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FLOOD MANAGEMENT STRATEGY IN THE SINGKAWANG CITY USING SWOT ANALYSIS

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Abstract

Singkawang City is a coastal city surrounded by mountains with an area of 504 km2. The Singkawang City area often experiences flooding, which gets worse every year. A deeper analysis is needed to determine strategic issues and flood management strategies in Singkawang City. This study analyzes flood control strategies and what mitigation is proper for Singkawang City. The results of this analysis are then used as a guide for stakeholders in making the best decisions to deal with floods in Singkawang City.

To identify strategic issues regarding flooding, a Focus Group Discussion (FGD) on flood issues in Singkawang City was held on 21 June 2023, which credible stakeholders attended. The results of the FGD mapped out which factors are Strengths, Weaknesses, Opportunities, and Threats. Then, an IFAS and EFAS analysis is carried out to determine the most influential flood control strategy, which will be carried out by AHP analysis to determine the most priority strategy to implement. After that, the strategy timeframe was obtained using SFAS analysis for the short-term, medium-term, and long-term. This strategy is then complemented by disaster mitigation before, during, and after the flood.

The analysis results show that the right strategy for flood management in Singkawang City in an integrated manner is the W-O Strategy, namely, improving the weaknesses in Singkawang City so that the existing opportunities can be maximized. The strategy with the highest priority from the AHP analysis is that the government can formulate a strategy for structuring the Singkawang River corridor with a weight of 0.247 and a score of 2.23. As well as getting flood mitigation for before, during, and after the flood.

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1. Introduction

Increasing economic activity in urban areas is driving Indonesia's economic growth. This causes massive rural-to-urban migration (Wuysang & Soeryamssoeka, 2021). One of the impacts of this urbanization is the conversion of land use for settlements, which reduces infiltration areas and causes flooding (Soeryamassoeka et al., 2018; Soeryamassoeka et al., 2022; Akafi et al., 2023). Floods reflect natural phenomena and damage to the earth's surface, which has been accelerated by human activities (Alfaro et al., 2023)., causing a potential level of vulnerability to flooding in certain areas.

In the West Kalimantan region, floods in the upstream areas usually occur during the rainy season, while in coastal areas, apart from occurring during the rainy season, they are also caused by sea tides, namely the rise in the position of the surface of the waters or the ocean caused by the influence of the gravitational forces of the moon and sun (Razi et al., 2023).

The phenomenon of flooding is a hot topic of discussion, starting from the causes of flooding to the best countermeasures. Flooding is a pool of water that occurs in areas where it is undesirable to have stagnant water during the rainy season and is caused by various factors. A flood is a natural phenomenon that natural or human factors can cause. Particularly in the West Kalimantan region, flooding in the upstream areas usually occurs during the rainy season, while in coastal areas, other than being caused by the rainy season, sea tides can also cause it.

There were 14 floods and one flash flood that occurred in Singkawang City. This flood disrupted the economic activities of the community. The damage caused by this flood is also a big problem that needs to be addressed. (Singkawang City Central Statistics Agency, 2018).

An appropriate and effective solution is needed to overcome this problem. Regulations regarding flooding are significant in that this becomes the authority of the local government. However, determining the proper regulation requires a more in-depth analysis. Planning an integrated flood management strategy aims to find a way out of the problems. There are various ways to identify the issues and find the right strategy to solve them. The most frequently used method is strategic environmental analysis (SWOT). This analysis is intended to examine the strengths, weaknesses, opportunities, and challenges of the problems in the flood case in Singkawang City.

2. Materials and Methods

2.1 Theoretical Frame Work

Singkawang City is a coastal city surrounded by the Pasi, Poteng, and Sakkok mountains. The Singkawang City area often experiences floods, which get worse every year. High rainfall, changes in land use, minimal drainage, and inaccurate policies in flood management measures are strong reasons why flooding worsens and requires more accurate handling.

A more in-depth re-analysis is needed to determine a flood management strategy in Singkawang City. The analysis must look at the conditions in the Singkawang City area and how they are related to the main problem. The results of this analysis are then used as guidelines in flood prevention policies in Singkawang City.

The analysis used in this case is the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. SWOT analysis was carried out on flood cases in Singkawang City so that the strengths, weaknesses, opportunities, and threats in Singkawang City will be considered in determining the appropriate strategy for the area. These factors are formulated based on the points obtained from the Focus Group Discussion (FGD).

The output of the SWOT analysis is the factors that influence the causes of flooding so that the most suitable flood management strategy formulation for Singkawang City can also be formulated. In addition, the strategies will be classified as pre-flood, during-flood, and post-flood strategies.

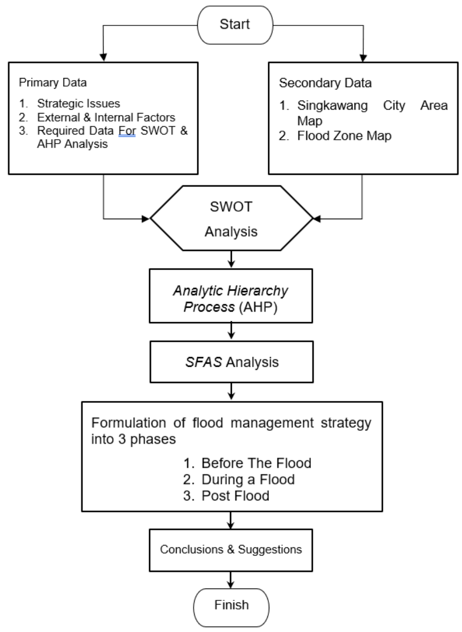

Fig.1 Research Flow Chart

2.2 Research Location

The location of this research covers the entire city of Singkawang, with an area of 504 km^2. The Singkawang City area is bordered by the Sambas Regency in the north, the Bengkayang Regency in the south and east, and the Natuna Sea in the west.

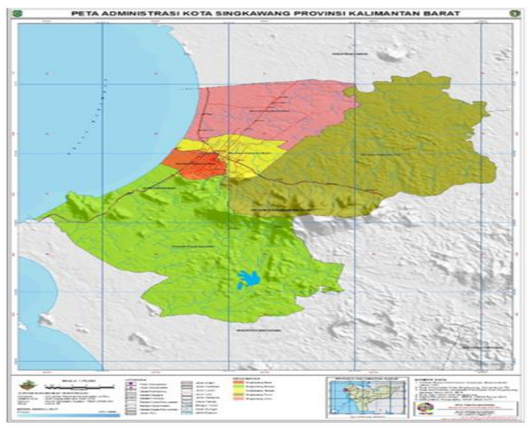

Fig.2 Singkawang City

2.3 Data

Primary and secondary data are needed for this research, obtained through Focus Group Discussions at the research locations and other research-supporting data through institutional surveys from agencies related to this problem. During the FGD, the questionnaire participants who understood the flood problems in their area explained the flood problems they were facing, the causes of the floods, the handling steps taken previously, and other related matters. The participants also filled out questionnaires, which would later be used as essential data for this study. After the data has been collected, this data is processed first using SWOT analysis, then processed using the Analytic Hierarchy Process (AHP), after which the implementation period is determined using the SFAS analysis. The mitigation formulation obtained will be prepared based on 3 phases, namely before the flood, during the flood, and after the flood.

2.4 Analysis Method

2.4.1 Internal Strategic Factor Analysis (IFAS)

The stages of preparing the IFAS table are as follows (Soeryamassoeka, 2020b):

a. Determine factors that are strengths and weaknesses.
b. In column 2, give each factor a weight based on the sum of the respondents' scores for each factor divided by the sum of the internal factor respondents' scores.
c. In column 3, calculate the rating for each factor using a numerical scale of 4 (outstanding) to 1 (poor) based on the number of respondents' scores for each factor divided by the number of internal and external factors.
d. Multiply the weight and rating to obtain each factor's weighting factor as a weighted score.
e. Sum the weighting scores in column 4 to obtain the total weighting score.

2.4.2 External Strategic Factor Analysis (EFAS)

The stages of preparing the EFAS table are as follows (Soeryamassoeka, 2020):

a. Determine the factors that become opportunities and threats.
b. In column 2, give each factor a weight based on the number of respondents' scores for each factor divided by the number of respondents' scores for internal factors.
c. In column 3, calculate each factor's rating using a scale of 4 (outstanding) to 1 (poor) based on the number of respondents' scores for each factor divided by internal and external factors. The more excellent the opportunity, the greater the rating, but the rating is also smaller if the opportunity is small. Rating threats are the opposite of rating opportunities; the greater the threat, the smaller the rating, and vice versa. When the threat value is smaller, the rating is more excellent.
d. Multiply the weight and rating to obtain each factor's weighting factor as a weighted score.
e. Sum the weighting scores in column 4 to obtain the total weighting score.

2.4.3 Analyzing with SWOT Matrix

TOWS analysis is conducted by combining internal factors (IFAS) and external factors (EFAS) (Radhakrishnan et al., 2020). The priority scale values obtained from the previous analysis are then summed up in a matrix, as in the table below, to obtain and compare the value of each strategy.

Table 1. SWOT Matrix

Internal / External	*Strengths* (S)	*Weaknesses* (W)
Opportunities (O)	**SO Strategy** Create strategies that use existing strengths to take advantage of opportunities	**WO Strategy** Create strategies that minimize weaknesses to take advantage of opportunities
Threaths (T)	**ST Strategy** Create strategies using existing strengths to overcome threats Strategy	**WT Strategy** Create strategies that minimize existing weaknesses to avoid threats

2.4.4 Decomposition

Decomposition is used to decompose a generalized goal into several hierarchical levels.

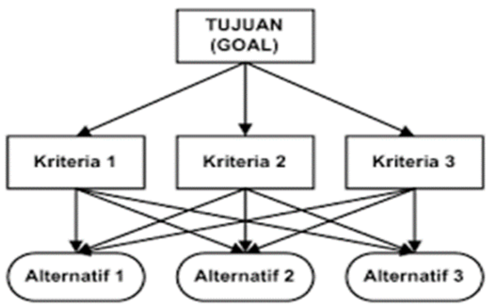

Fig.3 AHP Diagram

2.4.5 Pairwise Comparison

Each element at the same hierarchical level must be compared with each other, so a scale of comparison is needed to reach the two aspects.

2.4.6 Compilation Of Matrix

Geometric Mean Calculation

Data was obtained from swot analysis that had been calculated previously, and each comparison's geometric mean value was entered into a comparison matrix.

$$G = \sqrt[n]{x_1 \text{ x } x_2 \text{ x } x_3 \text{ x } \ldots \text{ x } x_n} \quad (1)$$

Where:
G = Geometric mean value
n = Number of data
X_n = n^{th} data

Compilation of Comparison Matrix

The obtained geometric mean value is entered into the comparison matrix on the upper diagonal, and the lower diagonal value is the inverse of the upper oblique value.

Table 2. Comparison Matrix

Criteria	K1	K2	K3
K1	K11	K12	K13
K2	K21	K22	K23
K3	K31	K32	K33
Total	J1	J2	J3

Compilation of Normalization Matrix

The value of the normalization matrix is obtained by dividing the value of each comparison by the sum of its columns.

Table 3. Normalization Matrix

Criteria	K1	K2	K3
K1	K11/J1	K12/J2	K13/J3
K2	K21/J1	K22/J2	K23/J3
K3	K31/J1	K32/J2	K33/J3
Total	1,000	1,000	1,000

Calculation of The Weight of Each Element

The weight of each element is obtained by calculating the average value of each row of elements in the normalization matrix.

Table 4. Matrix Normalization and Weights

Criteria	K1	K2	K3	Weight
K1	K11/J1	K12/J2	K13/J3	B1
K2	K21/J1	K22/J2	K23/J3	B2
K3	K31/J1	K32/J2	K33/J3	B3
Total	1,000	1,000	1,000	

2.4.7 Logical Consistency

We now calculated the data's consistency ratio (CR).

Calculation of Eigenvector Value (λ)

The eigenvector value is obtained by multiplying the comparison matrix by the weight of each element.

$$\begin{bmatrix} K11 & K12 & K13 \\ K21 & K22 & K23 \\ K31 & K32 & K33 \end{bmatrix} \text{ X } \begin{bmatrix} B1 \\ B2 \\ B3 \end{bmatrix} = \begin{bmatrix} \lambda 1 \\ \lambda 2 \\ \lambda 3 \end{bmatrix} \quad (2)$$

Calculation of Maximum Eigenvector Value (λ_{max})

The maximum eigenvector value is obtained by dividing the eigenvector value by the weight of each element, and then the results are averaged.

$$\lambda_{max} = \frac{((\lambda 1/B1) + (\lambda 2/B2) + (\lambda 3/B3))}{n} \quad (3)$$

Where:
λ_{max} = Maximum eigenvector value
n = Order of matrix

Calculation of Consistency Index (CI)

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (4)$$

Where:
CI = Consistency index
N = Order of matrix

Calculation of Consistency Ratio (CR)

$$CR = \frac{CI}{RI} \quad (5)$$

Where:
CR = Consistency ratio
CI = Consistency index
RI = Random index

2.4.8 Strategic Factors Analysis Summary (SFAS)

Strategic Factor Analysis Summary (SFAS) is a summary of the analysis of strategic factors taken from the EFAS table and IFAS table while determining the timeframe of each strategy.

Table 5. Strategic Factors Analysis Summary Matrix

Rumusan Strategi	Bobot	Rating	Skor	Jangka Pendek	Jangka Menengah	Jangka Panjang
S1	x_1	y_1	$x_1.y_1$			
S2	x_2	y_2	$x_2.y_2$			
...	...	...	...	...	...	...
Total	$\sum x$	$\sum y$	$\sum x.y$			
Max						
Min						
SFAS			Max-Min			

The steps to compile the SFAS table are as follows:

a. Identify and compile several items for each of the most critical internal and external strategic factors based on the scores in the IFAS and EFAS tables.
b. Give weight to these items based on the results of the QSPM analysis.

c. Give a rating in column 3 for each factor based on the importance of each factor.
d. Multiply the weight of each factor in the second column by the rating in the third column to get the weighted score in the fourth column.
e. Based on the final score, determine whether each strategy factor can be used in the short, long, or medium term. If the score value < ($SFAS$/ 3 + Min) strategy is declared short-term if the score value > ($Max - SFAS$/3) strategy is stated to be long-term, and if the score value is between ($SFAS$/3 + Min) and (Max – $SFAS$/3) the strategy is stated to be medium-term.

3. Result and Discussion

3.1 IFAS and EFAS Weighting

From the questionnaire data, the sum of the respondents' scores for each strategic issue and the total score of the factors are obtained to obtain the weight value. The calculation description for internal factors of strength on the first strategic issue is as follows:

a. Calculating the weight by dividing the total value of the respondents for each factor by the total value of the internal factor respondents (Sum of Strengths and Weaknesses).

$$\text{Weight} = \frac{\sum \text{respondent score for each factor}}{\sum \text{internal factor respondent score}} = \frac{35}{563} = 0{,}06$$

b. Calculate the rating using the total value of the respondents for each factor divided by the number of internal and external

$$\text{Rating} = \frac{\sum \text{respondent score for each factor}}{\text{Number of strategic issues}} = \frac{35}{32} = 1{,}09$$

c. Calculates a weighted score by multiplying the weight and rating.

Weighted Score = *Weight* x *Rating*
= 0,06 x 1,09
= 0,07

This calculation is used for all other strategic issues and external factors. The overall results for the IFAS and EFAS weightings are summarized in the following tables.

Table 6. Results of Weighting Strength Factors

No	Strength	Average	Total	Weight	Rating	Weighted Score
1	There is an RTRW in the administrative area which is included in Singkawang City.	3,18	35	0,06	1,09	0,07
2	There is a Regional Disaster Management Agency (BPBD).	3,45	38	0,07	1,19	0,08
3	There is coordination between OPDs in managing floods in the Singkawang City area.	3,09	34	0,06	1,06	0,06
4	There is a plan for spatial revision in flood-prone areas.	3,27	36	0,06	1,13	0,07
5	Singkawang is famous as a tourism area.	3,09	34	0,06	1,06	0,06
6	Management of water resources in Singkawang City can be organized.	2,55	28	0,05	0,88	0,04
7	There is assistance from foundations and community organizations.	3,27	36	0,06	1,13	0,07
8	Shelters have been made for residents affected by the floods.	3,45	38	0,07	1,19	0,08
		Total of Power	**279**	**0,50**	**8,72**	**0,54**

Table 7. Results of Weighting Weakness Factors

No	Weakness	Average	Total	Weight	Rating	Weighted Score
1	Floods that keep recurring and increasing.	3,73	41	0,07	1,28	0,09
2	Lack of coordination between the Singkawang City government and the surrounding government areas.	3,36	37	0,07	1,16	0,08
3	A large budget is needed to deal with flood disasters.	3,55	39	0,07	1,22	0,08
4	Singkawang City does not yet have environmental carrying capacity and capacity documents that are useful for managing land use.	3,45	38	0,07	1,19	0,08
5	Regulatory constraints that caused the government to be late in providing assistance.	2,64	29	0,05	0,91	0,05
6	Many settlements were built on the banks of the river.	3,00	33	0,06	1,03	0,06
7	There is a drainage that is not connected to other drainage.	2,82	31	0,06	0,97	0,05
8	The incoming sea tide exceeds the capacity of the existing river causing flooding in coastal areas.	3,27	36	0,06	1,13	0,07
		Total of Weakness	**284**	**0,50**	**8,88**	**0,57**

Table 8. Results of Weighting Opportunities Factors

No	Opportunities	Average	Total	Weight	Rating	Weighted Score
1	There is an application for anticipation/information on which areas are flooded.	3,55	39	0,07	1,22	0,09
2	Plan for the psychological recovery of children affected by the floods.	2,73	30	0,05	0,94	0,05
3	There is normalization of the river which is indicated to be shallow due to sedimentation.	3,45	38	0,07	1,19	0,08
4	Trying to empower residents to work together to clean drainage.	3,18	35	0,06	1,09	0,07
5	The level of disaster can be managed to a minimum.	3,00	33	0,06	1,03	0,06
6	Flood disasters can be anticipated so as not to take casualties.	3,27	36	0,06	1,13	0,07
7	There is a flood zoning mapping.	3,36	37	0,07	1,16	0,08
8	Green open space available.	3,55	39	0,07	1,22	0,09
	Total of Opportunities		**287**	**0,51**	**8,97**	**0,58**

Table 9. Results of Weighting Threats Factors

No	Opportunities	Average	Total	Weight	Rating	Weighted Score
1	Wilayah resapan air singkawang berubah menjadi wilayah permukiman.	3,36	37	0,07	1,16	0,08
2	Potensi banjir besar di area jalan pesisir pantai.	2,82	31	0,06	0,97	0,05
3	Masyarakat membuang sampah ke sungai dan saluran drainase.	3,27	36	0,06	1,13	0,07
4	Masyarakat yang tinggal di bantaran sungai membuang sampah MCK langsung ke sungai.	3,18	35	0,06	1,09	0,07
5	Kota Singkawang memiliki risiko bencana banjir yang cenderung meningkat yang dapat memperlambat proses pembangunan.	3,18	35	0,06	1,09	0,07
6	Ada korban harta benda akibat bahaya banjir di Kota Singkawang.	2,91	32	0,06	1,00	0,06
7	Banjir dari hasil kiriman wilayah lain, khususnya daerah hulu/timur Kota Singkawang.	2,91	32	0,06	1,00	0,06
8	Curah hujan tinggi yang meingkat setiap tahun.	3,09	34	0,06	1,06	0,06
	Total of Threats		**272**	**0,49**	**8,50**	**0,52**

3.2 Comparing Factors with SWOT

The SWOT analysis is followed by TOWS, which is an analysis to determine the grand strategy, namely the matching stage so that it can show the position of strengthening the application of regulations in flood prevention, whether the IFAS and EFAS touch points are in quadrant-1, quadrant-2, quadrant-3, and quadrant-4. Here are the following results.

Table 10. IFAS and EFAS Matching Results

Faktor Internal / Faktor Eksternal	**Strength (S)/ Kekuatan**	**Weakness (W)/ Kelemahan**
Opportunities (O)/ Peluang	**Strategi S+O** 0,54 + 0,58 = 1,12	**Strategi W+O** 0,57 + 0,58 = 1,15
Threats (T)/ Ancaman	**Strategi S+T** 0,54 + 0,52 = 1,06	**Strategi W+T** 0,57 + 0,52 = 1,09

The value in the SWOT matrix table above is the weighted score obtained during IFAS and EFAS weighting. From the SWOT matrix, the best strategy alternative is the W-O strategy, which combines Weaknesses and Opportunities with a score of 1.15.

Determination of the coordinate points in the quadrant positions resulting from the SWOT analysis using positive factors against harmful factors. The x-axis represents strengths and weaknesses, while the y-axis represents opportunities and threats.

$$X = 0{,}54 - 0{,}57 = -0{,}02$$
$$Y = 0{,}58 - 0{,}52 = 0{,}06$$

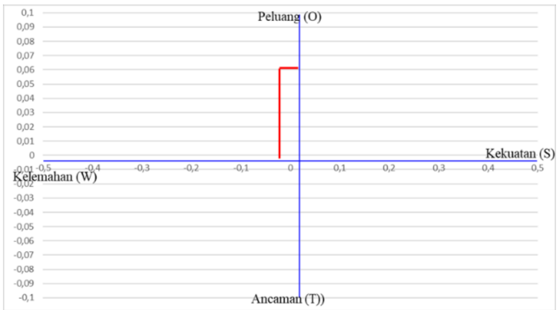

Fig.4 Strategic Factor Position.

From the analysis, it can be seen that the right strategy for strengthening and implementing regulations for flood control in Singkawang City is the W-O strategy, namely by improving weaknesses in Singkawang City so that existing opportunities can be maximized. Thus, for the policy to strengthen the implementation of regulations to be carried out, the strategy refers to Minister of Home Affairs Regulation Number 13 of 2006, Singkawang City Regional Regulation Number 1 of 2022 concerning the Singkawang City Regional Spatial Plan for 2022 – 2042, the City Regional Development Planning Agency Strategic Plan Singkawang Year 2018-2022, and the National Disaster Management Agency (BNPB) Regulations regarding disaster mitigation guidelines are formulated as follows.

Table 11. Strategy Formulation

No	Strategy Formulation
S1	The government can reformulate the RTRW related to the utilization of water catchment areas.
S2	Formulate environmental carrying capacity and capacity documents to manage land use.
S3	Revision of regulations related to flood disaster management.
S4	The government can formulate rules regarding the work area of the BPBD.
S5	The government can determine the arrangement of Singkawang City drainage outlets.
S6	The government can implement a flood early warning system (EWS) in Singkawang City, as well as socialize the flood EWS to all levels of society.
S7	The provincial government can develop policies to improve flood management coordination in Singkawang City.
S8	The government can make policies and regulations regarding the area of buffer/absorbing areas that must be available.
S9	The government can determine the strategy for structuring the Singkawang City river corridor

3.3 Decomposition

The hierarchies used in this study are.

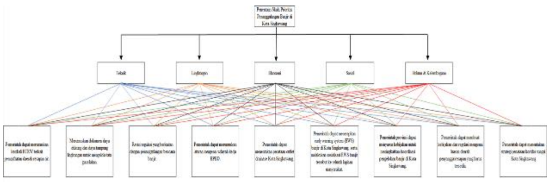

Fig 5. Hierarchical Structure of Flood Management

3.4 Compilation of Matrix

The weight of each element from each hierarchy level is required to determine the priorities of the flood countermeasure strategies used in Singkawang City.

Criteria

The following is the matrix preparation and weight calculation of the criteria hierarchy.

Table 12. Criteria Comparison Matrix

Criteria	Comparison Matrix				
	Enggineering	Environmental	Economic	Social	Legal and Institutional
Enggineering	1,000	0,930	0,830	0,788	0,941
Environmental	1,075	1,000	1,108	1,090	0,697
Economic	1,205	0,903	1,000	0,907	0,686
Social	1,269	0,918	1,102	1,000	0,712
Legal and Institutional	1,063	1,434	1,457	1,404	1,000
Total	5,612	5,185	5,497	5,189	4,036

Table 13. Criteria Normalization Matrix and Weight

Criteria	Normalization Matrix					Weight
	Enggineering	Environmental	Economic	Social	Legal and Institutional	
Enggineering	0,178	0,179	0,151	0,152	0,233	0,179
Environmental	0,192	0,193	0,202	0,210	0,173	0,194
Economic	0,215	0,174	0,182	0,175	0,170	0,183
Social	0,226	0,177	0,200	0,193	0,177	0,195
Legal and Institutional	0,189	0,277	0,265	0,271	0,248	0,250
Total	1,000	1,000	1,000	1,000	1,000	

Based on the results, the highest weight in this hierarchy of criteria is obtained by Legal and Institutional.

Alternative

The following is the matrix preparation and weight calculation of the alternative hierarchy.

Table 14. Alternative Comparison Matrix

Alternative		Comparison Matrix								
		S1	S2	S3	S4	S5	S6	S7	S8	S9
		1	2	3	4	5	6	7	8	9
S1	1	1,000	1,319	0,905	2,574	0,905	1,288	2,012	0,566	0,379
S2	2	0,758	1,000	0,640	1,726	0,686	1,059	1,392	0,501	0,318
S3	3	1,105	1,562	1,000	2,515	0,955	1,467	2,172	0,650	0,429
S4	4	0,389	0,579	0,398	1,000	0,354	0,544	0,636	0,331	0,244
S5	5	1,105	1,457	1,048	2,824	1,000	1,413	2,208	0,707	0,382
S6	6	0,776	0,944	0,682	1,838	0,707	1,000	1,147	0,568	0,351
S7	7	0,497	0,718	0,461	1,571	0,453	0,872	1,000	0,345	0,266
S8	8	1,767	1,998	1,537	3,018	1,413	1,759	2,899	1,000	0,574
S9	9	2,637	3,145	2,331	4,104	2,617	2,846	3,754	1,743	1,000
Total		10,034	12,723	9,001	21,170	9,090	12,249	17,219	6,412	3,944

Results on this table are used to count the normalization matrix of the alternative comparison matrix by dividing the value of each comparison by the sum of its columns.

Table 15. Alternative Comparison Normalization Matrix

Alternative		Normalization Matrix									Weight
		S1	S2	S3	S4	S5	S6	S7	S8	S9	
		1	2	3	4	5	6	7	8	9	
S1	1	0,100	0,104	0,101	0,122	0,100	0,105	0,117	0,088	0,096	0,103
S2	2	0,076	0,079	0,071	0,082	0,075	0,086	0,081	0,078	0,081	0,079
S3	3	0,110	0,123	0,111	0,119	0,105	0,120	0,126	0,101	0,109	0,114
S4	4	0,039	0,046	0,044	0,047	0,039	0,044	0,037	0,052	0,062	0,045
S5	5	0,110	0,115	0,116	0,133	0,110	0,115	0,128	0,110	0,097	0,115
S6	6	0,077	0,074	0,076	0,087	0,078	0,082	0,067	0,089	0,089	0,080
S7	7	0,050	0,056	0,051	0,074	0,050	0,071	0,058	0,054	0,068	0,059
S8	8	0,176	0,157	0,171	0,143	0,155	0,144	0,168	0,156	0,146	0,157
S9	9	0,263	0,247	0,259	0,194	0,288	0,232	0,218	0,272	0,254	0,247
Total		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

To get the weight value of each alternative, calculate the average value of each alternative row in the alternative normalization matrix. For example, to get the alternative weight for Strategy 1, you need to look for the average value of row 1 in Table 15 (0,100 + 0,104 + 0,101 + 0,122 + 0,100 + 0,105 + 0,117 + 0,088 + 0,096) / 9 = 0,103. This calculation applies to finding all alternative local weight values.

Table 16. Global Weight of Alternative

Alternative	Criteria Global Weight					Alternative Global Weights
	Engineering	Environmental	Economic	Social	Legal & Institutional	
The government can reformulate the RTRW related to the utilization of water catchment areas.	0,018	0,020	0,019	0,020	0,026	**0,1035**
Formulate environmental carrying capacity and capacity documents to manage land use.	0,014	0,015	0,014	0,015	0,020	**0,0787**
Revision of regulations related to flood disaster management.	0,020	0,022	0,021	0,022	0,028	**0,1138**
The government can formulate rules regarding the work area of the BPBD.	0,008	0,009	0,008	0,009	0,011	**0,0455**
The government can determine the arrangement of Singkawang City drainage outlets.	0,021	0,022	0,021	0,022	0,029	**0,1150**
The government can implement a flood early warning system (EWS) in Singkawang City, as well as socialize the flood EWS to all levels of society.	0,014	0,015	0,015	0,016	0,020	**0,0798**
The provincial government can develop policies to improve flood management coordination in Singkawang City.	0,011	0,011	0,011	0,011	0,015	**0,0591**
The government can make policies and regulations regarding the area of buffer/absorbing areas that must be available.	0,028	0,030	0,029	0,031	0,039	**0,1573**
The government can determine the strategy for structuring the Singkawang City river corridor	0,044	0,048	0,045	0,048	0,062	**0,2474**

After calculating the local weight of the alternatives, proceed with calculating each alternative's global weight by multiplying each alternative's local weight by the weight of each criterion.

Table 17. Prioritization of Alternatives

Alternative	Weight	Rank
S9	0,2474	I
S8	0,1573	II
S5	0,1150	III
S3	0,1138	IV
S1	0,1035	V
S6	0,0798	VI
S2	0,0787	VII
S7	0,0591	VIII
S4	0,0455	IX

Based on Table 16, a global weight ranking list has been created for each strategy to determine its priority level.

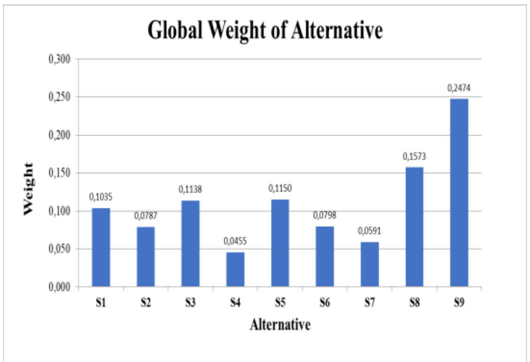

Fig 6. Global Weight of Alternative

3.5 Consistency Ratio Calculation Criteria

Table 18. Consistency Ratio of Criteria

Parameter	Value	Information
λ	0,899	Consistent
	0,975	
	0,921	
	0,979	
	1,258	
λ max	5,032	
CI	0,00803	
RI	1,120	
CR	0,00717	
	0,72%	

Because the value of CR = 0,38% < 10%, the data is considered consistent, and the calculation is acceptable.

Alternative

Table 19. Consistency Ratio of Alternative

Parameter	Value	Information
λ	0,936	Consistent
	0,712	
	1,029	
	0,411	
	1,041	
	0,721	
	0,533	
	1,426	
	2,244	
λ max	9,044	
CI	0,00548	
RI	1,45	
CR	0,00378	
	0,38%	

3.6 Determining the Strategy Timeframe with SFAS Analysis

a Make a rating of the weight values obtained from the AHP analysis because there are nine strategies; the highest score for the rating is 9, and the lowest is 1.

b Enter the rating value based on the rating; the strategy with the highest weight is rated 9, and the strategy with the lowest weight is rated 1.

c Calculate the score by multiplying the weight and rating as an example for calculating the first strategy with a weight value of 0.1035 and a rating of 5.

Skor = 0,103 × 5 = 0,52

d Do the same calculation for each strategy and determine the maximum and minimum score values. So, the top score is 2.23, and the minimum score is 0.05.

e Calculate the strategic factor analysis summary (SFAS) by subtracting the maximum value from the minimum value to get 2.18.

f Determine the limit values to determine the short-term, medium-term, and long-term strategy.

g Lower limit value = $\frac{SFAS}{3} + Minimum = \frac{2,18}{3} + 0,05 = 0,77.$

h Upper limit value = $Maximum - \frac{SFAS}{3} = 2,23 - \frac{2,18}{3} = 1,50.$

i Obtained short-term limit value score < 0,77, medium-term limit value 0,77 < score < 1,50 dan long-term limit value score > 1,50.

Table 20. Strategic Factor Analysis Summary Results

No	Strategy Formulation	Weight	Rating	Score	Short Term	Mid Term	Long Term
1	The government can reformulate the RTRW related to the utilization of water catchment areas.	0,103	5,00	0,52			
2	Formulate environmental carrying capacity and capacity documents to manage land use.	0,079	3,00	0,24			
3	Revision of regulations related to flood disaster management.	0,114	6,00	0,68			
4	The government can formulate rules regarding the work area of the BPBD.	0,045	1,00	0,05			
5	The government can determine the arrangement of Singkawang City drainage outlets.	0,115	7,00	0,81			
6	The government can implement a flood early warning system (EWS) in Singkawang City, as well as socialize the flood EWS to all levels of society.	0,080	4,00	0,32			
7	The provincial government can develop policies to improve flood management coordination in Singkawang City.	0,059	2,00	0,12			
8	The government can make policies and regulations regarding the area of buffer/absorbing areas that must be available.	0,157	8,00	1,26			
9	The government can determine the strategy for structuring the Singkawang City river corridor	0,247	9,00	2,23			
	Total =	**1,00**	**MAX =**	**2,23**			
			MIN=	**0,05**			
			SFAS	**2,18**			
			Short Term		s.d. 0,77		
			Mid Term	0,78	- 1,50		
			Long Term		> 1,50		

4. Conclusion

Based on the results of research analyzed using the Strengths Weakness, Opportunities, Threats (SWOT) method, it can be concluded that the right strategy for flood control in Singkawang City is the W-O Strategy, namely by improving existing weaknesses in Singkawang City so that existing opportunities can be maximized. Based on the AHP analysis carried out to determine the priority scale of the predetermined strategy, it can be seen that it is necessary to arrange river corridors in Singkawang City.

Using SFAS, it can be formulated to control flooding in Singkawang City; the short-term strategy is to implement strategies 1, 2, 3, 4, 6, and 7 for the medium-term strategies 5 and 8, and long-term strategies 9.

The research shows that data collection using the Focus Group Discussion (FGD) method should choose respondents who understand the problems. In addition, the strategies applied need to be adjusted and evaluated in the future because their development will continually change. From this research, it is also suggested that in future research, it is necessary to use more parameters that cause flooding and use more respondents so that the data obtained is more accurate. In addition, it is also suggested that in determining the priority scale, more than one method should be used so that the analysis results have a comparative value and more accurate results are obtained.

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6. Author's Note

Everything written in this article is original because it sums up my studies with Dr. S.B. Soeryamassoeka, S.T., M.T., IPM, and Mr. Eko Yulianto, S.T., M.T., The contents of this article have been reviewed in a thesis defense at the Department of Civil Engineering, The University of Tanjungpura, on July 31, 2023, by Ir. Azwa Nirmala, M.T., IPM. and Dr. Eng. Mochammad Meddy Danial, S.T., M.T.

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