Survival Decisions and Adaptation Strategies of Small-scale Fishers in the Face of Extreme Weather Impacts in Coastal Areas

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Abstract

The survival decision of small-scale fisherman in coastal regions amidst adverse weather conditions is a constant one due to the absence of alternative employment opportunities. Their survival is contingent upon their catches and revenues. Severe weather conditions in coastal regions offer fishermen limited alternatives for making judgments regarding fishing in marine seas. Fishermen must design adaptation methods to address the difficulties and opportunities presented by the detrimental impacts of environmental change in coastal regions. This study employs quantitative methodologies, including surveys and descriptive techniques. A logistic regression model employing maximum likelihood estimation (MLE) is utilized to examine the determinants affecting survival decisions during extreme weather events and the adaption tactics of fishermen to such conditions through a SWOT analysis. This study determined that fishing revenue, fishing experience, and programs promoting environmentally responsible fishing gear enhance the likelihood of fishermen's survival decisions under harsh weather circumstances. Fishermen can apply adaptation techniques for extreme weather circumstances by minimizing damages through economic and environmental adjustments, optimizing various government assistance programs, and enhancing patron-client relationships and interaction patterns. Policymakers can enable fishermen's adaptive strategies to develop solutions that assist them in managing harsh weather according to their requirements, capacities, and interests.

Keywords

Survival decision | logistic regression model | adaptation strategy | SWOT analysis | small-scale fishers

Introduction

Global climate change is inducing extreme weather phenomena (Ilarri et al., 2022). These circumstances present limited alternatives for small-scale fishers when making decisions about fishing in marine waters (Erauskin-Extramiana et al., 2023). Elevated wave heights, augmented precipitation, and severe wind velocities (Maltby et al., 2021) instill fear in fishermen over venturing into the sea. These conditions also change the way fish migrate, which lowers the quantity and quality of fish stocks that are fished for profit (Diouf et al., 2020; Mozumder et al., 2023; Shaffril et al., 2019). The viability of small-scale fishers is significantly reliant on their catches and profit margins (Ruiz-Jarabo et al., 2022). Fishermen's choices can create possibilities to adapt and execute local remedies in anticipation of future disruptions (Lopez-Ercilla et al., 2021). Small-scale fishermen must implement effective adaptation strategies to confront difficulties, leverage opportunities, and mitigate the effects of climate change in coastal regions.

The research in the coastal region of Makassar City, Indonesia, adjacent to the Sulawesi Strait, examines global climate change, particularly extreme weather phenomena. A lot of different places around the world are affected by global events. Some of these places are the Pacific Islands (Hanich et al., 2018), Ghana (Mabe & Asase, 2020), Portugal (Mabe & Asase, 2020), the eastern Malaysian peninsula (Samah et al., 2019), the coast of Bangladesh (Jakariya et al., 2020), the coast of Senegal (Diouf et al., 2020), southern India (Sreya et al., 2021), and the coast and sea of China (Cai et al., 2021). Coastal regions are limited locations with considerable human, economic, and environmental stakes and various susceptibilities to climate change (Lemée et al., 2019).

The small-scale fishermen's decision to endure adverse weather conditions in the study area is irrevocable due to the absence of alternative employment opportunities. Severe weather influences the adaptive behavior of fishers as they endeavor to acclimate to their surroundings. Small-scale fishers have a greater susceptibility to climate threats compared to other populations. Fishermen persist in fishing to fulfill the economic requirements of their families. Despite the potential risks to their safety, fishermen continue fishing. Fishing transpires near shorelines or in coastal regions with brief fishing seasons. Despite the endeavors of fishermen to capture fish, they frequently encounter unsuccessful catches. Moreover, fishermen engage in fishing solely when they secure alternative employment, such as in construction, pawning, or selling their spouses' gold. Small-scale fishers require targeted support to meet their household economic needs (Ali et al., 2023; Rahim et al., 2022).

Over the previous two years, the study region has witnessed tidal flooding in the form of rising sea levels, resulting in floods. According to the Intergovernmental Panel on Climate Change (IPCC) study, global sea level rise is 3.2 mm per year (Shaffril et al., 2017). In coastal countries, this state will pose enormous worldwide economic, social, and environmental challenges (Muringai et al., 2022). The Meteorology, Climatology and Geophysics Agency (BMKG) has also published a forecast predicting that sea breezes would be between 5 and 25 knots, traveling from north-northeast to southwest-northwest at 8–20 knots. The research also indicates that sea waves in the Sulawesi Sea, directly adjacent to

Makassar City's coastal sections, might reach 2–4 meters. The Ministry of Maritime Affairs and Fisheries (KKP) has warned fishermen and fishing boat owners to be wary of adverse weather conditions. They have even instructed them not to sail until the weather returns to normal since it poses a considerable risk to the safety of ships.

Extreme weather phenomena resulting from climate change constitute a significant concern in contemporary society (Gallicchio, 2017). Coastal communities are particularly susceptible to extreme weather events that significantly jeopardize their livelihoods and local resources (Uddin et al., 2021). Small-scale fishing communities are especially susceptible to extreme weather events generated by climate change due to their restricted capacity and operational range in open waters (Selvaraj et al., 2023). Climate change influences the adaptive behavior of fishers (Begum et al., 2022). Fishers must adjust to the changes induced by climate change. Adaptation is crucial for survival and alleviating the adverse effects of climate change (Mozumder et al., 2023). A higher degree of adaptation correlates with an enhanced capacity to maintain livelihoods. Adaptation is a strategy aimed at mitigating the adverse effects of climate change on the fishing sector. Adaptation is a strategy aimed at mitigating the adverse effects of climate change on the fisheries industry (N'Souvi et al., 2024). Climate change adaptation constitutes a significant global challenge in economic development policy and has garnered the attention of scientists and policymakers for decades (Mbaye et al., 2023). Climate adaptation policies in fisheries (Szmkowiak & Steinkruger, 2023) may alleviate poverty (Kalikoski et al., 2018; Rahim & Hastuti, 2023).

This research emphasizes the necessity of comprehending small-scale fishers' survival choices and adaptation tactics amid harsh weather effects in coastal regions. To reach the Sustainable Development Goals (SDGs), we need to fight poverty that hurts the Blue Economy (Schutter et al., 2024) and encourage long-term marine economic growth (Croft et al., 2024) to make people in coastal countries happier and healthier (Daly et al 2021). Global climate change predominantly dictates management methods and practices (Sultan, 2020), affecting economic development policies (Mbaye et al., 2023) and fisheries climate adaptation policies (Szmkowiak & Steinkruger, 2023). Small-scale fishers generate fishery commodities that contribute to food supply (Marín-Monroy & Ojeda-Ruiz de la Peña, 2016), global food security production systems (Limuwa et al., 2018), and food security in communities worldwide (Hastuti et al., 2022; Torres et al., 2022). Moreover, integrating small-scale fisheries into domestic and international market chains is a progressive process, as their livelihoods heavily depend on marine fisheries (Steenbergen et al., 2019). Consequently, they are intricately associated with employment (Marín-Monroy & Ojeda-Ruiz de la Peña, 2016).

Various studies in different nations have independently or partially investigated fisher survival and adaptation. The survival of artisanal fishers is significantly influenced by low-profit catches in the Gulf of Cadiz, Southern Spain (Ruiz-Jarabo et al., 2022), the susceptibility of coastal fishing households to extreme weather events due to climate change in India (Koya et al., 2017) and South India (Sreya et al., 2021), climate change adaptation strategies employed by fishers in Asia (Shaffril et al., 2019), the relationship between climate change adaptation and fishing catchability among artisanal fishers in the Volta Basin, Ghana (Mabe & Asase, 2020), the evaluation of changing ocean climate drivers, risks, and adaptation measures in China's coastal zones and oceans (Cai et al., 2021), and the social, economic, and ecological adaptation strategies for small-scale Hilsa fishers in coastal Bangladesh in response to climate change impacts (Mozumder et al., 2023). Nevertheless, research has yet to be undertaken on small-scale fishers' survival decisions and adaptation methods in response to global climate change, including extreme weather events. This study aims to look into the factors that affect fishermen's decisions about how to stay alive during bad weather by using a logistic regression model and maximum likelihood estimation (MLE). It will also look at how fishermen in coastal areas adapt to bad weather by using SWOT analysis.

Material and Methods

The study was performed in the western coastal region of Makassar City, directly bordering the Sulawesi Strait. We executed a quantitative study strategy from October to December 2023 using a survey approach. We obtained cross-sectional data from primary sources provided by fishing respondents, focusing on the temporal dimension. Methods of data collection include surveys, observations, and interviews. 79 small-scale fishing households were surveyed as research participants in the fisheries industry within the coastal region of Makassar City. This study analysis model evaluates the determinants affecting fishermen's survival choices and adaptive techniques amid extreme weather conditions in coastal regions.

The probability of survival for small-scale fishermen during harsh weather is analyzed using a logistic regression model with the maximum likelihood estimation (MLE) method (Albert & Anderson, 1984; Pampel, 2000) as detailed below:

$$P_i = F(Z_i) = (\beta_0 + \beta_0 X_i) = \frac{1}{1+e^{-Zi}} = \frac{1}{1+e^{-(\beta_0+\beta_1 X_i)}} \tag{1}$$

Where, e (Euler's constant) is the base of the natural logarithm, with a value of 2.718. P_i is the probability (with a value between 0 and 1). Z lies between $-\infty$ and $+\infty$.

The equation above can be manipulated by multiplying $1 + e^{-Zi}$ on both sides, giving the following equation:

$$(1 + e^{-Zi})P_i = 1 \tag{2}$$

From the above equation will result in the following equation:

$$\frac{e^{-Zi}P_i}{(1-P_i)/P_i} \tag{3}$$

The above equation can be converted into the following equation model:

$$Z_i = \left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_i X_i \tag{4}$$

Equation (4) can be used to analyze the factors affecting the survival decisions of small-scale fishers during extreme weather events as follows:

$$\frac{P_i}{1-P_i} = SDExtWhr = \beta_0 + \beta_1 \pi CB + \beta_2 FAge + \beta_3 FFEdu + \beta_4 FExp + \beta_5 QFM \\ + \delta_5 DmBLTp + \delta_6 DmIFA + \mu_1 \tag{5}$$

Where, $\frac{P_i}{1-P_i}$ is the probability of survival decision as a fisherman during extreme weather (1, to survive; and 0, other). β_1 is the intercept. $\beta_9, \ldots, \beta_{13}$ are regression coefficients of independent variables. $\delta_5, \ldots, \delta_6$ are regression coefficients of dummy variables. πCB is fishing income (IDR). $FAge$ is the age of fishermen (years). $FFEdu$ is the fisher's formal education. $FExp$ is experienced as a fisherman. QFM is the number of family members. Bantuan Langsung Tunai Programme, BLT, 1, for BLT programme; 0, for other. Fishing facility assistance, IFA, 1, for fishing gear facility; 0, for others. μ_1 is the error term.

Moreover, the adaptation approach employed by fishermen confronting extreme weather in coastal regions utilizes SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). SWOT analysis is among the most extensively utilized strategic instruments globally (Puyt et al., 2023). This strategy tool, referred to as a strategic planning tool, evaluates the internal factors (Strengths and Weaknesses) and external circumstances (Opportunities and Threats) confronting the company (Cheng et al., 2021) or serves as a strategic technique that facilitates the assessment of both internal and external factors (Longsheng et al., 2021). The execution of the adaptation plan utilizing SWOT analysis occurs in two phases. In the first step, an Internal Factors Analysis Summary (IFAS) with Strengths (S) and Weaknesses (W) is made, along with an External Factors Analysis Summary (EFAS) with Opportunities (O) and Threats (T). Stage 2 involves the execution of the adaptation plan design through the development of a SWOT matrix comprising the Strength-Opportunity (SO), Strength-Threat (ST), Weakness-Opportunity (WO), and Weakness-Threat (WT) categories.

Result and Discussion

A. Survival Decisions of Small-scale Fishermen

This study employed logit model regression analysis to identify the factors affecting the survival decisions of small-scale fishers under harsh weather (Table 1). Goodness of fit for Fisher's survival decision function was shown by a Nagelkerke R^2 of 36.7%. This shows that all independent variables, such as socioeconomic factors (fisher's age, fishing experience, and fishing income), the *Bantuan Langsung Tunai (BLT)* program, and fishing infrastructure assistance programs, have an effect on the changing likelihood of a fisher's survival decision. The Nagelkerke R^2 value obtained through the Maximum Likelihood Estimation (MLE) approach is analogous to the Adjusted R^2 value derived from the Ordinary Least Squares (OLS) method. Hypothesis testing concurrently employs -2 Log Likelihood for the survival decision function of small-scale fishers, yielding a value of 56.36. The results indicated that all independent variables concurrently affected the survival decisions of fishers, unlike the partial impact of independent variables assessed using the Wald test on each fisher's survival decision function.

Relating to the fishermen's survival decision, use the Exp (βi) value or odds ratio to evaluate whether the probability of extended survival under adverse weather conditions increases or decreases. If the Exp (βi) value surpasses 1, the probability of survival as a fisherman rises. The probability decreases if the Exp (βi) value is below 1. In adverse weather conditions, survival probabilities are influenced by fishermen's earnings from catches, their fishing expertise, and assistance from fishing infrastructure support programs, with Exp (βi) values of 1.004, 1.081, and 6.583, respectively. An Exp (βi) score of 6.583, exceeding 1, indicates that the fishing infrastructure aid program is the paramount element influencing the likelihood of long-term survival as a fisherman. Conversely, the formal education of fishermen, the size of their families, and cash transfers do not facilitate the sustainability of small-scale fishermen in coastal regions.

Table 1. Estimation of factors influencing Fishers Survival Decisions under Extreme Weather Conditions

Independent Variable	β_i	Std. Error	Wald-test	Sig.	Exp(β_i)
Fisherman income	0.004	0.003	2.174	0.140	1.004
Fisherman age	-0.142	0.076	3.543	0.060	0.867
Fisherman formal education	-0.115	0.120	0.930	0.335	0.891
Experience at sea	0.077	0.076	1.047	0.306	1.081
Number of family dependents	-0.497	0.182	7.485	0.006	0.608
Dummy of BLT program	-1.213	1.156	1.101	0.294	0.297
Dummy for fishing gear assistance program	1.884	0.950	3.932	0.047	6.583
Intercept					**7.190**
Nagelkerke **R^2**					**0.367**
-2 Log Likehood					**56.361**

Notes: BLT (*Bantuan Langsung Tunai*) Program. If the value of Exp (βi) > 1, then the probability is getting bigger, otherwise if the value of Exp (βi) < 1, then the probability is getting smaller

The research purpose articulates the relationship between study variables as a hypothesis, whereby the economic element of fishermen's income provides small-scale fishermen in coastal regions with decision-making opportunities to sustain their livelihoods. This can be seen from the Exp (βi) value greater than 1, namely 1.004 (Table 1). Although the fishing income per trip obtained during extreme weather is much smaller than the fishing income per trip during the fishing season, the results can provide opportunities for survival. During the fishing season, the IDR is 656 thousand per trip; during extreme weather, it is only 213 thousand per trip (Table 2). The decrease in fishermen's income during extreme weather is due to fishermen fishing near the land or coast with short fishing operations or not usually during the fishing season. However, it is hazardous for their safety. However, to meet the economic needs of their households, fishermen must do so. Fish catches have little economic value, so the fishermen often consume them. In this condition, fishermen often do not get any catches. The number of fishing trips is reduced to 2–3 times per week compared to 5–6 times per week during the fishing season. In addition, there are also some fishermen, when not caught, looking for other jobs, such as becoming construction laborers for the economic needs of their families. There are even fishermen who pawn or sell their wife's gold.

Comprehending fishing income is essential for managing fisheries to enhance efficiency, particularly regarding operational expenses (Purcell et al., 2018). Operational expenses impact the revenue of fishers (Al-Jabri et al., 2013). Operating expenses, encompassing engine gasoline, correlate with the fishing season, amounting to IDR 62,000 each trip and IDR 75,000 per trip during adverse weather conditions (Table 1). This results from the extended fishing period along the shoreline, notwithstanding the diminished economic value of the catch. Fishers typically assume a portion of the operational expenses incurred. These expenses stem from financial support or obligations to merchants. During the fishing season, merchants procure the complete haul. Fishers incur a 10 percent fee upon each sale of their catch as part of the profit-sharing agreement. However, this circumstance alters during inclement weather, when the catch possesses negligible commercial value and is frequently self-consumed. The reliance of small-scale fishers on lenders and marketers for financial assistance has led to debt bondage. Small-scale fishers have lower net profits than fish traders (Jueseah et al., 2020).

Table 2. Socio-Economic Conditions of Small-Scale Fishers during Extreme Weather Events

Socio-economic	Case	Description		
		Revenue (IDR)	Cost (IDR)	Income (IDR)
Catch business income per trip (IDR)	Fishing season	731,726.27	75,462.02	656,264.20
	Extreme weather	276,156.65	62,784.81	213,371.80
			Frequency (People)	Percentage (%)
Fishers age (year)	≥ 20 - 29		14	17.72
	30 - 39		24	30.38
	40 - 49		26	32.91
	50 - 59		15	18.99
	≥ 60		-	-
Fishers education (year)	Did not finish elementary school		21	26.58
	Finished elementary school		37	46.83
	Graduated from junior high school		15	18.99
	High school graduate		6	7.60
Experience at Sea (year)	5 – 10		29	36.70
	11 – 15		14	17.72
	16 – 20		17	21.52
	21 – 25		6	7.60
	26 – 30		11	13.92
	> 30		2	2.54
Number of family dependents (people)	1 – 2		29	36.70
	3 – 4		37	46.84
	5 – 6		12	15.19
	≥ 7		1	1.27

Note: USD 1 (IDR 16,000)

Alongside economic factors, social elements like fishing experience influence fishermen's survival choices during severe weather conditions. The Exp (βi) value exceeds one and exerts a considerable influence (Table 1). The predominant fishing experience among the 79 respondents is 5 to 10 years, represented by 29 fishermen, or 36.70% (Table 2). From a young age, fishermen frequently accompany their parents to the sea during the fishing season, resulting in a swift acquisition of fishing skills. Fishermen can leverage their expertise to endure adverse weather conditions when fishing. Fishermen's maritime experience primarily influences their success in capturing fish at sea (Macusi et al., 2021). This experience can ensure their sustenance as a framework for resource management and poverty reduction (Njock & Westlund, 2010). Moreover, this experience will yield insights into biodiversity and food webs within the fishing ecosystem (Rosa et al., 2014).

Moreover, other government aid programs, including fishing gear and fisheries infrastructure, substantially influence survival decision-making among fishermen during extreme weather, with Exp (βi) above 1 (Table 1). This initiative encompasses eco-friendly fishing equipment, including fishing poles and gill nets. This gear, according to the Code of Conduct for Responsible Fisheries (CCRF), safeguards marine habitats (Kumawat et al., 2015) and fosters sustainable blue economy advancement (Yulisti et al., 2024). Only along the coastal margins do extreme weather occurrences provide high-quality catches. Substantial governmental assistance for sustainable infrastructure initiatives can alleviate poverty and enhance food security within the fisheries industry (McManus et al., 2019). Poverty in small-scale fishing is a prevalent issue, impacting a significant population and presenting a complex challenge that is arduous to describe, elucidate, and resolve (Onyango & Jentoft, 2010). Policy programs in the fisheries industry influence income, a crucial determinant of fishers' behavior in their respective locations (Hadjimichael et al., 2013).

Conversely, the government aid program, represented by BLT money, only sometimes influences the survival decisions of fishermen. Interviews with small-scale fishers revealed the need for increased support to meet the economic demands of their households. The BLT program provides IDR 500,000 in cash monthly for each member of a fishing family. BLT aims to preserve the purchasing power of the fishing community and mitigate the effects of the fuel price increase. Nevertheless, fishers utilized the BLT to meet their domestic consumption requirements. Although insufficient, it was necessary for their survival. The BLT assists individuals categorized as impoverished in meeting their daily necessities, particularly those impacted by severe weather resulting from global climate change.

B. Adaptation Strategies of Small-scale Fishermen

The adaptation strategy of small-scale fishers in coastal regions facing extreme weather employs the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis framework. Table 3 shows the Internal Factor Analysis Summary (IFAS), and Table 4 shows the External Factor Analysis Summary (EFAS). These are small-scale fishers in coastal areas' social, cultural, and economic situations. The SWOT analysis framework may concentrate on social, technological, economic, environmental, and regulatory dimensions (Glass et al., 2015). The coastal fishing communities' social, cultural, and economic conditions are crucial for their adaptability. Social considerations encompass fishermen's age, formal education, fishing experience, and family size. Cultural elements manifest as collaborative ties among fishermen. Economic variables include fishing income. Additionally, the strategy design utilizing the SWOT Matrix (Table 5) constitutes a SWOT analysis of empowering initiatives for small-scale fishermen.

According to the IFAS SWOT analysis, the strength parameter with the highest score, 1.08, is the age of fishermen. This is higher than other parameters like being aware of extreme weather (1.04), having fishing experience (0.75), knowing the best places to fish (0.72), and having strong cooperative relationships among fishermen (0.72) (Table 3). The age of small-scale fishers in the coastal region of Makassar City ranges from 20 to 49 years; 64 fishers, constituting 81.01% of the total 79 small-scale fishers, are of productive age. Age is a source of physical strength for fishermen seeking to venture into the water. Age influences the capacity to adjust to changes, including fishing expertise (Lu et al., 2020). The advancing age of fishermen contributes to a deterioration in their physical capacity to work (Adnan et al., 2021) and adversely impacts their physical health (Samah et al., 2019).

A further aspect of the adaptation method is the expertise of fishermen, which is called Integrated Fisheries Advisory Services (IFAS). With over 15 years of fishing experience, 36 fishermen (45.58%) are a benchmark for assessing adaptability during harsh weather conditions. Fishermen recognize natural indicators such as sea wind, seawater temperature, marine organisms, and ocean currents. The experience of fishermen influences the length of fishing operations, both in the fishing season and during inclement weather. Fishermen in the research area of extreme weather, known as IFAS, have also acknowledged this condition based on the parameters of their adaptation strategy. The severe winds, elevated sea waves, and substantial rains compel them to consider continuing fishing to fulfill their household's economic requirements. Fishermen perceive that recent climate changes have adversely impacted their safety.

Fishermen in coastal Malaysia (Shaffril et al., 2017), coastal Southeast Bangladesh (Alam & Mallick, 2022), and coastal Togo in West Africa (N'Souvi et al., 2024) also exhibit this syndrome.

Another IFAS involves identifying optimal fishing locations for fishermen near land or coastal regions, facilitating brief fishing operations. The shallow sea serves as the fisher's fishing field during severe weather events affecting the coastal region. Small-scale fishermen need access to current meteorological data, thus depending exclusively on their fishing experience to forecast and identify fishing locations (Muskananfola et al., 2021). The socio-cultural dimensions of the community form the foundation of the robust cooperation partnership between fishermen and IFAS. If fishermen fail to secure catches during severe weather, their peers assist by supplying some of the obtained fish for sustenance. The cultural aspect of familial relationships is crucial during the fishing season and adverse weather conditions.

Table 3. IFAS Assessment of Small Fishermen's Adaptation Strategies in Extreme Weather Conditions

Internal Factors	Parameter	Indicator	Weight	Ratings	Score
Strengths	Age of fishermen	81.01% are of working age (under 50 years old)	0.27	4	1.08
	Experience at sea	Experience at sea > 15 years (45.58%)	0.25	3	0.75
	Fishermen's cognizance of severe meteorological conditions	Intense winds, elevated tides, and augmented precipitation	0.26	4	1.04
	Understanding of the optimal fishing site	Fish near land or coastal areas	0.24	3	0.72
	Strong cooperative relationship between fishermen	If some fishermen fail to catch fish, other fishermen assist by supplying fish for consumption needs	0.24	3	0.72
Total Strengths					**4.31**
Weaknesses	Fishermen's education is still low	As many as 73.41% of fishermen do not finish primary school and finish primary school	0.25	2	0.5
	Catches are unpredictable and inadequate	Fishing occurs at the coastline adjacent to the shore and distant from the designated fishing grounds	0.26	1	0.25
	Fishing Technology	The fishing equipment employed is inappropriate for shallow waters next to mangrove ecosystems	0.27	1	0.27
	Minimal trip frequency and duration at sea	Infrequent fishing activities because to heavy winds	0.27	2	0.54
Total Weaknesses					**1.56**
Total Overall Score (Strengths + Weaknesses)					5.87

Additionally, Table 3, which pertains to the IFAS evaluation of the SWOT analysis, reveals that the frequency of trips and minimal fishing time (0.54) have the lowest scores compared to other criteria. Fishing activities across multiple excursions comprise fishing time (Muallil et al 2013)—the infrequent occurrence of fishing expeditions and the duration spent at sea. Intense gusts and elevated sea swells instill fear in numerous fishermen regarding venturing into the ocean. Fishermen operate near the coast, leading to diminished fish yields. Severe weather conditions lead to substantial global economic losses in the fishing sector. Moreover, elevated precipitation diminishes fishermen's inclination to venture out to sea. Rain will infiltrate the boat and accumulate water, resulting in its submersion, particularly the smaller vessels. Severe weather can impede maritime fishing activities (Predragovic et al 2023).

The educational attainment of small-scale fishers, reflected by a score of 0.5, signifies the caliber of human resources. The formal education of fishermen needs enhancement, as 73.41% still need to complete primary schooling. The poor economic circumstances and the fishing community's perception of education hinder fishermen from affording adequate education for their children. Despite their limited educational attainment, fishermen depend on their fishing experience as a significant asset. In severe weather conditions, education serves as a decision-making instrument for fishermen regarding fishing activities (Olale & Henson, 2012).

Apart from the fishermen's education level, fishing techniques are also a weak aspect of IFAS. The fishing technique, rated at 0.27, is inappropriate for shallow seas adjacent to mangrove forests during severe weather conditions. Harsh weather conditions lead to inconsistent and inadequate fish catches, resulting in a score of 0.25. Interview results with fishermen indicate that the research region comprises three distinct seasons: the west, east, and fishing seasons. The winter season often transpires from November to February and is marked by intense winds, precipitation, and elevated sea swells. In the western season, sea waves may exceed 2 meters, accompanied by wind gusts of 30 to 40 knots per hour. The East Season transpires from March to June, marked by vigorous winds and substantial precipitation but calm seas. In the East Season, the wind velocity is 5 knots per hour. The fishing season spans from March to June, marked by low wind velocities, moderate precipitation, and mild oceanic swells. Global climate change, including extreme weather events, has adversely affected catch productivity and the revenue of fishers. This phenomenon is occurring globally, including in the marine seas of Ghana (Mabe & Asase, 2020).

Table 4. EFAS Assessment of Small Fishermen's Adaptation Strategies in Extreme Weather Conditions

External factors	Parameter	Indicator	Weight	Ratings	Score
Opportunities	Intense demand for marine fish	Demand from consumers and fish processing facilities both within and beyond Makassar City	0.25	3	0.75
	BLT program initiated by the Central Government via the Social Service	BLT can go up to IDR 600,000 per month per household	0.26	3	0.78
	Support for fishing equipment from the Regional Government via the Marine and Fisheries Office	Environmentally sustainable fishing apparatus based on CCRF, such as EFFGs	0.26	3	0.78
	Insurance provided by the Regional Government via the Social Service	A total of 10,000 fisherman will receive insurance	0.27	3	0.81
Total Opportunities					3.12
Threat	Extreme weather conditions	Strong winds, high sea waves, and tidal flooding	0.30	2	0.60
	Alterations in the relocation of fishing locations	Fishermen operate in secure locations to safeguard against severe weather conditions	0.28	2	0.56
	Distance to fishing location	Small-scale fishing vessels of 10 GT are incapable of withstanding severe weather conditions	0.26	1	0.26
Total Threat					1.42
Total Overall Score (Opportunities + Threats)					**4.54**

The EFAS evaluation of the SWOT analysis indicates that insurance has the highest score of 0.81, surpassing other characteristics such as the high demand for fresh sea fish (0.75), BLT (0.78), and fishing gear infrastructure support (0.78). The opportunity parameter with the highest score, 0.81, is insurance, surpassing other characteristics such as the high demand for fresh sea fish (0.75), BLT (0.78), and fishing gear infrastructure support (0.78). The opportunity parameter is the significant demand for fresh marine fish (0.75) at all times. The demand originates from the public, as customers, and fish processing factories inside and outside Makassar City. The expansion of the global population, rising purchasing power in developing nations, and shifts in dietary preferences have resulted in heightened demand for food (protein) from fish stocks (Masi et al., 2022). Fish contains more protein than other animal products (Fathoni et al., 2019). In bad weather, small-scale fishermen's catch loses its commercial value, leading them to eat the fish themselves.

The national government provides a BLT through the social service, amounting to IDR 500,000 per month for each fishing household. The fisherman's family collects BLT at the Makassar City Post Office. Fishermen's interviews revealed that they used BLT to purchase essential cooking items. Although it is insufficient, it must suffice. Particularly under severe weather circumstances, fishermen take more pauses than they engage in fishing. We remunerated BLT from the outset to mitigate the effects of escalating fuel prices and to preserve the spending power of fishermen. It can provide an alternative for sustenance while fishermen are not at sea.

In addition to the national government, local governments also contribute. The local government provides fishing infrastructure support via the Marine and Fisheries Service (0.78) by supplying fishing gear appropriate for shallow marine waters. Fishing rods and gill nets are environmentally sustainable fishing equipment that do not threaten the ecosystem or deplete fish populations. Yulisti et al. (2024) have extensively recommended eco-friendly fishing gears (EFFGs) as tools for the sustainable development of the blue economy. The regional government will provide insurance through the Social Service (0.81) to 10,000 fishermen. This insurance is available for individuals who encounter maritime mishaps resulting from severe weather conditions. Fishermen, nonetheless, capture fish in shallow waters or adjacent to the coastline. People conduct fishing operations to meet their household's economic needs. The local government additionally promotes aquaculture as an alternative to traditional fishing for fishermen. Additionally, the government encourages fish processing to guarantee the transformation of fish into value-added products during extreme weather events.

Additionally, the EFAS evaluation of the SWOT analysis was conducted. The threat parameter of natural conditions received the highest score of 0.6, surpassing other characteristics such as changes and moves of fishing locations at 0.56 and distance to fishing grounds at 0.26, with natural conditions also scoring 0.56 as a danger from EFAS. Severe weather in the study area results in intense winds, elevated sea waves, and tidal inundations. This jeopardizes the survival of fishermen, as their primary source of income derives from their catches. The global climate poses a significant danger to the capture fisheries subsector (Mcowen et al., 2015). Tidal inundations have also affected the research area due to rising sea levels. The IPCC study indicates that global sea levels increase by 3.2 mm yearly during extreme weather events (Shaffril et al., 2017).

Extreme weather events alter the displacement of fishing areas (0.56) for fishermen. Fishermen operate in secure locations to protect themselves from severe weather conditions, including strong winds and substantial sea swells. Fishing vessels with a gross tonnage of merely 10 GT cannot withstand severe weather conditions. The distance to the fishing ground (0.26) is proximate to the fishermen's residences or adjacent to the coastal region. The typical fishing duration is about 3 to 5 hours per excursion, compared to 7 to 10 hours during the fishing season. The frequency of fishing excursions is closely associated with fishing activities or the duration of fishing (Muallil et al., 2013). Operating expenses, particularly gasoline expenditures, significantly impact the extent of fishing areas, thereby influencing fishermen's earnings.

The IFAS calculation findings (Table 3) indicate an X-axis value of 2.75, derived from a total strength of 4.31 subtracted by a total weakness of 1.56. In Table 4 (EFAS), the Y-axis value is 1.7, derived from total opportunities of 3.12 minus total Threats of 1.42. We can formulate fishermen's adaptation techniques for confronting extreme weather in coastal regions (Figure 1) by leveraging Strengths (S) and Opportunities (O), which hold greater significance. Compared to the minimal value, specifically Threats (T), which externally obstructs the current weakness (W). The adaptation plan for small-scale capture fishermen uses strategy development based on the outcomes of the IFAS and EFAS assessments. The development of an efficient alternative adaptation approach employed is the SWOT Matrix (Table 5). The alternative to be developed is. We can initially achieve adaptation and mitigation in response to extreme weather by reducing its repercussions, including economic and environmental adjustments. They were ranked second in terms of optimizing various governmental aid programs. Third, the dynamics of patron-client relationships and interactions require enhancement.

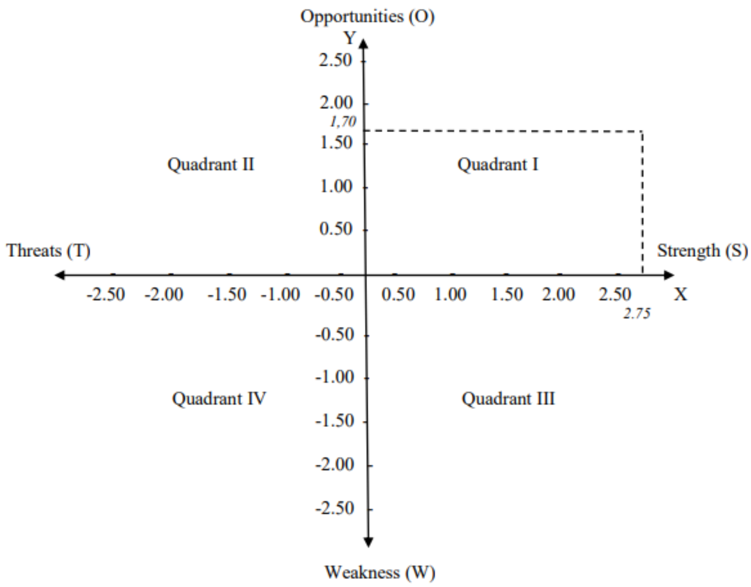

Fig 1. *Grand Strategy* Matrix

Table 5. SWOT Matrix of Adaptation Strategies of Small-Scale Capture Fishermen during Extreme Weather Conditions

Internal Factor / External Factor	**Strength (S)** 1. Fisherman's age 2. Experience at sea 3. Fishermen's cognizance of severe meteorological conditions 4. Understanding of the optimal fishing site 5. Strong cooperative relationships between fishermen	**Weakness (W)** 1. Fishermen's education is low 2. Catches are unpredictable and inadequate 3. Fishing Technology 4. Minimal trip frequency and duration at sea
Opportunities (O) 1. Intense demand for marine fish 2. BLT program initiated by the Central Government via the Social Service 3. Support for fishing equipment from the Regional Government via the Marine and Fisheries Office 4. Insurance provided by the Regional Government via the Social Service	**Strategy (SO)** 1. Adaptation and mitigation in the face of extreme weather (SO1) 2. Optimise various government assistance programs (SO2) 3. Improving patron-client relationships and interactions (SO3)	**Strategy (WO)** 1. Utilise capture technology 2. Utilise various government assistance programmes 3. Utilising trip frequency to increase catches
Threats (T) 1. Extreme weather conditions 2. Changes in fishing location displacement 3. Distance to fishing location	**Strategy (ST)** 1. Alternative jobs for fishermen when not at sea 2. Change the fishing ground area 3. Provide information on the impact of extreme weather	**Strategy (WT)** 1. Provide education on the impact of extreme weather 2. Provide education on the impact of environmentally friendly fishing gear

Adaptation and mitigation strategies of small-scale fishers in the face of extreme weather. (SO1). Small-scale fishers employ strategies for adaptation and mitigation in response to adverse weather conditions. Adaptation refers to modifying oneself to the environment to enhance resilience against environmental alterations, including extreme weather resulting from global climate change. Implementing adaptation strategies in the fisheries sector can mitigate the adverse effects of extreme weather resulting from climate change (N'Souvi et al., 2024). Adaptation includes measures to diminish susceptibility and enhance resilience, facilitating mitigation efforts to lower disaster risk. Mitigating damages, including economic and environmental adaptations, allows small-scale fishers in the research region to implement adaptation techniques during extreme weather. Revenue diversion measures and the diversification of alternative livelihoods achieve economic adaptation. Coastal small-scale fishermen can engage in aquaculture as an alternate source of livelihood in addition to their maritime activities. Moreover, during adverse weather conditions, they can employ fish processing to transform fish into value-added goods.

Moreover, the adaptation of the ecosystem through mangrove forests safeguards coastal regions. Mangrove forests are an important place for blue carbon to stay in coastal ecosystems (Malik et al., 2023), and they provide homes for fish and shrimp that live in brackish water and are very important to the way people make a living (Trialfhianty et al., 2022). Moreover, it is a feasible supplementary income source for fishing and aquaculture (Malik et al., 2024). Intense winds and elevated oceanic waves can lead to abrasion or erosion. Abrasion can harm mangrove ecosystems and jeopardize the existence of coastal populations. Abrasion is the process of coastal erosion due to the destructive force of ocean waves and currents. The disruption of the natural equilibrium in coastal regions causes shoreline erosion due to abrasion. Coastal damage can jeopardize the nation's sovereignty.

The effects of harsh weather may yield varying degrees of adaptability among fishermen and across different regions (N'Souvi et al., 2024). Fishermen in other regions, including Malaysia, also implement similar adaptation strategies, such as reducing fishing activities, enhancing social networks, engaging in climate change adaptation planning, and improving access to credit (Shaffril et al., 2017). Fishers in Ghana's Volta Basin employ adaptation techniques such as extending fishing hours, intensifying fishing efforts, cultivating aquaculture, relocating to different fishing areas, engaging in alternative non-fishing livelihoods, and implementing a fishing moratorium (Mabe & Asase, 2020). Bangladesh's fishermen employ adaptation measures such as building tube wells for potable water, elevating home foundations to mitigate flooding, and utilizing solar panels or biogas for electricity (Alam & Mallick, 2022). Fishers in India employ adaptation techniques such as migrating and offering work to the local community (Roy et al., 2024).

Adaptation strategies optimize various government assistance programs. (SO2). Government aid initiatives encompass the BLT Programme, fishing gear infrastructure, and insurance for fishermen. The BLT program is an initiative by the Indonesian central government, administered by the Ministry of Social Affairs, targeting mostly low-income families or households as recipients of financial assistance. Fishing households are categorized as impoverished, mainly small-scale fishers. The BLT program provides IDR 500,000 in cash monthly for each member of a fisher family. BLT seeks to enhance the purchasing power of the fishing community and mitigate the effects of the fuel price increase. BLT can be enhanced by utilizing fishing households to meet their daily requirements, particularly for those impacted by severe weather resulting from global climate change.

Additional government support programs include eco-friendly fishing equipment such as poles and gill nets. These fishing apparatuses can be enhanced to facilitate the augmented application of technology. Nonetheless, it fails to yield excellent fish catches as it only captures them on the periphery of the land under severe weather conditions. Nonetheless, it can safeguard marine ecosystems, including coral reefs and juvenile fish populations that have the potential to mature into adults. Eco-friendly fishing gear (EFFGs) can facilitate the sustainable advancement of the blue economy (Yulisti et al., 2024). These mechanisms safeguard marine ecosystems and cannot harm the environment, including coral reefs in deep and shallow waters. This eco-friendly fishing gear is founded on the Code of Conduct for

Responsible Fisheries (CCRF). The CCRF was created in 1995 by over 180 member countries of the Food and Agriculture Organisation (FAO) (Kumawat et al., 2015). This code serves as an international policy tool for the sustainability of marine fish resources, founded on guiding principles and rules. Robust assistance from the government and FAO member nations for sustainable infrastructure initiatives would alleviate poverty and enhance the economic earnings of coastal small-scale fishing communities. The issue of poverty within the small-scale fisheries sector is intricate and formidable.

Another government support initiative is fishermen's insurance for risk mitigation. Fisheries insurance is a fundamental fisheries management instrument essential for loss compensation, risk mitigation, minimizing the adverse effects of natural disasters, and alleviating poverty within the fisheries sector (Zheng et al., 2020). Fishermen's insurance is a safeguard that can be offered to secure their survival under severe weather conditions. Mitigation can reduce the likelihood of disasters, including accidents in fishing and those caused by storms and ocean waves. The government has provided insurance for 1,000 fishermen in several cities and regencies of South Sulawesi Province impacted by severe weather, mainly targeting small-scale fishermen with vessels under 10 GT capacity.

Adaptation strategies to improve patterns of patron-client relationships and interactions. (SO3). Socioeconomic and cultural tactics employ patron-client dynamics between fishermen and intermediaries (capital proprietors). Researchers have developed a patron-client cooperative connection among fishermen. The cultural aspect of familial relationships is crucial during the fishing season and in adverse weather conditions. In adverse weather conditions, it is common for fishermen to share a portion of their catch with those who are unable to catch fish for their household sustenance.

The dynamics of patron-client relationships and interactions between fishermen and intermediaries are distinct. Despite intermediaries possessing a superior bargaining position compared to fishermen, the latter can nonetheless sustain their family economy, particularly during adverse weather circumstances. Intermediaries frequently provide emergency loans to fishermen in need. Moreover, intermediaries influence the price of fish. Intermediaries acquire all economically valuable fish captures. Small-scale fisheries exhibit patron-client systems with diverse cooperative ties in Southeast Asia, East Africa, Brazil, Mexico, and India (Miñarro et al., 2016).

The patron-client system in small-scale fishing is essential for exploiting marine resources. It can also establish a value chain in island-based fisheries systems (Roberts et al., 2022). Patron-client connections can link small-scale fishers with local, national, and worldwide buyers. Although patronized fishers earn better profits than independent fishers, their debt escalates when they factor in supplementary expenses. Financial aid in this manner remains crucial for the capture fisheries' output, yet it may impede socioeconomic equity and sustainable fishing practices.

Conclusion

In extreme weather conditions resulting from climate change, fishermen cannot catch fish due to intense winds and elevated sea waves. Nevertheless, fishermen engage in coastal and beach fishing to meet their family's economic needs. Surviving adverse weather conditions is necessary for fishermen who lack alternative employment opportunities. Their survival is significantly contingent upon the catch and the resultant earnings. Fishing revenue, fishing expertise, and government support programs, including eco-friendly fishing equipment, influence the survival choices of small-scale fishers during extreme weather events.

Severe weather conditions in coastal regions provide limited opportunity for small-scale fishers to make decisions regarding fishing in marine waters. Small-scale fishers must use adaptation techniques to confront obstacles and capitalize on opportunities presented by the detrimental impacts of environmental change in coastal regions. Fishermen can implement adaptation techniques to mitigate the effects of extreme weather by limiting economic and environmental damages, maximizing government aid programs, and enhancing patron-client relationships and interaction patterns. Policymakers can influence fishermen's conduct to design adaptation techniques that assist them in coping with extreme weather resulting from global climate change. Small-scale fishers in their respective coastal regions can customize adaptation strategies to suit their needs, capabilities, and interests.

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