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CHARACTERISTICS OF COMMUNITY ADAPTIVE RESILIENCE IN OVERCOMING THE HAZARDS OF FLOOD DISASTER IN KAMPAR REGENCY-INDONESIA

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ABSTRACT: This research aims to formulate a flood hazard model, a community adaptation resilience model, and a community adaptation model for flood disasters in Kampar Regency, Indonesia. The flood disaster hazard model was analyzed using the Geomorphic Flood Index (GFI), while the characteristics of community adaptation resilience in mitigating flood disaster hazards were analyzed through the Climate and Disaster Resilience Initiative (CDRI). This research showed that the flood-free zone in Kampar Regency covered 715850 ha, the low hazard zone spanned 86357 ha, the medium hazard zone extended across 142821 ha, and the high hazard zone included 88658 ha. Areas with a high risk of flood disasters include the sub-districts of Tapung, Tapung Hulu, TapungHilir, Siak Hulu, Tambang, Kampar Kiri Hilir, and Kampar Kiri. Based on the assessment, the community adaptation resilience in Kampar Regency in facing flood disaster hazards scored 49, indicating that the characteristics of community adaptation still lack adequate resilience.

Keywords: Adaptation, Flood disaster, Hazard, Kampar, Resilience, Community.

1. INTRODUCTION

Flood disasters are events or series of events that threaten and disrupt community lives and livelihoods. Floods are caused by overflowing river water resulting from natural factors, including damage to the upper watershed buffer zone. This condition results in casualties, environmental damage, property loss, and significant psychological impacts [1-3]. Flood disasters broadly impact the environment, economy, and social, making social vulnerability a top priority in flood disaster mitigation efforts [4].

Kampar Regency is one of the areas very prone to flood disasters in Riau Province, Indonesia. Kampar Regency has an area of 1033688 ha. It is comprised of 22 sub-districts (with names in Indonesian): Bangkinang, Bangkinang City, Bangkinang Seberang, Kampar, Kampar Kiri, Kampar Kiri Hilir, Kampar Kiri Hulu, Kampar Kiri Tengah, Kampar Timur, Kampar Utara, Kuok, Perhentian Raja, Rumbio Jaya, Salo, Siak Hulu, Tambang, Tapung, TapungHilir, Tapung Hulu, XIII Koto Kampar, Koto Kampar Hulu, and GunungSahilan. Kampar Regency experiences flooding more than once yearly due to the influence of the Kampar and Siak watersheds. Areas prone to flooding include Koto Kampar Hulu, Kuok, Salo, Bangkinang Kota, Kampar, Kampar Utara, Rumbio Jaya, Kampa, Tambang, Siak Hulu, Kampar Kiri, Perhentian Raja, Tapung Hulu, and GunungSahilan sub-districts. Between 2019 and 2024, there were 44 flood events and 24 flash flood events. These incidents resulted in 2009 houses being damaged, 20 houses being destroyed, around 3691 people being evacuated, and 150 people being treated [5-7]. The overflow of the Kampar River causes a high vulnerability to flooding due to the high intensity of rainfall that occurs every year, land conversion from wetland to built-up land, and intense illegal logging and land burning [8].

The Kampar and Siak rivers play an important role in the lives of the community in Kampar Regency but also pose a significant threat when rainfall is high. The existence of lowlands in Kampar makes it easier for flooding to occur when the rivers overflow. The inadequate capacity of the river channel to accommodate and drain water, coupled with the physical condition of the embankments which are inadequate, causes river water to overflow into the surrounding area. This process is exacerbated by climate change which increases the frequency and intensity of rain, as well as human activities which disrupt the balance of river ecosystems [6].

Floods that occur frequently in Kampar Regency are natural disasters attributable to the region's morphological and physical conditions being dominated by lowlands. Relatively high rainfall conditions result in inundation, especially on land

around the Kampar and Siak rivers and other rivers in Kampar Regency, due to the inability of river channels to collect, store, and channel the water, causing the water to overflow out of the channel through the embankment and inundate the surrounding area.

Resilience is the ability to survive in the face of any conditions. The community's adaptive resilience in overcoming the hazards of flood disasters is the ability to adapt and remain steadfast in facing these hazards. Resilience serves as a key foundation for developing community adaptation models [9-15]. Initial surveys show that the resilience of the Kampar community is still low in adapting to flood disasters, which has a direct impact on the community's ability to survive and recover after the event. This also shows that there is no effective adaptation model, either developed through the community or adapted for each individual in Kampar Regency [7].

This research aims to formulate a flood hazard model, a community adaptive resilience model, and a community adaptation model for flood disasters in Kampar Regency. The novel contribution of this research lies in the development of the three models, which include: 1) Flood Hazard Model: This model helps identify areas with high potential for flood hazards, and supports more effective spatial planning in dealing with flood risks; 2) Community Adaptive Resilience Model: The focus of this model lies in the social, economic, infrastructure, and institutional aspects that affect the community's ability to face and recover from the impacts of floods; and 3) Community Adaptation Model to Flood Disasters: This model examines adaptation strategies implemented by the community to reduce flood risk. This includes preventive measures such as infrastructure improvements and socio-economic adaptations that aim to reduce vulnerability and strengthen community resilience in the future. These three models are new developments that have never been implemented effectively in Indonesia before. In addition, this research also highlights the importance of community adaptation as a top priority in flood disaster mitigation efforts, which have not been optimally implemented in Kampar Regency.

This article is structured as follows: Section 2 describes the method used in developing the flood hazard model, adaptive resilience model, and community adaptation model to flood disasters in Kampar Regency. Section 3 presents the results of flood hazard mapping and resilience analysis, followed by a discussion on the community's adaptive capacity. Finally, Section 4 concludes this research by summarizing the main contributions and providing recommendations for further research and practical implementation in flood disaster management.

2. METHODS

The hazard zone for flood disasters was analyzed using the Geomorphic Flood Index (GFI) method through an additional analysis tool (plugin) available in Quantum Geographic Information System (QGIS) software [16-18]. The Geomorphic Flood Index (GFI) is a method that can be used to estimate flood inundation areas on a large watershed scale and is an effective and fast procedure for regions with limited hydrological data. The Geomorphic Flood Index (GFI) is calculated [19-21] using the following equations as shown in (1) and (2) below.

$$WD = hr - H \quad (1)$$

$$Hr = b\,(Ar)n \quad (2)$$

Where:
WD : inundation height
Hr : potential water level in the river/water depth
H : the height difference and the riverbed
Ar : catcment area connected to the tested location
n : exponent of hydrological and hydraulic
b : a scale factor

The characteristics of community's adaptive resilience in overcoming the hazards of flood disasters were analyzed using the Climate and Disaster Resilience Initiative (CDRI) method, and scoring techniques. The grouping and assessment of each indicator and sub-indicator were carried out using a scoring method [22] from selected respondents who live in the flood hazard zone. For more details, see Table 2 below.

Table 1. Resilience of community adaptation in overcoming the hazards of flood disasters

Interval	Criteria	Information
>88.4	Very high	The community already has good resilience and adaptation
67.7-88.4	High	The community already has good resilience and adaptation but is not yet well organized in overcoming the impact of the flood disaster.
46.9-67.6	Medium	The community does not yet have good resilience and adaptation so that flood disasters damage the social and economic life of the community in a period of <1 year
26.1-46.8	Low	The community does not have good resilience and adaptation, so the flood disaster damages the social and economic life of the community in a period 1-5 years.
<26	Very low	The community does not have good resilience and adaptation, so the flood disaster damages the social and economic life of the community in a period >5 years

This research uses a quantitative approach with data collection conducted through questionnaires distributed to respondents living in flood hazard zones. The number of respondents was selected based on an estimated sample size for a population of 50,000 people, with a confidence level of 95% and a margin of error of 5% [23], resulting in a total of 380-400 respondents selected randomly. Indicators used to analyze the characteristics of community adaptation resilience include population, health, disaster awareness education, social capital, and social unity in flood disaster preparedness.

3. RESULTS

3.1 Flood Disaster Hazard Zone

Geomorphologically, the land system of Kampar Regency is composed of alluvial plains, alluvial valleys, fans and lahars, hills, meander belts, mountains, plains, swamps, and terraces. The region has many rivers, both large and small, as well as lakes and swamps. One of the largest rivers is the Kampar River, which has a length of around 413 km with an average depth of 7.7 m and an average width of 143 m. For more details, see Fig. 1 below.

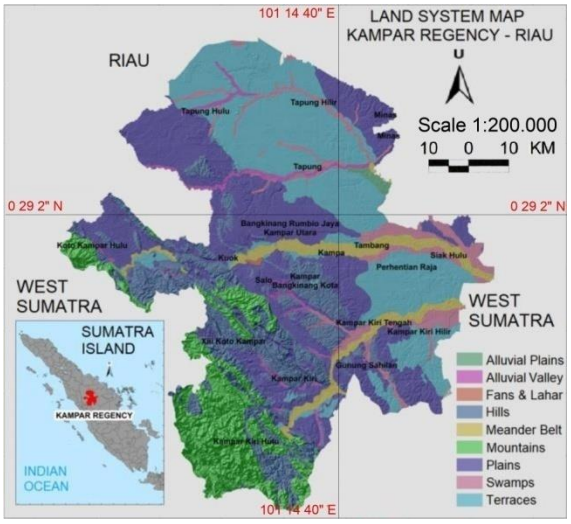

Fig.1 Map of Land System, Kampar Regency

Kampar Regency is an area with varied landscapes, including lowlands, swamps, highlands, hills, and some mountainous regions, with an average elevation of 1000 Meters Above Sea Level (MASL. The topography is mostly gentle, with slopes of less than 8% dominating the central and northern parts, mainly lowlands and swamp areas. In the southern and western parts, the slopes become steeper, ranging from 8% to 45%, especially in the transition zones towards the highlands. The steepest slopes, over 45%, are found in the mountainous regions, particularly in the south, bordering West Sumatra. For more details, see Fig. 2 below.

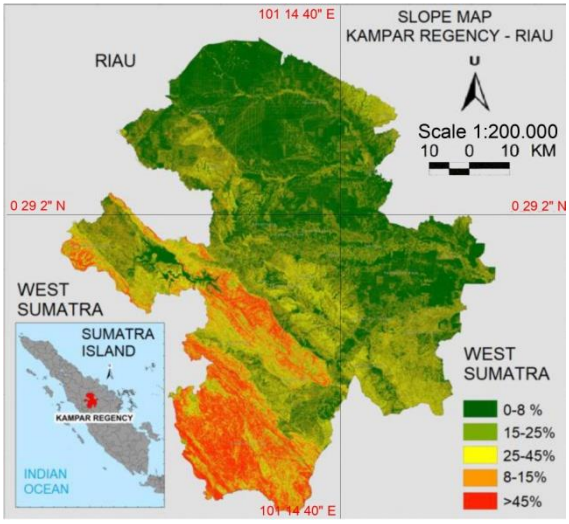

Fig.2 Map of Topography, Kampar Regency

The upstream source of the Kampar River is located on the Bukit Barisan ridge and flows eastward, passing through the sub-districts of Koto Kampar Hulu, XIII Koto Kampar, Kuok, Salo, Bangkinang, Kampar, Kampar Timur, Kampar Utara, Rumbio Jaya, Tambang, and Siak Hulu. Additionally, there is also the Kampar Kiri River, which flows through the sub-districts of Kampar Kiri, GunungSahilan, Kampar Kiri Tengah, and Kampar Kiri Hilir. Kampar Regency is also the upstream region of the Siak River, which has a length of around 90 km with an average depth of 8-12 m, crossing the Tapung sub-district. The Tapung River is divided into the TapungKanan River, which crosses the Tapung, TapungHilir, and Tapung Hulu sub-districts, and the Tapung Kiri River, which crosses the Tapung sub-district.

This research uses the Geomorphic Flood Index (GFI) method to determine the effectiveness flood potential in estimating flood-prone areas on a large watershed scale, especially in regions with limited hydrological data. The Geomorphic Flood Index (GFI) takes into account differences in land elevation, river depth, and catchment area [21], which are analyzed using a specialized plugin in Quantum Geographic Information System (QGIS) software to divide the area into three flood hazard zones. The low hazard zone has the potential for flooding that occurs once per year. The medium hazard zone is predicted to experience flooding 1 to 3 times in five years, while the high flood hazard zone is predicted to experience flooding every year [24]. Additionally, there are non-hazard zones, which generally consist of mountainous and highland areas with low flood risk. For more details, see Fig. 3 below.

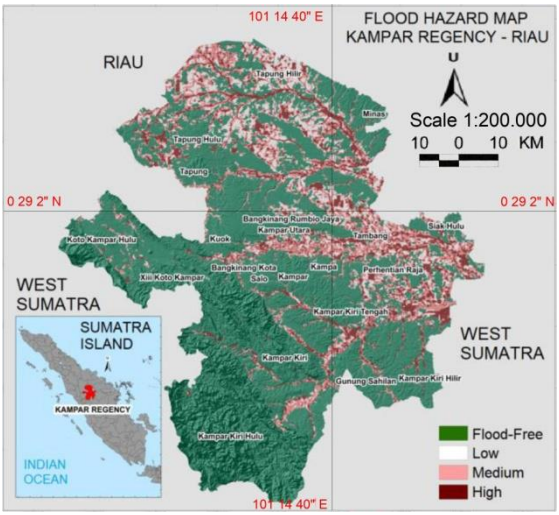

Fig.3 Map of flood hazard, Kampar Regency

Kampar Regency has a total area of 1033688 ha. Of this area, approximately 317837 ha are classified as vulnerable to flood disasters. The low flood hazard zone covers 86357 ha, the medium hazard zone covers 142821 ha, and the high hazard zone covers 88658 ha. Meanwhile, the area not affected by flood hazards is 715851 ha. This data indicates that about one-third of Kampar Regency is highly vulnerable to flood disasters, which can non-hazard the community's safety. Based on these results, mitigation measures can be focused on the most vulnerable areas to reduce the negative impacts of flood disasters on the environment, economy, and social in Kampar Regency. For more details, see Table 2 below.

Tabel 2. Flood hazard class (ha)

No	Sub-districts	Flood Hazard Class (Ha)							
		Free	Low	%	Medium	%	High	%	Total
1	Bangkinang	11936	1069	1.2%	1535	1.1%	868	1.0%	15408
2	Bangkinang Kota	6371	224	0.3%	730	0.5%	692	0.8%	8016
3	GunungSahilan	24938	1093	1.3%	4065	2.8%	3508	4.0%	33603
4	Kampa	10998	1550	1.8%	3200	2.2%	1317	1.5%	17064
5	Kampar	16682	563	0.7%	2823	2.0%	1190	1.3%	21258
6	Kampar Kiri	70966	2143	2.5%	8668	6.1%	5077	5.7%	86854
7	Kampar Kiri Hilir	38715	5789	6.7%	12726	8.9%	10562	11.9%	67792
8	Kampar Kiri Hulu	127213	189	0.2%	697	0.5%	390	0.4%	128488
9	Kampar Kiri Tengah	24686	1382	1.6%	2850	2.0%	2190	2.5%	31109
10	Kampar Utara	4742	1236	1.4%	2008	1.4%	1307	1.5%	9293
11	Koto Kampar Hulu	36954	417	0.5%	1797	1.3%	605	0.7%	39773
12	Kuok	21256	1000	1.2%	2924	2.0%	1234	1.4%	26414
13	Minas	5191	3	0.0%	218	0.2%	332	0.4%	5745
14	Perhentian Raja	4156	1886	2.2%	2549	1.8%	1934	2.2%	10525
15	Rumbio Jaya	3089	1111	1.3%	1767	1.2%	1030	1.2%	6997
16	Salo	17874	659	0.8%	1763	1.2%	864	1.0%	21161
17	Siak Hulu	14060	6455	7.5%	12360	8.7%	8436	9.5%	41312
18	Tambang	12103	7187	8.3%	12756	8.9%	6472	7.3%	38518
19	Tapung	74374	17334	20.1%	23701	16.6%	14025	15.8%	129435
20	TapungHilir	39045	18433	21.3%	17514	12.3%	11076	12.5%	86068
21	Tapung Hulu	51687	15947	18.5%	24377	17.1%	13685	15.4%	105696
22	XIII Koto Kampar	98815	688	0.8%	1791	1.3%	1864	2.1%	103159
	Total	715851	86357	100%	142822	100%	88658	100%	1033688

In Tapung, areas at high risk of flooding cover 14024 ha out of 129434 ha, equivalent to 15.8%. In Tapung Hulu, the area at risk is 13685 ha out of 105696 ha, equivalent to 15.4%. Meanwhile, in TapungHilir, the flood hazard cover 11076 ha out of 86068 ha, equivalent to 12.5%. In Kampar Kiri Hilir,

the area at risk covers 10562 ha out of 67792 ha, equivalent to 11.9%. Siak Hulu has 8436 ha at risk of flooding out of 41311 ha, equivalent to 9.5%. In Tambang, 6472 ha out of 38517 ha, equivalent to 7.3%, are in the flood hazard area. Kampar Kiri cover 5076 ha at risk of flooding out of 86853 ha, equivalent to 5.84%. Finally, in GunungSahilan, the flood risk area covers 3507 ha out of 33602 ha, equivalent to 4.0%. For more details, see Fig.4 below.

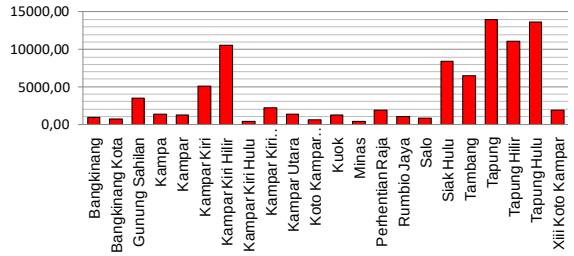

Fig. 4. Graph for high flood hazard (ha)

Medium flood hazards are spread across several sub-districts in Kampar Regency. In Tapung Hulu, the area at risk of flooding covers 24377 ha out of a total of 105,696 ha, equivalent to 17.1%. In Tapung, the flood risk area covers 23701 ha out of 129434 ha, equivalent to 16.6%. In TapungHilir, the area at risk of flooding covers 17514 ha out of 86068 ha, equivalent to 12.3%. In Kampar Kiri Hilir, the flood risk area covers 12726 ha out of 67792 ha, equivalent to 8.9%. In Tambang, the flood risk area covers 12755 ha out of 38517 ha, equivalent to 8.9%. In Siak Hulu, the flood risk area covers 12360 ha out of 41311 ha, equivalent to 8.7%. Finally, in Kampar Kiri, the area at risk of flooding covers 8668 ha out of 86853 ha, equivalent to 6.1%. For more details, see Fig. 5 below.

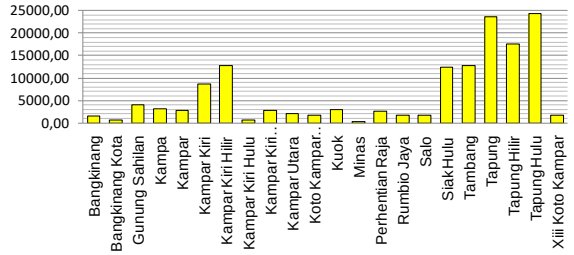

Fig. 5. Graph for medium flood hazard (ha)

Low flood hazards are spread across several sub-districts in Kampar Regency. In TapungHilir, the area at risk of low flood hazards covers 18432.51 ha out of a total of 86068 ha, equivalent to 21.3%. In Tapung, the area at risk covers 17,334 ha out of 129434 ha, equivalent to 20.1%. In Tapung Hulu, the flood hazard area covers 15947 ha out of 105696 ha, equivalent to 18.5%. In Tambang, the area at risk of low flood hazards covers 7186 ha out of 38517 ha, equivalent to 8.3%. In Siak Hulu, the flood hazard area covers 645492 ha out of 41311 ha, equivalent to 7.5%. Finally, in Kampar Kiri Hilir, the area at risk covers 5788 ha out of 67792 ha, equivalent to 6.7%. For more details, see Fig 6 below.

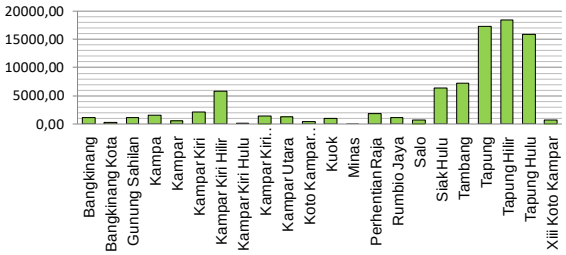

Fig. 6. Graph for low flood hazard (ha)

3.2 Community Adaptation Resilience in Overcoming the Hazards of Flood Disasters

In 2023, Kampar Regency had a population of 898,840 people spread across 22 sub-districts with a population density of 79.62 people/km² and a sex ratio of 104.62. This area also has a total of 956 educational facilities. When analyzing the data, based on data analysis of each indicator and sub-indicator, the total weighted value of the community's adaptive resilience in dealing with flood disasters in Kampar Regency is 49, which indicates that the community does not yet have adequate adaptive resilience. As a result, the threat of flooding still has the potential to cause significant damage to people's lives, especially in the social, economic, and cultural dimensions. Considering the vulnerability in disaster-prone areas, especially in settlement areas, the low adaptive resilience of the community further increases the risk of damage to housing infrastructure.

Without improving adaptive resilience, settlement areas in flood-prone areas will remain vulnerable to the impacts of flooding, such as physical damage, disruption of economic activities, and loss of social and cultural assets. Thus, implementing strategies such as early warning systems, community-based disaster preparedness training, and environmental management initiatives to increase adaptive resilience, both through infrastructure improvements and societal empowerment, are very important to reduce the risk of flooding in the future. Furthermore, coordinated efforts at the governmental and community levels are crucial to ensure the effectiveness of these adaptive measures. For more details, see Table 3 below.

Table 3. Communityadaptation resilience in overcoming the hazards of flood disasters

No	Indicators	Values	Criteria	
Population: Data is taken from census reports, demographic surveys, or government databases in Kampar Regency.				
1	Population growth	2	4-5.9%	High
	Number of population age <14 Years	2	29-34%	High
	Number of population over 64 years of age	2	29-34%	High
	Number of population in informal settlements	3	25-37.4%	Medium
	Population density	3	61-90	Medium
Health: Health data could be collected from public health records, hospital reports, or community health surveys.				
2	Population of residents who are sick due to water pollution due to floods	2	36-47%	High
	Access to nearest health facilities	2	51-75%	Low
	Functioning of health facilities after a flood disaster	2	11-25%	Low
	Accommodation capacity of health facilities when a disaster occurs	1	<10%	Very low
	Health service system capabilities in preparing for pre-disasters	2	11-25%	Low
	Health service system capabilities in preparing for disaster times	1	<10%	Very low
Disaster Awareness Education: Data was obtained through a community knowledge survey on flood risks conducted by the government.				
3	Literacy rate	3	62,6-75%	Medium
	Number of disaster aware people	1	<10%	Very low
	Availability of public awareness programs or training on disasters	2	1 time in 5 years	Low
	Internet access	2	11-25%	Low
	School functioning after a disaster	2	11-25%	Low
Social Capital: Data was collected through interviews, group discussions, and individual skills during emergencies.				
4	Number of population joined by the community	1	<10%	Very low
	Number of population participating in social activities	1	<10%	Very low
	Population communication skills to reach consensus	1	Unable	Very low
	Population ability in the decision-making process (level of democracy)	2	Low Participation	Low
	Level of grouping consequences differences	3	Mingle Limited	Medium
Social unity in flood disaster preparedness: This data uses qualitative methods to see how well communities work together when facing floods.				
5	Logistical, material, and flood disaster management preparedness	2	11-25%	Low
	Number of population participating relieve activities (volunteers)	2	11-15%	Low
	Availability of shelters for societies affected by disasters	1	<10%	Very low
	Support from NGOs/CBOs	3	Limited help	Medium
	Voluntarily evacuated population	1	0%	Very low
	Total	49	Community does not yet have good resilience and adaptation so flood disasters damage the social and economic life of the community in a period of <1 year	

The numbers in the Value Weight column in Table 3 above reflect the weights given to the various indicators used to assess the community's resilience and adaptation in dealing with flood disasters in Kampar Regency. This weight indicates the level of influence or significance of each indicator on the community'sability to survive and recover from the impact of flooding.

Each indicator is given a weight value based on the level of importance of its contribution to the community's adaptive resilience. For example, a weight of 1 indicates that the indicator has a very low influence, such as the voluntarily evacuated population indicator, which has a minimal impact on the community's resilience. A weight of 2 indicates a medium influence, as seen in the health service system's ability to deal with disaster indicators, which show a significant contribution although not

dominant. Meanwhile, a weight of 3 is given to indicators that have a strong influence, such as population density, which plays an important role in the community's resilience to flooding. The total overall weight of 49 is the result of the sum of all weight values for each indicator (as in Table 1 in the research method for criteria 46.9-67.6). This figure provides a general overview of the level of the community's adaptive resilience in Kampar Regency, which is still relatively low. The community does not yet have adequate resilience, so flood disasters continue to damage social and economic life in less than a year. Thus, the results of this analysis indicate that greater efforts are needed to improve the community's resilience and adaptation to flood disasters in the area.

Characteristics of the adaptive resilience of the community of Kampar Regency, especially in areas that are very vulnerable to the hazards of flood disasters, namely in Tapung, Tapung Hulu, TapungHilir, Kampar Kiri Hilir, Siak Hulu, Tambang, Kampar Kiri, GunungSahilan, and other areas, are generally influenced by the high number of children and elderly people living in areas prone to flood disasters, which results in a low community response to flood disaster mitigation and adaptation efforts. The non-optimal function of health facilities in mitigating flood disasters has a direct impact on reducing the community's adaptation in dealing with the hazards of flood disasters.

Steps that must be taken to improve the adaptive resilience of the community in facing flood disasters in Kampar Regency can be based on the value of each indicator listed in Table 3. Efforts that must be made include: 1) Optimizing the readiness of logistics, materials, and flood disaster management, which is currently in the "low" category with a weight value of 2 (11-25%); 2) Increasing community participation as volunteers through outreach and flood disaster mitigation training, which is also in the "low" category with a weight value of 2 (11-15%); 3) Arranging evacuation routes and providing adequate temporary shelters, which are currently in the "very low" category with a weight value of 1 (<10%); 4) Increasing the role of schools in flood disaster preparedness so that schools have good resilience in adapting to flood disasters, which is currently in the "low" category with a weight value of 2 (11-25%); and 5) Utilizing health facilities to provide socialization regarding the impact of flood disasters to the community, which is currently also in the "low" category with a weight value of 2 (11-25%).

4. CONCLUSION

The level of adaptive resilience of the community of Kampar Regency in facing the hazards of flood disasters in 2023 is relatively low with a total score of 49, indicating that the community does not have good resilience to flood disasters. This has the potential to cause significant damage in various dimensions of life, including social, economic, and cultural. Most of the Kampar Regency area is highly vulnerable to flooding, with more than a third of its area, or around 317837 ha, falling into the flood hazard zone. Recommendations to increase the community's adaptive resilience must be focused on optimizing logistics and flood disaster management, increasing the community participation as volunteers, arranging evacuation routes and temporary shelters, the active role of schools in disaster preparedness, and utilizing health facilities to socialize the impact of flood disasters.

5. ACKNOWLEDGMENTS

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