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Disaster risk assessment: Hazards, vulnerabilities, and capacities for the environmental risk management in Banjarmasin City, Indonesia

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ABSTRACT

Aligning with the sustainable development goals 13 (SDGs 13) which aims at handling climate change and disaster management, and since Banjarmasin City is very strategic and is fairly densely populated, the Government needs to ensure that the people of Banjarmasin are safe from disasters. Conducting a disaster risk assessment (DRA) in Banjarmasin City, Indonesia, is the basis for planning the implementation of integrated, structured, directed and measurable disaster management. The disaster risk assessment document contains the process and results including hazards, vulnerabilities, and capacities which are the basis for determining disaster risk. The results of DRA are steps to determine the direction of disaster management policies in Banjarmasin City that are more focused and directed in the future. The involvement of all stakeholders related to disasters in Banjarmasin City and the community can support efforts to implement disaster management by following the results of DRA and calculating the potential for life exposure, property loss as well as environmental damage that have been prepared in the city. The DRA document is expected to be the basis for clear and comprehensive direction for disaster management. Therefore, the results of this assessment can be agreed and legalized by the local government, so that the implementation of disaster management in Banjarmasin City can be more focused. This produces a DRA document and disaster risk map in Banjarmasin City. The form of support and legality from policy makers in the regions is needed. So that, the results of DRAs can be used as a reference in disaster management efforts in Banjarmasin City.

Keywords: Disaster, Risk, Assessment, Environment, Management.
Article type: Research Article.

INTRODUCTION

SDGs 13 encourages governments to strengthen resilience and adaptation capacity to climate-related hazards and natural disasters, as well as integrating climate change anticipation actions into policies, strategies and planning. One of the busiest cities in Indonesia is Banjarmasin City (Michiani & Asano 2019). Its name comes from Latin *Bandierma sinensis,* one of the cities and the capital of South Kalimantan Province, Indonesia. The city is the center of regional activities (PKW), as the center of government (capital of South Kalimantan Province), and the national gateway, as well as the city center of national economic activity. It is also an important city in the South Kalimantan region which currently attained a very strategic geographical position. Furthermore, it is the most populous city in Kalimantan and one of the big cities in Indonesia, albeit smaller than West Jakarta. Cities separated by rivers include Tatas Island, Kelayan Island, Rantauan Keliling Island, Insan Island and others (Misransyah *et al.* 2023). Since ancient times until now, Banjarmasin is still the most important commercial city and port city on the island of Kalimantan. It is still de jure the capital of South Kalimantan. However, the regional secretariat office of South Kalimantan Province in August 14, 2011 coincidence with the 61st anniversary of South

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Kalimantan Province, has been moved to the Gunung Upih area in Cempaka Banjarbaru sub-district which stands at a location with a height of 44 meters above sea level and is about 60 km from the old office. The Ministry of Public Works placed Banjarmasin as one of the important cities along with four regions or cities, that are satellites of one of the strategic areas of the province, called the Banjarmasin urban area. Geographically, Banjarmasin City is located at 3 0 15″ to 33 0 22′ south latitude and 144 0 32″ east longitude, the height of the original land is 0.16 m below sea level and almost the entire area is inundated by water during high tide. It is located in the Kuala Martapura River area which empties into the east side of the Barito River. Its location is almost in the middle of Indonesia (Michiani & Asano 2019). The city is located on the east bank of the Barito River and is bisected by the Martapura River which originates in the Meratus mountains. Banjarmasin City is influenced by the tides of the Java Sea, thus affecting the drainage of the city and providing its own characteristics to the lives of the surrounding community, especially the use of rivers as one of the infrastructures for water transportation, tourism, fisheries and trade. Sine Banjarmasin is very strategic and is a densely populated city, the Government needs to ensure that its people are safe from disasters, by conducting a Disaster Risk Assessment (DRA) in Banjarmasin City, which is the basis for planning the implementation of integrated, structured, directed, and measurable disaster management. The DRA document contains the process and results including hazards, vulnerabilities, and capacities which are the basis for determining disaster risk. The assessment was carried out for all potential disasters in Banjarmasin City, namely floods, extreme weather, and drought (Rosa *et al.* 2020). DRA and public discussion by regional and community officials determine priority disasters, i.e., floods, extreme weather and drought. Therefore, the regional apparatus together with the community agreed to make the high-risk disaster as a priority in the implementation of disaster management in Banjarmasin City. The results of DRA are steps to determine the direction of disaster management policies in Banjarmasin City that are more focused and directed in the future (Musriha *et al.* 2021). Based on the results of these priorities, disaster management policy recommendations were formulated for the Banjarmasin City government aimed at minimizing the level of danger and reducing the vulnerability of exposed residents (Cuthbertson *et al.* 2023). The implementation of disaster management policy directives requires the participation of all parties, from the government to the levels of society. The involvement of all stakeholders related to disasters in Banjarmasin City and the community can support efforts to implement disaster management by following the results of disaster risk assessments that have been prepared in Banjarmasin City, the DRA document is expected to be the basis for clear and comprehensive direction for disaster management. This is intended to further minimize the loss of lives and losses caused by disasters in Banjarmasin City (Rudiansyah *et al.* 2019; Siswati *et al.* 2020; Xue *et al.* 2022). DRA is used as a foundation in the preparation of disaster management plans in Banjarmasin City. Therefore, the results of this assessment can be agreed and legalized by the local government. So that, the implementation of disaster management in Banjarmasin City can be more focused. It is expected that the local government of Banjarmasin City will strengthen DRA, so as to create a basis for disaster management policy making. The policies taken will be able to touch more on efforts to reduce the impact of disaster victims, physical and economic losses and environmental damage in Banjarmasin City (Lan Huong *et al.* 2022). The DRA document is a guideline to build a strong foundation in the disaster management plan process. Therefore, this guideline needs to be clarified in a technical guide for the assessment of every disaster in Banjarmasin City. This assessment produces a DRA document and disaster risk map in Banjarmasin City. The DRA document is an initial recommendation in policy making that is equipped with a disaster risk map for each type of hazard (Sun *et al.* 2022). The benefits of DRA in Banjarmasin City include:

1. As a conceptual basis to reduce the impact caused by disasters, as well as in the context of recognition and adaptation to existing hazards, as well as sustainable activities to reduce or eliminate long-term risks, both to human life and property.
2. DRA is one of the efforts to reduce the disaster risk index in accordance with the targets of the National Medium-Term Development Plan (RPJMN) and Regional Medium-Term Development Plan (RPJMD) of the Banjarmasin City Regency.
3. The results of the DRA are expected to be able to become a technocratic basis for plans related to disaster management in the regions such as disaster management plans, technical plans for disaster risk reduction, disaster emergency management plans, contingency plans, emergency operation plans, and post-disaster recovery plans. The results of DRA are also the basis for planning activities and utilization of space and the resources contained therein, as an effort to minimize potential disaster risks.

4. The results of DRA are important and strategic for regional development, as well as the factual conditions of district/city conditions by considering the dynamics of disaster causes and the development of science and technology and scientific methods in mitigation efforts.

Data processing based on DRA and DR maps include threats, vulnerabilities, and capacity to produce conclusions on the type of disaster and disaster level. There are three disasters that have the potential to occur in Banjarmasin City, i.e., floods, extreme weather, and drought. Therefore, it is necessary to be responded by the Banjarmasin City Government to reduce the impact of the potential DR, so that it will reduce losses both exposed lives, property and the environment damaged by the disaster that will occur. In dealing with this, the Banjarmasin City Government needs to take disaster management measures. One of them is by increasing regional capacity in dealing with disasters. This is strengthened by policies related to disaster management that have the potential to occur in Banjarmasin City (Chang *et al.* 2022). The DRA document is expected to be mutually agreed upon by stakeholders involved in the preparation of DRA. The form of support and legality from policy makers in the regions is needed, so that the results of DRAs can be used as a reference in disaster management efforts in Banjarmasin City.

Geographic condition and administrative boundaries

Banjarmasin City is geographically located between 3° 16' 46" to 3° 22' 54" South Latitude and 114° 31' 40" to 114° 39' 55" East Longitude, located at an average height of 0.16 m below sea level with relatively flat and swampy area conditions. At high tide almost the entire area is inundated. Banjarmasin City is located in the south of South Kalimantan Province, bordered by:

- North: Barito Kuala Regency.
- East: Banjar Regency.
- West: Barito Kuala Regency.
- South: Banjar Regency.

In accordance with its conditions, Banjarmasin City has many tributaries that are used by the community as a means of transportation apart from existing land roads. The area of Banjarmasin City is 9,846.80 ha or 0.26% of the area of South Kalimantan Province, consisting of 5 districts, namely South Banjarmasin, East Banjarmasin, West Banjarmasin, Central Banjarmasin, and North Banjarmasin with the total number of kelurahan is 52 kelurahan. South Banjarmasin District is the largest sub-district with 399% (3,833.41 ha).

Table 1. Area of Banjarmasin City.

1	West Banjarmasin	1,306.49	13%
2	South Banjarmasin	3,833.41	39%
3	Central Banjarmasin	665.6	7%
4	East Banjarmasin	1,690.55	17%
5	North Banjarmasin	2,350.72	24%

Source: Banjarmasin City in 2021 Figures, BPS Banjarmasin City.

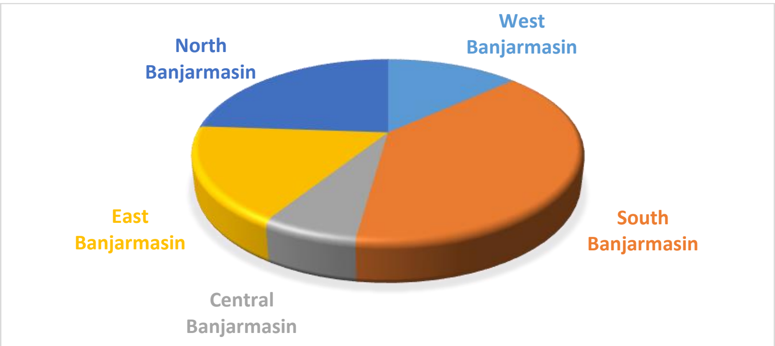

Fig. 1. Percentage of Banjarmasin City Area; Source: Banjarmasin City in 2021 Figures, BPS Banjarmasin City.

Literature Review

DRA is one of the important foundations for local governments to determine disaster risk reduction strategies. At the community level, the results of the assessment are expected to be used as a strong basis in planning disaster risk reduction efforts. The disaster risk value is determined by the magnitude of the threat, vulnerability and capacity in an area (Chang *et al.* 2022; Lan Huong *et al.* 2022). DRA is basically determining the magnitude of 3 (three) risk components, namely hazard, vulnerability and capacity. This component is used to obtain the disaster risk level of an area by calculating the potential for life exposure, property loss and environmental damage. In addition, it also produces risk maps for each potential disaster that exists in an area. This DRA and map should be able to be an adequate basis for regions to formulate disaster management policies. The purpose of the DRA method is to produce disaster management policies derived from disaster risk maps. These maps are obtained from overlaying hazard maps, vulnerability maps and capacity maps. Hazard maps are obtained from the components of probability and intensity of disaster events. The vulnerability map consists of socio-cultural, economic, physical, and environmental components. The capacity map is influenced by 71 indicators and community capacity (Sun *et al.* 2022). In general, the methodology of DRA in an area is carried out with several processes. Starting from the collection of related data to the results of DRA. Related data taken in an area will be processed to produce a DRA index. From the results of this index, hazard maps, vulnerability maps, capacity maps and disaster risk maps were compiled. The summary of the mapping results will be concluded into a level that is a summary of the results of DRAs in an area. The methodology of DRA in an area is carried out using the process described above. Briefly, it can be concluded that the process starts from taking related data to the results of DRAs. Related data taken in an area will be processed to produce a DRA index. Based on the results of this index, hazard maps, vulnerability maps, capacity maps and disaster risk maps are prepared. The summary of the mapping results will be concluded into a level that becomes a recapitulation of the results of DRAs in an area in the form of a DRA document (Chang *et al.* 2022). In this DRA document, several components of DRA will be discussed, including hazards, vulnerabilities, capacity and disaster risk. Danger is the potential for disasters that will occur in an area and later cause losses. If the scale of the danger is too high, the vulnerability is too great, and the capacity and preparedness of the community or government is not sufficient to overcome it, then disaster occurs. Based on this, Banjarmasin City needs to conduct a DRA. General methods of DRA can be seen in Fig. 2. The results of DRA are in the form of maps and tables. The map provides information on the distribution of affected areas. The resulting map includes hazard, vulnerability, capacity, and risk maps. On the other hand, the study table presents data such as area, number of people exposed, property losses, environmental damage, and class. From these results, the level of threat, level of loss, level of capacity, and level of risk of each hazard can be determined which are classified into low, medium, and high levels. In general, the threat level indicates that not all areas affected by danger have a high threat level. For example, landslides that occur on hills far from settlements have a lower threat level compared to landslides that occur in residential areas. Therefore, the threat level is obtained from the comparison between the hazard index and the exposed population index. Afterward, the loss rate is obtained from the comparison between the threat level and the loss index. The loss rate indicates areas that have a high loss index in regions with medium and high threat levels (Lee *et al.* 2022; Uehara *et al.* 2022). On the other hand, the capacity level is obtained from the threat level and capacity index. The high level of capacity indicates that the area is capable of dealing with the level of threat. For example, although often hit by drought, residents and the government have prepared various kinds of anticipations. Finally, the level of risk obtained from the comparison of the level of loss with the level of capacity. A high-risk level indicates that the region's capacity to reduce existing losses is still low, while a low risk level indicates that the region already has the capacity to reduce the level of existing losses. In the study table, recapitulation is presented from the village, sub-district, and district levels. Based on these two outputs, it can be determined which villages have a high level of risk, so that the implementation of disaster risk reduction efforts becomes more focused.

MATERIALS AND METHODS

Disaster risk is the potential loss caused by a disaster in an area within a certain period of time which can be in the form of death, injury, illness, threatened lives, loss of security, displacement, damage or loss of property, and disruption of community activities (Chang *et al.* 2022; Sun *et al.* 2022). Disaster risk is the potential loss caused by disasters in an area and a certain period of time which can be in the form of death, injury, illness, threatened lives, loss of security, displacement, damage or loss of property, and disruption of community activities. DRA is an integrated mechanism to provide a comprehensive picture of an area's disaster risk by analyzing the Threat Level, Loss Level and Regional Capacity in the form of documents and maps (Xue *et al.* 2022). Disaster risk assessment is prepared based on three risk components, namely hazard, vulnerability and capacity in the smallest analysis unit 30 m × 30 m with algorithms according to the concept of risk measurement directly proportional to hazards and vulnerabilities, as well as inversely proportional to capacity. These components will be reviewed based on the supporting index of each component. The hazard component is assessed based on the hazard index, vulnerability based on the exposed population index, while the loss index and capacity component based on the capacity index. The village index is the basis for categorizing the village risk level, while the sub-district index for categorizing the sub-district risk level, and the district index for categorizing the district risk level with Low provisions (0-0.333); Medium (> 0.333-0.666); High (> 0.666-1; Cuthbertson *et al.* 2023).

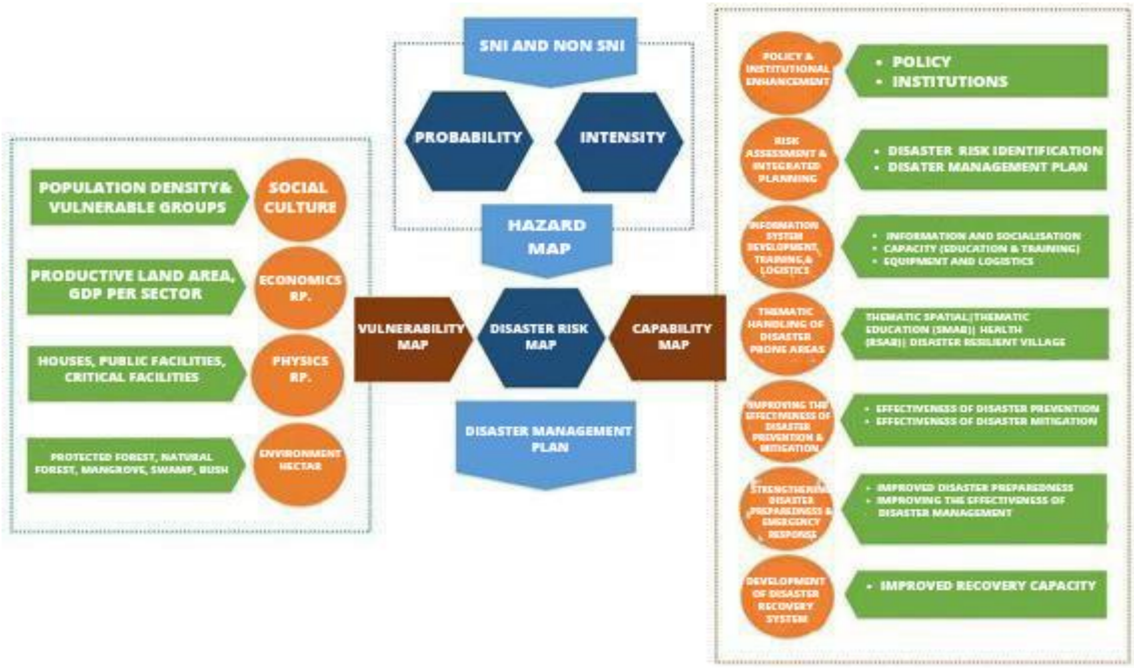

Fig. 2. Disaster Risk Assessment Method; (Source: Perka BNPB No. 2 Year 2012).

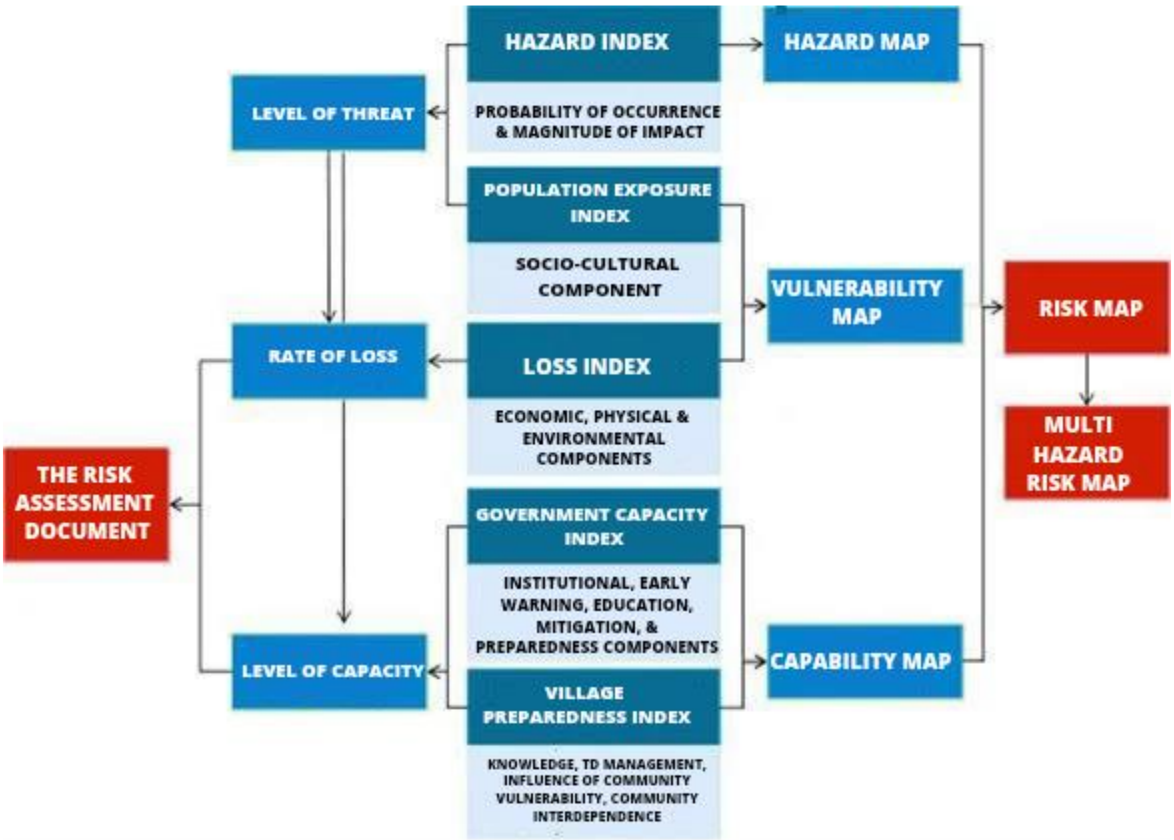

Fig. 3. Risk Management Process Diagram; (Source: Perka BNPB No. 2 Year 2012).

The value of disaster risk depends on the magnitude of the hazard and vulnerability that interact. The interaction of hazards, vulnerabilities and external factors is the basis for conducting DRA for an area. DRA efforts are carried out based on the following general concepts:

$$R_{isk} = H_{azard} \frac{V_{ulnerability}}{C_{capacity}}$$

Information:

R_{isk}	:	Disaster Risk: Disaster Risk.
H_{azard}	:	Hazard Threat: The frequency (probability) of certain disasters tends to occur with a certain intensity in certain locations.
$V_{ulnerability}$	:	Vulnerability: The expected loss (impact) in a particular area in the case of a particular disaster occurring with a certain intensity
$C_{apacity}$	:	Adaptive Capacity: The capacity available in that area to recover from a particular disaster

DRA is carried out to identify hazards and vulnerabilities from an area which then analyzes and estimates the possibility of potential disaster threats. In addition, to study weaknesses and gaps in existing protection mechanisms and adaptation strategies to disasters, as well as to formulate realistic recommendations for measures to overcome weaknesses and reduce the risk of disasters that have been identified (Anelli *et al.* 2022). The preparation of DRA requires additional tools after obtaining the required indices. DRA provides an overview of the area related to the level of risk of a disaster in an area. The assessment process should be carried out for all disasters in each region. DRA is prepared based on Hazard, Exposed Population, Loss and Capacity Indices. Apart from the Capacity Index, other indices depend on the type of disaster threat. The Capacity Index is differentiated based on the administrative area of the study. DRA is carried out by considering the hazard index, vulnerability index and capacity index of a region. The hazard index is measured using parameters that have been determined by ministries / agencies that have the main tasks and related functions that will produce DRA documents as well as risk maps and multi-risk maps. DRA methods include hazard levels, vulnerability levels, and capacity levels. The mechanism for preparing a Disaster Risk Map is interrelated with the mechanism for preparing a DRA document. The Disaster Risk Map provides a basis for determining the level of disaster risk which is one of the components of the achievement of the DRA document. In addition, this document should also present a minimum regional disaster management policy aimed at reducing the number of lives exposed, property losses and environmental damage (Durrant *et al.* 2023). DR mapping method can be seen in Fig. 4. This specialization is because the Capacity Index is focused on government institutions in the study area (conditions of the studied area). The correlation between the preparation of the Map and the DRA document is a general method of DRA in Indonesia as shown in Fig. 5.

Disaster level conclusion making

Risk assessment and rating is a packaging of the results of the assessment of the threat, vulnerability and capability / resilience of an area to disasters to determine the priority scale of actions made in the form of work plans and recommendations to reduce disaster risk. The difference is only in the order of using each hazard index, vulnerability index, capacity index and disaster risk index. The magnitude of the index changes, since the human soul cannot be valued in rupiah. Therefore, the threat level takes into account the level of loss and the level of capacity. The DRA document uses village analysis units to describe the extent of disaster. The majority index value (mode value) of the analysis unit is the disaster index value per village (Anelli *et al.* 2022). This index per village is the basis for determining the categorization of hazard levels, vulnerabilities and risks per village. The maximum index value (max) for hazard, vulnerability and risk thematic from the index per village becomes the value of the hazard, vulnerability and risk index at the sub-district level. The thematic index value of danger, vulnerability and maximum risk per sub-district becomes the thematic index value of the district / city where the sub-district is located according to the provisions of low, medium and high classes. As an illustration, if a village has an area of 100 ha with 10 ha, 30 ha and 60 ha of low, medium and high classes respectively, then the danger class in the village is high (Xue *et al.* 2022).

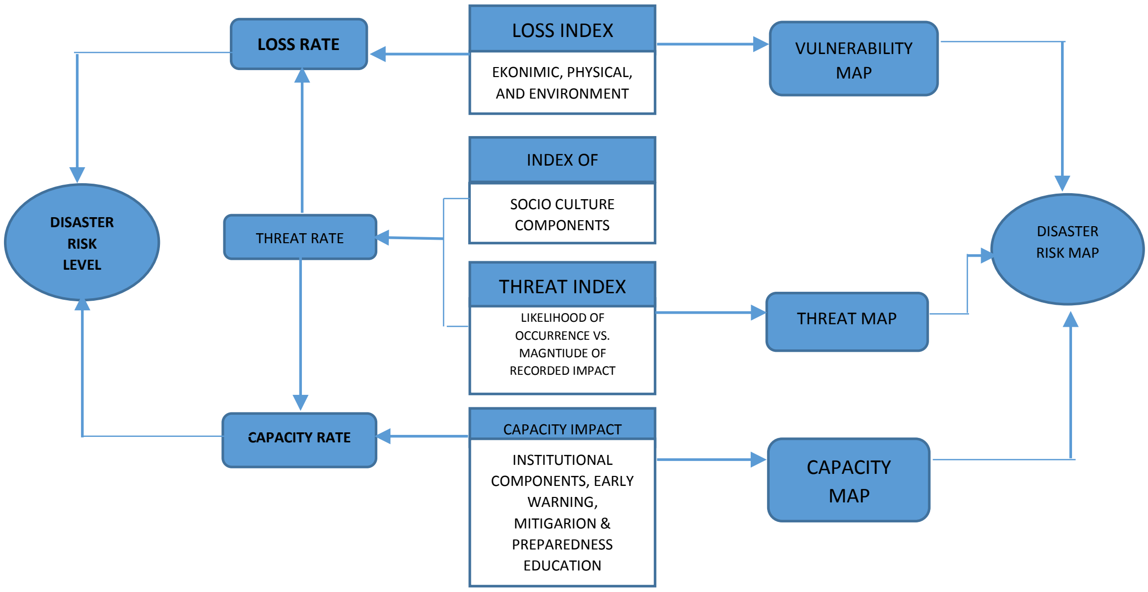

Fig. 4. Disaster risk mapping methods; Source: Perka BNPB No. 2 Year 2012.

At the sub-district level, class determination uses the maximum village hazard class found in the sub-district. As an illustration, a sub-district consists of 5 villages with 3, 2 and 1 hazard class villages of low, medium, and high respectively, so the hazard class in the sub-district is high. At the district / city level, the sub-district inference method applies in the district, where the hazard class is taken based on the maximum sub-district hazard class found in the district. The illustration is, if a district/city consists of 6 sub-districts with 2, 3 and 1 hazard class sub-districts of low, medium, and high respectively, then the hazard class in the district/city is high. This method of inference is also applicable to thematic vulnerabilities and risks. This method of drawing conclusions is used to read the hazard, vulnerability and risk classes in the study matrix table attached to this document from the village, sub-district, and district / city levels (Durrant *et al.* 2023).

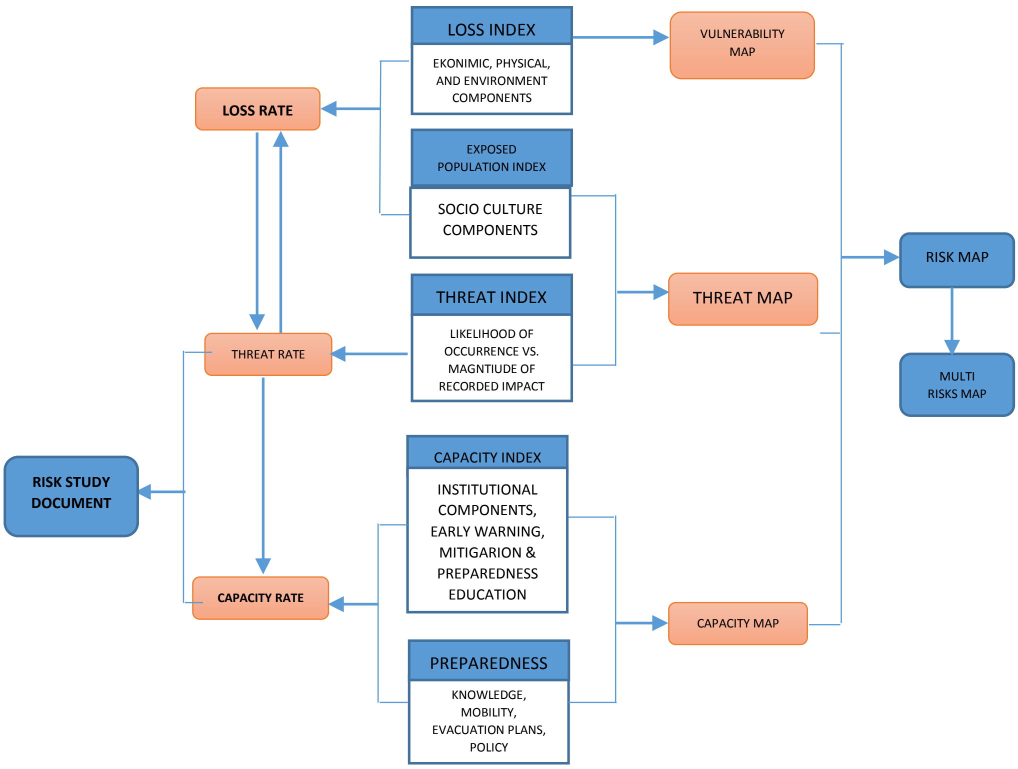

Fig. 5. Methods for preparing DRA documents; Source: Perka BNPB No. 2 Year 2012.

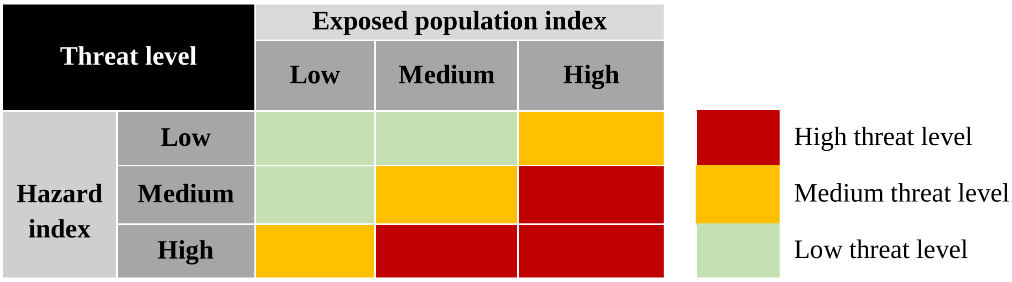

Fig. 6. Threat Level Inference; Source: Perka BNPB No. 2 Year 2012.

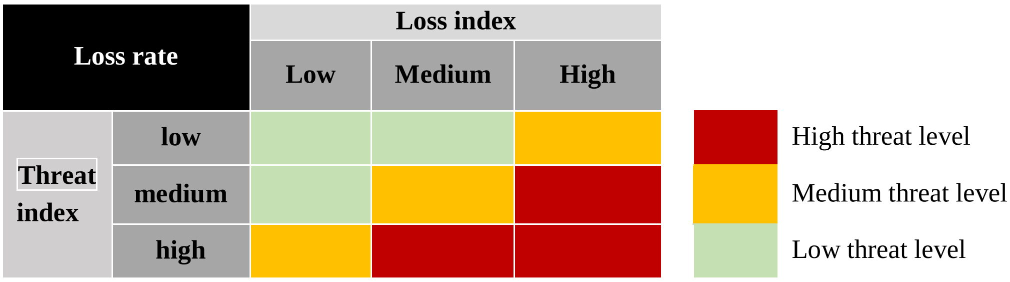

Fig. 7. Loss Rate Inference; Source: Perka BNPB No. 2 Year 2012.

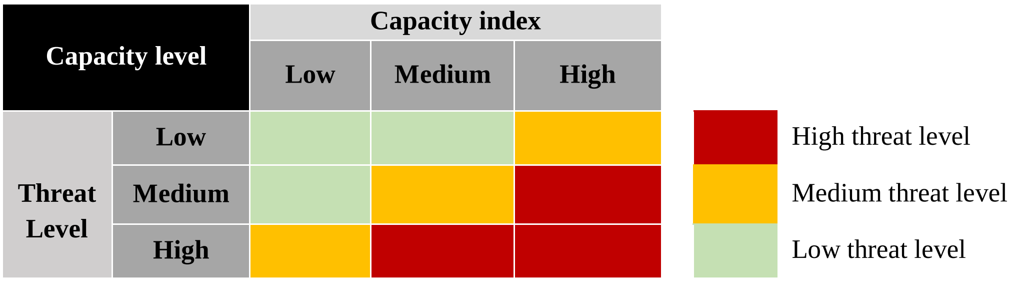

Fig. 8. Capacity level inference; Source: Perka BNPB No. 2 Year 2012.

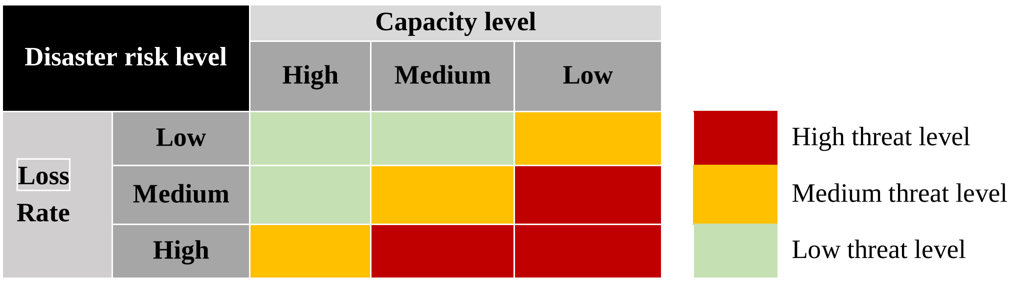

Fig. 9. Disaster risk level conclusion making; Source: Perka BNPB No. 2 Year 2012

Based on the matrix, it can be concluded that if the hazard index is in the low class and the exposed population index is in the low class, then the threat level is in the low class. Likewise, if the hazard index is in the medium class and the exposed population index is in the medium class, then the threat level is in the medium class. If the hazard index is in a high class and the exposed population index is in a high class, then the conclusion of the threat level is in a high class. Based on the matrix, it can be concluded that if the threat level is in the low class and the loss index is in the low class, then the loss level is in the low class. Similarly, if the threat level is in the medium class and the loss index is in the medium class, then the loss level is in the medium class and finally, if the threat level is in a high class and the loss index is in a high class, then the conclusion of the loss rate is in a high class. Based on the matrix, it can be concluded that if the loss level is in the low class and the capacity level is in the low class, then the disaster risk level is in the medium class. Similarly, if the loss level is in the medium class and the capacity level is in the medium class, then the risk level is in the medium class. Finally, if the loss level is in the high class and the capacity level is in the high class, then the conclusion of the risk level is in the medium class.

RESULT AND DISCUSSION

Flood Risk

Flood hazard assessment was carried out using the GFI (Geomorphic Flood Index) approach method which is an approach to see vulnerable areas and flood potential based on geomorphological parameters in the region. The resulting map will depict areas that have the potential to be inundated if factors causing flooding occur such as river overflow, high tides, and high-intensity rain for a long period of time (Barros *et al.* 2023).

Hazard

Areas that are included in flood-prone areas are those with flat topography and located around rivers. The determination of the flood hazard class is analyzed based on the inundation height value. Quoted from the BNPB Flood Risk Assessment Preparation Module in 2019, areas with an inundation height of less than 75 cm are included in the low hazard category; Territories with a puddle height of 75 - 150 cm belong to the category of moderate danger; and areas with inundation heights above 150 cm are included in the high hazard category (BNPB, 2019). Banjarmasin City is an area traversed by many rivers. Based on topography, the city is an area that has a flat topography and is located in a lowland. A flood event is the inundation of a land area that is normally dry and caused by a number of things, including overflowing water caused by high rainfall. Under some conditions, floods can be catastrophic that damage the environment and even take human lives. Therefore, handling the causes of floods is always a serious matter. Based on the calculation of flood hazard parameters, it can be determined as the hazard class and the magnitude of the potential area of danger in Banjarmasin City. Based on the flood hazard parameters, the potential area of flood hazard and flood hazard class in this city is obtained, which is shown in Table 2.

Table 2. Potential flood hazards in Banjarmasin City.

		Low	Medium	High			
1	West Banjarmasin	25.85	690.70	589.94	1306.49	13%	Medium
2	South Banjarmasin	21.62	1173.13	2638.69	3833.41	39%	High
3	Central Banjarmasin	0.68	303.85	361.07	665.60	7%	High
4	East Banjarmasin		301.96	1388.59	1690.55	17%	High
5	North Banjarmasin	36.33	1302.84	1011.55	2350.72	24%	Medium

Source: Analysis Results 2022.

Table 2 shows the results of the hazard assessment of flood disasters, so the potential area of flood hazard in Banjarmasin City is obtained for five sub-districts. Since the area of danger and hazard class has a major effect on the entire sub-district, hence, this city which is in the high-class hazard classification covers an area of 5989.84 ha.

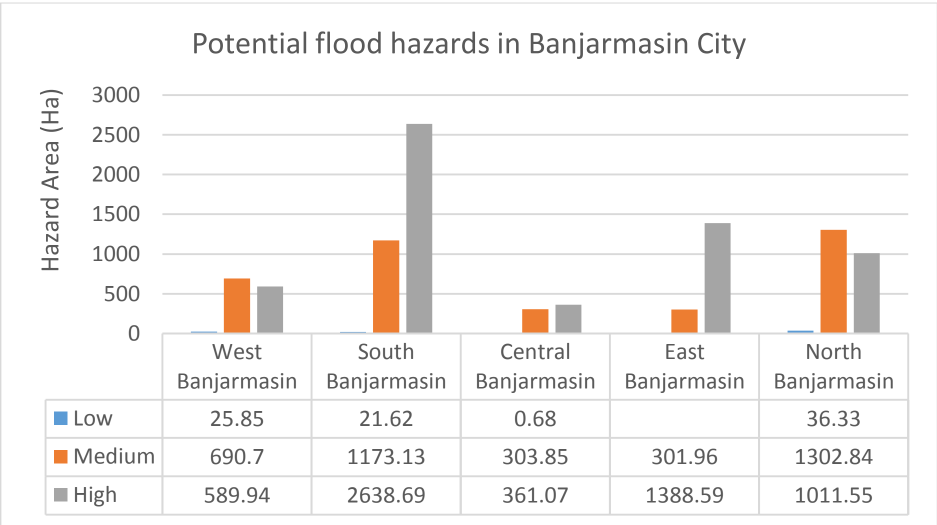

Fig. 10. Graph of potential area of flood hazard in Banjarmasin City; Source: Data processing results (2022).

Vulnerability

The vulnerability assessment for flood disasters in Banjarmasin City was obtained from the potential of exposed residents and vulnerable groups as well as potential losses, both physical, economic, and environmental damage. The potential number of people exposed and these potential losses are analyzed and then displayed in the form of flood vulnerability classes. A recapitulation of the potential population exposed and the potential losses potentially caused by flooding in Banjarmasin City can be seen in Table 3 (Angriani *et al.* 2018).

Table 3. Potential Exposed Population and Flood-Vulnerable Groups in Banjarmasin City.

		Low	**Medium**	**High**						
1	West Banjarmasin	1,820	76,896	58,899	137,615	21%	High	10,771	1,052	7,208
2	South Banjarmasin	1,206	61,455	83,825	146,486	23%	High	13,698	1,190	8,473
3	Central Banjarmasin	66	38,430	52,880	91,375	14%	High	7,649	490	4,756
4	East Banjarmasin		35,436	88,094	123,530	19%	High	10,502	579	6,437
5	North Banjarmasin	2,817	79,726	68,753	151,296	23%	High	12,757	586	7,967

Source: Analysis Results (2022).

The sub-district that has the highest number of potential residents exposed to flood hazards is North Banjarmasin district, which is 146,486 people or about 23% of the total number of potential residents exposed in this city (totals 650,302 people). Meanwhile, South Banjarmasin district has the highest potential for vulnerable age groups, poor people, and people with disabilities. The number of potential population of vulnerable group categories can describe the ratio of the number of vulnerable group population and can be used as a reference in planning to meet basic logistical needs in flood contingency plans (Angriani *et al.* 2018).

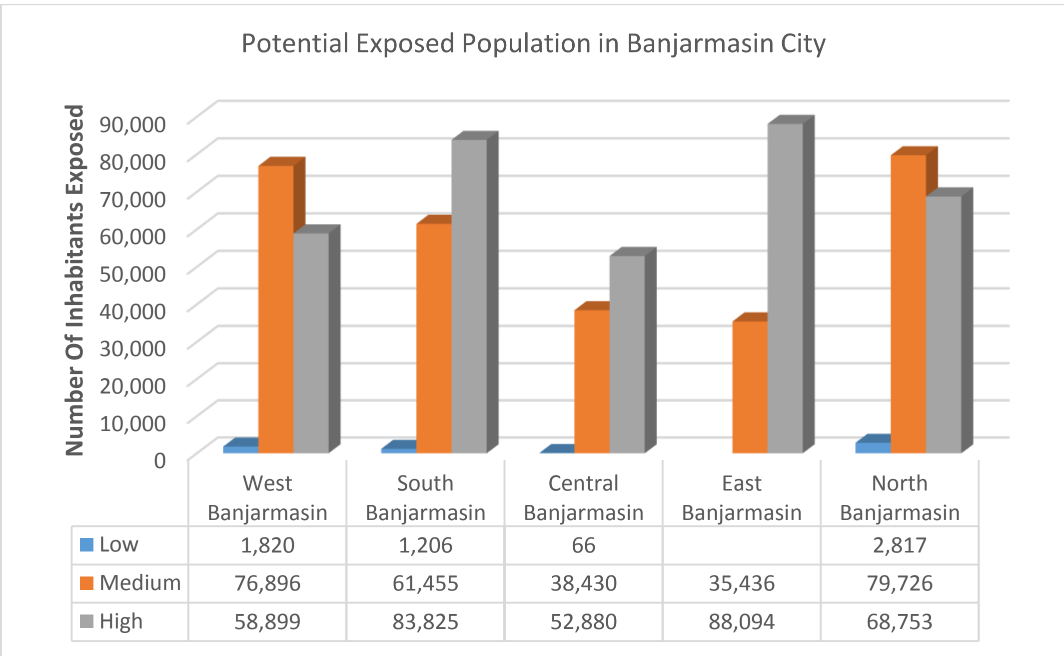

Fig. 11. Graphs of potential population exposed to floods in Banjarmasin City; Source: Data Processing Results 2022.

The total loss of flood disaster in Banjarmasin City is a recapitulation of the potential physical and economic losses of all areas affected by flood disasters. The potential physical losses include damage to critical facilities, damage to public facilities and damage to homes. The potential for physical losses due to flooding in Banjarmasin City falls into the high category. The total potential physical losses caused by floods in this city reached 1,203,731 million rupiah, where South Banjarmasin district is the district with the most potential physical losses in this city. For more details about the potential physical losses of flood disasters in Banjarmasin City, it can be seen in Table 4. The potential economic losses due to the benajir disaster in Banjarmasin City totaled 2,162,682 million rupiah, where the East Banjarmasin District area is the district with the most potential economic losses in the city. The class of economic losses due to flooding in the city is high.

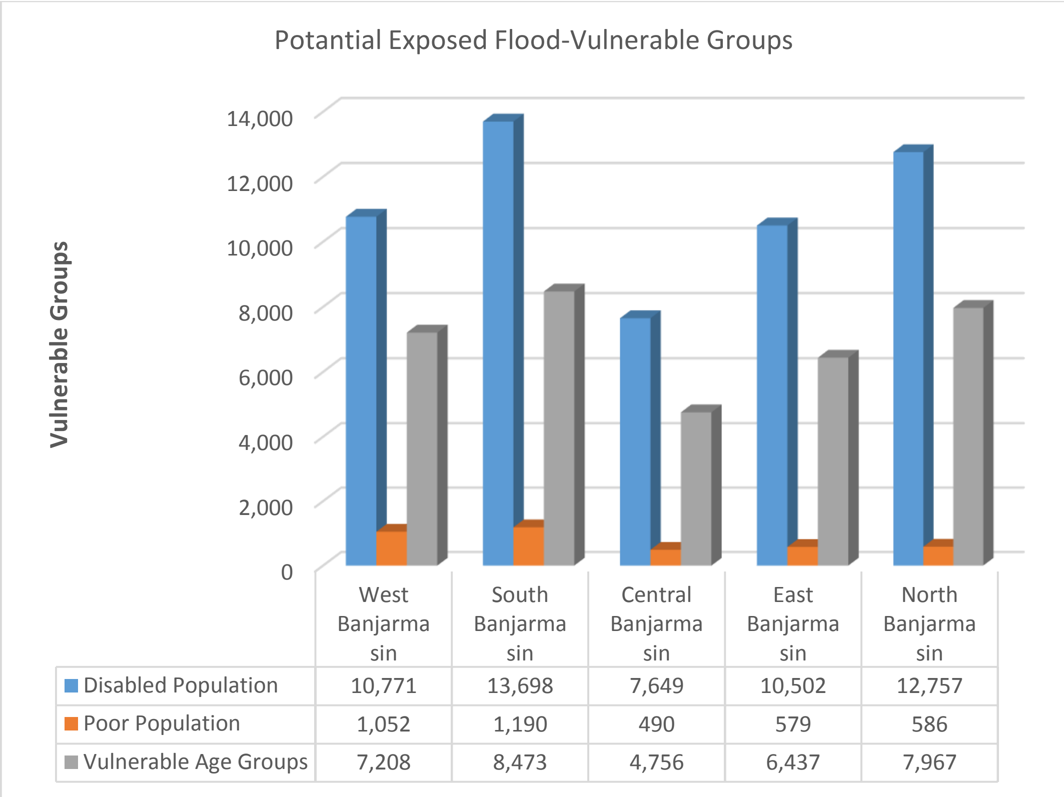

Fig. 12. Graphs of Potential Flood-Prone Population in Banjarmasin City; Source: Data Processing Results 2022.

Table 4. Potential physical losses of flood disaster in Banjarmasin City.

		Physical losses (Millions Rupiah)
1	West Banjarmasin	294,181
2	South Banjarmasin	250,410
3	Central Banjarmasin	173,739
4	East Banjarmasin	259,309
5	North Banjarmasin	226,092
	Banjarmasin City	1,203,731

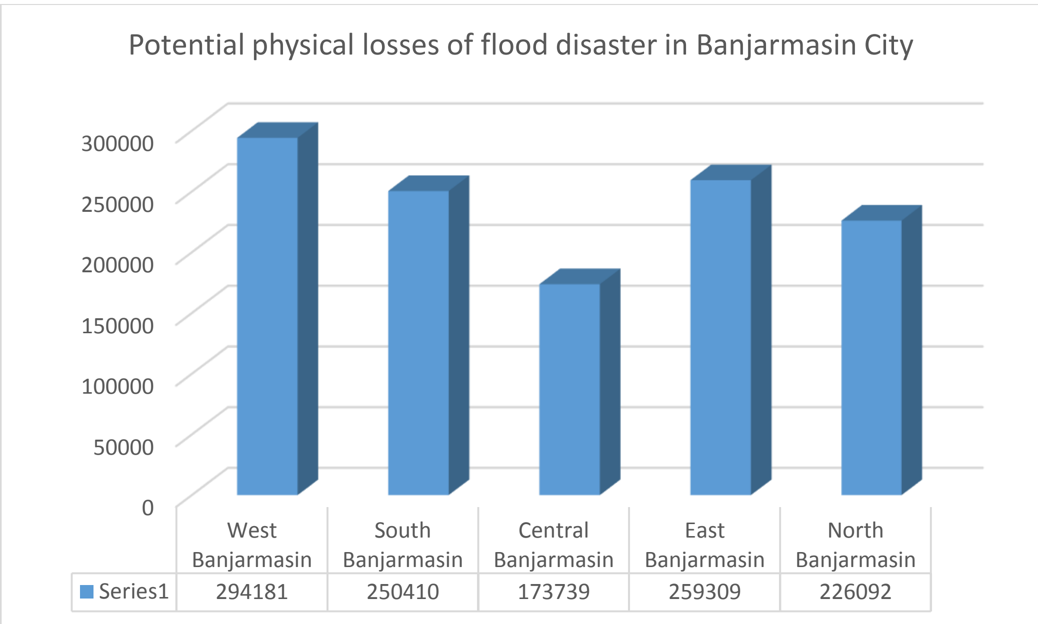

Fig. 13. Graph of Potential Physical Losses of Flood Disaster in Banjarmasin City; Source: Data Processing Results (2022).

Table 5. Potential economic losses of flood disaster in Banjarmasin City.

		Low	Medium	High		
1	West Banjarmasin	-	-	-	-	Low
2	South Banjarmasin	-	12,741	6,576	19,317	Medium
3	Central Banjarmasin	-	168,099	259,752	427,851	High
4	East Banjarmasin	-	159,057	1,141,758	1,300,815	High
5	North Banjarmasin	-	19,317	395,382	414,699	High

Source: Analysis Results (2022).

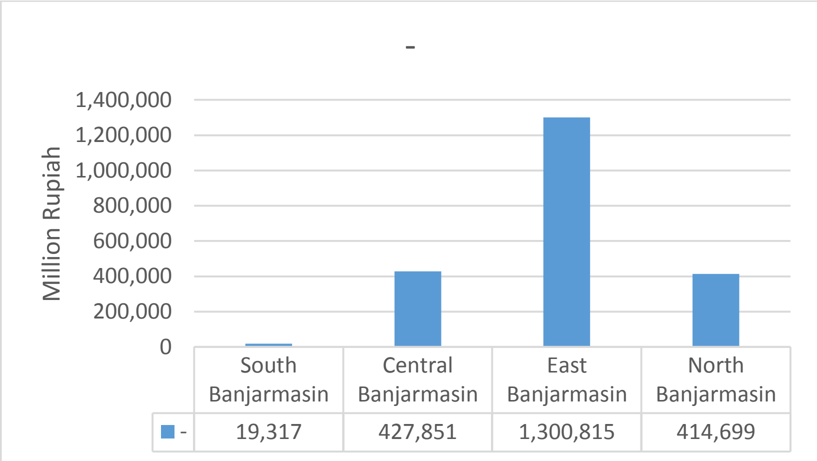

Fig. 14. Graphs of potential economic losses of flood disaster in Banjarmasin City; Source: Data processing results (2022).

Potential environmental damage is a recapitulation of the potential environmental damage of all flood-affected areas. The class of environmental damage in Banjarmasin City is seen based on the maximum class from the results of the study of all areas affected by floods. The potential for environmental damage to flood disasters in Banjarmasin City is 21,503 Ha. The district affected by the highest potential flood environmental loss is East Banjarmasin with an area of 15,599 ha. The class of flood environmental damage in this city is high.

Table 6. Potential Environmental Losses for Flood Disaster in Banjarmasin City.

		Low	Medium	High		
1	South Banjarmasin	-	38	75	113	High
2	East Banjarmasin	-	1,844	13,755	15,599	High
3	West Banjarmasin	-	5	2	7	Medium
4	North Banjarmasin	-	64	3,486	3,550	High
5	Central Banjarmasin	-	1,706	529	2,235	Medium

Source: Analysis results (2022).

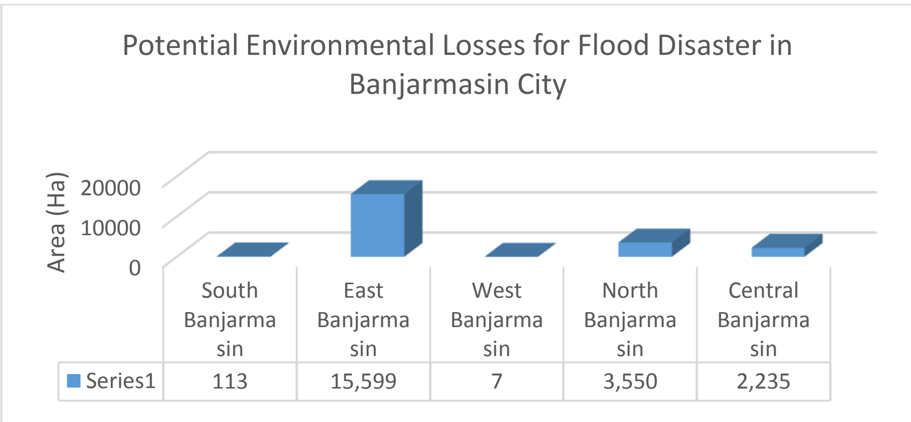

Fig. 15. Graphs of potential environmental losses for flood disaster in Banjarmasin City; Source: Data processing results, (2022).

Capacity

The combination of the results of regional resilience studies with village/community preparedness for flood disasters per sub-district resulted in a flood disaster capacity class in Banjarmasin City. Based on the assessment of the capacity of the city in dealing with flood disasters, a capacity class was obtained in dealing with flood disasters ("Evaluation of Engineering Properties of Banjarmasin Clay, Indonesia," 1992). The results of capacity analysis for flood disasters can be seen in Table 7.

Table 7. Banjarmasin City's capacity to face disasters.

1	West Banjarmasin	0.29	Low	0.30	Low	0.29	Low
2	South Banjarmasin	0.29	Low	0.30	Low	0.30	Low
3	Central Banjarmasin	0.29	Low	0.34	Low	0.32	Low
4	East Banjarmasin	0.29	Low	0.36	Low	0.33	Low
5	North Banjarmasin	0.29	Low	0.37	Low	0.34	Low

Source: Analysis Results (2022).

Risk

Flood risk assessment is prepared based on three components, namely flood hazard, flood vulnerability and flood capacity. Based on the results of the study in Table 8, it shows that the potential risk of flood disasters covers five sub-districts in Banjarmasin City with five sub-districts having a high risk class. Overall, the potential risk of flooding in Banjarmasin City is placed in the high class. This level of risk is influenced by the high level of flood danger, high potential vulnerability, especially exposed residents and the low capacity of this city in dealing with flood disasters (Asmu'i & Fitriati 2014). The overall high risk area of flood disasters in Banjarmasin City reaches 3,897.32 ha, with North East District which is a district area with a high risk level of flood disasters.

Table 8. Flood risk classes in Banjarmasin City.

		Low	Medium	High			
1	West Banjarmasin	283.2	338.91	684.38	1,306.49	13%	Medium
2	South Banjarmasin	374.4	2,607.77	851.27	3,833.44	39%	High
3	Central Banjarmasin	32.79	118.29	514.52	665.6	7%	High
4	East Banjarmasin	179.45	660.21	850.89	1,690.55	17%	High
5	North Banjarmasin	280.15	1,074.31	996.26	2,350.72	24%	Medium

Source: Analysis results (2022).

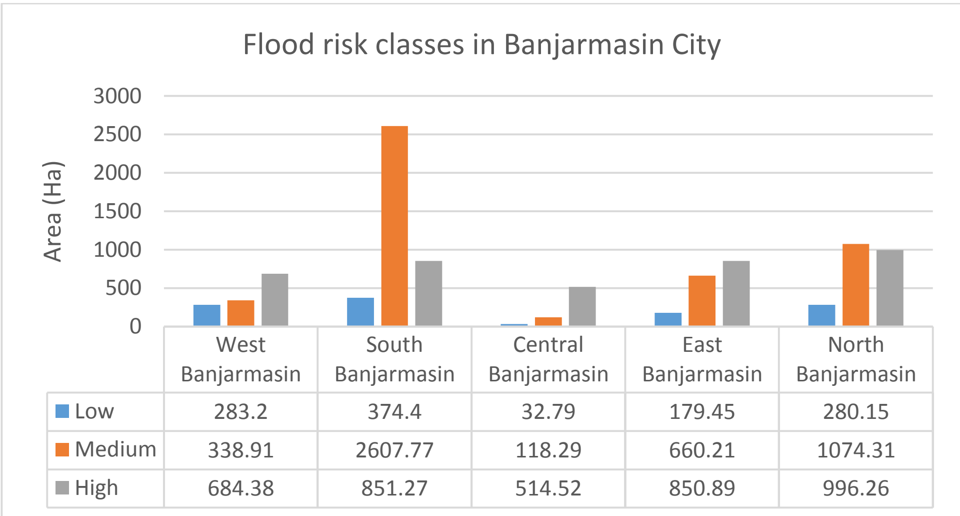

Fig. 16. Graphs of potential flood risk in Banjarmasin City; Source: Data processing results (2022).

Risk of extreme weather disasters

Extreme weather is an extreme meteorological phenomenon in history (distribution), especially weather phenomena that have the potential to cause disasters, destroy the order of social life, or cause human casualties.

In general, extreme weather is based on a climatological distribution, where the smaller extreme events equal to 5% distribution. The potential for extreme weather hazards is in areas with high land openness and gentle plains (Cuthbertson *et al.* 2023). The extreme weather studies discussed in this document are strong winds and tornadoes. This strong wind and tornado disaster occurs due to a high enough air pressure difference and can suddenly turn into dark and low clouds, thus creating strong winds and cumulonimbus clouds accompanied by lightning. This pile of clouds plays a big role in the formation of tornadoes. The extreme weather study in this document uses parameters of land clearance, slope, and rainfall in determining potential areas for strong winds and tornadoes in Banjarmasin City (Anelli *et al.* 2022).

Hazard

Table 9 depicts the results of the hazard assessment of extreme weather disasters, so the potential area of flood hazard in Banajrmasin City is obtained for five sub-districts. Based on the area of danger and the hazard class, it has a major effect on the entire sub-district. The area of extreme weather disasters in this city resulted in a total high-class hazard area of 4,043.62 ha. The sub-district with a high-class danger area for extreme weather disasters is South Banjarmasin, covering an area of 2,319.66 ha or about 39% of the total area of extreme weather hazard areas.

Table 9. Potential Dangers of Extreme Weather in Banjarmasin City

		Low	**Medium**	**High**			
1	West Banjarmasin	-	1,226.40	80.08	1,306.48	12%	MEDIUM
2	South Banjarmasin	-	1,513.75	2,319.66	3,833.41	39%	HIGH
3	Central Banjarmasin	-	659.16	6.46	665.62	7%	MEDIUM
4	East Banjarmasin	-	1,010.23	680.32	1,690.55	18%	MEDIUM
5	North Banjarmasin	-	1,393.64	957.10	2,350.74	24%	MEDIUM

Source: Analysis results (2022).

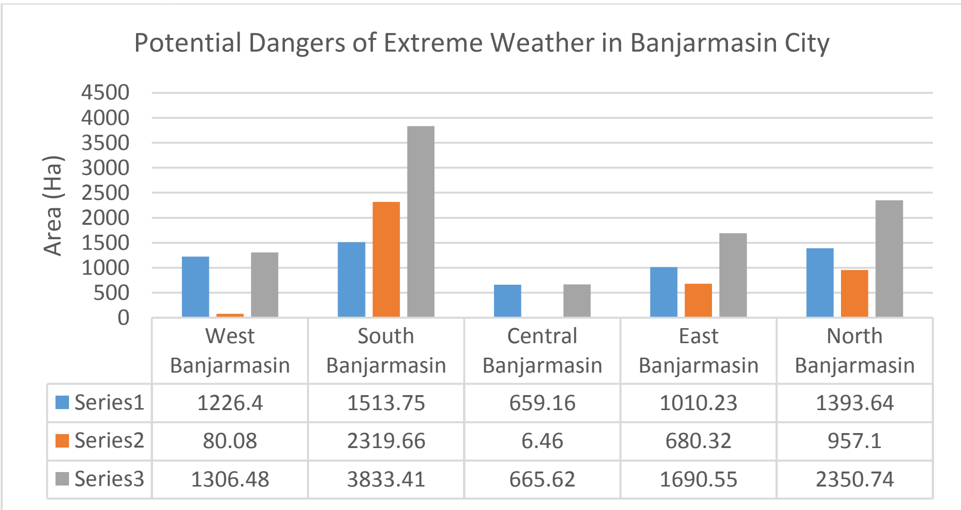

Fig. 17. Graph of potential area of extreme weather hazard in Banjarmasin City; Source: Data processing results (2022).

Vulnerability

The vulnerability assessment in this chapter was conducted to determine the level of vulnerability of Banjarmasin City during extreme weather disasters (strong winds / tornadoes). Vulnerability assessment for extreme weather disasters in this city is obtained from the potential of exposed residents and vulnerable groups as well as potential losses, both physical and economic. The potential number of people exposed to extreme weather disasters in Banjarmasin City reaches 650,302 people. South Banjarmasin district is the district with the potential number of people exposed to extreme weather the most in this city.

Capacity

The combination of the results of regional resilience studies with village/community preparedness for flood disasters per sub-district resulted in a flood disaster capacity class in Banjarmasin City. Based on the assessment of the capacity of Banjarmasin City in dealing with disasters, a capacity class in dealing with disasters was obtained. The results of capacity analysis for disasters can be seen in Table 12.

Table 10. Potential exposed population and flood-vulnerable groups in Banjarmasin City.

		Low	Medium	High					
1	West Banjarmasin		126,345	7,193	133,538	21%	1.052	7.208	10,771
2	South Banjarmasin		98,408	47,418	145,826	23%	1.190	8.473	13,698
3	Central Banjarmasin		89,603	1,772	91,375	14%	490	4.756	7,649
4	East Banjarmasin		103,831	19,772	123,602	19%	579	6.437	10,502
5	North Banjarmasin		117,282	32,290	149,572	23%	586	7.967	12,757

Source: Analysis Results (2022).

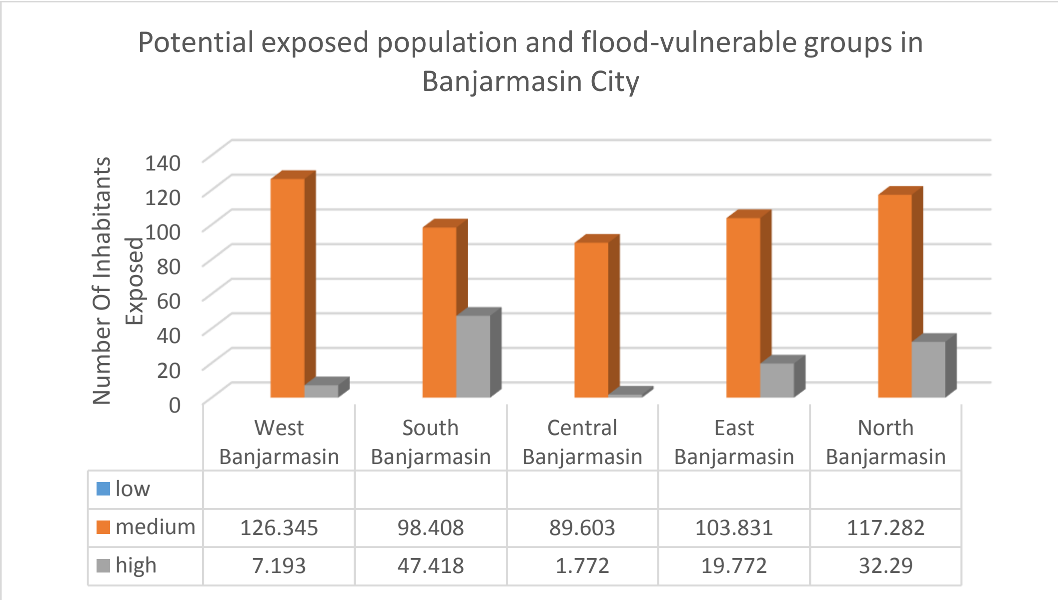

Fig. 18. Graphs of Potential Residents Exposed to Extreme Weather in Banjarmasin City; Source: Data processing results (2022).

Table 11. Potential physical and economic losses of extreme weather disasters in Banjarmasin City.

		Medium	High	Medium	High	Medium	High	Medium	High	Medium	High	
1	South Banjarmasin	43,000	12,000	8,050	-	17,982	63,173	69,032	75,173	1	8	9
2	East Banjarmasin	-	-	4,900	1,800	119,707	49,213	124,607	51,013	16	441	457
3	West Banjarmasin	-	-	16,050	300	4,430	44,801	20,480	45,101	-	-	-
4	North Banjarmasin	1,000	-	9,825	1,300	51,427	51,922	62,252	53,222	5	131	135
5	Central Banjarmasin	250	-	9,725	2,150	82,183	58,649	92,158	60,799	7	180	187

Source: Analysis Results, 2022.

Table 12. Banjarmasin City's capacity to face disasters.

1	West Banjarmasin	0.29	Low	0.26	Low	0.27	Low
2	South Banjarmasin	0.29	Low	0.21	Low	0.24	Low
3	Central Banjarmasin	0.29	Low	0.20	Low	0.24	Low
4	East Banjarmasin	0.29	Low	0.24	Low	0.26	Low
5	North Banjarmasin	0.29	Low	0.25	Low	0.27	Low

Source: Analysis results (2022).

Risk

The components used in extreme weather disaster risk assessment are hazard, vulnerability and capacity indices. The potential risk of extreme weather disasters covering all sub-districts in Banjarmasin City is high.

Table 13. Risk classes for extreme weather disasters in Banjarmasin City.

		Low	Medium	High			
1	West Banjarmasin		919.60	386.91	1,306.51	13%	Medium
2	South Banjarmasin		1,393.08	2,440.32	3,833.40	38%	High
3	Central Banjarmasin		341.55	324.04	665.59	7%	Medium
4	East Banjarmasin		874.01	816.54	1,690.55	18%	Medium
5	North Banjarmasin		1,366.33	984.42	2,350.75	24%	Medium

Source: Analysis Results (2022).

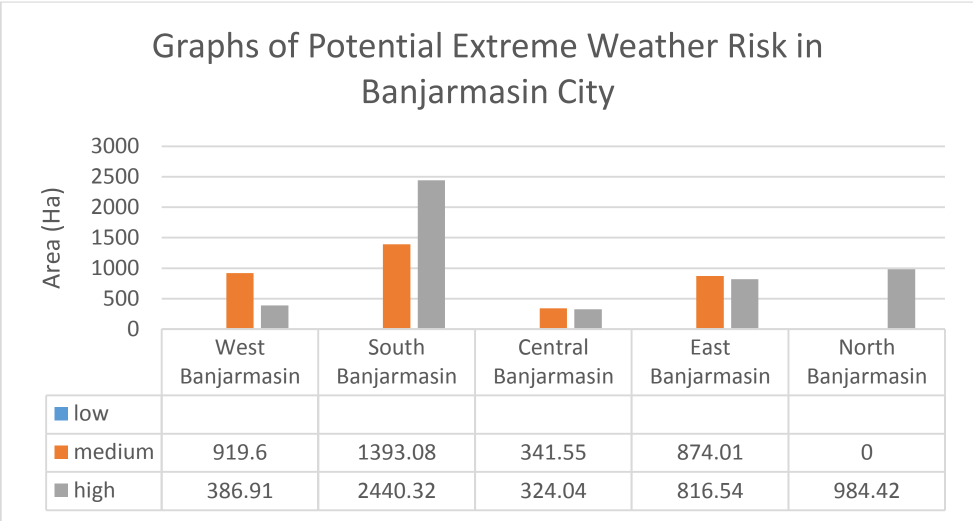

Fig. 19. Graphs of Potential Extreme Weather Risk in Banjarmasin City; Source: Data processing results (2022).

Risk of Drought

Drought is a relationship between the availability of clean water that is far below the needs of both life, agriculture, economic activities and the environment. The drought studied in this document is a meteorological drought, which is a drought related to below-normal rainfall levels in one season. Meteorological drought studies are the first indication of a drought disaster. The method used in drought hazard assessment is the Standardized Precipitation Index (SPI) which uses rainfall data as the main parameter (Terzi *et al.* 2022; Mitra & Shaw 2023).

Hazard

Table 14 depicts the results of the hazard assessment of drought disasters, so the potential area of flood hazard in Banajrmasin City is obtained for five sub-districts. Based on the area of danger and the hazard class, it has a major effect on the entire sub-district. The resulting area of drought in Banajrmasin City showed that the total danger area is 9,846.78 ha which is in the medium hazard class. The district with the highest danger area is South Banjarmasin, covering an area of 3,833.40 ha or about 39% of the total flood hazard area.

Table 14. Potential drought hazards in Banjarmasin City.

		Low	Medium	High			
1	West Banjarmasin		1,306.51		1,306.51	13%	Medium
2	South Banjarmasin		3,833.40		3,833.40	39%	Medium
3	Central Banjarmasin		665.59		665.59	7%	Medium
4	East Banjarmasin		1,690.55		1,690.55	17%	Medium
5	North Banjarmasin		2.350.75		2,350.75	24%	Medium

Source: Analysis results (2022).

Vulnerability

The vulnerability assessment for drought in Banjarmasin City was obtained from the potential of exposed residents and vulnerable groups as well as potential economic losses, and environmental damage. The potential number of people exposed, and these potential losses are analyzed and then displayed in the form of drought vulnerability classes (Wu *et al.* 2022). Overall, the total potential population exposed to drought are 652,003 people.

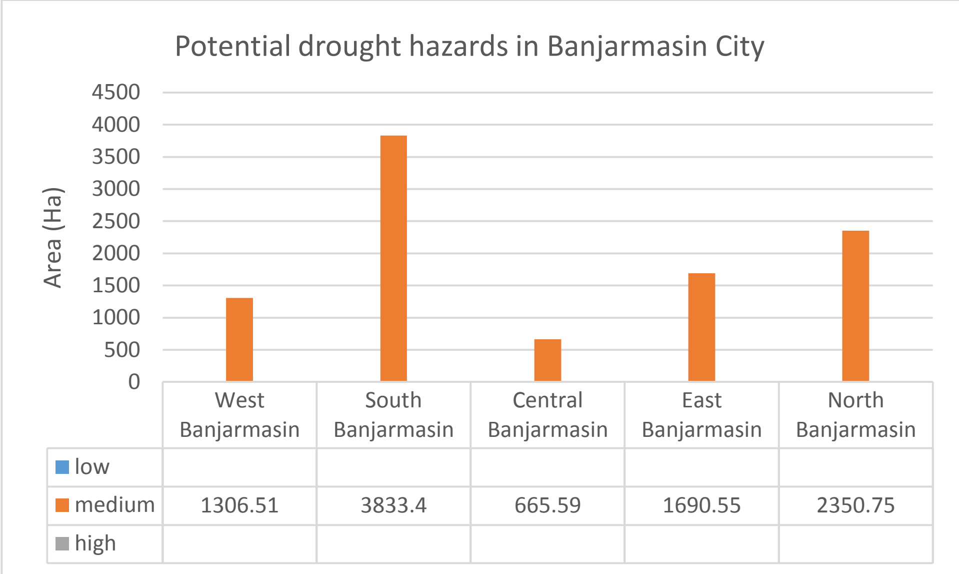

Fig. 20. Graph of potential area of drought hazard area in Banjarmasin City; Source: Data processing results (2022).

TableError! No text of specified style in document. **15.** Potential Exposed Population and Drought-Prone groups in Banjarmasin City.

1	South Banjarmasin	138,230	10,751	1,050	7,194
2	East Banjarmasin	146,836	12,354	1,080	7,642
3	West Banjarmasin	91,375	7,649	490	4,756
4	North Banjarmasin	123,515	10,488	579	6,429
5	Central Banjarmasin	152,047	12,670	583	7,913

Source: Analysis Results (2022).

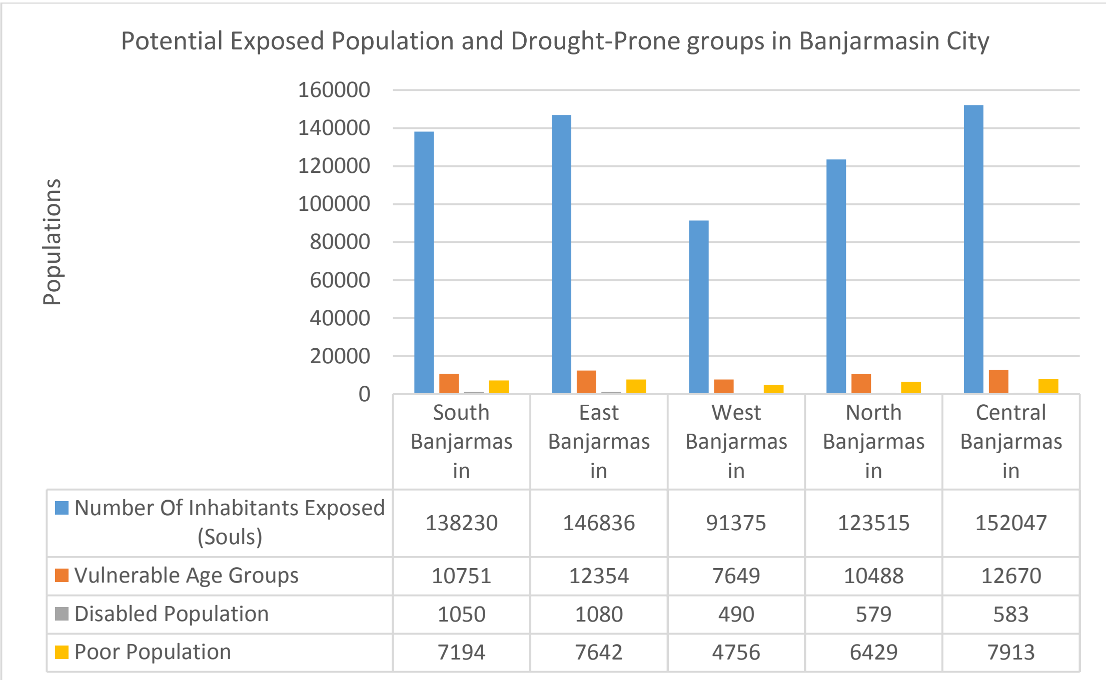

Fig. 21. Graphs of potential population exposed to drought in Banjarmasin City; Source: Data processing results (2022).

The total loss of drought disaster in Banjarmasin City is a recapitulation of the potential physical and economic losses of all areas affected by drought. In the case of potential physical losses, it includes damage to critical facilities, damage to public facilities and damage to homes.

Table 16. Potential Physical and Economic Losses of Drought Disaster in Banjarmasin City.

1	South Banjarmasin	5	134
2	East Banjarmasin	238	14,699
3	West Banjarmasin	-	6
4	North Banjarmasin	70	2,297
5	Central Banjarmasin	96	3,082

Source: Analysis Results (2022).

Capacity

The combination of the results of regional resilience studies with village/community preparedness for flood disasters per sub-district resulted in the Banjarmasin City drought disaster capacity class. Based on the assessment of the capacity of this city in dealing with disasters, a capacity class in dealing with disasters was obtained. The results of capacity analysis for disasters can be seen in Table 17.

Table 17. Banjarmasin City's capacity to face disasters.

1	West Banjarmasin	0.29	Low	0.14	Low	0.20	Low
2	South Banjarmasin	0.29	Low	0.15	Low	0.21	Low
3	Central Banjarmasin	0.29	Low	0.15	Low	0.21	Low
4	East Banjarmasin	0.29	Low	0.17	Low	0.22	Low
5	North Banjarmasin	0.29	Low	0.15	Low	0.20	Low

Source: Analysis results (2022).

Risk

The components used in extreme weather DRA are hazard, vulnerability and capacity indices. The potential risk of drought covering all sub-districts in Banjarmasin City is medium.

Table 18. Drought Risk Classes in Banjarmasin City.

		Low	Medium	High			
1	South Banjarmasin	323.46	983.05		1,306.51	13%	Medium
2	East Banjarmasin	1,344.84	2,488.56		3,833.40	38%	Medium
3	West Banjarmasin	29.65	635.94		665.59	7%	Medium
4	North Banjarmasin	266.71	1,423.84		1,690.55	18%	Medium
5	Central Banjarmasin	524.26	1,826.49		2,350.75	24%	Medium

Source: Analysis Results, 2022.

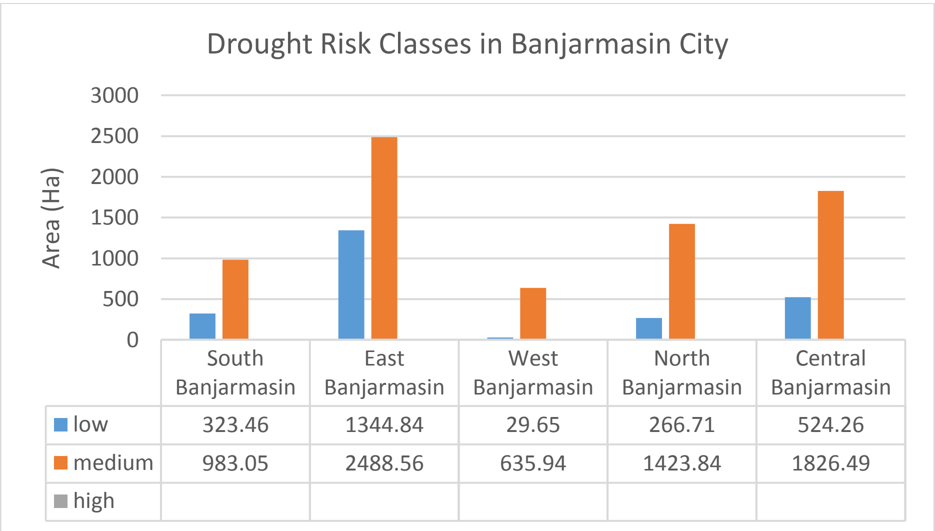

Fig. 22. Graphs of potential drought risk in Banjarmasin City; Source: Data Processing Results (2022).

The limited resources and authority of Banjarmasin City require a tool that is able to limit policy interventions objectively. This is due to limited resources and restrictions on regional authority. This should be considered in formulating disaster management implementation policies (Chang *et al.* 2022). Observing this, it is necessary to create a device that is able to provide choices for disaster threats that are priorities for disaster management selected based on objective standards. Therefore, the tool is prepared based on combining the parameters of the level of disaster risk and the results of the analysis of the tendency of disaster events in Banjarmasin City obtained in the previous chapter. The results obtained based on the combination of all these parameters are priority disasters that need to be overcome quickly, precisely, purposefully and integratedly in this city. Priority disasters that need to be overcome in Banjarmasin City can be seen in the results of the trend analysis and the level of disaster risk (Wu *et al.* 2022). The identification of potential disasters that are prioritized is determined on the basis of information on the classification of risk classes that are in the high category. Based on the results of an analysis conducted by a disaster study in Banjarmasin City, it is known that a high-class disaster hazard risk class occurs for floods, extreme weather and droughts. However, if we look again at the historical disaster events recorded, the most frequent potential disaster risks are floods and extreme weather (Durrant *et al.* 2023; Liu *et al.* 2023). The disaster risk study is the basis for implementing regional disaster management, because the assessment is carried out to map the risk level of all potential disasters based on hazard, vulnerability and capacity. Mapping the level of disaster risk is carried out to assess the impact caused by disaster events, so that disaster risk reduction efforts can be made by reducing the number of losses both from the number of lives exposed, property losses and the amount of environmental damage (Terzi *et al.* 2022). Efforts to reduce disaster risk need to be supported by actions taken by local governments. Taking such actions needs to be aimed at reducing disaster risk and increasing the resilience of local governments and communities in facing disaster threats. To carry out the choice of action, it is necessary to strengthen the basic components supporting the implementation of disaster management, so that regional focus in carrying out optimal disaster management can run more purposefully through the results of disaster risk assessment analysis (Anelli *et al.* 2022; Priyanto *et al.* 2022; Semin *et al.* 2023).

Handling priority		**Risk propensity**		
		Down	**Still**	**Up**
Threat Index	**Low**			
	Medium			
	High		Drought	Flood, Extreme weather

Priority 1
Priority 2
Priority 3

Fig. 23. Priority Disaster Determination Matrix in Banjarmasin City.

Treats/ Obstacles

In the preparation of the Banjarmasin City DRA, there are several obstacles in its implementation, including:

a. Limited availability of basic data and maps.
b. Record of historical events of disasters that are not rigid in the last 5 years.
c. Disaster-prone maps that are not yet available or not in accordance with conditions or provisions.
d. Lack of information/data related to the impact caused by both casualties and material.

Solutions

Alternative solutions that may be healed in the preparation of the Banjarmasin City DRA, there are several obstacles in its implementation, including:

a. One of the basic data used in the preparation of the Banjarmasin City DRA is the Banjarmasin City Map with a scale of 1:25,000 in *. shp format
   Base maps and thematic maps in *. shp format can be obtained from the Banjarmasin City RTRW which is supervised by the Banjarmasin City PUPR Office
b. Not all districts/cities have a rigid historical record of disaster events. Historical records of disaster events can be obtained from secondary BPBD data or interviews with policy makers and the community

c. In the RTRW document, Banjarmasin City should also have a Map of Disaster-Prone Areas. It is necessary to check again whether the map has referred to INARISK or not. If not, it needs to be adjusted to INARISK
d. Data related to the impact can be obtained from secondary data BPBD. If there is none, it can be assumed by looking at the extent of impact on a disaster that can be converted into units / volumes.

CONCLUSION AND RECOMMENDATION

Effective disaster management can be achieved if supported by good policy and institutional strengthening. The availability of strong policy and institutional facilities can result in systematic, directed and effective management of disaster management plans. Local governments as organizers of disaster management plans at the regional level are expected to be able to carry out systematic efforts in achieving disaster risk reduction. Thus, disaster management policies produced by local governments can be in line with national development planning. The following are the results of regional resilience studies outlined in an overview of general conditions and recommendations for action options in efforts to strengthen policies and institutions, as follows:

a. The Banjarmasin City Government together with the community implement local regulations related to the implementation of disaster management. The implementation of disaster management in accordance with established regional regulations is expected to be able to reduce disaster risk in Banjarmasin City effectively and systematically.
b. The Banjarmasin City Government applies technical rules related to the implementation of BPBD functions that have been formed in Banjarmasin City. Technical regulations related to the implementation of BPBD functions facilitate the implementation of programs and strategic plans of BPBD Banjarmasin City in the implementation of disaster management.
c. The local government of Banjarmasin City will strengthen the rules and mechanisms of the DRR forum. The strengthening of DRR forum rules and mechanisms is expected to facilitate DRR Forum in planning budgets and programs needed for disaster risk reduction.
d. The local government of Banjarmasin City will optimize the implementation of rules and mechanisms for disseminating disaster information. The disaster information dissemination system will be applied to the village level, so that villagers will be more alert in facing danger.
e. The local government of Banjarmasin City will strengthen local regulations on disaster management plans. Strengthening local regulations related to RPB can make it easier for local governments to plan programs and budgets related to disaster risk reduction.
f. The local government of Banjarmasin City will strengthen the Regional Regulation on Regional Spatial Plan (RTRW) based on Disaster Risk Assessment (DRA) for Disaster Risk Reduction. DRA-based RTRW is expected to reduce disaster risk in Banjarmasin City because all development planning refers to the Disaster Risk Assessment Document.
g. The local government of Banjarmasin City needs to improve the capabilities and governance of BPBD. BPBD Banjarmasin City needs to improve institutional capabilities and governance in order to carry out its functions and roles optimally in the implementation of disaster management.
h. The local government of Banjarmasin City needs to strengthen the DRR Forum in order to facilitate coordination between DRR related institutions and communities who are members of the DRR Forum.
i. The local government of Banjarmasin City needs to strengthen the structure and mechanism of regional disaster information. The local government will prepare an integrated disaster information dissemination plan from related institutions to village devices by utilizing electronic media, namely websites and cellular phones.
j. The local government of Banjarmasin City needs to build disaster information independence for disaster prevention and preparedness for the community. Independence of disaster information will be built by the community with evacuation directions and danger warning sounds at the village center.
k. The local government of Banjarmasin City needs to formulate a Strategy and Mechanism for Providing Electricity Reserves for Disaster Emergency Management. For example, during a tornado disaster, generally the electricity supply is cut off, so alternative electricity supply is needed for disaster management in the worst conditions.
l. The local government of Banjarmasin City needs to strengthen the strategy of Meeting Food Needs for Disaster Conditions Especially for floods, extreme weather and droughts, better coordination with the Social Services and Bulog is needed.

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