

Navigating Climate Uncertainty: Local Cultural Strategies for Building Resilience among Nias Fishermen

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Abstract— Climate change increases the vulnerability of fishing communities through weather uncertainty, changes in fishing seasons, declining catch yields, and household income instability. This study aims to formulate strategies to enhance the resilience of fishermen on Nias Island based on local culture in the face of climate change. The study employed a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis based on internal and external factors affecting fishermen's adaptive capacity. The analysis results show an IFAS score of 2.314 and an EFAS score of 2.120, with the strategy positioned in Quadrant I (aggressive). The primary strengths of Nias fishermen stem from their cultural values and seafaring traditions, as well as their local knowledge in understanding ocean conditions and seasons. Conversely, the main weaknesses lie in the low level of processing and value addition of fishery products, as well as the weak economic capacity of fishing households. The greatest opportunities stem from the potential of fishery resources and support from capacity-building programs, while the main threats include weather uncertainty, declining catch yields, and fluctuations in the prices of fishery products. The resulting strategies focus on strengthening adaptation based on local culture, increasing the value added of fishery products, strengthening institutions, and community-based management of coastal resources. These findings indicate that local culture and traditional ecological knowledge are key assets in enhancing the resilience of Nias fishermen to climate change.

Keywords— climate adaptation, coastal communities, cultural capital, fisheries governance, SWOT analysis, traditional ecological knowledge

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I. INTRODUCTION

Climate change has become one of the global challenges that significantly impacts the sustainability of the capture fisheries sector, particularly for coastal communities that are highly dependent on marine resources. A report by the Intergovernmental Panel on Climate Change (IPCC) confirms that rising sea surface temperatures, changes in rainfall patterns, increased frequency of extreme weather events, and rising sea levels have altered the productivity of coastal and marine ecosystems in various regions around the world [1]. The Food and Agriculture Organization (FAO) also reports that more than 600 million people worldwide depend on the fisheries and aquaculture sectors for their livelihoods,

while small-scale fishers are the group most vulnerable to climate-related disruptions due to limited capital, technology, access to information, and social protection [2]. In Indonesia, the fisheries sector is a key pillar of the national economy, with marine capture fisheries production reaching approximately 7.8 million metric tons in 2023; however, this productivity is increasingly under pressure due to climate variability, which causes uncertainty in fishing seasons, shifts in fish stock distribution, and heightened risks to maritime safety [3]. These conditions indicate that enhancing the adaptive capacity and resilience of fishing communities is a strategic priority for sustainable fisheries development.

As one of Indonesia's outermost archipelagic regions, Nias Island has geographical characteristics that make its communities heavily dependent on the capture fisheries sector as their primary source of livelihood. The majority of fishermen in this region are still small-scale fishermen who use simple vessels with limited range, making them highly vulnerable to changes in oceanographic and weather conditions. Indonesian statistical data show that the majority of capture fisheries operations in the archipelago are still dominated by vessels under 5 GT, reflecting both low production capacity and high vulnerability to climate change [4]. In recent years, fishermen on Nias Island have faced increasingly unpredictable fishing seasons, more frequent and intense high waves, declining catches during certain seasons, and rising operational costs due to longer fishing distances. These conditions have led to a decline in fishing households' incomes, increased economic uncertainty, and limited ability to invest or diversify their livelihoods. On the other hand, the people of Nias still possess various forms of local culture, such as traditional

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knowledge regarding seasons, wind directions, ocean currents, and natural signs, as well as practices of mutual cooperation in the management of coastal resources—all of which have the potential to serve as important social capital in building resilience to climate change.

Various previous studies have shown that the resilience of coastal communities is influenced by a combination of livelihood capital, adaptive capacity, institutional capacity, and social capital. A study published in the journal *Ecosystems* found that fishermen's adaptive capacity is influenced not only by economic factors but also by local social and institutional capacities [5]. Another study also explains that coastal communities with strong social networks and effective local institutions tend to exhibit higher levels of resilience to climate-related disturbances [6]. In Indonesia, studies on the vulnerability and resilience of fishermen generally employ the Sustainable Livelihood Framework, the Livelihood Vulnerability Index (LVI), or adaptation capacity analysis to identify factors affecting the resilience of fishing households [7][8][9][10][11][12]. However, most of these studies focus primarily on economic aspects, livelihood assets, or formal institutions, while the dimension of local culture as an adaptive resource has received relatively little attention. In fact, various recent studies indicate that local ecological knowledge can enhance the effectiveness of community adaptation to climate change through the utilization of intergenerational experience, observation of natural phenomena, and the strengthening of social cohesion [13].

The limitations of previous research lie in the failure to integrate local cultural dimensions into a comprehensive model for developing strategies to enhance fishermen's resilience. Most studies still treat local culture as a supporting variable or a qualitative description, rather than as a strategic component whose contribution to enhancing the adaptive capacity of fishing communities can be measured. Furthermore, research on fishermen's resilience on Nias Island remains very limited, even though this region possesses distinct geographical, social, and cultural characteristics compared to other coastal areas in Indonesia. Therefore, this study offers a novel approach by developing a strategy to enhance fishermen's resilience that integrates local cultural capital with natural capital, human capital, physical capital, financial capital, social capital, and institutional capital using a quantitative approach. The research findings are expected to yield strategic recommendations that are more contextually appropriate to the characteristics of the Nias community and to enrich the development of culture-based resilience theory in coastal communities, a topic that has so far received relatively little attention in the Indonesian context.

Based on the above discussion, research on strategies to enhance the resilience of Nias fishermen based on local culture in the face of climate change is of critical importance. Climate change is projected to continue increasing risks to the sustainability of coastal communities' livelihoods; therefore, adaptation strategies are needed that not only rely on technical and economic approaches but also harness the strength of

local culture as a resource for community adaptation. This research is expected to make a scientific contribution to the development of a concept of resilience based on local culture, enrich the literature on climate change adaptation among coastal communities, and generate policy recommendations that can serve as a basis for local governments and stakeholders in formulating adaptive, inclusive, and sustainable fisheries development programs on Nias Island and other archipelagic regions in Indonesia.

II. METHOD

A. Time and Location of the Study

This study was conducted in May 2026 in coastal villages located in Nias Regency, North Sumatra Province. The study sites included Somi Village and Somi Botogo'o Village in Gido Subdistrict, Bozihona Village and Laira Village in Idanogawo Subdistrict, and Botohaenga Village and Tagaule Village in Bawolato Subdistrict. These villages were selected through purposive sampling, considering that the majority of their residents work as fishermen and are coastal communities whose livelihoods are under threat due to climate variability. Additionally, these villages were recommended as research sites by the Nias Regency Office of Food Security, Agriculture, and Fisheries.

B. Data Collection

This study employed a survey method with a descriptive approach to formulate strategies for enhancing the resilience of fishermen on Nias Island in the face of climate change. Primary data were collected through structured interviews using a questionnaire administered to fishing households. The sample was selected using accidental sampling. The sample size for this study was 200 fishing households.

In this study, the research instruments were developed based on the Fisheries Livelihoods Resilience Check (FLIRES Check) and adapted to the socio-ecological characteristics of the Nias fishing community [14]. The factors analyzed included natural, human, physical, financial, social, institutional, and cultural capital, which were subsequently used as the basis for identifying internal and external strategic factors.

Secondary data were obtained from scientific publications, government agency reports, fisheries statistics, and various documents related to climate change, fisheries development, and coastal communities. All collected data were then tabulated and analyzed using Microsoft Excel.

C. Data Analysis

The data in this study were analyzed using the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. This method is widely used in strategic planning because it can identify and evaluate both internal and external factors that influence the achievement of a system's objectives [15][16]. In the context of rural communities, SWOT analysis can be used to determine strategies for ensuring the resilience of sustainable livelihoods in the face of climate change [17]. Internal factors consist of strengths and

weaknesses, while external factors consist of opportunities and threats.

The first stage of the analysis involves identifying all internal and external factors derived from survey results and literature reviews. These factors are then organized into the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) matrices. Each strategic factor is weighted based on its level of importance with a value between 0.00 and 1.00, where the total weight in each matrix is 1.00. Next, each factor is rated to describe its actual condition in relation to fishermen's resilience.

$$S_i = B_i \times R_i \quad (1)$$

Where S_i is the score for the i factor, B_i is the weight of the i factor, R_i is the rating for the i factor.

The IFAS and EFAS scores are obtained by summing all weighted scores in each matrix. These scores are used to determine the strategic position of fishermen's resilience on the SWOT matrix [18][19].

The strategic position is determined by calculating the coordinates on the X-axis and Y-axis. The X-axis value represents the difference between the total scores for strengths and weaknesses, while the Y-axis value represents the difference between the total scores for opportunities and threats. The calculations are performed using the following equations:

$$X = \sum S - \sum W \quad (2)$$

$$Y = \sum O - \sum T \quad (3)$$

Where $\sum S$ is the total strength score, $\sum W$ is the total weakness score, $\sum O$ is the total opportunity score, and $\sum T$ is the total threat score.

The coordinate values (X, Y) are then plotted on the SWOT matrix to determine the position of the strategy for developing fishermen's resilience. This position serves as the basis for formulating alternative strategies: SO (Strength–Opportunity), WO (Weakness–Opportunity), ST (Strength–Threat), and WT (Weakness–Threat). The resulting strategies are then used to formulate recommendations for enhancing fishermen's resilience—based on local culture—in the face of climate change.

III. RESULTS AND DISCUSSION

A. Characteristics of Internal and External Factors Affecting Fishermen's Resilience

Internal and external factors were identified to determine the strategic conditions that influence fishermen's resilience in the face of climate change. Internal factors consist of strengths and weaknesses stemming from the characteristics of fishing communities, while external factors include opportunities and threats arising from the social, economic, institutional, and ecological environments. The results of this identification were then analyzed using the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) matrices to determine the degree of influence each factor has on fishermen's resilience.

Based on the analysis results in Table 1, the total IFAS score was 2.314 and the total EFAS score was 2.120. These values indicate that the resilience of Nias fishermen is supported more by internal factors than by external ones. This suggests that the fishing community still possesses relatively strong internal resources to cope with various pressures resulting from climate change, although support and challenges from external factors continue to influence the sustainability of their livelihoods. These results show that fishermen's adaptive capacity is influenced not only by environmental conditions but also by the social, cultural, economic, and institutional assets possessed by the community [20][21][22]. Similar findings have also been reported in previous studies, which indicate that the internal strengths of coastal communities play a crucial role in enhancing their ability to adapt to environmental changes through the utilization of social and local institutional capital [23][24].

In terms of internal factors, the main strengths stem from cultural values and seafaring traditions, as well as local knowledge of ocean conditions and seasons, each of which has a weight of 0.393. The high weights of these two factors indicate that local culture and traditional ecological knowledge still play a vital role in the lives of the Nias fishing community. Knowledge passed down through generations regarding wind direction, fishing seasons, sea conditions, and signs of weather changes serves as adaptive capital that helps fishermen make decisions during their fishing activities. Traditional fishermen generally face economic constraints that limit their access to modern navigation technology; consequently, when setting out to sea, they tend to rely on local knowledge to observe and interpret various natural phenomena as the basis for determining the timing and direction of their fishing trips [25]. One study explains that traditional ecological knowledge is an accumulation of knowledge, practices, and beliefs that has developed through communities' interactions with their environment over several generations [26][27]. Local knowledge, social learning, and social capital are important components in enhancing the adaptive capacity of coastal communities to climate change [28][29][30]. In addition, another study explains that fishermen in Indonesia have developed various adaptation strategies based on experience, social networks, and local knowledge in response to ecological changes [31].

On the other hand, the main weaknesses of Nias fishermen lie in the low level of processing and value addition of fishery products (weight 0.355) as well as the weak economic capacity of fishing households (weight 0.318). These conditions indicate that most fishermen still rely on "on-fishing" activities—that is, catching and selling their catch fresh (Figure 1)—making them vulnerable to price fluctuations and changes in production. In fact, processing the catch not only increases value added but also extends the shelf life of fishery products [32]. This finding aligns with the characteristics of the livelihood structure of fishermen along the western coast of North Sumatra, which remains dominated by on-fishing activities, while off-fishing

activities—such as the processing and marketing of fishery products—as well as non-fishing activities outside the fisheries sector remain relatively limited [33]. As a result, the diversification of income sources for fishing households has not developed optimally, so dependence on catch remains high. This low level of income diversification is one of the factors that increases

the vulnerability of fishing households to various economic and environmental shocks [34][35]. In the context of climate change, this situation further amplifies the risks faced by small-scale fishermen, as they generally have limited economic assets, restricted access to capital, and relatively low adaptive capacity [36].

TABLE 1.
KEY FACTORS INFLUENCING THE RESILIENCE OF NIAS FISHERMEN BASED ON A SWOT ANALYSIS

Component	Dominant Factor	Weight
Strengths	- Cultural values	0,393
	- Local knowledge of ocean conditions and seasons	0,393
Weaknesses	- Processing and value addition of fishery products remain low	0,355
	- The economic capacity of fishing households remains weak	0,318
Opportunities	- The potential of available fishery resources and coastal ecosystems	0,374
	- Support for programs to build fishermen's capacity	0,374
Threats	- Unpredictable weather and fishing seasons	0,270
	- Declining fish catches	0,270
	- Fluctuations in the prices of fishery products	0,270
IFAS Score		2,314
EFAS Score		2,120

In terms of external factors, the greatest opportunities stem from the potential of available fishery resources and coastal ecosystems, as well as support for programs to strengthen fishermen's capacity, each with a weight of 0.374. The availability of these resources provides opportunities for the development of more productive and sustainable fisheries enterprises when supported by adaptive and participatory management. According to the Food and Agriculture Organization (FAO), community capacity building, ecosystem-based fisheries management, and increasing the value added of products are key components in achieving sustainable fisheries transformation [37]. Opportunities to enhance adaptive capacity will be more effective if accompanied by improved access to information, institutional support, and policy support [38].

However, fishermen also face various threats in the form of weather uncertainty, declining catch yields, and fluctuations in the prices of fishery products, each of which has a weight of 0.270. These three factors pose

major challenges for small-scale fishing communities because they directly affect the stability of production, income, and the sustainability of fishermen's household livelihoods. These threats are intensifying due to climate change and global market dynamics, which amplify uncertainty in fishing activities [39]. A report by the Intergovernmental Panel on Climate Change (IPCC) indicates that an increase in the frequency of extreme weather events, changes in seasonal patterns, and rising sea temperatures have reduced fisheries productivity while simultaneously increasing socioeconomic risks for coastal communities [40]. In response to these conditions, fishermen have adopted various adaptation strategies, such as shifting fishing grounds, adjusting the timing of fishing trips, and diversifying their livelihoods to maintain household income [41]. The diversity of adaptation strategies employed reflects the adaptive capacity of fishing households; the more strategies they are able to implement, the higher their level of resilience in facing the pressures caused by climate change [42].



Figure 1. Small-scale traders wait for fishermen to dock so they can buy their catch directly in Laira Village, Idanogawo Subdistrict, Nias Regency.

Overall, the results of the IFAS and EFAS analyses indicate that Nias fishermen possess fairly strong internal

capital, particularly that derived from local culture and traditional ecological knowledge. However, various

economic constraints and evolving external threats suggest that enhancing resilience cannot rely solely on the community's internal strengths. Strengthening economic capacity, diversifying livelihoods, increasing the value added of fishery products, and providing institutional support and adaptation policies need to be integrated with the social and cultural capital that the community already possesses. These findings are consistent with the concept of social-ecological resilience, which emphasizes that the resilience of coastal communities is built through the interaction between internal capacity, institutional support, and the ability to respond adaptively to environmental changes [43].

B. Cultural Capital as the Primary Source of Fishermen's Resilience

The results of the SWOT analysis show that the internal factors with the highest weights stem from cultural values and seafaring traditions, as well as local knowledge of ocean conditions and seasons, each of which has a weight of 0.393 (Table 1). These findings indicate that local culture is a strategic asset that significantly contributes to the resilience of Nias fishermen in the face of climate change. The Nias fishing community has a close relationship with the marine environment that has been forged through a long-term process of adaptation. Seafaring experiences passed down from generation to generation have shaped local knowledge regarding seasonal patterns, wind directions, wave conditions, fishing locations, and various natural indicators used as a basis for determining the timing and location of fishing [44][45]. This knowledge not only serves as an operational guideline for fishing activities but also acts as a mechanism for adapting to dynamic environmental changes.

The existence of local knowledge as part of coastal communities' culture has been widely recognized as a form of traditional ecological knowledge (TEK) that plays a vital role in supporting the sustainable management of natural resources [46][47]. Previous studies explain that traditional ecological knowledge is an accumulation of experiences, practices, and cultural values that have evolved through communities' interactions with the environment over several generations [48]. This knowledge enables communities to understand environmental changes in a more contextual manner and supports decision-making processes in the face of various uncertainties.

In the context of climate change, communities' ability to utilize local knowledge can enhance their adaptive capacity to changing environmental conditions. Other studies indicate that the adaptive capacity of coastal communities is determined not only by the availability of economic resources but also by their ability to learn, share knowledge, and draw on local experience to cope with environmental changes [49]. This is evident among the fishing communities of Nias, who continue to maintain traditional practices of interpreting ocean conditions and seasonal patterns as part of their daily adaptation strategies.

In addition to local knowledge, the presence of cultural values and seafaring traditions also reflects the strong social bonds within fishing communities. Values of solidarity, mutual aid, and information-sharing among fishermen contribute to the formation of social capital that can enhance the community's ability to respond to various social, economic, and environmental pressures. Strong social capital facilitates faster exchange of information and experiences, enabling communities to be better prepared to face changes in sea conditions and weather.

These findings indicate that local culture serves not only as the social identity of fishing communities but also as adaptive capital that supports socio-ecological resilience. Therefore, efforts to enhance fishermen's resilience must go beyond simply providing technology and infrastructure; they must also prioritize the preservation of local knowledge and the reinforcement of cultural values that have evolved within coastal communities. Integrating local knowledge with modern scientific approaches has the potential to yield adaptation strategies that are more effective and better suited to the characteristics of the Nias fishing community.

C. Economic Vulnerability of Fishing Households in the Face of Climate Change

The results of the SWOT analysis show that the main weaknesses affecting the resilience of Nias fishermen are the low level of processing and value addition of fishery products, with a weight of 0.355, and the weak economic capacity of fishing households, with a weight of 0.318 (Table 1). These findings suggest that although fishing communities possess strong cultural capital and local knowledge, their economic capacity remains relatively limited in coping with the various pressures caused by climate change. These conditions indicate that the resilience of coastal communities is determined not only by social and cultural assets but also by households' economic capacity to manage risks and maintain the sustainability of their livelihoods [50].

The low value added of fishery products indicates that most catches are still marketed fresh, without undergoing processing that could increase the products' market value. This situation causes fishermen's income to be heavily dependent on catch volume and market prices, which tend to fluctuate. When production declines due to unpredictable weather conditions or changes in the fishing season, the income of fishing households also decreases directly. This situation demonstrates that reliance solely on fishing activities can increase the economic vulnerability of coastal communities. Several studies indicate that small-scale fishermen are the group most vulnerable to the impacts of climate change due to their limited economic assets, low livelihood diversification, and high dependence on fishery resources [51][52]. Similar findings have been reported in other studies, which show that fishing households in Indonesia tend to experience a decline in economic capacity when ecological conditions and catch yields change [53].

Furthermore, the weak economic capacity of fishing households reflects the community's limited ability to

manage risks arising from environmental changes and market uncertainties. Unstable income, limited access to capital, and a lack of livelihood diversification can reduce households' ability to weather periods of crisis. High dependence on a single source of income is one of the main factors that increase the vulnerability of fishing communities to economic shocks and environmental changes [54]. Similar conditions are also found in various small-scale fishing communities in developing countries. The FAO reports that climate change not only affects the availability of fish stocks but also impacts the stability of fishermen's incomes through increased operational risks, reduced catch productivity, and market uncertainty [55]. Meanwhile, other studies indicate that shifts in fishing seasons prompt fishermen to adopt various adaptation strategies—such as diversifying their work and adjusting fishing patterns—to maintain household income. In such situations, households' ability to develop alternative sources of income and increase the value added of their products becomes a key factor in strengthening economic resilience [56].

The economic vulnerabilities identified in this study indicate that strengthening fishermen's resilience cannot rely solely on cultural capital and local knowledge. Although both factors play a crucial role in supporting adaptive capacity, the sustainability of fishermen's livelihoods still requires adequate economic support. Therefore, developing fisheries processing businesses, improving access to markets and capital, and diversifying household income sources are crucial steps toward enhancing fishermen's ability to cope with the impacts of climate change. This approach aligns with the concept of livelihood resilience, which emphasizes the importance of strengthening economic assets, access to resources, and livelihood diversification as strategies to reduce the vulnerability of coastal communities [57][58].

These findings indicate that the resilience of Nias fishermen is built through the interaction between sociocultural capital and economic capacity. Strong cultural capital can help communities adapt to environmental changes, but without adequate economic support, this adaptive capacity will be difficult to sustain in the long term. Thus, strategies to enhance resilience must focus on strengthening the economic well-being of fishing households without neglecting the cultural values that have long served as the foundation of coastal communities' way of life. The resilience of coastal communities is the result of the interplay between social, economic, cultural, and ecological systems that mutually influence one another in the face of environmental change [59].

D. Opportunities and Threats to the Resilience of Nias Fishermen

The results of the external factor analysis indicate that the greatest opportunities for enhancing the resilience of Nias fishermen stem from the potential of available fishery resources and coastal ecosystems, as well as support from programs aimed at strengthening fishermen's capacity. These two factors have the highest weight in the opportunities group, at 0.374 (Table 1). These findings indicate that the external environment

still provides sufficient scope for the development of the fisheries sector and the enhancement of the fishing communities' adaptive capacity.

The potential of available fishery resources is a crucial asset in supporting the sustainability of coastal communities' livelihoods. The relatively good availability of fish resources provides opportunities for fishermen to maintain their fishing activities while also developing various businesses based on coastal resources. Furthermore, the presence of productive coastal ecosystems contributes to the sustainability of ecological functions that support fisheries productivity. The sustainability of fishery resources is a key factor in maintaining the economic and food security of coastal communities, particularly in areas with high dependence on the capture fisheries sector [60].

Other opportunities stem from various capacity-building programs organized by the government and related institutions. Training programs, mentoring, access to information, and institutional strengthening can enhance fishermen's ability to cope with environmental changes and the dynamics of the fishing industry. Previous studies have noted that the adaptive capacity of coastal communities is determined not only by the assets they possess but also by their access to knowledge, institutional networks, and adequate policy support [61]. Nevertheless, Nias fishermen also face various threats that could potentially reduce their resilience. The main threats identified include uncertainty regarding weather and fishing seasons, declining fish catches, and fluctuations in the prices of fishery products. These three factors have the same weight, namely 0.270 (Table 1), indicating that each exerts a relatively balanced pressure on the sustainability of fishermen's livelihoods.

Weather uncertainty is one of the tangible impacts of climate change directly felt by fishermen. Changes in seasonal patterns and the increasing frequency of extreme weather events can reduce the number of fishing days, increase occupational safety risks, and affect the efficiency of fishing operations [62]. These conditions can ultimately lead to a decline in catch yields and instability in the income of fishing households. Coastal communities and small-scale fisheries are among the groups most vulnerable to the impacts of climate change due to their high dependence on marine environmental conditions [63].

In addition to ecological pressures, fishermen also face economic threats in the form of fluctuations in fish prices. Price volatility can reduce income even when catch levels are relatively good [64]. This situation becomes more complex when processing capacity and the value added to fishery products remain limited, as indicated by internal weaknesses. Therefore, the external threats faced by fishermen stem not only from environmental changes but also from market dynamics that are difficult for fishing households to control.

Overall, the analysis shows that Nias fishermen still have significant opportunities to enhance their resilience through the utilization of fishery resources and capacity-building programs. However, these opportunities must be balanced with adequate adaptive capacity to address the threats of climate change and evolving economic

uncertainties. This situation underscores the importance of strategies that can optimize external opportunities while minimizing the impact of threats on the sustainability of fishermen's livelihoods.

E. The Strategic Position of Fishermen's Resilience Based on a SWOT Analysis

Strategic positioning was conducted to determine the direction of fishermen's resilience development based on previously analyzed internal and external conditions. The strategic position was determined by calculating SWOT coordinates using the difference between the total score

for strengths and weaknesses on the X-axis and the difference between the total score for opportunities and threats on the Y-axis. Based on the analysis results, the total score for Strengths was 1.732 and the total score for Weaknesses was 0.582, resulting in an X-axis value of 1.149. Meanwhile, the total score for Opportunities was 1.187 and the total score for Threats was 0.932, resulting in a Y-axis value of 0.255. These calculations place the resilience of Nias fishermen at the coordinates (1.149; 0.255), as shown in Figure 2.

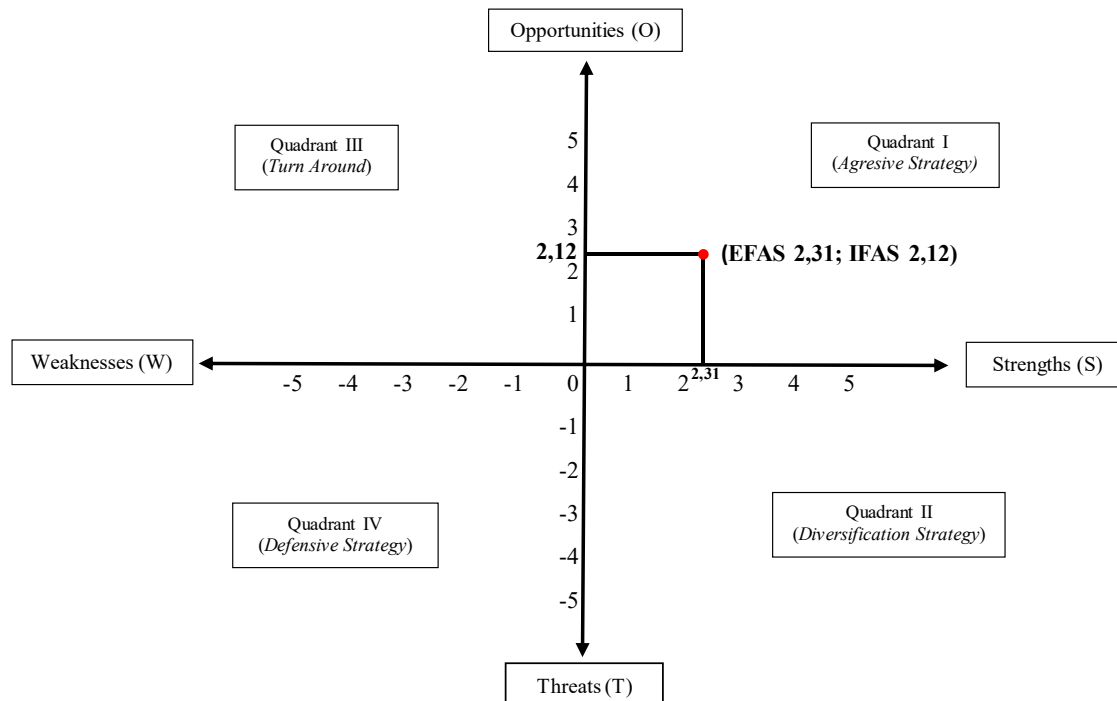


Figure 2. SWOT Quadrant Positions for the Resilience of Nias Fishermen

The position in Quadrant I indicates that Nias fishermen possess greater internal strengths than weaknesses and are supported by external opportunities that can still be leveraged. Quadrant I represents a favorable condition because the organization or system has the ability to utilize its strengths in responding to available opportunities. Therefore, the recommended strategy for this quadrant is an aggressive strategy or a growth-oriented strategy [65].

This position indicates that enhancing the resilience of Nias fishermen relies not only on efforts to reduce vulnerability but also on the ability to take advantage of various available opportunities to strengthen adaptive capacity. Key strengths stemming from seafaring culture and traditions, as well as local knowledge of ocean conditions and seasons, serve as vital assets in supporting this process. On the other hand, opportunities such as the availability of fishery resources and support from capacity-building programs can be leveraged to enhance the sustainability of fishing communities' livelihoods.

These results indicate that the fishing communities of Nias still possess a strong socio-ecological foundation for coping with climate change. These findings are

consistent with previous studies stating that the adaptive capacity of coastal communities will increase if supported by strong internal assets as well as access to external opportunities and support [66]. Thus, strategies to enhance fishermen's resilience should focus on optimizing the strengths that these communities already possess to capitalize on available development opportunities.

Although the community is in Quadrant I, several weaknesses and threats still warrant attention. Low value-added from fishery products, weak household economic capacity, weather uncertainty, and fluctuations in fishery product prices have the potential to hinder the utilization of existing opportunities if not addressed through appropriate strategies. Therefore, strategies for building fishermen's resilience must be designed in an integrated manner, optimizing internal strengths while simultaneously reducing the various limiting factors still faced by fishing communities.

F. Priority Strategies for Enhancing Fishermen's Resilience Based on Local Culture

The SWOT analysis yielded 18 alternative strategies formulated based on combinations of strengths,

weaknesses, opportunities, and threats. These strategies were grouped into four categories: SO (Strength–Opportunity), WO (Weakness–Opportunity), ST

(Strength–Threat), and WT (Weakness–Threat), as presented in Table 2.

TABLE 2.
SWOT STRATEGY MATRIX FOR ENHANCING THE RESILIENCE OF NIAS FISHERMEN

SO (Strength–Opportunity) Strategy SO1. Development of climate change adaptation systems based on local knowledge and maritime culture SO2. Strengthening community-based coastal resource management SO3. Capacity building for the younger generation of fishermen as agents of adaptation SO4. Optimizing fishing operations through the use of fisheries technology and information
WO (Weakness–Opportunity) Strategy WO1. Diversification of livelihoods based on coastal resources WO2. Development of value chains and added value for fishery products WO3. Strengthening fishermen’s institutions through education and training WO4. Strengthening coastal resource conservation practices WO5. Improving infrastructure to support the fishing industry
ST (Strength–Threat) Strategy ST1. Revitalizing local knowledge as a tool for climate change adaptation ST2. Strengthening collective community action in addressing environmental risks ST3. Preserving maritime culture as the foundation of community resilience ST4. Improving the efficiency of fisheries operations to mitigate the impact of production uncertainty ST5. Building the capacity of the younger generation to address environmental change
WT (Weakness–Threat) Strategy WT1. Strengthening the economic resilience of fishing households WT2. Improving access to fisheries infrastructure and support services WT3. Strengthening local institutions in climate change preparedness WT4. Sustainable management of coastal resources

Strategies positioned in Quadrant I indicate that an aggressive approach is the most appropriate choice for enhancing the resilience of Nias fishermen. Therefore, priority strategies are directed toward leveraging internal strengths to capitalize on available opportunities. Based on the analysis results, there are four main groups of strategies deemed most relevant for supporting the enhancement of fishermen’s resilience. The first strategy is strengthening adaptation systems based on local culture and traditional ecological knowledge. This strategy is crucial because the culture and traditions of seafaring, along with local knowledge of ocean conditions and seasons, constitute the primary strengths of the Nias fishing community. Integrating local knowledge with weather information and modern fishing technology can enhance fishermen’s ability to cope with environmental uncertainties caused by climate change. Other studies confirm that traditional ecological knowledge plays a vital role in enhancing communities’ adaptive capacity to dynamically changing environmental conditions [67].

The second strategy is to strengthen household economies through business diversification and increasing the value added of fishery products. The research findings indicate that the low level of fishery product processing and the weak economic capacity of households are major weaknesses that require attention. Diversifying income sources and developing fisheries processing businesses can reduce dependence on catch yields while increasing fishermen’s income stability. These findings align with previous studies indicating that livelihood diversification is a key mechanism for enhancing the resilience of fishing households against various economic and environmental shocks [68].

The third strategy is to strengthen the capacity of the younger generation and fishermen’s institutions. The existence of strong fishermen’s groups, supported by an adaptive younger generation, will accelerate the transfer

of knowledge, innovation, and technology adoption. In addition to enhancing adaptive capacity, institutional strengthening can also expand fishermen’s access to information, training, and empowerment programs organized by the government or relevant institutions.

The fourth strategy is community-based coastal resource management. This strategy aims to ensure the sustainability of fishery resources, which form the basis of fishing communities’ livelihoods. Community involvement in coastal resource management can foster a sense of ownership, strengthen compliance with management regulations, and maintain the ecological sustainability of coastal ecosystems. According to the FAO, a community-based management approach is a key tool for supporting the sustainability of small-scale fisheries amid the pressures of climate change [69].

Overall, strategies to enhance the resilience of Nias fishermen must be implemented in an integrated manner, incorporating cultural, economic, institutional, and environmental aspects. This approach is expected to strengthen the adaptive capacity of fishing communities while supporting the sustainability of the socio-ecological fisheries system on Nias Island.

IV. CONCLUSION

The results of the SWOT analysis show that the resilience of Nias fishermen is supported more by internal factors than by external factors, as indicated by an IFAS score of 2.314 and an EFAS score of 2.120. The fishermen’s main strengths stem from their cultural values and seafaring traditions, as well as local knowledge of ocean conditions and seasons, while their main weaknesses lie in the low level of processing and value addition of fishery products, as well as the weak economic capacity of fishing households. Regarding external factors, the greatest opportunities stem from the

still-available potential of fishery resources and coastal ecosystems, as well as support from programs to strengthen fishermen's capacity, while the main threats include weather uncertainty, declining catch yields, and fluctuations in the prices of fishery products.

The results of the SWOT analysis place the resilience of Nias fishermen in Quadrant I (aggressive) with coordinates (1.149; 0.255), indicating that the fishing community possesses significant internal strengths to capitalize on available opportunities. This suggests that strategies to enhance resilience should focus on optimizing these internal strengths to support their capacity to adapt to climate change. Recommended priority strategies include strengthening adaptation systems based on local culture and traditional ecological knowledge; strengthening household economies through business diversification and increasing the value added of fishery products; building the capacity of the younger generation and fishermen's institutions; and implementing community-based coastal resource management. These strategies are expected to enhance adaptive capacity and strengthen the sustainability of the social-ecological systems of fishing communities on Nias Island in the face of climate change.

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