Management of Sustainable Coastal Reclamation Areas: A Case Study of the Reclamation of Tering Bay in Batam Island, Indonesia

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Abstract

Batam's location is very strategic as it lies on international trade routes and is located in the center of Indonesia-Malaysia-Singapore (IMS-GT) growth triangle. Considering the increasing land demand in Batam Island, Batam City government has expanded the area through reclamation process for industrial and other commercial area. Reclamation process has significantly impacted the deterioration of environmental quality in Batam Island. The condition of the damage will become more severe so that it will cause the poor quality of waters due to pollution of coastal and marine waters. One of the reclaimed areas is Tering Bay. The reclamation of the Tering Bay is currently under conditions with very poor water quality. The purpose of this research is: (1) to study the management of Tering Bay area which is sustainable; and (2) considering the reclamation is an activity that become the society need. The method used in this research using Partial Least Square (PLS) and Analytical Hierarchy Process (AHP) method. PLS is used to determine whether or not there is a relationship between latent variables in coastal reclamation, as well as forming a constructive model. Meanwhile, AHP method is useful to determine the priority scale of handling management of coastal reclamation area sustainable. The results show that to achieve sustainable reclamation requires good management. The management includes: increased role of community, local government, private sector and tightening of rules. However, the management should pay attention to the process of erosion and abrasion with considering that this region has a strong enough sea waves.

INTRODUCTION

Goods and services are essential elements for world economic activities, and those are coming from coastal ecosystems such as mangroves, coral reefs, seagrass, sands, and estuaries. Ecosystems can improve themselves, and they can be sustainable. However, humans who use ecosystems are too excessive and increasingly irrational. This means that humans exploit coastal ecosystems without considering the aspects of sustainable plant growth. The impact is humans do not optimally feel the damage to the ecosystem and the services provided by the ecosystem. Burke *et al.* (2001) stated that coastal ecosystems are unique ecosystems found along continental boundaries. Coastal ecosystems have exceptional biological productivity and high accessibility. Coastal ecosystems

provide services in the form of health, food, safety, recreational sites, marine ecotourism, ports, hotels, and housing for humans. Thus, the coastal area becomes the center of human activity with various activities, such as used for residential spaces, trade, hospitality, industrial areas. Also, coastal ecosystems are suitable habitats for mangroves, coral reefs, seagrass beds. The coastal habitat is ideal for the habitat of fish, shellfish, seaweed, however, with the increasing population in coastal areas experiencing pressure and burdened.

So that the services of coastal ecosystems are increasingly limited, land requirements for anthropogenic activities on the coast are increasingly limited, so additional land is needed through coastal reclamation (Chee *et al.*, 2017; Burt *et al.*, 2010; Pawitro, 2015).

Reclamation is to be government policy to meet the needs of its people with increasingly narrow land in the land. According to Larson (2015) that the construction of artificial islands in the reclamation area to support the needs of the community, including infrastructure development, is considered not a new concept, but there are increasing concerns about the environmental and political impacts of this development.

Zhang *et al.* (2017) stated that the new area of sea reclamation reached 3,264 km^2 in 35 years in the South China sea from 1975 to 2010. The average annual growth rate was nearly 93 km^2. Among them, the area of sea reclamation in Vietnam reached 1856 km^2. Sea reclamation in China is about 1044 km^2 compared to the newly-reclaimed land in Indonesia that added up to 306 km^2. Sea reclamations in Malaysia and Singapore were similar, about 120 Km2. One of the excessive coastal exploitation is the beach reclamation project, which has been carried out to develop new trade centers, residential areas, and tourist attractions. Apart from public debate and criticism from the environment, the beach reclamation project is still planned and built-in several places in the city. In Indonesia, the spread of reclamation locations occurs not only in metropolitan cities such as Jakarta but also in large cities such as in Makassar, Bali, Bandar Lampung. Rudianto (2018) mentions that reclamation causes significant changes in coastal landscapes and harms the threatened existence of biodiversity, including the threat of the socio-economic life of the community. However, there is a positive effect obtained from the reclamation activities mainly related to economic growth.

Priyandes and Majid (2009) stated that Batam's economic growth in 2012 was around 6-7.4%. This economic growth is very high when compared to the national economic growth of around 5.3%. This high economic growth shows that Batam has excellent economic prospects to be developed in the future. For this reason, the Indonesian government determined Batam Island as an exclusive economic zone (Aritenang, 2017). This status encourages the Batam city government to carry out various development activities, including the reclamation project. Reclamation in Batam Island is intended to develop integrated areas, which include: housing, tourism, trade, and public facilities. One of the reclamation activities is the reclamation of Tering Bay.

Batam Island has two institutions related to its status as a bonded zone to expand industrial areas with export destinations. The Batam Authority Agency, one of its authorities, is to hold the management rights over land in the Batam area based on Presidential Decree number 41 of 1973. Meanwhile, the Batam city government was formed as a consequence of the implementation of regional autonomy based on Indonesia Law Number 53 of 1999 (Qadariani, 2017). Therefore, land handling overlapping occurred on the island of Batam.

The overlapping authority between the city of the Batam government and the Batam Authority Regional Governments caused the management of Batam Island

to be in disharmony (Zaenuddin *et al.,* 2017; Murti, 2014). However, in the implementation of reclamation, there has been severe damage to environmental impacts. Team 9 of the Batam City Government has issued a reclamation stop letter at 14 points, including the Tering Bay (Batam News, 2016). These 14 locations are suspected of being illegal and damaging to the environment. These locations have been the media spotlight. Some of them allegedly actually triggered damage to the environment. Environmental damage is quite severe seen not only in the sea but also on land.

The hills have been razed and haphazardly cut, and the intensive sedimentation process occurs and pollutes the quality of seawater. Arsyad (2008) mentions that one of the over-exploitation of beaches is the beach reclamation project, which has been carried out to develop new trade centers, housing areas, and tourist attractions. Apart from public debate and criticism from environmentalists, the beach reclamation project is still planned and built-in several places in the city. Therefore, controlling reclamation activities and considering ecological protection due to reclamation must be regarded (Zhang *et al.,* 2017). Thus, the purpose of this research is to study the sustainable management of the

Tering Bay area, considering that reclamation is an activity that is a necessity of the community.

METHODOLOGY

The main focus according to the research objective is to manage the reclamation of the Tering Bay to be sustainable, although it cannot be denied that reclamation has resulted in changes in the landscape, and changed the variable hydro oceanography. For this reason, it is necessary to first observe the changes that occur in the Tering Bay reclamation.

Besides, changes in the lives of people around Tering Bay were observed whether they are affected by the reclamation. The input from the impact of Tering Bay from both the biophysical and socio-economic aspects became the input for managing the Tering Bay reclamation. The role of various stakeholders is needed to maintain the reclamation of Tering Bay. Then the stakeholders must focus on handling the impact of reclamation on the changing aspects of the hydro-oceanography elements and climate change adaptation. In various works of literature, the effect of reclamation is very significant. (Nadzir *et al.*, 2014; Zhu *et al.*, 2016). The concept of thinking's framework is outlined in Figure 1.
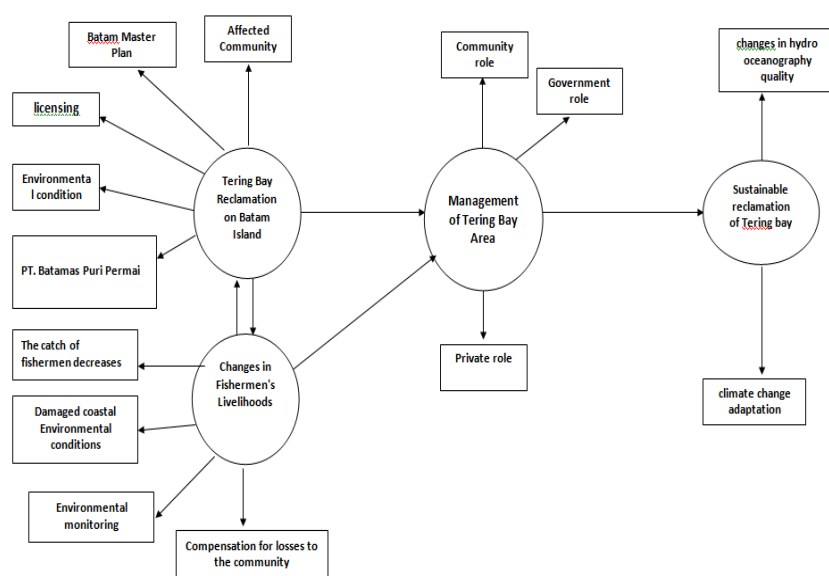

Figure 1. Sustainable reclamation management model of Tering Bay.

Research Material

The Tering Bay reclamation was carried out based on an agreement between the Batam city government and PT Batamas Puri Permai as the permit holder for the Tering Bay reclamation in 2004. The Batam City Government granted a coastal reclamation permit to PT. Batamas Puri Permai in Tering Bay Village on Nongsa District on an area of ± 300 hectares, including land for public facilities. In the utilization of the property, PT. Batamas Puri Permai is willing to follow the Batam City Spatial Plan and the Batam City Spatial Detail Plan. However, on the Tering Bay reclamation process, there has been environmental damage due to investors not following the rules of environmental impact analysis. Thus, ecological disaster has occurred, such as sedimentation. Also, the extracted material used for reclamation is not suitable due to the land directly put into the sea. The effect of reclamation is more on the aspect of sedimentation in the sea, and it can change the landscape of the coastline landscape.

Law Number 27 of 2007 concerning Management of Coastal Areas and Small Islands states that reclamation is an activity carried out by people to increase the benefits of land resources in terms of environmental and socio-economic aspects through landfilling, land drainage or drainage. Based on this definition, it was conducted interviews with respondents from the government, community, and private parties related to the reclamation of the Tering Bay. The total respondents surveyed using a questionnaire totaled 25 people. The method used is to use probability sampling or use a random sampling method. By taking this sample, all members of the population are assumed to have the same opportunity to be selected as a research sample.

Table 1 shows the type and number of respondents. Table 1 shows the type and quantity of respondents. The amount and type of respondents are based on stakeholders directly related to the reclamation area. The opinions of scientists are extracted from scientific journals, while the views of Bappeda have been summarized from the Batam environmental agency.

Table 1.   The types and number of respondents.

No	The Types of Respondents	The Number of Respondents
1.	Batam environmental agency	3
2.	Public Works Office of Batam City	3
3.	The fishing community	6
4.	NGO	4
5.	Village officials	4
6.	Private Sector	5
	Total Respondents	25

Source: Interview (2017)

Data Analysis

Structural model of PLS

Partial Least Square (PLS) and often called soft modeling is possible to model structural equations with relatively small sample sizes and do not require normal multivariate assumptions. According to Monecke and Leisch (2012), the approach of partial least squares (PLS) to SEM offers an alternative to covariant-based SEM, which is very suitable for situations when data is not normally distributed. Tenenhaus *et al*. (2005) mentioned that PLS path models consist of three components: the structural model, the measurement model, and the weighting scheme. Whereas the structural and

measurement model are components in all kinds of SEMs with latent constructs, the weighting scheme is specific to the PLS approach.

According to Jaya and Sumertajaya (2008), PLS is a powerful analytical method because it can be applied to all data scales, it does not require many assumptions, and the sample size does not have to be significant. PLS can also be used as a confirmation of the theory. It can also be used to build relationships that have no underlying terror or to test propositions. PLS can also be used for structural modeling with indicators that are reflective or formative.

Analytical Hierarchy process (AHP)

The relationship between the stakeholders is shown by the significant relationship through the PLS model, while to know the priority of the problems that need attention, Analytical Hierarchy Process (AHP) is used. AHP is a method of decision making by pairwise comparisons between choice criteria and pairwise comparisons between choices. It is generally composed of criteria and choices (Saaty, 1988). Information about the reclamation of the Tering Bay is then synthesized to determine the relative ranking of the alternative options available. The criteria of the type of qualitative and quantitative can be compared using informed judgment to calculate the weight and priority. The number and kind of variables used in AHP can be seen in Figure 3.

RESULTS AND DISCUSSION

The position of Batam Island is on the western side of Indonesia, facing the Singapore Strait and 20 Km distance from Singapore. The population of Batam Island is estimated at 1,1 million people in 2016. Economic growth is 4.3 % in 2016 (BP Batam, 2016).
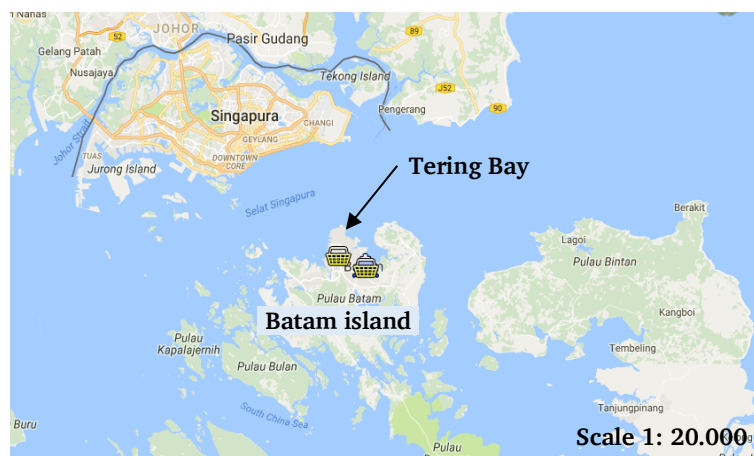

Figure 2. Map of Tering Bay in Batam Island.

The operation of the PLS corrects Figure 1 above by displaying a structural model, as shown in Figure 2. This is because data to obtain changes in the income of fishers affected by reclamation activities is difficult to gather in the field. Other elements of data about changes in fishermen's response, degraded coastal environmental conditions, and monitoring of environmental conditions from before and after reclamation are also challenging to obtain, so there is a modification of Figure 1 to Figure 2. The position reaches the state of sustainable reclamation must be a position before the final goal of attaining the control of the reclamation area to achieve proper management of the reclamation area.

To achieve the management of the Tering Bay reclamation area, the role of each stakeholder is central, namely the part of the government, society, and the

private sector. While the role of the three stakeholders is based on reclamation regulations, modification of the structural model in Figure 3 that comes from the

Figure 1 frame of mind is shown below, while the convergent validity test results can be seen in Table 2.
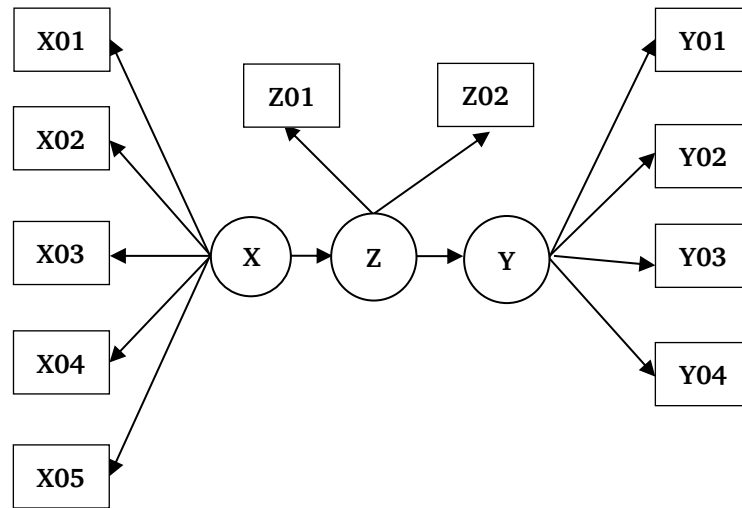

Figure 3.   Structural model of PLS.
Remarks:

X   : Reclamation of Tering Bay   Y03: Reclamation regulation
Y   : Management of the Tering Bay area   Y04: Private role
Z   : Reclamation of Sustainable Tering Bay Z01: Climate Change
X01   : Affected Community   Z02: Hydro oceanography change
X02   : Regional spatial plan
X03   : License for reclamation
X04   : Environmental condition
X05   : PT Batamas Puri Permai
Y01   : Community role
Y02   : Government role

Table 2.   Outer loading (Mean, STDEV, T-Values).

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STERR)	P Values
X01 < Affected Community	0.916	0.911	0.031	29.261	0.000
X02 <Regional Spatial Plan	0.852	0.847	0.045	18.900	0.000
X03 < License for Reclamation	0.843	0.839	0.044	19.286	0.000
X04 <Environmental Condition	0.904	0.899	0.034	26.954	0.000
X05 <PT Batamas Puri Permai	0.842	0.846	0.033	25.460	0.000
Y01 > Community Role	0.945	0.943	0.016	60.755	0.000
Y02 > Government Role	0.871	0.867	0.039	25.500	0.000
Y03 > Reclamation regulation	0.786	0.789	0.071	11.063	0.000
Y04 > Private Role	0.881	0.879	0.040	22.193	0.000
Z01< Climate Change	0.943	0.944	0.013	74.775	0.000
Z02< Hydro Oceanography change	0.917	0.912	0.032	28.670	0.000

Based on the analysis in Table 2 between the parameter coefficients of Tering Bay reclamation (X) with each

parameter coefficient X01 (Affected community), X02 (Regional Spatial Plan), X03 (License for reclamation), X04

(Environmental condition) and X05 (PT Batams Puri Indah) shows a significant relationship. These things are caused by the parameter coefficient value above 0.7.

Cross loading is another measure of discrete validity. The expected value that each indicator has is higher loading for the construct measured than the loading value to another construct.

The value of cross-loading on Table 3 below between these indicators and the construct variable value below 0.70 should be removed from the model. According to Ghozali and Latan (2015), the outer loading value below 0.5 can still be tolerated to be included in the model.

Table 3.   Cross loadings (Mean, STDEV, T-Values).

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STERR)	P Values
X01 < Affected Community	0.212	0.211	0.031	16.377	0.000
X02 <Regional Spatial Plan	0.205	0.206	0.020	10.394	0.000
X03 < License for Reclamation	0.242	0.243	0.027	9.036	0.000
X04 <Environmental Condition	0.208	0.207	0.012	16.770	0.000
X05 <PT Batamas Puri Permai	0.283	0.286	0.030	9.376	0.000
Y01> Community Role	0.311	0.310	0.017	18.496	0.000
Y02 > Government Role	0.301	0.300	0.021	14.576	0.000
Y03 > Reclamation regulation	0.244	0.247	0.032	7.738	0.000
Y04 > Private Role	0.286	0.285	0.019	15.456	0.000
Z01< Climate Change	0.586	0.591	0.036	16.070	0.000
Z02< Hydro Oceanography change	0.488	0.485	0.023	21.479	0.000

The second criterion for discriminating validity is to compare the roots of Average Variance Extracted for each construct with the correlation between constructs and other constructs in the model. AVE value is used to measure the amount of variance that can be captured by the construct compared to the variation caused by a measurement error. The model has sufficient validity discriminant if the AVE root for each construct is higher than the correlation between other constructs. The AVE value for the Reclamation of Sustainable Tering Bay (Z) can be seen in Table 4.

Table 4.   Average Variance Extracted (AVE).

	AVE
Reclamation of Sustainable Tering Bay (Z)	0.691
Reclamation of Tering Bay (X)	0.687
Management of the Tering Bay area (Y)	0.745

The value of this composite reliability test reflects the reliability of all indicators in the model. The minimum value is 0.7, while ideally, it is 0.8 or 0.9.

The composite reliability value for Z is 0.853, for X is 0.917, and for Y is 0.897. The amount of reliability composite can be seen in Table 5 below.

Table 5.   Composite reliability.

	Composite Reliability
Reclamation of Sustainable Tering Bay (Z)	0.853
Reclamation of Tering Bay (X)	0.917
Management of the Tering Bay area (Y)	0.897

The amount of the parameter coefficient for the Tering Bay Reclamation variable (X) is 0.768 according to the original sample, which means that there is a positive influence between Tering Bay Reclamation (X) on the Management of the Tering Bay Area (Y). This can be interpreted that the better the role of the community, the management of the Tering Bay will increase. The value of t - Statistics of 15.337 is considered very significant, with the value of the t significance table of 5% = 2. Therefore, the value of t statistic is smaller than t-table 2, which is 15.337> 2.

Then the parameter coefficient for the Sustainable Development variable (Z) is 0.839, according to the original sample. This means that there is a positive influence between Tering Bay Reclamation (X) on the Management of the Tering Bay Area (Y). It can be interpreted that the better the Sustainable Development, the management of the Tering Bay Area will increase. The value of t - Statistics of 18.750 is considered significant, with the value of the t significance table of 5% = 2. Therefore, the t value of statistics is smaller than t-table 2 (18.750> 2). Table 6 can be seen below.

Table 6.   Path coefficients (Mean, STDEV, T-Values).

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STERR)	P Values
Reclamation of Tering Bay (X) → Reclamation of Sustainable Tering Bay (Z)	0.768	0.771	0.050	15.337	0.000
Reclamation of Sustainable Tering Bay → Management of the Tering Bay area (Y)	0.839	0.838	0.045	18.750	0.000

The magnitude of the parameter coefficient for the Tering Bay Reclamation variable (X) is 0.644 from the original sample, which means that there is a positive influence between Tering Bay Reclamation (X) on the Management of the Tering Bay Area (Y). It can be interpreted that the better the role of the community, the management of the Tering Bay Area will increase. T value - Statistics of 9.098 means significant (t significance table 5% = 2). Therefore, the statistic value is smaller than t-table 2 (9.098> 2).

The magnitude of the parameter coefficient for the Tering Bay Reclamation variable (X) is 0.768 from the original sample, which means there is a positive influence between Tering Bay Reclamation (X) on Sustainable Development (Z). It can be interpreted that the better the Reclamation of the Tering Bay, the Sustainable Development will increase, seen in Table 6 below. The value of t - statistics is 15.337, meaning, which is significant with t significance table 5% = 2. Therefore, the value of t statistic is smaller than t-table 2, which is 15.337> 2.

The amount of the parameter coefficient for the Sustainable Development variable (Z) is 0.839, according to the original sample. This means that there is a positive influence between Sustainable Development (Z) on the Management of the Tering Bay Area (Y). This can be interpreted that the better the Sustainable Development, the management of the Tering Bay Area will increase. Value of t - Statistics of 18.337 means significant, namely t significance table 5% = 2. Therefore, the value of t statistic is smaller than t-table 2 or 18.337> 2.

Table 7.   Total Effect Model of Batam Island.

|	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STERR)	P Values
Reclamation of Tering Bay (X) → Management of the Tering Bay area (Y)	0.644	0.648	0.071	9.098	0.000
Reclamation of Tering Bay → Management of sustainable Tering Bay (Z)	0.768	0.771	0.050	15.337	0.000
Reclamation of Sustainable Tering Bay → Management of the Tering Bay area (Y)	0.839	0.838	0.045	18.750	0.000
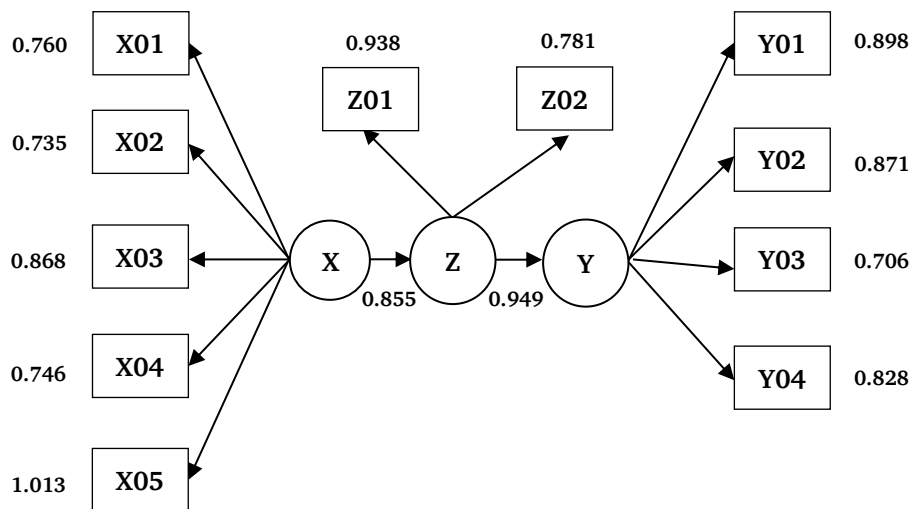
Figure 4.   Path coefficient model.

The results of this study empirically have sufficient significant evidence. They can predict that the reclamation of Tering Bay, management of the Tering Bay, and reclamation of sustainable of Tering Bay has a positive influence on the environment caused by reclamation activities if the handling of environmental damage caused by reclamation can carefully be resolved. With the results of the PLS, the problem of reclamation in the bay can be overcome and can be verified. Indeed, so far, the public, government, and the private sector are very doubtful, and some experts differ in their views on the benefits and disadvantages of reclamation. Based on the results of PLS, state of the art was obtained that reclamation did indeed have a substantial impact on the biogeophysical, socio-economic, and socio-cultural aspects. However, the essential components of the significant effects to get attention need to be carried out in a comprehensive environmental treatment. For this reason, AHP analysis is required to find out which components are the most important to be managed so that they do not cause negative impacts on the environment.

AHP analysis results in Figure 5 has the environmental components include: a) considerable erosion and abrasion; b) prone to high wave; c) unarranged reclamation of Tering Bay ; d) flood potential; e) In general Tering Bay is good condition.
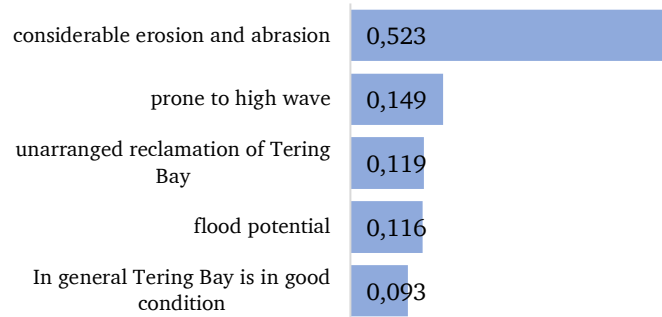
Figure 5.   AHP results.

AHP analysis results in Figure 5 that the environmental component with its values includes: a) considerable erosion and abrasion (0. 523); b) prone to high wave (0.149); c) unarranged reclamation of Tering Bay (0.119); d) flood potential (0.116; e) In general Tering Bay is in Good condition (0.093). Thus, the management of sustainable coastal reclamation, which prioritizes attention, is the handling of erosion and abrasion, which is currently very intensive in the Tering Bay. The slope of the Tering Bay slope ranges from 0 - 3%. The typology of the beach in the Tering Bay is a sandy beach, clay, and partly composed of rock. Besides, mangroves, which are the primary ecosystem supporting habitat for flora and fauna, are damaged due to erosion and abrasion.

Erosion and abrasion that occurs in the Tering Bay result in a decline in fisheries resources (both capture and cultivation fisheries). As a result of reclamation in the Tering Bay, there was considerable damage to mangrove forests, including damage to coral reefs. Damage to mangrove ecosystems and coral reefs has an impact on the amount of fishing caught by fishermen. Overall fishing has been reduced to 55% after the reclamation project. Catching mullets that thrive in mangrove areas has decreased at most by 70% (Priyandes and Majid, 2009).

Ecological functions as a provider of nutrients for aquatic biota, a place for solitary fund spawning for various biota, abrasion retention, retaining storm surges, and tsunamis, absorbing waste, preventing seawater intrusion. Damage to the coastal ecosystem will result in lower ecosystem services to surrounding communities. This can be seen from the conversion of mangrove land due to landfill activities.

Waves due to the wind in the Tering Bay are the most dominant waves occurring on the surface of the sea. The existence of these waves due to winds at sea level affects almost all activities at sea. As stated by Priyandes and Majid (2009) that the strength of the tidal wave in the study area from December to January and June to July might reach 0.0 – 3.4 knot. During high tide in windy seasons, flood as deep as 0.5 meters hits the fishermen's villages near the shoreline.

High waves can certainly disrupt fishing activities and inter-island sea transportation, which can have an impact on people's lives on land. The scarcity of foodstuffs on some small islands and the disruption of various development activities happened due to constraints in the supply of construction materials. The wave of Tering Bay at the time of reclamation activities must be a concern so that the impacts caused both on land and at sea have no significant effect, especially for the biophysical, socio-economic and socio-cultural aspects.

The reclamation of the Tering Bay has not been regulated, so the use of land after reclamation is still unclear. The use of reclamation layout. This is based on the experience that the preference for land ownership resulting from reclamation is vague. Tering Bay reclamation planning before, during, and after reclamation is

unclear so that there is no clarity in the regulation of land-use conflicts.

Flooding will be a severe threat to the reclamation area. Tering Bay reclamation area is avoided not to experience floods caused by high tides causing losses and disrupting community activities. Flood prevention must be controlled by the construction of dams to provide multiple benefits. Tering Bay reclamation ideas focused more on consideration of land expansion and economy. This plan was also stated in the Batam Island Spatial Plan. For flood prevention, the main things related to marine objects are essential for protection concerning reclamation, among others: inland waters, territorial sea, additional zones, exclusive economic zones, continental shelf, and coral rock. These objects need to be considered in planning and designing flood control and prevention.

Based on the results of research, the Tering Bay experienced coastal conditions that tend to be worse after the reclamation activities. Tering Bay after reclamation has made life difficult for the people, especially related to fulfilling the daily lives of fishers. The fishers find it challenging to find fish. The sedimentation process ran intensively and forced many residents to move to other places to look for safer areas. Water conditions have very low oxygen content due to bacterial activity in breaking down organic waste. This problem has caused Tering Bay to be heavily polluted by sediments, heavy metals, and organic matter. For this reason, a comprehensive restoration plan is needed, considering the previously available species, but after reclamation, there has been a change in the landscape, so reclamation restoration is needed.

CONCLUSION

The management of a sustainable coastal reclamation area is carried out by paying attention to the handling of erosion and abrasion, which are intensified in the Tering Bay area. For this reason, the objects in the reclamation area are increasingly threatened with erosion or abrasion, which damages some facilities in the reclaimed land. Thus, the barrier is needed in the form of mangrove planting, the construction of offshore breakwaters, and other alternatives by building a revetment.

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