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Flood Disaster Mitigation Strategy in Tempe Sub-District Wajo Regency due to the Overflow of Lake Tempe

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Abstract:- Wajo Regency is one of the regencies in South Sulawesi Province that frequently suffers from flooding. The overflow of Tempe Lake causes one of the floods. The primary problem formulation in this research is: how is flooding distributed, how is flood danger level, and how is flood disaster mitigation plan in Tempe Sub-district, Wajo Regency. In this work, image rectification was utilized to answer the first problem formulation; flood data overlay was used to respond to the second problem formulation, and SWOT analysis was used to answer the third problem formulation. A flood distribution area of 318.25 hectares was obtained based on the analysis findings. It was distributed among Tempe urban village, Mattirotappareng urban village, Laelo urban village, and Salomenraleng urban village—all designated as having a high flood hazard level. Implementing a turnaround strategy (quadrant III) with strategy adaptation and protection is based on the SWOT analysis findings.

Keywords:- *Flood, Hazard Level, Strategy*

I. INTRODUCTION

Floods are overflows or inundations caused by a river or water body, and they frequently endanger people's lives and assets [5]. The increasing problem of flooding is mainly driven by regional planning factors, where it is commonly found in regional planning that establishing residential areas or development centers is precisely in flood areas [4].

Wajo Regency is one of the regencies in South Sulawesi Province that is frequently afflicted by flooding. One of the floods was caused by Lake Tempe overflowing due to the Walanae River, Bila River, Belokka River, Batu-batu River, and Lawo River carrying silt from upstream and emptying into Lake Tempe [2].

Tempe Sub-district is one of the most badly impacted by Tempe Lake flooding. Tempe Sub-district, directly surrounded by Tempe Lake and receives 1500-2000 mm of rain per year, witnessed flooding as high as 1.5 meters, inundating local inhabitants' settlements, rice fields, and plantations [3].

Based on the flood disaster in Tempe District, Wajo Regency, which is caused by the overflow of Lake Tempe that occurs from year to year, and by looking at several existing phenomena, the authors feel it is essential and compelled to conduct research in the area by looking at the distribution of floods, the level of flood hazard and implementing strategies flood disaster mitigation to minimize the impact that occurs with the title 'Flood Disaster Mitigation Strategy in Tempe Sub-District Wajo Regency Due to the Overflow of Lake '.

II. METHODS

➢ *Flood Distribution*

The image rectification process is used to identify the distribution of flooding in the research location. Because picture rectification is a crucial step, it must be completed before beginning image data processing. We match geometrics in this process such that the image coordinates on the Google Earth image match the coordinates on the Quickbird image, which has been rectified by the relevant agencies [7]. The following is the process that must be followed:

- Open ArcGIS and then add data to open Google Earth and Quickbird imagery.
- Activate the Quickbird image layer and point the cursor at a clearly visible place.
- After that, do Add Control Points to add points to the Quickbird and Google Earth images, then deactivate the Quickbird image layer and activate the Google Earth image layer, left-click, then right-click to reveal the X and Y input coordinates.
- After entering the coordinates of the Quickbird image, the Google Earth image will shift according to the coordinates that have been entered. Do this a number of times and spread it so that the image is really precise according to the Quickbird image that has been verified.

➢ *Flood Hazard Levels*

By examining some of the floods' obtained characteristics, it is possible to identify the level of flood hazard in the research location. Using a scoring method where the weight of each parameter has been predetermined, the spatial analysis method used in this planning is the process of overlaying between two or more thematic layers or overlapping maps to obtain new thematic combinations based on the equations and findings from expert and public interviews.

Table 1 Flood Hazard Scoring Analysis

Flood height				
Depth (cm)	**Class**	**Value**	**Weight %**	**Score**
< 76	Low	1	40	0.4
76 -150	Medium	2		0.8
> 150	High	3		1.2
Length of flooding				
Duration (Hours)	Class	Value	Weight %	Score
< 12	Low	1	20	0.2
24	Medium	2		0.4
> 24	High	3		0.6
Flood duration				
Number of Occurrences	Class	Value	Weight %	Score
0-5	Low	1	20	0.2
20	Medium	2		0.4
> 20	High	3		0.6
Flood extent				
Extensive (m²)	Class	Value	Weight %	Score
< 100	Low	1	40	0.4
100-300	Medium	2		0.8
> 300	High	3		1.2

Table 2. Flood Hazard Scoring

Flood Hazard Level	**Score**
Low	< 1.5
Medium	1.5 - 2
High	> 2

The scoring of flood hazard levels in this research is shown in Table 2 above [1].

➢ *Flood Mitigation Strategy*

After figuring out the form of a flood disaster mitigation strategy at a flood hazard location, the next step is to conduct in-depth interviews with stakeholders who play an essential role in developing a flood management strategy. SWOT analysis is employed, which involves formulating internal factors (strengths and weaknesses) and external factors (advantages and threats).

The formulation of the SWOT analysis compares internal factors, which are classified into the IFE (Internal Factor Evaluation) matrix, while external factors are classified into the EFE matrix (External Factor Evaluation).

The weight for each criterion is in the range of 1-5 (not important-very important). The weight value indicates the importance level of one criterion against other criteria. Meanwhile, the rating is determined to determine the level of importance of each factor. A scaled score of 4 is given to each criterion based on a literature review where a value of 4 means that the influence of these criteria on development is very high, while a value of 1 is very low. Meanwhile, the score calculation for each factor is the weight multiplied by the rating [6].

Determine the coordinates of the diagram with internal analysis coordinates (x) = (total strength score – total weakness score): 2 and external analysis coordinates (y) = (total opportunity score – total threat score) : 2

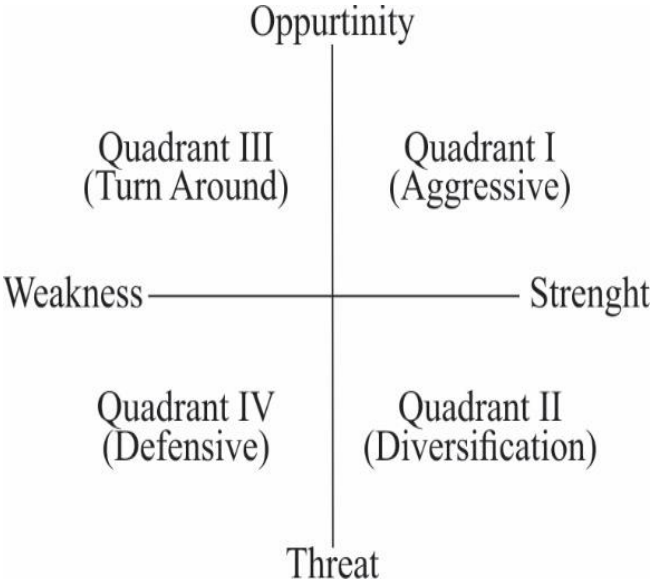

Fig 1 Quadrant SWOT

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III. RESULTS AND DISCUSSION

➢ *Flood Distribution*

The Wajo Regency BPBD agency provided QuickBird imagery at the affected location, and a map rectification process was used to determine the distribution of flooding, as seen below:

Fig 2 QuickBird Image

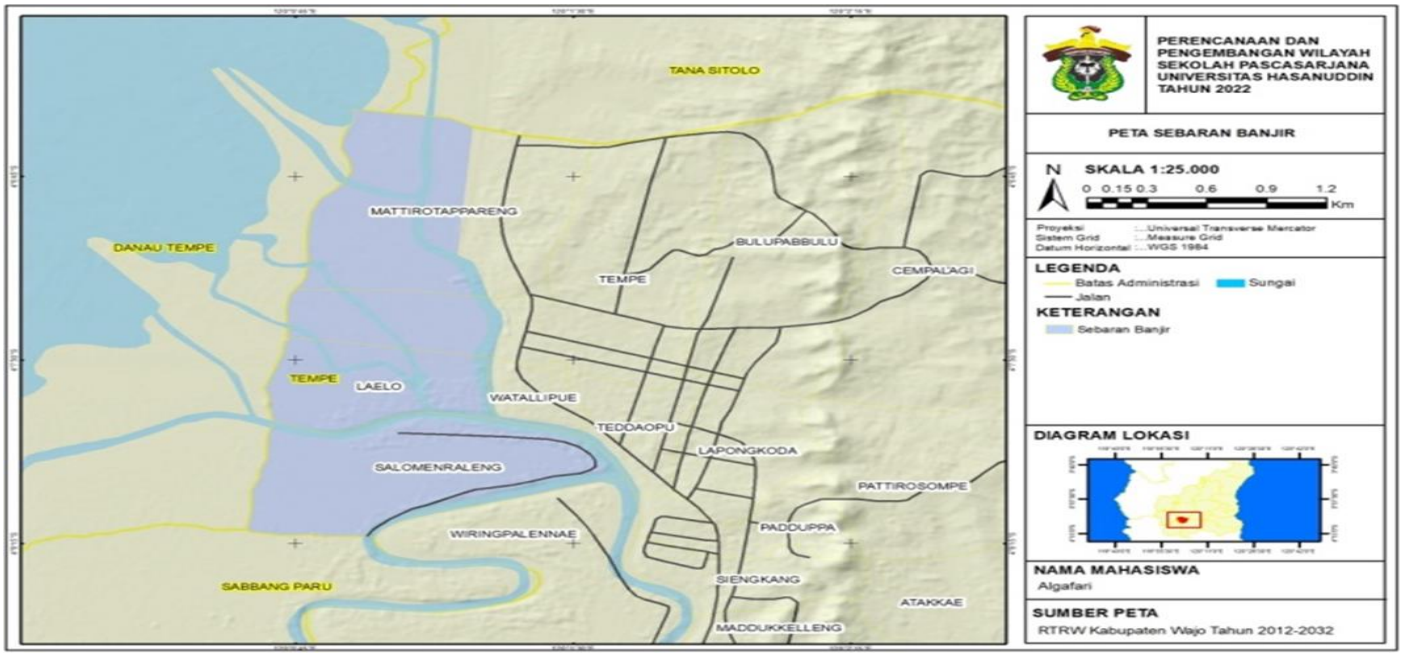

Fig 3 Flood Distribution Map

➢ *Flood Hazard Level*

The flood hazard level in Tempe Sub-district can be classified into three classes: low, medium, and high. Based on reference table 1, the flood hazard level is calculated from the score of each parameter from the flood hazard level calculation, including flood depth, flood area, number of flood events, and flood inundation duration.

Table 3 Flood Extent Scoring Data

No	Urban Village	Extensive (Ha)	Score
1	Mattirotappareng	95,19	0,6
2	Tempe	43,92	0,6
3	Laelo	60,81	0,6
4	Salomenraleng	118,33	0,6

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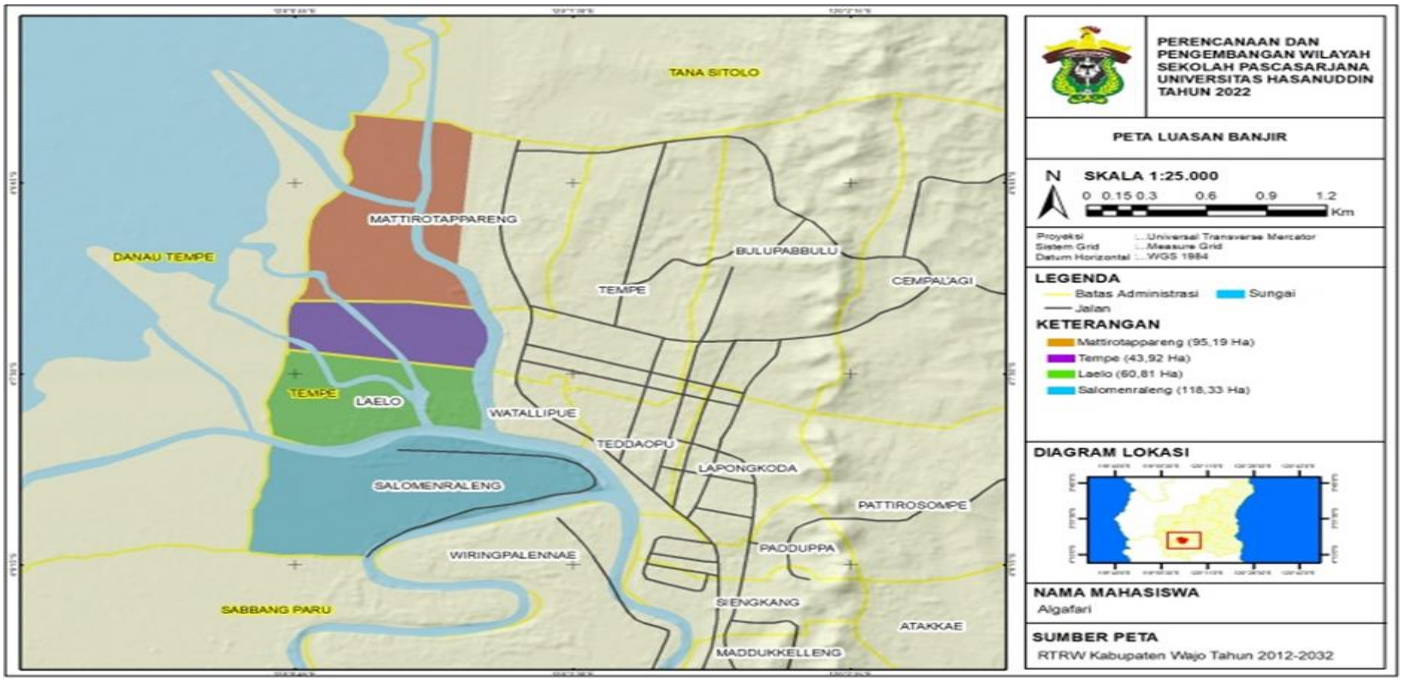

Fig 4 Flood Extent Map

Table 4 Length of Flood Scoring Data

No	Urban Village	Duration of Occurrence (Month)	Score
1	Mattirotappareng	1	0,6
2	Tempe	1	0,6
3	Laelo	1	0,6
4	Salomenraleng	1	0,6

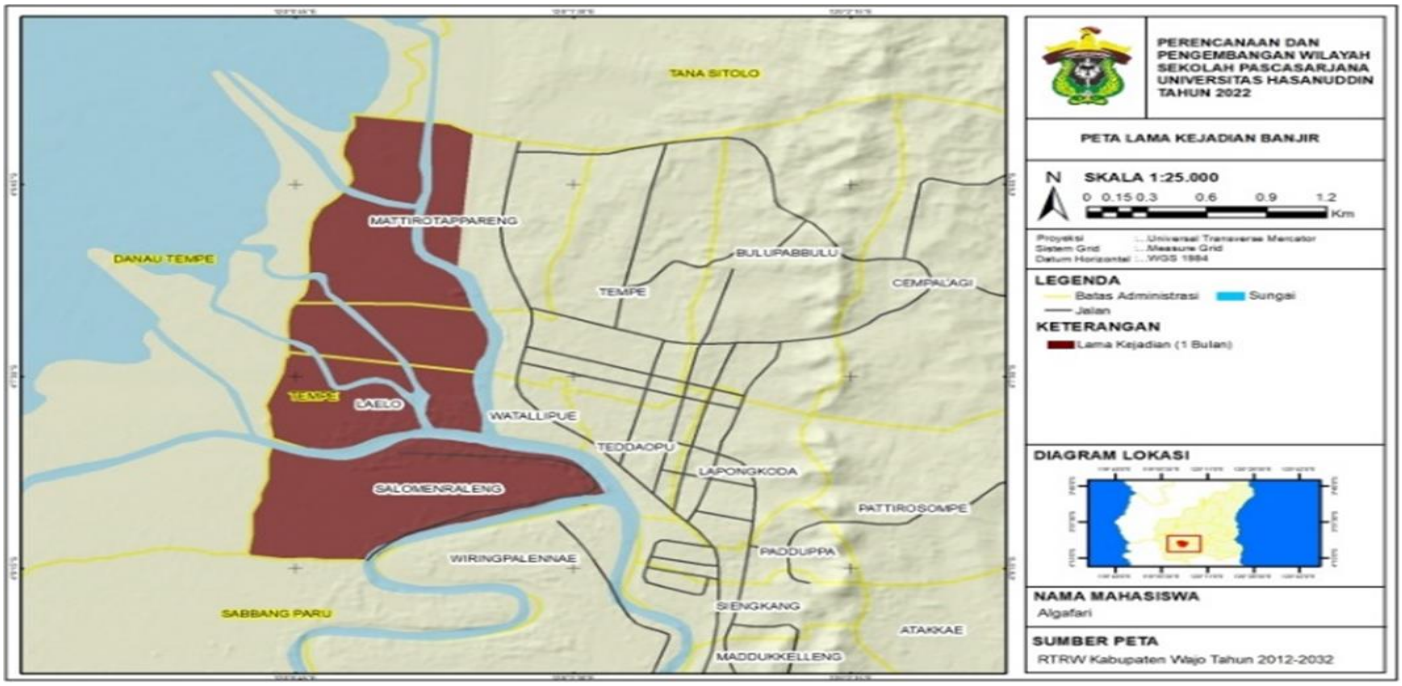

Fig 5 Flood Event Length Map

Table 5 Scoring Data of the Number of Flood Events

No	Urban Village	Number of Occurrences	Score
1	Mattirotappareng	6	0,4
2	Tempe	6	0,4
3	Laelo	6	0,4
4	Salomenraleng	6	0,4

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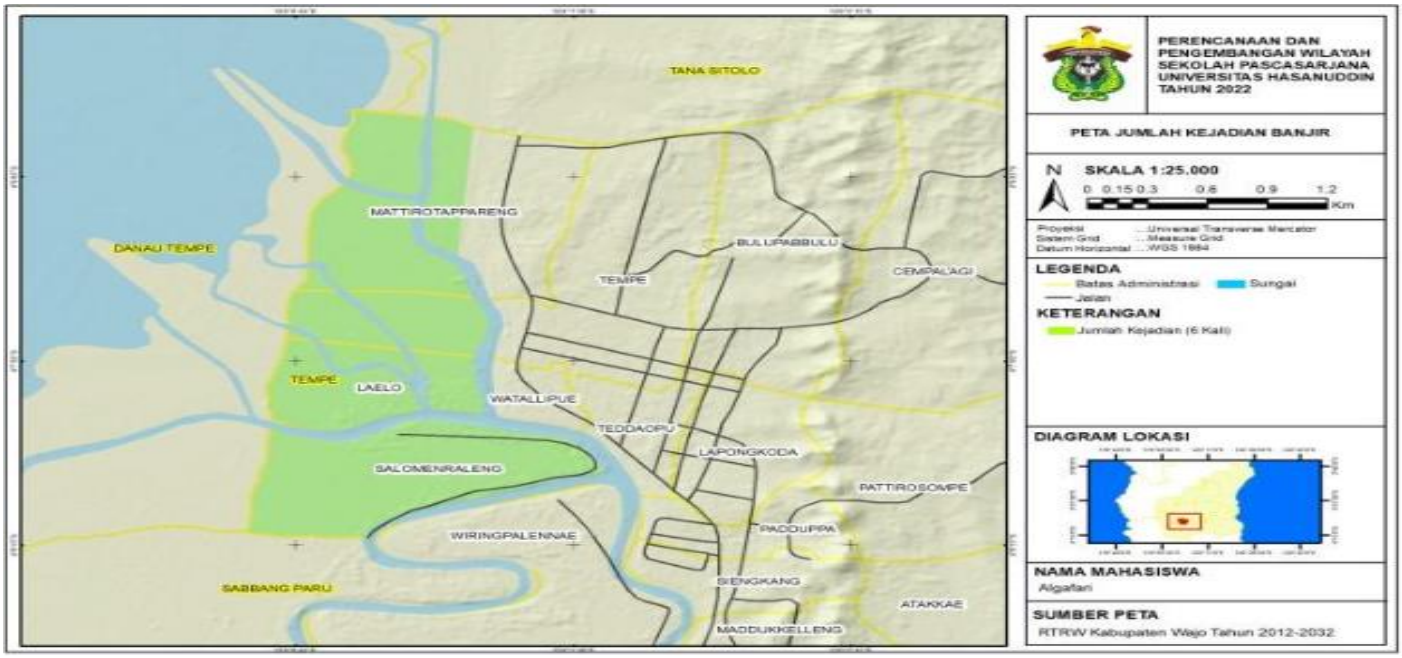

Fig 6 Map of Number of Flood Occurrences

Table 6 Flood Depth Scoring Data

No	Urban Village	Depth (cm)	Score
1	Mattirotappareng	180-300	1,2
2	Tempe	180-300	1,2
3	Laelo	180-300	1,2
4	Salomenraleng	180-250	1,2

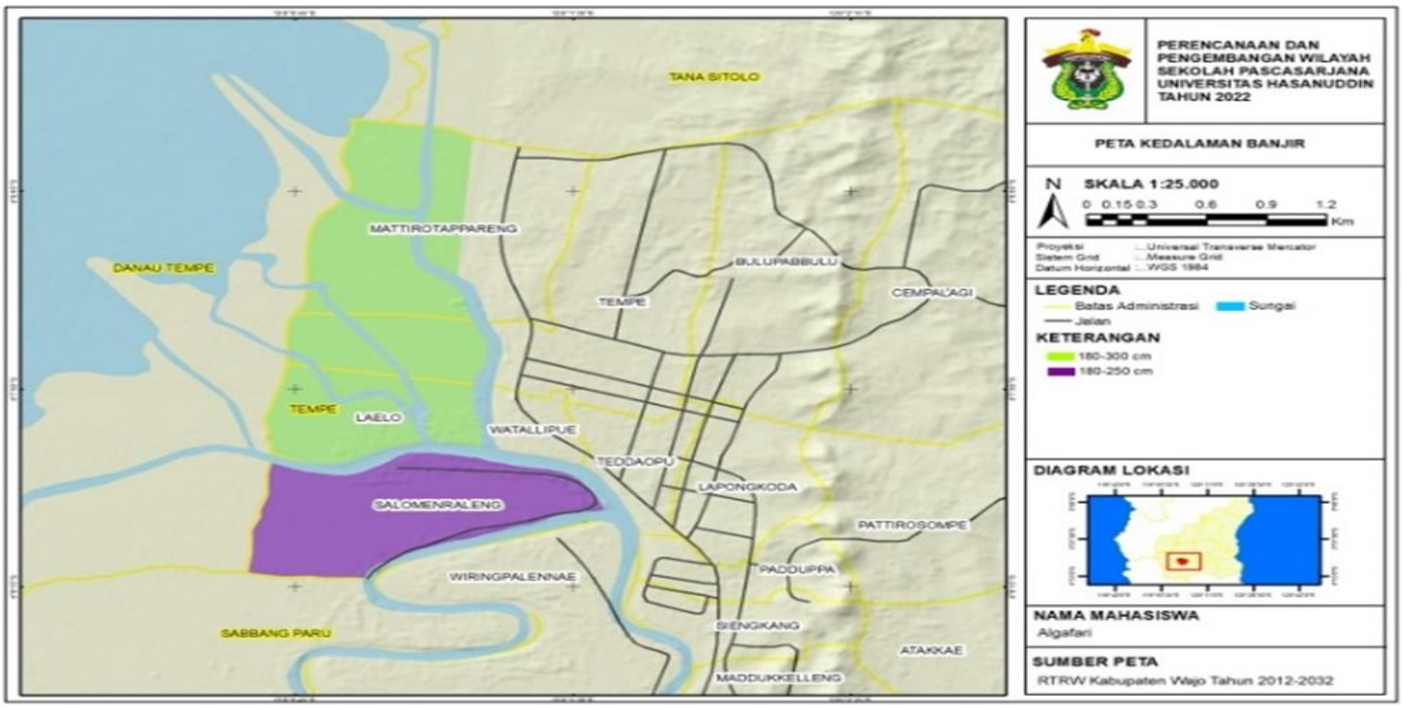

Fig 7 Flood Depth Map

Table 7 Final Flood Hazard Score

No	**Urban Village**	**Score**	**Flood Hazard Level**
1	Mattirotappareng	2,8	High
2	Tempe	2,8	High
3	Laelo	2,8	High
4	Salomenraleng	2,8	High

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According to the Flood Hazard Level Map overlay results, Tempe Sub-district includes the four most severely affected villages, namely Mattirotappareng Village, Tempe Village, Laelo Village, and Salomenraleng Village, is classified as having a high flood hazard level. Please refer to the map below for further details:

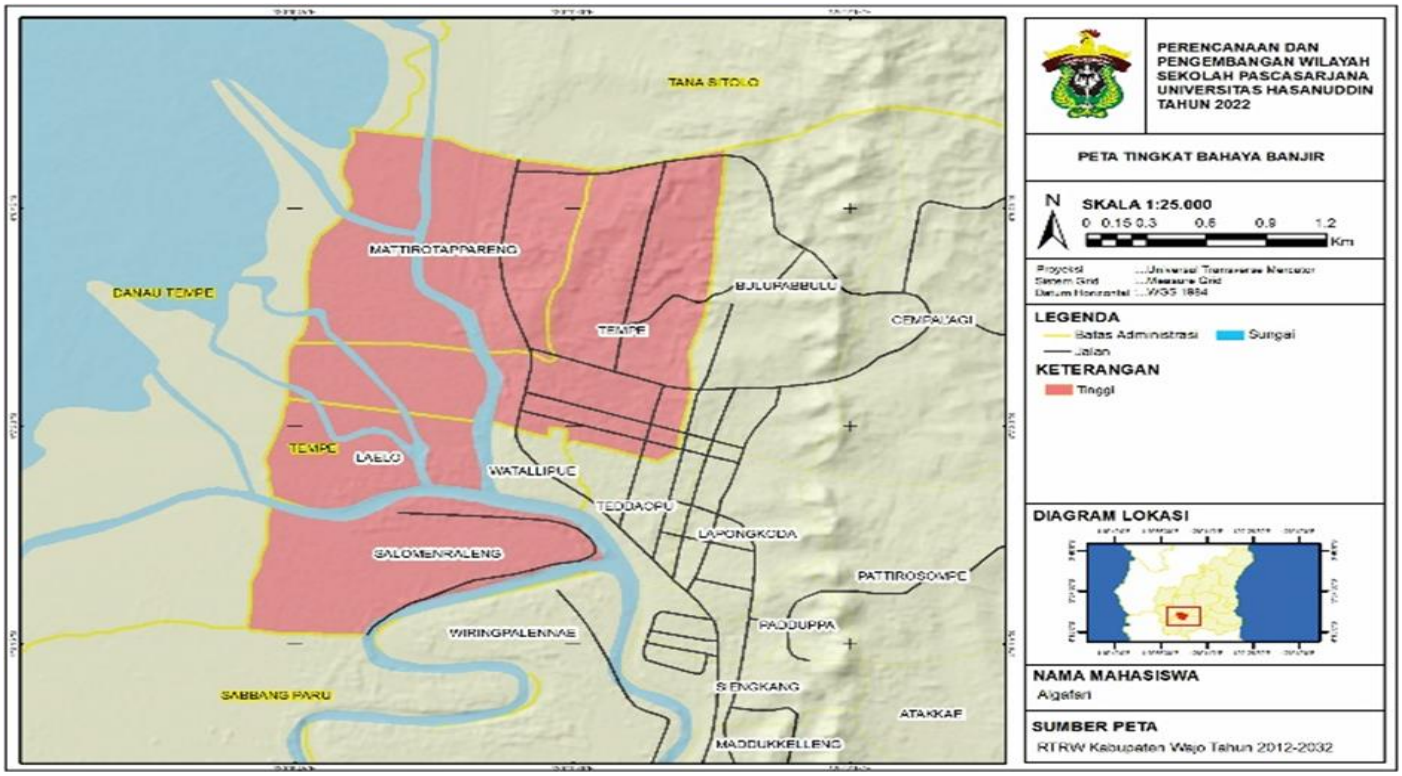

Fig 8 Flood Hazard Level Map

➢ *Flood Mitigation Strategy*

SWOT analysis was used to analyze flood disaster mitigation strategies in Tempe Sub-district, Wajo Regency, separated into internal and external elements. Internal factors are those that originate inside the community and events that occur within the area (prone to floods) itself, and they are classified as either strengths or weaknesses. External factors are outside influences that can affect the region, in the case of government regulations and other factors which have an impact, which are then classified as opportunities or threats.

Table 8 Internal Factor Analysis

No	Strength	Weight	Rating	Score
1	The majority of the community has taken up flood disaster mitigation efforts independently	0.106	3.80	0.40
2	Most of the people often carry out mutual cooperation activities for environmental preservation	0.106	4.00	0.42
3	The native wisdom of the society is still preserved, such as the Bugis/Wajo tribe's building model (house on stilts)	0.111	3.60	0.40
4	An embankment has been built around the settlement along Lake Tempe	0.087	4.20	0.37
Total Strength		**0.409**	**15.6**	**1.59**
No	**Weakness**	**Weight**	**Rating**	**Score**
1	The majority of people are unconcerned with environmental cleanliness	0.096	4.00	0.38
2	The majority of people are unaware of early warning and disaster evacuation efforts	0.087	3.40	0.30
3	The number of people who live in the Tempe Lake area	0.106	4.00	0.42
4	Infrastructure such as Drainage is not yet optimal	0.111	3.80	0.42
5	Damage to embankments in some areas	0.101	3.60	0.36
6	Economic disparity between communities	0.091	3.60	0.33
Total Weaknesses		**0.591**	**22.4**	**2.22**

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Table 9 External Factor Analysis

No	Opportunity	Weight	Rating	Score
1	The existence of regional regulatory instruments and flood catastrophe management measures implemented by regional authorities in Wajo Regency	0.112	3.80	0.43
2	The Wajo District BPBD agency has an important role in the function of disaster prevention, emergency management, rehabilitation and post-flood reconstruction	0.117	4.20	0.49
3	Lake Tempe's strategic location is surrounded by three regencies simultaneously, making it an essential concern for the three district governments in their efforts to deal with flood disasters	0.117	4.60	0.54
4	The existence of a disaster information instrument with early warning when a flood disaster will occur	0.102	4.00	0.41
5	The existence of technology makes the opportunity to distribute disaster information quite quickly	0.107	4.40	0.47
Total Opportunity		**0.553**	**21**	**2.33**
No	**Threats**	**Weight**	**Rating**	**Score**
1	Lake sedimentation that causes flooding	0.121	5.00	0.61
2	The rapid development of the population has raised the demand for land, which has led to changes in land use from water catchment areas to residential areas	0.112	4.60	0.52
3	Climate change or erratic weather	0.117	4.60	0.54
4	A global pandemic that may occur at any time	0.097	4.40	0.43
Total Threats		**0.447**	**18.6**	**2.09**

Tables 8 and 9 detail how internal and external factors affect how flood disaster mitigation is handled in Wajo Regency due to Lake Tempe overflowing. Internal factors show weaknesses as the most influential factor, with a score of 2.22 compared to strengths, while external factors show opportunities to be the most significant factor, with a score of 2.33 compared to threats, with a score of 2.09. Based on these findings, the coordinate points in the SWOT quadrant are calculated from the scores of internal and external elements, and the results are as follows:

Internal (x) = Total strength score - total weakness score
= 1.59 – 2.22
= -0.63

External (y) = Total opportunity score - total threats score
= 2.33 – 2.09
= 0.24

The point (x) is obtained at -0.63 and the point (y) is obtained at 0.24, describing the swot quadrant as follows:

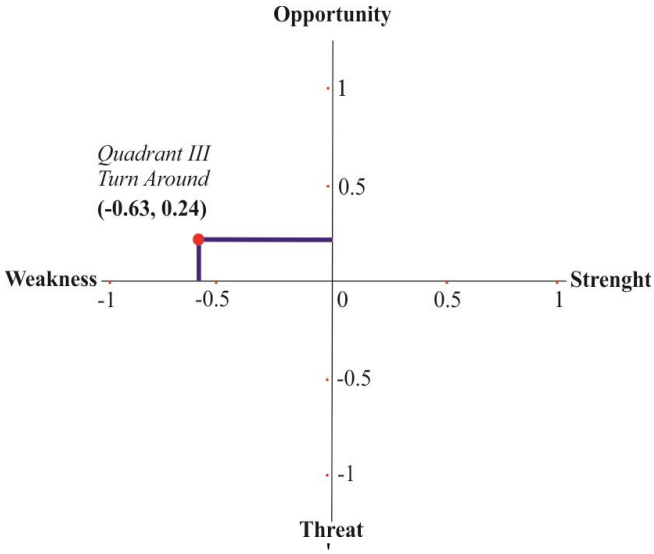

Fig 9 SWOT Quadrant Results

The figure above shows that the obtained strategy is in quadrant III, indicating the turnaround strategy, where mitigation is the dominant opportunity. As a result, the priority strategy in accumulating the W-O strategy is to maximize its chances while minimizing its weaknesses. The following is a SWOT matrix that may be used to describe strategic factors:

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Internal Factor / External Factor	Strengths (S)	Weakness (W)
	1. The majority of the community has taken up flood disaster mitigation efforts independently 2. Most of the people often carry out mutual cooperation activities for environmental preservation 3. The native wisdom of the society is still preserved, such as the Bugis/Wajo tribe's building model (house on stilts) 4. An embankment has been built around the settlement along Lake Tempe	1. The majority of people are unconcerned with environmental cleanliness 2. The majority of people are unaware of early warning and disaster evacuation efforts 3. The number of people who live in the Tempe Lake area 4. Infrastructure such as Drainage is not yet optimal 5. Damage to embankments in some areas 6. Economic disparity between communities
Opportunities (O) 1. The existence of regional regulatory instruments and flood catastrophe management measures implemented by regional authorities in Wajo Regency 2. The Wajo District BPBD agency has an important role in the function of disaster prevention, emergency management, rehabilitation and post-flood reconstruction 3. Lake Tempe's strategic location is surrounded by three regencies simultaneously, making it an essential concern for the three district governments in their efforts to deal with flood disasters 4. The existence of a disaster information instrument with early warning when a flood disaster will occur 5. The existence of technology makes the opportunity to distribute disaster information quite quickly	**Strategy S-O** 1. Maximize collaboration between the government and the community so that programs can run optimally. (S1, S2 – O1, O2, O3) 2. Strengthening community empowerment, for instance through collaboration or the establishment of an environmental concern institution. (S1, S2, -O1) 3. Creating community empowerment programs based on local wisdom. (S3, -O1, O2)	**Strategy W-O** 1. Strengthen the empowerment of socialization programs on environmental sustainability to the community. (W1, W3-O1, O2, O3) 2. Improve the quality and capacity of drainage networks and water absorption areas. (W3, W4, W5, -O1, 03) 3. Empowering the use of information technology instruments in this case socialization of the *early warning system* in knowing disaster information. (W2 – O4, O5) 4. Strengthen the application and supervision of spatial regulations, especially in the environmental sector. (W1, W3 – O1)
Threats (T) 1. Lake sedimentation that causes flooding 2. The rapid development of the population has raised the demand for land, which has led to changes in land use from water catchment areas to residential areas 3. Climate change or erratic weather 4. A global pandemic that may occur at any time	**Strategy S-T** 1. Increase the public's awareness of the necessity of environmental protection, particularly of rivers and lakes. (S1, S2 – T1, T3) 2. Increase community socialization and a sense of mutual support to other disaster sufferers. (S2, S3, - T2, T3, T4)	**Strategy W-T** 1. Maximize and maintain environmental facilities and infrastructure, especially health facilities and clean water. (W1, W3, W6 – T1, T2, T3, T4) 2. Classify and prioritize handling assistance to underprivileged communities (W6-O1, O2, O3, -T1)

Fig 10 SWOT Matrix

IV. CONCLUSIONS

- The distribution of floods in the affected locations was derived using the image rectification process, which included the Tempe, Mattirotappareng, Laelo, and Salomenraleng Villages, totaling 318.25 Ha.
- Based on the results of the overlay analysis on four flood parameters, namely flood area, number of flood events, flood duration, and flood depth, which resulted in a map of the flood hazard level, it was found that the level of flood hazard in Tempe Sub-district, Wajo Regency, due to the overflow of Tempe Lake, was classified as a high flood hazard level in the flood-affected urban villages (Tempe, Mattirotappareng, Laelo, and Salomenraleng).
- Based on the results of the analysis of flood disaster mitigation strategies using SWOT analysis resulted in the implementation of turnaround strategies (quadrant III) with adaptation and protection, namely: Strengthening the empowerment of socialization programs regarding environmental sustainability to the community, improving the quality and capacity of drainage networks and water absorption areas, empowering the use of information technology instruments, in this case, the socialization regarding the early warning system in obtaining disaster information, as well as strengthening the application and supervision of the rules regarding spatial planning, especially in the environmental sector.

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