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Environmental Reliability Assessment for the Small-Scale Fisheries after the 2018 Earthquake and Tsunami in Donggala, Indonesia: The Voice from the Fishers

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Abstract

Despite increased fish catches reported by most local fisheries agencies, it is undeniable that small-scale fisheries have expressed dissatisfaction about the difficulty of capturing fish in their fishing operations over the past decade. Numerous studies have shown that most coastal fishing grounds are already overfished, one of the causes the contribution of traditional fishers frequently undervalued. The investigation was conducted in the tsunami-devastated coastal villages of Donggala, Indonesia, in 2018, causing coastal degradation, including the destruction of mangrove and coral reef habitats, which diminished the diversity of coastal marine ecosystems. Using a modified version of the McKinnon Framework, this study assessed the environmental viability of small-scale fisheries from the perspective of their fishers. Eleven environmental variables, including its index and the relationships between the yield from fishing operations (revenue) and other environmental conditions of the fisheries, were evaluated. The study found that the reliability index was of 0.47, indicating that fishermen's evaluations on their fisheries are still marginally reliable (fair). Hence, improved coastal management must be implemented concurrently with disaster mitigation. Otherwise, the situation would be further marginalizing fishermen.

keywords: Small-Scale Fisheries, Reliability Index, Coastal Management, Over Fishing

1. Introduction

Most often, natural disasters like earthquakes and tsunamis are unpredictable and unavoidable. This can occur in coastal seas, with potentially catastrophic consequences that endanger aquatic life and its biotic habitat. Humans are capable of repairing the damages, but obtaining precise data and information about the condition of the biotic resource might be exceedingly challenging afterwards [1]. The 2018 earthquake and tsunami in Central Sulawesi, Indonesia, had devastating impact on human life and the environment, especially on the west coast of Donggala Regency, Indonesia.

Aside from the previously stated earthquake, Indonesia's marine fishery, in especially the capture fishery, confronts number of difficulties. Illegal fishing, unreported fishing operations, and lax law enforcement are common issues facing the catch fishery. An estimated USD 20 billion is lost annually as a result of this scenario. The use of unfriendly fishing gear has resulted in harm to around 65% of Indonesia's coral reefs. Furthermore, the uncontrolled disposal of organic waste, plastics, toxic materials, and oil spills has increased the already complex marine fishery [2].

The Minapolitan Program has been run by the Ministry of Marine and Fisheries in many Indonesian regencies, including Donggala, since 2011. The Minapolitan Program is a development model that encompasses a coastal region and the adjacent land area. On the other hand, there have never been any reliable scientific reports regarding the success of a program like this [4] [5] [6].

Of the 16 sub-regencies that make up Donggala Regencies, 14 are found in coastal areas around the Makassar Strait. The accumulation of fishing activity along the coastal water using 10 GT of fishing vessels, however, indicates that the capture fishery is still dominated by the use of small-scale and traditional fishing operations. The aggregation of fishing operations in coastal areas can easily lead to an overfishing situation, which is one way to view the small-scale fisheries in the ocean. Second, the fishing ground's environment has suffered significant harm as a result of the 2018 earthquake.

Research has been done in this regard to examine the fishery's dependability, specifically the fishing area where fishermen have been fishing ever since. The best ways to assess such a reliability are to find out how fishermen view their own fishery and investigate how they place value on it. By identifying holistic aspects of the ecosystem in which they live, the research made reference to the environment approach.

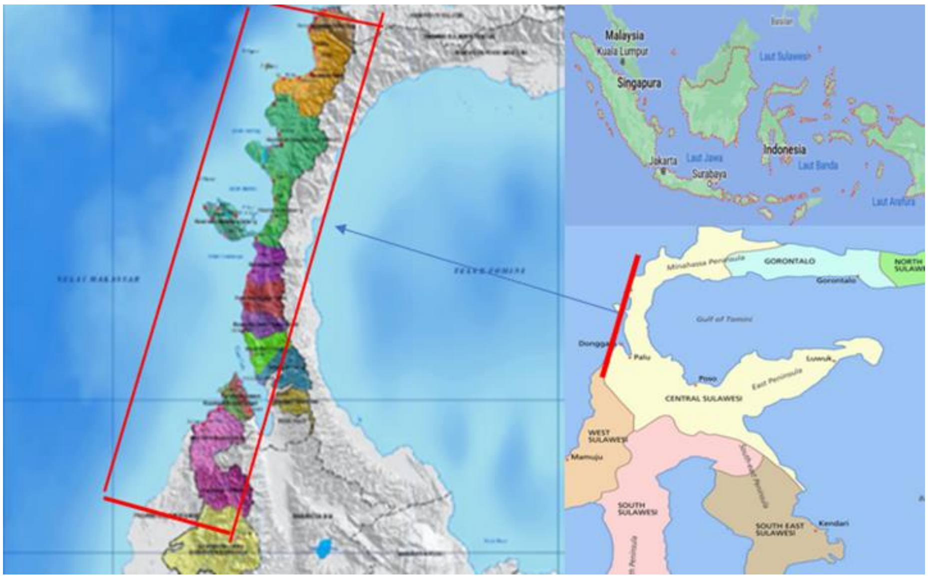

Figure 1. Research Location

2. Research Methods

Research method used was survey. The data gathered through interview and observation using a modified framework for investigating environment viability proposed by McKinnon (2013) [7]. Village sample method undertaken by purposive technique. The selected villages taken as research samples were those that have been impacted by the earthquake and tsunami 2018 while respondent for interviews were randomly selected proportionally from the selected villages. The total number of respondents were 90 fishermen.

A) Fishery Reliability calculated from the fisher's perception using the forced Liker Scale (4 scores)

The fishery reliability was predicted using 12 indicators, hence treated as variables i.e.,

a. Habitat Connectivity (x_1)
b. Habitat Heterogenity (x_2)

c. Habitat Damage (x_3)
d. Coastal Wastes/Pollution (x_4)
e. Amount of Catch (x_5)
f. Catch Diversity (x_6)
g. Commercial Value (Revenue) (x_7)
h. Fishing Ground Zonation (x_8)
i. Law Enforcement (x_9)
j. Village Fisher Co-operation (x_{11})

Interview results were scored according to the rank given by the respondents. The ranking category was set as follows:

- Very Good = 4
- Good = 3;
- Fair = 2;
- Poor = 1;

The collected data will be analyzed using Likert Scale Data Analysis.

B) Reliability Index obtained from scored valued by respondents divided by the total number of indicators (McKinnon, 2013) [7].

Table 1. Example of Reloability Index Calculation

No	**Indicator**	**Score**	**Real Score**
1	Connectivity	Very Good. (4) Good. (3) Fair. (2) Poor (1)	3 (example)
2	Habitat Heterogeneity	Very Good. (4) Good. (3) Fair. (2) Poor (1)	4 (example)
3	Habitat Damage	Very Good. (4) Good. (3) Fair. (2) Poor (1)	2 (example)
…	…	…	…
11	Fishermen Cooperation	Very Good. (4) Good. (3) Fair. (2) Poor (1)	2 (example)
	Scores	Total Standard Score = 16	Total Real Score = 11
	Reliability Index	(Total Real Score) / (Total Standard Score)	11/16 = 0.69 (example)

C) ***Relation between Revenue (Commercial Value) whereby x_7 was taken as dependent variable and the rest of the selected variable treated as independent variables.*** *Mathematically arranged as multiple linear regression as follows:*

$$y: (x_7) = b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_8 x_8 + b_9 x_9 + b_{10} x_{10} + b_{11} x_{11} + a$$

where a = constant

b = regression coefficient

$x_1, \ldots x_{11}$ = independent variables were those described earlier

To identify whether any multi-colleanearity among the independent variables, the two following formulas were used.

a. Tolerance Test (T)
   $T = 1 - R^2$
   where R^2 is Determination Coefficient, if $T < 0.1$ then multicollinearity occurs
b. Variance Inflation Factor (VIF)
   $VIF = 1/(1 - R^2)$
   where R^2 is Determination Coefficient, if $VIF > 10$ then multicollinearity occurs

3. Results and Discussion

3.1. Results

3.1.1. Likert Scale Results for Reliability Index as Fishers' Perception

The fishery's reliability resulting from the Likert Analysis can be seen in the following table (arranged from very good, good, fair, and poor criteria):

Table 1. Fishery's Reliability Perceived by the Fishers

No	Indicator		Criteria/Flag
1	Habitat Connectivity		Very Good
2	Law Enforcement		Good
3	Conservation Effort		Good
4	Habitat Wastes/Pollution		Fair
5	Amount of Catch		Fair
6	Catch Diversity		Fair
7	Commercial Value (Revenue)		Fair
8	Habitat Damage		Fair
9	Fisherman Cooperation		Poor
10	Habitat Heterogeneity		Poor
11	Tourism Benefits		Poor
Final Result			**Fair**

3.1.2. McKinnon Index on the Fisheries Reliability

Using mechanism described in Table 1, fisheries reliability was found to be **0.47**. As mentioned earlier that the index obtained by dividing the real scores given by the fishers with the total number of the scores given to the eleven variables.

3.1.3. Relation between Economic Value and Socio-economic Condition

By taking Economic Value as dependent variable, the regression equation as follows.

$$y = 2{,}91 + 0{,}07\, x_1 - 0{,}013\, x_2 + 0{,}17\, x_3 + 0{,}09\, x_4 + 0.03\, x_5 + 0{,}16\, x_6 + 0{,}02\, x_8 + 0{,}03\, x_9 + 0{,}02\, x_{10} + 0{,}03\, x_{11} + 0{,}24\, x_{12}$$

ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F table*
Regression	11	9,228573	0,838961	0,938664	0,508664
Residual	78	69,71498	0,893782		
Total	89	78,94356			

Regression Statistics	
Multiple R	0,341908
R Square	0,116901
Adjusted R Square	0,00764
Standard Error	0,9454
Observations	90

Anova revealed that F_{count} is higher than F_{table} indicating that all dependent variables significantly influenced the dependent variables. Besides, no multicollinearity identified among the independent variables as the calculated T is about 0,88.

Discussion

4.2.1. Fishery Reliability

The 7.4 Richter scale tectonic earthquake and tsunami that struck in 2018 had a major effect on the Donggala capture fishery. An incident like this would also affect the environment, the economy, and society. As a result, ongoing mitigation and adaptation must be done continuously.

Important supporting information was that the reliability index of the fishery was only 0.47 indicating the fishery was in the fair level. This revealed that all selected indicator were not reliable enough to support the fisheries [9].

Two variables were classified as poor. They were tourism and habitat heterogeneity. According to the theory of habitat heterogeneity, a habitat's diversity increases with its degree of heterogeneity [10]. It is reasonable to assume that the 2018 earthquake and tsunami have had an impact on the quality of fish habitat, even though no research has been done on the subject. Fish species diversity consequently declines. This is consistent with the idea that species diversity decreases with habitat heterogeneity decreases. The decline in fish species diversity is thought to be caused by damages to the mangrove, coral reef, and sea grass ecosystems [11].

Following the earthquake and tsunami, there was a dramatic decline in the number of fish catch. According to reports, Indonesia has overfished more than half of its fishing grounds while, it was reported as well that about 14 million people were employed in coastal waters, primarily as fishermen. This is the rationale behind the quota system that the Indonesian government will be implementing for the capture

fishery. At this time, this policy is still up for debate, though, because it could lead to disputes between traditional and non-traditional fishermen because the former will receive a smaller quota than the latter.
The 2018 disaster had a significant direct effect on the community's socioeconomic condition [9]. The damage to the fishing gear and houses was substantial. Their fishing earnings were only sufficient to support their home and the repair of their fishing gears, which kept them from making investments in their daily fishing operation [10]. In connection to this issue, it was found that there was very little cooperation between the government, non-governmental organizations, and the community. No institutions have yet to engage in cooperation, or at least to carry out partnership activities that involve both financial and technical support.
Fortunately, two variables classified as very good and good. These, subsequently, were habitat connectivity and conservation activity. The degree to which natural processes or living things can freely move throughout their environment without interference is referred to as connectivity. Natural processes like the food chain, migration, and nutrient cycle could not occur normally in the absence of connectivity [16]. There was no habitat fragmentation at the study site as a result of either human activity or earthquakes.
In the meantime, waste management, or "kerja-bakti," was directly handled by the community as part of conservation efforts. There were no large-scale, heavy-producing industrial activities nearby, so the only wastes that needed to be handled were domestic and organic.

4.2.2. Relation between Revenue and Socio-environment Aspect

An additional method utilized to examine the fishery's reliability was to find out how much the environmental and socioeconomic facets of the relationship reinforce one another [13]. In these cases, the reliability was to be measured using income as the determinant. The fishery is more reliable as the higher the income and vise-versa.
Technically, revenue was the multiplication of the fish catch by price [14] [15]. It can be seen that the independent variables that has direct relation to the economic value was habitat damages and fish catch. From the regression equation it can be said that the increase in the damages to 100% will decrease the revenue as much as 13%. Similarly, the increase in the catch to 100%, it can only increase the revenue as much as 16%. This showed that the reliability of the fishery was only in fair level.

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