Coastal Work Protection Election in SouthernBadung Area Basedon Analytical Hierarchy Process (AHP) Method

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ABSTRACT : *Badung Regency is one of the regencies in the island of Bali that has a beach with high assets as an international coastal area. Badung Regency has a coastline of 64 km, but along the coast of 12.10 km has been eroded. The purpose of this research is to choose an appropriate coastal work protection for coastal protection in the southern Badung area which is determined based on several criteria with the Analytical Hierarchy Process (AHP) method so that it is expected that based on AHP analysis the best coastal work protection will be obtained from several assessment criteria so that the existence the beach will be sustainable. This research is a literature review research which is then continued by making a model of the selection of appropriate coastal work protection in Southern Badung region, especially in the form of sandy beaches, this selection model is carried out by the Analytical Hierarchy Process (AHP) method. Based on the analysis the results consistently show that an alternative submerged breakwater as a coastal work protection is the best alternative as a coastal work protection in the Southern Badung area based on the suitability criteria, implementation methods, costs and environmental aesthetics.*

KEYWORDS: *Coastal work protection, Analytical Hierarchy Process (AHP), Southern Badung.*

I. INTRODUCTION

Bali Province is one of the provinces in Indonesia which has a lot of astonish natural scenery, especially the coastal area. The total area of Bali Province is 5,634.40 ha with a coastal length of 529 km [1]. The coastal area in Bali Province is not only used as a tourist area but there are also several temples that are utilized by local people especially those of Hinduism as a place for religious ceremonies. Badung Regency is one of the regencies in Bali Province which is very crowded with tourists, both domestic and foreign tourists. The astonish scenery offered by Badung Regency, especially the southern Badung which has white sand beaches such as Kuta Beach and Legian Beach, if you want to find a beach that has high cliffs, you can visit Pandawa Beach and Melasti Beach. Badung Regency is one of the regencies on Bali Island that has a beach with high assets as an international coastal area. Badung Regency has a coastline of 64 km, but along the coast of 12.10 km has been eroded [1].

One effort that can be done to prevent further damage due to erosion is a right planning in terms of coastal work protection based on several aspects of planning and taking into account the condition of the coastal area. So that planning and utilization as well as the handling of coastal problems can be sustainably efficient, better visibility is needed. In order to overcome the problems in decision making, a decision-making method called Analytical Hierarchy Process (AHP) is presented. The use of the AHP method will help solve the choice of building a coastal work protection. Analytical Hierarchy Process (AHP) method is a method that models complex and unstructured problems in the form of tiered / tiered problems, then elements at each level will be given a qualitative subjective assessment [2].

This research is a literature review research which is then continued by making a model of the selection of appropriate coastal work protection in the Southern Badung region, especially in the form of sandy beaches, this selection model is carried out by the Analytical Hierarchy Process (AHP) method.

II. LITERATURE REVIEW

A. *Decision Making*

A decision is a choice made between two or more available alternatives. Decision making is the process of selecting the best alternatives for achieving goals. Saaty [3] defines decision making as a process of choosing between several alternative actions for the purpose of achieving a goal or more. Decision making involves four main stages: intelligence, design, choice and implementation.

1) Multi-Criteria Decision Making

Multi-criteria decision making is part of the scope of research called multi-criteria decision objects. This decision making is a descriptive approach.

2) Analysis of Multi Criteria Decision Making

The type of analysis used to solve multi-criteria problems is multi-objective decision making which is used to solve problems that require the choice of a continuous set of choices, and multi-criteria decision making, which is used to solve problems that require the selection of discrete multi-criteria choices.

B. Analytical Hierarchy Process (AHP) Method

1) Decision Theory

Outline of the decision analytical cycle steps: from the initial information collected, the definition and linking of the variables that influence the decision at the deterministic stage are carried out.

2) Decision Model based on AHP

The Analytical Hierarchy Process (AHP) was developed by Dr. Thomas L. Saaty of the Wharton School of Business in the 1970s to organize information and judgment in choosing the most preferred alternative [3].

3) Arrangement of Hierarchy

A hierarchical structure can be formed by using a combination of ideas, experiences and views of others [4]. Therefore, there is no set of standard procedures that apply generally and absolutely to the formation of a hierarchy. The structure of the hierarchy depends on the conditions and complexity of the problems encountered and the desired completion details.

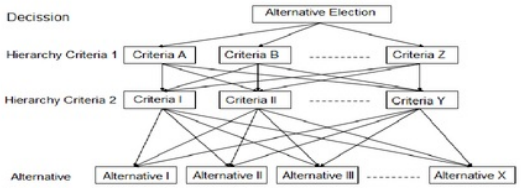

Figure 1. AHP Model in General
Source: Saaty (2000)

C. Coastal Work Protection

1) Revetment

Revetments are coastal structures that have the primary function of preventing or reducing sea water runoff and flooding of land and structures behind the coast due to storms and waves. Revetment are built parallel to the coastline as a reinforcement part of the beach profile. Revetments are also often used to protect promenades, roads and houses, usually these structures are installed facing the sea from the top edge of the natural beach profile. Revetment is an onshore structure with the main function of protecting coastlines from erosion. Revetment structures usually consist of stone, concrete, or asphalt for the armor, sloping in shape following the natural profile of the coastline.

Figure 2. Revetment in General
Source: www.google.com

2) Groin

Groin is a coastal security structure built protruding relative to the direction of the beach. Construction materials are generally wood, steel, concrete (concrete pipe), and stone. The installation of groins interrupts the flow of coastal currents so that the sand is trapped on the "up current side," while on the "down current side" erosion occurs, due to the movement of coastal currents that continue.

The use of groins using one groin is not effective. Usually the protection of the beach is done by making a series of buildings consisting of several groins placed at a certain distance. This is so that changes in coastline are not too significant.

Figure 3. T-shaped Groin and L-shaped Groin
Source: www.google.com

3) Breakwater

Breakwater is built to reduce the wave action that is expected to disrupt a structure. Wave action is reduced through a combination of reflection and dissipation of incoming wave energy. If used for ports, the breakwater that is built is intended to create calm enough waters so that loading and unloading operations on ships be easy and safe, and also as a protection for port facilities.

Breakwater was also built to improve maneuvering conditions at the port entrance and to help regulate sedimentation by directing currents and by creating areas with different levels of wave interference. In addition, coastline protection against tsunami waves is another application of breakwaters. When used for coastal protection, breakwaters are built in near shore waters and are usually parallel to the coast such as detached breakwater.

The layout of the breakwater used to protect the port is determined by the size and shape of the area to be protected and by the prevailing direction of the storm surge, the net direction of the current, and the maneuverability of the ship using the port. Breakwaters that protect ports and inlets (for ships) can be detached or shore-connected.

Breakwater or breakwaters can be divided into two types, namely breakwaters and offshore. The first type is widely used in harbor waters protection, while the second type is for coastal protection against erosion. In general the planning conditions of the two types are the same, only the first type needs to be reviewed in terms of the characteristics of the waves at several locations along the breakwater, as is the case with groins.

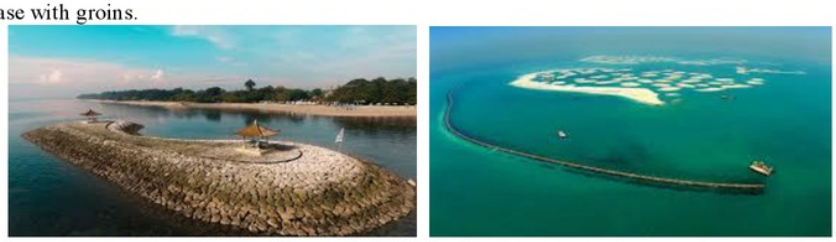

Figure 4. Off-shore Breakwater
Source: www.google.com

4) Coastal Physical Process

If beach stabilization is a destination and lost sediment is caused by long shore transport, groin is one solution. If lost sediment is dominated by offshore transport, the groin may not be effective as a beach stabilization building and may cause rip current formation. Breakwater reduces sediment loss caused by long shore and offshore transport, but significantly reduces wave energy along the coast and causes a reduction in wave height in the surf zone. On the one hand this condition will reduce the wave pressure on the coast, but on the other hand with the reduction of waves in the surf zone area may not be pleasant for surfers [5].

III. RESEARCH METHODS

A. Research Location

This research took several beach locations such as Munggu Beach, Batu Mejan Beach, Batu Bolong Beach and Brawa Beach. These beaches were chosen with the assumption that they have nearly the same characteristics so that they can be generalized for the selection of a coastal work protection.

Figure 5. Research Location
Source: Google Earth

B. Research Tools and Materials

The tool used in this study is the Expert Choice program used in making alternative selection models for coastal work protection for the southern Badung area. While the required data in the form of primary and secondary data, where primary data in the form of existing data on the condition of the coast as one of the criteria for the selection of coastal work protection, and secondary data used is a literature review of several coastal work protection planning in the area of Munggu Beach, Batu Mejan Beach, Batu Bolong Beach and Brawa Beach are used to determine the weights of each criterion and the alternatives to be chosen.

C. Data Analysis Techniques

This research is a literature review research which is then continued by making appropriate coastal work protection selection models in accordance with the characteristics of beaches in the southern Badung region especially in the form of sandy beaches. From this Expert Choice program, the most optimal alternative for proper coastal work protection is chosen according to the characteristics of the beach in the southern Badung region so that the existence of the coastal region in the southern badung region can be sustainable.

IV. RESULT AND DISCUSSION

A. General Overview of the Research Location

Badung Regency is one of the regencies in Bali Province that has a beach with high assets as an international coastal area. Badung Regency has a coastline of 64 km in length, but an average of 13.75 m has changed the coastline in Badung Regency, with an average erosion rate of 1.96 m / year [6]. Conditions in the dominant study area have been enlivened by tourism facilities. It can be seen from aerial photographs from Google Earth, there are many umbrellas used for tourists and around the seaside there are many hotels and public facilities that support tourism and there are temples used for religious ceremonies.

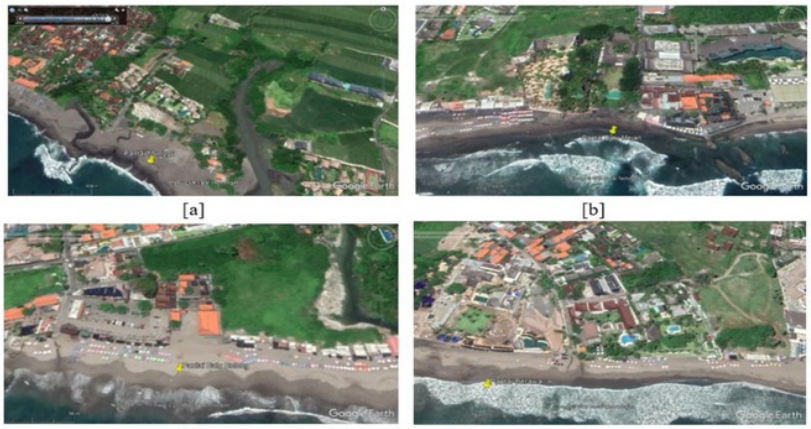

Figure 6. Existing Condition of Research Location
Source: Google Earth

\Wind Speed

Wind is moving air caused by the rotation of the earth and also due to differences in air pressure around it. The wind moves from a place of high pressure to low pressure air. Wind data is needed for forecasting height and wave periods. The wind data obtained are then presented in tabular form (summary) or diagram called wind rose.

From the analysis of wind speed from BMKG Ngurah Rai [7], it is found that the dominant wind direction blowing from the West is 38.34% with the most dominant wind speed in the range of 15-20 knots (Figure 7). From the analysis of wind data, it can be seen that the dominant wind blows from the west which means that the direction of the perpendicular to the coast, so that if sediment transport occurs it will occur onshore-offshore sediment transport.

Table 1. Percentage of Wind Speed in Specific Intervals in 2007-2016

Wind Speed (Knot)	Wind Direction							
	U/N	TL/NE	T/E	TG/SE	S/S	BD/SW	B/W	BL/NW
0<V<5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5<V<10	0.00	0.00	4.17	2.50	0.00	0.00	4.17	0.00
10<V<15	0.00	0.00	14.17	12.50	0.00	0.00	12.50	0.00
15<V<20	0.00	0.00	19.17	9.17	0.00	0.00	15.00	0.00
V>20	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00
Total	0.00	0.00	37.51	24.17	0.00	0.00	38.34	0.00

Source: Analysis Results, (2017)

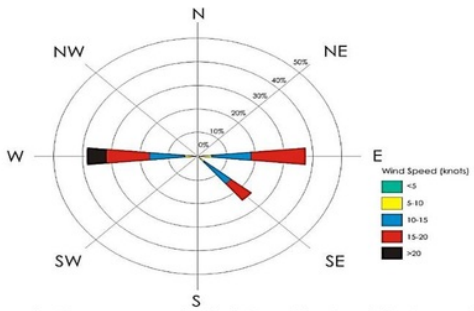

Figure 7. Wind rose based on the Percentage of Wind Speed in Specific Intervals in 2007-2016
Source: Analysis Results, (2017)

B. AHP Model Making

The initial step in the selection of a coastal work protection in the Southern Badung area using the AHP method begins with the selection of criteria and possible alternatives to the problems that exist on the coast in the Southern Badung area. Where the criteria and alternatives will be made in the following hierarchy diagram.

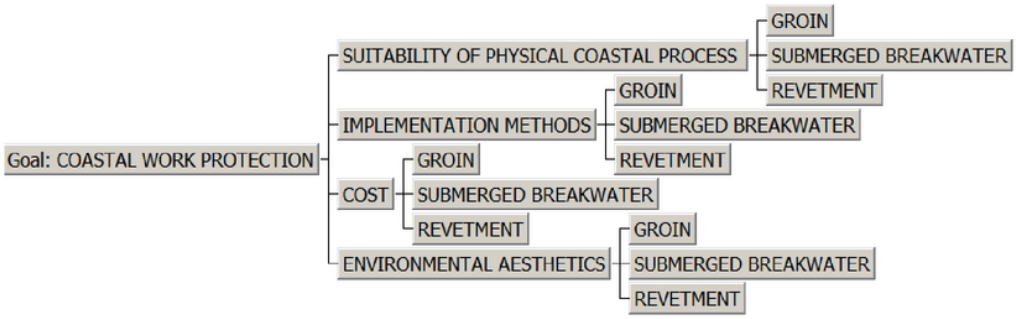

Figure 8. Model Hierarchy Diagram

C. Model Criteria

Then after making a hierarchical diagram continued with an assessment based on previous research to determine the weight of each criteria and alternatives. The weight of each criterion is determined as follows.

1) Suitability to the Physical Coastal Process

This criteria shows the level of suitability of the coast work protection with the physical process of the coast in the Southern Badung area.

- High score 5-6 : indications can have a high suitability
- Medium score 3-4 : indications can have a medium suitability
- Low score 1-2 : indications can have a low suitability

2) Implementation Methods

This criteria shows the ease in the method of implementing the construction of coastal work protection in the Southern Badung area.

- High score 5-6 : the indications do not require complicated methods
- Medium score 3-4 : the indications require a rather complicated method
- Low score 1-2 : the indications require complicated methods

3) Cost

This criteria shows the cost of the project in accordance with the volume of coastal work protection in the Southern Badung area.

- High score 5-6 : indications are low project costs
- Medium score 3-4 : indications are medium project costs
- Low score 1-2 : indications are high project costs

4) Environmental Aesthetics

This criteria shows how the impact of the construction of coastal work protection on environmental aesthetics or views on the beach in the Southern Badung region.

- High score 5-6 : the indications do not damage the view and tend not to interfere with tourism activities
- Medium score 3-4 : the indications do not spoil the view and still interfere with tourism activities
- Low score 1-2 : the indications are eyesore and disrupt tourism activities

D. Related Research in Research Location of Coastal Work Protection

Sahadewa [8] in planning the revetment at Batu Mejan Beach using andesite stone with a length of 200 m, a budget plan of IDR 6,577,697,000. Heavy equipment used in the form of dump trucks, backhoe excavators, and wheel loaders.

Jayantari [9] in the planning of submerged breakwater with artificial stone (tetrapod) in Batu Mejan Beach, Badung Regency, it was obtained a budget plan for two submerged breakwater structures, namely IDR 17,861,989,813. Heavy equipment used is molen, vibrators, excavators, pontoon, cranes, and stamper.

Kertyarisadi [10] in the planning of groins with tetrapod material in Batu Bolong Beach, Badung Regency, it was obtained that the budget plan for one series groins in Batu Bolong Beach was IDR 11,526,067,300. Heavy equipment used are excavators, molen, vibrators and cranes.

Sukarata [11] in the planning of the revetment building on Brawa Beach with a length of 250 m, a budget plan of IDR 5,299,077,000. Heavy equipment used are dump trucks, back hoe excavators, wheel loaders and stamper.

Gianatha [12] in planning of the of T Type Groin with Modified Cube Material in Munggu Beach, Badung Regency, it was obtained that the budget plan for the groin building planning on Munggu Beach of IDR 7,050,014,242. The tools used are excavators, molen and vibrators.

E. Criteria Weights and Alternatives

After determining the weights of each criterion, it is continued with the process of modeling the selection using the AHP method which is assisted by the Expert Choice program. The weight of each criterion and each alternative is adjusted to the literature review and related research, then tabulated in the following Table 3 and Table 4.

Table 3. Weight of Each Criteria

Criteria	Suitability	Implementation Methods	Cost	Environmental Aesthetics
Suitability	1	5	3	3
Implementation Methods	1/5	1	1/2	1/3
Cost	1/3	2	1	1
Environmental Aesthetics	1/3	3	1	1

Table 4. Alternative Weights based on Each Criteria

	Suitability			**Implementation Methods**		
	Submerged Breakwater	Groin	Revetment	Submerged Breakwater	Groin	Revetment
Submerged Breakwater	1	3	5	1	1/3	1/5
Groin	1/3	1	3	3	1	1/3
Revetment	1/5	1/3	1	5	3	1
	Cost			**Environmental Aesthetics**		
	Submerged Breakwater	Groin	Revetment	Submerged Breakwater	Groin	Revetment
Submerged Breakwater	1	1/3	1/5	1	3	3
Groin	3	1	1/3	1/3	1	1/3
Revetment	5	3	1	1/3	3	1

F. Results of Analysis by AHP Method

In the analysis with the AHP method will be assisted with the help of Expert Choice Software v.11. First the hierarchy of criteria and alternatives is made first as Figure 9.

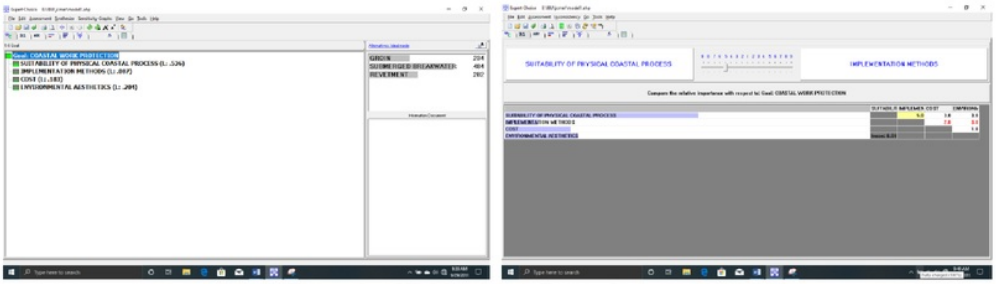

Figure 9. AHP Model with Expert Choice v.11

From the analysis results it can be seen the percentage for each criteria, where the suitability of physical coastal process criteria has the highest percentage of 52.6% in the assessment, followed by environmental aesthetics of 20.4%, the project cost of 18.3% and the method of implementation of 8.7%.

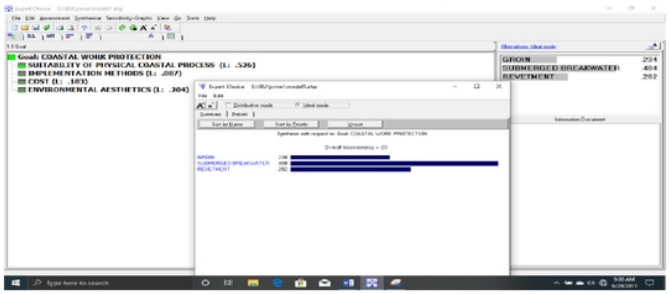

Figure 10. Results of AHP Model Calculation with Expert Choice v.11

Then for each alternative the largest percentage obtained showed the best alternative that is submerged breakwater with a value of 48.4%, followed by a revetment of 28.2% and a groin of 23.4%. And from the analysis obtained an inconsistency value of 0.03 <0.1 (maximum inconsistency limit). So the results consistently show that an alternative submerged breakwater is the best alternative as a coastal work protection in the Southern Badung area, based on the suitability of physical coastal process criteria, implementation methods, costs and environmental aesthetics. Besides like Figure 10, Expert Choice software also produces some graphical output like Figure 11 below.

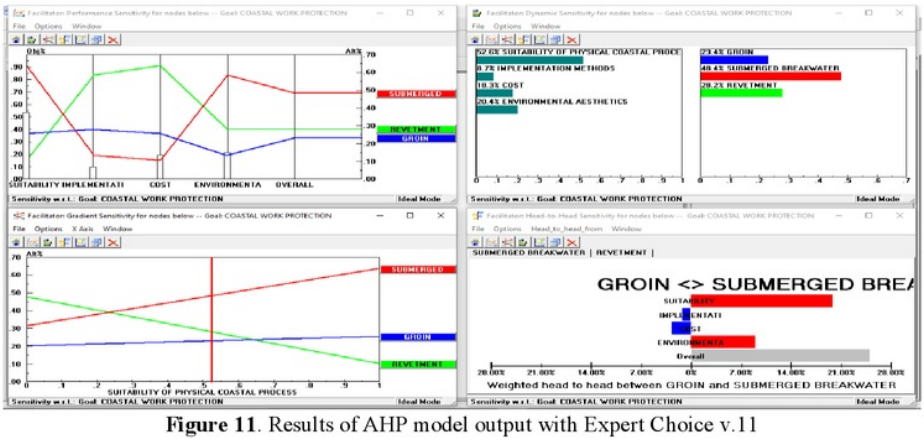

Figure 11. Results of AHP model output with Expert Choice v.11

V. CONCLUSION

From the analysis conducted it can be concluded as follows.

1. Analytical Hierarchy Process method is a fairly representative method in helping the decision making process of several alternatives that have positions that are close to each other. And in the case of coastal work protection in southern Badung Region, Analytical Hierarchy Process is suitable method can be seen from the inconsistency result of 0.03 (3%) which shows that the results of this model are consistent.
2. From the analysis results it can be seen the percentage for each criteria, where the suitability of physical coastal process criteria has the highest percentage of 52.6% in the assessment, followed by environmental aesthetics of 20.4%, the project cost of 18.3% and the method of implementation of 8.7%. Then for each alternative the largest percentage obtained showed the best alternative that is submerged breakwater with a value of 48.4%, followed by a revetment of 28.2% and a groin of 23.4%. And from the analysis obtained an inconsistency value of 0.03 <0.1 (maximum inconsistency limit). So the results consistently show that an alternative submerged breakwater is the best alternative as a coastal work protection in the Southern Badung area, based on the suitability of physical coastal process criteria, implementation methods, costs and environmental aesthetics.

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