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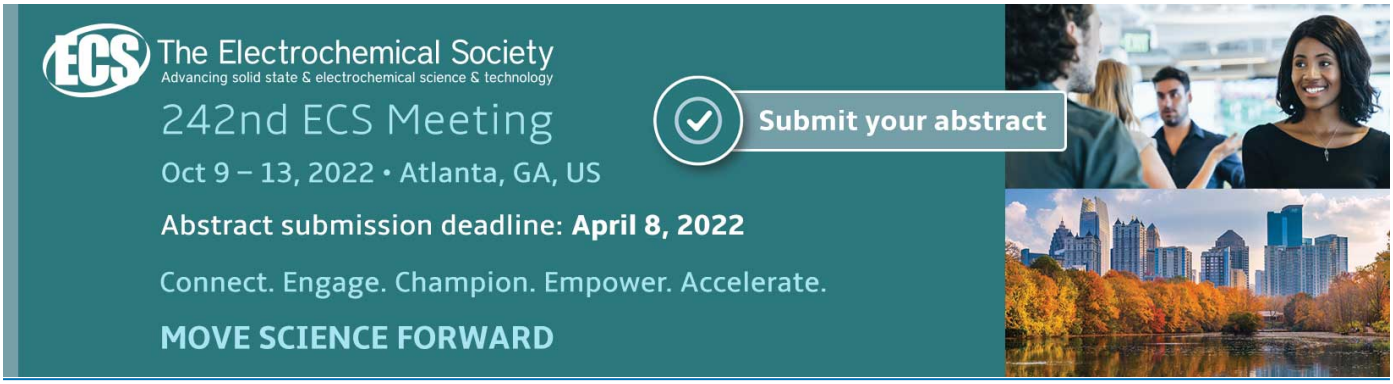

Study of Flood Disaster Mitigation Analysis for Transportation Routes in Panakukkang District, Makassar City

N K Nur[1,*], A I Yunus [1], A M D Satriawan [1]

[1]Department of Civil Engineering, Faculty of Engineering, Fajar University, Makassar.

*corresponding author : Enkha93@gmail.com

Abstract. This study conducted an analysis study of flood disaster mitigation for transportation routes in the Panakukkang district of Makassar City. By using ArcGis software, the results of the simulation of safe and vulnerable zone levels based on color indicators are known. There are 5 villages in Panakukkang District which are flood safe zones, with the number of evacuation sites, namely 21 buildings. Then there are 4 villages which are flood alert zones with 2 evacuation sites, 2 buildings. On the first evacuation route there are 8 reference points namely Reference Point C with the distance to the nearest evacuation site 3.22 km and a travel time of 64.3 minutes. Then the reference point A with a distance to the nearest evacuation site is 2.85 km and a travel time of 57 minutes. While the reference point F is the closest point to the nearest evacuation distance 0.71 km and the travel time is 14.2 minutes. All these reference points require travel speeds of 3 km / h on foot. On the second evacuation route there are 6 Reference Points namely reference point A with distance to the nearest evacuation point 1.94 km and travel time 38.8 minutes, reference point E with distance to nearest evacuation location 1.23 km and travel time 24.6 minutes. Then at the reference point C is the closest point to the nearest evacuation distance 0.72 km and the travel time is 14.4 minutes.

1. Introduction

One of the natural phenomena that occurs in some parts of Indonesia in the form of floods, causing huge losses that can threaten human life. Based on the value of losses and the frequency of flood disasters is strongly influenced by natural factors such as the amount of rainfall above normal conditions and high tides. In addition, the factor of human behavior is one of the causes of floods [1]. Floodingis an event that occurs when an excessive flow of water submerges land. Directing flooding The EuropeanUnion defines flooding as temporary immersion by water on land which is usually not submerged in water. In the meaning of "running water", this word can also mean the entry of tides. Flooding is caused by the volume of water in a body of water such as a river or lake that overflows or overflows from a damso that water comes out of the river. Floods are often known in two forms, in the form of inundation inzones that are usually dry or not swampy, and flooding as a result of runoff from river channels caused by discharge in the river exceeds its drainage capacity [2]. Puddles have different characteristics depending on the area of the puddle, the depth of the puddle, the length of the puddle and the frequency of the occurrence of puddles if not immediately addressed will cause greater harm to thecommunity [3]. Flood Mitigation in Nusukan sub-district, Banjarsari Sub-district, Surakarta City, Drainage such as sewers and culverts that are still not wide enough and siltation occurs, so that if there is heavy rainfall, the water volume will increase and can affect the swift flow of water in these waterways and water can overflow to the surface [4].

Flooding is a common problem found in several large cities, such as Makassar city which is the center of the capital of the province of South Sulawesi. The tragedy of the flood disaster on January 21, 2019 which had hit most of the South Sulawesi Province, especially in Makassar City and Gowa Regency, still left a deep sorrow and also a huge loss for the flood victims. Panakukkang District is one of 14 sub-districts in Makassar. Panakukkang District can be said to be the focal point of Makassar city because there are many Government agency offices, corporate offices, hotels, entertainment venues, shopping venues, and there are 2 (two) malls located in this district. But behind the grandeur that all is not supported by adequate infrastructure, from the lack of green land, and the poor drainage / drainage system in this zone. As it is known that besides functioning as a supporting factor for life, green land

also functions as a water catchment zone. Likewise, the sewer / drainage does not function properly so it cannot drain water smoothly in the event of prolonged rain. Case in point: as can be felt if there is prolonged rain, Andi Pangeran Pettarani street road becomes one of the zones that become a puddle point, where the height of the puddle sometimes reaches the knees of adults. Likewise with Street Sukaria, and Andi Pangeran Pettarani Street I also have the same case. Different from what happened in the Pampang village, if it is rained with rain it has a high intensity it is certain that the zone will be immediately flooded and the inundation height reaches approximately 100 cm of data according to [5]. Such is the picture that occursat several points in Panakukkang Sub district, which is one area that has a large population, so it is important for the community to be more important to understand mitigation / mitigation efforts againstflooding, by knowing which zones are the points prone to puddles and which zones are safe points if later Panakukkang sub-district is affected by the tidal / flood waves that inundate the zone. Mitigation isan action taken to reduce the impact caused by a disaster. Mitigation measures consist of structural mitigation and non-structural mitigation. Structural mitigation is an action to reduce or avoid the possibility of physical disaster impacts. While non-structural mitigation is an action to reduce disaster risk through policies, knowledge development, regulations and security of dangerous objects. Mitigation is the most efficient measure to reduce the impact caused by a disaster [6].

Based on the Makassar City Regional Disaster Management Agency (Zone Disaster Management Agency) data that there are 3 (three) villages that are flood-prone points in Panakukkang sub-districts, namely: Panaikang, Paropo, and Tello Baru. However, the data from the the Makassar City Regional Disaster Management Agency is data from 2014, therefore re-calibration of data is needed to validate the data from the above the Makassar City Regional Disaster Management Agency [5].

Departing from the above, it is deemed necessary to conduct a flood disaster mitigation analysis study for transportation routes in the Panakukkang district of Makassar city, as a reference to obtain the latest data on flood disaster prone zones in the city of Makassar especially in the Panakukkang district.

2. Materials and Methods

2.1. Disaster Mitigation

Disaster mitigation is a series of efforts to reduce disaster risk, both through physical development and awareness and enhancement of the ability to face the threat of disaster [7] concerning the Implementation of Disaster Management. Mitigation is defined as an effort aimed at reducing the impact of a disaster. Mitigation is a series of efforts to reduce disaster risk, both through physical development and awareness and enhancing the ability to face the threat of disaster [8], Chapter I General Provisions [9].

2.2. Geographic Information System (GIS)

According to [10] GIS is an information system that has spatial data taken based on the geographical location of an area for the process of analysis, storage and visualization. GIS or GIS is a special information system that manages data that has spatial information (spatial reference), or in a more narrow sense, is a computer system that has the ability to build, store, manage and display geographical reference information, for example data identified by location , in a database. Utilization of Geographic Information Systems and Simple Additive Weighting Methods in Determining the Locations of Flood Evacuation in Surakarta City. There are 6 best locations. The sixlocations have the same criteria and sub criteria, namely to determine the evacuation location in order to become a temporary shelter when floods hit the city of Surakarta [11].

2.3. Determine the Safe Zone and Flood Prone Zone

To identify critical zones of urban flood puddles using GIS-based software by combining some data that is automatically processed by the system with its own aggregate count.

1. Determine Coordinate Points
2. Flow Direction
   Serves as data to determine the direction of water flow along the research object.
3. Flow Accumulation
   Get the value of water accumulation in each runoff.
4. Watershed / River Flow Zone
   To find out which water runoff will be upstream and downstream.
5. Basin
   Create drainage basins that connect all water flow and other substances carried by water to public channels as concentrated drainage / ponds.

6. Reclassify
   After all processes are completed, it is known which zones are at risk of being flooded.

2.4. Evacuation Area and Shelter Point (Refugee Camp)

The refugee camp is an area that is close to the centers of the residential neighborhoods which, in the event of a disaster, becomes a meeting point for residents who want to be evacuated to safer places. The criteria used as places of refuge in this study are:

1. The place / building used as the evacuation location of the ground level must be at a safe point, according to [5], the safe distance from the ground level is the middle of the highest elevation point in the zone.
2. The location must have direct access to the primary road (district road) or secondary road (local road) with a distance or range of approximately 30 meters.
3. The building must have a large area that can accommodate large numbers of people, or at least 225 square meters.

Data Architect, said that the standard size of space needed for each person at the evacuation site is 2.25 m^2 in standing (1.5 max 1.5 m) and 1.08 m^2 in a state of lying (1.8 max 0.6 m). In this case, the highest size of space is taken, is standing 2.25 m^2 [12-13].

2.5. Designing Evacuation Routes

2.5.1. Vissim PTV PTV VISSIM is a transportation modeling program to analyze the existing traffic conditions, such as: the creation of new road infrastructure, the changeover or diversion to the use of public transportation, the development of new land use zones, the development of policies regarding signs, markers, and other road completeness facilities, demographic developments and changes, developments and changes in the use and expenditure of funds for fuel, and others.

In the guideline for using Vissim, Vissim is a PTV software from Germany. Vissim itself is an acronym for Verkehr In Städten Simulations Modell which means a simulation model of city traffic [14]. Simply put, making a model using VISSIM PTV is divided into 5 stages, namely:

1. Identify the Scope of the Area to Be Modeled
2. Data Collection
   As for the data needed, namely: the size of the road segment, vehicle volume, road segment conditions, and others.
3. Network Coding
   Stages of making a model based on data that has been obtained.
4. Error Checking
   Review if something goes wrong, as is usual with vehicle routes or vehicle inputs.
5. Model Validation / Simulation

2.5.2. Evacuation route

Evacuation Route is a path that is specifically intended to connect all areas to a safe area as a Gathering Point. In an emergency, the Evacuation Route becomes very important and absolutely must be placed as a direction. [15] in [16] Evacuation route is a path that is used as a direct and fast transfer of people who will move away from threats or events that can be dangerous. There are two types of evacuations that can be distinguished, namely small-scale evacuation and large-scale evacuation. Examples of small-scale evacuation that is a rescue carried out from a building caused by a bomb or fire threat. Examples of large-scale evacuation that is saving from an area due to flooding, eruption volcano or storm. Geraldo, et al, [17], Flood Tragedy in Manado City. Evacuation routes and evacuation sites in flood-prone areas in Manado City are spread in 10 sub- districts, namely: Bunaken District with 6 lanes and 4 evacuation sites, Tuminting District with 31 routes and 17 evacuation sites, Singkil District with 18 routes and 10 evacuation sites, Wenang District 16 routes and 8 evacuation sites, Paal Dua District 27 routes and 18 evacuation sites, Mapanget District 6 routes and 3 evacuation sites, Tikala District 20 routes and 13 evacuation sites, Sario District 15 routes and 7 evacuation sites, Wanea District as many as 25 routes and 22 evacuation sites, and Malalayang District as many as 8 routes and 3 evacuation sites.

3. Results and Discussion

3.1. Mapping Flood Areas

Based on the results of data analysis of flood area mapping in Panakukkang Subdistrict, the results of 5 district which are very safe flood zones are: some Panaikang District, Tello Baru District, Paropo district, Pandang District, and Masale District; 6 district which are flood safe zones, namely: a

portion of Panaikang Village, Tello Baru Village, Paropo Village, Karampuang Village, Pandang Village, and Masale Village; 6 district which are flood-prone zones, namely: a portion of Tello Baru Village, Paropo Village, Karampuang Village, Tamamaung Village, Masale Village, and Karuwisi Village; 4 district which are very flood-prone zones, namely: a portion of Pampang Village, Panaikang Village, Tamamaung Village, and North Karuwisi Village; and 4 district which are flood alert zones, namely: Sinri Jala District, parts of Pampang District, Tamamaung District, and North Karuwisi District.

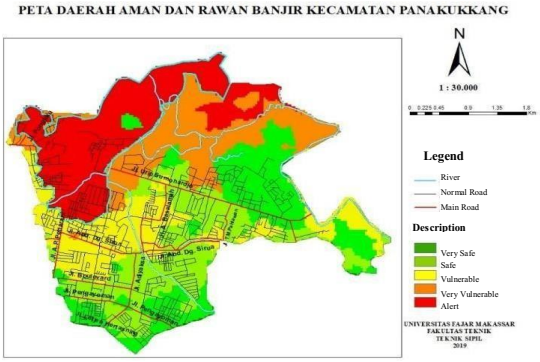

Figure 1. Map of the Flood District of Panakkukang District

Table 1. Regional Condition Parameters

Urban Village	Ground Elevation (meters)	Accumulation Value Based on DAS and Direction of Water Flow/Flow direction	Basin Area	Regional Conditions
Pampang	2 – 12	2,191	√	alert
Panaikan g	5 – 35	2,131	√	safe
Tello Baru	7 – 28	814	partly	Some are safe and vulnerable
Paropo	6 – 25	917	partly	Some are safe and vulnerable
Karampu ang	6 – 22	978	√	Some are safe and vulnerable
Pandang	5 – 20	724	partly	safe
Tamama ung	6 – 10	1,094	√	alert
Masale	6 – 25	1,096	partly	Some are safe and vulnerable
Sinri Jala	3 – 10	519	√	Alert
Karuwisi	5 – 12	85	√	vulnerable
Karuwisi Utara	4 – 13	496	√	alert

In table 1 shows data on land elevation, the value of water accumulation, the basin zone where the data is a parameter to determine the condition of the safe, vulnerable, and alert zones. The condition of land with high or low elevation in the form of hills or valleys is one of the factors where the zone is said to be safe or prone to flooding due to lack of availability of runoff / river flow zones and water catchment zones so that it becomes a pool of water that causes flooding in the area.

Table 2. Categories of Flood Impacts by Area of Flood Affected Zones in the District.

Number	Category Affected	Urban Village	Area of Affected Zone (Ha)
1	Very Safe	Panaikang dan Tello Baru	157.145059
		Pandang dan Paropo	11.025328
		Pampang	6.6049
		Panaikang	9.126502
		Tello Baru	32.348107
		Paropo	4.320598
		Masale	37.231607
	Total area		257.802
2	Safe	Panaikang, Karampuang, Paropo, dan Tello Baru	97.976245
		Karampuang, Paropo, Pandang, dan Masale	197.26991
		Tello Baru	26.241543
	Total area		321.488
3	Prone	Karuwisi, Tamamaung, Karampuang,dan Masale	203.942259
		Paropo	10.92114
		Tello Baru	54.073135
		Karampuang	4.813518
		Karuwisi Utara	1.07105
	Total area		274.821
4	Very vulnerable	Tamamaung, Pampang, dan Panaikang	256.938072
		Karuwisi Utara	19.732853
		Tamamaung	2.107839
		Pampang	8.566171
	Total area		287.344
5.	Alert	Karuwisi Utara, Pampang, Tamamaung, dan Sinri Jala	330.966192
		Pampang	48.56038
	Total area		379.52

In table 2 shows the categories of floods, ranging from very safe flooding, safe flooding, flood prone, very prone to flooding and flood alert with a total area of affected zones based on wards, that is, for very safe categories covering 257,802ha covering the villages of Panaikang and Tello Baru, Pandang and Paropo , Pampang, Panaikang, Tello Baru, Paropo, Masale. For the Safe Category covering an area of 321,488ha, covering Panaikang, Karampuang, Paropo, Tello Baru, Pandang and Masale villages. For the Prone category covering an area of 274,821ha covering the villages of Karuwisi, Tamamaung, Karampuang, Masale, Paropo, Tello Baru and North Karuwisi. For the Very Prone category covering an area of 287,344ha, covering the villages of Tamamaung, Pampang, Panaikang and North Karuwisi. Then for the vulnerable category covering an area of 379.52ha, covering the villages of North Karuwisi, Pampang, Tamamaung, and Sinri Jala. So the total area affected by flooding (prone, very vulnerable, and alert) in the Panakukkang sub-district is 9.41 km² with the total area of the Panakkukang sub-district amounting to 17.05 km².

3.2. Evacuation Area and Shelter Point (evacuation site)

According to [12], the area or building used as an evacuation area with safe area conditions, is said to be a safe flood area if the height of the surface of the puddle is in the middle of the height of the evacuation area. Evacuation areas and evacuation sites must have direct access to primary roads (district roads) or secondary roads (local roads)with a distance or range of approximately 30 meters and buildings must have a large enough area that can accommodate many people, or have an area of more or less 225 square meters.

Table 3. Evacuation Sites Based on Regional Conditions

No.	Evacuation Sites	Total (m^2)	Area Distance from themain road (meter)	Capacity(people)	Regional Condition
1	Governor Office	91,492	< 10	20,331	Safe
2	Baiturahman Mosque	2,964	< 10	658	
3	Panaikang Police Hostel	56,259	< 10	12,502	
4	Kodam XIV Hasanuddin	78,128	< 10	17,361	
5	Makassar BLK Building	11,700	< 10	2,600	
6	Makassar High School 5	9,360	< 10	2,080	
7	Makassar MaxOne Hotel	22,116	< 10	4,914	
8	SPN Batua	37,180	< 10	8,262	
9	Terminal Litha & Co	19,809	< 10	4,402	
10	Camba Field	3,705	< 30	1,646	
11	Fajar University	4,932	< 10	4,192	
12	Sultan Alauddin Mosque	1,764	< 10	392	
13	Elektrik Futsal Court	1,443	< 10	320	
14	BBIH Estate Building	4,725	< 10	2,050	
15	STMIK Handayani	2,400	< 10	1,566	
16	SwissBel Hotel	9,130	< 10	4,057	
17	Myko Hotel	760	< 10	1,685	
18	Panakukkang Mall	25,263	< 10	5,614	
19	Carefour Mall	25,935	< 10	5,763	
20	PT. Sinar Galesong Building	1,620	< 10	1,800	
21	Indonesia Moeslim University	24,772	< 30	11,009	Vulnerable
22	Nipah Mall	21,450	< 10	4,766	

In Table 3 shows the area, the distance from the main road to the evacuation area with a capacity based on the condition of the area and the evacuation area. There are 2 regional conditions that can be used as evacuation areas, namely: safe areas and vulnerable areas. For safe flood evacuations, namely: South Sulawesi Governor's Office, Baiturahman Mosque, Panaikang Police Dormitory, Kodam XIV Hasanuddin, Batua Sulsel SPN, Litha and Co Terminal, BLK Makassar Building, SMAN 5 Makassar Building, MaxOne Hotel Makassar Building, Camba Field, Camba Field, Makassar Fajar University Building, Makassar Sultan Alauddin Mosque, Electric Futsal Field, BBIH Estate Building, STMIK Handayani Makassar Building, SwissBel Hotel, Myko Hotel, Panakukkang Mall, and PT. Sinar Galesong Mandiri. As for the conditions of flood-prone areas, namely: Building of the Muslim University of Indonesia and Makassar Nipah Mall.

3.3. Flood Evacuation Transportation Routes

After doing the data it is known that the Panakukkang District is one of the areas with high flood-prone levels, it can be seen in the table that the total area of the flood area is 9.41km² to the area of Panakukkang District which is 17.05km². With the data obtained from safe areas and flood-prone areas, the data becomes a reference to determine which routes will be evacuation routes to get to flood-safe areas. In determining the evacuation route, the transportation route is divided into 2 flood evacuation routes.

3.4. First Flood Evacuation Route

In the first evacuation route, there were determined 8 (eight) roads that would serve as the evacuation destination route. All roads that have been evacuation routes have been surveyed to determine their suitability with the required evacuation criteria. After that, a road network analysis is carried out to obtain an evacuation route as shown in Figure 2.

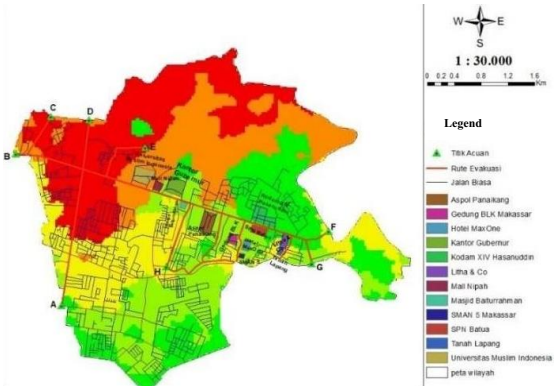

Figure 2. First Evacuation Route Map

In Figure 2, there are 8 (eight) reference points which are flood-prone areas, where the reference point is the farthest point from the evacuation site of each evacuation route which will be a benchmark of how long the mileage will be required from each reference point to go to the evacuation site. In the Decree of the Director General of Land Transportation No. : SK.43 / AJ 007 / DRJD / 97, walking speed in normal situations is 1.5 km/hour, in this case a speed sample is taken in an emergency situation (evacuation) of 3 km / hour.

Table 4. Travel Time, Distance and Speed from Reference Point to Road as Route for the nearest Evacuation Site

Reference Point	Street Name	Distance to the nearest evacuation site (km)	Speed (km/hour)	Travel time (minutes)
A	A.P. Pettarani St. (South Side)	2.85	3	57
B	Urip Sumohardjo St. (West side)	1.85	3	37
C	Pongtiku St	3.22	3	64.3
D	Tol Reformasi St. (North Side)	2.46	3	49.2
E	Pampang St. (East Side)	1.38	3	27.6
G	Urip Sumohardjo St.	0.71	3	14.2
H	Dr. Leimena St.	0.76	3	15.1
I	Baiturahman St.	1.05	3	21

Based on Table 4, it is known that there are 8 Reference Points on the first evacuation route. Reference Point C becomes the farthest point that must be reached with the distance to the nearest evacuation site as far as 3.22km and the travel time of 64.3 minutes. Then reference point A with the distance to the nearest evacuation site is 2.85 km and travel time for 57 minutes. While the referencepoint F is the closest point that must be traveled with the distance to the nearest evacuation site as far as 0.71 km and travel time for 14.2 minutes. All of these reference points on the first evacuation route equire a travel speed of 3 km / h on foot.

3.5. Second Flood Evacuation Route

In the first evacuation route, it was determined that there were 6 (six) roads that would serve as the evacuation destination route. All roads that have been evacuation routes have been surveyed to determine their suitability with the required evacuation criteria. After that, a road network analysis is carried out to obtain an evacuation route as shown in Figure 3.

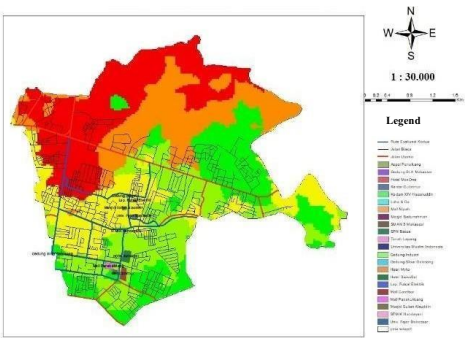

Figure 3. Map of the Second Evacuation Route

In Figure 3, there are 6 reference points which are flood-prone areas, where the reference point is the farthest point from the evacuation site of each evacuation route which will be a benchmark of how much distance will be needed from each reference point to get to the evacuation site. In the Decree of the Director General of Land Transportation No. : SK.43 / AJ 007 / DRJD / 97, walking speed in normal situations is 1.5 km / hour, in this case a speed sample is taken in an emergency situation (evacuation) of 3 km / hour.

Table 5. Mileage Time from Reference Point to Nearest Evacuation Sites

Reference Point	Street Name	Distance to the nearest evacuation site (km)	Speed (km/hour)	Travel time (minutes)
A	A.P. Pettarani St. (North Side)	1.94	1	38.8
B	Abdurrahman Basalamah St.	0.90	3	18
C	Abd. Dg. Sirua St. (East Side)	0.72	3	14.4
D	Boulevard St.	1.05	3	21
E	Abd. Dg. Sirua St. (West Side)	1.23	3	24.6
F	A.P. Pettarani I St.	1.29	3	25.8

Based on Table 5, there are 6 Reference Points found on the second evacuation route. Reference Point A becomes the farthest point that must be reached with the distance to the nearest evacuation site as far as 1.94 km and travel time of 38.8 minutes. Then the reference point E with the distance to the nearest evacuation site is 1.23 km and the travel time is 24.6 minutes. While the reference point C is the closest point that must be traveled with the distance to the nearest evacuation site as far as 0.72km and travel time for 14.4 minutes.

4. Conclusion

Based on the results of the analysis and discussion of the data, the following conclusions areobtained:

The total area affected by flooding (Prone, very vulnerable, and alert) in Panakukkang District is 9.41 km² of the total area of 17.05 km². The category of flooding based on district, that is, for the very safe category of 257,802 ha includes Panaikang and Tello Baru, Pandang and Paropo, Pampang, Panaikang, Tello Baru, Paropo, Masale district. For the Safe Category covering an area of 321,488ha, covering Panaikang, Karampuang, Paropo, Tello Baru, Pandang and Masale villages. For the Prone category covering an area of 274,821ha covering the villages of Karuwisi, Tamamaung, Karampuang, Masale, Paropo, Tello Baru and North Karuwisi. For the Very Prone category covering an area of 287,344ha, covering the villages of Tamamaung, Pampang, Panaikang and North Karuwisi. Then for the Waspada category covering an area of 379.52ha, covering the villages of North Karuwisi, Pampang, Tamamaung, and Sinri Jala. Places that can beused as evacuation areas (safe zones), namely: the Office of the Governor of South Sulawesi (20,331 people), Baiturrahman Mosque (658 people), Panaikang Police Dormitory(12,502 people), Kodam XIV Hasanuddin (17,361 people), SPN Batua Sulsel (8,262 people), Litha & Co Terminal (4,402 people), BLK Makassar Building (2600 people), SMAN 5 Makassar Building (2,080 people), MaxOne Makassar Hotel Building (4,914 people), Cambajawayya Lapland (1,646 people), Makassar Fajar University Building (4,192 people), Sultan Alauddin Makassar Mosque (392 people), Electric Futsal Field (320 people), Large Plantation Industry Hall (2,050 people), STMIK Handayani Makassar Building (1,566 people), SwissBel Hotels (4,057 people), Hotels Myko (1,685 people), Panakukkang Mall (5,614 people), and PT. Sinar Galesong Mandiri (1,800 people), with a total capacity of 123,131 people. For transportation routes divided into 2 routes: - The first route is centered north of Panakukkang District, there are 8 reference points on the first evacuation route, Reference Point C with the distance to the nearest evacuation site as far as 3.22km and travel time of 64.3 minutes. Then reference point A with the distance to the nearest evacuation site is 2.85km and travel time for 57 minutes. While the reference point F is the closest point to the nearest evacuation distance of 0.71 km and the travel time of 14.2 minutes. All of these reference points on the first evacuation route require a travel speed of 3 km / h on foot. - The second route is centered south of Panakukkang District. There are 6 Reference Points on the second evacuation route, namely reference pointA with distance to the nearest evacuation site 1.94 km and travel time for 38.8 minutes, reference point E with distance to the nearest evacuation location 1.23 km and travel time for 24.6 minutes and then at reference point C is the closest point with distance to the nearest evacuation site as far as 0.72km and travel time for 14.4 minutes.

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