III. MATERIAL AND METHOD

3.1 Time and Location

The research was conducted in March 2007 until June 2007. The area of study is covering the whole area of Bener Meriah district. The area is located between 96.649192 to 97.332778 East Longitude and 4.971228 to 4.567314 North Latitude.

![Figure 1. Bener Meriah District](image)

3.2 Type of Data and Sources

The data provided are elevation data, spot heights data, contours data, landcover data, soil type data, rainfall data, river and lake data, population density, ecology data, and ecology data. The other data available are administrative data such as province, district and subdistrict and village boundaries, settlement data such as capital, main cities and villages, and also ports, and road network data. The data here taken from Bakosurtanal, Badan Rehabilitasi dan Rekonstruksi...
(BRR), and owned by ICRC (International Committee of the Red Cross)

Table 1. Type of data and its sources

<table>
<thead>
<tr>
<th>No.</th>
<th>Data</th>
<th>Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Administrative Boundaries</td>
<td>Vector</td>
<td>BRR ICRC</td>
</tr>
<tr>
<td>2</td>
<td>Settlement</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>3</td>
<td>Elevation</td>
<td>Raster/Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>4</td>
<td>Spot Heights</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>5</td>
<td>Contours</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>6</td>
<td>Landcover</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>7</td>
<td>Soil Type</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>8</td>
<td>Rainfall</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>9</td>
<td>Population Density</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
<tr>
<td>10</td>
<td>Road Network</td>
<td>Vector</td>
<td>Bakosurtanal</td>
</tr>
</tbody>
</table>

3 Methodology

The study consists of Spatial Analysis and Analytical Hierarchy Process to determine suitable area for dairy cattle farm development, in Bener Meriah District, Aceh Province. Spatial Analysis used to create map of suitable area. The method of the study is:

1. To determined the objectives. The objective of this study is to find out the suitable area for dairy cattle farm development.
2. To determined unit analysis of the study area. It is determined that District level is to be used as unit analysis.
3. Identified the criteria of suitable area for dairy cattle farm development.
4. Data collection.
5. Data analyzing.

The following diagram represents the overview of the research process structure.
Figure 2. Flowchart of Research Process

START

GIS Process

Carrying Capacity Data

Carrying Capacity Data

Economic Factors Data

Dairy Cattle Farm Development

Suitable area for Dairy Cattle Farm Development

AHP

Technical Factors Data

Best Suitable area for Dairy Cattle Farm Development

END

Physical Factors Data
3.3.1 Model for Determining Suitable Area of Dairy Cattle Farm

The model for determining suitable area of dairy cattle farm is shown in hierarchical model below.

![Hierarchical Model of Suitable Area for Dairy Cattle Farm](image)

Figure 3. Model for Determining Suitable Area of Dairy Cattle Farm
3.3.2 Criteria and Its Measurement

The criteria that influence the determination of suitable area are divided into four factors. Those factors are carrying capacity, physical factors, technical factors and social-economic factors.

a. Carrying Capacity

Carrying capacity describes the average number of animals that can be placed on a pasture for a season without harming them. This is to measure the number of animals that can be breed in such area.

Available Carrying Capacity calculated by using the following formula:

\[
\text{Carrying Capacity} = \frac{\text{Forage Production} \times \text{Utilization Rate}}{\text{Average Daily Intake} \times \text{Length of Grazing Season}}
\]

Equation 1. Carrying Capacity

Annual forage production is the total amount of forage dry material produced per acre on an annual basis. Seasonal utilization rate is the percentage of the annual forage production that will actually be harvested by the grazing livestock, this will be very dependent upon rotation frequency and expected level of animal performance. Average daily intake should be set at the level that will be required to yield the desired animal performance level. Length of the grazing period is a function of how many paddocks are available and the required rest period.

b. Physical Factors

Physical factors consists of four sub factors, those are water supply, climate factors, soil factors and constructions factors.

(1) Water Supply
Water is an essential factor for life. Dairy cattle needs high amount of water to live and maintain the cleanliness of the area. Typically, cattle will consume approximately 12 gallons or 45 liters of water per day (Siregar, 1989). Sanitation is one of the most important factors in managing dairy cattle, since it will influence to the quality of milk produced. Elephant grass is fairly tolerant to soil condition, but does not withstand to flood or water logging well (Humphreys, 1980). The sources of the water supply are from lakes and rivers around the area.

(2) Climate Factor consists of:

- Temperature (degree Celsius). Animals can survive only in certain temperature. In the case of dairy cattle, it will effect its milk production. Dairy cattle should live in low temperature area at around 12-23 Celsius degree. (Vercoe, 1999)

- Rainfall (mm/month). This is an important factor for cattle's water supply and pasture growth. Elephant grass growths in the area received over than 1100 mm rainfall (Humphreys, 1980). Cattle are not directly influenced by rainfall as long as they have sufficient water supplies. (Vercoe, 1999)

(3) Soil Factors consists of:

- Landcover. Landcover selected are bushes and open or unused field hence it will not sacrifice the forest, agricultural land or other natural resources. According to Humphreys (1980), scrub soil gives best growth to elephant grass. The cattle itself can live at any kind of land as long they have good pastures and water.

- Altitude (m). This factor is one of the most important factors in developing dairy cattle farm. Altitude has close relationship with temperature. The best dairy cattle farm must be located above 1000 m of sea surface level.

(4) Constructions Factors consists of:
• Roads. The farm should not be located too far from the road. This is to enable the farmers to have easy access to the town to sell their production. It is recommended that development the farm is within 1 km from the road.
• Settlement. The farm should build 1 km away from the settlements to avoid animal waste from the dairy cattle farm.

c. Technical Factors
(1) Accessibility.
Accessibility means the easy access to reach the area. This is important for milk marketing reason. There are two factors that influence accessibility:
• Road condition. It is define from condition of the road cover.
  (good, moderate, poor)
• Distance to town. It is related with marketing and selling the product to town. The site that located far away from the town will give less benefit to the farmer since the transportation cost is higher than the one closer to town.

d. Economic Factors
(1) Economic Factor
Economic factor has close relationship with money circulation.
Economic Factor consists of:
• Marketing. Means how potential the area for milk marketing, how far the farm to market and how is the accessibility. Those factors above may influence the milk price in the market.
• Cooperation. The existence of cooperation to support the farmer.

3.4 Analysis
The analysis method use for this project is the Analytical Hierarchy Process. Through this method, decision was made to determine the most suitable area to develop dairy cattle farm. This method is based on expert's or decision-maker's judgment. The decision-maker has to give score to each factor given, and
the Analytical Hierarchy Process decides the level of importance of the factors to be considered. This method is useful, especially for unmeasured factors such as technical factors and social-economic factors.

The AHP is based on the concept of "exploding tree", also referred to as a value tree which allows splitting a goal into sub-criteria. It is assumed that the relevant importance of one attribute influenced a goal over other attributes can be determined via a pair-wise comparison. These comparisons are executed between attributes in all combination to avoid repetitions. The tree may consist of several levels, where a goal for the lower level at the same time can be a sub-criterion for the upper level (Atthirawong and MacCarthy, 2001).

4.1. Establishment of a Structural Hierarchy

This step allows a complex decision to be structured into a hierarchy descending from an overall objective to various 'criteria', 'sub-criteria', etc, until the lowest level. The objective or the overall goal of the decision is to represent at the top level of the hierarchy. The criteria and sub-criteria contributing to the decision are represented at the intermediate levels. Finally, the decision alternatives or selection choices are laid down at the last level of the hierarchy.

4.2. Establishment of Comparative Judgments

Once the hierarchy has been structured, the next step is to determine the priorities of the elements at each level ('elements' here means every member of the hierarchy). A set of comparison matrices of all elements in a level of the hierarchy with respect to an element of the immediately higher level are constructed to priorities and convert individual comparative judgments into ratio scale measurements. The preferences are quantified by using a nine-point scale. The description of each scale measurement is explained in Table 1. The pair-wise comparisons are given in terms of how much element A is more important than element B.
Table 2. Scale of preference between two elements
(adapted from Saaty, 2000; Atthirawong and MacCarthy, 2001)

<table>
<thead>
<tr>
<th>Preference weights / level of importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equally Preferred</td>
<td>Two activities contributes equally to the objective</td>
</tr>
<tr>
<td>3</td>
<td>Moderately Preferred</td>
<td>Experience and judgment slightly favor one activity over another</td>
</tr>
<tr>
<td>5</td>
<td>Strongly Preferred</td>
<td>Experience and judgment strongly or essentially favor one activity over another</td>
</tr>
<tr>
<td>7</td>
<td>Very Strongly Preferred</td>
<td>An activity is strongly favored over another and its dominance demonstrated in practice</td>
</tr>
<tr>
<td>9</td>
<td>Extremely Preferred</td>
<td>The evidence favoring one activity over another is the highest degree possible of affirmation</td>
</tr>
<tr>
<td>2,4,6,8</td>
<td>Intermediates Value</td>
<td>Used to represent compromise between the preferences listed above</td>
</tr>
</tbody>
</table>

Reciprocals Reciprocals for inverse comparison

3.4.3. Synthesis of priorities and the measurement of consistency

The pair-wise comparisons generate a matrix of relative rankings for each level of the hierarchy. The number of matrices depends on the number elements at each level. The order of the matrix at each level depends on the number of elements at the lower level that links to it. After all matrices are developed and all pair-wise comparisons are obtained, eigenvectors or the relative weights (the degree of relatives importance amongst the elements), global weights, and the maximum eigenvalue (λ_max) for each matrix are then being calculated.
The $\lambda_{\text{max}}$ value is an important validating parameter in AHP. It is used as a reference index to screen information by calculating the consistency ratio CR of the estimated vector in order to validate whether the pair-wise comparison matrix provides a completely consistent evaluation. The consistency ratio is calculated as per the following steps:

1) Calculate the eigenvector or the relative weights and $\lambda_{\text{max}}$ for each matrix of order $n$.

2) Compute the consistency index for each matrix of order $n$ by the formula:

$$\text{CI} = (\lambda_{\text{max}} - n)/(n-1) \quad (3)$$

3) The consistency ratio is then calculated using the formula:

$$\text{CR} = \text{CI}/\text{RI} \quad (4)$$

Where RI is a known random consistency index obtained from a large number of simulations runs and varies depending upon the order of matrix. Tables show the value of the random consistency index (RI) for matrices of order 1 to obtained by approximating random indices using a sample size of 500 (Atthirawong and MacCarthy, 2001).

### Table 3: Average random index (RI) based on matrix size
(Adapted from Saaty, 2000; Atthirawong and MacCarthy, 2001)

<table>
<thead>
<tr>
<th>Size of matrix (n)</th>
<th>Random Consistency Index (RI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
</tr>
<tr>
<td>4</td>
<td>0.89</td>
</tr>
<tr>
<td>5</td>
<td>1.11</td>
</tr>
<tr>
<td>6</td>
<td>1.25</td>
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<tr>
<td>7</td>
<td>1.35</td>
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<tr>
<td>8</td>
<td>1.40</td>
</tr>
<tr>
<td>9</td>
<td>1.45</td>
</tr>
<tr>
<td>10</td>
<td>1.49</td>
</tr>
</tbody>
</table>
If the value of CR is equal to, or less than that value, it implies that the evaluation within the matrix is acceptable or indicates a good level of consistency in the comparative judgments represented in that matrix. In contrast, if CR is more than the acceptable value, inconsistency of judgments within that matrix has occurred and the evaluation process should therefore be reviewed, reconsidered and improved.