The process of adaptation related to physical environmental and social interaction systems changes on coastal morphodynamical

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Abstract. The morphodynamical change provides greater impact to the ecosystem, especially the coastal environment. Since the coastal region is vulnerable to environmental changes, this study aims to develop an adaptation models morphodynamical related to changes in the coastal area. The study adopts the AHP method to analyze the elements stated in the hierarchy. There are three levels builds Contain the adaptation models based on morphodynamical changes as the objective, three criterion, and three alternative strategies. The factors the which influence the strategy of preference are a socioeconomic impact, the environmental sustainability, and social network. However, the morphodynamical changes involve; the human activity, so the demography growth contributes in the process of change. The population growth has increased every year, and most live in coastal areas leading to increased human activity in coastal areas, especially in the utilization of natural resources and coastal ecosystems. Various kinds of human activities are conducted both on land and at sea contributed to the changes in the environment. The interaction between community creates another challenge that should be solved to preserve the environmental sustainability. The limited ability of the environment, including in coastal ecosystems and their shoreline change the caused imbalances hazard that the sustainability of marine and coastal environment and the community as well.

1. Introduction

Indonesian has a territory where extends along 3.977 miles between the Indian Ocean and the Pacific Ocean [1]. Furthermore, Indonesia located 6 degrees latitude North and 11 degrees South latitude, 97 degrees to 141 degrees East Longitude. The risk of sea level rise is significant for the future of Indonesia. This condition occurs because of the borders with other countries separated by the waters bounded by small islands. The potential sinking of small islands where directly adjacent to other countries is a threat to all regions of the country. On a global scale, sea level rise also threatens human civilization as a result of the effect [2].

Report from Military Advisory Board in cooperation with the Center for Analysis of the United States Navy titled National Security and the Threat of Climate Change said that rising sea levels, droughts, and extreme weather caused by global warming threaten national security in the United States. This condition occurs because it can result in large-scale population migration, boost border tensions, the spread of disease, and food shortages that could lead to conflict triggered by the seizure of material/sources of food [3], [4].

The cause of rising sea levels is still being debated by the scientists. The previous research has shown the result based on records of tidal stations in Jakarta, Semarang, Jepara, Kupang, Biak and Sorong found that elevation of the sea levels increases varied from 1990 to now approximately 8 mm
/ year. Diposaptono [5] research found results that sea level rise of 7.83 mm in Belawan, Jakarta 4.38 mm, 9.17 mm Semarang and Surabaya 5.47 mm.

One of the main causes of sea level rise is the greenhouse effect, causing glaciers and ice sheets in Antarctica melt and increase the volume of seawater. This ice sheet melting process causes the thermal expansion of seawater surface layer and cause mass movements of seawater [6].

Archipelagic waters are all waters located on the inner side of straight baselines maritime regardless of the depth or distance from the coast. Archipelagic waters are waters which is next in line of the base (maximum length of 100 nautical miles) that connects the outermost islands of an archipelago. The base of the straight line can reach 125 nautical miles if the amount is less than 3% of the amount used baselines that country [7].

Bray, Hook and Carter [8] conducted a study on planning the face of rising sea water off the coast of England. This research seeks to predict the specific factors causing the rise in sea levels that affect beaches in the UK. The researchers concluded from rising seas, coastal areas in the UK potentially damaged and sank.

Nicholls [4] examined the effects of rising sea levels on mitigation and policy. The research also focuses on how adaptation and mitigation strategies based on government policy by detailing what should be done to deal with the impact of sea level rise as efforts to reduce greenhouse gases to adaptation socio-economic conditions in the future.

The coastal area has its unique characteristics both from the aspects of bio-geophysical as well as social, economic and cultural. Dahuri suggests that there are at least six coastal characteristics:

a. There is a good ecological linkage between ecosystems in the coastal areas as well as between the coastal areas with topsoil and seas.

b. Usually in a coastal region, there are more than two kinds of natural resources and environmental services that can be developed for the sake of development.

c. In a coastal area, in general, there is more than one group of people who have the skills / expertise and pleasure to work differently. This resulted in the utilization of various resources.

d. Both ecologically and economically, the utilization of a coastal area in monoculture is very vulnerable to internal and external changes that lead to business failure.

e. The coastal area is an area of the common property that can be used by everyone. Each resource users wishing to maximize profits, causing pollution, over-exploitation of natural resources and conflict utilization of space [9].

In addition to the above characteristics, the coastal region is an area that is biologically very productive and fertile. In coastal areas Also do a variety of human activities and the interaction between humans and coastal and marine resources that directly indirectly related to shoreline change [10], [11].

The coastline is the boundary of seawater at high tide Reached had shore leave. Changes in the shoreline are mostly done by human activities such as land clearing, exploitation of minerals in the coastal mainland that could alter the balance of the shoreline through an excessive supply of sediment load. The high intensity rainfall could Affect changes on the coastline. Along the coastal areas, there are segments that have beaches erosion, besides there are parts that undergo accretion/sedimentation and stable segments[12].

The previous research suggests that approximately 70% of the beach is mainly sandy in the world are experiencing coastal erosion. The main cause is the diversity of human influence directly or indirectly caused a reduced number of availability of reserves of sediment on the beach. It is compared to sediment out from the coast due to natural influences. In some parts of the world's beaches, coastal erosion that has occurred the caused great losses in the form of the destruction of residential areas, farms, and highways. Beach erosion is a serious problem of shoreline degradation the caused by wind, rain, currents, and waves as well as due to human activities. The forms of coastal lands are formed and changed from time to time following the energy and material inputs into the environment of coastal areas. Energy input can be a wave, tidal and wind. While the input material in
the form of sediment, particles, and pollutants through river flow and the formation of biological landform[13].

The study proposes a comprehensive, approach to implement the adaptation models as a result of the coastal morphodynamic changes. The adaptation process plays an essential part to preserve the coastal ecosystem. Therefore, the strategy proposal contribution should consider several aspects.

2. Methodology

The research uses the AHP (Analytical Hierarchy Process) approach to Determine the best strategy proposals related to the adaptation models [14]. A few specialists have utilized an AHP approach for arranging the environmental problems. This method was used by Lee et al.,[15]for evaluating national innovation intensity in the hydrogen part. Wang et al [16]. AHP practiced technique to observe your reasonable leadership essential vitality. Similarly, a probe directed by Ghimire and Kim [17] reviewed restaurants the obstacles for sustainable power source enhancement in Nepal.

This study draws the three hierarchy levels, consists of objectives, criteria, and alternatives. The hierarchy consists of three levels, include objective (top level), criteria (middle level) and alternatives (bottom level). There are three criteria are set, socioeconomic impact, environmental sustainability, and the social network aspect. Each criterion is weighed based on expert opinions and compared to literature. The alternative strategies contain the option to develop cooperation among stakeholders, that our government, academics, and public sectors, improve a coastal risk management and the status quo. The status quo means that policymakers play business as the usual strategy to maintain the changes.

Figure 1 below Described the hierarchy models for developing an adaptation development proposals.

![Figure 1. The AHP decision-based models for adaptation morphodynamic proposal](image)

The AHP concept to decide alternatives preference Involved four steps (see figure 2 below).

![Figure 2. Four steps of the AHP method [18]](image)

Furthermore, the AHP method the 1-9 scale used to describe the importance level of criteria or alternatives. Table 1 shows the definition of the 1-9 scale using in this decision making.

| Intensity of Importance | Definition                                           |
|-------------------------|------------------------------------------------------|
| 1                       | The importance and scale of criteria/alternatives A and B are equal |
| 3                       | The importance of criteria/alternatives A is moderate than B |
| 5                       | The importance of criteria/alternatives A is stronger than B |
The importance of criteria/alternatives A or demonstrated is very stronger than B
The criteria/alternatives is extremely important than B
Reciprocals of above
If activity \( i \) has one of the above non-zero numbers assigned to it when compared with activity \( j \), then \( j \) has the reciprocal value when compared with \( i \).

source: [14]

3. Result and Discussion
Table 2-4 shows the pairwise comparison analysis between three levels of the hierarchy. The analysis aimed by Super Decision software to calculate the comparison.

| SCE            | SE              | SN            | Normal | Ranks |
|----------------|-----------------|---------------|--------|-------|
| Moderate       | Very strong     |               | 0.669  | 1     |
| important (3)  | important (7)   |               |        |       |

| SE             | Moderate        |               | 0.243  | 2     |
|----------------|-----------------|---------------|--------|-------|
| 1              | (3)             |               |        |       |

| SN             | 0.088           | 3             |        |       |
|                | 0.11            | 0.33          |        |       |

| consistency    | Ratio           |
|----------------|-----------------|
| 0.007          |                 |

Notes: SCE = Socioeconomic factors; SE = sustainability of the environment; SN = social network

The table 2 above described socioeconomic factor that is the most important criteria to compare environmental sustainability and social network. The consistency ratio indicates that the calculation is consistent since the number is lower than 0.10 [19]. After this process, the steps continue to weigh the alternatives with respect to the criteria.

| CS  | CRM | SQ | Normal    | CS  | CRM | SQ | Normal    | CS  | CRM | SQ | Normal    |
|-----|-----|----|-----------|-----|-----|----|-----------|-----|-----|----|-----------|
| 1   | 3   | 9  | 0.672     | 1   | 3   | 7  | 0.669     | 1   | 5   | 9  | 0.751     |
| CRM | 0.33| 1  | 0.265     | 0.33| 1   | 3  | 0.243     | 0.20| 1   | 3  | 0.178     |
| SQ  | 0.11| 0.20| 0.063    | 0.33| 0.14| 1  | 0.088     | 0.11| 0.33| 1  | 0.070     |

| consistency   | Ratio          |
|---------------|----------------|
| 0.028         | 0.007          |

Notes: CS = cooperation system; CRM = coastal risk management; SQ = status quo

From the result of pairwise comparison analysis between the criterion to the alternatives in Table 3, it was found that all of the comparisons are consistent as Consistency Ratio is lower than 0.10. However, the analysis showed that the strategy to encourage the coordination system is the priority amongst the calculation by 0.672; 0.669; and 0.751. It is followed by the establishment of coastal risk management (0.265; 0.243; and 0.178). The last remaining preference strategy is the business as usual or the status quo condition (0.063; 0.088; and 0.070).

| Strategy             | Total | Normal | Ranking |
|----------------------|-------|--------|---------|
| Cooperation system   | 0.449 | 0.675  | 1       |
| Coastal risk         | 0.173 | 0.259  | 2       |
| Status quo           | 0.044 | 0.066  | 3       |

Table 4 provided a final calculation of the AHP method to develop and adaptative models based on the morphodynamic proposal. The analysis is consistent as the result shown in the previous table, the
which maintains a cooperation system among stakeholders is the most important strategy. Develop a cooperation system to solve the environmental issues provides a solid point for improving the coastal risk management based on morphodynamical changes[20].

Human activities such as the clearing of mangrove forests, sea sand mining and mining of coral reefs in some locations have made significant contributions to coastal erosion, due to the loss of coastal protection from waves and storms blow. Likely this is the caused by the occurrence of large waves from the sea continuously or perpendicular to the coast resulted in beaches eroded, and eventually get to the pond behind shoreline residents redundant. One of the properties for the affected wave wave sharpness that usually occurs during high winds or storms that resulted in much coastal erosion.

Vreugdenhil [21] says that if a huge wave coming perpendicular to the coastline with a long time can erode the beach. It also agreed with what was raised by Wyrtki[22] says that the waves coming in perpendicular beach continuously with a long time can cause beach erosion. Hurricanes and typhoons are a normal phenomenon in the coastal environment and are also a major factor in modifying the shape of the land and coastal ecosystems. However, along with the increasing pressure of the coast due to the activity of the population, natural disasters such as hurricanes, typhoons, and tsunamis are a grave threat to the population, coastal, and shoreline.

The power or force that accompanies hurricanes and typhoons including big waves and floods, rising wave action and strengthened and strong winds. Flooding due to storm/hurricane could result in substantial beach erosion, erosion/destruction of barrier islands and coastal lands solution so as to form a niche or a small bay/inlet. Other possibilities also riding with the caused tidal high water, there can be intensified coastal erosion, a lot of mud carried by sea to sea settles more recesses. This event is repeated as a natural phenomenon or cycles the beach transversely roomates tends seasonal, so consequently become a retreat or an eroded beach. On the other hand, the global warming due to an increase of concentrations of greenhouse gases (CO, CH4, and others) can improve the appearance/surface waters for two reasons: (1) thermal expansion and (2) the melting of the polar ice caps. Estimates of the impact of global warming widely vary but range between 0.5 to 2 meters in 2100. The impact of rising sea levels is flooding, loss / damage to biodiversity, damage to buildings and infrastructure[11].

The coastal area is an area that has land and sea interaction highest intensity, the region has a relationship with over the land (upland), so that the damage the caused to land on may have a negative impact on the shoreline. For example, agricultural and forestry activities without regard to principles of conservation cause erosion and flooding damaging river ecosystems and continues to coastal ecosystems and to the coastline. Other examples of community activities on land such as industrial waste and household cause sedimentation and Carried by the river flow into coastal areas[11], Dahuri et al.,[12] say that any change of landscape mainland and other negative impacts such as pollution.

4. Conclusion

The hypothesis of morphodynamics changes shoreline affected by social and economic conditions is interrelated. Typology of coastal ecosystems especially coastline change now facing challenges in addressing issues of sustainable development. In the other hand, the demography growth environment requires beyond its capacity. The limited ability of the environment, Including in coastal ecosystems and their shoreline facts change the caused imbalances that Threaten the sustainability of marine and coastal environment and the people who Inhabit it.

The AHP approach used in the study proposes to establish a coordination system among relevant stakeholders to develop an adaptation models based on morphodynamical changes. The strategy considered by three criteria so far, socioeconomic impact, the environmental sustainability, and social network.
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