ENVIRONMENTAL GEOLOGICAL RECOMMENDATION FOR URBAN DEVELOPMENT OF PIDIE AND PIDIE JAYA DISTRICT, NANGROE ACEH DARUSSALAM PROVINCE

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Abstract

Population growth in Pidie and Pidie Jaya Regencies is increasing every year. This condition demands regional development, while the available land is very limited. This study aims to provide direction in the development of urban areas in several areas of Pidie and Pidie Jaya Regencies. The method used in this research is quantitative method by performing superimposed statistical analysis and scoring method, by using Global Mapper and Mapinfo software to facilitate the data processing. Based on the results of data processing, land suitability score> 93 is categorized as a potential area so it is very good for urban area, then score 48 - 71 is a constraint area that has various constraints in some places and score <26 is a limitation region that is not feasible for the region urban areas

Keywords: development area, constraints, limitation, scoring method, Pidie and Pidie Jaya.

1. INTRODUCTION

Increased population density and industrialization also have an impact on increasing needs of space utilization. Space utilization that is not suitable with the capacity of its environment can cause damage to the area. Therefore, spatial planning is required to produce spatial pattern and space structure in accordance with the capacity of the environment. Law no. 26 of 2007 on Spatial Planning, Article 5 paragraph (2) is the legal basis for the arrangement of the physical environment (geology). Environmental Geology is a media in the application of geological information through spatial planning in the framework of regional development and environmental management, which provides information about the geological environment characteristic of a location / region based on the integration of geological resources as a supporting factor and geological disaster aspect as a constraint factor.

Furthermore, the result of environmental geology study describes the level of flexibility of a region to be developed. information of Environmental geology can solve environmental concerns and management efforts through recommendation of used land and also providing an alternative solution to the problem. With such a problem, it is necessary to conduct a research to assess the basic aspects of regional development such as ground water availability, soil type / constituent rock, slope inclination, and disaster potential as a guide in land planning for a good regional development effort.

2. LITERATURE REVIEW

Land is an important object because it is both input and product of the planning process. Called input because the land is the basic capital of space formation. Land is a container of activity that have important economic value in the formation of settlements with complex activity. Meanwhile, land is referred to as a product because of planning activities that produce a set of spatial system and its management where the organized land is a part of it. (Kaiser et al, 1995: 196)

In accordance with the mandate of Spatial Planning Law, the governance of spatial planning activities is carried out by using a set of technical guidelines, one of controlling the analysis and classification of using-land for a rural and urban areas. Minister of Public Works Regulation number 41 of 2007 regulate the classification of using-land into two major groups, with the following explanation:

1. Protected area is a designated area with the main function of protecting the environment which includes natural resources and artificial resources.
2. Cultivation area is a designated area with a main function to be cultivated on the basis of conditions and potential of natural resources, human resources, and artificial resources

In general, used-urban land patterns have 3 characteristics (Sadyohutomo, 2006: 71):

- High intensity utilization is caused by higher population of rural areas. Thus, in the investment market the level of demand for land is also high and the used of urban areas tend to be higher.
- There is a close relationship between land used units.
- The size of land used units is dominated by a relatively small area. This is very different from the rural areas allowing a large plot of land to have one function that is suitable for agrarian cultivation.

The classification of landuse in urban areas is be divided into 7 types (Sadyohutomo, 2006: 72), among others:

- Housing, a group of houses as a place to live with environmental facilities.
- Trade, in the form of transaction goods and services that are physically in the form of market buildings, shops, warehousing and so forth.
- Industry, is the area for processing activities of raw materials into finished goods.
- Services, in the form of government office services, semi-commercial, health, social, cultural and educational activities.
- Park, is an area that serves as public open space, urban forest and city parks.
- Waters, is an artificial and natural area of inundation or stream of water or seasonality.
- Empty land, in the form of unused land.

In analyzing the land capacity, an assessment and weighting of each land capability by weighting and scoring methods based on the standards of the Groundwater and Environmental Geology Center 2017 (table 1 - 3). The magnitude of weight and value is determined by the importance degree of each parameter to the objectives of land suitability. Scores are the result of a multiplication of weights and values. The multiplication of the value of ability and weight will result in the value of a land's ability level, for example with a low score range reflecting poor land skills, while a high score range reflects good land capability.

Table 1. Opt-out Components

No	Components	Criteria	Class	Explanation
1.	Active fault zone	Distance <100 meter	Not feasible	Related to factor of safety
2.	High prone tsunami areas	Elevation <10 masl	Not feasible	
3.	Volcanic hazards	Vulnerable area III	Not feasible	
4.	Ground vulnerability	High vulnerability	Not feasible	
5.	Protected area	In protection area	Not feasible	By law

Table 2. Geological Resource Components

No.	Components	Score	Range				Value
1	Aquifers productivity (to fulfill needs of clean water)	14	High(>10 l/s)				3
			Moderate (5 - 10 l/s)				2
			Low (<5 l/s)				1
2	Morfology (for accessibility)	8	Flat (0 – 5%)				3
			Sloping (5 – 15%)				2
			Steep (>15%)				1
3	Physical Properties Soil / rock (for ease of foundation)	2		N-SPT (Drilling)	kg/cm^2 (Son-dir)	ton/m^2 (Qall)	
	Hard		Thickness up to 5 m	>50	> 150	> 21,6	3
	Moderate			30– 50	60-150	7,2-21,6	2
	Soft			< 30	< 60	<7,2	1

Table 3. Geological Hazard Components

No	Components	Score	Range			Value
1.	Earthquake (disrupting the stability of the construction)	4	$\propto$	Richter	MMI	
			<0,05 g	<5	I - V	3
			0,05-0,15g	5-6	VI,VII	2
			>0,15g	>6	VIII - XII	1
2	Tsunami (associated with damage of buildings, and construction)	3	Elevation			
			>50 m			3
			10 - 50 m			2
3.	Ground vulnerability (related to the stability of the construction)	2	Very low			3
			Low			2
			Moderate			1
4.	Volcano (related to land and building damage)	1	Safe Area			3
			Vulnerable areas I			2
			Vulnerable areas II			1

3. METHODOLOGY

Research starts from the preparatory phase and secondary data review involves making survey permit, procurement of field equipment and preparation of work plan. Secondary data processing is depend on the availability of data. The methodology for processing this secondary data is to inventory data related to the environmental geology aspect. In the inventory phase of secondary data obtained from the relevant agencies, in the form of satellite images, reports and maps.

The next step is to collect primary data by conducting field investigation and includes landscape mapping and slope measurement, surface geology mapping, ground water potential mapping, and water and soil sampling from the research area. Furthermore, the stage of land capability analysis of environmental geology parameters. This analysis was conducted to obtain a description of the level of land capability to be developed as urban, as a reference for land suitability directives at the next analysis stage.

In determining the area of urban land use recommendation is used overlay method of thematic maps of parameters used by first giving value and scoring on each parameter used in accordance with the level of influence.

From all elements in the planning of a land is using superimposed method, so that it can be known the value of land ability in the research area. In the classification of land capacity used statistical methods, namely:

1. The total score (Σx), calculated from the sum of the overall total score.
2. The average total score (x̄), calculated from the total overall score divided by the number of scores, used the formula
3. Standard Deviation

$$\delta x = \sqrt{\frac{\sum(\bar{x} - x)^2}{n-1}}$$

After the standard deviation is obtained, the land capability class can be calculated with the following conditions:

Table 4. Land Capability Class Criteria

Land Capability Class	Criteria
Very high	$> \bar{x} + 1\frac{1}{2}\delta x$
High	$\bar{x} + \frac{1}{2}\delta x - \bar{x} + 1\frac{1}{2}\delta x$
Moderate	$\bar{x} - \frac{1}{2}\delta x - \bar{x} + \frac{1}{2}\delta x$
Low	$\bar{x} - 1\frac{1}{2}\delta x - \bar{x} - \frac{1}{2}\delta x$
Very low	$< \bar{x} - 1\frac{1}{2}\delta x$

Total Value of Land Capability

The determination of land suitability classification is process by using statistical method, that is determination of total score, average score of overall data capability, and deviation standard to determine the land suitability classification range.

1. The total score (Σx), calculated from the sum of the overall total score. From the calculation of all aspects of land capability so the value obtained Σx = 34507
2. The average total score (x̄), calculated from the total overall score divided by the number of scores, used the formula:

$$\bar{x} = \frac{\sum x}{n} = \frac{34507}{576} = 59{,}9$$

Based on the calculation, the development of urban area is divided into five areas, namely:

1. The total score score> 93, goes into the area with very high land capability.
2. The total score score in the range 71 - 93 goes into areas with high land capability levels.
3. Total score scores in the range 48 - 71, goes into areas with moderate level of land capability.
4. Total score scores in the range 26 - 48 goes into areas with low land capability.
5. Total score <26, goes into the area with very low land capability.

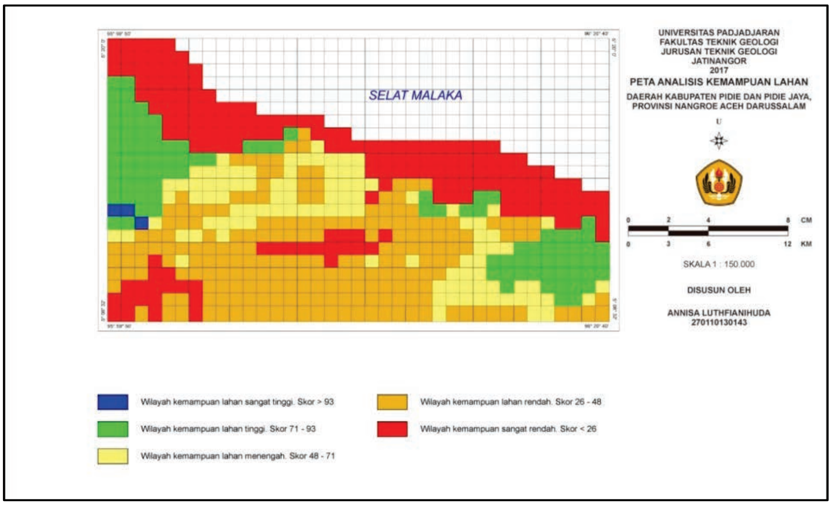

Figure 2. Map of Land Capability Analysis

Land Conformity Zone

Based on calculations with statistical analysis of the ability of land in the development of urban areas, it can be classified more specifically the level of land suitability. The study area is divided into 3 areas of land suitability as follows:

1. Possible Areas

The area is scattered over the western, northwest and eastern part of the research area, with a very high land capability to be developed into an urban area. Because in this zone, the groundwater potential is good, has a flat slope, has a very low level of soil vulnerability and is a safe area of volcanic hazard.

2. Constraint Areas

The area is scattered in the middle and southeast of the research area. This area has a moderate classification of land capability that is being developed into an urban area. Because in some aspects this region has a poor ground water potential, high prone of tsunami, and the majority of this region has a low bearing capacity. However, with the help of engineering techniques it can be improved to minimize the constraints occur.

3. Limitation Areas

This region dominates in the south, central and southwest, with bad to very bad class of land capability. This is based on steep slopes, poor groundwater potential, and in some areas it has high ground vulnerability.

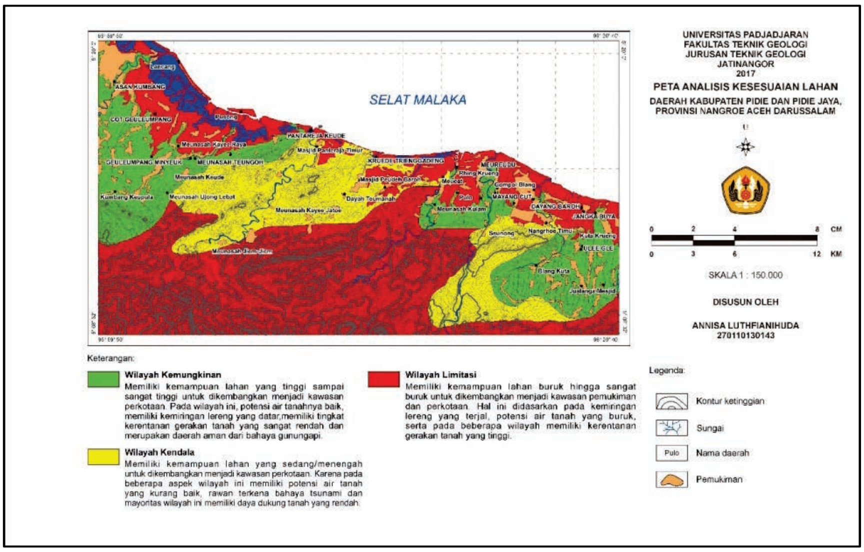

Figure 3. Map of Land Conformity Analysis

B. Recommendations of Regional Development

In general, the majority of residential areas have occupied the possibility area. There are only a few settlements that still occupy the constraints and limitation areas. The areas of rice fields and plantations are also almost entirely in the area of possibility. This is because the area has a flat slope and good ground water availability. Forest areas that are conservation areas in the southern part of the study area are suitable because they belong to the limitation zone for residential development areas. So it needs to be held supervision and intelligence to the community and local government for the implementation of urban development is not disrupted.

For residential areas along the north coast that already under construction in the limitation areas, an evacuation line should be established in the event of a tsunami disaster. As well as for coastal beaches planted with mangrove forests to reduce the energy of incoming waves. Not only it will provide physical and environmental benefits, but also provide other benefits that can be empowered by coastal communities and others.

The research area is included into high prone of earthquake zones. This will certainly impact on the strength of infrastructure facilities in the research area. One way to reduce the impact of earthquake is to build the earthquake resistant buildings. The earthquake resistant building is a building that can survive the collapse due to earthquake vibration, and has the flexibility to reduce vibration.

To build earthquake resistant building, actually all types of foundations can be used even in earthquake conditions. Based on SNI 03-1726-2002 and SNI 03-2847-2002, the types of foundations that can be used are:

1. Stone foundation
   Stone foundations are usually only used for construction that is not heavy, such as fences and simple homes that are not stratified. Stone foundations are usually placed continuously for the walls foundation. All the loads are usually carried by columns and walls, passed to the ground through a continuous foundation along the wall of the building.
2. Frame concrete foundation
   Frame concrete foundation is used for skyscraper which the number of level not too much and soil bearing capacity is not too low.
3. Pile foundation
   In general, the application of pile foundation is used when the bottom ground under the building

does not have sufficient bearing capacity to bear the weight of the building and the load above it, and also if the location of hard soil that has sufficient bearing capacity to bear the weight of the building load above it lies in the very deep position.

5. CONCLUSIONS AND SUGGESTIONS

Based on the results of processed data, land suitability that has score> 71 is categorized as a potential area, so it is very good for urban area. Then score 48 - 71 is a constraint area that has various constraints such as in some places has steep slope, inadequate ground water potential , and this region is dominant in the vulnerable ground zone, but this area may still be solved by engineering.

A score of <26 is a limitation area that is unfeasible for urban areas, the condition of this region has a steep slope, the availability of groundwater is poor because it is include in rare groundwater area, so it will be difficult to fulfill daily needs and in some places there are zones of high vulnerability ground.

The research area has various characteristics both from the slope aspect, ground water availability, threatening factors, the bearing capacity of the soil foundation, etc. All these aspects must be well utilized, for steep terrain that cannot be utilized for urban areas can be utilized as protected forest conservation areas. Then to the constraints that located in the northern part of the research area can be used as a recreation place becaose the area is close to the beach. Then for settlements that have been built in the limitation area, should be given a evacuation route in case of disaster.

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