Opportunities and Challenges Application of Desalination Technology for the Clean Water Availability in Bangka Islands

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Abstract. Bangka Belitung islands is a province with limited clean water due to a lot of tin mine which is not environmentally friendly. on the other hand, Bangka Belitung has a 1200 km coastline more easily to access seawater. for this reason, the desalination technique is used as a way to overcome the limitations of freshwater. In addition to answering the needs for clean water, desalination techniques can also answer the need for salt on the island of Bangka by utilizing brine as waste from the processing of desalination techniques. this study applies the interpretive structural modeling (ISM) method which is based on several criteria such as social, economic, and environmental considerations in assessing the opportunities and constraints of implementing seawater desalination techniques. Result shows of the hierarchical analysis, the main challenges in desalination technique are high operational costs, distribution, and access to water resources and a regulatory framework that has not yet been established. the main opportunities in the desalination development are raw materials (seawater) are easy to access, environmentally friendly technology and support from local government.

1. Introduction
The explosion in the world population is correlated with an increase in food demand which increases water demand. This is revealed in a study by Hoekstra and Chapagain in a report by the United Nations Agency for Water (UN-Water) which states that to produce 1 kg of water it takes around 3500 liters of water [1]. The high water demand is not matched by the provision of adequate clean water infrastructure, which results in scarcity of clean water. Furthermore, UN-Water noted that 780 million people in the world could not access clean water and 80 million of them are Indonesian residents.

Development in Indonesia is growing rapidly. This increase in population has an impact on increasing the need for clean water. Under the SNI 2012 standard, the need for water for urban households is 120 liters/day/capita, while the rural population is 60 liters/day/capita. Population growth projections are carried out by the Central Statistics Agency. shows that the number of Indonesians is predicted to continue to increase from 238.5 million in 2010 to 306.5 million in 2035. Household water demand in 2035 is estimated at 11.5 billion cubic meters. Water resource problems are related to quantity, quality, and institutional issues. The problem of water is not just a quality issue but a question of quantity and continuity [2].

Statistical data shows that the proportion of households and drinking water sources used in Indonesia varies depending on geographical conditions. Nationally, this can be shown as follows:
households use tap water around 16%, groundwater around 11%, well water approximately 49%, spring water 13%, river water 5%, 2.6% and 0.8% respectively rainwater and others. It can be seen that the use of water from springs, groundwater, and river water is the most widely used, but the problem that arises is that the quality of groundwater and river water used by the community does not meet the requirements as healthy drinking water even in some places it is not suitable for drinking [3].

Currently, it is difficult for some people in several regions in Indonesia to meet their needs for clean water. So that one effort that can be done is to provide water using existing water resources, one of which is by using seawater. However, in its use, it requires processing first. The coastal area and small islands in the middle of the ocean are one of the areas that are poor in clean water sources, causing problems regarding the need for clean water.

Bangka Belitung Province is a province with a coastline of 1200 kilometers with a total of 950 islands. Based on the results of the research on Sabri's needs, water demand in Bangka Island in 2013 was 711.75 m³/capita/year. The available water in Pilau Bangka from 2013 to 2023 shows a surplus in the rainy season (November-April) and a deficit in the dry season (May-October).

The condition where there is a deficit of water availability from May to October is a problem that must be resolved by the local government. The lack of availability of raw water is felt more by the people along the coast of Bangka Island. Based on research conducted by Yudo, the coastal communities of the Bangka island, especially in Sungai Liat, is a water prone area [3]. Drinking water treatment facilities that have been built cannot operate optimally. This is assumed to be due to the lack of community involvement in planning, construction, and operation. Based on this background, a form of policy strategy is needed to meet the needs of raw water by desalination in Bangka Belitung Province, especially on the coast of Bangka Island.

2. Method
Bangka Belitung Islands Province located between 104°050' – 109°030' East Longitude and 0°50' – 4°10' South Latitude and is bordered by the Natuna Sea and the South China Sea to the north, the Karimata Strait to the east, the Java Sea to the south and the Bangka Strait to the northwest side. The archipelago consists of land and water areas. The water area has a large proportion of the land area. Bangka Island which consists of Bangka Regency, West Bangka Regency, Central Bangka Regency, South Bangka Regency, and Pangkalpinang City is much bigger than Belitung Island. (Fig 1).

This study uses primary and secondary data. Primary data in the study is data derived from the results of the assessment of respondents (expert judgment), of which the respondents in this study are experts. While secondary data is data in the form of documents, government reports related to research.
The data collection method is a technique or method used to obtain data following the research design that has been compiled [4]. The data collection methods used in this study were survey methods and literature study methods. The survey was conducted using a closed questionnaire. Five experts as respondents in this study such as desalination technology expert, Bappeda, Director of BUMD who founded desalination in Bangka, representatives of Bangka City Environmental Service and Academics, and Head of Regional Drinking Water Company (PDAM).

This study applies the Interpretive Structural Modeling (ISM) modeling method. This method consists of several different sets of factors in the interactive learning process. In addition, there is a direct relationship with each factor and is built into a systematic and comprehensive model [5] [6] [7] [8]. ISM method is very important in developing the complexity of the relationship between elements in a system. Furthermore, Faisal et al., also explains that the structure of a complex problem or system can be designed in detail through a drawing and graphics along with its description [9]. Thus, the ISM method provides linkage information from each expert and supports the development of a hierarchical structure based on the level of importance and the visualization of the scenario. Moreover, this method is an interpretation of group assessments to produce decisions on the relationship of a variable. A group of variables that have relationship complexity will form the basis of the model structure to be built. Thus it can be interpreted that the ISM method provides an overview through a diagrammatic model that shows the specific relationship of the entire structure. Marimin's research underlines that the direct relationship of each element can have different contexts such as policy objectives, organizational targets, and assessment factors [10]. The ISM method has been widely applied in solving problems, such as investigation of the AIDS epidemic [11]; conservation and recycling [12]; renewable energy [13], agriculture [14]; reverse logistics [15]; green production [16], Car Industry [17].

Broadly speaking, there are two parts to the ISM method, namely the classification of elements and hierarchical modeling.

This ISM technique can be used to perform program analysis in accordance with vision and mission. In general, the ISM technique is divided into two parts: the classification of elements and the preparation of the hierarchy. Determining the elements associated with the problem is the initial stage that must be done in the ISM analysis. Then each element is arranged based on the selected sub-elements. This selection is based on the results of discussions with experts.

Furthermore, an expert assessment is carried out which will be compiled into a Structural Self Interaction Matrix (SSIM). This matrix then converts V, A, X, O into numbers 1 and 0 in the Reachability Matrix (RM) table. Then, based on the Structural Self Matrix (SSM), elements will be classified using the VAXO system as follows:

V if eij = 1 and eji = 0;
A if eij = 0 and eji = 1;
X if eij = 1 and eji = 1;
O if eij = 0 and eji = 0

The next step is to change the SSM matrix into a closed matrix. This stage is carried out to improve the relationship in the matrix that follows the transitivity rule. For example, if factor A affects factor B and factor B affects factor C, then factor A should affect factor C. The value 1 shows the contextual relationship of elements i and j elements, meanwhile, eij = 0 indicates there is no contextual relationship between elements i and j. The next stage is to determine Driven Power (DP) and Dependence (D) which is based on the fulfillment of the transitivity rules in the matrix. The final step in the ISM method is to group the sub-elements into 4 sectors, as follows:

a. Weak driver-weak dependent variable (AUTOMATIC): this sector shows no linkages between systems in general.
b. Weak driver strongly-Dependent variables (DEPENDENT): this sector represents a group of dependent elements.
c. **Strong driver-Strongly dependent variables (LINKAGE):** This sector shows very strong interrelationships between elements that have the potential to influence the system and should be carefully examined.

d. **Strong driver-Weak Dependent variables (INDEPENDENT):** This sector shows the strong influence of elements on a system and has the potential to determine which program will succeed.

The ISM analysis conducted in the study focused on the opportunity elements and constraints related to policy strategies to meet the needs of raw water with the desalination process in Bangka Belitung Province. Stages of research include; preparation stage (preparation of questionnaire), survey stage, and data analysis stage. The data analysis in this study was conducted with the help of Professional ISM software 2.0 (free access).

3. **Result and Discussion**

3.1. **Opportunity Element**

Based on the results of a systematic review, and brainstorming with experts obtained several elements of opportunity in the formulation of policy strategies to meet the needs of raw water with desalination process in Bangka Belitung Province, as follows:

**Table 1. Opportunity Element**

| Symbol | Opportunities Element                                      | Source |
|--------|-----------------------------------------------------------|--------|
| A1     | Clean water fulfillment                                   | [18]   |
| A2     | Consumers of clean water                                  | [19]   |
| A3     | Regional income                                           | [20]   |
| A4     | Economic growth                                           | [20]   |
| A5     | Raw materials (seawater) are easy to access               | [18]   |
| A6     | Available desalination technology                         | [21]   |
| A7     | Labor absorption                                          | [21]   |
| A8     | Improved preservation of water resources                 | [22]   |
| A9     | Eco-friendly technology applications                      | [3]    |
| A10    | Government Support                                        | [23]   |

The results of the ISM analysis on the element of opportunity show that there are 5 (five) keys elements in the formulation of a policy strategy for meeting raw water needs with the desalination process in Bangka Belitung Province. The results of the quadrant and hierarchical (level) analysis are as follows:
Figure 2. The results of the analysis Opportunity Element

The results of the analysis showed that there are 5 (five) key elements related to opportunities in the development of policy strategies to meet the needs of raw water with the desalination process in Bangka Belitung Province, namely; Clean water fulfillment (A1), Raw materials (seawater) easy to access (A5), Improved water resource preservation (A8), Environmentally friendly technology application (A9) and Government Support (A10). The greatest opportunity that can be grasped is the fulfillment of the clean water needs of the people of the island of Bangka, considering a study conducted by Hambali, 2013, where there has been a deficit in effect of clean water during the dry seasons in May to October.

3.2. Constraint Element

Based on the identification of elements of constraints related to the formulation of policy strategies to meet the needs of raw water with the desalination process in Bangka Belitung Province, 10 elements are obtained as follows:

Table 3.2. Constraint Element

| Symbol | Constraint Element                                           | Source |
|--------|-------------------------------------------------------------|--------|
| A1     | Expensive investment costs                                  | [20]   |
| A2     | Expensive operating costs                                   | [25]   |
| A3     | Expensive Water cost                                        | [25]   |
| A4     | Lack of desalination treatment                              | [21]   |
| A5     | Adjustment to the culture of society                         | [3]    |
| A6     | High Tech                                                   | [21]   |
| A7     | Desalination operational institutions have not yet been established | [23]   |
| A8     | Distribution and access to water                             | [18]   |
| A9     | Unformed Regulatory Framework                                | [23]   |
| A10    | Strategic location                                          | [19]   |

The results of the ISM analysis of the constraint elements show that there are 3 (three) keys elements in the formulation of a policy strategy to meet raw water needs with the desalination process in Bangka Belitung Province. The results of the quadrant and hierarchical (level) analysis are as follows:
The results of the analysis showed that there are 5 (five) key elements related to opportunities in the development of policy strategies to meet the needs of raw water with the desalination process in Bangka Belitung Province, namely; costly operating costs (A2), distribution and access to water (A8) and unformed regulatory frameworks (A9). The operational cost incurred are more expensive than operational cost of PDAM with conventional technology. This is due to the better quality of the air produced, in the form of ready to drink water (Cahyana, 2010). Based on a study conducted in Bangka by Alimah Siti (2011), reverse osmosis technology for desalination is the cheapest technology that can be used. The distribution of the air generated and regulatory frameworks are the main breakdown factors (Aliwei 2017) says institutional strengthening through permanent capability and capacity building of agencies responsibilities for water policies, being operational and distribution function, should be separated institutionally.

4. Conclusion

The increase in population has an impact on increasing the need for clean water. Water resources problems are related to quantity, quality, and institutional issues. This study attempts to identify and analyze the main criteria for opportunities and challenges in applying desalination technology for the availability of clean water in the Bangka Islands. There are ten elements of opportunity and challenge criteria respectively in the application of desalination technology. The application of the ISM method reveals major constraints such as operational costs, distribution, and access to water resources. Key opportunities in desalination development include the availability of raw materials, environmentally friendly technology, and support from local governments. This research is the first step in uncovering the opportunities and challenges of the water desalination technology program in the Bangka Islands. This research also has many shortcomings. Thus, it is necessary to carry out further and in-depth analysis and study in further research.

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