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SMALL-SCALE MARINE FISHERMEN LIVELIHOOD VULNERABILITY TO SOCIAL-ECOLOGICAL DYNAMICS: CASE STUDY AT COASTAL OF BATANG, INDONESIA

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Abstract

Socio-ecological changes in coastal areas impact the livelihoods of small-scale fishers. This study aims to determine the livelihood vulnerability of small-scale fishers due to socio-ecological changes. This study uses a quantitative approach with the Livelihood Vulnerability Index (LVI) to measure small-scale fishers' livelihood vulnerability levels. This study used 184 small-scale fishers as samples with purposive sampling. The analysis results show that the highest level of livelihood vulnerability occurs in Roban Barat Fishermen, with an index value of 0.540. The LVI's main components show that the most vulnerable is dependence on the fishery sector in all research areas. Meanwhile, judging from the research area on small-scale fishers in Roban Barat, the highest contributing factor is Sensitivity, with an index value of 0.5778. Meanwhile, in other locations, the element that contributes the most to vulnerability is Adaptive Capacity. On the other hand, to reduce the exposure of small-scale fishers, the government can improve resources in coastal areas.

Keywords: Socio-ecological change, Vulnerability, Marine Fishermen, Livelihood

INTRODUCTION

This study aims to determine the level of vulnerability of small-scale fishers' livelihoods due to socio-ecological changes. Socio-ecological systems are complex and integrated systems in which humans and nature are interdependent and are formed by each other (Hossain et al., 2020). The concept of a socio-ecological system openly recognizes the deep relationship between humans and nature. Human actions affect the form and function of ecosystems, which in turn provide humans with ecosystem goods and services for welfare (Cinner & Barnes, 2019). The fishing community is an example of a socio-ecological system (SES), which consists of human and biophysical subsystems closely related and highly dependent on the environment (Silva et al., 2020). Instability and changes in socio-ecological systems can affect human well-being (Sampantamit et al., 2020)

Nearly half a billion people earn a living from the fisheries sector, which provides about 15% of animal protein and supports the livelihoods of 10-12% of the world's population (Barua et al., 2020). More than 90% of the world's fishers are small-scale and located in developing tropical countries (Teh et al., 2020; FAO, 2020). Small-scale fisheries serve as economic and

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social drivers, nutrition and food security, employment opportunities, and multiplier effects on the local economy and provide life support for communities in coastal areas (FAO, 2019).

Despite the important role of small-scale fisheries as a driver of local economies, this sector is increasingly marginalized and vulnerable worldwide (Short et al., 2021; Sumaila et al., 2019). The fisheries sector is impacted by climate change worldwide (Finkbeiner et al., 2018), especially in small-scale fisheries that experience other non-climatic threats such as overfishing, habitat loss, pollution, and other disturbances (Eriksson et al., 2018). Therefore, small-scale fishers are very vulnerable to socio-ecological changes. Small-scale fishers are vulnerable to global and local change processes, given their high dependence on natural resources and strong attachment to coastal areas (Arkham et al., 2022; Fabinyi et al., 2022). In addition to human factors, climate change adds to the threat to capture fisheries, threatening the livelihoods of small-scale fishers in coastal areas (Hidayati et al., 2021; Osman et al., 2021; Rahman et al., 2021).

Globally, early research on fishers' livelihoods centered on the issue of fishers' ability to sustain sustainable livelihoods in the context of diminishing fisheries resources due to overfishing. (Sumaila et al., 2019). Several studies have attempted to assess the livelihood status of marine fishers concerning external biophysical drivers (e.g., climate change, storm surges, and ocean acidification) in recent years (Ankrah, 2018; Sowman & Raemaekers, 2018). However, studies on the livelihoods of marine fishers in the context of socio-ecological dynamics are still relatively few (Freduah et al., 2017).

In general, previous research can be divided into two categories: a study based on vulnerability (Alves & Mariano, 2018; Macusi et al., 2021) and an analysis based on livelihood capital (Apine et al., 2019; Yamazaki et al., 2018). This study combines the vulnerability assessment framework and the concept of livelihood assets into a modified framework for assessing the vulnerability of fishers' livelihoods and then analyzes the differences that underpin the vulnerability of fishers' livelihoods in various ways. The findings of this study are useful for policymakers who assist fishers in building sustainable livelihoods.

In both global and local contexts, coastal areas are very important for human settlements, human well-being, and economies (Lin & Pussella, 2017; Neumann et al., 2017; BPS, 2020). Around 60% of Indonesians live and depend on coastal and oceanic areas (Inara, 2020), where their livelihood is fishing as fishermen dominate the people who live and live in coastal areas (Anggraini, 2018). One of the coastal areas on the north coast of Java is the coast of Batang Regency. Batang Regency is a development location for one of the national strategic projects in the energy sector, namely the construction of a coal-fired Steam Power Plant (PLTU) with a capacity of 2x1000 MW which is part of the program to increase the capacity of the Java-Bali electricity system.

The location of the PLTU construction in the coastal area of Batang Regency creates shock and pressure on the lives of fishers. In addition to the economic blessings created by the construction of the PLTU, including changes in the community's economy such as the creation of jobs for the community and business opportunities around the location, this is not the case

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for fishers who feel decreased fish catches and environmental damage (Prabandari & Rengga, 2018). Likewise, the results of research by Pramanik et al., (2020) concluded that the construction of the PLTU in Batang Regency has an impact on the destruction of the ecosystem and the economy of the surrounding community as new job opportunities are opened. However, fishermen can no longer catch fish and other marine animals due to the destruction of the ecosystem. This phenomenon indicates a socio-ecological business in the coastal area of Batang Regency. These changes may affect the livelihoods of small-scale fishermen.

Based on the explanation above, this research was conducted to determine the level of vulnerability of small-scale fishermen. This research is a quantitative study using primary data obtained by questionnaire, and a Livelihood vulnerability index (LVI) analysis was conducted to find out the vulnerability level of small-scale fishermen in the research area so that the authorities can take policies to reduce the vulnerability of small-scale fishermen according to the condition of their vulnerability.

LITERATURE REVIEW

Fishery Livelihood Vulnerability Concepts

Fisheries are all activities related to managing and utilizing fish resources and their environment, from pre-production, production, and processing to marketing, which are carried out in a fishery business system (BPS, 2020). Small-scale fisheries are used to describe the sub-sector and distinguish it from medium and large-scale fisheries. FAO (2018) defines small-scale fisheries as traditional fishing involving fishing households, relatively small capital and labor used, relatively small fishing boats/boats, short fishing trip times, proximity to the coast, and mostly local consumption. Meanwhile, to describe the category (scale) of small fisheries, the State of Indonesia uses the term small fisherman as stated in Law Number 7 of 2016. The document defines small fishers as those who fish for their daily needs, whether they use fishing vessels or not, with a maximum size of 10 (ten) gross tons (GT). Thus, small-scale fishermen are people who have a livelihood catching fish by using boats, fishing gear, and relatively small capital with a short time and fishing locations not far from the coast.

The definition of vulnerability generally refers to the potential for loss. However, vulnerabilities are often identified and defined from a sectoral or thematic specific point of view, for example, only focusing on the environment, food security, gender, etc. (Puteri et al., 2017). According to (Kim et al., 2021), vulnerability is a state of vulnerability to danger due to exposure to stress associated with environmental and social changes and the absence of the ability to adapt. On the other hand, the vulnerability of Nayak & Berkes (2019) in the context of small-scale fisheries is distinguished in several ways, namely; (1) vulnerability can be seen as the absence of well-being; (2) capital or resources become the basis for individuals in determining their position of vulnerability; (3) building resilience is a way to overcome vulnerability. Vulnerability is also considered a system condition that refers to its vulnerability to changes from a combination of socioeconomic factors and environmental stresses. Vulnerability can also be seen in the lack of access to capital, human, physical, natural, social, and financial assets (Ansah et al., 2019)In addition, the vulnerability stems from the loss of

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system resilience, the capacity to absorb disturbances and adapt when changes occur to maintain the same function, structure, identity, and feedback (Timmer et al., 2021). Stress refers to unexpected changes and disruptions to livelihoods.

Livelihood is how to make a living to live (Omitoyin et al., 2021). The study of Jakariya et al., (2020) found that coastal communities face various environmental pressures and shocks that affect their ability to survive. Socio-ecological changes in coastal areas can cause small-scale fishermen to experience livelihood vulnerability because, in general, people living in coastal areas depend on coastal and marine ecosystem resources. It is widely recognized that these resources contribute to society, culture, and the economy, especially regarding employment, food security, and income (Cojocaru et al., 2022; Thomas et al., 2021; Zamzami et al., 2020). Sources and causes of vulnerability of coastal communities include limited availability of resources, overfishing, excess capacity, poor governance, and large-scale factors such as climate change, competition with the fishing industry, global markets, urban development, and land transformation (Edwards et al., 2019; Fabinyi et al., 2022; Mafaniso, 2022). Research on vulnerability in socio-ecological systems has been carried out in social science disciplines such as human geography (Turner et al., 2020). The framework proposed by the Intergovernmental Panel on Climate Change (IPCC) has been widely adopted to assess the level of vulnerability, including the livelihoods of individuals and communities. The framework suggests that the vulnerability measure consists of exposure, sensitivity, and adaptive capacity indicators to identify the relationship between social response and ecological change (Zhang et al., 2018; Nagy et al., 2018).

This research uses the concept of livelihood assets. The idea is derived from the sustainable livelihoods approach, a people-centered approach that can be used to establish principles and as an analytical tool to evaluate the livelihood levels of certain groups (Zhang et al., 2019). In the sustainable livelihoods approach, livelihoods are defined as capabilities, assets, and activities needed for living (Su et al., 2019) and livelihood assets consist of 5 (five), namely natural, physical, financial, human, and financial capital social (Gai et al., 2018; Yoade et al., 2020). In general, previous research can be divided into two categories: an analysis based on vulnerability (Alves & Mariano, 2018; Macusi et al., 2021) and livelihood capital (Apine et al., 2019; Yamazaki et al., 2018). This study combines the vulnerability assessment framework and the concept of livelihood assets into a modified framework to assess the vulnerability of fishermen's livelihoods and analyze the differences that underlie the vulnerability of fishermen's livelihoods at the study sites.

Indicators of Livelihood Vulnerability of Small-Scale Fishermen

IPCC exposure is defined as a degree of natural and social pressure on the livelihoods of marine fishers (Turner et al., 2020). Natural disturbances faced by fishers mainly include recession of fishery resources, environmental pollution sea, maritime natural disasters, and the loss of the nearest fishing ground (Mulyasari et al., 2020; Ordoñez-Gauger et al., 2018). The social disturbance is mainly measured by investigating whether fishers' families suffer from property losses, illness, and decreased income (Chen et al., 2020). The sensitivity indicates the possibility that fishers' livelihoods are affected by the impact of external threats. The sensitivity

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index is usually measured by job dependence, housing dependence, and income dependence (Su et al., 2019).

Exposure and sensitivity represent the potential impact of a stressor, fully experienced in the long term, depending on the adaptive capacity of the entity (Thiault et al., 2018). Adaptive capacity is the ability of fishermen to respond to and recover from the potential impact of stressors. Fishers' adaptive capacity can be divided into five categories based on their livelihood assets: natural capital, physical capital, financial capital, human capital, and social capital (Chen et al., 2020).

Table 1: Dimensions, Components and Measurement of Fishermen's Livelihood Vulnerability

Dimensions	Component	Sub Components	Measurement
Exposure	Natural Disturbance	○ Decrease in fish resources	very serious = 5, serious = 4, average = 3, slightly = 2, not affected = 1
		○ Weather (high waves, storms, etc.)	
		○ Marine pollution	
	Social Disturbance	○ Decrease in income	%
		○ Loss of property	yes=1; no =0
		○ Have you ever had a serious illness	yes=1; no =0
Sensitivity	Dependency of fishery	○ The share of income from the fishery sector is	very large=4, large=3, small=2, very small=1
		○ Portion of family members working in the fishing	sector is divided by the total share of
		○ income for fishing activities	%
	Dependency on Local Residence	○ Desire to move/migrate	yes=1; no =0
Adaptive Capacity	Social Capital	○ Have friends who both look for fish in the sea	yes=1; no =0
		○ Have relatives as village	officials yes=1; no =0
		○ Be a member of a fishing organization or other	yes=1; no =0
		○ number of family or friends you can turn to for help	Numerical
	Economic Capital	○ The average price of fish caught	is very high=4, high=3, low=2, very low=1
		○ The ease of getting a loan from a financial institution is	very easy=4, easy =3, difficult = 2, very difficult = 1
		○ ease of getting help from family/friends	very easy = 4, easy = 3, difficult = 2, very difficult = 1
		○ opportunity to get subsidies from the government	is very large = 4, large = 3, small =2, very small=1
	Human Capital	○ workforce	numerical
		○ Long Time Become a	numerical
		○ Have you ever received training	yes=1; no =0
	Natural Capital	○ coastal environment is in good condition	yes=1; no =0

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Dimensions	Component	Sub Components	Measurement
		○ The size of the fishing area	is very wide = 5, wide = 4, moderate = 3, narrow = 2, very narrow = 1
	Physical Capital	○ Number of rooms in the house owned by	one room = 1, two rooms = 2, three rooms = 3, four /more =4
		○ Own boat	yes=1; no =0
		○ owns fishery processing equipment	yes=1; no = 0

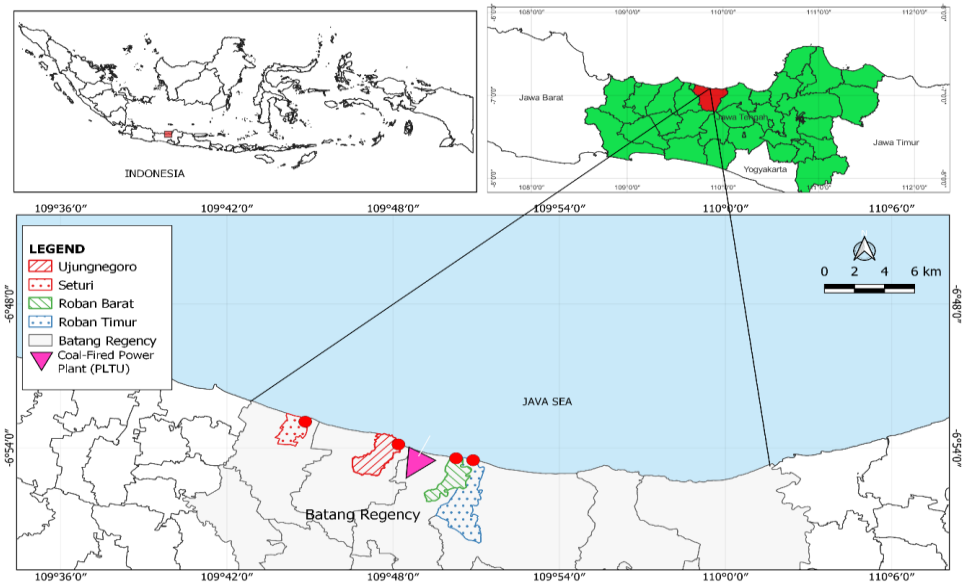
Source: Chen et al., (2020), Mulyasari et al., (2020)

MATERIAL AND METHOD

Study area

This research uses a quantitative approach carried out in fishing villages, namely Seturi, Ujungnegoro, Roban Barat, and Roban Timur Districts Batang, located on the north coast of Java, Central Java province, Indonesia (Figure 1). Most fishers on the coast of Batang Regency are small-scale fishers dependent on coastal resources. Socio-ecological changes can impact the availability of fish and other marine biotas, disrupting small-scale fishers' livelihoods.

Figure 1: Study Area on the coast of Batang Regency



Source: Author by Quantum GIS Application

Data analysis technique

A total of 184 small-scale fishers were taken as samples by purposive sampling. Furthermore, the data is analyzed with index numbers to see the level of vulnerability of small-scale fishers' livelihoods. The data analysis method used in this research is quantitative analysis. Quantitative

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analysis is data analysis used to solve problems related to the amount (numbers and data) (Ardiansyah et al., 2019). The livelihood vulnerability index (LVI) was used in this study to assess the livelihood vulnerability of fishers. The LVI method is flexible in adding or removing indicators and can be applied to any community. The LVI method involves two approaches, namely; (1) calculating LVI as a composite index of principal components and; (2) another approach that presents the main components in the IPCC. The approach is determined by three main factors (exposure to change, sensitivity to change, and adaptive capacity to change) to vulnerability (Sadekin et al., 2021).

Before calculating the index value, the data is normalized first because the sub-components are measured with different scales (e.g., percent, numeric, Likert scale) using the index formula (Sadekin et al., 2018; Priyadarshi et al., 2019; Zacarias, 2019; Poudel et al., 2020; Venus et al., 2022) as follows:

$$\text{index } S_d = \frac{S_d - S_{min}}{S_{max} - S_{min}} \qquad (1)$$

Description:

Index S_d = sub-component index

S_d = mean value of sub-component

S_{min} = minimum value of sub component

S_{max} = maximum value of sub-components

After all sub-components are standardized, the value of each main component is calculated by the following equation (Sadekin et al., 2018; Poudel et al., 2020):

$$M_d = \frac{\sum_{i=1}^{n} \text{Index } S_{in}}{n} \qquad (2)$$

Description:

Index Sdi = index of sub-component

M_d = value of the main component

n = number of sub-components

then calculate the value of the livelihood vulnerability index based on the main component with the following formula Chen et al., (2020);

$$Ex, Se, AC = \sum_{i=1}^{n} W_i Y_i \qquad (3)$$

Where Ex, Se and AC show the value of exposure, sensitivity, and adaptation capacity. While Wi shows the weight of each component and Y indicates the value of each principal component that has been normalized. Furthermore, vulnerability (FLVI) can be determined from the following equation (Chen et al., 2020; Dzantor et al., 2020):

$$FLVI = (Ex + Se - AC) \qquad (4)$$

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Note:

FLVI = fishermen livelihood vulnerability index

Ex = exposure index

Se = sensitivity index

AC = Capacity Index

In the calculation of FLVI, EI, SI, and ACI are treated equally, and each is normalized with a scale of 0-1. To divide the FLVI score into three levels as presented in Table 2,

Table 2: Vulnerability Score

Score Range	Category
0.1 – 0.3	Low
0.31 – 0.50	Medium
0.51 – 1.00	High

Source: Jakariya et al., 2020; Chen et al., 2020

RESULT RESEARCH

Characteristics of Fishermen

The profiles of fishermen in this study consist of age, education level, number of families, experience as a fisherman, and frequency of fishing per month and the weight of the boat used, as can be seen in Table 3.

Table 3: Characteristics Respondents (Mean)

Characteristics	Description	Fishing Village			
		Seturi	Ujungnegoro	Roban Barat	Roban Timur
Age	year	42.02	44.83	41.44	44.86
Education	year	6.00	5.50	5.76	5.45
Family size	Natural number	3.36	3.58	2.94	3.18
Household income	Million rupiah per mont	2.38	2.11	2.58	2.45
Frequency of fishing/month	Trip	23.18	19.12	20.40	19.08
Weight vessel	Gross Tone (GT)	7.2	5.62	5.08	6.5

Source: primary data, 2022

Based on table 3, be explained that the characteristics of fishermen in 4 (four) fishing villages have an average age, education level, family size, household income and experience as fishermen who are not far away. At the same time, the intermediate fishing frequency and the boat's size are different. The average number of times to go to sea in one month is between 19

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and 23; this shows that small-scale fishermen in the study area do daily fishing. The average size or size of vessels used by small-scale fishermen in the study area is between 5 – 7 GT. The size of the boat indicates the ability to fish farther from the coast and to hit ocean currents.

LVI Small-Scale Fishermen

A vulnerability study was conducted to determine the extent to which small-scale fishers on the coast of Batang Regency, which is adjacent to the PLTU area, are vulnerable to socio-ecological changes. Vulnerability assessment is a tool for assimilating and analyzing social, ecological, and economic information relevant to marine fisheries, helping to define priority areas for action and implementing adaptation strategies (Jara et al., 2020; Thiault et al., 2018). The level of vulnerability of small-scale fishers can be measured by the Livelihood Index (LVI) as applied by Chen et al., (2020) by determining the main components and subcomponents. The main features are a natural disturbance, social disturbance, dependence on the fisheries sector, dependence on housing, social capital, economic capital, human capital, natural capital, and physical capital with 26 sub-components. LVI calculations were carried out for four fishing village locations: Seturi, Ujungnegoro, Roban Barat, and Roban Timur. Several steps in calculating the LVI index are normalizing the values for each sub-component, calculating the composite index for each factor of exposure, sensitivity, and adaptation capacity

The results of the measurement of the livelihood vulnerability index of small-scale fishermen in the study area can be seen in Table 4.

Table 4: LVI of small-scale marine fishermen

Major component	sub-components	seturi	Ujungnegoro	Roban Barat	Roban Timur
Natural disturbance	3	0.6611	0.3762	0.6652	0 ,1575
social Disturbance	3	0.1794	0.2447	0.2615	0.1752
Exposure		**0.4203**	**0.310408**	**0.463322**	**0.166373**
Dependency on fisheries	3	0.6126	0.5592	0.7496	0.6158
on local residence	1	0.0400	0.0833	0.0625	0.0458
Sensitivity		**0.4695**	**0.4402**	**0.5978**	**0.37392**
Social Capital	4	0.5307	0.4911	0.5039	0.5771
Financial capital	4	0.4800	0.5417	0.5326	0.5491
Human capital	3	0.2546	0.3776	0.3458	0.3493
Natural capital	2	0.5700	0.5677	0.4473	0.2733
Physical capital	3	0.6860	0.4722	0.6441	0.7100
Adaptive capacity		**0.5003**	**0.4884**	**0.5006**	**0.5143**
FLVI		**0.3894**	**0.25621**	**0.5405**	**0.125621**
		Medium	Low	High	Low

Source: primary data, 2022

Table 4 shows the level of vulnerability of fishermen's livelihoods in 4 (four) research locations tian shows that the vulnerability category "High" occurs in Roban Barat. The “moderate” type occurs in Seturi fishermen, and the low vulnerability category appears in Ujungnegoro and Roban Timur. The highest LVI value is Roban Barat, with an index value of 0.5405. Of the main components forming the LVI, the element that most contributes to livelihood

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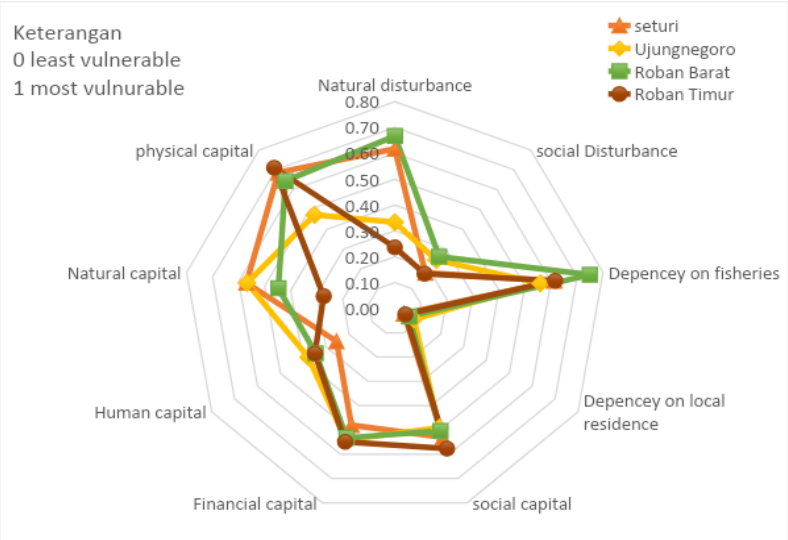
vulnerability is dependence on the fisheries sector in all research locations, as seen in Figure 2.

Figure 2: Spider Diagram of the vulnerability index of the main components



Source: Primary data, 2022

Based on Figure 2, the most vulnerable sub-component depends on the fishery sector, while the lowest is the population. The data shows that the small size of the research area is very dependent on fishery resources, where the condition of the coastal ecosystem greatly affects fishery resources. However, small fishermen still survive/live in coastal areas. Therefore, if the shape of the coastal ecosystem in the Batang Regency decreases, it will have an impact on reducing fish resources so that the livelihoods of small-scale fishermen will be increasingly threatened. So this will impact most fishermen in the research area because they do not have other skills besides working in the fisheries sector and have low levels of education. The main component forming the level of vulnerability in the research area was highest for fishers in Roban Barat, followed by Roban timur, Seturi, and Ujungnegoro. For the Natural Disturbance component, the highest occurred in fishers in Roban Barat, while the lowest occurred in fishers in Roban Timur. For the natural capital component, the highest is fishers in Ujungnegoro, and the lowest is in Roban Timur. The contribution of each LVI-forming factor can be made with a triangle diagram as follows.

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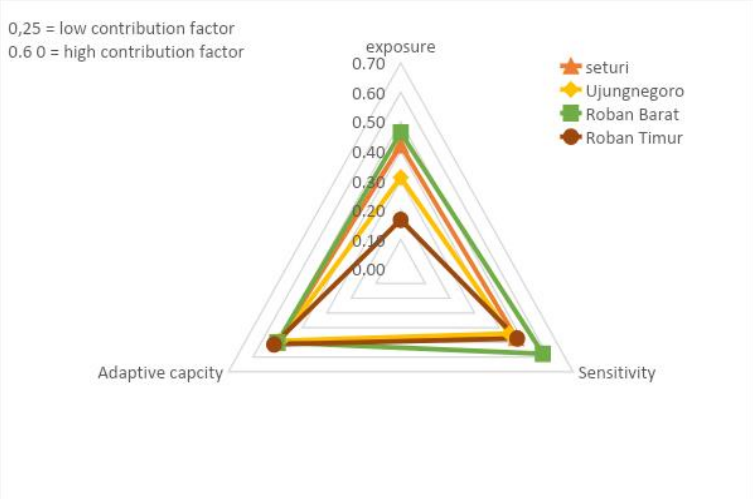
Figure 3: Triangle Diagram of the contribution of vulnerability factors



Source: Primary data, 2022

From Figure 3, the contribution of each LVI-forming factor is Exposure, Sensitivity, and Adaptive Capacity. The highest contributing factor to the level of vulnerability is exposure to fishers in Roban Barat, and the lowest is to fishers in Roban Timur. Based on the research area, the highest contributing factor to the vulnerability of small-scale fishers in Roban Barat is Sensitivity, with a value of 0.5778. Meanwhile, it is Adaptive Capacity in Roban Timur, Seturi, and Ujungnegoro. Fishers in Roban Timur have the largest adaptive capacity with an index value of 5143. Fishers in Roban Timur have the largest adaptive ability with an index value of 5143. The index shows that Roban Timur has a better adaptive capacity to socio-ecological changes than fishers in other locations. Adaptation capacity is reduced from exposure and sensitivity so that the higher the adaptation capacity of fishers to socio-ecological changes, the lower the level of vulnerability of fishers' livelihoods.

DISCUSSION

Fishers are a community group with a high vulnerability to changes in the availability of surrounding resources (Hafsaridewi et al., 2019). Socio-ecological changes can increase the vulnerability of small-scale fishers if there is no effort from various parties to save coastal ecosystems. Previous research has proven that fishers' livelihoods are affected by multiple disturbances such as climate change, resource decline, environmental pollution, and high levels of vulnerability (Freduah et al., 2017). This study considers natural indicators and social disturbances in determining exposure factors and develops a framework for assessing the vulnerability of fishers' livelihoods under socio-ecological stress.

The results of this study confirm that the level of vulnerability with a high category occurs in fishers in Roban Barat and has a high sensitivity to the fisheries sector. The result is in line with the explanation research (Freduah et al., 2017), which found that the vulnerability of fishers' livelihoods is influenced by dependence on fisheries and the availability of alternative

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livelihoods. In addition, the uncertainty of fishery income can also increase the sensitivity of fishers (Apine et al., 2019). Fishers' livelihood assets are a key factor in reducing the livelihood vulnerability of small-scale fishers as a form of adaptation capacity. Livelihood assets have different effects on increasing adaptive capacity. For example, fishers with high social capital get information more quickly to determine and adjust strategies in the face of change (Chen et al., 2020). People are often more resilient to socio-ecological changes when they access various financial, technological, and service-related assets (e.g., health care). As a result of climate change, many important fishery species are shifting farther from the coast.

Fishers with access to financial and technical assets can keep up with these fishery stocks by purchasing larger boats and freezers, enabling them to go on fishing expeditions longer and farther. As a result, it is generally believed that the rich are more resilient and better able to adapt to change. However, due to socio-ecological relationships, assets that enhance people's ability to exploit natural resources can weaken resilience by undermining the long-term viability of ecosystems (Cinner & Barnes, 2019). Thus, this exploitation capability can be detrimental to fishing communities long-term if no good coastal resource management effort exists. In this part, the government is important in protecting coastal resources and all their contents, including small-scale fishers.

CONCLUSION

From a disaster perspective, vulnerability is considered a function of exposure, sensitivity, and adaptive capacity. The concept of livelihood assets is used in this study. The idea stems from the sustainable livelihoods approach, which defines livelihood as the capabilities, assets, and activities required for survival, which include natural capital, physical capital, financial capital, human capital, and social capital. To identify the vulnerability of small-scale fishers in the study area using the Livelihood Index (LVI).

The analysis results show that the highest level of livelihood vulnerability occurs in Roban Barat Fishermen, with an index value of 0.540. The main components forming the LVI show that the most vulnerable is dependence on the fishery sector in all research areas. Meanwhile, judging from the research area on small-scale fishers in Roban Barat, the highest contributing factor is Sensitivity, with an index value of 0.5778. Meanwhile, the element that contributed the most was Adaptive Capacity in other locations. The findings illustrate that Roban Barat is more affected by socio-ecological changes than fishers elsewhere.

The highest adaptive capacity is the Timur Roban, which means that the Roban Timur has better adaptability in dealing with socio-ecological changes. Adaptation capacity is reduced from exposure and sensitivity, so the higher the adaptive capacity of fishers to socio-economic-ecological changes, the smaller the vulnerability of fishers' livelihoods. This study focuses on vulnerability due to socio-ecological changes with the concept of livelihood assets for marine capture fishers.

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