Estimated economic value of the lost coastal resources due to tsunami in September 2018 in Palu City, Indonesia

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Abstract. The coastal area of Palu City has natural resources that are utilized by the community for fishing activities, marine tourism, salt pond, and culinary business. However, the tsunami disaster in September 2018 caused the loss of some coastal resources and community businesses that affected the regional economy. This study aims to estimate the value of the presence and loss of Palu coastal resources through fisheries activities, marine tourism, and other utilization activities. The analytical method used is the analysis of Total Economic Value. The results showed that before the earthquake and tsunami disaster in Palu City, the total economic value of coastal resource services owned was IDR 237.92 billion per year. The economic value lost due to the disaster is estimated at IDR 127.53 billion or more than half the initial economic value.

1. Introduction
Coastal cities characterized by valleys, rivers that divide the city, and are in the bay area are the unique geographical conditions in Palu City. Another uniqueness is the different climatic conditions compared to other coastal cities in Indonesia, where the dry month per year is generally more than the wet month, and the air temperature is relatively high compared to the average temperature in other coastal cities [1]. With its unique geographical and climatic conditions, Palu City has diverse natural resource potentials such as gold reserves, C mining, forests, agriculture, animal husbandry, fish resources, coral reefs, and coastal tourism objects. The potential of coastal resources and Palu Bay is characterized by activities in capture fisheries, marine culture and seaweeds culture, salt ponds, and coastal tourism to provide high value. Gross Regional Domestic Product according to agriculture, forestry, and fishing in 2019 reached IDR 899.95 billion [1], lower than in 2018 which was IDR 929.76 [2]. Administratively, Palu City is also the capital of Central Sulawesi Province, making it the center of government, trade, industry and services, and other economic activities.

Although it has the potential for a diversity of natural resources and high economic value, coastal areas are also a very dynamic and complex geo-morphologically complex system that responds in various ways to extreme weather events. Increased sea levels or tidal floods and storms are the most dangerous natural disasters and become a threat to humans who inhabit (social) and economic activities in the coastal areas of the city [3] creating scarcity resources [4]. Many coastal cities grow organically,
without proper planning and paying attention to the vulnerability generated by the sea to residential areas and other activities. This vulnerability is demonstrated by the occurrence of tidal floods, tsunamis, and storms that eliminate human lives and damage to infrastructure along the coast, as well as the loss of economic activity (industry, trade, and services) that have been invested [5]. The next impact is the high social problems and the decline in community income [6]. Coastal cities with weak governance, poor and growing populations, and large influx of migrants are very sensitive to these risks. Therefore, it needs to handle the risks [7].

Fear of vulnerability and impending disaster will also be manifested in the coastal area of Palu City, namely the earthquake followed by the tsunami on Friday 28 September 2018 which caused changes in the Talise Beach coastline [8], damage to economic and government infrastructure, and loss of village housing fishing villages along the Talise Coast of Palu City to the west coast of Donggala Regency. According to the National Disaster Management Authority (NDMA) report as of October 27, 2018, the impact of losses and damage for all disaster-affected areas in three districts/cities in Central Sulawesi reached IDR 18,48 trillion, the biggest losses came from the settlement sector, then the infrastructure sector, economic sectors, social sectors, and across sectors. When compared to the impact of the tsunami in the Lampung Province of Indonesia, the loss and damage in the housing sector were at most 30% [9]. In Palu city, the damage to flat and heavily damaged buildings almost along the coast of Palu Bay and the value of losses reaching IDR 8.3 trillion is the highest compared to Donggala, Sigi and Parigi Moutong Regencies which are caused by housing damage estimated at IDR 7.03 trillion, IDR 494.1 billion damage to the infrastructure sector and 774.52 billion damage to the economic sector [6]. This shows that the damage and loss of natural resources due to the earthquake and tsunami disaster also causes the loss of economic value of coastal resources. Based on the study of natural disasters by UN-ESCAP in 2015, between 1970 and 2014, Asia and the Pacific accounted for 56.6% of global fatalities due to natural disasters, 88.0% of citizens being affected by natural disasters, and in this time frame, 1.15 trillion US Dollars were lost from natural disasters; 92.0% of which are attributed to earthquakes, tsunamis, floods and storms [10]. The loss of ecosystems or natural resources is an economic problem because it causes the ability of the ecosystem to provide goods and services is also lost.

To recover some or all of the lost economic value of the coastal resources, the economic valuation study of coastal resources based on the typology of resources in each coastal ecosystem [10,11], species and communities are very important. The importance of economic valuation because it can provide methods and techniques to determine how changes in coastal resource services can be translated into benefits and costs for community welfare [11], and regional economic growth over time [12]. The economic value of resources obtained from calculations before and after a disaster provides useful information about the welfare conditions of coastal communities. Economic valuation of coastal ecosystems can also provide a framework in the form of policies on infrastructure development planning, fisheries, tourism, conservation in coastal and marine areas, for the continuation of mutual interaction between people and coastal resources [13]. Based on these problems, this paper is intended to estimate the loss of economic value of coastal resources due to the earthquake and tsunami disaster in Palu City.

2. Analysis

The location of the study of the economic valuation of coastal resources includes coastal areas affected by the earthquake and tsunami in the administrative areas of the Districts of West Palu, Ulujadi, Mantikulore, East Palu, North Palu, and Tawaeli in Palu City in the Central Sulawesi Province of Indonesia. Research targets and objects include fishing communities, micro and small business units (UMKM), salt farmers, local tourists, and community users of the area and resources (coral reefs and beaches) of Palu City. The types of economic activities in the use of coastal areas and the analytical methods used to assess the economy value in Palu City are presented in Table 1.

Table 1. Land use, typical economic activities and analysis methods used in assessing the economics of coastal resources in Palu City.
## Resources/Activities [14,15]

| Resources/Activities | Data Description | Valuation Method |
|----------------------|------------------|------------------|
| Fishing: subsistence, artisanal, commercial fishing: pelagic fish, demersal, and others coastal-marine culture | - Fish production (kg) - Output Price (IDR per kg) - production cost (IDR) - economic rent (IDR per year) | Direct use value (Market Value) [15,16] |
| Beach Tourism: Hotels, resorts, sporting activities, culliner tourism | - Land rent (IDR per m²) - Large area (m²) | Direct use value (Market Value) [15,16] |
| Recreation: Adventure fishing, swimming, kayaking, sunbathing, recreation park | - Tourist number (person) - Travel cost (Rp/trip) | Non-consumptive direct use value, Travel Cost Method [15,17] |
| Coral Reef Ecosystem | - Coral reef damage (m²) - Loss of ecosystem services (IDR per m²) | Total economic value approach to ecosystem services [16,18,19] |
| Coastal land use: cafe and seafood, Salt Ponds | - Land rent (IDR per m²) - Large area (m²) | Direct use value (Market Value) [15,16] |

Based on Table 1, the economic value of Palu City Coastal resources is obtained from the sum of economic values based on the use-value (UV) and non-use value (NUV) of coastal resources. UV consists of Direct Use Value (DUV), Indirect Use Value (IUV), and Option Value (OV). While NUV-based economic value consists of 2 components namely Bequest Value (BV) and Existence Value (XV). Mathematically estimating the Total Economic Value of coastal resources before and after the tsunami disaster was formulated [15]:

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TEV = UV + NUV = (DUV + IUV + OV) + (XV + BV)
\]

The economic value of coastal resources before the earthquake was obtained from literature studies before the disaster [20] and primary data processing [2]. The total difference in the economic value of each component of environmental goods and services in coastal resources is the loss in the economic value of resources from the earthquake and tsunami.

### 3. Results and discussion

#### 3.1. Economic Value of Fisheries Resources

Fishery resources on the coast of Palu City include small pelagic reef fish and demersal fish groups, that are utilized using traditional fishing gear such as Raft Lift Net, Gillnet, Beach Seine, Guiding Barrier, Hand Line, Portable Trap, Harpoon, and Spin-gun. The entire coastal waters and the Gulf of Palu are fishing ground for fishermen, while aquaculture is limited in the villages of Watusampu and Kayumalue Pajeko. The number of fishermen in Palu City in 2019 was 815 people. Fisheries production in 2019 was 985.6 tons and fisheries production in 2017 and 2018 were 1629.5 tons and 1110.7 tons respectively. Based on the fisheries production, the production value (revenue) of fisheries by Palu City fishermen and cultivators in 2019 reached IDR 37.49 billion and in 2018 it reached IDR 29.57 billion. The results of the survey, the proportion of fishing costs to total revenue of 37.81%. Based on these values, the economic value of capture fisheries is IDR 4.92 billion.

Marine culture activities on the coast of Palu City gave an economic value of IDR 2.67 billion per year, but in 2019 there was a decline in production so that it only provided an economic value of IDR 347.07 million, or there was a loss of economic value of IDR 2.33 billion. Likewise, there has been a loss of the value of coastal resources from the use of waters for seaweed cultivation since 2015 which amounted to IDR 8.39 billion. The total economic value of coastal resources from fishery activities is IDR 15.64 billion per year. The decline in marine culture production and the loss of seaweed farming activities in the City coast are thought to be caused by a decrease in the quality of the waters around the utilization area. The bioeconomic model integrates coastal breeding and nursery habitat availability with quota rules to limit the harvest of near-shore stocks [12]. To recover some of the lost economic value it
requires planning and adaptive Co-Management that can be defined as a partnership approach where government and resource users share the responsibility and authority for the management of a fishery or area, based on collaboration between themselves and with other stakeholders [21].

3.2. The economic value of tourism and recreation in the coastal area of Palu City

The coastal area of Palu City has a beach and marine tourism area of Mamboro Beach, Taipa Beach, Talise Beach, Kampoeng Nelayan, Besusu Beach, Anjungan Nusantara, Taman Ria, Tumbelaka Beach, and Amazing Beach Resort. The priority development areas and favorite destinations of the people in conducting beach tourism and recreation activities (bathing locations both for snorkeling, bathing for treatment and sports, diving, jetski, and rowing) are Talise Beach and Kampoeng Nelayan Beach. The quality of the waters around the coastal area is still possible for recreational activities. However, with the high level of community activities in settlements, industries, restaurants, and hotels it is suspected that seawater pollution has occurred. Both of these locations are also used for nature tourism areas (sunrise, sunset, and night atmosphere) and culinary tourism. The number of tourists visiting Central Sulawesi in 2018 was 3 757 670 people, and by using the number of rooms and beds of the total Central Sulawesi, the index of tourists visiting Palu was 0.24. Assuming all hotel rooms are occupied, 24.0% of tourists visiting Central Sulawesi are tourists visiting Palu City, which number 884 931 people (10 619 foreign tourists and 874 312 domestic tourists), and an estimated 60% of tourists plus 18 000 local tourists visit the beach tourism location so that a total of 553 206 people is obtained so that the calculation of travel costs starts from home or lodging.

The results of the field survey showed that the average travel expenses incurred from the location of the into the beach tourism location amounted to IDR 51 375 per person. The magnitude of the loss of economic value of coastal resources due to the loss of some of the infrastructure and resulted in a 15.03% reduction in occupancy and the number of tourists visiting the coastal area of Palu, which amounted to IDR 8.87 billion per year. The lost economic value is obtained from the difference between the economic value before the earthquake and tsunami disaster of IDR 28.42 billion per year and after natural disasters of IDR 19.55 billion per year. To increase the number of visitors back at the beach tourism location (sunbathing and snorkeling), efforts to improve the quality of coastal waters are needed [12].

3.3. Economic value of coral reef

The results of measurements of coral cover by Palu Municipally Government [15] in 2014 at 9 coral reef observation points in the Coastal waters of Palu City were found with variations in coral cover conditions from the poor category at four observation stations, moderate conditions at four stations to good coral cover categories found at one station. The types of coral found were lifeform hard coral, for Acropora branching, coral massive, and another hard coral lifeform. The percentage of the cover was also found for soft corals with a percentage of cover between 3% - 56% in Watusampu and Pantoloan. From the nine points, it is estimated that the area of coral reef life form cover in Palu City is 18.00 Ha.

The Office of Maritime Affairs and Fisheries in Central Sulawesi Province has conducted an initial survey conducted in the coastal areas of Kayu Malue and Mpanau in the North Palu District after the earthquake and tsunami showed that coral reef damage reached 80%. The tsunami disaster also damaged coral reef ecosystems that have been rehabilitated since 2008 on the coast of Loli and Silae beaches in Palu City, covering an area of 3.0 to 4.0 hectares.

The results of the calculation of the economic value of coral reefs using monetary values for each service per biome [18] on the function of coral reef ecosystems as provisioning services, regulating services, habitat services and cultural services [22], obtained loss of economic value of coral reefs due to the earthquake and tsunami amounting to IDR 75.59 billion. The value of the loss is very large compared to the results of studies in Cilik island, Karimunjawa Subdistrict, Jepara Regency, Central Java Province, showing that the total claim of compensation amounted to IDR 3.07 billion [19]. This difference is due to the impact of the damage caused by the earthquake disaster on the bottom of the Palu Bay sea is very large compared to the damage from anthropogenic activities. Also, the difference in the monetary value of an ecosystem service depends on the conditions of the population's livelihood,
income level, and other socioeconomic conditions such as price level, population density, the distance between beneficiaries and resources, affordability, and the existence of replacement and complementary sites [18].

3.4. Economic Value of Coastal Area

The use of coastal land in Palu City consists of residential land, salt ponds, beach recreation and tourism areas, culinary tourism business land, and sports activities (jogging and cycling). This condition shows the varied land uses, although in general it is dominated by land for food/beverage sales, especially in Kampung Lere, Talise, and Tondo Beaches. According to the data from the Department of Cooperatives, Micro, Small and Medium Enterprises in the Palu City, the number of local specific culinary businesses in Palu City in 2018 was 16,000 units, and 21.88% of them were in the Talise Coast and Kampung Lere areas, so the estimated number of culinary businesses was 3,500 business units. The economic value of the utilization of coastal land through culinary tourism business activities before the disaster amounted to IDR 75.60 billion. As a result of the tsunami disaster, 1,200 culinary businesses were affected, resulting in a loss of economic value of coastal resources of IDR 25.92 billion.

Utilization of coastal areas in the Palu City covering an area of 18.1 hectares with the number of salt farmers as many as 165 people. After the disaster, 116 salt farmers actively reused their land. Based on the economic rent per production, a value of IDR 1.016 million is obtained and in a year there is 30 times the process of salt production, the economic value of the utilization of coastal land from salt ponds before the disaster is IDR 5.03 billion, and after the earthquake and tsunami an economic value of IDR 3.52 million per year. This means that the economic value of Palu City's coastal resources from salt pond activities is IDR 1.50 million. The total economic value lost from the use of coastal land due to the earthquake and tsunami on the Coast of Palu City is IDR 27.43 billion.

3.5. Total Economic Value of Resources Lost Due to the Earthquake and Tsunami

Based on the results of the calculation of the economic value of Palu City coastal resources for each type of resource and its use, it is obtained the total economic value and the lost economic value as presented in Table 2.

| Resources/Activities                        | Coastal Economic Value (IDR million per year) | Before Disaster | Lost Value  |
|--------------------------------------------|-----------------------------------------------|----------------|-------------|
| Fishery Catch                              | 23 311.92                                    |                | 4 923.58    |
| Marine Culture                             | 2 673.55                                     |                | 2 326.48    |
| Seaweed Culture                            | 8 387.34                                     |                | 8 387.34    |
| Coastal Tourism and Recreation             | 28 420.98                                    |                | 8 874.10    |
| Coral reef                                 | 94 492.20                                    |                | 75 593.76   |
| Coastal Area Use                           | 80 629.20                                    |                | 27 428.76   |
| Total Economic Value                       | 237 915.19                                   |                | 127 534.02  |

Table 2 shows that after the earthquake and tsunami disasters, the percentage of the total economic value of lost coastal resources in Palu City was 53.61%, the largest was contributed by coral reef ecosystem services, utilization of coastal areas (80.00%) and loss of coastal services for seaweeds culture activities. The high value of coral reef ecosystem services shows the magnitude of the role of these resources for the coastal environment, especially ecological protection and communities around the coast. The value obtained will be the basis of development planning to restore the ecological and socio-economic functions of the coastal area. The economic values obtained from the calculation of ecosystem services differ in each region, so these values apply at the scale of the region concerned [18] to be used as a basis for developing regional development policies that lose the economic benefits of resources. Budget planning for development by the government and the business sector must consider...
the negative impacts that occur and prioritize positive contributions to the business and surrounding households [23], increasing the capacity of communities to prepare for and cope with a disaster by encouraging full participation of government, private and public [24].

4. Conclusion
Three important things can be stated in this conclusion, first, more than half of (IDR 127.53 billion) the total economic value of the Palu coastal resources lost due to the earthquake and tsunami natural disasters, as well as massive coastal pollution since the loss of coastal environmental services through the use of marine culture and seaweeds culture. Second, the value of coral reef ecosystem services lost in the coastal area of Palu City shows the amount of sacrifice that must be issued by the local government through development plans to restore the function of coral reef ecosystems. Finally, it requires a large, planned and integrated effort between stakeholders (government, business, and other users) in rebuilding the coastal environment and economic infrastructure to increase the economic value of coastal resources by taking into account geological factors and the Palu City area which is prone to earthquake and tsunami disasters.

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