The readiness of small island community to the development of potential renewable energy: case study of Bulang Kebam Island, Riau Island province, Indonesia

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Abstract. Bulang Kebam Island is one of the small islands located in the west part of Batam City, Riau Islands Province. The region has a deficiency of energy because both central and local governments have not been able to build electrical grid connections for the region, hence the electricity demand can only be met for six hours per day using a diesel generator. In order to provide a more continuous supply, an alternative source of energy by utilizing the potential of tidal energy resources around Bulang Kebam Island is needed. In support of an effective and efficient renewable energy project development, a study of the community readiness level in Bulang Kebam Island is conducted. Rapid Appraisal for Community Readiness (RAPCR) method is used for this purpose, which consists of social, economic, environment, technology, and institutional factors. The results showed that the community readiness index were categorized as sufficiently ready with values of 61.84, 64.15 and 72.55 for the environment, technology, and institutional factors respectively. While from the economic and social factors, community readiness index were categorized as ready with values of 82.94 and 84.93. Furthermore, the dominant attributes from each factor were analyzed and ranked by using Leverage analysis. The most dominant attribute from economic, environment, technology, social, and institutional factors respectively are potential for renewable energy funding from the community, level of environmental difficulty on the implementation of renewable energy, area availability for renewable energy technology, a clear roles in the implementation of renewable energy, and commitment of local government to renewable energy. The results of this study is expected to be a reference and recommendations for the development of appropriate target and advantage of renewable energy project development in Bulang Kebam Island.
1. Introduction

Indonesia consists of many small islands and most of the islands had been recorded in the United Nation and about 2.509 new verified islands had been reported to the United Nation in the 11th United Nations Conference on the Standardization of Geographical Names (UNSCSGN) on August 2017. Remote location, distance from main islands, and accessibility are main obstacles for the development of small islands. Therefore the small islands are left behind compare with other.

![Image](image_url)

**Figure 1.** Research Locations is located at Bulang Kebam Island, Riau Island Province Indonesia.

On the other hands, the potential of marine resources in small islands is quite large, such as the potential of fisheries, minerals, sea currents and tides. Abundant marine resources in Indonesia are still not utilized optimally, especially in the potential of currents and tides that can be used as a source of renewable energy. The utilization of the current and tidal currents energy can be converted as the fulfillment of electricity needs in the small island in Indonesia. However, at this time the fulfillment of electric energy sources contained in small islands is still relying from fossil energy sources by using oil fuel. Fossil energy sources certainly have limited amounts. In term of that someday in the future scarcity of the fossil energy will occur and even running out. In Bulang Kebam Island the fossil energy only support six hours per day and that was not enough to fulfill the need of electrical energy in this island. Therefore, it needs a supply of renewable and environmentally friendly power source by considering that the source of the fossil energy is running low and also challenge to distribute fossil energy in small island [1].

Implementation of renewable energy in Indonesia has its own challenge where every area has different characteristic of resource potential, weather and climate variability as well as community characteristic. These complexities well recognized so that the complete image of area readiness in the implementation of renewable energy can be achieved.

The successful of renewable energy development in Bulang Kebam Island is influenced by environment, technology, economic, social and institutional factors. Community norms and values must be considered as important factors affecting the support of community-based development [2]. This research aim to assess the community readiness based on the factors above in the development of renewable energy in Bulang Kebam Island

2. Methods

2.1. Location and time research

This research was conducted on February until March 2017 in Bulang Kebam island which is administratively located in Bulang District, Riau Island Province (Figure 1). The geographical location is at 00° 51’ - 1° 06’ North Latitude and 103°48’ - 104°06’ East Longitude. Primary data were attained...
from questionnaire of selected respondents in Bulang Kebam Island. Secondary data were obtained from the Central Bureau of Statistics (BPS), Agency of Marine and Fisheries or Ministry of Maritime Affairs and Fisheries (KKP), Bulang District, Riau Island Province and other publications.

2.2 RAPCR method

RAPCR (Rapid Appraisal for Community Readiness) is a rapid appraisal technique that conducted to evaluate the community readiness in order to prepare communities to be more successful in their effort to address a variety of issues. It was adopted from Pitcher and Preikshot, 2001. This allows us to describe the developmental level of a community to specific issue [3]. RAPCR steps can be outlined as follows:

(i) **Identification and scoring of each attribute.** Identification conducted with review and determine the attribute in 5 factors: environment, technology, economic, social and institutional. Each factor has 5 attributes so that the total of attribute is 25. Determination of attribute for each factor is acquired through the study literature that is relevant with this research. The field survey and interview with the communities, expert and related institution were conducted to receive more accurate information. At the final step is scoring of each attribute which refers to technique from Pitcher T.J and Preikshot, 2001 and Susilo, 2003 ranging from the lowest score 0 for the most unprofitable condition and the highest score 2 for the most profitable condition. Scoring is also determined by primary data that resulted from questionnaire and supported with literature and competent experts. Attribute and scoring of 5 factors can be seen in the Table 1.

(ii) **Ordination process.** Process to visualize the position of seaweed farming sustainability point in two dimensional based on the scoring of each attribute which is conducted by using Multidimensional Scaling method [4] and [5]. The distance calculation between attribute points, horizontal and vertical reference points, and anchor reference points are conducted by using euclidian distance formula below:

\[
d = \sqrt{|x1 - x2^2| + |y1 - y2^2| + \cdots}
\]

Where d is distance between attribute, x is attribute of factor 1, y is attribute of factor 2, …

(iii) **Rotation process and arrangement of readiness scale in RAPCR.** This process is to align the quality (good or bad) position of horizontal reference points with the horizontal axis x. Reference point up is located above the horizontal axis x, whereas reference point down is located below the horizontal axis x. Position of environment, technology, economic, social and institutional points which is located in the scale 0 – 100 describe the community readiness status of potential renewable energy development in Bulang Kebam Island. Category of community readiness status adopted from [5] and [6] shown in Table 2. Meanwhile to know the correlation of continuity index within each factors, the kite diagram was built up, therefore the integrated review from all related factors can be conducted [4] and [7].

(iv) **Leverage analysis.** This process is conducted to find the most dominant to the community readiness status of potential renewable energy development [4] and [7]. The leverage analysis is the calculation of Root Means Square (RMS) from each attributes in five factors by using formula below:

\[
Total RMS = \sqrt{\frac{\sum_{j=1}^{n}(Vf(i,1) - Vf(cent,1))^2}{n}}
\]

Where Vf (i,1) is position of attribute point matrix V in line i column 1 (x axis), Vf (cent, 1) is center value of position of attribute point matrix V in line i column 1 (x axis) and n is number of attributes.
### Table 1. Factor and Attribute of Renewable Energy Development

| Factor | Attribute                                                                 | Score (min 0 – max 2) |
|--------|---------------------------------------------------------------------------|-----------------------|
| Environment | 1. Potential resource of renewable energy                                   | 2 (available)         |
|          | 2. Impact of renewable energy utilization to environment condition         | 1 (neutral)           |
|          | 3. Level of environment difficulties to the renewable energy implementation | 2 (difficult)         |
|          | 4. Sea water suitability to the renewable energy                           | 1 (sufficient)        |
|          | 5. Affordability of renewable energy location                              | 1 (sufficient)        |
| Technology | 1. Availability of power generator technology                               | 2 (available)         |
|          | 2. Availability of electrical distribution technology                       | 2 (available)         |
|          | 3. Technology suitability for electrification supply and demand            | 1 (sufficient)        |
|          | 4. Area availability for technology of renewable energy                    | 1 (sufficient)        |
|          | 5. Infrastructure availability to support technology of renewable energy   | 0 (not available)     |
| Economic | 1. Potential funding of renewable energy from government                   | 1 (few)               |
|          | 2. Potential funding of renewable energy from private sectors              | 2 (available)         |
|          | 3. Potential funding of renewable energy from community                    | 2 (available)         |
|          | 4. Absorption of employee                                                  | 2 (many)              |
|          | 5. Existence of formal finance institution                                  | 0 (not available)     |
| Social | 1. Influence the existence of electricity resource from renewable energy to the socio cultural values | 2 (high)             |
|          | 2. Community awareness to the resources and benefits of renewable energy   | 2 (high)              |
|          | 3. Consumer users potential of renewable energy                            | 2 (high)              |
|          | 4. Clear roles distribution in the renewable energy implementation         | 1 (sufficient)        |
|          | 5. Impact of renewable energy to the community welfare                    | 2 (high)              |
| Institutional | 1. Maintenance institution existence of renewable energy technology        | 2 (available)         |
|          | 2. Local institution existence for electricity management from renewable energy | 2 (available)         |
|          | 3. Commitment of local government to renewable energy                     | 1 (sufficient)        |
|          | 4. Community group involvement to manage renewable energy technology       | 2 (available)         |
|          | 5. Monitoring of related institution to the power plant company             | 1 (sufficient)        |

### Table 2. Status Category of Community Readiness

| No | Index | Category       |
|----|-------|----------------|
| 1  | 0 - 25| Not Ready      |
| 2  | 26 - 50| Less Ready    |
| 3  | 51 - 75| Sufficiently Ready |
| 4  | 75 - 100| Ready        |
3. Result and discussion
3.1. Community Readiness Index for Renewable Energy Development
Community readiness index from environment, technology, economic, social and institutional factor can be seen from Figure 2 below.

3.1.1. Environment
Index of community readiness based on RAPCR analysis in environment factor is 68.14 that categorized in sufficiently ready category. This show that community readiness level in environment factor is sufficiently ready to support renewable energy development. This condition should have more attention since the index is closer to 50 which can be easily shift into less ready category. Environment factor is the important factor for renewable energy development because the natural environment especially from the ocean can provide potential natural resources that can be converted as new source of renewable energy. For instance, the location of Bulang Kebam island is between small islands in Batam area, this condition leads to the tidal current energy potency from its surrounding straits.

![Figure 2. Community Readiness Index for Renewable Energy Development](image)

3.1.2. Technology
Index of community readiness based on RAPCR analysis in technology factor is 64.15 that categorized in sufficiently ready category. Proper technology can support sustainability of renewable energy development but on the other hand, some of improper technology might be the hardest obstacles to find, since the price of renewable energy cannot compete with the price of subsidized fossil energy. The circumstance conducts the renewable energy development running slow. In case of that, the selection of renewable energy technology must be done properly.

3.1.3. Institutional
Index of community readiness based on RAPCR analysis in institutional factor is 72.55 that categorized in sufficiently ready category. Readiness criteria in this factors focus on the integration of
involvement, monitoring and existence of institutional from community, government and also related stakeholders in renewable energy development.

3.1.4. Economic
Index of community readiness based on RAPCR analysis in economic factor is 82.94 that categorized in ready category. Funding for the implementation, operational and maintenance of renewable energy should be integrated properly in order to achieve the sustainability of renewable energy development. The contribution should come from government, private and community institutional.

3.1.5. Social
Index of community readiness based on RAPCR analysis in social factor is 84.53 that categorized in ready category. In social factor, community in Bulang Kebam island had already expected another source of energy form several years ago. Lack of electricity supply became a main problem in this small island and the community really want the solution as soon as possible. Social aspect should integrate the impact of renewable energy, community assessment, clear distribution from roles of renewable energy development.

3.2. Leverage Analysis
Leverage analysis was conducted by calculating root mean square of each attribute from environment, technology, economic, social and institutional factors by using equation (2). The most dominant attribute for each factors can be seen from Figure 3 to Figure 7 below.

![Leverage analysis of environment factor](image)

**Figure 3.** Leverage analysis of environment factor
Figure 4. Leverage analysis of technology factor

Figure 5. Leverage analysis of institutional factor
Figure 6. Leverage analysis of economic factor

Figure 7. Leverage analysis of social factor
The most dominant attribute in environment factor analysis based on RMS changed value is the level of environment difficulties to the renewable energy implementation within value of 8.44 as the result of total RMS calculation by using equation (2). Difficulties level from the location of renewable energy implementation must be noticed properly since it can affect the successful of renewable energy development in Bulang Kebam island. Including the distance, characteristic of location, geomorphology, oceanographic and weather condition, and road condition.

From technology factor analysis, the most dominant attribute as the result from calculation of equation (2) is area availability for technology of renewable energy within value of 8.49. In some cases, the equipment of renewable energy technology need some spaces to be installed. This area of installation should be well prepared to support the equipment of renewable energy technology.

Furthermore, the most dominant attribute in institutional factor analysis is commitment of local government to renewable energy within value of 13.23 as the result of calculation by using equation (2). Local government plays an important role to the sustainability of renewable energy development in Pulau Panjang. Local government should taken into account the annual budget in its local budget planning to support the development.

Based on economic factor analysis, the most dominant attribute is potential funding of renewable energy from community within value of 6.94 as the result of calculation by using equation (2). Community participation in renewable energy development in Bulang Kebam island should also be supported by the funding from community itself. Nevertheless the funding implementation must be integrated properly with funding from government and also private sectors. So that the roles from each stakeholders can be clearly implemented. In this case, community in Pulau Bulang Kebang are willing to pay cost for energy availability. This case was similar with Madura Island where community in Madura had a high willingness to pay for electricity that reach 486.38 IDR per kwH. This rate was higher than State Electricity Company (PLN) rate [8].

From social factor analysis, the most dominant attribute is clear roles distribution in the renewable energy implementation within value of 15.46. Each stakeholders need to now and understand their roles in renewable energy development, so that the development can run smoothly and integrated each other.

3.3. Kite Diagram

Figure 8. Kite Diagram of Community Readiness in Bulang Kebam Island
From the kite diagram above, it can be seen that community readiness from social factor has the highest value that describe Bulang Kebam community is very ready to support renewable energy development in view of the fact that electricity is the most important things that must be fulfilled immediately and it will bring impact to the social activity sectors in Bulang Kebam island. Economic factor as the second high value (82.94) from kite diagram emphasizes that most of community in Bulang Kebam island is willing to pay more for the electricity availability. They really need the availability of continuous electrical energy expected from renewable energy.

4. Conclusion

Result of community readiness in Bulang Kebam Island to the development of renewable energy by using RAPCR method shows that factor of environment, technology and institutional are categorized in sufficiently ready category within value RAPCR of 68.14, 64.15 and 72.55. Other factors such as economic and social are categorized in ready category with value RAPCR of 82.94 and 84.53.

Findings on leverage analysis show that the most dominant attribute in environment factor is level of environment difficulties to the renewable energy implementation within value of 8.44. From technology factor is area availability for technology of renewable energy within value of 8.49. From institutional factor is commitment of local government to renewable energy within value of 13.23. While from economic factor is potential funding of renewable energy from community within value of 6.94. And social factor is clear roles distribution in the renewable energy implementation with value of 15.46.

Kite diagram shows social factor has the highest value which emphasizes that community in Bulang Kebam Island is very ready to support renewable energy development. Development since electricity is the most important things that must be fulfilled immediately and it will bring impact to the social activity sectors in Bulang Kebam Island. From economic factor, most of community in Bulang Kebam Island is willing to pay cost of electricity availability. They are really looking forward to the availability of continuous electrical energy that is expected from renewable energy.

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