Resilience to climate change among small-scale fishery on the Northern Coastal of Bengkulu Province, Indonesia

Gita Mulyasari*, Agung Trisusilo1, and Nola Windirah1

1Universitas Bengkulu, Department of Agricultural Socio-Economics, Faculty of Agriculture, Bengkulu, Indonesia

Abstract. Climate change has become a global phenomenon and has become the focus of world attention. The resilience of fishermen in facing climate change shows the ability of fishermen to respond, organize, learn and adapt in the face of climate change. The purpose of this study is to analyze the livelihood resilience of small fishermen in the face of climate change based on three main indicators, namely buffer capacity, self-organization, and learning capacity. A total of 300 fishermen were selected using quota sampling and interviewed through a structured questionnaire. Data were analyzed using the descriptive and livelihood resilience index to explain the fishermen's resilience. The findings indicate that most fishermen in the coastal area of Bengkulu have a low level of livelihood resilience. The dimension of fisherman's learning capacity needs to be improved to strengthen livelihood resilience. Ecological, social, and economic adjustments to the capture fisheries business system in response to climate change can help fishermen in increasing their adaptive capacity and livelihood resilience is highly dependent on the ability and experience of fishermen in adapting.

1 Introduction

Climate change will act as a major threat to the fisheries sector in Indonesia. Climate change has an adverse impact on the lives of coastal communities in Indonesia, especially on the socio-economic aspects. Changes in seasonal patterns as a result of climate change make it difficult for fishermen to predict precisely when to change from one season to another. As is known, so far fishermen have local wisdom in reading natural signs that occur in the sea. Changes in nature that are difficult to anticipate will further add to the panic because they will affect the catch. Coastal areas are the most vulnerable areas to the impacts of climate change. In recent years, fishermen have felt a change in seasonal patterns in line with global climate change.

Bengkulu Province is a western coastal area in Indonesia that is vulnerable to climate change. Bengkulu Province in the west is directly adjacent to the Indonesian Ocean with a coastline of ± 525 km with a relatively narrow plain. These conditions make the Bengkulu...
Province area prone to natural disasters caused by weather/climate (hydrometeorological cycle) which can cause floods, landslides, bad weather, hurricanes, droughts, and others [1]. The Coordinator of the Cahaya Perempuan Woman Crisis Center (WCC) Disaster, Bengkulu, Nurcholis Sastro, revealed, based on the results of the study, by 2040 at least 20 villages in the coastal area of Bengkulu are predicted to disappear due to the very high rate of abrasion. Fishermen are not only required to allocate but also use resources by climate change.

An important concept in dealing with climate change is resilience. The resilience of fishermen in facing climate change shows the ability of fishermen to respond, organize, learn and adapt to climate change. Households with low human, social and physical capital will have a low capacity to deal with climate disasters [2]. Wongke [2] also stated that most of fishing households have a low level of climate change resilience. The resilience of fishermen in facing climate change needs to be improved. Resilience provides the capacity for fishermen to maintain and increase livelihood and welfare opportunities due to the disruption of climate change [3]. Based on this background, this study aims to analyze the resilience of small-scale fishermen to climate change in the Northern Coastal of Bengkulu province.

**2 Methodology**

**2.1 Study area**

This research was conducted in the coastal area of Bengkulu Province, which includes Bengkulu City, Bengkulu Utara Regency, Mukomuko Regency, Bengkulu Selatan Regency, and Kaur Regency (Fig. 1). The coastal of Bengkulu Province is considered to be the centre of the world's climate, because it is the meeting place for four ocean currents which cause the process of evaporation and the formation of rain clouds, which affect the world's climate [4].

![Fig. 1. Study area.](image)

**2.2 Sampling and questionnaire**

Respondents in this research are small-scale fishermen that have activity one-day fishing, with a total of 300 fishermen selected. Data collection in this study used a questionnaire consisting of two parts, namely the characteristics of fishermen and the fishermen’s resilience to climate change based on their knowledge, understanding, and experience.
2.3 Data analysis

The livelihood resilience of fishermen was analyzed using an equal weighting approach with indicators and sub-indicators referring to Speranza et al. [5]. Each indicator contributes equally to the overall index. The steps taken to measure the level of livelihood resilience of fishermen [6, 7] include:

2.3.1 Standardizing the size

Sub-indicators for each indicator are measured on a different scale, so it needs to be standardized so that the value lies between 0-1.

- Indicators with higher values indicate better resilience, normalized using the formula:

\[ I_a = \frac{s_a - s_{\min}}{s_{\max} - s_{\min}} \]  

(1)

- Indicators with higher values indicating lower resilience are normalized using the formula:

\[ I_a = \frac{s_{\max} - s_a}{s_{\max} - s_{\min}} \]  

(2)

Description:
- \( I_a \): standardization value of each item
- \( s_a \): the real value of the item
- \( s_{\min} \): the minimum value of items from all households
- \( s_{\max} \): the maximum value of the item from the whole household

2.3.2 Finding indicator values and dimensions

After the standardized value of each item is obtained, the next step is to calculate the indicator value. The indicator value is calculated using the equation:

\[ M_a = \frac{\sum_{i=1}^{n} I_a^i}{n_i} \]  

(3)

Description:
- \( M_a \): indicator value
- \( I_a^i \): i-th item standardization value
- \( n_i \): numbers of item

The next step is to calculate the value of each dimension through the equation:

\[ K_a = \frac{\sum_{a=1}^{n} M_a^a}{n_k} \]  

(4)

Description:
- \( K_a \): the value of each dimension
- \( M_a^a \): i-th indicator value
- \( n_k \): number of indicators

2.3.3 Measuring resilience index

The resilience index is obtained from the average value of the dimensions of livelihood resilience, namely buffer capacity, self-organization and learning capacity which is calculated from the equation:
\[ R_n = \frac{K_{kp} + K_{od} + K_{kb}}{3} \]

Description:
- \( R_n \): Livelihood resilience of fishermen
- \( K_{kp} \): Buffer capacity value
- \( K_{od} \): Self-organization value
- \( K_{kb} \): Learning capacity value

### 3 Results and discussion

#### 3.1 Small-scale fishermen's characteristics

The results of the study (Table 1) show that the average age of fishermen is in the productive category, thus supporting work as a fisherman who requires a strong physique because of dealing with unpredictable natural environmental conditions. Age is one of the factors that support the fishing effort because at a productive age a person can do work to the maximum and the productive age based on BPS data ranges from 15-64 years [8].

Table 1 explains that the average level of formal education of fishermen is 8.78 years. Fishermen have an education level equivalent to junior high school. The level of education in fishing communities is relatively low, one of which is caused by the poverty that exists in fishing communities, with weak economic conditions fishermen can't provide proper education for their children. In addition, fishermen's views on education also affect the level of education in fishing communities. Education is needed among fishermen's children for future provisions so that fishermen do not continue to be trapped in an endless cycle of poverty.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>14.00</td>
<td>75.00</td>
<td>41.06</td>
<td>10.51</td>
</tr>
<tr>
<td>Years of schooling (years)</td>
<td>0.00</td>
<td>12.00</td>
<td>8.78</td>
<td>2.84</td>
</tr>
<tr>
<td>Fishing experience (years)</td>
<td>1.00</td>
<td>46.00</td>
<td>17.51</td>
<td>9.06</td>
</tr>
<tr>
<td>Household size (person)</td>
<td>0.00</td>
<td>8.00</td>
<td>3.03</td>
<td>1.32</td>
</tr>
<tr>
<td>Boat power (horsepower)</td>
<td>3.50</td>
<td>40.00</td>
<td>24.93</td>
<td>10.03</td>
</tr>
<tr>
<td>Fishing days (days/month)</td>
<td>10.00</td>
<td>28.00</td>
<td>20.00</td>
<td>2.41</td>
</tr>
<tr>
<td>Fishing distance (miles)</td>
<td>1.00</td>
<td>55.00</td>
<td>10.71</td>
<td>9.87</td>
</tr>
<tr>
<td>Fishing time (hours)</td>
<td>3.00</td>
<td>12.00</td>
<td>7.33</td>
<td>2.35</td>
</tr>
<tr>
<td>Catch capacity (kg/trip)</td>
<td>5.00</td>
<td>1000.00</td>
<td>112.75</td>
<td>162.36</td>
</tr>
</tbody>
</table>

Source: Primary data, 2021

Fishermen in the coastal area of Bengkulu have a fairly high average experience (Table 1). This shows that fishermen never switch jobs as fishermen. The low level of education means that fishermen do not have the opportunity to get other jobs outside of fishing. Based on the results of the study, the majority of fishermen have business experience ranging from 1 to 46 years. The life of fishing communities is a real situation that can be expressed through their efforts which are influenced by the fishing season, unsupportive natural conditions, limited capital and low levels of education resulting in weak socio-economic conditions. The results of the study (Table 1) show that the average engine power of fishing boats in the coastal area of Bengkulu is quite strong, namely 24.93 PK with a range of 3.50 PK to 40.00 PK. For fishermen, fishing activities in the sea are very dependent on the weather. If the weather is favourable, almost every day the fishermen go to sea. But if the weather is bad
like the west wind season, some fishermen do not dare to go to sea. In bad weather conditions, fishermen cannot rely on catches within a radius of fewer than 3 miles because overfishing has occurred. On the other hand, fishermen cannot go to sea any further because they are at risk of being hit by waves. Table 1 shows that the average fishing day for fishermen is 20 days per month under normal weather conditions. In Bengkulu city, some fishermen have 10 days of fishing in a month. This is because fishermen have other professions as Mangrove forest tour guides. So that the ship they use to go to sea is converted into a tourist ship.

Catching capacity is the number of catches obtained by fishermen from fishing activities. The number of catches and number of catches is related to the level of income earned by fishermen. Table 1 shows that the average catch of fishermen on the Bengkulu coast reaches 112.75 kg per trip. The characteristics of the coast facing the high seas also determine the catches obtained by fishermen.

### 3.2 Livelihood resilience of small-scale fishermen to climate change

The livelihood resilience of fishermen to climate change is composed of three dimensions, namely buffer capacity, self-organization and learning capacity. Each of these dimensions is composed of several indicators. The buffer capacity is formed from five indicators, namely human, financial, social, physical and natural capital. Self-organization is formed from three indicators, namely cooperation and networking, trust and resource reliability. Learning capacity is formed from seven indicators, namely knowledge of opportunities and threats, shared vision, commitment to learning, monitoring knowledge identification capability, knowledge sharing capability, knowledge transfer capability and feedback function mechanism.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Bengkulu City</th>
<th>Bengkulu Utara</th>
<th>Mukomuko</th>
<th>Bengkulu Selatan</th>
<th>Kaur</th>
<th>Bengkulu Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital</td>
<td>0.47(3)</td>
<td>0.50(3)</td>
<td>0.48(3)</td>
<td>0.50(3)</td>
<td>0.48(3)</td>
<td>0.49(3)</td>
</tr>
<tr>
<td>Financial capital</td>
<td>0.28(2)</td>
<td>0.32(2)</td>
<td>0.29(2)</td>
<td>0.30(2)</td>
<td>0.30(2)</td>
<td>0.30(2)</td>
</tr>
<tr>
<td>Social capital</td>
<td>0.01(1)</td>
<td>0.02(1)</td>
<td>0.03(1)</td>
<td>0.03(1)</td>
<td>0.02(1)</td>
<td>0.02(1)</td>
</tr>
<tr>
<td>Physical capital</td>
<td>0.84(5)</td>
<td>0.89(5)</td>
<td>0.92(5)</td>
<td>0.90(5)</td>
<td>0.87(5)</td>
<td>0.88(5)</td>
</tr>
<tr>
<td>Natural capital</td>
<td>0.44(3)</td>
<td>0.63(4)</td>
<td>0.64(4)</td>
<td>0.57(3)</td>
<td>0.61(4)</td>
<td>0.58(4)</td>
</tr>
<tr>
<td>Buffer Capacity</td>
<td>0.41(5)</td>
<td>0.47(3)</td>
<td>0.47(3)</td>
<td>0.46(3)</td>
<td>0.46(3)</td>
<td>0.46(3)</td>
</tr>
<tr>
<td>Cooperation and network</td>
<td>0.28(2)</td>
<td>0.38(2)</td>
<td>0.20(1)</td>
<td>0.39(2)</td>
<td>0.15(1)</td>
<td>0.28(2)</td>
</tr>
<tr>
<td>Trust</td>
<td>0.61(4)</td>
<td>0.60(4)</td>
<td>0.66(4)</td>
<td>0.72(4)</td>
<td>0.69(4)</td>
<td>0.66(4)</td>
</tr>
<tr>
<td>Reliance on own resources</td>
<td>0.79(4)</td>
<td>0.80(4)</td>
<td>0.67(4)</td>
<td>0.94(5)</td>
<td>0.83(5)</td>
<td>0.81(5)</td>
</tr>
<tr>
<td>Self-organization</td>
<td>0.56(3)</td>
<td>0.59(3)</td>
<td>0.51(3)</td>
<td>0.68(4)</td>
<td>0.56(3)</td>
<td>0.58(3)</td>
</tr>
<tr>
<td>Knowledge of threats and opportunities</td>
<td>0.60(3)</td>
<td>0.78(4)</td>
<td>0.63(4)</td>
<td>0.79(4)</td>
<td>0.76(4)</td>
<td>0.71(4)</td>
</tr>
<tr>
<td>Shared vision</td>
<td>0.03(1)</td>
<td>0.09(1)</td>
<td>0.10(1)</td>
<td>0.09(1)</td>
<td>0.05(1)</td>
<td>0.07(1)</td>
</tr>
<tr>
<td>Commitment to learning</td>
<td>0.07(1)</td>
<td>0.21(2)</td>
<td>0.03(1)</td>
<td>0.07(1)</td>
<td>0.16(1)</td>
<td>0.11(4)</td>
</tr>
<tr>
<td>Knowledge identification capability</td>
<td>0.06(1)</td>
<td>0.11(1)</td>
<td>0.09(1)</td>
<td>0.09(1)</td>
<td>0.05(1)</td>
<td>0.08(4)</td>
</tr>
<tr>
<td>monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Cont.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Bengkulu City</th>
<th>Bengkulu Utara</th>
<th>Mukomuko</th>
<th>Bengkulu Selatan</th>
<th>Kaur</th>
<th>Bengkulu Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge sharing capability</td>
<td>0.01(1)</td>
<td>0.02(1)</td>
<td>0.02(1)</td>
<td>0.01(1)</td>
<td>0.00(1)</td>
<td>0.01(1)</td>
</tr>
<tr>
<td>Knowledge transfer capability</td>
<td>0.24(2)</td>
<td>0.34(2)</td>
<td>0.32(2)</td>
<td>0.18(1)</td>
<td>0.27(2)</td>
<td>0.27(2)</td>
</tr>
<tr>
<td>Functioning feedback mechanism</td>
<td>0.07(1)</td>
<td>0.10(1)</td>
<td>0.02(1)</td>
<td>0.01(1)</td>
<td>0.05(1)</td>
<td>0.05(1)</td>
</tr>
<tr>
<td>Learning Capacity</td>
<td>0.15(1)</td>
<td>0.23(2)</td>
<td>0.17(1)</td>
<td>0.18(1)</td>
<td>0.19(1)</td>
<td>0.19(1)</td>
</tr>
<tr>
<td>Livelihood Resilience Index</td>
<td>0.37(2)</td>
<td>0.43(3)</td>
<td>0.38(2)</td>
<td>0.44(3)</td>
<td>0.40(3)</td>
<td>0.41(3)</td>
</tr>
</tbody>
</table>

Source: Primary data. 2021

Information: Category (5) = very high (0.81-1.00), (4) = high (0.61-0.80), (3) = moderate (0.41-0.60), (2) = low (0.21-0.40), (1) = very low (0.00-0.20)

Fishermen's self-organization contributes the most to fishermen's livelihood resilience (Table 2). In rural areas, the sense of kinship and the level of trust among fishermen are still very high. Fishermen are willing to share and lend their assets to other fishermen in need without any collateral. The relationship between fishermen with small and large boats is also very good, this situation is seen from the socio-economic capital that exists in fishermen. Trust and mutual help are related to the strength of social relations in society, including the life of fishermen in families, as well as social groups. The second indicator that contributes to the value of livelihood resilience is buffer capacity and then learning capacity.

The culture of the fishing community is a system of ideas or cognitive systems of the fishing community that are used as a reference for sociocultural behaviour by individuals in social interactions. This culture is formed through a long socio-historical process and the crystallization of intensive and intense interactions between people and their environment. In carrying out the process of deep social interaction, fishing communities have different characteristics from other communities. This can be seen from the process of utilizing fishery resources both through capture fisheries and aquaculture [9]. The livelihood resilience of fishermen in the research location relies on self-organization. Fishermen dealing with climate change should take advantage of this self-organization to increase their buffer capacity and learning capacity. Ecological, social, and economic adjustments to capture fisheries business systems in response to climate change can assist fishermen in increasing their adaptive capacity [10] and livelihood resilience is highly dependent on the ability and experience of fishermen to adapt [11].

Figure 2 shows that most fishermen in the coastal area of Bengkulu have a low level of livelihood resilience. The dimension of fisherman's learning capacity needs to be improved to strengthen livelihood resilience. For example, in the capability of sharing knowledge and interaction of fishermen with fishery instructors. In the coastal area of Bengkulu, fishery instructors are still very rare and several areas on the Bengkulu coast do not have extension workers in the field of capture fisheries. In fact, with the existence of extension workers, it is hoped that changes in the behaviour of fishermen include changes in knowledge or things that are known, changes in skills or habits in doing things and changes in attitudes and mentality towards the better with the ultimate goal of counselling is better life welfare [12].
Fig. 2. Distribution of respondents based on the level of livelihood resilience.
(Source: Primary data, 2021)

4 Conclusion

The majority of fishermen in the coastal area of Bengkulu have livelihood resilience in the low category. This is due to the low dimensions of the buffer capacity and learning capacity of fishermen. The dimension of fisherman's learning capacity needs to be improved to strengthen livelihood resilience. For example, in the capability of sharing knowledge and interaction of fishermen with fishery instructors. Social capital indicators also have a small contribution to the buffer capacity of fishermen’s resilience. This is due to the lack of organizations/groups for fishermen and also the low participation of fishermen involved in an organization or group of fishermen.

References

1. H. Wongke, Mencari solusi atas perubahan iklim (Pusat Pengkajian dan Pengelolaan Data dan Informasi (P3DI) Sekretariat Jenderal DPR RI, 2011)
4. BPPT 2016 Agency for the Assessment and Application of Technology Indonesia Retrieved from Bengkulu Pusat Iklim Dunia... Bagaimana Bisa ? (climate4life.info).