A Conceptual Approach to Land Suitability Evaluation for Residential Settlement in Aceh
Sing Geographic Information System (GIS)

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Abstract. This article introduces the concept of land suitability evaluation for possible application in residential settlement in Banda Aceh. On December 26th, 2004 the earthquake and tsunami has struck the west coast of northern Sumatra Island, Indonesia. Banda Aceh is the largest residential area and most severely affected by this disaster impact. Ten years after the tragedy, it is essential to assessed physical environment in suitability evaluation of new residential settlement area with the aim of knowing the regions conformity. Emphasis of research is focused on the selection criteria, parameters and variables reviewed from literatures and its possibility of applying it in Geographic Information System (GIS). To validity of method is ensured through working on observed and measured criteria, variable and parameter that fulfills the residential settlement requirements. The relationship between land characteristic/quality and ideal condition requirement of settlement is important to be ascertain in GIS conceptual model. The result can be used for the application and validation of GIS land suitability model in the subsequent stage of research.

Keywords: land evaluation, land suitability, residential settlement, GIS.

INTRODUCTION

Settlement has an important role in supporting efforts to improve people's lives and the region. In connection with the development of community life, housing plays a central role in supporting the economic growth of the community. The role is also important and a related settlement in the formation of social support, among others, is to realize that a healthy environment and culture, and can cause a sense of comfort. Sector settlements in Banda Aceh were destroyed during the earthquake and tsunami on 26 December 2004. Rebuilding the disaster areas associated with comfort and anxiety towards disaster could happen again. Therefore, residential development should be adapted to the physical land and environmentally. Therefore it is necessary to evaluate the suitability of land settlement with the current environmental conditions. Land suitability evaluation is an approach or a way to determine the potential of land resources. The results of land suitability will provide information or direction on the use of the land required. [1] stated that the land evaluation is also an integral part of the design of land use to support sustainable land-use management.

[2] stated that the physical land suitability analysis is needed to assess the use of land resources in the future. The aim was to ensure obstacles and opportunities for maintenance, planning and development of the land sustainable. Good planning in the management and implementation of the physical development of land is important, particularly for disaster-prone areas [3]. The process of evaluating its suitability for settlement with the manual requires a lot of time, effort and expense. Use of data and mapping variables measuring relatively long time for the purposes of time. [4] stated that the use of spatial technology in residential land suitability evaluation will facilitate and speed up the process of data analysis. Geospatial technology has the ability to input, editing and analysis of data, both the main data and attribute data or graph (schedule). In addition, the use of geospatial also very instrumental in the proper way in a short time. In general, the shape of the geospatial technology can be seen in GIS (Geographic Information System).

GIS was introduced by the General Assembly of the International Geographical Union in Ottawa Canada in 1967. Later developed by Roger Tomlinson, and recognized as CGIS (Canadian GIS). CGIS created to save, analyzing and processing data to inventory of land in Canada. It was conceived as an initiative to recognize the land's ability to map a variety of information on the land [5,6]. Since were then, GIS developing on several continents, especially America, Europe, Australia, and Asia. In general, the experts said that GIS is a computer system used to collect, save, integrate and analyze information relating to the earth's surface [7,8]. As for stated that GIS is a system that can support the process and make decisions related to spatial data.
This study is reviewing the concept of land suitability evaluation and the opportunity to apply variable/parameter to settlement by using the concept of GIS in Banda Aceh. This is necessary as a foundation for further studies to evaluate the existing residential areas and seek opportunities regions with less risk of disaster for sustainable urban planning. This information is needed, especially areas that have been hit by disasters [10,11].

**METHODS AND MATERIALS**

Most of this research is concentrated on the investigation of the way, the process of evaluation methods of the land suitability. Furthermore the analysis of the literature review to obtain variable and parameter entered into the method of land suitability evaluation methods that are adjusted for the settlement based on the basic physical of environment and opportunities using GIS technology.

**DISCUSSION**

In a land of evaluation there are two terms those are often used, namely land capability and land suitability. The term of land capability is used by soil classification system USDA [12]. In the USDA system, the unit of land map soil collected primarily on the basis of ability (capability) to produce output, without causing damage in the long run. The ability means the capacity of a land for productivity. Meanwhile, the term of land suitability means the compatibility of a land for specific use. This term is introduced in the system of land evaluation by FAO. The concept of land suitability was introduced in 1976 which was published in the FAO soils bulletin no. 32 entitled A framework for land evaluation [13]. The land suitability can be used for quantitative and qualitative grouping, depends on available data. The data is in the form of land characteristics following the criteria suitability classes than what will be evaluated in this study for housing. This FAO land suitability concept has been adopted and used widely in Indonesia [14,15,16]. The system of land evaluation is done by using a matching approach (matching) between land qualities/characteristics with the requirements of growing plants will be evaluated. FAO does not use definitive criteria with numbers. By that every country is recommended to make each of their criteria appropriate with local condition. These are aim to flexibility and specific with characteristic site of area evaluated. [17] stated that the land evaluation system have ever been used and being developed in Indonesia, among others: classification of area ability, system prediction of land suitability for parametric, P3MT (Agricultural Research support Transmigration), Reconnaissance Land Resources Surveys System, Land Evaluation Computer System (LECS), Automated Land Evaluation System (ALES).

By using the same concept in the evaluation of suitability for land of agriculture, so it can be done for the case of settlement. Land qualities/characteristics measured are adjusted with requirements criteria for the settlement. Observations and measurements of land qualities/characteristics for settlement in the field it is matched and is adapted with the criteria of settlement requirements (Table 1). The success of this concept is depends on get the variables and parameters of the environment requirements for the suitability settlements. In illustration of process of land suitability for the settlement can be seen in Figure 1.

**TABLE 1. Variable and parameter, the environment requirement for the land suitability**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Suitability class</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>N1</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contour Soil</td>
<td>Slope</td>
<td>0%-8%</td>
<td>&gt;8%-25%</td>
<td>&gt;25%-40%</td>
<td>&gt;40%</td>
<td>&gt;40%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bearing Capacity(kg/cm2)</td>
<td>&gt;2</td>
<td>2-12</td>
<td>1.2-6</td>
<td>0.6-0.3</td>
<td>0.3-0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permeability (cm/jam)</td>
<td>&gt;12.5</td>
<td>6.25-12.5</td>
<td>2-6.25</td>
<td>0.5-2.0</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Texture</td>
<td>rough</td>
<td>rather rough</td>
<td>moderate</td>
<td>rather smooth</td>
<td>smooth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gravel</td>
<td>No</td>
<td>moderate</td>
<td>Many</td>
<td>Very much</td>
<td>Very much</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Groundwater (m)</td>
<td>&lt;15m</td>
<td>15-25m</td>
<td>25-50m</td>
<td>&gt;50m</td>
<td>&gt;50m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>6.6-7.5</td>
<td>5.6-6.5/7.6-7.9</td>
<td>4.5-5.5/8.0-8.4</td>
<td>4.0-4.5/8.5-9.0</td>
<td>&lt;4 / &gt;9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conductivity (umhos/cm)</td>
<td>&lt;250</td>
<td>250-750</td>
<td>750-2000</td>
<td>2000-3000</td>
<td>&gt;3000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Salinity (%)</td>
<td>0</td>
<td>0-0.5</td>
<td>0.6-1.0</td>
<td>1.1-1.5</td>
<td>&gt;1.5</td>
<td></td>
</tr>
</tbody>
</table>
All the variables and parameters of the settlement requirement and consideration of disaster are changed into a spatial shape. That spatial data are used in each of separate layer based on the variable/parameter or criteria. In general, spatial analysis is a technique or process involving a number of count and evaluation of mathematical logic, is done to look for or finding relationships or patterns among geographic elements [19,20]. Reclassify is a process of re-classifying spatial data into a new class classification based on desired criteria. In the application of this function to classify the spatial elements based on the value of belonging to one field [5,9]. Further analysis of interpolation is one way to estimate the surface that is continuous from the sample data. Data taken in some areas can be used to generate value for the whole region. In summary interpolation is the process of changing the data points into areas such as polygons. Inverse distance weighted, natural neighbor, spline, trend and kriging is the tools contained in the interpolation. Next is the process of taking the spatial information of a feature, it is known as extract. Some of the tools included in the extract of such clip, split and select [21]. Various parameters are exchanged into spatial layers are combined based on the overlay concept. Overlay is a process of combining two or more spatial data to generate new data, without losing the basic data attributes. Information can be added to the new data in accordance with the previous attribute data. Erase, Intersect and union is a tool that is found in the overlay concept [22,23,24,25]. In illustration picture collection of spatial data analysis in GIS is shown in Figure 3.

**FIGURE 1.** Description of the land suitability process for the settlements in Banda Aceh

**GIS concept for Land Suitability Process**

The evaluation to determine the suitability of land has become a standard part of regional planning analysis. A Suitability shows the style of spatial information from a series of process [18] stated that there were some concepts had been long introduced to produce the suitability, such as at gestalt, mathematical combination, identification of region and logical combination. As for the series of process to achieve land suitability is presented in Figure 2.
Land suitability variable
- Variable 1
- Variable 2

Land suitability layer
- Variable 1
- Variable 2

Source: modified from Hopkins [18]

FIGURE 2. Description of process in using a suitability map

Recalculate
Dissolve

Interpolation

Extract
- clip
- split
- select

Overlay
- erase
- intersect
- union

Sources: modified from Prahasta [5]; Indarto and Faisal [21]; ESRI [9]; and ESRI [26]

FIGURE 3. Illustration collection of spatial data analysis
CONCLUSION

The evaluation of land suitability that often used for agriculture is widely applicable to the evaluation of land suitability for settlement. Land quality/characteristic and requirement should be adapted with the requirements of settlement. Speciality at the region has ever attacked the major disaster of (tsunami) as the city of Banda Aceh, the assessment of land suitability in environment physical strongly needed to be added to the city planning. In this perspective, the requirement criteria is built is matching opened. This provides an opportunity to repair, add and combine with variety of other studies. The Spatial analysis is very possible especially in the matching variable process and requirement parameter for settlement. GIS can be applied and is a very important role in all stages of the process spatial analysis data.

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