population Distribution The aforementioned data is processed using Arc GIS 10.5 software with Hydrological Methods: Flow direction, Fill, Flow accumulation, Watershed, and Basin. The reclassification toolbox is then used to reclassify the hydrological values. After acquiring data using GIS calculations, analysis is performed using Overlays, Scoring, and Weighting to determine the zone of places classified as vulnerable, safe, and evacuation shelter points.

Results and Discussion

A. Examining the Research Area from a Geographical Perspective

a. Panakukang District's Geographical Situation

Panakkukang District is one of Makassar City's 14 sub-district districts. Panakkukang District is the heart of Makassar City, with several government agencies, corporate offices, hotels, entertainment venues, shopping malls, and two shopping malls. However, beneath the opulence, there is a lack of proper infrastructure, ranging from a lack of green space to a bad drainage system in this neighbourhood. Green land, in addition to serving as a life-sustaining component, also serves as a water catchment region, as is widely known. Similarly, the culvert/drainage system is malfunctioning, making it impossible to drain water smoothly in the event of continuous rain. For example, during periods of heavy rain, Jl. Andi Pangeran Pettarani became one of the sites where puddles formed, with the height of the puddles occasionally reaching an adult's knee. I had the same problem with Jl. Sukaria and Jl. Andi Pangeran

Pettarani. In contrast to what happened in Pampang Village, if it rains heavily, the region will be promptly flooded, with an inundation height of around 100 cm. Such is the picture that occurs at several points in Panakkukang District, which is one of the areas with a large population, so the community must understand flood mitigation/mitigation efforts by knowing which areas are prone to standing water and any area that can serve as a haven if the Panakkukang District is later affected by tidal waves/floods that remember the area.

b. Rappocini District's Geographical Situation

Rappocini District, with a total size of 9.23 km2, is one of Makassar City's sub-districts. Because the Rappocini Subdistrict is a heavily populated area with few water catchment sites, it is frequently flooded each year, causing traffic to be disrupted. These influences community activities in Makassar City, particularly in the Rappocini District Area. The Rappocini Subdistrict has had repeated flooding in recent years, resulting in standing water on one of Makassar's main roadways, which includes some of the roads on Jalan Andi Pangerang Pettarani, Jalan Letjen Hertasning, and Jalan Sultan Alauddin. Rappocini Subdistrict is a residential area in desperate need of significant handling efforts by relevant parties in assessing flood disaster mitigation for transportation routes in the Rappocini District region so that the community can prepare for a flood disaster.

c. Geographical Condition of Manggala District

With a total size of 24.14 km2, Manggala District is one of Makassar City's sub-districts. Because Manggala Subdistrict is densely inhabited and lacks water catchment areas, it is frequently flooded each year, resulting in stalled transportation and obstructing community activities in Makassar City, particularly in Manggala District. The Manggala District area has experienced frequent flooding in recent years, resulting in standing water on one of the main roads in the Manggala sub-district, including some of the roads on Jalan Antang Raya, Jalan Borong Raya, and Jalan Tamangapa Raya, all of which are located in the Manggala District Region.

Manggala Subdistrict is a population-density residential area in desperate need of significant handling efforts by associated parties in studying flood disaster mitigation for transportation routes in the Manggala District area so that the community can be prepared in the event of a flood disaster.

d. Tamalanrea District's Geographical Situation

Tamalanrea District is one of Makassar City's 14 sub-districts, each of which contains eight sub-districts. Tamalanrea District is a school district with 15 (fifteen) public and private higher education institutions. Hasnuddin University and Ujung Pandang State Polytechnic are two of them, both of which are located in Tamalanrea Indah Village. Tamalanrea District also has a warehouse, factory, and industrial sector. In the villages of Bira and Parangloe, there are around 960 (nine hundred and sixty) units. However, beneath the opulence, there is a lack of proper infrastructure, ranging from a lack of green space to a bad drainage system in this neighbourhood. Green land, in addition to serving as a life-sustaining component, also serves as a water catchment region, as is widely known.

Similarly, drainage does not function effectively, preventing water from draining smoothly in the event of continuous rain. For example, what may be felt in Tamalanrea Indah Village, Tamalanrea Jaya Village, Tamalanrea Village, and Buntusu Village when it rains for a long time. 4 This sub-district is a region that becomes a puddle's point, with the puddle's height sometimes reaching an adult's waistline. These four sub-districts had the most number of victims, as well as the highest number of casualties. As a result of this picture occurring at multiple locations in Tamalanrea District, which is one of the areas with a high population, the community must grasp flood mitigation/countermeasures by recognizing which areas are the points. prone to standing water, and which regions will become safe havens if the Tamalanrea District is hit by tidal surges or floods..

B. Mapping of Flood Zone Categories

a. Flood Zone Category Mapping in Panakukang District

According to the findings of data analysis and mapping of flood areas in Panakkukang District, five urban villages are very flood-safe areas, namely some Panaikang Village, Tello Baru Village, Paropo Village, Pandang Village, and Masale Village; six sub-districts are flood-safe areas, namely some Panaikang, Tello Baru, Paropo, Karampuang, Pandang, and Masale villages; and six urban villages are prone to flooding Soil conditions with high or low elevations in the form of hills or valleys are one of the elements that determine whether an area is safe or vulnerable to floods owing to a lack of runoff/river basin and water catchment areas, resulting in a pool of water that causes flooding. System simulation results by calibrating elevation, slope, the direction of water flow, river flow, and drainage basins/ponds are shown on the map using ArcGIS software, as well as benchmarks for indicators of safe and flood-prone data, namely: elevation, slope, the direction of water flow, river flow, and drainage basins/ponds. In Panakkukang District, the total area impacted by flooding (prone, very prone, and alert) is 9.41 km^2, out of a total area of 17.05 km^2. Sinri Jala Village, with an affected area of 0.17 km^2, Part of Pampang Village, with an affected area of 2.23 km^2, Tamamaung Village, with an affected area of 0.45 km^2, and Karuwisi Utara Village, with an affected area of 0.51 km^2, are the four flood-alert sub-districts.

Then there are 5 (five) flood-safe sub-districts: Part of Panaikang Village, with an area of 1.79 km^2, Sub-district Tello Baru, with an area of 0.90 km^2, Sub-district Paropo, with an area of 1, 52 km^2, Sub-district Pandang, with an area of 0.77 km^2, and Sub-district Masale, with an area of 0.76 km^2 (Figure 1).

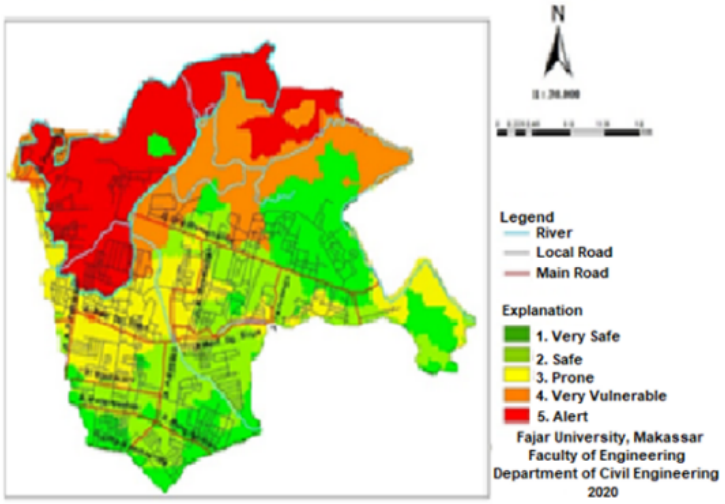

Figure 1. Map of the Flood District of Panakkukang

b. Flood Zone Categories in Rappocini District District Mapping

A waterlogging hazard zone and a safe zone have been determined using Arch GIS software in the Rappocini District area, with 5 (five) areas, namely Ballaparang, Rappocini, Buakana, part of the Banta-bantaeng area, and part of the Tidung area, falling into the very safe category. Furthermore, Bontomakkio Village, which is part of the Banta-bantaeng region, is the Aman's dominant territory. Meanwhile, it is prone to dominance in some areas, such as the Kassi-kassi sub-district, while it is the dominant prone region in the Karunrung and Gunung sari areas, and it is also included in the Waspada category in portions of Gunung sari, making Gunung sari village a common location. There had been a flood. Because of the lack of runoff/river basin and water catchment areas, the area is deemed to be a safe zone or a flood-prone zone. The Rappocini sub-safe district's zone and flood-prone zones are depicted on the map below. According to the number of individuals affected by the flood-prone zone, Gunung Sari Village had the biggest population, with 42,039 people, while Rappocini Village had the smallest population, with 9,584 people. Gunung Sari Village, Karunrung Village, Mappala Village, Kassi-Kassi Village, Bonto Makkio Village, and Tidung Village are among the locations in the Rappocini sub-district that have been reported to have been impacted by the flood. Then there are around 106,066 people in the area who are affected by floods and must be relocated to safer areas in the case of a flood disaster (Figure 2).

Then there are 5 (five) flood-safe sub-districts: Part of Panaikang Village, with an area of 1.79 km^2, Sub-district Tello Baru, with an area of 0.90 km^2, Sub-district Paropo, with an area of 1, 52 km^2, Sub-district Pandang, with an area of 0.77 km^2, and Sub-district Masale, with an area of 0.76 km^2 (Figure 2).

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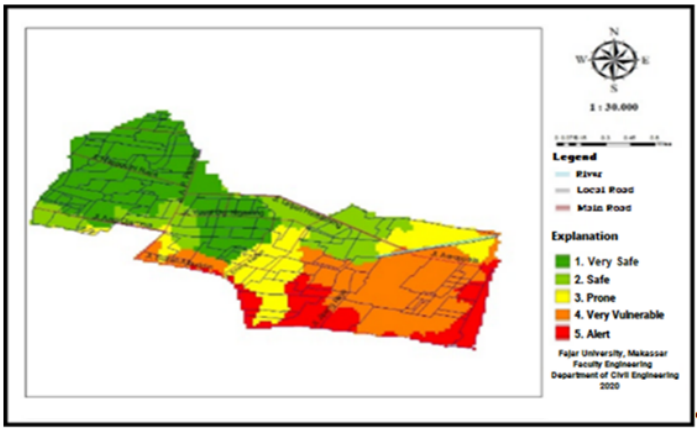

Figure 2. Map of the Flood District of Rappocini District

c. Flood Zone Category Mapping in the Manggala District

According to the results of data analysis and mapping of flooded areas in Manggala District, Batua Village is a very flood-safe area; Sub-district Antang is a flood-safe area; Manggala Village, Bangkala Village, and Borong Village are three urban villages that are prone to flooding; and Sub-district Tamangngapa is a flood alert area. Land conditions with high or low elevations in the form of hills or valleys are one of the elements that determine whether an area is safe or prone to flooding owing to a lack of runoff/river flow areas and water catchment areas, resulting in standing water that causes flooding. According to the results of data processing, four (four) sub-districts, namely Borong, Bangkala, Manggala, and Tamangapa Villages (Figure 3), are classified as flood-prone and flood alert, with a total population of 81,811 persons who must be evacuated to a safe location. As a result, the total area of the flood-prone, very prone, and alert zones in Manggala District is 10.8 km^2, out of a total area of 24.14 km^2. Part of Borong Village, with an affected area of 0.84 km^2, Part of Bangkala Village, with an affected area of 2042 km^2, Part of Manggala Village, with an impact area of 2416 km^2, and Sub-district Tamangngpa, with an affected area of 5121 km^2 are flood-alert areas. Part of Borong Village, with an area of 0.53 km^2, Sub-district Batua, with an area of 1084 km^2, Sub-district Antang, with an area of 3215 km^2, Part of Bangkala Village, with an area of 1444 km^2, and Part of Manggala Village, with an area of 2271 km^2 are flood-safe places.

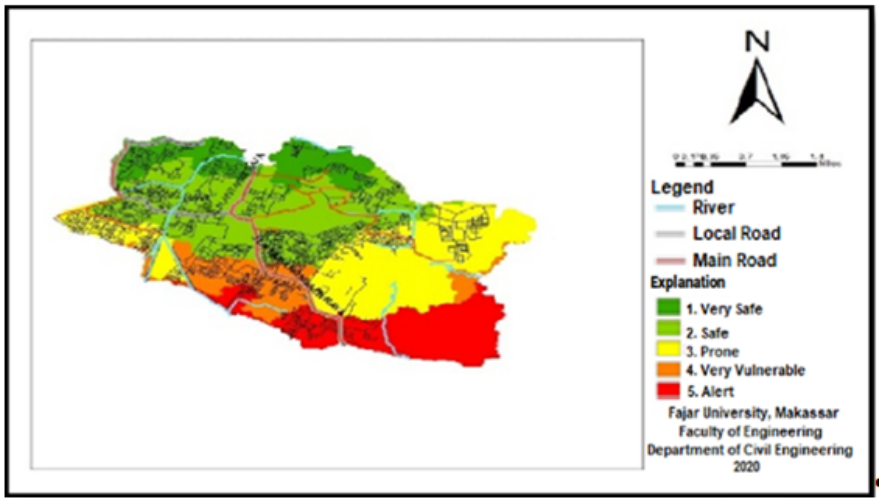

Figure 3. Map of the Flood District of Manggala District

Conclusion

The following conclusions can be drawn from the data analysis:

a. In Panakkukang District, the area inundated by flooding (prone, very prone, and alert) is 9.41 km^2, out of a total area of 17.05 km^2. A total of 226,244 hectares are located in the Rappocini sub-district (2.26 km^2). In Manggala District, the zone area impacted by flooding (prone, very prone, and alert) is 10.8 km^2, out of a total area of 24.14 km^2. In Tamalanrea District, the total area impacted by flooding (prone, very prone, and alert) is 19.6 km2, out of a total area of 31.84 km^2.

b. In the Panakukang District, the safe area is 5.74 km^2. In Rappocini District, the safe area is 220.395 hectares (2.20 km^2). Meanwhile, 5 sections in Manggala Subdistrict are designated as flood-safe zones, covering an area of 8,544 km^2 (854.4 Ha). Tamalanrea District has a total area of 14.7 km^2 (14,700Ha).

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