Decision Support System for Selecting Type of Moveable Dam Gate to Handle Tidal Flood Issued (A Case Study in The Parid River, Cilacap, Indonesia)

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Abstract. Cilacap is one of the regions in Indonesia in the southern coastal region bordering the Indonesian Ocean. In the coastal areas of Cilacap including Kawunganten district, there are frequent floods due to sea level rise. Tidal flood problem in Cilacap can be overcome by constructing a moveable dam. The selection of moveable dam gate is needed so that it can be work optimally. Data in this study were obtained through a questionnaire and distributed to respondents who were experts in the field of water. There are 5 criteria used to select the type of moveable dam gate, namely material, function, operational and maintenance, cost and location. There are 4 alternatives of moveable dam gate namely flap gate, radial gate, sliding gate and rubber dam. The results of the questionnaire were then processed using Analytical Hierarchy Process. The results showed that the most important criteria to select the type of moveable dam gate is cost (0.273). The best alternative of moveable dam gate based on all criteria is flap gate (0.291). Movable dam with flap gate became the priority because it is easy to operate and low cost. The best location for moveable dam placement is before Ujungmanik Bridge with a score 0.376.

Keywords: tidal flood, moveable dam, gate

1. Introduction
Global warming followed by climate change has become a new disaster in the world. Unlike tsunami disasters, volcanic eruptions, and earthquakes that have a large impact but are temporary, global warming has a slow but sure and permanent effect. One of the impacts of climate change that can be clearly seen is sea-level rise. Sea level rise causes the land area to decrease and the coastline to decline. This causes when the tide occurs, sea water enters settlements and other land uses and disrupts the activities of residents [1].

Cilacap Regency is one of the regions in Central Java which is located on the south coast border of the Indonesian Ocean. The topography of the Cilacap Regency has resulted in frequent flooding due to high tides. One area that experienced flooding in Cilacap Regency was Kawunganten District. In that area, there are hundreds of hectares of rice fields, but the flooding caused by tides causes the area to be less functioning. Land becomes increasingly narrow or even lost due to drowning by tidal floods. The problem of flooding due to high tides in the region can be overcome by the construction of a moveable dam. A moveable dam consists of a dam body, sluice gates, retrieval gates, energy dampening ponds and drainage gates. The types of gates in the moveable dam include flap gates, radial gates, sliding gates and rubber dams [2]. The choice of the type of moveable dam gate and the exact location of placement has an important influence in dealing with tidal flooding and regulating water discharge.
Therefore, a decision-making simulation is needed to determine the type of the moveable dam gate and the exact location of placement to overcome the flooding problem in the area.

2. Literature Review

2.1 Tidal Flooding Management

Some studies reveal that flooding and tidal flooding have occurred for more than 50 years. This means that in fact coastal communities have long had difficulty in adapting to tidal flood and flood. Thus, the best alternative approach to the management of coastal areas that will forever face floods and tides is to build life values harmonious with water, namely the sustainable management paradigm [3]. Some alternative treatments for tidal flood have been put forward by experts, including:

- Adaptation
  The purpose of this adaptation is to adjust the community to the condition of tidal flood, namely: moving to a higher location, building polders and pumps, adding land in places that have low topography, changing the type of building houses (houses on stilts and flats), and increasing the height of the house.

- Maximizing drainage function.
  One of them is by developing the construction of tidal drainage with a polder system. This system is synergized with river normalization, construction of water storage ponds, pumps and flood gates. The drainage system, especially in the coastal area, is a very important basic infrastructure of the settlement, given the problem of flooding due to high tides and rainwater that always inundates the area.

- Another alternative to flood control techniques in environmentally-friendly tidal areas is the combination of the use of water tendons (longshore trenches) and pumping with wind power.

- Construction of dams / offshore dams.

2.2 Benefits Types of Dam

Dams are useful for preventing flooding, measuring river discharge, slowing river flow, and making the river more easily traversed. Dams make hydrologists and engineers do simple volumetric flow rate measurements in medium-sized rivers or at industrial dumpsites. Because the geometry of the Dam height is known and all water flows past the top of the dam, the water level behind the dam can be calculated as the flow or discharge rate [4]. There are 2 (two) types of dams, they are permanent and movable dam.

- The permanent dam is a building used to raise the water level in a river to the height needed so that water can flow into irrigation channels or tertiary plots. There are 2 types of permanent dam seen from the structure of the overflow threshold, namely:
  - A fixed straight threshold from the edge to the right bank, meaning that the threshold is in the form of a straight line connecting two riverbank points.
  - Fixed thresholds that turn like a sawtooth. This type is needed if the threshold length is insufficient and usually for rivers with a small width but large water discharge.

- Moveable dam construction consists mostly of doors that can be moved to regulate the water level in a river [5]. There are 3 types of dams, namely:
  - Vertical Dam
    This dam consists of a dam body with a low fixed threshold equipped with doors that can be moved vertically or radially. This type has a dual function, namely regulating the water level in the upstream of the dam in relation to the flood water level and raising the river water level in relation to water tapping for various purposes.
  - Rubber dam
    This dam serves to raise the water level by inflating the dam's body and lowering the water level by deflating it. The dam body made of rubber tubes can be filled with air or water.
  - Bottom filter dam
This dam is in the form of an overflow dam which is equipped with catching channels and filters. This dam passes water through a filter by making a water reservoir in the form of a transverse catchment channel and flowing the water to the river bank to be brought to the irrigation network.

2.3 Types of Dam Gates
There are 4 types of dams based on the type of door used, namely:

a. Dam with Flap Gate
Flap Gate is a dam gate that opens and closes automatically. However, this automatization is influenced by differences in water levels both upstream and downstream of the building. The location of the valve gate can be set to enter the water at high tide and can hold water at low tide or vice versa as needed. Flap Gate is usually made of steel material that is considered strong and easy to be formed as needed [6].

![Figure 1. Flap gate type.](image)

b. Dam with Radial gate
This gate part consists of a gate in the form of a bow, legs and main beam. The water pressure of this gate is supported by the right and left joints. This sluice is made of strong steel plates so the price is relatively cheap compared to other types of the sluice. The advantage of this radial gate is that the opening gap is not too high due to the movement around the joint [7].

![Figure 2. Radial type](image)

c. Dam with sliding gate
The sliding gate is suitable for small and medium width and height openings. The material used for sliding gate is expected to have a small weight because the sliding gate moved by lifting up will require large lifting equipment as well if the gate weight is too heavy [8].
Rubber dam

The rubber dam is a dam made of rubber tubes that expand as a means of damming water operations. Rubber dam has the same function as other dams, namely, raising the surface of the water by looking to inflate the body of the dam, and deflating the body of the dam to lower the water level. Rubber dam can be opened automatically by deflating the rubber tube, but developing it can only be done manually [9]

3. Research Method

The data in this study were obtained through a questionnaire for selecting the type of dam. The questionnaire was distributed to respondents who were experts in the field of water. There are 5 criteria used to select the type of dam, namely the type of material, function of the dam, operation of the dam, cost of manufacture and location of door placement. The alternative types of dam that can be implemented in the study area are the dam with flap gate, radial gate and sliding gate. The results of the questionnaire were then processed using the Analytical Hierarchy Process (AHP) method with the application of Expert Choice v.11 to get priority criteria and alternative dams as part of efforts to protect against tides. In general, the steps taken in this study were as the following:

a. Compiling a research questionnaire and disseminate it to experts in the field of water
b. Processing the results of the questionnaire and look for the geometric mean value for each criterion that is compared.
c. Performing pairwise comparisons on each criterion at one level with the help of expert choice software.
d. If the inconsistency ratio is greater than 10%, then data retrieval will be performed,
e. Weighting of criteria and alternatives
f. Ranking criteria and alternatives from those that have the greatest weight to the smallest of each element.
4. Result and Discussion

4.1 Structure of the Hierarchy of Criteria and Alternatives for the Selection of the Dam Gate

Criteria to be considered in the selection of moveable dam gate include the criteria for materials, functions, operations and maintenance, manufacturing costs and location of placement. The alternatives used are Flap Gate, Radial Gate, Sliding Gate, and Rubber Dam. The hierarchy of criteria and alternative hierarchies can be seen in the following figure.

![Hierarchy structure of criteria and alternative type of moveable dam gate.](image)

**Figure 5.** Hierarchy structure of criteria and alternative type of moveable dam gate.

4.2 Weighting Criteria for Choosing the Type of Moveable Dam Gate

The calculation of criteria weights was done by comparing each criterion. Respondents filled in the questionnaire provided by giving a score of importance on a scale of 1 to 9 in each comparison between the 2 criteria variables. The results of the questionnaire were then calculated geometric mean. Then the importance level score of each component was processed using the Expert Choice application v.11. Figure 5 below is the result of the pairwise comparison between criteria.

![Pairwise comparison between criteria of moveable dam gate selection.](image)

**Figure 6.** Pairwise comparison between criteria of moveable dam gate selection.

Based on the results of pairwise comparisons, the next priority ranking criteria can be obtained. These results can be used to find out what criteria are most important to consider in choosing the type of gate of moveable dam. In Figure 6. It can be seen that the priority ranking criteria that must be considered in order are cost criteria (0.273), location of gate placement (0.259), function (0.249), gate operation (0.116) and material (0.104).
4.3 Priority Ranking of Moveable Dam Gate Type Alternatives

The alternative types of moveable dam gate that can be implemented in the study area were dam with a flap gate, dam with radial gate and dam with a sliding gate. The calculation of alternative weights was done by comparing each alternative to each criterion. The respondents would fill out the questionnaire that had been provided by giving a score of importance on a scale of 1 to 9 in each comparison between the two alternatives in one criterion. Then, the importance level score of each component was further processed using the Expert Choice application v.11. Based on the consideration of all the criteria used in selecting the type of dam gate, an alternative ranking of the dam gate can be generated based on the compilation of all criteria. Figure 7 shows the priority ranking of the dam gate-type based on all the criteria, while Figure 8 shows the Relative Priority Graph resulting from the compilation of the alternative dam gate.

Based on the Relative Priority Graph above, it can be seen that Flap Gate is the top priority most recommended by experts. The sliding gate is the second priority that can be considered as a gate in the dam. Whereas the rubber dam becomes the third priority with consideration in terms of material assessed according to the condition of the Kawunganten region, while Radial Gate is not recommended because of the high cost, and requires expertise in the process.

4.4 Hierarchical Structure of Criteria and Alternatives for the Selection of the Moveable Dam Gate

There are 3 (three) criteria that were considered in choosing the location of the dam, i.e. the ease of access to the ship, the area that can be protected from tidal flooding, and the ease of operation and
maintenance. Moveable Dam was planned to be placed in the Parid River channel in Ujungmanik, Kawunganten. Figure 9 shows the Ujungmanik Bridge, while Figure 10 shows the alternative locations of the dam location covering 3 locations, i.e. before the first port, before the Ujungmanikbridge and after the second port.

Figure 10. Ujungmanik Bridge, Kawunganten, Cilacap

Figure 11. Alternative location of moveable dam placement

Figure 12. Hierarchical structure of criteria and alternatives on moveable dam location

4.5 Weighting Criteria for Site Selection of Moveable Dam Gates

The calculation of criteria weights was done by comparing each criterion. Based on the score of importance given by respondents, then the data were processed using the Expert Choice application
v.11. Figure 12 below is the result of pairwise comparison between the criteria in the selection of the location of the dam.

![Figure 12](image)

**Figure 13.** Pairwise comparison between criteria of moveable dam location

Based on the results of pairwise comparisons, the priority ranking criteria could be obtained. These results can be used to find out what criteria are most important to consider in selecting the location of the moveable dam gate. In figure 10, it can be seen that the priority ranking criteria that must be considered is protected area from tidal floods (0.387), easy to operation and maintenance access (0.373) and ship access (0.340).

![Figure 14](image)

**Figure 14.** Priority ranking of selecting moveable dam gate location

### 4.6 Priority Ranking

Based on consideration of all the criteria used in selecting the location of the moveable dam gate, then an alternative ranking of locations can be generated based on a compilation of all criteria. Figure 11 shows the priority ranking of the location of the gate based on all criteria, while Figure 12 shows the Relative Priority Graph resulting from an alternative compilation of the location of the gate.

![Figure 15](image)

**Figure 15.** Priority ranking of alternative location of moveable dam gate
Based on the compilation of all criteria, it can be concluded that the location of the placement of the moveable dam gate shows the most favored location is before the Ujungmanik Bridge with a weight of 0.376, then the location after port 2 with a weight of 0.327 and location before port 1 with a weight of 0.297.

5 Conclusions
According to the results of the calculations, the conclusions can be drawn as follows:

a. Tidal flood handling in Ujungmanik Village, Kawunganten district can be done by building a moveable dam
b. The type of moveable dam gate and the right location is needed so that it can be done optimally.
c. The most important criteria for determining the moveable dam gate are cost (0.273), location (0.259), function (0.249), operational and maintenance (0.116) and material (0.104).
d. The priority order of the moveable dam gate is flap gate (0.291), sliding gate (0.265), rubber dam (0.249) and radial gate (0.196).
e. The priority order to determining the location of moveable dam placement is a protected area (0.387), operational and maintenance access (0.373) and ship access (0.240).
f. The priority order of moveable dam location is before Ujungmanik Bridge (0.376), after the second port (0.327) and before first port (0.296).

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