Fishermen's resilience-based management policy on small islands

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Abstract. Community resilience and resource management are closely related, particularly when it comes to preserving social, economic, and environmental well-being in small islands. Policies and regulations that promote sustainable resource management also contribute to the development of more resilient communities. Identifying the indicators also rely on the context of the resilience measured. The purpose of this study is to measuring Fishermen's Resilience in a Policy Framework. Resilience was calculated by comparing scores obtained with maximum scores of resilience index. For data collection, survey method was conducted in Karimunjawa Islands, Central Java Province, Indonesia. The five dimensions of resilience used are social, economic, institutional, infrastructure, and resource. The results presented two categories of resilience namely sufficiently resilient and resilient. Fishers in the category of resilient are fishers in Karimunjawa, Kemujan, and Parang. Fishers in Nyamuk Island are in the category of sufficiently resilient. To enhance the resilience of small-scale fishermen on small islands, the following strategies are recommended: diversify livelihoods, strengthen social protection systems, optimize family and social networks, adapt fishing techniques, strengthen capacity and knowledge, and improve market access and supply chains. This, in turn, will ensure more sustainable fisheries and stronger, more resilient coastal communities in the long term.

1 Introduction

Fishers in small islands are considered to be vulnerable, which is due to their dependence on resources, limited jobs, infrastructures, and access to markets. Another factor is weather condition, such as: tidal floods, hurricanes, storm surges, wave activity, sea level rise, ecosystem debasement dan vulnerability to climate change [1], which limits their access to natural resources. This dynamic circumstance encourages fishers in small islands, such as

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Karimunjawa Islands, to adapt to environmental change. The ability to change and adapt influences the fishers' level of resilience.

Karimunjawa Islands are a group of small islands located in Jepara city of central Java. The biodiversity in these islands is protected as the government began to focus on sustaining the ecosystem in those islands. Since 1982, the Karimunjawa islands have been considered as preserved oceanic resources and become a national park named Karimunjawa National Park (KJNT). KJNT is managed by Karimunjawa National Park Bureau/ Balai Taman Nasional Karimun Jawa (BTNKJ). To enable people to benefit from the national park and sustain the resources, the area was organized using a zone system. The oceanic and fishery resources in Karimunjawa islands undergo dynamic changes and offer a lot of potentials, which leads to exploitation using harmful fishing tools. The use of potassium was high from 1991-1995 as demand of shellfish from Hong Kong arose. Another harmful tool was the use of *muroami*, which damages the ecosystem of coral reefs - a natural habitat for fish and other biotas. BTNKJ states that damages on coral reefs before 2003 were caused by fish bombs, *muroami*, and potassium [2]. *Muroami* is a fishing net harmful to coral reefs and is banned by the ministry through Regulation of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number Per02/men/2011. The damages on coral reefs influence the livelihood of fishers in Karimunjawa. The decrease of fish was reported by BTNKJ. In addition to this decrease, the fishing ground has expanded. Initially, the fishing grounds were located around local areas, but the fishers were forced to explore fishing areas outside KJNP. This adjustment is one factor shaping the fishers' resilience.

Simply put, resilience can be defined as a response towards environmental disruptions This response relates to the ability of the system to self-sustain its functions. Resilience is "power" or fisher's' ability to face changes in order to maintain their livelihood in fishing [5]. Efforts to measure a system's resilience are essential to reduce harmful effects as well as to manage disruptions and create an adjustment pattern [6]. Measurable indicators and parameters are needed to understand resilience and benchmarking performance in a community [7]. Resilience is a difficult concept to define particularly in operation [8] and quantification [9], which means that the indicator used to measure resilience cannot be standardized.

There has been no standard measurement of resilience in relation to methods as well as indicators in measuring resilience. Assets owned by fishers (social, economic, institutional, and resources) help shape fishers' resilience. Institutional changes, private sectors, and regulations on resource management will affect the adjustment strategies. Fishers' resilience also affect their capacity to adapt so this strategy will offer the outcomes: reducing vulnerability and sustaining the use of oceanic and fishery resources, which will lead to sustainable management. Other studies on fishers were conducted who discussed the reslience of small fishermen's livelihood [8], and indicator reslience [9].

Resource management policies on small islands need to be based on fishermen's resilience due to several key factors : high vulnerability of small-scale fishermen, increasing pressure on fihermen's living space, vital role of small-scale fishermen in the national fisheries sector and the dyanamics of environmental change. These factors emphasize the importance of developing policies that focus on enhancing the adaptability and resilience of fishermen in facing various challenges in small island areas. With a resilience-based approach, policies are expected to be more effective in maintaining resource sustainability while protecting the welfare of fishing communities. The purpose of this study is to : (1) analyze the level of fishers' resilience fishers in the region, and (2) developing resilience-based management policies.

2 Materials and method

2.1 Time and Location

The research was conducted four populated islands in KJNP area, Karimunjawa Islands of Jepara, Central Java. The four islands are divided as four villages which are Karimunjawa Village, Kemujan Village, Parang Village and Nyamuk Village. The following figure presents the location of research.

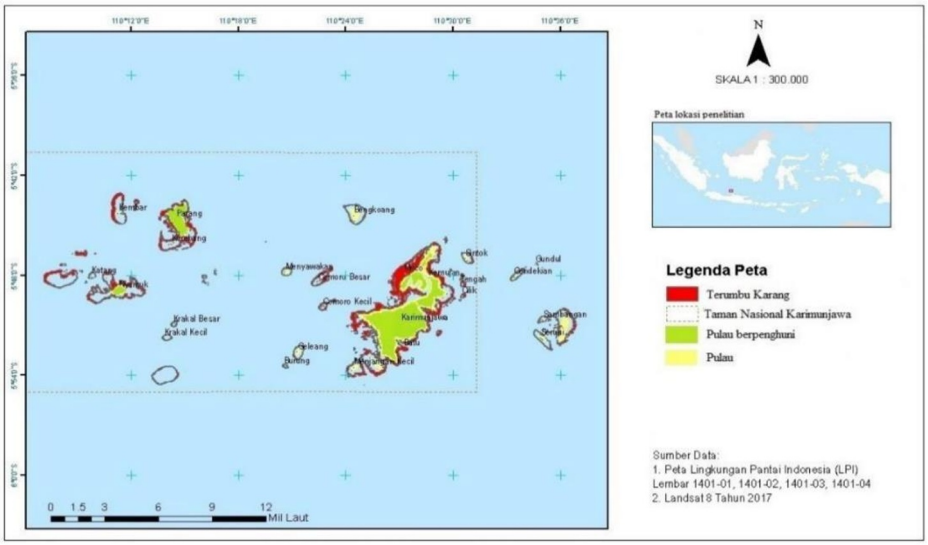


Fig. 1. Classification of resilience level.

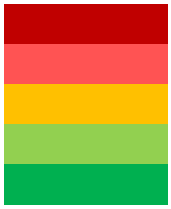
2.2 Methods and data analysis

Survey method was used in this study as it is the most suitable approach in collecting original data describing the field conditions. This study used primary and secondary data. Primary data was collected from in-depth interviews and focus groups. The respondents were fishers in the four islands i.e. Pulau Karimunjawa, Pulau Kemujan, Pulau Parang dan Pulau Nyamuk, and focus groups were attended by representatives of fishers, village leaders, NGO, and fishery supervisors. Secondary data includes information on shellfish production, shellfish biomass, population demography, and socio-economic conditions of Karimunjawa island. Data was collected from literature and documentation from previous studies as well as relevant official documents. Prior to indexing, all data was standardized by collating them based on similarity in scales to enable comparison with other data. This standardization is crucial to avoid bias during measurement [14]. Measurement of resilience index was done using the following formula:

$$RI = \frac{Et}{Emax} \quad (1)$$

Information:
RI = Resilience Index
Et = Resilience score on location t
Emax= Resilience maksimum score

After calculation, level of resilience was categorized using the following *flag model.* There are five categories: no resilient (0.0 – 0.2); low resilience (0.21 – 0.40); sufficient resilience (0.41 – 0.60); resilient (0.61 – 0.80) ; and high resilience (0.81 – 1.00). Categories are color-coded as presented in Fig 2.



0.00 – 0.20	Irresilient
> 0.21 – 0.40	Low resilience
> 0.41 – 0.60	Sufficient resilient
> 0.61 – 0.80	Resilient
> 0.81 – 1.00	High resilient

Fig. 2. Classification of resilience level.

3 Result and discussion

Community resilience is related to economic, social, political, spatial, institutional, and social aspects [10]. Mayunga (2007) [11] suggested five assets in measuring resilience which are social, economic, human resources, physical, and natural resources. Communal competency is also another form of resilience supporting quality of lives [12]. This variety of aspects that shape resilience creates difficulties in quantification process

3.1 Analysis of level of fisher's resilience

3.1.1 Social dimension

In this dimension, the quantification parameter includes level of education, job opportunities outside fishing, fishers' involvement in government programs, technological awareness and adoption, conflicts, and community support. According to calculation, fishers in Parang Island have the highest resilience index at 0.76 (Table 1).

The lowest resilience level is of fishers in Kemujan. Fishers in Parang Island have the highest resilience as they are the older community in Karimunjawa Islands. Out of 7 parameters, three indicate the highest resilence compared to other islands i.e., level of poverty, technological adoption, and community support. Level of poverty is the lowest one in Parang Island, which is at 1.62% underprivileged household.

The fishers in Parang Island was considerd as a higher level of technological adoption for Fish capture technology. These fishers are the first group who used GPS in 2006 and during study, almost the fishers have started using GPS and fish finder. Fishers' capacity to learn also affected their resilience level. Level of education of fishers in the four islands is considered low, but the fishers in Karimunjawa island have a higher capacity to learn compared to fishers in other islands. This is assumed to be a result from having job alternatives in the island. To improve resilience in the social dimension, it is important to improve the fishers' capacity to learn, for example by giving them skills training.

Table 1. Resilience index of fishers' in Karimunjawa Islands in social dimension

No	Parameter	Max Score (E Maks)	Score (Et)				Criteria
			Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	
1	Poverty level	4	1	2	4	3	The higher the level, the lower the resilience
2	Education level	3	1	1	1	1	>74% elementary school: low (1); 50-74% elementary + junior high school: medium (2); <50% elementary + junior high school: high (3)
3	Ability to work in other fields aside fishing	4	4	3	2	1	The higher the ability, the higher the resilience
4	Involvement in government programs	4	4	3	2	1	The more involvement, the higher the resilience
5	Level of technology adoption	4	2	1	4	3	The more adoption, the higher the resilience
6	Conflict occurrences	2	2	2	2	2	With conflicts: low (1); without conflicts: high (2)
7	Community support and cooperation	4	2	1	4	3	The more support, the higher the resilience
Total Score		**25**	**16**	**13**	**19**	**14**	
Social resilience index		**1.00**	**0.64**	**0.52**	**0.76**	**0.56**	

3.1.2 Economic dimension

In this dimension, fishers in Karimunjawa Islands have the same level as the fishers in Kemujan (0.67). Fishers in Nyamuk island show the lowest at (0.42) compared to other islands, and Parang Island at the third place (0.50). It can be seen from Fig 1 that Karimunjawa Island is the center district of the regions which means they have supporting infrastructure to maintain the economy in the island. All the economic activities are mainly conducted in Karimunjawa Island and this results in a high economic resilience.

Kemujan Island is located near Karimunjawa and can be accessed via land travel, whereas Prang and Nyamuk Islands are quite far from the center of economic activities in addition to limited economic infrastructure. Jepara is the main market in which fishers sell their fish. This means Karimunjawa Island is close and has an easier access to the market as it is essential in economic sustainability. Kemujan and Nyamuk Islands do not have a local market and trading depends on markets in Jepara or Semarang. The group of fishers that have a high reliance on resources is in Parang Island followed by Nyamuk Island. According to fishers, there are no alternative jobs in these two islands beside fishing. This results in unemployment during windy season as fishers are left without work. Usually this season is called low fish catches (*paceklik).* Some fishers work in the fields or plantations, especially coconuts. However, this type of work is not considered to be a stable income as the windy season also makes it difficult to sell products from plantations.

In data collection, it was difficult to attain information about financial savings. Almost all fishers claim not to have any saving let alone funds to increase their investment. However, almost all fishers state that they are involved in a type of local lottery (*arisan*) in their neighborhood. *Arisan* is a routine social gathering and all members deposit a sum of money and they can get their money through the lottery. Through this saving from *arisan* is usually used for school supplies. Financial needs for their work are accommodated by their "boss" (*juragan*), and payment is completed through installments every time they fish. For household needs, fishers also depend on their *juragan* during *packelik* season, especially in Parang and Nyamuk Islands.

Table 2. Resilience index of fishers' in Karimunjawa Islands in economic dimension.

No	Parameter	Max Score (E Maks)	Score (Et)				Criteria
			Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	
1	Income sources	3	2	1	1	1	<50% has > income sources= low (1); 50% - 75% has > income sources= medium (2); >75% has > income sources= high (3)
2	Access to market	3	3	2	1	1	Has means of transportation and short distance to market= high 2; short distance but limited transportation and infrastructure = medium (2); long distance and limited transportation (1)
3	Possibility to sell in the local market	2	2	2	1	1	Possible = high (2); Not possible = low (1)
4	Dependence on resources	4	4	3	1	2	The higher the dependence, the lower the resilience
5	Bargaining power	3	1	1	1	1	Price determined by other parties= low (1); Negotiated price = medium (2); price determined by fishers= high (3)
6	Alternative income sources	4	4	3	2	1	The more alternatives, the higher the resilience
7	Source of capital fund	2	1	1	1	1	Other parties= low (1); self-funding = high (2)
8	Vessel ownership	3	1	3	2	1	<50% respondents are vessel owners = low (1); 50% - 75% respondents are vessel owners = medium (2); >75% respondents are vessel owners = high (3)

Table 2. Resilience index of fishers' in Karimunjawa Islands in economic dimension (*continue*)

No	Parameter	Max Score (E Maks)	Score (Et)				Criteria
			Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	
9	Technology supporting fishing activities	3	2	1	3	3	<50% fishers using GPS and *fish finder* = low (1); 50% - 75% fishers using GPS and f*ish finder*= medium (2); >75% fishers using GPS and *fish finder*= high (3)
10	Dependence on capital fund donors	3	1	1	1	1	Highly dependent= low (1); has other sources= medium (2); self-funding = high (3)
11	Saving accounts	3	2	3	2	1	<50% respondents have a saving account = low (1); 50% - 75% respondents have a saving account= medium (2); >75% respondents have a saving account= high (3)
12	Investment funds	3	1	3	2	1	<50% respondents have investment funds = low (1); 50% - 75% respondents have investment funds = medium (2); >75% respondents have investment funds = high (3)
Total Score		**36**	**24**	**24**	**19**	**15**	
Economic resilience index		**1.00**	**0.67**	**0.67**	**0.50**	**0.42**	

3.1.3 Institutional dimension

In this dimension, the highest resilience is seen from fishers in Karimunjawa and Parang Islands, which is at 0.76. Kemujan and Nyamuk island's resilience level is at 0.59 as shown in Table 3. In the institutional dimension, the role of government is important to create communal industry groups i.e., small business group (*Kelompok Usaha Bersama-KUB*). In Parang Island, the local government was actively managing the institution especially after the Regulation of Ministry of Home Affairs Number 14 in 2016 about guidelines for grants and social benefits. Out of the four islands, Parang island is the only one that has the official status of *KUB*, whereas the other islands do not. According to interviews, fishers in Karimunjawa and Nyamuk Island face difficulties in managing supplies, whereas fishers in Kemujan Island experience financial burden to attain this official status. However, the local

administration was willing to facilitate the legality of the *KUB* status. In this case, the level of involvement can be seen in each island.

Table 3. Resilience index of fishers' in Karimunjawa Islands in institutional dimension

No	Parameter	Max Score (E Max)	Resilience score (Et)				Criteria
			Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	
1	Existence of *KUB*	3	2	2	3	2	No *KUB* = low (1); *KUB* exists but not official= medium (2); official KUB= high (3)
2	Involvement in KUB	4	2	1	4	3	High score presents high involvement of *KUB*
3	*KUB* membership	2	2	2	2	2	Without membership = low (1); With membership = high (2)
4	Cooperative (*Koperasi*)	2	1	1	1	1	With *koperasi* = high (2); without *koperasi* = (1)
5	Financial institution	2	2	1	1	1	With financial institution = high (2); without financial institution= (1)
6	Involvement in Community monitoring group/ *Kelompok masyarakat pengawas* (*Pokmaswas*)	4	4	3	2	1	High score shows high involvement in Pokwasmas
Total Score		**17**	**13**	**10**	**13**	**10**	
Institutional resilience score		**1.00**	**0.76**	**0.59**	**0.76**	**0.59**	

3.1.4 Infra-structural dimension

In this dimension, Karimunjawa Island has the highest resilience (0.94). This island is a sub-district city which has strong infrastructure. Mechanic/repair service for vessels is needed and is only available in Karimunjawa Island. This causes delays in repairing fishing vessels for other fishermen. To increase their resilience, fishermen need boat repair facilities on each island.

Table 4. Resilience index of fishers' in Karimunjawa Islands in infra-structural dimension.

No	Parameter	Max Score (E Max)	Score				Criteria
			Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	
1	Gasoline supply/outlets	2	2	1	1	1	With gasoline supply/outlets= high (2); without gasoline supply/outlets= (1)
2	Auction/ *Tempat Pelelangan Ikan* (TPI)	2	1	1	1	1	With TPI = high (2); without TPI= (1)
3	Electricity	3	3	3	2	2	24-hour electricity = high (3); electricity < 24 hours = medium (2); no electricity= low (1)
4	Vessel necessity supplier	2	2	2	1	1	With vessel necessity supplier> 2 = high (2); vessel necessity supplier < 2 = (1)
5	Local market	2	2	2	1	1	With local market = high (2); without local market = (1)
6	Vessel repairment facility	2	2	1	1	1	With vessel repairment facility = high (2); With vessel repairment facility = (1)
7	Communication facility	2	3	2	2	2	With means of communication= high (3); limited means of communication = medium (2); no means of communication = low (1)
Total Score		**16**	**15**	**12**	**9**	**9**	
Infra-structural resilience index		**1.00**	**0.94**	**0.75**	**0.56**	**0.56**	

3.1.5 Resources dimension

In this dimension, fishers in Parang Island have the highest resilience at 0.79 while fishers in Kemujan island have the lowest at 0.63. Resource availability is the main factor of this study and can be measured from the width of resorts in Taman Nasional Karimunjawa. Coral reefs are the most important ecosystem for fishers in Karimunjawa islands particularly in windy seasons, both west wind or east wind. In windy seasons, fishers cannot fish outside the TNKJ area, though they can still benefit from demersal fishing around the coral reef ecosystem. This is a similar case for fishers using spears who do not have GPS. Good condition of coral

reefs is necessary to sustain their livelihood. According to FGD, the issues faced by fishers in Karimunjawa islands include damaged coral reefs, and fishing competition from inside and outside of the areas which cause decrease in fishing outcomes. The resilience index in this dimension can been seen in Table 5.

Table 5. Resilience index of fishers' in Karimunjawa Islands in resources dimension

No	Parameter	Max Score (E Max)	Score				Criteria
			Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	
1	Destructive fishing practice	4	1	3	4	2	The more use of potassium, the lower the resilience
2	Coral reef damage level	4	4	4	4	3	coral reef spatial decline 0-25% = high resilience (4); 26-49% = medium resilience (3); 50 - 69% = lack of resilience (2); 70-100% = not resilient (1)
3	Coral reef condition in the last 5 years	3	3	1	3	3	Coral reef spatial decline = low resilience (1); no decline = medium resilience (2); coral reef spatial growth = high resilience (3)
4	Fishing opportunity	3	2	1	3	4	The higher the ration, the higher the resilience
5	Resource availability	4	4	3	1	2	The bigger area of coral reef, the higher the resilience
Total Score		**19**	**14**	**12**	**15**	**14**	
Resilience index in resources		**1.00**	**0.74**	**0.63**	**0.79**	**0.74**	

Based on the coral reef condition in 2017, fishers in Karimunjawa island have the widest coral reef area and therefore a higher fishing opportunity to fishers in Nyamuk dan Parang (Table 6). Fishing opportunity is attained by comparing the area of reef and number of vessels. It is assumed that fishing activities are conducted in winter where fishers only work around the island. Damage to the island's coral reefs will cause fishing areas to expand further offshore. Changes in the ecosystem conditions on Lae-Lae Island can result in fishing areas becoming more distant, which increases the operational costs required for fishing activities. Additionally, marketing the catch would also incur higher expenses due to these ecological shifts [13].

Table 6. Change in coral reef in Karimunjawa Islands

Year	Coral reef area (Ha)			
	Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village
1998[a]	1108.01	784.255	322.947	496.17
2003[a]	967.5	642.51	318.552	395.55
2008[a]	906.66	639.27	295.105	296.19
2013[b]	983.52	697.95	322.962	380.07
2017[b]	1134.4	674.013	392.76	400.41
Number of vessels	293	219	61	59

Source: [1)] Landsat 5
[2)] Landsat 8

3.2 Developing resilience-based management policies

According to calculation, fishers in Karimunjawa have the highest resilience compared to the other islands and are categorized as resilient. Fishers in Nyamuk Island have the lowest resilience categorized as sufficient resilience. According to the spidergram, in the social dimension, fishers in Kemujan island have the lowest resilience. Karimunjawa is a sub-district city and has many infrastructural facilities supporting the fishers' livelihood. It is also the center of economic activities as it offers a lot of alternatives of income sources. On the other hand, Nyamuk island is located far from this city centre. The lowest index is seen in the economic dimension due to the remoteness of small islands especially considering access to market. According to calculation, fishers in Karimunjawa islands are divided into two categories: resilient and sufficiently resilient. Index of resilience can be seen in Table 7.

Table 7. Resilience index of fishers' in Karimunjawa Islands

Dimension	Karimunjawa Village	Kemujan Village	Parang Village	Nyamuk Village	Average index
Sosial	0.64	0.52	0.76	0.56	**0.62**
Economic	0.67	0.67	0.50	0.42	**0.56**
Institutional	0.76	0.59	0.76	0.59	**0.68**
Infra-structural	0.94	0.75	0.56	0.56	**0.70**
Resources	0.74	0.63	0.79	0.74	**0.72**
Average resilience score	**0.75**	**0.63**	**0.68**	**0.57**	

Resilience is a crucial factor in the sustainability and wellbeing of fishing communities. The capture fisheries industry in the Karimunjawa Islands is primarily dominated by artisanal fisheries, characterized by single-day fishing trips that predominantly utilize hand line fishing gear as the main equipment [14, 15]. Understanding the resilience of fishermen, particularly in diverse and geographically dispersed regions such as the Karimunjawa Islands, is central to developing effective management policies. The first step in developing resilience-based management policies is to assess the resilience of fishermen across different dimensions—social, economic, and environmental. As highlighted in the Karimunjawa Islands case, resilience varies significantly across different villages. For instance, fishers in Karimunjawa Village exhibit high resilience due to better infrastructural support, whereas those in Nyamuk Village face challenges due to remoteness and limited market access.

Develop policies by identifying key indicators that influence resilience. For example, the social dimension encompasses community networks and support systems, while the economic dimension involves income diversification and market access. Environmental resilience may relate to the sustainability of fishing practices and the health of marine ecosystems. Market access limitations are quite significant in the economic dimension. Fishermen in the Karimunjawa Islands have limited market access, particularly on Parang and Nyamuk Islands. They face difficulties in accessing markets, especially during the windy season. On Parang and Nyamuk Islands, fish processing businesses have potential for development. The fishermen's wives were even given training for making crackers or other processed products. However, they lack a marketing channel for their products. They rely on tourism in Karimunjawa Island. Consequently, prices become higher and do not guarantee continuity of production due to the absence of regular transportation routes. This situation has led to the resilience index of fishermen on Nyamuk Island being less resilient compared to the other three islands.

Engage with fishing communities to gain insights and ensure that policies are grounded in local realities. This participatory approach can help identify unique challenges and opportunities within different communities. Workshops, surveys, and interviews can be effective methods for involving fishermen in the policy development process. Socio-economic engineering through leadership systems, institutions, and social networks can be implemented at the knowledge level of fishermen. Fishermen can enhance their adaptation to sustainable utilization patterns by considering diversity, biomass, connectivity, ecological services, and food security. Leadership systems through fishermen's institutions can improve their independence. The management of marine fisheries resources in the Karimunjawa National Park area must adhere to the principle of "healthy for the ecosystem and wealthy for the community". The designation of the Karimunjawa Islands as a national park aims to preserve the ecosystems within the area, but it must also consider the welfare of its fishermen. However, to ensure community welfare within the area, it should not violate the principles of ecosystem sustainability. Therefore, with increased resilience among fishermen, it is hoped that they can prosper while maintaining a well-preserved ecosystem. Strategies to enhance the resilience of small-scale fishermen on small islands: livelihood diversification, strengthening social protection systems, optimizing the role of the family and utilizing social networks, adaptation of fishing techniques, strengthening capacity and knowledge, and improving market access and supply chains.

4 Conclusion

Quantification of resilience was difficult to complete because there are no fixed methods or indicators to measure the resilience index. Identifying the indicators also rely on the context of the resilience measured. In general, resilience is measured against potentials of disasters. However, this study measures resilience based on availability of and accessibility to fishery resources. Indicators used are classified into 5 dimensions: social, economic, institutional, infrastructural, and resources. Fishers in Karimunjawa islands have the highest resilience at 0.75 with the highest score in infra-structural dimension. Fishers in Nyamuk island have the lowest resilience at 0.57. Other islands, Kemujan and Parang islands are measured at 0. 63 and 0. 68 respectively. Overall, the fishers in Karimunjawa islands have an average resilience index of 0.66.

The results have presented two categories of resilience: sufficiently resilient and resilient. Fishers in the category of resilient are fishers in Karimunjawa, Kemujan, and Parang. Fishers in Nyamuk island are in the category of sufficiently resilient. Karimunjawa island has the highest index of resilience compared to the other three islands as it is a sub-district city. In this island, Infrastructural facilities are completely available; it is the centre of economy as

well as an entry point for tourism in Karimunjawa islands. This condition also allows alternatives of income sources. Factors which support fishers' resilience in Parang island are the availability of and accessibility to resources. Most fishers in Parang island use GPS technology and fish finder in order to explore fishing in areas up to 125 miles from the island.

Strategies to enhance the resilience of small-scale fishermen on small islands: livelihood diversification, strengthening social protection systems, optimizing the role of the family and utilizing social networks, adaptation of fishing techniques, strengthening capacity and knowledge, dan improving market access and supply chains.

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