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Environmental Adaptation Strategies for Sustainable Small-Scale Fisheries in Prigi Bay, Trenggalek

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Abstract

The sustainability of small-scale fisheries livelihoods is highly vulnerable to environmental changes. This study uses the Sustainable Livelihood Approach (SLA) through five capitals that shape sustainable livelihoods. Environmental changes in Prigi Bay into a tourist area encourage small-scale fisheries households to implement sustainable livelihood strategies. The analysis results show that human capital in education, health and alternative employment has the ability and convenience for small-scale fishers. Natural resource capital using natural resource forecasting is used as a consideration or control for production in the coming year that exceeds or is still below C_{MSY}. The financial capital of small-scale fishers produces a value that is profitable and feasible to run. The social capital of small-scale fishers in the form of trust, social norms, and social networks is running well. Infrastructure in physical capital is generally in good condition and available. Market capital that runs in small-scale fishers is following supply chain standards. The government provides policies and training for small-scale fishers to improve their skills and expertise. Efforts to achieve strategies to enhance the sustainability of small-scale fishers' livelihoods with S-O strategies, through increasing fish catches with the help of the use of technology such as GPS and fish finder, implementing other alternative business practices by utilizing available yard land, and expanding distribution channels to reach a wider market by utilizing relationships, through natural, social, financial, human resources, market, fiscal, and policy aspects.

Keywords: Small-Scale Fisheries, Strategy, Sustainable Livelihood Approach, Sustainability.

Introduction

Sustainable livelihoods have the purpose of capturing people's ability to live. The measurement of this approach uses five indicators: human capital, natural resource capital, financial capital, physical capital, and social capital (1). Sustainable livelihood needs capacity, ability, the ownership of assets, and the underlying causes and dimensions of poverty that focus on several factors (2). In fisheries, scholars mostly used sustainable livelihoods to analyze fisher's livelihoods (2-4). Previous research has found that the fisher's household is on a sustainable status, with social capital as the most prominent indicator (3). This finding is further supported by researchers in the past those who found that fishers still maintain social capital, conduct traditional fishing, and carry out activities outside fishing by empowering their family members (3). Additionally in the past, researchers stated that the fishers' group's human and social capital received a high value, while physical and capital had a low value (4). Interestingly, economic activity is not only affected by the five indicators of sustainable livelihoods but also strongly influenced by access to the market and political policies. The combination of both factors influencing economic activity is known as the heptagon concept of access (5). Access to the market is related to the fisher's ability to sell their catches in the market and to the supply chain of fishery product marketing. Then, political policies are explained in the government programs by the local government to be implemented for societal empowerment. This study area is at Prigi Bay, Trenggalek Regency. This area was chosen as the study area due to their rapid development. Prigi Bay has a port called Prigi Coastal Fishing Port; in 2005 the government changed the management to Prigi Archipelago Fishing Port. This status is the primary regulation for managing fisheries resources in the Prigi Bay area (6). Due to the

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status change, there is a massive development in the Prigi Bay area. Despite the enormous growth, small-scale fishers are still dominating this area. The small-scale fishers have the characteristics of only doing one day of fishing and using motor engines less than 30 gross tons (GT). The Prigi Bay port's status change to a national one led to significant infrastructure improvements, including the construction of the Southern Cross Line of Java Island in 2023. This line connected Trenggalek Regency with Tulungagung Regency, rapidly increasing the development of the Prigi Bay coastal area. The area, now a national fishing port and a tourist destination, has seen a surge in tourist numbers, mainly from Trenggalek Regency and the surrounding areas. This situation is affected not only by economic growth but also by environmental development. As a tourist destination and national port, the impact on the small-scale fisher's household is unavoidable. Small-scale fishers must adapt to the current situation and develop social and economic strategies. Their adaptation behaviour is making a living outside the fishing activities at sea as their coping mechanism. The fishers can change jobs by becoming tourist guides or opening a local food store. Thus, the current situation is that not all fishers conduct fishing activities all the time (7). The status and regulation changes in the area's port and development impact the environment, society, and economy, mainly on the small-scale fisher's household. The underlying reason for this study is to analyze the small-scale fisher's household strategy for maintaining sustainability. Therefore, this study will examine their development strategy using the Sustainability Livelihoods Approach (SLA) and marketing paradigm. The marketing view is mainly based on supply chain analysis, which forms the marketing institutions. The Sustainable Livelihood Approach (SLA) is the main framework in this research. The approach emphasises the interconnectedness of social, economic, and environmental factors. In addition, SLA can understand and address complex environmental adaptation challenges, especially in climate change and sustainable Development. The three interrelated factors in SLA provide a holistic view of livelihood strategies and their resilience to environmental stress. SLA fills the limitations of traditional development approaches that often ignore the complexity of poverty and environmental degradation (8). SLA is supported by several key theoretical principles, namely a) people-centeredness, which places people at the centre of Development (8, 9); b) Holism, with consideration of the various factors that influence livelihoods (8); c) Sustainability, which emphasises the importance of sustainable livelihoods for the resilience of individual and household well-being over time (8); d) Vulnerability and resilience, which seek to increase the resilience of livelihood systems by strengthening the capacity of individuals and households to adapt to change (8, 10); e) Institutional and Policy, which recognise the important role of institutions and policies in shaping and advocating for policies that create an enabling environment for sustainable livelihoods (8).

This research aim is to develop policy recommendations for integrating the factors which significantly strength among six indicators into the existing regional fisheries management framework. Furthermore, to develop policy recommendations, this study will use a Strength Weakness Opportunities Threats (SWOT) analysis that analyses internal and external factors in small-scale fisheries based on the capital in the sustainable livelihood approach and its market and institutional capital. Internal factors are strengths and weaknesses, while external factors are opportunities and threats to be detailed.

Methodology

This study was conducted in Prigi Bay, Trenggalek, from July to August 2024, with a sample of 75 small-scale fishers' households. Small-scale fishers used boats less than 20 GT and conducted one-day fishing trips with a sampling technique, simple random sampling. This research uses descriptive research to describe systematically and accurately the phenomena or characteristics of a particular population. Data was collected through interviews, observations, questionnaires, documentation, and Focus Group Discussions, which were used as strategy development. Prigi Bay was chosen as the research site because it is a strategic area that combines various social, economic and geographical aspects relevant to the lives of small-scale fishers. The Southern Crossing Line crosses the location, increasing accessibility while influencing local economic dynamics. In addition, Prigi Bay is a growing tourist destination, creating

interactions between the fisheries and tourism sectors. The existence of Prigi Perikanan Nusantara Port is the centre of fisheries activities, from fish landing to the distribution of catches. The presence of a fisheries processing industry also strengthens the economic value chain in the region, providing a comprehensive picture of the challenges and opportunities facing small-scale fishers. Thus, research in Prigi Bay is expected to provide in-depth insights into the sustainability of fishermen's lives in the context of multisectoral regional development. Written informed consent was obtained from all participants involved in this case study. A comprehensive informed consent process was followed for the fishers and local community members of Prigi Bay who participated in this research. The study protocol and consent procedures were reviewed and approved by the research ethics committee of Universitas Brawijaya on 25 June 2024. All procedures followed were by the ethical standards of the responsible committee on human experimentation. The study analysed household livelihood strategies based on five capitals, which form sustainable livelihoods, market access and institutional. The five capitals are

- Human capital indicates a person's ability to access better livelihood conditions. This study's human capital assessment includes education, health, labour, and skills (11).
- Natural capital comes from households' control over land, water, and other amenities that support their survival. The relationship between natural capital owned and livelihood strategies is directly proportional, meaning that the higher the household's ownership of natural capital, the further the household's livelihood strategies will be from mere survival (11).
- Financial capital indicates the financial resources used to achieve livelihood goals, including flows and reserves that can contribute to consumption and production (12). Financial capital capability is measured through profitability and financial viability analyses.
- Social capital shows the household's interactions with other people in the social environment. This study's social capital analysis includes participation, kinship relations, social networks, and community organisations (11).
- Physical capital is the basic infrastructure and facilities supporting the community's livelihood. Mastery of physical resource assets describes the ease of access that helps households survive (11). Physical capital consists of basic infrastructure and ownership of equipment that can produce goods or services. Therefore, it can encourage the growth of infrastructure livelihoods, including transport, buildings, clean water, etc. (12)

Besides the five capitals above, other capitals that also build the SLA are market political and policy capital. Market capital is the supply chain network for the fishery product marketing area. The assessment will determine the reach and institutionality of fishery product marketing (5). Meanwhile, political and policy capital is the linkage of budgeting programs/institutional development by the government (5). Other capitals that contribute to the SLA include cultural capital, which encompasses traditional knowledge and practices, and intellectual capital, which consists of the skills and knowledge of the fishers.

SWOT analysis to determine the sustainability strategy of small-scale fishers. This SWOT analysis consists of internal factors in strengths and weaknesses and external factors in opportunities and threats. The SWOT is compiled from the results of the SLA heptagon access evaluation. The strategies resulting from the SWOT stages are as follows (1):

- Identification of the Internal and External Environment of Fishery Resources:
  - Identify internal and external environmental variables
  - Develop criteria for giving weight and rating values.
- Weight assessment, relative weight and score

The strengths and weaknesses are measured by relative weight and rating assessment of the internal factor. Then, the opportunity and threat are found by the relative weight and rating measurement of the external factor. Next, the relative weight is multiplied by the rating results to find the strength, weakness, opportunity, and threat score. Then, the alternative strategies result from the SWOT analysis matrix. It comprises four strategies: SO, WO, ST and WT. Strategies generally use strengths and opportunities and minimise weaknesses and threats to fisheries resources.

Table 1: The Strategy Types

No	Type of strategy	Strategy
1	Strength Opportunities (SO): Aggressive	Utilizing the internal factor strengths of fisheries resources to achieve opportunities in the external factor.
2	Weaknesses Opportunities (WO): Turn Around	Minimizing weaknesses in the internal factor by making maximum use of opportunities from the external factor of fisheries resources.
3	Strength Threats (ST): Diversification	Utilize the strengths of the internal factor in overcoming emerging threats.
4	Weaknesses Threats (WT): Defensive	Maintaining the internal factor by minimizing weaknesses and avoiding threats from the external factor.

The types of strategy are shown in Table 1, column 2, in which there are four types: aggressive, turn around, diversification, and defensive. The aggressive strategy utilizes the strength of internal factors to achieve the opportunity from the external factors. The turnaround strategy minimizes the weakness of internal factors by maximizing external opportunities. Diversification is utilizing the strength of internal factors to overcome external threats. Last is defensive, which refers to minimizing the internal factor weaknesses to avoid the external factor threats. The SWOT analysis matrix has to be assessed to know the detailed situation for making a strategy in optimizing the fisheries resources. Table 2 provides the relationship between two variables as the basis for formulating problem-solving strategies. The relationship between variables is considered when determining the plan to be carried out. The SWOT analysis matrix is formulated into a grand strategy matrix to determine the quadrant of the current situation. From the quadrant, the policy implications can be more effective and efficient.

The strategies selected in the grand strategy matrix are not just random choices. They are carefully chosen to achieve our objectives. Understanding these strategies is key to implementing the programs and planning the activities to achieve our goals.

Table 2: SWOT Analysis Matrix

Internal Factors (IFAS)	STRENGTH (S) 1. Strength variable 1 2. Strength variable 2 3. etc	WEAKNESSES (W) 1. Variable weakness1 2. Variable weakness 2 3. etc
External Factors(EFAS)		
OPPORTUNITIES (O) 1. Variable opportunities 1 2. Variable opportunities 2 3. etc	STRATEGY SO Develop a strategy by utilizing strengths to achieve opportunities	STRATEGY WO Develop a strategy for exploiting opportunities by minimizing weaknesses
THREATS (T) 1. Variable threats 1 2. Variabel threats 2 3. etc	STRATEGY ST Develop a strategy to prevent threats with the strengths you have	STRATEGY WT Develop a strategy to prevent threats by minimizing weaknesses

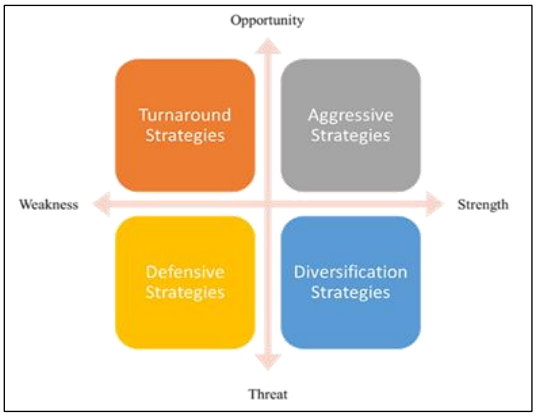

Figure 1: Grand Strategy Matrix

The calculation results of the internal and external environment produce x and y coordinates, which play a pivotal role in the strategic planning process. The x coordinate, derived from the difference between the overall strength and weakness values in the internal environment, and the y coordinate, obtained from the difference between the overall value of opportunities and threats in the external environment, are instrumental in determining the quadrant position of fishery resources and the subsequent strategies to be implemented. The result can be shown in a graphic such as in the Figure 1. Figure 1 provides the information that quadrants in the grand strategy matrix consist of:

Quadrant 1 represents conditions that provide distinct advantages or benefits for fisheries resources. The strengths in this quadrant make it easier to achieve opportunities, necessitating an aggressive growth strategy to be implemented.

Quadrant 2: The conditions faced are threats, but the internal environment still has strengths. The strategy must be carried out to minimize threats by utilizing strengths through diversification strategies.

Quadrant 3: Conditions offer good opportunities but face weaknesses in the internal environment. The strategy is to minimize the internal problems of fisheries resource management to take advantage of opportunities better.

Quadrant 4: Conditions that do not provide benefits because fishery resources experience various threats and internal weaknesses.

Following the SWOT analysis, we employed the IFAS (Internal factor Analysis Summary) and EFAS (External factor Analysis Summary) matrices to quantify the strategic factor. This method transforms qualitative SWOT findings into measurable metrics through systematic weighting and rating procedures for internal (strengths and weaknesses) and external (opportunities and threats) factors. We applied a two-step evaluation process where each factor was assigned a weight ranging from 0.0 to 1.0, with the sum of all weights equaling 1.0. It reflects their relative importance to program success. The weighted score for each factor was calculated by multiplying its weight by rating on a scale of 1 to 4. 1 represents the major weakness/threat. Otherwise, 4 indicate the major strength/opportunity. Total IFAS and EFAS scores were then computed by summing all weighted scores. Their potential values range from 1.0 to 4.0. Scores above 2.5 indicate a strong strategic position, while scores below 2.5 suggest areas requiring strategic intervention. Thus, it provides an empirical basis for strategy formulation.

Results and Discussion

Sustainable Livelihood and Market Access of Prigi Bay Fishers

Human Capital

Human capital plays a fundamental role in identifying the Sustainable Livelihood Approach, which is needed to assess people's readiness, willingness, and ability to achieve the group goals. In this study, the components of human capital that will be examined are the scope of education, health and improvement of professional abilities or skills (13). The first component is education. Education is an essential aspect needed to obtain quality human capital. Education can be obtained through formal and informal education. Formal education is education from elementary school to college, while informal education can be through webinars, training, self-study, etc. The purpose of this education is the same. It can form a more advanced and empowered mindset and, therefore, can

benefit others (14). Educational capital in this study includes the ease of paying tuition fees, the ease of accessing educational institutions from elementary to college, and the ease of fulfilling educational needs in Trenggalek, East Java coastal communities. The results showed that 82.93% of fishers' households could quickly pay for education. The indicator is the ease of accessing elementary, junior high and high school education. It shows that 85% of fishers' households have easy-to-access elementary education. Moreover, 81% and 50% of fishers' households have easy-to-pay and access to junior and senior high school education, respectively. Meanwhile, 4% of fishers' families have the ease of accessing university-level education. Therefore, 91% of fishers' households have the easiness and accessibility to educational needs. The second component is the health aspect. Health is an important aspect to study because it is related to the quality of human capital and productivity. There is a work risk in the form of work accidents that impacts the health problems faced by the fishers. Therefore, the fishers' environment must support prevention and control measures to reduce accidents (15). The measurement of health aspects in this study covers the ease of accessing health facilities, buying medicines, paying health costs and the intensity of illness that occurs in the family. The result shows that 97% of fishers' households have easy access to buy and pay for health costs. Ironically, only 72% of fishers' households often experience illness. The results indicate that easy access for fishers' households to buy and pay for health costs does not impact their healthiness. Despite the easiness of health cost access, the condition can affect the fishers' households' productivity and income. The frequency of experiencing illness can increase the number of days lost and the efficiency of working, particularly in fishing activities (16). The third component is the ability or skill at work. It is essential to continue to hone this ability or skill because expertise or profession will produce new people and increasingly sophisticated technology. The discussion about professional ability includes the ease of obtaining skills/business development training, the intensity of training activities for skills/business development, and the ability to implement training results (17). Technical abilities and practical skills are the cornerstones of workplace effectiveness. Studies show that fishers who consistently develop their skill sets while maintaining strong work ethics achieve superior performance metrics and advanced opportunities. This study's results further reinforce this, showing that 86% of fishers find it very easy to obtain skill/business development training. Moreover, 91% can implement the training results, demonstrating their confidence in their skills and potential. The next indicator alternative works. The indicators are (i) the ease of finding alternative employment other than fishing rods/nets and (ii) the wife's ability to help the household economy. This study shows that the fishers' households also have supportive and diligent behaviour to support their income. The fishers' households, especially the small-scale fishers, have alternative employment to earn additional income to fulfil their daily lives. Their alternative jobs are construction workers, gardening, farming, animal husbandry, and trading. Moreover, the wives also work to help fulfil their needs (18). The results showed that finding alternative jobs other than fishing was easy. More than half of fishers (59%) find that fitting to alternative jobs is more accessible than fishing. Then, 63% of the wives can help the household economy. To conclude, human capital accessibility revealed a robust educational and healthcare infrastructure and improvement of professional abilities or skills within the fishing communities. In educational indicators, most fishing households have proper access to educational funding and primary education facilities. Healthcare accessibility was also extreme due to easy access to medical facilities and services. Furthermore, the fishers' household also has an initiative in capacity building. Therefore, the findings suggest a well-developed human capital support system that enables fishing households to maintain sustainable livelihoods through access to essential services and skill development opportunities.

Natural Capital

Fishing effort in 2020 was 21,926 trips. It becomes a consideration that could boost up to 7,498.53 visits next year. This number is the standard amount of fishing efforts. In detail, the number of fishing efforts using the dominant purse seine gear per vessel is 110 trips, with a total fishing effort of 14,253 visits. In 2020, the number of purse seine (fishing gear trips) increased to 130 fishing gear. This policy increased fishing efforts by 58 visits.

Financial Capital

The financial capital covers the source of funds, cost requirements (investment), estimated income/profit, and balance sheet and profit and loss statement. The financial capital analysis aims to determine the feasibility level of the business run by small-scale fishermen. One of the characteristics of small-scale fishers is the use of fishing gear. Table 3 presents the financial analysis of small-scale fishing businesses in the study location.

Table 3: Financial Capital Analysis of the Small-scale Fishing Businesses

No	Analysis Types	Number (IDR)
1	Fixed Capital	91,560,000
2	Current Capital	78,840,000
3	Fixed Cost (FC)	3,288,457
4	Variable Cost (VC)	78,840,000
5	Total Cost (TC)	82,128,457
6	Total Revenue (TR)	127,475,000
7	Revenue Cost Ratio	1.55
8	Profit	45,346,543
9	BEP Sales	8,619,226
11	Profitability	55%

This report presents a comprehensive financial analysis of a small-scale fishing business. It includes an overview of the financial capital, fixed and variable costs, revenue, and key financial metrics. The financial capital represents an assemblage of productive assets that generate income within a business. The second line of the second row on Table 3 shows that the fixed capital of a small-scale fishing business averages IDR 91,560,000. The number comprises both depreciation and maintenance cost components. In detail, the annual depreciation expenses average IDR 2,512,857, while maintenance costs amount to IDR 775,600 per annum. The third line of the second row in Table 3 depicts the number of current capitals as IDR 78,840,000. The number of fixed and current capital indicates substantial in both long-term assets and working capital. The fourth and fifth lines of the second row demonstrate fixed costs (FC) and variable costs (VC) of IDR 3,288,457 and IDR 78,840,000, respectively. Those costs culminate in a total cost (TC) of IDR 82,128,457. The FC consists of depreciation costs of IDR 2,512,857 and maintenance costs of IDR 775,600. Meanwhile, the VC per year of IDR 78,840,000 includes several components, such as diesel fuel for the boats, engine oil, generator oil, food and drink supplies for the crew, cigarettes, petrol, ice, and crew wages. The seventh line of the second row presents the total revenue (TR). The TR analysis indicates IDR 127,475,000 yielding a revenue-cost ratio of 1.55. This ratio, which measures the relationship between revenue generation and cost management, suggests a favorable balance. It indicates operational efficiency, with the business generating IDR 1.55 in revenue for every IDR 1 spent. The revenue is coming from some fishery commodities sales, including Largehead hairtail (Trichiurus lepturus sp), Chub mackerel (Scomber japonicus sp), Eastern little tuna (Euthynnus affinis sp), Northern red snapper (Lutjanus campechanus sp), Epinephelus spp, Skipjack tuna (Katsuwonus pelamis sp), Oncorhynchus spp, Polynemus spp, octopus, and squid. The operations generate a profit of IDR 45,346,543 with a break-even point (BEP) in sales at IDR 8,619,226. Notably, the enterprise achieves a profitability rate of 55%, demonstrating robust financial performance. The financial metrics collectively indicate solid economic performance, with revenue substantially exceeding the break-even point and generating significant profit margins. The positive revenue-cost ratio and high profitability percentage suggest effective cost management and revenue generation strategies, contributing to the overall financial sustainability of the fishing operations and painting an optimistic picture of the business's financial future.

Social Capital

Social capital is developed from trust within localized communities and facilitating enhanced access to assets, financial opportunities, and social assistance programs. This capital needs

investment in diverse social resources, encompassing social networks, trust mechanisms, value systems, normative frameworks, and power structures that mobilize social relations toward the efficient and effective achievement of individual and collective objectives. Social capital emerges from dynamic interactions among community members, manifesting at personal and institutional levels of social engagement. Within the present study's analytical framework, the investigation of social capital components centres specifically on three key dimensions: trust, social norms, and social networks (19, 20). The results of this study validate the theory of social capital in community development and resource accessibility. Social capital theory contains multidimensional aspects used to understand community dynamics and social resource mobilization. The assessment results showed a social capital score of 84.25%. This result is a significant indicator of the collaboration of trust, social norms, and social networks in small-scale fishing communities. This high score suggests the effective functioning of social capital components and underscores their crucial role in community development. The study site encompasses 15 small-scale fishermen affiliated with Joint Business Groups (Kelompok Usaha Bersama—KUB), an institutional framework for economically disadvantaged family units collaborating within defined territorial boundaries. These Joint Business Groups, such as Truntum Jaya, Karangasem, Octopus Jaya, Mina 10, Mitra Bahari, Usaha Jaya, Putra Jaya, Karya Laut, Karya Samudra, Baruna Sejati, Tapak Buto, Tuna Jaya, Tuna Sejati, Rembeng Raya, and Samudra, are all operated by small-scale fishermen. They are part of an institutional framework in joint business groups that support economically disadvantaged family units collaborating within defined territorial boundaries. The formation of this group makes the government's social development initiatives well implemented. The formation of this group is in line with the Department of Social Affairs' institutional framework for a community-based economy (dinsos.kalbarprov.go.id). This group shows the formation of formal institutions based on social capital in small-scale fishing communities. The group accommodates members to undertake collective economic activities and resource mobilization. The high component analysis score suggests the effective implementation of these institutional arrangements in supporting community-based fishing operations, which could have significant implications for similar communities. The following paragraphs will explain the three key dimensions: trust, social norms, and social networks. Trust is an essential component in social capital analysis that is the foundation of collaborative relationships and group dynamics. It is necessary for participation, effective communication, and strong cooperation between people. More than that, trust is a cornerstone in social relations, significantly influencing the development of personality and social cohesion in different layers of society. The framework used to analyze trust in this study includes various indicators. The indicators are social relationship patterns, interaction dynamics, and expectations. An empirical investigation of 15 joint business groups found consistent communication, shared decision-making, and mutual respect (Table 4) manifestations of trust capital. The existence and operation of trust within the organizational structure demonstrate the importance of this component in facilitating collective action and sustainable community development. These findings align with contemporary theories that place trust as a crucial determinant of social capital formation and institutional effectiveness in community-based resource management systems, underscoring its weight in these contexts.

Table 4: The Trust Indicators

No	Indicator Items	Total
1	Maintaining trust in the Joint Business Group	360
2	Maintain trust with other community groups	356
3	Help each other if there are members/community members who experience difficulties	368
4	Have trust in local leaders (village heads/community leaders in the village)	360

No	Indicator Items	Total
5	Maintain and preserve assistance from the government or other parties provided to the group	334
6	Mutual openness	375
7	Freedom of expression	375
8	Cooperative efficiency	375
	Total	2.903
	Percentage	96.75%

Table 4 presents the item indicators in trust, a key component of social capital. The table's seventh, eighth, and ninth lines highlight the highest-performing metrics, each scoring 375 points. These metrics, which include mutual openness, freedom of expression, and cooperative efficiency, point to robust participatory mechanisms and transparent communication channels. Trust, as revealed by these indicators, significantly enhances fishery management consciousness among small-scale fishers. It is intricately linked with social networks and cooperation, both of which are crucial for the sustainability of fishers' livelihoods. In the Philippines, trust within social networks is a cornerstone of maintaining food security among fishing households, particularly during challenging times (21). Institutional trust measurements include the joint business group cohesion in the second line of Table 4 and leadership relations (which are indicated by having trust in local leaders) in the fifth line of Table 4, maintaining strong performance at 360 points. It suggests effective vertical and horizontal integration of trust networks. Trust significantly impacts fishery management consciousness among small-scale fishers. In the Philippines, trust and cooperation significantly affect fishery management in certain municipalities, indicating that higher levels of trust can lead to better management practices (22). In Malaysia, trust, as a part of social capital, significantly contributes to the household income of small-scale fishers. Community trust can enhance economic outcomes and improve well-being (23). The mutual assistance indicator in the fourth line of Table 4, demonstrated by the helping each other behaviour (368 points), reflects a well-developed community support network. Inter-group trust, shown in the third line of Table 4 with 356 points, demonstrates effective cross-community relationships. The sixth line of Table 4 provides the preservation and maintenance of external assistance resources, scoring lowest at 334 points. This result indicates satisfactory implementation. The tenth line of Table 4 shows the total score of 2,903 points across all indicators. This result suggests a well-integrated trust framework supporting community cohesion, with potential for further enhancement in resource management protocols. In summary, the last line of Table 4 depicts the aggregate score of trust indicators at 96.75%, demonstrating exceptional implementation effectiveness. This comprehensive analysis reveals a social structure characterized by high transparency, strong participatory mechanisms, and effective collaborative frameworks. While there are marginal enhancement opportunities in external resource management systems, the current state of affairs is reassuring. Therefore, trust is a vital indicator of social capital in fishers' households, influencing various aspects of their socio-economic life. It enhances fishery management, contributes to household income, supports food security, and correlates with better economic outcomes. Fostering trust within fishing communities can lead to more sustainable and resilient livelihoods. Moreover, participating in community organizations is a core aspect of social capital in fishers' households. This participation often leads to stronger household networks and better access to resources essential for sustaining livelihoods (24). Social norms are a set of unwritten principles that govern behaviour and cooperation between people in the general community. These standards make rules about appropriate and inappropriate, whether regarding how individuals behave, social communication, or collaboration in local life. Social norms reflect the qualities, beliefs, and assumptions the gathering shares and are a rationale for maintaining social control. Social norms, unwritten rules, or guidelines for life that still apply to community life are necessary for groups. Actions and social life can influence them at large. Various kinds of written

sanctions generally accompany social norms. There are two types of social capital in fishers' households, namely bonding and linking social capital. Bonding social capital refers to the close-knit relationships within the fisher community itself. These relationships are characterized by strong trust and mutual support, essential for the community's cohesion and resilience. Unfortunately, these bonds have a fragility that poses a risk. Then, consistency is necessary to strengthen these relationships and maintain their effectiveness. In contrast, the linking social capital portrays the relationships between fishers and external authority groups. These relationships are generally weaker and less developed, indicating a need for efforts to enhance these connections to improve the community's overall social capital (25). This study assessed the components of social norms, particularly social capital bonding. The results are presented in Table 5.

Table 5: Social Norm Indicators

No	Indicator Items	Total
1	The nature of obeying the rules	375
2	Honest behaviour (not cheating)	75
3	Social laws enforcement	338
4	Fair aid distribution by the group leader	356
5	Fair justice among group member	353
6	Fair task distribution among group member	338
7	Avoid sailing in the bad weather	356
8	Active in mutual cooperation activities to keep the coast clean	263
	Total	2,454
	Percentage	81.75%

Table 5 on the second line shows that the rule compliance is exceptional adherence (375 points). The result indicates robust institutional framework effectiveness. In contrast, the third line depicts that honest behavior is at a low score (75 points). This low score in honest behavior suggests potential challenges in the transparency mechanism, which could lead to issues such as dishonesty or lack of trust. This stark contrast with other indicators needs further investigation into underlying causative factors and potential intervention strategies. This finding contrasts with the scholars, who found that trust among community members and reciprocal obligations are foundational norms that support social capital. These norms help coordinate actions for mutual benefit and maintain social cohesion (20, 26). Environmental and group responsibility indicators demonstrate varying implementation numbers. The fifth and eighth lines in Table 5 provide that fair aid distribution and weather-related safety protocols achieve robust scores (356 points). It indicates effective risk management and resource allocation systems. Fishers' households often form tighter, more homogeneous networks in response to environmental and social changes. This bonding helps manage risk and sustain cooperation. Similarly, the sixth line of Table 5 points out that fair justice maintains a strong performance (353 points), providing reassurance about the well-functioning internal fairness mechanisms within the community. The fourth and seventh lines of Table 5 show that social law enforcement and task distribution share identical scores (338 points), reflecting the consistent implementation of regulatory frameworks. However, coastal environment activities score relatively low (263 points). The results mean that there are potential areas for enhancement in community-based environmental management initiatives, such as improving resource allocation or strengthening community participation. These enhancements could lead to more effective environmental management and a higher score in this area. Overall, the social norm aggregate implementation rate is 81.75%. It reveals a community structure with strong formal rule adherence and equity mechanisms. The opportunity to improve transparency systems and environment engagement protocols is crucial, as it can significantly enhance the community's functioning. The social norms within fisher communities are critical as they guide behaviour and facilitate cooperation. These norms are embedded in the social capital and are essential for sustaining the community, especially during times

of change or challenge (27, 28). Social networks: Social capital refers to the resources accessible through social networks, including trust, reciprocity, and shared norms that facilitate cooperation among individuals and groups. Meanwhile, social networks consist of patterns of relationships among individuals or groups, which are crucial for accessing social capital (29). Social networks combine various types of correspondence, such as friendship, participation, and information exchange, which play an important role in forming social elements. A strong social network can provide substantial support, open employment opportunities, and access to different assets. At the same time, its absence can affect social well-being and commitment to the community. Patterns in social networks also have rules about how they behave in the community. Social networks have several theories divided into several parts: social capital, bonded social capital, connected social capital, and social and economic relations, which refer to the connections and interactions between individuals or groups that involve both social and economic aspects. There is a linkage between community dependence and social capital in the fishers' communities. Fishers in communities with high fishing reliance (high fishing activities per capita) exhibit higher fishing-related social capital and identity levels. This finding includes strong familial connections to fishing and higher individual reliance on fishing income. Social capital in these communities is also linked to higher social vulnerability and lower reliance on non-fishery income sources (30). The results of this study on social network components are presented in Table 6.

Table 6: Social Networks Indicators

No	Indicator Items	Total
1	Regularly carry out friendly relations with the surrounding community	338
2	The networking needed to sell fish at outside area	113
3	Collaborate with friends in agencies who can support your work	128
4	Regular communication	375
5	Sensitivity to help other people's needs	368
6	Participation in activities related to the coastal environment	315
7	Provide assistance to neighbours affected by disaster	364
8	Maintain the safety of under age children	364
	Total	2,365
	Percentage	78.75%

Table 6 on line 5 shows that communication efficacy achieves the highest score, with 375 points. It expresses that the information exchange mechanism within the community structure is strong. Regular communication is part of local practical and social norms. The practices and social norms significantly influence the sustainability of fishing livelihoods (31). The second rank demonstrated in Table 6, line 5, is sensitivity to helping other people's needs. It stipulates that the fishers' household has a highly functional interpersonal empathy and a well-developed social support system. The third rank is displayed in Table 6, lines 7 and 8, with the helping behaviour towards the neighbourhood affected by disaster and the underage children's safety maintenance, respectively. Both have 364 points. This finding supports, who mentioned that social networks are crucial for disaster resilience (32). The next rank in Table 6, line 5, is regular communication, with a moderate score (338 points). Participation in activities related to the coastal environment, in Table 6, line 7, has 315 points. It shows the lack of awareness of fishers' households in keeping the coastal environment. These circumstances could be due to minimum literacy in environment management. Last, the two indicators with the lowest are in Table 6, lines 4 and 3. It is related to networking for working and selling the fish catch in the outside area. In small-scale fishing communities, social capital significantly contributes to household income and overall well-being (23). Moreover, the effective co-management of resources in fishing communities often relies on high levels of linking and bridging social capital. This study reveals that the fishers' household has a strong internal social bond but limited external network development. It suggests opportunities

for enhancing external relationship-building and market access strategies while maintaining existing strengths in internal community support mechanisms. Fishers' households with strong social networks tend to perform better in resource management, indicating the importance of maintaining positive social relationships (33).

Physical Capital

Physical capital, which includes infrastructure, equipment, and technology, plays a crucial role in determining the sustainability and productivity of fishing communities. In the study area, it was found that most small-scale fishers own houses with a land area of 90 - 242 m2 and a building area of 50 - 80 m2. These houses, typically made of bricks and with tiled roofs, floors, and a bathroom inside, provide a comfortable living environment for the fishers. The road infrastructure consists of paved roads with a width of 0.8 - 4.5 m2. Most small-scale fishers use motorised transportation for daily activities, including delivering caught fish to collectors' houses, taking kids to school, and shopping at the market. Moreover, individuals in the community own some gasoline stations, and the Prigi Archipelago Fishing Port (Pelabuhan Perikanan Nusantara - PPN) is near the village. The gasoline stations near the fishers' village are crucial in refuelling the boats before sailing and fishing. It's worth noting that purchasing fuel at petrol stations outside the fishing port using drums requires a Fishing Business License. The port and fish markets are essential for trading activities, especially for small-scale fishers. After fishing, some of them directly sell their catches to collectors in the small party. For large party collectors, the small-scale fishers sell their catches directly to their houses. This condition proves that physical capital encompasses the availability and quality of infrastructure, such as roads, ports, and fish markets, which are essential for efficient fish trading and transportation (34). The study result shows that the infrastructure and facilities of fishers on Prigi Bay are adequate to make their production more effective and efficient. Another type of physical capital is fishing equipment and technology. The type and condition of fishing gear and vessels significantly impact the productivity and sustainability of fishing activities. In Prigi Bay, the type of boat used by fishers is a fibre boat, a more modern and efficient choice. However, some fishermen still use traditional wooden boats with ½ - 5 GT engines and a capacity of passengers of one to three people. Most use 15-24 Horsepower (HP) for boat engines and generators. The boat engine is used to operate the boat, and the generator is only used as lighting power to turn on the boat lights. The type of fishing gear used by fishers is the handline fishing gear with fishing line numbers 9, 6, and 12, consisting of fishing lines made of strings with sizes 4-9 inches. The motorised vessels and fishing boats indicate that the small-scale fishers on Prigi Bay already have technological upgrades. This condition shows that the fish catch and income could be boosted (35). However, financial limitations often hinder access to physical capital, which is crucial for the sustainability and productivity of fishing communities. The lack of financial capital restricts fishers' ability to invest in modern fishing technology, which is vital for improving their livelihoods. This gap can lead to a reliance on outdated or inefficient tools, negatively impacting productivity and income. The urgency of addressing this issue is underscored by the fact that the sustainability of physical capital also depends on regular maintenance and upgrades, as highlighted in a previous study that mentioned the overall livelihood capital was deemed unsustainable due to inadequate maintenance and support for other capital types. Therefore, fishers' households in Prigi Bay use coping strategies to fulfil their family needs by working as fishers and farmers. In the past, researchers called coping strategies to fulfil the family needs of the fishers' households (7). Their side jobs are clove and durian farmers. The period is during the off-season or in the bad weather. The tools used for farming are still simple, such as hoes, sickles, sacks, sharpeners, and some medicines for plants, such as grass medicine to remove weeds and fertilisers to fertilise clove and durian plants.

Market Capital and Supply Chain of Small-Scale Fishers' Catches

The market capital and supply chain influence fishers' income, resource management, and social dynamics. Integrating market mechanisms and sustainable practices to enhance fishers' livelihoods often leads to improved economic conditions and community resilience. The study found that in Prigi Bay, the supply chain of fishers' catches starts with small-scale collectors. These collectors are responsible for distributing and

reselling the caught fish, with the target sales being the local community and large collectors. The process starts with the fish catch arriving at the fish landing and then being transported to collectors for sale. Fishers have provided information on the fish landing to the collectors about whether they are going to sell their catch. Fish are obtained from regular fishing lines, which are sorted first to determine the price. All types of fish obtained by fishermen are still purchased at varying prices depending on the type, size and quality of the fish. The collectors will inform traders about the kind of fish, price, volume, and freshness level of the fish before sending it to large collectors or restaurant owners around Prigi. The trader makes payment at the time of fish purchase. The bond between fishermen and collectors is patron-client, a form of agreement based on mutual trust and informal. The second chain consists of food stalls. These food stalls take fish from collectors and sell various grilled fish, such as snapper, grouper, shrimp, squid, octopus, tuna, and other similar types. The fresh and high-quality fish purchased from the collectors weigh between 5 ounces and 1.5 kg. The price ranges from IDR 60,000 to IDR 65,000 per kg. Other food stalls that sell traditional fish-based dishes and smoked fish also buy fish from the collectors. The fish types that have high demand include squid, snapper, tuna, octopus, mackerel, and more. The third chain is the partners of the collectors. The partner is to get the small fish. The collectors are tasked with distributing and reselling the caught fish, with the sales target being the local community to factories outside the city and the province. Depending on the seasons, collectors can buy fish from fishermen during the fish season with IDR 1,000 to IDR 10,000 per kg.

The findings show that the market capital and supply chain of the fishers at Prigi Bay is successfully connected. However, to increase the market share and value of the local fisheries', the reconnection of fishers with local communities is crucial for enhancing territorial development (36). Integrating small-scale fisheries into global markets can also influence local socio-economic conditions. However, the response of fishers to market signals, such as price changes, can be complex and influenced by socio-economic factors, as seen in the Philippine 'suki' system (37).

Political and Policy Capital

The allocation of political or policy capital on technology policy within the SLA framework can significantly influence the socio-economic status of fisher communities. This influence is about enhancing livelihood assets, governance structures, and socio-economic resilience and empowering these communities. Integrating technology policy into SLA can lead to improved access to resources, diversification of income sources, and better management of natural resources, collectively contributing to the socio-economic upliftment of fisher neighbourhoods. However, the effectiveness of these policies is contingent upon their alignment with local contexts and the active participation of the communities involved. Technological advancements can improve fisher communities' financial and physical capital by increasing efficiency and productivity. For instance, in Prigi Bay, Indonesia, technology has stimulated the community's ability to utilise fishery resources, enhancing household sustainability (31). Small-scale fishermen in Prigi Bay have used satellite and sonar technology to increase fish catches at sea. This finding underscores the crucial role of the government, which provides support such as engines, boats, Global Positioning System (GPS), fish finders, and other tools that significantly enhance the fishers' fishing activity. GPS is handy for fishers to know their position at sea, determine travel routes, and mark important places, such as places with lots of fish, shipwrecks, shallow areas, etc. Currently, there is also a sea map or blue chart that contains data on sea topography, depth, and small islands, which is very helpful for fishermen when navigating using GPS. Fishfinder is a tool for fishermen to find fish and find information on the presence of fish, underwater topography, and sea depth. This tool allows fishermen to find fish more efficiently to increase fishing yields. In addition, many government agency programs provide counselling or training for fishermen to use this equipment to make fishing at sea easier. Some of the training that fishermen have attended include training on machinery, safety, and ship operations; fishing gear repair procedures, assembly, and fastening; things to avoid; how to maintain gillnet gear; fishing operational management planning, and planning fishing operations with purse seine gear; making and repairing fibre boats; Training on

Global Positioning System (GPS) allocation such as determining the direction key of the GPS fishing location, determining (bait) fish spot points according to their type and adjusting weather predictions; Training on loading and unloading boat engines, determining the correct position of fishing rods, adjusting to waves, and fishermen's skills when catching fish at sea; Training on correct fishing procedures; Training on making gillnet fishing gear; Training on using environmentally friendly fishing technology and machining of small-scale fishing vessels. In the fishers' environment, policy misalignments can exacerbate existing inequalities. For example, urban marine subsistence fishers in the US face challenges due to inadequate integration of their practices into public policies (38). However, the study findings above show conditions that contrast those of the prior study. Effective governance policies well-aligned with local contexts have already been implemented in Prigi Bay as the study area. The match between policy objectives and local livelihood conditions could result in sustainable outcomes (39). In conclusion, policies must be adaptable and inclusive, considering fisher communities' diverse needs and vulnerabilities. This inclusivity ensures that all stakeholders' concerns are addressed and considered, contributing to sustainable and equitable socio-economic development.

Small-scale Fisheries Sustainability Strategies

Environmental changes to the tourism environment force small-scale fishers to adapt to the new environment. SWOT analysis in this study was conducted to identify internal and external factors of small-scale fisheries sustainability in Prigi Bay. Determination of variables in SWOT analysis based on the six capitals of the Sustainable Livelihood Approach described above.

Identification of Internal Factors

Table 7, row 2 shows five capital assessments in the internal factors of the Sustainable Livelihood Approach. The five capitals are human resources, financial, social, environmental, and physical. Table 7, row 3, lines 2 and 3 provide the primary strength of human resources, including the ability to cover education (S1) and health costs (S2). On the contrary, Table 7, row 5, lines 2, 3 and 4 provide weakness, which consists of the intensity of illness occurring in the family (W1), the wife's ability to help the household economy (W2), and the ability to improve professional skills (W3). The analysis reveals strong basic resource management capabilities but limits on human capital development. Next is Table 7, row 3, line 3, which depicts the strength of the financial capital, which is the number of fish catches per month (income) (S6), which supports the fishers' household basic needs. Conversely, the increase in monthly expenses needed (W5) is the weakness factor of the fishers' household. This dichotomy indicates potential opportunities for financial management optimization. Moreover, the strengths of the social capital are present in row 3; lines 5 to 7 cover the institutional views such as trust in groups (S3), fairness in the rules of rights and obligations within the group (S4), and cooperative behavior (S5). The social capital weakness in Table 7, row 5, lines 5 and 6, including the nature of committing the fraud and active participation in the group, suggests the crucial need for social cohesion enhancement. The strength of natural capitals is in Table 7, row 3, line 8. The availability of agricultural and plantation land (S8) is significant. The frequency of use of fishing gear (W6), displayed in Table 7, row 5, line 8, emerges as a constraint, indicating potential resource allocation optimization opportunities. The last capital is physical. The strength of physical capital is portrayed in Table 7, row 3, line 9. Housing adequacy and availability (S8) constitute a primary strength. On the contrary, the weakness displayed in Table 7, row 5, line 8 limits the fisheries and non-fisheries production assets (W7) and presents operational challenges. The comprehensive analysis reveals a complex interplay of factors affecting fishers' households, particularly due to the environmental changes from natural to the tourism environment. These changes are of utmost importance and need to be addressed. The particular strengths are social infrastructure and essential resource management. It highlights the opportunities for enhancement in professional development and asset utilization domains.

Table 7: Strengths and Weaknesses Identification of Internal Factors

No.	Capitals	Strengths	Code	Weaknesses	Code
1	Human Resources	Ability to cover education costs	S1	Intensity of illness occurring in the family	W1
		Ability to cover health costs	S2	The wife's ability to help the household economy	W2
				Ability to improve professional skills	W3
2	Financial	Number of fish catches per month (income)	S6	Monthly expenses needed	W5
3	Social	There is trust in groups, communities and local leaders	S3	The nature of committing the fraud	W4
		There is fairness in the rules of rights and obligations within the group	S4	Participation and activeness in the group	W8
		There is a social norm of mutual cooperation (helping each other)	S5		
4	Environment	Availability of agricultural and plantation land	S7	Frequency of fishing (use of fishing gear).	W6
5	Physical	Availability and suitability of housing	S8	Availability of fishery and non-fishery production assets	W7

Identification of External Factors

Table 8, row 2 shows that the external factors assessments of the Sustainable Livelihood Approach have seven capitals. The seven capitals are human resources, social, environmental, market, financial, policy, and physical. Table 8, row 3, shows the opportunities of each capital. To begin with, Table 8, rows three, lines 1 and 2, provide the information that opportunities encompass accessible education system (O1) and healthcare services (O2). Still, in row 3, line 3, they present that governmental and external party assistance (O3) represents a key opportunity. In row 3, lines 5 and 6 show that the easy access to fish distribution (O7) and market (O8) are the opportunities in market capital. Moreover, row 3, lines 5 to 7 demonstrate the financial, policy and physical capital as the opportunity for the fishers' household. The availability of capital assistance from another party (O4) is categorized as financial capital. The availability of training by the government (O5) is categorized as policy capital. The last is the accessible transportation and refuelling of gasoline for sailing and fishing (O6), categorized as physical capital. Conversely, the threat is shown in Table 8, row 5. Lines 2 and 3 threaten human resources capital through limited alternative employment opportunities (T1) and constraints in skills development training (T2). The circumstances suggest challenges in human capital diversification. Furthermore, line 4 gives the limitations on social capital in the form of the lack of an external support network (T3). It presents a notable threat, which indicates potential areas for network development. Interestingly, lines 5 to 7 present multiple threats to natural capital. The threats are weather uncertainty (T4), seasonal fishing variability (T5), fish stock availability (T6), and species diversity challenges (T7) in Prigi Bay. This pattern suggests significant environmental vulnerability requiring strategic management. Next is the threat to market capital in the form of price instability (T8). Climate change is a threat to small-scale fisheries because it is changing marine ecosystems and fishing communities. Rising sea temperatures are triggering poleward migrations of fish, forcing fishers to travel further from their traditional areas and adapt to these fishing grounds. This is happening alongside increasing ocean acidification that is destroying important habitats such as coral reefs. Frequent extreme weather, unpredictable seasons and damaging marine heat waves are not only damaging fishing infrastructure, but also limiting fishing days and dangerous fishing conditions. These ecological disruptions are becoming profound socio-

economic challenges. The resulting unpredictable catches are undermining household income stability and market disruptions are affecting the entire value chain. The impacts felt by fishing communities are different by gender and economic status. This is forcing fishing communities to develop new ways of surviving that are able to respond to ongoing environmental change. It indicates market structure vulnerabilities despite strong access frameworks. The findings suggest the need for strategic interventions focusing on environmental resilience and market stability enhancement while leveraging existing infrastructural and policy support mechanisms. Interventions that should be provided by the government include economic support through. Special funds allocated for climate adaptation, insurance programs and subsidies for safety equipment to protect livelihoods during unpredictable conditions. Capacity building investments made by the government such as early warning systems can increase community resilience. The government can undertake infrastructure development that focuses on landing sites, cold chain facilities, and ecosystem-based coastal defenses to provide physical protection.

Table 8: Opportunities and Threats of the External Factors

No.	Capital	Opportunities	Code	Threat	Code
1	Human resources	Ease of gaining access to education	O1	Ease of finding alternative jobs other than fishing/net fishing	T1
		Ease of obtaining access to health	O2	Ease of obtaining training for skills / business development	T2
2	Social	There is assistance from the government or other parties	O3	The existence of external social networks that support work	T3
3	Environmental			Uncertainty of weather conditions	T4
				Uncertainty of fishing seasons	T5
				Availability of fish in the sea (Prigi coast)	T6
				Diversity of fish species on the Prigi coast	T7
4	Market	Ease of access to fish distribution	O7	Fish price instability	T8
		Ease of market access	O8		
5	Financial	There is capital assistance from collectors/other parties	O4		
6	Policy	Procurement of programs/training by the government	O5		
7	Physical	Easy access to transportation and refuelling	O6		

The data and information obtained from the identification results are processed into the IFAS and EFAS matrix, multiplying the relative weight with the rating results in a score. The score measures the level of influence in the internal or external environment or between external environments. Table 9 and 10 shows that the IFAS value is 3.95, and EFAS is 4.01, respectively. It means that external factors have more influence than internal factors. The strength variable produces the highest score, which is the priority value. The three highest scores generated from the strength variables under consideration are:

- The ability to meet health costs is one factor that encourages fishermen to look for alternative livelihoods other than fishing to meet these costs. In general, small-scale fisher communities could finance their health needs

independently, although some fishers use government health insurance.

- The availability and feasibility of small-scale fishers' residences can currently be said to be livable and comfortable. Although not luxurious, the facilities owned by their residences are quite complete, such as bathrooms, kitchens, bedrooms, and living rooms.
- Social norms of cooperation (helping each other) help fishers get along well in society and when working for fish in the sea. This behavior positively impacts small-scale fishers, who can have many friends and relations. Therefore, it is easy to find colleagues as crew members and as suppliers of fish collectors, restaurants, etc.

Moreover, the weakness generates the lowest score, a prioritized value. The three lowest scores generated from the weakness variables under consideration are:

- Fraud in the group can harm the group and individuals. However, there are no strict rules in the group to deter fishers. These conditions have caused the majority of the groups to be disbanded or group members to switch to other groups.
- The intensity of sickness that occurs in the families of fishers is categorized as frequent. However, some suffer from non-communicable diseases such as diabetes and mental illness, which are considered quite dangerous diseases, while they seek treatment at their own expense.
- The ability to improve professional skills is crucial to increase the income of fishers. The more skilled fishers are in catching fish effectively and efficiently, the more profitable they will be. The efficiency and effectiveness of the methods used by fishers in catching fish will affect the expenditure and income earned from fishing.

Table 9: IFAS development of alternative livelihoods for small-scale fishers

No	Strength	Value	Ratings	Score
1	Ability to meet education costs	0.08	4.53	0.36
2	Ability to fulfill Health costs	0.10	4.8	0.48
3	There is trust in groups, communities and local leaders	0.09	4.5	0.41
4	There is fairness in the rules of rights and obligations within the group	0.09	4.3	0.39
5	There is a social norm of mutual cooperation (helping each other)	0.09	4.6	0.41
6	Number of fish catches per month (income)	0.08	4.35	0.35
7	Availability of agricultural land	0.09	4.25	0.38
8	Availability and suitability of housing	0.09	4.75	0.43
No	Weakness	Value	Ratings	Score
1	Intensity of illness occurring in the family	0.03	1.4	0.04
2	The wife's ability to help the household economy	0.06	3	0.18
3	Ability to improve professional skills	0.03	1.45	0.04
4	There is the nature of fraud	0.02	1	0.02
5	Expenditure costs for meeting needs per month	0.03	1.85	0.06
6	Frequency of fishing (use of fishing gear).	0.05	2.45	0.12
7	Availability of fishery and non-fishery production assets	0.03	1.45	0.04
8	Participation and activeness in the group	0.04	2	0.08
	Total	1		3.95

Furthermore, the opportunity resulted in several high-priority scores, with three primary considerations emerging from the analysis. The most significant opportunities identified were the accessibility of fish distribution networks, market access, and healthcare facilities. The distribution infrastructure presents a notable advantage for small-scale fishers, characterized by readily available transportation access and distribution partnerships. This infrastructure enables fishermen to consistently distribute their catch, regardless of volume. Market accessibility constitutes another substantial opportunity, particularly given the significant domestic and export demand for fish products. The current supply-demand gap in the market presents an

opportunity for market penetration and expansion. Additionally, the proximity of healthcare facilities—including community health centres, pharmacies, and hospitals—to fishermen's residences represents a significant advantage. The availability of affordable medical supplies through both pharmaceutical and alternative retail channels further enhances this opportunity. Regarding the threat, the study identified several critical challenges facing small-scale fishing operations. Price instability emerges as a primary concern, particularly during moderate or low seasons when catch quality and quantity may not meet market standards. This volatility is especially pronounced when fish size falls below consumption standards or when catch volumes are insufficient to meet market demand, resulting in significant price depreciation compared to optimal seasonal conditions. The unpredictable biodiversity patterns along the Prigi bay present another significant challenge. The seasonal variation in fish species availability, coupled with specific market demands, creates a mismatch between supply capabilities and market requirements. Some species are available only seasonally, while others follow different patterns, making it difficult for fishermen to consistently meet market demands for specific species. Finally, the inconsistent access to skill development and business training programs represents a structural challenge. Despite the existence of government-sponsored training initiatives, the distribution of these opportunities remains uneven among small-scale fishers in Prigi Bay. While various government agencies conduct outreach and training programs, participation is often limited to select representatives from fishing groups or village delegates, leaving some fishermen entirely without access to training opportunities.

Table 10: EFAS Development of Alternative Livelihoods for Small-Scale Fishers

No	Opportunity	Value	Ratings	Score
1	Ease of gaining access to education	0.08	4.42	0.35
2	Ease of obtaining access to health	0.09	4.8	0.43
3	There is assistance from the government or other parties	0.08	4.45	0.36
4	There is capital assistance from collectors/other parties	0.06	3.2	0.19
5	Procurement of programs/training by the government	0.07	4.15	0.29
6	Easy access to transportation and refueling	0.08	4.45	0.36
7	Ease of access to fish distribution	0.09	5	0.45
8	Ease of market access	0.09	5	0.45
No	**Threat**	**value**	**Ratings**	**Score**
1	Ease of finding alternative jobs other than fishing/net fishing	0.05	2.85	0.14
2	Ease of obtaining training for skills/business development	0.03	1.7	0.05
3	The existence of external social networks that support work	0.08	4.45	0.36
4	Uncertain weather conditions	0.08	4.75	0.38
5	Uncertainty of fishing seasons	0.04	2.2	0.09
6	Availability of fish in the sea (Prigi Bay)	0.03	1.95	0.06
7	Diversity of fish species on the Prigi Bay	0.03	1.65	0.05
8	Fish price instability	0.02	1.4	0.03
	Total	1		4.00

Analysis of the interaction between internal and external environmental factors reveals that internal environmental factors significantly influence the development and sustainability of small-scale fisheries' livelihoods. The quantitative assessment utilized a coordinate system where the x-coordinate represents the differential between strengths and weaknesses, while the y-coordinate denotes the margin between opportunities and threats. Both environmental dimensions yielded positive values, positioning the results in Quadrant I with coordinates [2.73, 1.64]. This positioning within the first quadrant of the analytical framework suggests a favourable configuration of both internal capabilities and external conditions. The magnitude of the x-coordinate [2.73] indicates a substantial positive differential between organizational strengths and weaknesses. At the same time, the y-coordinate [1.64] demonstrates a positive, though relatively minor, margin between

environmental opportunities and threats.

The quantitative analysis uncovers significant insights into the strategic positioning of small-scale fisheries through a quadrant-based assessment framework. In Table 11 column 3 line 2, we can see that the strength variable has a robust score of 3.34, substantially exceeding the weakness score of 0.61, resulting in a positive x-coordinate of 2.73. This substantial differential is a testament to the system's strong internal capacity.

Table 11: Determination of Quadrants and Strategy

No (1)	Variable (2)	Score (3)	Coordinate (4)	Sign (5)	Total (6)	Quadrant (7)
1	Strength	3,34	2,73	(+)	3,95	I (one)
2	Weakness	0,61				
3	Opportunity	2,82	1,64	(+)	4,01	
4	Threat	1,19				

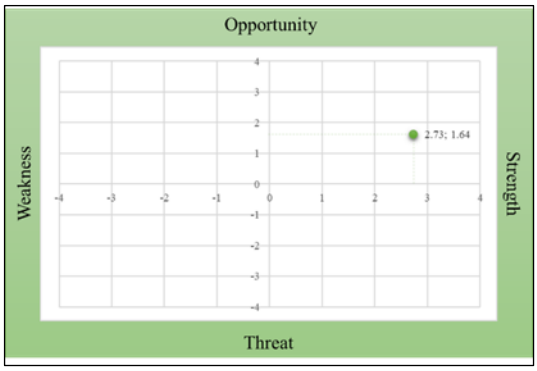

Figure 2: The IFAS EFAS Quadrant

The opportunity variable registers a score of 2.82, which markedly surpasses the threat score of 1.19, yielding a positive y-coordinate of 1.64. The aggregate scores of 3.95 for internal factors (strength-weakness differential) and 4.01 for external factors (opportunity-threat differential) position the strategic analysis firmly within Quadrant I. This positioning in Quadrant I is particularly noteworthy as it indicates a favourable alignment of internal capabilities and external conditions. Figure 2 provides the positive coordinates [2.73, 1.64] which suggest that the small-scale fisheries sector maintains a strong internal foundation while operating in an environment rich with opportunities. Such positioning typically indicates optimal conditions for strategic growth and development initiatives. In Figure 2, the larger magnitude of the x-coordinate [2.73] compared to the y-coordinate [1.64] suggests that internal strengths play a more decisive role in the sector's strategic position than external opportunities, though both remain positive contributors. This finding has important implications for strategic planning and resource allocation, suggesting that while external opportunities should be pursued, the reinforcement and leveraging of internal strengths may yield the most significant returns. The analytical results indicate that the strength coordinate value exceeds the opportunity coordinate, suggesting a strategic imperative for small-scale fishers to optimize their internal strengths while capitalizing on available external opportunities. This differential in coordinate values provides a clear strategic direction: robust internal capabilities should serve as the primary foundation for development, with external opportunities functioning as complementary vectors for growth. The higher strength coordinate implies that internal competencies and resources constitute a more reliable basis for strategic initiatives than external opportunities alone. This finding suggests that small-scale fishermen would benefit from an approach that prioritizes leveraging existing strengths while simultaneously pursuing selective opportunity exploitation in alignment with these core capabilities. This strategic orientation aligns with resource-based theoretical frameworks, which emphasize the primacy of internal capabilities in sustainable competitive advantage. The data supports a strategy that emphasizes the systematic

deployment of existing strengths in pursuit of market opportunities rather than allowing external opportunities to drive strategic direction exclusively.

The SWOT (Strengths, Weaknesses, Opportunities, Threats) matrix delineates four distinct strategic quadrants for operational implementation: Strengths-Opportunities (S-O), Weaknesses-Opportunities (W-O), Strengths-Threats (S-T), and Weaknesses-Threats (W-T). Based on the quantitative analysis, the S-O strategy emerged as the optimal strategic orientation for implementation. The selection of the S-O strategic quadrant indicates an approach that emphasizes the synchronization of internal strengths with external opportunities, suggesting favourable conditions for aggressive growth strategies. This strategic positioning enables the organization to leverage its core competencies while capitalizing on environmental opportunities, potentially yielding optimal outcomes regarding sustainable development and competitive advantage. Table 12, row 2, line 2 (green colour) shows the most suitable strategic framework for improving the livelihood sustainability of fishers in Prigi Bay according to the IFAS EFAS analysis. It is utilising an S-O (Strengths-Opportunities) approach, which encompasses multiple initiatives: enhancement of fish capture through technological integration (GPS and fish finder systems), development of alternative business practices leveraging available residential land resources, and expansion of distribution channels to access broader markets through relationship cultivation. In detail, the strategies are systematically categorised across seven critical indicators:

Environmental Indicators: The strategy encompasses six key interventions focusing on environmental sustainability and economic diversification in coastal fishing communities. These interventions integrate regulatory compliance through registered fishing equipment implementation, methodological optimisation aligned with regional characteristics, and systematic coastal reforestation initiatives. The framework further incorporates technological integration for environmental preservation, reinforcement of indigenous knowledge systems for ecosystem protection, and ecotourism development for economic diversification. This comprehensive approach seeks to balance environmental conservation with sustainable economic growth. It emphasises ecological preservation and community livelihood enhancement through diversified income generation opportunities.

Table 12: The SWOT matrix

Internal Factor **External Factor**	**Strength (S)** **S2, S5, S8**	**Weakness (W)** **W1, W3, W4**
Opportunity (O) O2, O7, O8	Strategy S-O 1. Increase in fish catches with the help of technology such as GPS and fish finder (S5, S8, O7, O8) 2. Implementation of other alternative business practices by utilizing the available yard space (S8, O7, O8) 3. Expansion of distribution channels to reach a wider market by utilizing relationships (S5, O7, O8)	Strategy W-O 1. Modernization and digitalization in the production system and supply chain of the capture fisheries industry (W3, O7, O8) 2. Facilitate capital, partnership and business protection for fishermen groups (W4, O7, O8) 3. Maximizing access to fish distribution (W3, O7) 4. Utilization of existing health facilities to support health needs (W1, O2)
Threats (T) T2, T7, T8	Strategy S-T 1. Implementation of joint learning practices by certified fishermen (S5, T2) 2. Procurement of production input assistance by related agencies	Strategy W-T 1. Increasing HR competency through competency certification and technical and managerial training through government programs and other agencies (W3, T2)

3. Efficiency and effectiveness of production inputs (materials, supplies and equipment) and infrastructure (the archipelago port, fish marketing centres, public and health services) (S2, S5, T2, T8)	2. Engineering, piloting, dissemination and assistance with fishing technology (W3, T2, T7) 3. There is a guaranteed price for production inputs and production results from the regional government (W4, T8) 4. Making binding and strict rules for each fishing group

Social Indicators: The social indicators cover three critical aspects focusing on institutional partnership and collaborative governance in small-scale fisheries management. The strategy prioritises the expansion of public-private partnerships for development and market access. Moreover, it implements participatory co-management systems and establishes non-governmental advisory mechanisms. This integrated approach emphasises multi-stakeholder engagement while balancing resource sustainability with community welfare objectives through institutionalised collaborative frameworks.

Financial Indicators: comprise three core aspects that centre on capital management and financial sustainability in small-scale fisheries. The structure incorporates professional capital management through public-private partnerships with embedded mentorship mechanisms, direct governmental support for technological infrastructure and grassroots financial literacy development. This approach integrates institutional support with operational capacity building, emphasising both systemic financial management and individual financial management.

Human Resource Indicators: This indicator consists of five strategic dimensions. Those are focused on capacity building and resource optimisation in small-scale fisheries. The priority recommendations are on educational enhancement and technological competency development to meet bigger potential market demands. Meanwhile, the training needs to be improved in quality. Additionally, it emphasizes the strategic utilization of local human capital and the development of livelihood diversification skills to mitigate weather-related operational risks. This approach integrates skills development with adaptive capacity building. It ensures both operational efficiency and economic resilience through diversified competencies.

Market Indicators: The market indicators formulate three strategic focuses on digital transformation and value chain optimisation in small-scale fisheries. The strategy emphasises technological integration for enhanced supply chain distribution, exploitation of multi-sectoral market opportunities spanning primary and processed products, and strategic product diversification aligned with market demands. This integrated approach prioritises digital accessibility and product value enhancement while optimising market penetration through diversified distribution channels and value-added product development.

Physical Indicators: The physical infrastructure covers three key strategies for spatial optimisation and operational capacity enhancement in small-scale fisheries. The framework prioritises efficient land-use management through integrated residential and agricultural planning, development of core fishing infrastructure, and strategic enhancement of fleet capacity with adapted fishing gear systems. This systematic approach integrates spatial resource optimization with operational infrastructure development, ensuring alignment between production requirements and physical resource capabilities.

Policy Indicators: The policy comprises four strategic dimensions focusing on governmental engagement and institutional support in small-scale fisheries development. The framework prioritizes enhanced local government participation in management and marketing initiatives, targeted facility and product management oversight, and systematic empowerment through technological and institutional capacity building. Additionally, it emphasizes the quantitative and qualitative enhancement of extension services for regional fishery planning. This comprehensive approach

integrates multi-level governmental support with institutional development, ensuring coordinated policy implementation for sustainable fisheries management.

There are several specific policy recommendations to overcome the weakness and threat on the small-scale fisheries in Prigi Bay due to the environmental changes. These are:

- Integrating local knowledge certification programs by creating a pathway for experienced fishers to become certified trainers in their communities. This program administered by the Ministry of Marine Affairs and Fisheries. The aim of this program is to provide legitimacy to traditional knowledge while creating knowledge transfer.
- Develop regency-specific climate information services through Meteorology, Climatology and Geophysics Agency (Badan Meteorologi, Klimatologi, dan Geofisika - BMKG). It provides the accessible forecast via community bulletin boards.
- Allocate village fund for fishing technology upgrades that enhance both productivity and climate resilience.
- Manage and establish a district-level minimum price guarantee system through Regional Owned Enterprise (Badan Usaha Milik Daerah – BUMD) for several main fish species during periods of climate-related variability
- Create public cold storage facilities operated as public-private partnerships to reduce post-harvest losses during extreme weather.

Those policy recommendations represent an integrated approach to sustainable development in small-scale fisheries, incorporating technological advancement, environmental conservation, and socio-economic development considerations. The strategy emphasises the importance of multi-stakeholder collaboration and the balanced utilisation of available resources for optimal outcomes.

Conclusion

Analysis of small-scale fisheries in Prigi Bay reveals robust potential for sustainable development across multiple dimensions. The study demonstrates significant strengths in human capital development, characterized by accessible educational infrastructure, healthcare systems, and diversified employment opportunities. This human resource foundation supports comprehensive skills development and adaptive capacity within fishing communities. The resource management practices in Prigi Bay's small-scale fisheries are a success story. They exhibit sustainable characteristics, with harvest levels consistently below maximum sustainable yield thresholds. Effective environmental monitoring systems provide a solid foundation for production planning and resource conservation efforts. The financial analysis further reinforces this success, indicating operational viability through profitable returns and effective market integration, suggesting sustainable economic models. Social capital demonstrates particular strength through well-established trust networks and community organizations. These social structures facilitate effective resource sharing, knowledge transfer, and collective action. Integrating physical infrastructure and market mechanisms with governmental policy support creates a conducive environment for sustainable development. This multi-dimensional analysis suggests that Prigi Bay's small-scale fisheries not only possess the fundamental elements necessary for long-term sustainability but also have the potential to thrive. The findings indicate that continued development should focus on maintaining and enhancing these existing strengths while addressing emerging resource management challenges and market dynamics, paving the way for a promising future. Moreover, according to the findings, the strategy for enhancing small-scale fishermen's livelihood sustainability employs an S-O (Strengths-Opportunities) approach, encompassing three primary initiatives:

- Enhancing fish capture efficiency through technological integration, specifically GPS and fish finder systems. Technical enhancement priorities focus on technological infrastructure investment, digital systems integration, and value-chain optimization. This technical foundation supports operational efficiency and market competitiveness while ensuring sustainable resource utilization.
- Implementation of alternative business practices, such as aquaculture or eco-tourism, that sustainably utilize available residential land resources, thereby diversifying the income sources for the fishing communities.
- Expansion of distribution channels through

relationship cultivation, which involves building strong partnerships with other stakeholders in the seafood industry, such as restaurants and retailers, to access broader markets for fish caught by small-scale fishers.

Furthermore, capacity building initiatives emphasize comprehensive training programs, strengthened institutional frameworks, and enhanced market access mechanisms. These interventions aim to develop human capital while establishing robust institutional support systems for sustainable operations. The framework integrates social capital development with market accessibility, creating sustainable pathways for community economic development. Policy support mechanisms prioritize governmental assistance programs, environmental protection measures, and market development initiatives. This policy framework provides the institutional foundation for sustainable development while ensuring environmental conservation and market stability. These initiatives are systematically implemented through seven critical aspects: natural, social, financial, human resource, market, fiscal, and policy considerations. This comprehensive approach, which ensures the integration of environmental sustainability with socio-economic development objectives, is a testament to the thoroughness and effectiveness of the strategy. This strategy provides a foundation for sustainable development in small-scale fisheries, emphasizing the importance of technological advancement while maintaining environmental and social considerations. The findings suggest that continued focus on these aspects and strategic implementation will contribute to the long-term sustainability of small-scale fishing communities. Moreover, this research reveals strong social capital and effective trust networks among fishing communities in Prigi Bay. Therefore, the policy implications for this research are formalizing collaborative governance structures and land use integration for local level, and climate adaptation financing that accessible to small-scale fishers with proof of licensing for national level.

Abbreviations

BMKG: Badan Meteorologi, Klimatologi, dan Geofisika (Meteorology, Climatology and Geophysics Agency), BUMD: Badan Usaha Milik Daerah (Regional Owned Enterprise), EFAS: External Factor Analysis Strategy, FC: Fixed Cost, GT: Gross Tons, GPS: Global Positioning System, HP: Horsepower, IFAS: Internal Factor Analysis Strategy, KUB: Kelompok Usaha Bersama (Joint Business Groups), PPN: Pelabuhan Perikanan Nusantara (Prigi Archipelago Fishing Port), SLA: Sustainability Livelihoods Approach, SWOT:Strength, Weaknesses, Opportunities, Threat, SO: Strength – Opportunities, ST: Strength – Threat, TC: Total Cost,TR: Total Revenue, VC:Variable Cost, WO:Weaknesses Opportunities, WT: Weaknesses Threat.

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Conflict of Interest

The authors declare no conflict of interest.

Ethics Approval

This study received ethical approval from Universitas Brawijaya due to all procedures was conducted in accordance with their ethical standards. Informed consent was obtained from all participants.

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