The adaptation to climate change by slerek boat fishermen in Muncar Subdistrict, Banyuwangi Regency

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Abstract. Climate change, the La Nina phenomenon, has various impacts on the fisheries sector, especially capture fisheries. One of the impacts of the La Nina phenomenon is that high rainfall causes fishermen to be unable to go to sea and reduces catches, so that it reduces fishermen's income. Therefore, fishermen need to adapt to climate changes that are occurring. This research aims to determine the form of climate change adaptation, measure the level of adaptation, and income earned by fishermen. This research uses descriptive and analytical methods. The results of the research show that there are 8 forms of adaptation carried out by Slerek boat fishermen. The level of adaptation of fishermen to climate change is 74%, of which 53.33% of fishermen are classified as low level of adaptation and 46.67% of fishermen are classified as high level of adaptation. Apart from that, there is a difference in income between fishermen with a high level of adaptation and fishermen with a low level of adaptation. It implied that fishermen with a high level of adaptation are able to combine various forms of adaptation to climate change and earn higher income.

1 Introduction

Climate change is a change in climate conditions that can be identified through temperature, rainfall, air pressure, humidity, wind speed and wind direction, which can last in the long term for decades or more [1]. The cause of global climate change is the El Nino and La Nina phenomena which affect oceans throughout the world. Indonesia, as a maritime country located between the Pacific and Indian oceans, will be affected when changes in temperature and extreme weather occur in the Pacific Ocean region due to El Nino and La Nina, which is increasing wave heights throughout Indonesian seas. This condition can be a challenge for society, especially in the fisheries sector.

The fisheries sector is one of the alternative employment opportunities for Indonesian people to earn income. Communities in coastal areas with livelihoods as fishermen rely on
catching fish or other marine products, including cultivating marine fish [2]. This condition shows that the fisheries sector plays an important role in the life of the Indonesian people to maintain food security [3, 4]. One of the southern coastal areas of Indonesia, precisely on the island of Java as the most numerous and extensive coastal areas, which has the largest production of capture fisheries is Banyuwangi Regency. Based on data from Central Agency on Statistics (BPS) of Banyuwangi Regency, Muncar subdistrict is the largest capture fisheries production center in Banyuwangi Regency with an average production of 35,031.23 tons with a decrease of 39.37% per year (2019–2021). Based on the Performance Accountability Report of Banyuwangi Regency Government Agencies 2020, the decline in capture fisheries production in Banyuwangi Regency was caused by external factors, which was uncertain weather conditions.

The problems that occur in Muncar subdistrict, Banyuwangi Regency are problems caused by climate change. Climate change that occurs is in the form of high waves, high rainfall, wind and changes in currents due to the La Nina phenomenon. Indonesia has experienced La Nina events from mid-2020 to the end of 2022 [5–7]. Based on Climatology Station of East Java, Southern Banyuwangi has an above normal rainy season, which Muncar subdistrict is included in this area. The impact caused by the La Nina phenomenon is an increase in rainfall to reach 50-90% of the average normal rainfall before the onset of the rainy season [7–8]. The occurrence of this phenomenon causes the surface temperature of sea water to change [9], so that it affects the behavior of fish. Changes in sea surface temperature not only affect the fish upwelling zone, but also shift fish species populations to colder or hotter seas and make it difficult for fishermen to catch fish because fish habitats tend to be on the underwater surface [4, 10–12].

Capture fisheries production in Muncar subdistrict comes from traditional fishing units, one of which is the Slerek boat. The Slerek boat has fishing route that is farther than other types of boats, so it is relatively more vulnerable to the effects of climate change. The occurrence of climate change has made it difficult for Slerek boat fishermen to catch fish so that fish catches have decreased. In addition, climate change causes an increase in waves which affect the cost of fishing for fishermen [4, 13]. This has implications for fishermen's income derived from fishing. The fewer fish were caught, the lower income earned will also be. Based on the background that has been described, the purpose of this study is to examine: 1) forms of adaptation to climate change, 2) the level of adaptation of Slerek boat fishermen in dealing with climate change, 3) and differences in income of Slerek boat fishermen according to the level of adaptation applied.

2 Methodology

The research was carried out purposively (purposive method), which was in Muncar subdistrict as the highest production center and supplier of captured fisheries in Banyuwangi Regency from November to December 2022. The sampling method used the total sampling method with a total of 30 respondents of Slerek boat owners. This method uses the population as sampling [14]. The method of data analysis to answer the problem regarding forms and adaptation levels of Slerek boat fishermen used descriptive methods and scoring techniques. The problem formulation related to fishermen's income was analyzed using income analysis with the following formulation [15–16]:

\[
\begin{align*}
TR &= P \times Q \\
TC &= TFC + TVC \\
\pi &= TR - TC
\end{align*}
\]

Information:

P : Price (Rp)
Q : Quantity (Kg)
The fishermen in dealing with climate change, also be. Based on the background that has been described, the purpose of this study is to income derived from fishing. The fewer fish which affect the cost of fishing for fishermen types of boats, so it is relatively more vulnerable to the effects of climate change to colder or hotter seas and make it difficult for fishermen to catch fish because fish habitats of sea water to change is an increase in rainfall to re

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of the island of Java as the most numerous and extensive coastal areas, which has the largest shows that the fisheries catching fish or other marine products, including cultivating marine fish sector plays an important role in the life of the Indonesian people to

3, 9

catcher of the following formulation

\[ \pi = \frac{\text{TC} - \text{TVC}}{\text{TFC}} \]

TC : Total cost (Rp)
TVC : Total variable costs (Rp)
TFC : Total fixed costs (Rp)
\( \pi \) : Income (Rp)

Furthermore, to determine the difference in income between fishermen with high adaptation levels and fishermen with low adaptation levels, it was analyzed using the average difference test (independent sample t-test) with the following formula [17–18]:

\[ t \text{ value} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (4) \]

Information:
\( \bar{x}_1 \) : Average income of fishermen with a high level of adaptation
\( \bar{x}_2 \) : Average income of fishermen with a low level of adaptation
\( S_1^2 \) : The standard deviation of fishermen's adaptation level is high
\( S_2^2 \) : The standard deviation of fishermen with low level of adaptation
\( n_1 \) : Sample of fishermen with a high level of adaptation
\( n_2 \) : a sample of fishermen with a low level of adaptation

Decision making criteria: H0 is rejected if the sig.(2-tailed) value < 0.05

3 Results and discussion

3.1 Forms of adaptation to climate change by slerek boat fishermen

Climate change adaptation is an effort by fishermen to minimize the reduction in fish catches due to climate change. There are several forms of adaptation carried out by Slerek boat fishermen as an effort to deal with climate change which is explained in Table 1.

Table 1. Forms of adaptation to climate change by slerek boat fishermen.

<table>
<thead>
<tr>
<th>No</th>
<th>Adaptation form</th>
<th>Number of Fishermen</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moving fishing location</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Stretching fishing gear (nets)</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Changing fishing times</td>
<td>25</td>
<td>83.33</td>
</tr>
<tr>
<td>4</td>
<td>Increasing the amount of oil in the engine</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Changing the catchment area</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Using plastic sheets as raincoats</td>
<td>24</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>Carrying used drums when going to sea</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>View weather forecast information</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Primary data (2022)

All fishermen (100%) move fishing locations as a form of adaptation to climate change. Location shifts are carried out when fishermen have determined the location points to go to, but are threatened by climate change such as high waves. Fishermen are faced with climate change scenarios while at sea, fishermen will stop fishing and look for alternatives, such as moving locations to a wider area to catch fish more intensively [19–21].

Stretching fishing gear (nets) is carried out by all fishermen (100%) to minimize the risk of reduced catches. Fishermen will stretch their fishing gear to keep catching fish despite climate change while at sea. Stretching the entire fishing gear helps in expanding the reach of fish catches, if the fishing gear is stretched less, fishermen will get results that are not optimal [22–23].

Fishermen (83.33%) made changes to fishing time when bad weather occurred due to climate change before departure. Slerek boat fishermen make changes to fishing times by delaying their departure time. The impact of climate variability and change such as extreme
events (storms, high waves) and erratic weather can affect fishermen to postpone departure times [24].

The addition of oil to the *Slerek* boat engine is carried out by all fishermen (100%) when climate change occurs such as big waves and also heavy currents. Adding oil to this engine affects the engine's speed when dealing with current. The greater the oil consumption used, the faster the boat will be when sailing against the current [25].

Changes in fishing areas are carried out by all fishermen (100%). If the target fishing area is affected by climate change, such as strong currents, the fishermen tend to change catchment areas that do not have fast currents. Fishermen will tend to change and stay away from fishing areas affected by climate change to avoid decreasing catches [12, 26].

The form of adaptation to the use of plastic sheets as raincoats was carried out by *Slerek* boat fishermen (80%) when it rained while fishing. The owner fishermen and other worker fishermen will enter inside a quite large plastic sheet, usually one sheet of plastic bag is filled by 4-5 people. The use of plastic sheets as raincoats by fishermen is very effective in preventing rainwater [27].

The form of adaptation to carrying used drums is also carried out by all *Slerek* boat fishermen (100%). Fishermen bring used refueling drums to be used as alternative floats when the boat overturns due to big waves, storms, and strong winds. Fishermen usually use plastic drums or bamboo as floats when a cyclone hit [28]. The number of used drums brought depends on the number of the owner and worker fishermen.

The form of adaptation to viewing weather forecast information to arrange departure schedules is carried out by all *Slerek* boat fishermen (100%). The fishermen have an online discussion forum to exchange information regarding weather forecasts through the Meteorological, Climatological, and Geophysical Agency (BMKG) website. This is conducted to anticipate and consider the departure time for fishing, make fishing safer, and preparations against any weather changes [29–30].

Based on the forms of adaptation that have been described, it can also be seen the level of adaptation to climate change based on the results of calculating the score for each form of adaptation presented in Table 2.

**Table 2. Level of implementation of climate change adaptation by *slerek* boat fishermen.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respondents (people)</td>
<td>30</td>
</tr>
<tr>
<td>Average total score</td>
<td>18</td>
</tr>
<tr>
<td>Average percentage (%)</td>
<td>74</td>
</tr>
<tr>
<td>Low level of adaptation (people)</td>
<td>16</td>
</tr>
<tr>
<td>High level of adaptation (people)</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: Primary data (2022)

Table 2 shows that the average level of adaptation carried out by *Slerek* boat fishermen in Muncar subdistrict, Banyuwangi Regency is 74%. Fishermen with scores below 74% are included in the category of applying a low level of adaptation as many as 16 fishermen or 53.33% of the total respondents. Meanwhile, fishermen with scores above the average are included in the category of applying a high level of adaptation as many as 14 fishermen or 46.67% of the total respondents.

### 3.2 Income of *slerek* boat fishermen

The results of the analysis of income of Slerek boat fishermen according to the level of adaptation implementation are presented in Table 3.
The results of the analysis of income of slerek boat fishermen according to the level of adaptation presented in Table 2.

Table 3. Income analysis of slerek boat fishermen

<table>
<thead>
<tr>
<th>Component</th>
<th>High Adaptation Rate</th>
<th>Low Adaptation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fixed costs</td>
<td>Rp1,265,748</td>
<td>Rp1,337,844</td>
</tr>
<tr>
<td>Total variable costs</td>
<td>Rp10,954,643</td>
<td>Rp9,061,875</td>
</tr>
<tr>
<td>Total cost</td>
<td>Rp12,220,391</td>
<td>Rp10,339,719</td>
</tr>
<tr>
<td>Total revenue</td>
<td>Rp21,085,714</td>
<td>Rp15,562,500</td>
</tr>
<tr>
<td>Income</td>
<td>Rp8,865,323</td>
<td>Rp5,162,781</td>
</tr>
</tbody>
</table>

Source: Primary data (2022)

Table 3. shows that the revenue earned and the total costs incurred by fishermen with a high level of adaptation is greater than fishermen with a low level of adaptation in one trip to sea as much as Rp 5,523,214 and Rp1,820,673. This is because fishermen with a high level of adaptation increase the use of oil in the engine, so that the boat is able to move locations or change fishing grounds with longer routes. The results of the income calculation show that the income of fishermen with a high level of adaptation is greater than that of fishermen with a low level of adaptation as much as Rp3,702,542. Based on income analysis, it can be known the income average difference between fishermen with a high level and low level of adaptation as explained in Table 4.

Table 4. Result of Slerek boat fishermen's income difference test (independent sample t-test)

<table>
<thead>
<tr>
<th></th>
<th>F-stat</th>
<th>Sig.</th>
<th>t-stat</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>2.003</td>
<td>0.168</td>
<td>-3.986</td>
<td>0.000</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-3.855</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Primary data (2022)

Table 4 shows the results of the income difference test analysis with sig. (2-tailed) values is 0.000 < 0.05, then the hypothesis H₀ is rejected. This means that there is a significant difference in income between fishermen with a high level of adaptation and fishermen with a low level of adaptation. This shows that fishermen with a high level of adaptation tend to be braver in taking risks and sailing longer routes [19]. Fishermen with a high level of adaptation are able to combine various forms of adaptation. These results also prove that the level of adaptation of fishermen influences the income earned by fishermen.

4 Conclusion

1. There are 8 forms of adaptation carried out by Slerek boat fishermen, including moving fishing locations, stretching fishing gear (nets), changing fishing time, increasing the amount of oil in the engine, changing fishing grounds, using plastic sheets as raincoats, bringing used drums, and view weather forecast information.
2. The level of adaptation to climate change of Slerek boat fishermen in Muncar subdistrict, Banyuwangi Regency is 74%, as many as 14 fishermen are implementing a high level of adaptation and 16 fishermen are implementing a low level of adaptation.
3. There is a significant difference between the income of fishermen with a high level of adaptation and fishermen with a low level of adaptation.

References

1. LAPAN, Perubahan Iklim: Penyebab, Dampak, dan Antisipasi (Pusat Sains dan Teknologi Atmosfer, Bandung, 2017)