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The Economic Prospects of Fisher-Laborers Amidst Climate Dynamics: From Vulnerability to Decent Conditions (Case Study of Tambakrejo Fishers, Semarang City)

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Abstract

The fisheries sector plays a crucial role in global economic development, particularly for food security and the well-being of coastal communities. It is a cornerstone of national economic development for citizens whose economic growth depends on the primary sector. In the context of fisheries, vulnerability arises from a combination of biophysical factors such as increased frequency of natural disasters, extreme weather changes, and oceanographic dynamics, all of which are beyond human control. Tropical coastal ecosystems are experiencing significant ecological stress as a direct consequence of atmospheric warming. The economic vulnerability of coastal communities is not only triggered by environmental aspects due to climate change, but is also caused by socio-economic factors, institutional access, fishing technology, and local social structures, which either strengthen or weaken the level of vulnerability. The environmental, social, and economic aspects of Tambakrejo fishing laborers' susceptibility might also be examined. The first objective is to explore the resources found in the waters of Tambakrejo; the second objective is to identify fishermen's perceptions of the factors that make them vulnerable; and the third objective is to identify the adaptive capacity of fishermen.

The qualitative approach was conducted thru simple triangulation with the assistance of the ATLAS.ti software to address the fourth research objective, which is to analyze strategies that enable fishermen to improve their conditions from vulnerable to sustainable. This research uses primary and secondary data. The respondents in this study consisted of 30 fishermen selected using purposive sampling technique.

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INTRODUCTION

The fisheries sector plays a crucial role in global economic development, particularly for food security and the welfare of coastal communities. The fisheries sector serves as a cornerstone in national economic development for citizens who depend on economic growth from the primary sector. The Tambakrejo area in Semarang City is one of the coastal centers dominated by small-scale fishers and fisher-laborers. According to provisions in Law Number 45 of 2009, small-scale fisher-laborers are individuals who depend on fish-catching activities for their daily livelihoods to meet their daily needs.

Fisher-laborers do not own their own boats yet they work for boat owners using small boats called jakung/cadik, up to boats measuring below 5 GT with a catch-sharing system. In line with Law Number 7 of 2016 concerning Protection and Empowerment of Fishers, Fish Cultivators and Salt Farmers, small-scale fishers are defined as those who catch fish for daily needs, either without boats or using boats smaller than 10 GT. Thus, the typology of fisher-laborers in Tambakrejo clearly reflects the category of small-scale fishers as formulated in national policy.

The concept of vulnerability in coastal and fisheries studies originally was initially rooted in studies of climate change impact assessments and has been extensively discussed in various interdisciplinary research. In the fisheries context, vulnerability emerges through a combination of biophysical factors such as increased frequency of natural disasters, extreme weather changes, and oceanographic dynamics, all of which are beyond human control. Tropical coastal ecosystems experience significant ecological pressure as a direct consequence of atmospheric warming. The economic vulnerability of coastal communities is not only triggered by environmental aspects due to climate but also caused by socio-economic factors, institutional access, fishing technology, and local social structures, all of which strengthen or weaken the level of vulnerability. From the social vulnerability perspective, Tambakrejo fisher-laborers face various limitations that affect their ability to obtain decent livelihoods. Most fisher-laborers do not own their own boats and work dependent on boat owners, resulting in very weak bargaining positions. Climate change causing increased high waves, tidal flooding, and abrasion increasingly has further exacerbated their vulnerability conditions due to uncertain catches that must be shared with boat owners. Economic limitations are also caused by lack of access to capital and fishing technology, unequal working relationships with boat owners, and minimal institutional protection and social security.

Vulnerability assessment is generally conducted quantitatively through measuring established indicators, resulting an index representing the level of vulnerability of a community or system (Senapati & Gupta 2017). This approach enables researchers and

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policymakers to differentiate vulnerability levels among coastal area and design more targeted interventions (Allison et al., 2009).

In the sustainability context, small-scale fisheries are often described as the future of the fisheries sector. The Tambakrejo community's attachment to marine resources fosters a sense of ownership alongside a responsibility to preserve environmental conservation through non-destructive fishing practices. Milan's (2019) theoretical framework on social, economic, institutional, and technological domains can be applied to understand Tambakrejo fisheries characteristics. The social domain encompasses kinship relationships among fisher-laborers, working networks with boat owners, and community solidarity. The economic domain relates to dependence on daily wages, limited access to capital, and low savings. The institutional domain concerns local regulations and government policies affecting access to fishery resources and social assistance. Meanwhile, the technological domain relates to the availability of simple fishing gear affecting fisher-laborers work efficiency.

The vulnerability of Tambakrejo fisher-laborers can also be analyzed through three dimensions: environmental, social, and economic, as explained by Nayak and Berkes (2019). The material dimension appears in the limitations of physical assets, equipment, and unstable income. The relational dimension reflects dependence on boat owners, a lack of bargaining position, and weak formal support networks. While the subjective dimension relates to perceptions of insecurity, future expectations, and social capital possessed to overcome life pressures.

Amidst these pressures, Tambakrejo fisher-laborers still possess adaptive capacity that can be strengthened. Adaptive capacity refers to the ability of individuals or groups to build resilience through learning, collaboration, and utilization of available resources. Factors such as experience facing weather changes, collective memory of survival strategies, and local social networks form the foundation of this adaptive capacity. Attributes of adaptive capacity including diversity of responses, social connectivity, resource reserves, collaborative abilities, and learning capacity can serve as a basis for enhancing coastal community resilience.

Considering this context, research on Tambakrejo fisher-laborers needs to be directed towards exploring the forms of vulnerability they experience based on environmental, social and economic dimensions, as well as identifying their adaptive capacities and formulate strategies to transform their condition from vulnerable to more decent and sustainable.

Research Area Description

The Tambakrejo Fishing Village study area in Semarang City was chosen because the majority of its fisheries activities are small-scale operations (Department of Marine Affairs, Fisheries and Animal Husbandry of Semarang City 2023). Tambakrejo has

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ecological characteristics in the form of shallow waters, pond areas, and a coastline that has historically been a mooring location for small boats and fishing motorboats. The majority of fishers in Tambakrejo work as small-scale fishers or fisher-laborers, with high dependence on potential fish catches rich in skipjack tuna and sardines.

The fishing community in this region also forms strong social networks, distinctive coastal culture, and livelihood patterns greatly influenced by weather conditions, tides, and coastal ecological changes. Tambakrejo is also an area vulnerable to tidal flooding, abrasion, and land subsidence, thus facing significant socio-ecological challenges. These conditions make Tambakrejo one of the important area for studying fisher livelihood sustainability, adaptation to coastal environmental changes, and socio-economic dynamics of the coastal community of Semarang City.

RESEARCH METHODS

The method used in this research is a combination of quantitative and qualitative analysis, as conducted in similar studies (Ardiansyah et al., 2019). The quantitative approach is carried out through descriptive statistics to address the first, second, and third research objectives. The first objective is to explore the resources availability in Tambakrejo waters; the second objective is to identify fishers perceptions regarding factors that make them vulnerable; and the third objective is to identify fishers adaptive capacity.

A qualitative approach is conducted through simple triangulation with the assistance of ATLAS.ti software to address the fourth research objective, namely to analyze strategies that enable fishers to improve their condition from vulnerable to sustainable. This research uses primary and secondary data. Respondents in this study consist of 30 fishers selected using purposive sampling technique. This sample size is considered capable of producing a sampling distribution approaching normal for sample mean values despite originating from a non-normal population distribution because it has met the minimum sample requirement of 30 respondents (Islam, 2018).

Fisher respondents were interviewed using semi-structured questionnaires and in-depth interviews with key informants to obtain a clearer picture for qualitative analysis (Guion et al., 2011; Kaur, 2020). Key informants were conducted using purposive sampling method. Key informants in this study include academics, business practitioners, representatives from the West Central Marine and Fisheries Department of Central Java Province, as well as the Marine and Fisheries Department of Semarang City, who were deemed capable of contributing to analyzing sustainability strategies for small-scale fishers in Semarang City. Fisher groups representatives were also involved as key informants.

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Research Findings

Environmental Characteristics

The Tambakrejo waters area located in Tanjung Mas District Semarang City, at coordinates approximately 6°57' South Latitude and 110°26' East Longitude, is one of the northern coastal areas of Java with strong estuarine ecological characteristics. This area is dominated by mangrove ecosystems, shallow muddy waters, and river estuaries functioning as transition zones between marine and terrestrial environments. These biophysical conditions make Tambakrejo an important habitat for various coastal organisms, including demersal fish, shrimp, mud crabs, shellfish, and other estuarine biota depending on nutrients from river watersheds. Geographically, its proximity of less than one nautical mile from the coastline makes this area a center for traditional fishing activities utilizing shallow waters for fishing with simple fishing gear. Ecologically, this area produces various marine commodities that become the main source of livelihood for local communities. The main marine products caught by Tambakrejo fishers include pony fish, mullet, sea catfish, wild milkfish, shrimp, mud crabs, and various types of shellfish (such as mussels and clams) that are highly dependent on mangrove ecosystem preservation and estuarine water quality.

Fisher Characteristics

Table 1 describe the socio-demographic profile of respondents including: gender, age, education level, marital status, number of dependents, type of fishing gear, and low-income side jobs.

Table 1. Fisher Characteristics

Variable	Category	% Respondents	Number of Respondents (35)	Notes
Age (years)	<30	11%	4 people	Min = 23
	30–40	16%	6 people	Max = 67
	41–50	34%	12 people	Mean = 47
	>50	39%	14 people	
Education	0 year	0%	0 people	Min = 0, Max 12
	1–6 year	62%	22 people	
	7–9 year	23%	8 people	
	10–12 year	9%	3 people	
	>12 year	0%	0 people	

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Income per trip for pursin fishermen (USD)	<50 USD	79%	28 people	Min = 13, Max = 77, Mean = 44
	>50 USD	21%	7 people	
Income per trip for payang fishermen (USD)	<50 USD	33%	12 people	Min = 25, Max = 73, Mean = 46
	>50 USD	67%	23 people	

The table depicts the main characteristics of fishers who served as research respondents. The majority of fishers are in the productive age range of 30-50 years, consistent with the average respondent age of approximately 40 years. Fishers education level is relatively low, with 62% having completed only 1-6 years of education (equivalent to primary school), reflecting the limited formal education commonly found in traditional fishing communities.

Fisher income also shows variation based on the type of fishing gear. Purse seine fishers mostly earn less than USD 50 per trip, ranging from USD 13-77 in good seasons. Conversely, payang fishers more frequently achieve income above USD 50 per trip, ranging between USD 25-73. However, all fisher groups have high dependence on weather conditions, large waves or storms can halt fishing activities, drastically reducing income. Overall, this table confirms that fishers are in vulnerable socio-economic conditions due to low education, fluctuating income, and high dependence on nature.

Vulnerability Measurement Based on Small-Scale Fisher/Fisher-Laborer Perceptions

This research was conducted to determine fishers perceptions regarding the vulnerability they experience. This vulnerability was identified by Prateep & Berkes (2019) and encompasses environmental (natural), social, and economic factors. Fishers perceptions of these vulnerability factors were then standardized through certain adjustments to obtain objective results.

Respondent 5 explained that the current season is no longer predictable. It is difficult to identify when the dry season or rainy season will come due to irregular seasonal changes (different from the past). Therefore, they only go to sea when weather conditions truly permit.

The economic vulnerability expressed by respondents is closely related to income data in the table. Fisher-laborers mostly earn less than USD 50 per trip (79% of respondents), and their income is highly fluctuating depending on the season. When the fishing season is better, many boats employ fisher-laborers with catch-sharing systems according to catches. Meanwhile, small-scale fishers who own their own boats are relatively more stable but still depend on sea conditions. This situation explains why the

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majority of respondents cited insufficient income, lack of capital, and seasonal dependence as major sources of vulnerability.

Social factors, according to fishers perceptions, relate to vulnerability arising from inadequate regulations, lack of access to health and employment insurance, and high migration rates. Respondent 17 also conveyed that the main problem for small-scale fishers regarding health insurance is the difficulty of the application process due to the long distance to insurance offices. They lack strong motivation to travel from the fishing village to service offices.

Table 2. Small-Scale Fisher Vulnerability Perceptions (N = 35)

Dimension	Vulnerability	Likert Scale				
		1	**2**	**3**	**4**	**5**
Natural	Flood and tidal waves	5	28	2	0	0
	The fishing season is difficult to predict	0	0	1	22	12
	Unpredictable season	0	2	2	14	17
	Unexpected waves	0	4	1	18	12
	Resource damage	0	9	11	12	3
Social	Regulations are not supportive	0	6	7	16	6
	No health insurance	0	0	0	28	7
Economy	Perceptions of Migration	6	17	4	8	0
	Insufficient income	0	6	4	14	11
	Seasonal sales	0	11	2	15	7
	Diffulties in obtaining fuel	0	18	0	11	6

The table illustrates the vulnerability perceptions of 35 small-scale fishers grouped into three main dimensions: natural, social, and economic. In the natural domain, the majority of fishers experience high vulnerability to seasonal uncertainty and ocean waves, evident from high responses in agree and strongly agree categories on statements regarding unpredictable fishing seasons, erratic seasons, and unexpected waves. In the social domain, most fishers feel they receive insufficient government regulatory support, and the majority acknowledge for not having health insurance, indicating quite serious social vulnerability. Meanwhile, in the economic domain, fishers face challenges including insufficient income, dependence on seasonal fish sales, difficulties in obtaining fuel, and perceptions of migration as a response to economic pressure. Overall, this table shows that fisher vulnerability is most strongly visible in natural and economic aspects, while

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socially they also experience limitations, especially in relation to access to health insurance.

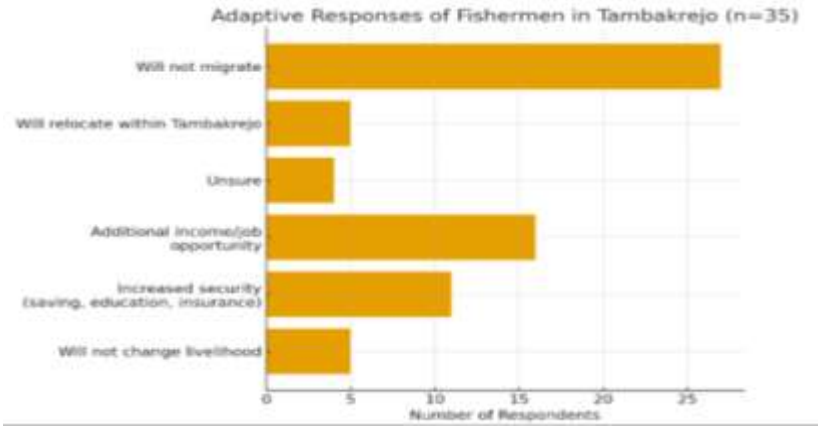
Assessing Adaptive Response

In resilience literature, community adaptive capacity is understood as the capacity to build socio-economic resilience through collective action (Folke, 2006). One way to analyze tendencies shaping local adaptive responses is by using various adaptive capacity attributes. Each attribute represents information supporting efforts to close the gap between goals and actions of actors involved in the system of adaptive capacity attributes. These attributes govern the extent to which a community can apply resilience and adapt or change in response to changes. Aspects of adaptive capacity include: response diversity, collaborative capacity, connectivity, reserves or resource abundance, and learning capacity (Kaur 2020).

Response Diversity

Changes in socio-ecological systems elicit various forms of responses from social and ecological subsystems. Various components such as organically built infrastructure, labor and expertise, institutional actors at various levels, and formal and informal actors play important roles in the adaptation process. In the social subsystem, livelihood diversity and income sources, economic opportunities, level of dependence on natural resources, migration patterns, and willingness to change become key indicators in assessing response variation (Whitney et al. 2017). Understanding this livelihood diversity is important for identifying potential social inequality and unequal access to opportunities amidst change. Community responses in this research were obtained through semi-structured interviews.

Figure 1. Adaptive Response of Small-Scale Fishers/Fisher-Laborers (N = 35)



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The graph shows hypothetical adaptive response tendencies of Tambakrejo fishers to changes in socio-ecological conditions. Most fishers (approximately two-thirds of respondents) stated they would not migrate, indicating strong attachment to location and minimal alternative opportunities outside their area. However, to improve their economic situation, fishers prefer to seek additional income or side jobs, illustrating short-term economic adaptation strategies to face catch uncertainty. Others choose to increase economic security through savings, education, or insurance, though in smaller proportions. Only a small portion of fishers stated they would not change their livelihood or felt unsure about what adaptive measures to take. Overall, this graph reflects an adaptation pattern leaning toward of local economic diversification; fishers choosing to stay plan to develop mangrove tourism areas and seafood restaurants around Tambakrejo.

Connectivity

With the development of various activities around Tambakrejo waters, communities can adapt by increasing connectivity. This is demonstrated through an increased number of associations at the local level, growing community awareness, and increased frequency of community meetings during periods of change or when facing unfavorable situations. Survey results show that approximately 64% of 35 fisher respondents (about 22 people) stated they participate in an organization, while the remaining 36% (about 13 people) do not join any organization. Most respondents who join participate in only one organization, and only about 7% (about 2-3 people) participate in more than one organization. These findings indicate the need to raise awareness about the importance of strengthening social and environmental connectivity through organizational participation. Additionally, the types of organizations joined by fishers are generally informal community groups or associations, not formal fisher organizations or associations.

Collaborative Capacity

Collaboration within communities often depends on human social systems and their level of involvement in socio-ecological systems (Leslie & McCabe 2013). Respondents were asked about their involvement in community-level decision-making and natural resource management. Of 35 fisher respondents, approximately 34% (±12 people) stated they participate in community decision-making, while 66% (±23 people) do not. Regarding natural resource management, only 17% (±6 people) of respondents acknowledged involvement in decision-making processes, while 83% (±29 people) are not involved. These findings indicate that fishers role in community decision-making

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remains low, and they are even less involved in decision-making related to natural resource management.

Reserves

Asset diversification as a form of reserves can play an important role in enhancing local-level growth capacity (Kaur 2020). Figure 7 illustrates various types of reserves owned by individuals or households in coastal communities. Survey results show that access to electricity is possessed by all respondents (35 people), as well as television and gas stove ownership reaching 100%, indicating that basic needs related to lighting, information, and cooking facilities have been universally met. Land or property ownership in the village is also very high at about 34 respondents, indicating a level of productive asset stability at the household level. Meanwhile, about 28 respondents own motorcycles, reflecting fairly good mobility levels. However, ownership of technological assets such as smartphones is only possessed by about 10 respondents, revealing significant gaps in digital access. In other household equipment aspects, refrigerators are only owned by about 7 respondents, and about 16 respondents own fans, suggesting limited financial capacity to meet comfort appliance needs. On the other hand, only 3-4 respondents have private wells, while about 26 respondents rely on water pumps, showing dependence on managed water sources that are not individual in nature. Overall, this data structure reflects that although basic needs have been met for almost all households, there is disparity in ownership of economically valuable assets and technology, which can be an indicator of varying welfare levels among households in the community.

Fisher Empowerment Strategy

After conducting comprehensive regional profiling, including its socio-ecological context characteristics, and identifying its strengths and problems, the next step is determining the best way to face various challenges and establish direction toward sustainability. It is important to formulate a collective vision with appropriate strategies and objectives, accompanied by innovative ideas that can drive job growth, environmental conservation, community welfare, and maintain such 'stability' in the years to come. We analyzed interview results using ATLAS.ti in-depth interviews with A-B-G-C (academics, business, government, and community) roles for key respondents to obtain a factorial structure for supporting strategies for small-scale fishers, as shown in Figure 2.

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Research findings from 35 respondents consisting of fisher-laborers and small-scale fishers in Tembakrejo waters show that fishing ground protection is a key factor supporting their livelihood sustainability. Respondents identified the Tambakrejo area as the main fishing location still rich in resources such as pony fish, mullet, sea catfish, wild milkfish, shrimp, mud crabs, and various types of shellfish (such as mussels and clams), making the existence of this area very important for maintaining small-scale fisheries productivity. This finding aligns with literature emphasizing that fishing ground protection plays an important role in maintaining ecological and economic sustainability of small-scale fisheries.

Implementation of Minister of Marine Affairs and Fisheries Regulation No. 31 of 2020 concerning Marine Conservation Area Management influences fisheries spatial utilization dynamics in Tembakrejo. Local government then proposed the establishment of Tambakrejo Marine Park, which brings new regulatory consequences for coral reef utilization and fisher activities. Some respondents consider that infrastructure development and conservation potentially support fisheries sustainability, but they also express concerns about estuary siltation and increasingly difficult dock access—a condition directly impacting fisher-laborers' and small-scale fishers' work efficiency. This finding is consistent with Stacey et al. (2021) emphasizing the importance of fisheries infrastructure as a main support for small-scale fisher livelihoods.

From the community empowerment perspective, respondents consider the need for periodic evaluation of conservation and coastal development policies to ensure such policies do not hinder small-scale fishers' economic activities. Most respondents also emphasize the importance of livelihood diversification, especially during lean seasons, aligning with González & Antelo (2020) regarding the need for alternative employment

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for coastal communities. In the Tembakrejo context, potential development of aquaculture and marine tourism activities is viewed as an opportunity to expand fisher household income sources if managed inclusively.

Research findings also confirm that women play significant roles in fisheries supply chains, especially in post-harvest stages. Respondents conveyed that women's empowerment, both through catch processing training and small business support, can strengthen fisher family economic resilience. This aligns with research by Harper et al. (2013), Febri et al. (2017), and Kusumawardhani & Susilowati (2021) emphasizing the importance of gender inclusion in fisheries management.

Work safety aspects also emerge as important issues. The majority of small-scale fishers and fisher-laborers interviewed admit they lack adequate access to life or health insurance, despite being aware of high work risks at sea. This condition indicates the need for more comprehensive social protection based on risk characteristics of fisheries sector work. Respondents consider that fisheries policy effectiveness is greatly influenced by communication patterns between fishers and policymakers. The lack of formal communication channels causes some policies to be deemed less suited to local needs. This reinforces the importance of coastal community participation in planning and decision-making.

Overall, research findings in Tembakrejo show that livelihood sustainability of fisher-laborers and small-scale fishers is highly dependent on fishing ground protection, infrastructure support, economic diversification, women's empowerment, social protection, and active community involvement in fisheries policy processes.

DISCUSSION

Fisher-laborers and small-scale fishers in Tembakrejo are in highly vulnerable positions to various environmental, social, and economic changes. This vulnerability requires contextual categorization of the types of risks faced. This aligns with the views of Buckle (1998), Paul (2014), and Havrilla (2017) that all community groups—both men and women, old and young, and various social statuses—can experience vulnerability in different forms, necessitating measurable and targeted vulnerability assessment mechanisms.

In this research, vulnerability factors were classified according to Nayak & Berkes (2019) framework dividing vulnerability into material, relational, and subjective dimensions. Field findings show that Tambakrejo fishers vulnerability perceptions are specific to local conditions. In this case, natural factors, especially seasonal changes and extreme weather, become the greatest pressure source for small-scale fishers. This finding is consistent with Hidalgo et al. (2018) research confirming that seasonal uncertainty makes fishers increasingly vulnerable to climate change impacts.

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Tambakrejo research findings actually strengthen D'Silva et al. (2012) findings that long experience does not always align with increased adaptive capacity. Small-scale fishers with more than 15-20 years of experience tend to persist with traditional fishing techniques and are less responsive to innovations such as catch diversification, use of new fishing gear, or utilization of navigation and weather information technology. This attitude aligns with Mohamed et al. (2015), who found that experienced fishers often remain in their 'comfort zone' and view modern technology as disruptive to their routines. In the Tambakrejo context, most respondents stated that modern technology use is not considered a priority and is even perceived to potentially hinder daily work effectiveness.

From external pressure perspectives, Andrews et al. (2021) show that small-scale fishers are vulnerable to impacts from large industry expansion such as oil or mass tourism. However, this research shows that Tambakrejo fishers relatively do not face such pressure types because there has not been significant large industry expansion around Tambakrejo. This situation makes ecological and seasonal factors the main sources of vulnerability, rather than pressure from corporations or coastal spatial plan changes.

Tambakrejo fishers adaptation strategies also show interesting tendencies. Although migration often becomes an effective adaptation strategy to respond to climate change, as stated by Islam (2014), respondents in this research show strong preferences not to migrate. They choose to continue fishing in the same area despite declining catches in certain seasons. Social attachment, residential location, and limited access to capital become main reasons preventing fishers from considering spatial mobility as an adaptation strategy. Socio-economic vulnerability is also reinforced by low awareness of social protection. Most respondents do not have health insurance or work safety insurance, despite very high work risk levels. This low insurance utilization level aligns with Rani (2016) findings and illustrates that social protection has not been considered an urgent need by small-scale fishers in Tambakrejo.

Building adaptive capacity to respond to small-scale fisher vulnerability in Tambakrejo requires complex adaptive responses. For example, efforts to manage climate change impacts through increasing resource access and developing alternative livelihoods may demand additional adaptation in other systems, such as local culture, community values, and institutions. Interconnected feedback in social system adaptive capacity in this research area indicates the need for continuous review and response processes. Understanding vulnerability, responses, and adaptive capacity can become the initial basis in establishing strategic policies to support sustainable transitions.

In efforts to build fisher resilience against vulnerabilities they face, fisher empowerment and adaptive capacity strengthening become very important (Kaur, 2020). Key informants consider that fishing ground protection is an urgent action. To protect

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fishing grounds while creating sustainable environments, local government proposes that coral reefs in Tambakrejo be designated as conservation areas, which can restore marine habitats and rebuild fish stocks. Marine protected areas (MPA) can provide benefits for conservation and fisheries, especially in areas experiencing overfishing pressure, as commonly occurs in many coastal regions (Cabral et al., 2020). Key informants also highlight that port infrastructure conditions remain concerning. Fisher empowerment policies aimed at long-term sustainability are appropriate choices (Courtney et al., 2017), but need to be accompanied by evaluation and monitoring to ensure such policies relevant.

In facing weather uncertainty and government policies, fishers tend to take side jobs as buffer strategies. Key informants suggest the importance of encouraging work diversification for fishers and women's empowerment to support family economies. Additionally, insurance is very important, considering fisher work has high risks and is vulnerable to accidents and disasters. Fishing activities cannot be separated from work accident risks, loss of life, boat and equipment damage, and crew health and safety risks of crew members (Mustikasari & Relawati, 2021). Weather and natural conditions can also damage fishing equipment such as boats or nets making them unusable, which becomes one cause of livelihood loss for fishers and their families (Safitri, 2018).

In general, this research confirms that the socio-ecological vulnerability of Tambakrejo fishers is not only caused by environmental factors but also by economic structures and local institutions that have not fully supported small-scale fisher adaptive capacity enhancement. Thus, policy interventions directed toward strengthening production assets, increasing financing access, and providing more efficient fishing technology become priorities for sustainably reducing coastal community vulnerability levels in Tambakrejo.

CONCLUSION

Analysis results show that vulnerability levels of fisher-laborers and small-scale fishers in Tambakrejo waters are mainly influenced by natural and social factors. This vulnerability is reinforced by weather uncertainty, fish seasonal changes, fishing gear limitations, and low bargaining positions of small-scale fishers in coastal economic structures. Adaptive capacity becomes an important indicator in understanding such vulnerability while reflecting community ability to survive and recover from environmental and economic pressures.

Adaptation strategies emerging from respondents remain limited to livelihood aspects, such as seeking alternative employment in tourism sectors, small boat repair services, or other seasonal activities. Although dependent on natural resources, such economic opportunities remain realistic choices for fisher households in Tambakrejo.

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Other forms of adaptive responses include strengthening social networks through fisher groups, utilizing local organizations as information channels, and desire to be more actively involved in decision-making processes related to coastal environmental management.

Overall, identifying vulnerability and adaptive capacity is important for formulating coastal community resilience strengthening strategies amidst uncertainty conditions. Further research is needed in different areas and fisher groups to enrich understanding of vulnerability perceptions and adaptive capabilities, so that formulated policies can be more targeted and responsive to local needs.

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