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RESEARCH ARTICLE

Planning of Evacuation Places and Routes for Flood Disaster in Kesambi District, Cirebon, Indonesia

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Abstract

The increasing frequency and intensity of flooding in Kesambi District, Cirebon City, has caused significant economic losses and disrupted people's lives. This study attempts to manage flood disaster risks through careful planning. By combining spatial data analysis and an associative descriptive approach, this study produces a map of evacuation places and routes that can be relied on to deal with future floods. The results of the study indicate that the potential for flooding in Kesambi District causes extensive damage and has a significant impact on people's lives, especially in Drajat, Kesambi, and Pekiringan Sub-districts. Thousands of residents of Kesambi District are exposed to disaster risks and damage to buildings and infrastructure that hinder mobility and economic activity. Based on the analysis of capacity, travel time, and distance, this study has determined 6 evacuation places that can accommodate the estimated number of evacuees and 40 existing evacuation routes can be safely passed. These six evacuation places are considered strategic because they are close and can be reached in a short time, making it easier for people to immediately carry out independent evacuation when a disaster occurs.

Keywords: Disaster, Flood, Evacuation Places, Evacuation Routes, Kesambi District

1. Introduction

Flooding is a natural phenomenon that occurs when the volume of water in an area exceeds its capacity. This condition is generally caused by extreme rainfall, high tides, or obstruction of river flows. As a result, low-lying areas will be inundated, causing infrastructure damage, economic losses, and even loss of life (Chan et al., 2018; Douglas, 2017; Javadinejad, 2022; Nguyen et al., 2021; Olbert et al., 2017).

Data from the National Disaster Management Agency (BNPB) for 2020-2024 shows that flooding is one of the disasters that often occurs in Indonesia, including the city of Cirebon. Geographical conditions, high rainfall, inadequate drainage systems, and rising sea levels are the main causes. As a result, the city of Cirebon has experienced an increase in the frequency and intensity of flooding in recent years. This condition not only causes infrastructure damage and economic losses, but also disrupts social activities in the community (Chabou et al., 2025; Haddad et al., 2025; Indrayani et al., 2025; Kausarian et al., 2018; Liu et al., 2025; Mantovani et al., 2025; Mondal et al., 2025; Qalbi et al., 2024).

Based on data from the Cirebon City Regional Disaster Management Agency (BPBD) for 2017-2024, flooding in Kesambi District is estimated to have affected thousands of residents with losses reaching hundreds of millions of rupiah. This illustrates that flood disaster risk management in Cirebon City, especially in Kesambi District, needs to be improved to reduce its negative impacts. One of these efforts is to prepare evacuation places/locations.

Evacuation places are temporary shelters for disaster victims. This place must be safe, far from the danger of flooding, and equipped with basic facilities such as clean water, food, and shelter (Kowalczyk et al., 2025; Shah et al., 2025, 2020; Shume et al., 2025; Wu et al., 2019). In addition, local governments need to establish clear and safe evacuation routes to direct residents to evacuation places when a disaster occurs. This route must be easily recognizable, free from obstacles, strategically located, in a low-risk zone, and planned by considering the distance and travel time from the disaster location to the evacuation place (SNI 7766: 2012; Hakim et al., 2017; Du, 2024; Sihombing et al., 2024).

Flooding is one of the priority problems in Cirebon City, especially in Kesambi District. To reduce its impact, good evacuation planning is needed. This study aims to analyze flood disaster evacuation places and routes in Kesambi District, and provide recommendations so that the government and community are better prepared to face floods, minimize casualties, and material losses in the future.

2. Data and Methods

This study uses a quantitative map overlay method with an associative descriptive approach, which is a method that aims to provide an objective, comprehensive, and in-depth description of the distance and time from disaster-prone areas to evacuation places in a certain period. The research design used is a survey and spatial modeling. The survey was conducted to collect data and information on the physical conditions of the area, infrastructure, etc. Spatial modeling is used to analyze geographic data and plan evacuation places and routes. The population in this study were residents, related stakeholders, flood-prone locations, and infrastructure in Kesambi District. The research sample used was a flood-prone location.

Research data on planning evacuation places and routes for flood disasters in Kesambi District were collected through

participatory field observation and documentation studies. Through participatory observation, researchers actively become part of the dynamics of the Cirebon City Government. Primary data from direct observations are then integrated with secondary data (documentation studies) to obtain a comprehensive understanding of the research object. Documentation studies are conducted by reviewing various documents, both spatial and non-spatial, researchers can obtain relevant and in-depth information regarding the history of floods, geographical conditions, infrastructure, government policies, etc.

In the context of disaster evacuation planning, the research instruments used are observation checklists and document analysis guidelines. The data obtained are then processed to become meaningful information according to the research objectives with data tabulation techniques. After the data is collected, the data is then analyzed using spatial analysis. This analysis technique consists of map overlay and analysis of the capacity of evacuation places and routes.

3. Result and Discussion

3.1 Overview of Kesambi District

Kesambi District, located in the western part of Cirebon City, consists of five sub-districts with geological conditions in the form of alluvial plains, quaternary deposits, Pliocene-Pleistocene sedimentary rocks, and Quaternary volcanic rocks with weathered rock types (soil) namely alluvial and grumusol. Kesambi has high rainfall, around 2.000-3.000 mm, and shallow groundwater with limited aquifers. This district is crossed by three main rivers and is dominated by settlements and dry fields. With a population of around 80,000 people and a population density of 155 people/ha, Kesambi has the potential for various disasters, including floods, extreme weather, forest and land fires, landslides, and earthquakes (DPUTR of Cirebon City, 2023; BPBD of Cirebon City, 2023; BPS of Cirebon City, 2024). The combination of these various factors forms the unique characteristics of Kesambi District which need to be considered in various aspects of regional development and planning, including planning disaster evacuation places and routes.

3.2 Flood Disaster Risk in Kesambi District

Kesambi District has 25 flood-prone areas in five sub-districts, with Drajat and Pekiringan Sub-districts being the most vulnerable. Severe flooding occurred in early 2018, submerging RW. 06 Suradinaya, Pekiringan, as high as 2.8 meters, causing 105 families to lose their homes. Based on direct observation data, this flood was caused by poor drainage, damage to rivers and embankments, and high rainfall. Lack of public awareness in maintaining environmental cleanliness also worsened the existing conditions. Infrastructure improvements and increased public awareness are needed to reduce the risk of flooding in this area.

Table 1. Potential number of population exposed to flood disaster in Kesambi District.

Sub-District	Exposed Population (People)			
	Low	Medium	High	Total
Karyamulya	43	830	488	1.361
Drajat	0	0	457	457
Sunyaragi	420	939	131	1.490
Kesambi	22	0	483	504
Pekiringan	826	335	788	1.949
Total Kesambi District	1.311	2.104	2.346	5.761

Source: BPBD of Cirebon City, 2023

The Disaster Risk Assessment (KRB) in Cirebon City for the 2023-2027 period shows that around 6% of the city's total population, or equivalent to 20.898 people, are potentially affected by flood disasters. Kesambi District is the area with the second largest number of affected residents, reaching 5.761 people. Each sub-district in Kesambi District has a number of residents exposed at varying levels, as shown in Table 1.

Determination of disaster risk areas is carried out by combining the results of the analysis of potential hazards, vulnerability, and capacity for flood disasters. From the results of the risk analysis, the level/classification of areas that are most likely to be affected by flood disasters can be determined. Disaster risk maps are obtained from the results of data overlay and maps produced from these analyses, as shown in Fig. 1 (BPBD of Cirebon City, 2023).

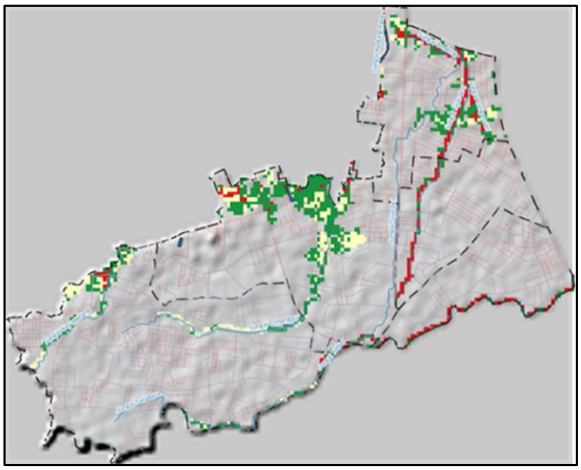

Fig. 1. Flood disaster risk map in Kesambi District based on KRB Cirebon City 2023-2027.

Drajat and Kesambi sub-districts were identified as having the highest disaster risk among other sub-districts. This condition is caused by several factors, including the high level of danger in both areas, a combination of low and high levels of vulnerability, and a moderate level of capacity. In addition, the geographical location of the two sub-districts which are directly adjacent to rivers (Sijarak II River and Suba/Kesunean River) makes them very vulnerable to flooding.

Sunyaragi sub-district is the largest area that has the potential to be affected by flooding, as shown in Table 2. Meanwhile, Pekiringan sub-district is the area with the highest flood hazard compared to other sub-districts in Kesambi District. This means that Pekiringan sub-district has the highest danger when a flood occurs. Overall, Kesambi District has a significant total area that has the potential to be affected by flooding, especially at moderate and high levels.

Table 2. Potential area of flood hazard in Kesambi District.

Sub-District	Flood Hazard Area (Ha)			
	Low	Medium	High	Total
Karyamulya	2,97	15,75	4,32	23,04
Drajat	0	0	6,39	6,39
Sunyaragi	9,99	24,66	7,92	42,57
Kesambi	0,36	0	5,31	5,67
Pekiringan	11,25	4,95	9	25,20
Total Kesambi District	24,57	45,36	32,94	102,87

Source: BPBD of Cirebon City, 2023

Considering the in-depth analysis of the potential vulnerable population and the scope of the flood-affected area in Kesambi District, it was identified that Drajat, Kesambi,

and Pekiringan Sub-districts occupy the highest priority in flood disaster mitigation and management efforts at the sub-district level. This priority determination is reinforced by the geographical characteristics of the northern area of Cirebon City which has a significantly lower elevation compared to the southwestern part of the city. Such topographic conditions make the northern area more vulnerable to waterlogging, both due to high rainfall and river overflows, thus requiring more intensive attention and action.

3.3 Potential of Buildings and Roads Affected by Flood Disaster in Kesambi District

Based on the overlay analysis conducted between the Kesambi District flood risk map and the 2020 High Resolution Satellite Imagery, the existing flood has the potential to cause quite severe damage to various types of buildings (Table 3), especially residential houses. This shows a significant impact on people's lives. In addition to residential houses, public facilities such as schools, health centers, and government buildings have also been damaged, which has the potential to disrupt public services. Damage to economic facilities such as malls and markets indicates a significant economic impact. Overall, there are 2.572 buildings that have the potential to be affected with a total area of 306.265 m2. Houses, malls, markets, and shops are buildings that are significantly affected if a disaster occurs.

Table 3. Potential number and area of buildings affected by flood disasters in Kesambi District.

No	Types of Buildings Affected	Total	Area (m2)
1	Hotel	2	1.546
2	Clinic	2	254
3	Mall/Market/Shop	3	8.785
4	Government	7	1.491
5	College	2	1.091
6	Defense	1	372
7	Community Health Center	1	9
8	Housing Area	2.546	291.653
9	Hospital	2	72
10	School	3	320
11	Gas Station	1	345
12	Private	1	205
13	Mortuary	1	120
	Total Buildings Affected	2.572	306.265

Source: Analysis, 2025

Table 4. Potential length of roads affected by flood disasters in Kesambi District.

No	Types of Roads Affected	Length (m)
1	Primary Arterial Roads	765
2	Primary Collector Roads	643
3	Secondary Collector Roads	184
4	Primary Neighborhood Roads	8.845
5	Primary Local Roads	210
6	Secondary Local Roads	1.856
7	Intercity Railway Network	41
	Total Roads Affected	12.543

Source: Analysis, 2025

Based on the overlay analysis conducted between the flood disaster risk map and the 2023 Transportation Network, the existing flood disaster risk has the potential to cause quite severe damage to various types of roads (Table 4), especially primary environmental roads. This shows a significant impact on people's lives. Main roads such as arterial and primary collectors which are usually the main traffic routes, are severely affected. Damage to primary environmental roads also shows that flooding has submerged community organizations. Damage to the intercity railway network shows that public transportation has also been disrupted by this disaster. Overall, the total length of roads affected by the flood disaster reached 12.543 meters.

These data provide an initial overview of the impact of the flood disaster in Kesambi District, both the risk of disaster and its impact on buildings or roads, as well as the importance of conducting further analysis to take appropriate handling steps, especially regarding the places and disaster evacuation routes that will be used.

3.4 Evacuation Place of Kesambi District

In determining the evacuation place, the number of residents potentially affected by flooding in Kesambi District is the main consideration. In this study, the population analyzed was only the population at moderate and high risk of exposure. This is because the population with low exposure is relatively more able to anticipate flooding and has a low level of vulnerability. Table 5 presents the calculation of the land area requirements for each evacuation place. This data is obtained from the results of multiplying the potential number of residents exposed by the standard space requirements. The minimum space requirement standard for flood refugees used is 2 m2 per person, which refers to the average bed size requirements of the Indonesian people.

Table 5. Estimated land area needs for flood disaster refugees in Kesambi District.

Sub-District	Total Refugees (people)	Land Area (m2)
Karyamulya	1.318	2.636
Drajat	457	914
Sunyaragi	1.070	2.140
Kesambi	483	965
Pekiringan	1.123	2.245
Total Kesambi District	4.450	8.901

Source: Analysis, 2025

After being analyzed, there are 6 locations that have the potential to be used as evacuation places and are spread across each sub-district of Kesambi District. To determine the capacity of each location, a calculation of the capacity or capacity of the evacuation place is carried out based on the area of land and buildings available, as shown in Table 6.

Based on the analysis of evacuation place capacity, there are various types of buildings that are used as evacuation places, ranging from open fields, closed fields, to government offices. The capacity of each location varies, adjusted to the area of land and buildings available. The majority of locations recorded function as temporary evacuation places, indicating that these locations are generally used to respond to emergency situations quickly or in the short term. Only one location is recorded as the final evacuation place, namely the Bima Stadium Area. This location is equipped with more adequate facilities to accommodate evacuees for a longer period of time, relatively close access, and can accommodate all residents who are potentially affected by flooding in Kesambi District.

In this study, six locations were selected as evacuation places. The selection of these locations took into account two main factors: the capacity of the evacuation place and the distance from settlements in areas with moderate-high flood risk. All six locations are able to accommodate the estimated number of evacuees. In addition, the average distance between the evacuation place and settlements at risk of flooding is also relatively close, which is around 1.3 km. A relatively close distance will make it easier for residents to reach the evacuation place shortly after a disaster occurs.

Table 6. Flood disaster evacuation location/place plan for Kesambi District.

No.	Sub-District	Coordinate	Building	Area (m2)	Capacity (People)	Clean Water and Sanitation	Types of Evacuation Places	Annotation	Photo
1	Karyamulya	108.5285 -6.7467	Junior High School 11 Cirebon City Field	1400	700	Junior High School 11 Cirebon City	Temporary Evacuation Place	Recommendation	
2	Drajat	108.5600 -6.7310	Kesambi Football Field	1900	950	Drajat Sub District Office	Temporary Evacuation Place	Recommendation	
3	Sunyaragi	108.5317 -6.7332	Bima Stadium Area	27000	13500	Youth and Sports Office	Final Evacuation Place	Regional Regulation No. 8 of 2012	
4	Kesambi	108.5549 -6.7258	GMC Basketball Arena	1800	900	GMC Basketball Arena	Temporary Evacuation Place	Recommendation	
5		108.5546 -6.7288	Kesambi District Office	1050	525	Kesambi District Office	Temporary Evacuation Place	Mayor Regulation No. 76 of 2021	
6	Pekiringan	108.5505 -6.7135	GTC Parking Lot	3000	1500	GTC	Temporary Evacuation Place	Recommendation	

Source: Analysis, 2025

3.5 Evacuation Route of Kesambi District

In determining effective evacuation routes and locations when flooding occurs, several crucial factors are the main considerations, especially for medium and high disaster risk zones. Evacuation places that have maximum capacity, shortest travel time, and closest distance when flooding occurs in each medium and high disaster risk zone are the main priority. This is because people in low-risk zones are relatively more able to anticipate flooding and have low levels of vulnerability. Evacuation planning is intensified in areas that are most at risk to ensure the safety of the most vulnerable population.

After being analyzed, there were 40 routes that could potentially be used as evacuation routes and were spread across each sub-district of Kesambi District (Fig. 2). To determine the travel time for each location, calculations were made based on the distance of the available evacuation place with the average walking speed standard for Indonesians. The minimum walking speed standard for flood disaster evacuees is 0.71 m/second or 42.6 m/minute per person referring to the average walking evacuation speed of the most vulnerable people (BNPB, 2023). In addition to calculating vulnerable groups, the speed of evacuation of affected residents using motorized vehicles was also carried out for comparison. The speed limit for motor vehicles in residential areas, including in Cirebon City, is 30 km/hour or 500 m/minute (Minister of Transportation Regulation No. 111 of 2015).

Evacuation route analysis (shortest path: point to point) shows that various types of roads, ranging from secondary local roads to primary arterial roads, are used. Evacuation travel times vary significantly, thus impacting evacuation planning. Wide roads with short travel times (primary arterial and collector) allow more people to reach safe places faster. Conversely, narrow roads with long travel times increase the risk of being trapped in a disaster. In addition, road conditions during a disaster can change, so it is important to consider the worst-case scenario in evacuation planning.

In this study, 40 routes were selected as evacuation routes. The selection of these routes took into account two main factors, namely the distance and travel time from settlements located in areas with moderate-high flood risk to evacuation places. The 40 routes are estimated to be passable by affected residents if a flood occurs. In addition, the average travel time between evacuation places and settlements at risk of flooding is also relatively moderate, which is around 30,4 minutes to cover a distance of 1,3 km. This travel time is the walking travel time for the most vulnerable people (elderly). Of course, the travel time using motorized vehicles is relatively faster when compared to walking. Evacuation travel time by motor vehicle is only 2,6 minutes for the same distance. The relatively short travel time certainly makes it easier for residents to reach the evacuation place when a disaster occurs.

Based on quantitative analysis of travel time and distance data in the Table 7, the classification of evacuation routes in Cirebon can be categorized into near and far using the average value as a threshold. It was identified that 23 routes (57.5%) were classified as near and 17 routes (42.5%) were classified as far. This percentage shows that the majority of evacuation routes from flood-prone settlements to evacuation points in the Cirebon area have relatively low distance and estimated travel time characteristics (quick and easy accessibility) compared to the average value.

This classification provides an initial picture of the level of accessibility difficulty from various flood-risk settlements to the designated evacuation places. Although this approach is general, this understanding is crucial in disaster mitigation planning and strategies. Identification of long routes underlines the need for special consideration in the provision of transportation resources, earlier evacuation information, or even the determination of alternative evacuation places that are closer to minimize risks and speed up the evacuation process for affected populations.

Table 7. Distance and travel time for flood disaster evacuation routes in Kesambi District.

Routes No.	Sub District Initial Point	Sub District End Point	Distance (m)	Vulnerable Group Travel Time (minutes)	Motor Vehicle Travel Time (minutes)	Classification Based on Average
1			2137	50.2	4.3	Far
2			1985	46.6	4.0	Far
3			2171	51.0	4.3	Far
4	Sunyaragi		2512	59.0	5.0	Far
5			2399	56.3	4.8	Far
6		Bima Stadium	1841	43.2	3.7	Far
7		Area, Sunyaragi	1385	32.5	2.8	Far
8		108.5317, -	1119	26.3	2.2	Near
9		6.7332	1728	40.6	3.5	Far
10			1929	45.3	3.9	Far
11	Karyamulya		2392	56.1	4.8	Far
12			1214	28.5	2.4	Near
13			1236	29.0	2.5	Near
14			1397	32.8	2.8	Far
15		Junior High	736	17.3	1.5	Near
16		School 11	822	19.3	1.6	Near
17		Cirebon City	1742	40.9	3.5	Far
18	Karyamulya	Field,	2289	53.7	4.6	Far
19		Karyamulya	2347	55.1	4.7	Far
20		108.5285, - 6.7467	2615	61.4	5.2	Far
21			649	15.2	1.3	Near
22		Kesambi Football	932	21.9	1.9	Near
23	Drajat	Field, Drajat	1200	28.2	2.4	Near
24		108.5600, -	1742	40.9	3.5	Far
25	Sunyaragi	6.7310	1972	46.3	3.9	Far
26		Kesambi District	738	17.3	1.5	Near
27	Kesambi	Office, Kesambi 108.5546, - 6.7288	1015	23.8	2.0	Near
28	Kesambi		401	9.4	0.8	Near
29		GMC Basketball	527	12.4	1.1	Near
30		Arena, Kesambi	878	20.6	1.8	Near
31	Pekiringan	108.5549, -	1063	25.0	2.1	Near
32		6.7258	849	19.9	1.7	Near
33			55	1.3	0.1	Near
34			68	1.6	0.1	Near
35		GTC Parking Lot,	604	14.2	1.2	Near
36	Pekiringan	Pekiringan	791	18.6	1.6	Near
37		108.5505, -	352	8.3	0.7	Near
38		6.7135	593	13.9	1.2	Near
39			572	13.4	1.1	Near
40			888	20.8	1.8	Near

Source: Analysis, 2025

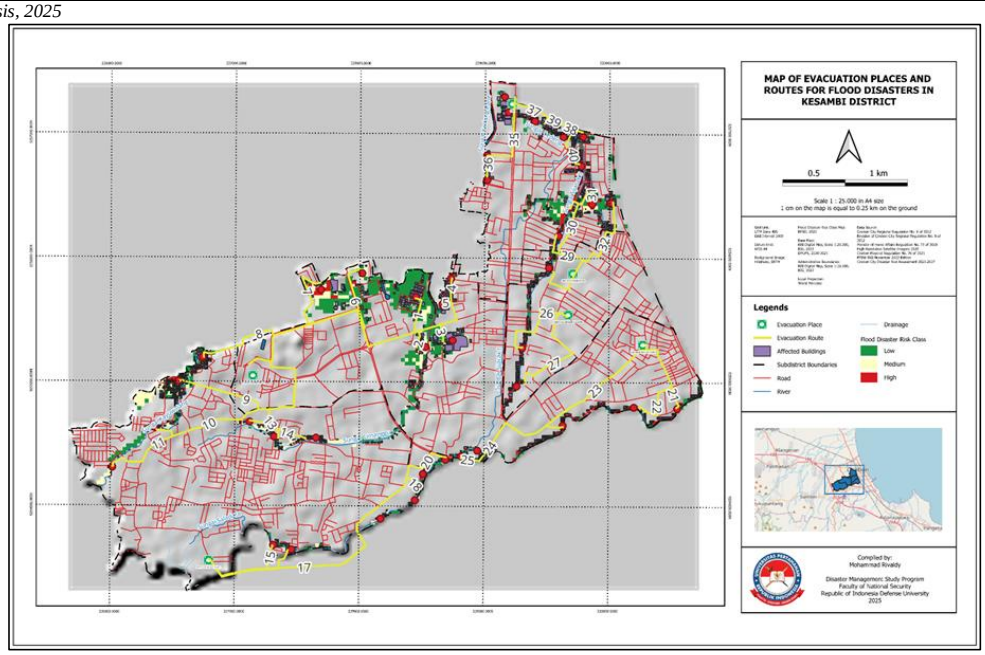

Fig. 2. Map of evacuation places and routes for flood disasters in Kesambi District.

4. Conclusion

Flooding is one of the serious problems of Cirebon City, especially in Drajat, Kesambi, and Pekiringan Sub-districts, Kesambi District, which requires special attention from the local government. Increasing the frequency and intensity of flooding has the potential to cause infrastructure damage, economic losses, and disruption of social activities. Therefore, effective disaster risk management is needed, including planning and analysis of evacuation places and routes. This study uses quantitative and descriptive methods to provide a detailed description of flood evacuation planning in Kesambi District, which is a flood-prone area in Cirebon City. Around 5,761 residents in this district are potentially affected by flood risk. Analysis of satellite imagery and disaster risk maps shows the potential for significant damage to buildings, public facilities, and road infrastructure. This damage can hinder mobility and have a negative impact on the local economy.

This study has identified six evacuation places and 40 potential evacuation routes. The selection of evacuation places and routes is based on three main criteria, namely evacuation place capacity, travel distance, and travel time. The six selected evacuation places have sufficient capacity to accommodate the estimated number of affected or displaced residents and the 40 existing evacuation routes can be safely passed. The majority (57.5%) of the 40 flood evacuation routes in Cirebon are categorized as close based on average travel time and distance, indicating the ease of residents to reach evacuation places quickly during a disaster. Meanwhile, 42.5% of the routes are categorized as far, indicating the need for special considerations in mitigation planning, such as providing transportation or earlier evacuation information.

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