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Abstract. The tsunami impact on capture fisheries production and environment in the area of South Lampung Regency of Lampung Province is necessarily assessed. This study aimed to analyze the impact of the 2018 Sunda Strait Tsunami on capture production and environment. The study was conducted from January to March 2020 in Way Muli Village, Rajabasa Sub-district, South Lampung Regency through the case study method. The data used in this research consisted of primary and secondary data. The method of data analysis applied was the quantitative and qualitative method. The result of the study indicated that the Sunda Strait Tsunami negatively affected the quantity of fish captured by fishermen. In average, capture production decreased from 41.35 kg/month to 16.35 kg/month or approximately 60.5%. The Tsunami also caused a negative impact on the environmental aspect, namely declining clean water availability, damaged village infrastructure, poor environmental sanitation, damaged fishing settlement, and damaged fishing support facility. The support from multi-stakeholder is also needed to increase capture production through the reconstruction of the damaged fisheries facility and infrastructure due to Tsunami. Moreover, it is required to establish a multi-stakeholder integrated partnership to solve problems of environment and infrastructure in Way Muli Village following the Tsunami disaster.

1. Introduction

The Law of the Republic of Indonesia No. 24 in 2007 states that natural disaster is a disaster caused by a series of natural events, such as earthquakes, tsunamis, volcanic eruptions, floods, hurricanes, droughts, and landslides. Tsunami is a series of ocean waves that could travel at speed up to 900 km per hour, particularly if it is resulted from undersea earthquakes [1], [2], [3]. Tsunami can cause negative impact by destroying everything in its path [4]. The occurrence of tsunami might lead to losses include death, damage to housing unit, damage to public infrastructure and facility, water availability, telephone and electricity connection, and so on [5], [6]. A large tsunami wave might cause damage in the sector of fisheries, agriculture, animal husbandry, forestry, and industry [7], [8], [9].

A tsunami in Sunda Strait hit the coastal area of Banten and Lampung on December 22,2018killed a total of 426 people, while 7,202 people were injured and 23 were still missing [10]. In Lampung Province, it was found that South Lampung Regency is the area experienced the worst impact of tsunami. Geographically, South Lampung Regency is located in Lampung coastal area and near Anak Krakatau

Mountain (GAK), hence Sunda Strait Tsunami in 2018 resulted in greatly impact on the damage to infrastructure in coastal area [11].

Way Muli Village in Rajabasa Sub-district of South Lampung Regency is one of areas affected by Sunda Strait Tsunami in December 2018. This village is geographically located in seashore facing Sunda Strait and Karakatau Mountain, thus severe damage due to tsunami is clearly seen. People in this village mostly work as fishermen in Sunda Strait. Facilities in Way Muli Village were found damaged post the 2018 Sunda Strait Tsunami. Moreover, the tsunami also adversely affected infrastructure (roads), fishing settlement, village public facility, and Fish Auction Place (TPI). Tsunami also caused damage to fishing boats and fishery harbor, preventing fishermen in Way Muli Village to fish. The damage of facility and infrastructure which support fishing activity results in the situation where fishermen loss their possibility to catch fish and decreasing capture production. Tsunami disaster is expected to decline the number of fish in the ocean, thus reducing the capture potential.

This study was focused on investigating the impact of Sunda Strait Tsunami on the quantity of fish captured by fishermen. Furthermore, this research assessed the impact of Tsunami on environmental aspect in Way Muli Village. The objective of this study was to analyze the impact of tsunami disaster on capture production and environmental aspect in Way Muli Village, Rajabasa Sub-district, South Lampung Regency.

2. Research methods

The study was carried out in Way Muli Village, Rajabasa Sub-district, South Lampung Regency from January to March 2020.Research was done using the method of case study. Research location was purposively selected with a total respondent of 52 fishermen determined through the technique of quota sampling according to three respondent criteria, included: 1) work as fishermen, before and after the tsunami, 2) the type of fishing boat owned is the outboard motor-fishing boat (*kelinting*), and 3) affected by Sunda Strait Tsunami disaster.

The type of data used in this study were primary and secondary data. Primary data were obtained from interview with fishermen, while secondary data were collected from literatures related to this study, such as books, journals, government documents, etc. the method of data analysis applied was quantitative and qualitative. Quantitative method is used to investigate fishermen condition based on the number obtained from the interview, while qualitative method is applied by observing the real situation in research location [12].

The quantitative method in this study was conducted to analyze the quantity of fish captured by fishermen. The method was applied to analyze the changes in fish quantity caught by fishermen in research location, while qualitative method was used to analyze the impact of tsunami on the environment in research site. The changes in the number of capture production was determined by comparing capture quantity before and after the tsunami in a unit of kilogram permonth. The formula applied to calculate the percentage of change in capture production due to tsunami is written as follows:

$$\text{Percentage of change} = 100 - \frac{\text{Average capture production after tsunami disaster}}{\text{Average capture production before tsunami disaster}} \text{ x } 100$$

Description:

- Percentage of change = the percentage of change in capture production due to tsunami disaster (%)
- Average capture production after tsunami disaster = Average of capture production after tsunami disaster by each type of fish (kg/month)
- Average capture production before tsunami disaster = Average of capture production before tsunami disaster by each type of fish (kg/month).

3. Results and discussion

3.1. Description of Sunda Strait tsunami in 2018

The Sunda Strait Tsunami occurred on December 22, 2018 around 21.27 WIB. The National Disaster Mitigation Authority (BNPB) said the tsunami disaster was caused by undersea landslide following the

eruption of Anak Krakatau Mountain and tides due to full moon. This tsunami disaster hit the coast of Sunda Strait and destroyed almost coastal area in Pandeglang Regency, Serang Regency, and South Lampung Regency of Lampung Province [13]. The majority of people in Way Muli Village were at their houses when tsunami hit their village. Afterwards, people seek for safer place to save themselves and became refugees in several places that were quite far from the beach, either in the garden or neighboring village located in higher place. Fishermen stayed in refugee camps for only 5-7 days to later move to the houses of their relatives, parents, children, etc. However, they still obtained the food given by donator and previously cooked in public kitchen.

People whose houses were severely damaged obtained government aid called temporary housing (*Huntara*) which is one of disaster relief programs provided by the local government. *Huntara* has a size of 4m × 6m and facilitated with one bed, MCK (public bath, wash, toilet) facilities, *musholla*, and security post. *Huntara* was built in several phases. A total of 30 houses were built in the first phase in February 2019 and about 18 houses were built in the second phase in April 2019. There are no special requirements asked by the government for this program. People whose houses severely affected by tsunami were only required to fill in the form given *via* village apparatus.

The tsunami victims started to fish again at different time. Some started to fish a month after the tsunami, while some others went fishing 2 to 3 months after the tsunami. Fishermen mostly joined the middlemen to catch fish or waited for government aid in the form of fishing boat because many fishing boats were destroyed by tsunami. Several fishermen no longer catch fish. They currently work as construction or agricultural workers since they do not have fishing boat anymore.

3.2. Impact of tsunami disaster on fish production

Capture production is defined as total amount of fish captured by fishermen during fishing activity. The quantity of capture production will affect the amount of revenue gained by fishermen. Higher capture production will result in higher revenue, *vice versa*. The quantity of capture depend on many factors, namely fishing gears used in fishing, fishermen experience, fishing bait used, fishing location, and the age of fishermen [14], [15]. Capture production in South Lampung Regency was affected by tsunami since fishermen faced difficulty in catching fish after the tsunami.

Capture production after the tsunami in South Lampung Regency was determined by comparing the quantity of fish caught by fishermen, before and after the tsunami. This study successfully identified 13 types of fish frequently captured by fishermen in South Lampung Regency. A significant production decrease was observed in a range of 52-66%. The declining capture production in South Lampung Regency after the tsunami is presented in Table 1.

Table 1. The decreasing capture production post the 2018 tsunami

No	Type of Fish	Average of Production before Tsunami (Kg/Month)	Average of Production after Tsunami (Kg/ Month)	Percentage of capture production decrease post Tsunami (%)
1	Yellow-striped scad	38.54	14.89	-61.4
2	Spanish Mackerel	38.81	13.12	-66.2
3	Mackerel Tuna	43.36	14.47	-66.6
4	Torpedo scad	45.23	21.62	-52.2
5	Scad	42.25	18.48	-56.3
6	Red Snapper	45.16	16.8	-62.8
7	Golden Threadfin Bream	43.52	16.24	-62.7
8	Indian Mackerel	40.13	15.71	-60.9
9	Fringe-scale Sardine	40.14	15.89	-60.4
10	Horse Mackerel	40.55	16.91	-58.3
11	Jawed Mackerel	40.75	18.46	-54.7
12	Golden Snapper	38.23	14.28	-62.6
13	Yellow Tail	40.84	15.62	-61.8
	Total	537.51	212.49	-60.5
	Average	41.35	16.35	-60.5

Source: Primary Data, 2020 (processed data)

Table 1 shows that capture production experienced quite a considerable decrease after tsunami in a range of 52-66% with total average of 60.5%. The highest decreasing quantity was observed in mackerel tuna (*tongkol*), namely from 43.36 kg/month to 14.47 kg/month or approximately of 66.6%, after the tsunami. Moreover, the torpedo scad fish was found to have the lowest quantity decrease from 45.23 kg/month to 21.62 kg/month, despite the fact that the declining amount reached 52.2%.

The decreasing capture quantity was caused by declining quantity of fish in the sea after the tsunami. Fishermen should therefore go fishing to further location to catch more fish. In addition to fish quantity in ocean, decreasing fish capture was also caused by the damaged fishing boats and climate change [16], thus affecting capture production. Moreover, fishermen were found to be traumatic due to tsunami and did not want to fish anymore.

3.3. Impact of tsunami on infrastructure and environment

Beside affecting capture fishery (production), tsunami also aversely affected environmental aspect, namely the declining clean water availability, the damaged infrastructure, poor environmental sanitation, the damaged fishing settlement, and the damaged public facility.

3.3.1. The declining clean water availability. Tsunami affected the availability of clean water.The water sourced from dug wells located near the beach was found destroyed by tsunami, hence cannot be used anymore. Term of water source, respondents obtained water from PAM (Water Service Company) or dug wells located far from the beach was not affected by tsunami. Similarly, declining clean water availability was also observed in Palu which was hit by tsunami on September 28, 2018 and resulted in destruction of buildings, houses, and clean water supply network. Clean water supply network damage might be caused by severe ground cracks due to earthquake and tsunami [17], [18].

3.3.2. The damaged village infrastructure. Infrastructures observed in this study were facilities in Way Muli Village. Furthermore, the facility included schools, village office, roads, and places of worship. The tsunami has caused damage to infrastructure in Way Muli Village. Several facilities found to be damaged were roads and buildings collapsed after tsunami. This finding is in line with the study conducted by Zulfan and Arie that infrastructure damage often occurred in area hit by tsunami and earthquake [19].

3.3.3. Poor environmental sanitation. The tsunami had impact on the declining environmental sanitation in Way Muli Village. After the disaster, sanitation facility such as disposal site, sewers, and others were found damaged. Ruins collapsed buildings along with garbage buildup in many locations after tsunami has harmed the environmental sanitation. Moreover, problem of environmental sanitation was also found in refugee camps where a huge number of people settled together, resulted in several health and environmental problems. Tsunami affected the level of food and water hygiene, particularly in refugee camp [20].

3.3.4. The damaged fishing settlement. The fishing settlement of respondents were located in two different locations. About 26 fishermen lived near seashore, while the rest 26 people lived far from the coast. The houses of fishermen lived near the beach suffered serious damage and impossible to repair, insisted fishermen to leave their house. However, the houses of those lived far from the beach were relatively safe and undamaged.

3.3.5. The damaged fishing support facility. The fishing support facility in Way Muli Village included boats, fishing harbor, and Fish Auction Place (TPI). The tsunami has destroyed those facilities, hence stopping most fishermen to go fishing. The location of Way Muli Village is next to the seashore, thus greatly contributed to the damaged fishing support facility.

4. Conclusion

The Tsunami affected the decreasing capture production in Way Muli Village. Before tsunami, the average quantity of fish caught by fishermen reached 41.35 kg/month, yet this quantity decreased by 60.5 percent to averagely of 16.35 kg/month after the tsunami. The tsunami disaster also caused impact on declining clean water availability, damaged village infrastructure, poor environmental sanitation, damaged fishing settlement, and damaged facility that support fishing activity.

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