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Reclassification of Soil Type Maps for Evaluation of Forest Areas Using SMCA in Bogor Regency

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Abstract
Soil is a layer of the earth's surface that is formed due to the process of decomposition and weathering over a very long period. Soil is also included in the forest ecosystem as a place for vegetation to grow. In particular, the forest in Bogor Regency based on its function consists of protected forest, conservation forest, limited production forest, permanent production forest, and forest area as a buffer function. However, from year to year, the forest area in Bogor Regency has decreased due to land conversion. The purpose of this study is to examine the use of soil type variables on the suitability of forest area functions and provide a reference for processing soil types in terms of GIS utilization. The method used is a reclassification of raster data with Arcmap GIS 10.7 software. Based on the research results, there are five types of soil in the research area. After reclassification, the available soil classes based on their area are four categories, namely insensitive, moderately sensitive, less sensitive, and sensitive. Furthermore, the soil type variable is processed by weighting and scoring to determine the suitability of the function of the forest area and evaluated with the 2016-2036 Bogor Regency RTRW.
Keywords: *Reclassification, Soil Type, Suitability, Forest Area*

INTRODUCTION

Forest is a land ecosystem that contains natural resources in the form of flora and fauna biodiversity and controlling water resources. Forests also have a wealth of land from the surface as well as into the ground such as the presence of minerals and mining materials. Forests are also natural features that are dominated by trees (Sambodo, Rahayu, Indriasari, & Natsir, 2014). The growth of trees is also closely related to the type of soil found in the forest area. Therefore, to assess the suitability of forest areas based on their functions, a soil type variable is needed which is used as a parameter in determining the suitability of forest area functions (Utami & Baskoro, 2017).

Soil-based on its type has very diverse properties, ranging from the nature of chemical and biological elements. It is also influenced by morphology and climatology. Soil type is very necessary to determine the function of forest suitability, for example, for soils with a high level of erosion sensitivity so that it reduces the productivity of the forest area, it will be used as a protected forest or other forests that functions as a sustainable flora and fauna habitat without any intervention by human activities (Pranata & Hamzari, 2020). Data in previous research in (Sukwika, Darusman, Kusmana, & Nurrochmat, 2018), stated that in the period 2013-2018, the forest area in Bogor Regency has a critical status of 31,800 hectares. This is due to the conversion of forest land into built-up areas for production and settlement. Many factors change forest ecosystems that are influenced by suboptimal forest management such as tree felling and exploitation of mining materials that affect nutrients from the forest (Wachyuni, Prasetyo, & Soekmadi, 2017; Kasnar, Hasan, Arfin, & Sejati, 2019; Oktavia & Siswandana, 2020).

In terms of the academic role, these problems need to be solved with the contribution of research and the collection of the latest data and facts so that information about the phenomenon of forest suitability conversion is still summarized in actual terms. Therefore, this study aims as a reference for processing soil type variables by utilizing GIS device technology, as well as enriching information on the development of further research on the transfer of function suitability of forest area functions with concrete solutions when viewed from the discipline of geography.

The Spatial Multi-Criteria Analysis (SMCA) method facilitates decision-making in terms of spatial aspects as a determination of the suitability of forest area functions based on expert knowledge references. certain GIS software. SMCA can be used for decision making that involves a hierarchy of problem identification processes based on the dynamics of the research object and evaluates it quantitatively by adding weighting criteria to produce a recommendation (Habtemariam & Fang, 2016)

Administratively, Bogor Regency is a strategic supporting area for the capital Jakarta and has a lot of resources because the area is dominated by highlands so that there are tropical forest areas. This district is starting to be affected by the development and development of infrastructure due to the pressure of urbanization which will naturally require land, especially forest areas to be converted, in the long term this will have a negative impact such as a decrease in carbon stocks (Setiawan, Syaufina, & Puspaningsih, 2015). From the discussion above, it is hoped that this research will become a source of additional information regarding the use of GIS for processing multi-criteria variables.

RESEARCH METHODS

Study Area

The research location is in Bogor Regency, West Java Province, Indonesia. Located at astronomical 6⁰18'0" - 6⁰47'10" latitude and 106⁰23'45" - 107⁰13'30" east longitude. The total area is 299.432,12 ha consisting of 40 districts containing 19 sub-districts covering 416 villages (Darmali, 2016). Geographical location, Bogor Regency is bordered by, on the south side: Cianjur Regency and Sukabumi Regency, on the west side: Lebak Regency, on the east side: Karawang Regency, Purwakarta Regency, on the north side: Tangerang Regency, Depok City, and Bekasi Regency, and the Middle Section: City Bogor. For visualization of the administrative location of Bogor Regency, see (Figure 1)

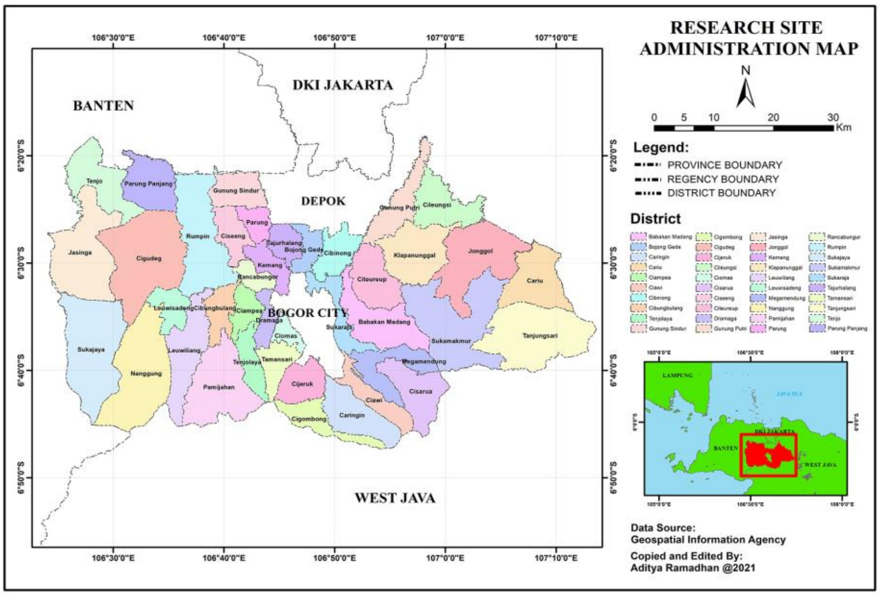

Figure 1. Research Site Administration Map

Research variable

Variables are an important part of research that is useful as a collection of information which is then measured based on the parameters used for problem-solving (Nasution, 2017).

The variables used for assessing land suitability for forest function areas are soil types found in the research area (Table 1).

Table 1. Variables and Data Sources

No	Variable	Year	Data Source
1.	Soil Type	2020	https://www.indonesia-geospasial.com/

Source: Author, 2021

The use of the soil type variable is a reflection of the level of sensitivity of soil conditions based on drainage characteristics, depth, and nutrients to the suitability of forest area land (Ritung, Wahyunto, Agus, & Hidayat, 2007). National soil classification is used based on the order of soil types listed in (Subardja et al., 2016).

Data Collection and Processing
The data used is data from previous research or related agencies based on data obtained from the field or secondary data (Omukuti, Megaw, Barlow, Altink, & White, 2021). For the classification of soil types, there are 5 classes of soil types according to the Guidelines for Compiling the RLKT Pattern in 1994 (Zulkarnain, 2013) which can be seen in Table 2.

Table 2. Scoring of Soil Type Variable Parameters

Variable	Class	Description	Score	Weight	Reference
Soil Type	Not Sensitive	Aluvial, Glei Planosol Soil, Gray Hidromorph Groundwater Literita	15	25	Results of Modification of Guidelines for the Preparation of RLKT Patterns in 1994; (Zulkarnain, 2013)
	Rather Sensitive	Latosol	30		
	Low Sensitive	Brown Forest Soil, Non Calcis Brown, Mediteran	45		
	Sensitive	Andosol, Laterit, Grumosol, Podsol, Podsolik	60		
	Very Sensitive	Regosol, Litosol, Organosol, Renzina	75		

Source: Author, 2021

Data analysis
To analyze the soil type variable, input is a vector data source which is then converted into raster data with the Poly to Raster feature. This feature works as a vector to raster converter. In the data analysis stage, consistent data is needed to obtain results that include all elements of data types. The algorithm of each feature used will also affect the processing results, such as spatial resolution (Arnone, Francipane, Scarbaci, Puglisi, & Noto, 2016). Furthermore, the soil type was reclassified with the classification of 5 classes (Figure 2). This also applies to other suitability variables such as slope and rainfall based on the parameter class reference used. This study uses a raster-based analysis with the Weighted Sum method.

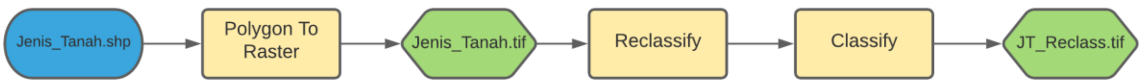

Figure 2. GIS Model of Forest Function Suitability Areas Based on Soil Type

Raster analysis was carried out in data processing using Weighted Sum which can combine several cell values to produce a reclassified raster model (Buruso, 2018). Where this method is a way for raster-based overlays as a solution to a multi-criteria problem for the suitability model (Sobaha, 2018), and applies the unification of variable layers by multiplying weights on the model builder (Hassan et al., 2020).

RESULTS AND DISCUSSIONS

Soil Type Before Reclassification

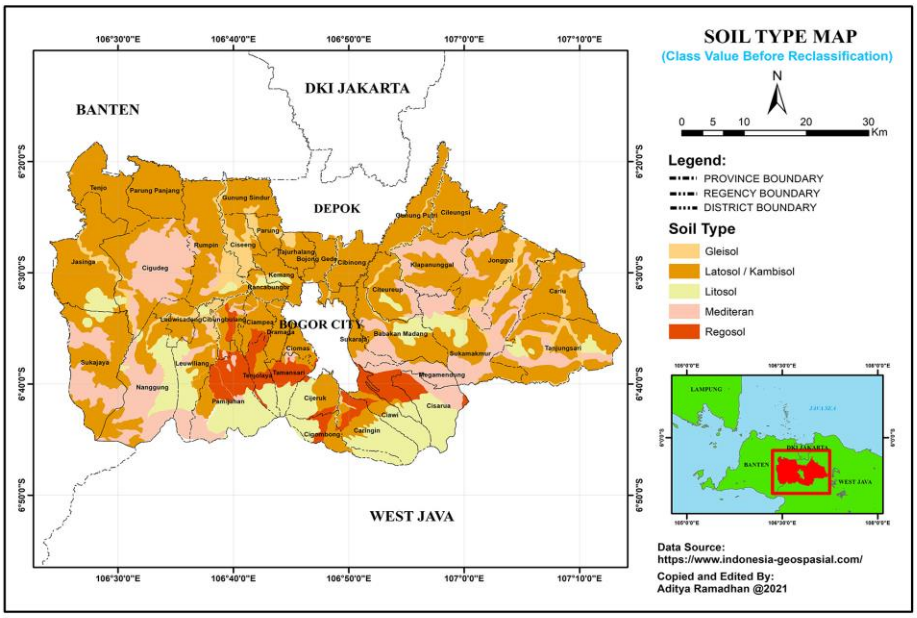

Figure 3. Soil Type Map Before Reclassification

Based on (Figure 3), there are 5 types of soil in Bogor Regency before the reclassification, namely Gleisol covering an area of 20,688 ha (6.91%), this soil has a high clay content and does not have vertical properties. Latosol covers an area of 164,528 ha (54.95%), this soil has a horizon layer with a red to dark red color. Litosol covering an area of 40,274 ha (13.45%), is soil made of alluvium and arranged in layers. Mediterranean area of 57,494 ha (19.2%), this land has a fairly slow permeability rate. Finally, Regosol covering an area of 16,449 ha (5.49%) of this soil has mineral content and is weak to erosion which is spread over mountainous areas. For more details, see (Table 3).

Table 3. Soil Types in Bogor Regency

No	Soil Type	Area (Ha)	Percentage
1.	Gleisol	20.688	6,91
2.	Latosol	164.528	54,95
3.	Litosol	40.274	13,45
4.	Mediteran	57.494	19,20
5.	Regosol	16.449	5,49
	TOTAL	299.432,12	100

Source: Analysis Results, 2021

Soil Type Map After Reclassification

Based on the soil type class (Table 2), it is stated that there are 5 classes, the findings show that there are only 4 soil classes in the research area. Class 1 was not sensitive with a score of 15 and an area of 25,863.9 ha (8.64%). The second class, somewhat sensitive with a score of 30, covers an area of 170,497.33 (56.94%). The third class, less sensitive with a score of 45 covering an area of 7,050.68 ha (2.35%). The fourth sensitive class with a score of 60, covers the area of 96,019.21 (32.07%). More details can be seen in (Table 4). The advantage of the map after reclassification is that it has a concrete sensitivity class level between soil types and their weight values according to the guidelines used. The sensitivity level of soil type variables to the suitability of forest area functions is a determinant of soil resistance to erosion accompanied by slope and water flow factors. of rainfall intensity. In the research area, the sensitive grade level is in flat and very steep morphology and has Latosol and Litosol soil types. The more sensitive the soil will be more susceptible to erosion. Vice versa, low sensitivity indicates that the soil condition will be strong and resistant to erosion.

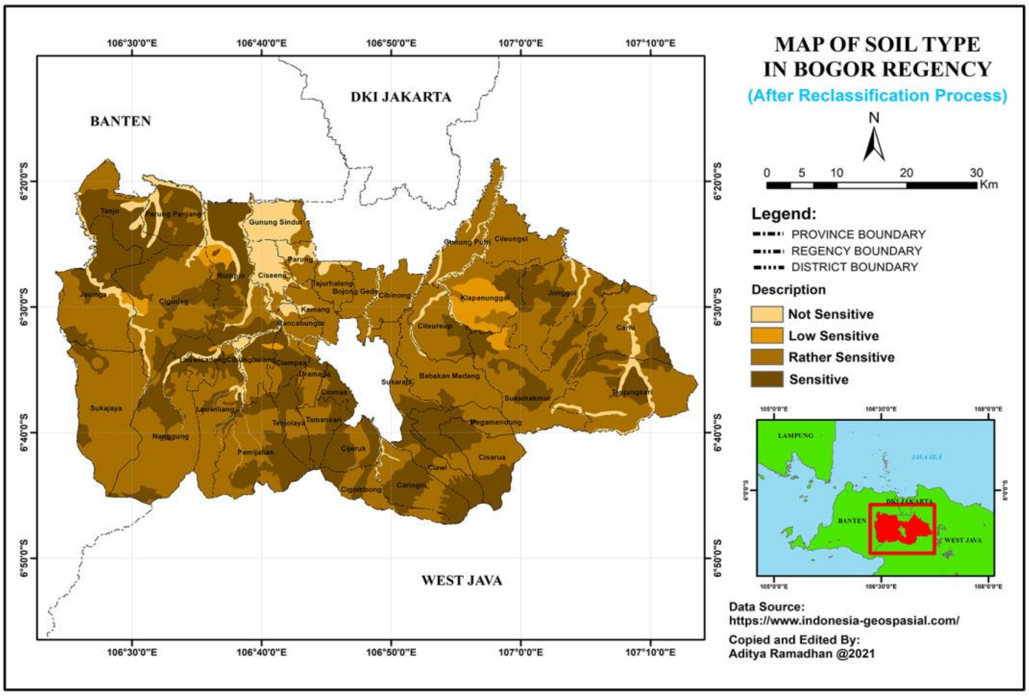

Figure 4. Soil Type Map After Reclassification

Table 4. Class Areas of Soil Types in Bogor Regency

No	Soil Type	Area (Ha)	Percentage
1.	Not Sensitive	25.863,90	8,64
2.	Rather Sensitive	170.497,33	56,94
3.	Low Sensitive	7.050,68	2,35
4.	Sensitive	96.019,21	32,07
5.	Very Sensitive	0	0
	TOTAL	299.432,12	100

Source: Analysis Results, 2021

The use of the SMCA method for spatial analysis is a novelty in GIS-based research. Because this method involves a multi-criteria spatial study compared to a simple overlay technique (Amjad, Agyekum, Syah, & Abbas, 2021). This supports the results of the study that 4 soil classes were generated based on the calculation of the pixel algorithm because it uses raster analysis which is more detailed than vector analysis. This method is also suitable for areas with wide coverage (Van Haaren & Fthenakis, 2011). For evaluations that use many parameters which are also a description of the progress of using research methods (Manzolli, Trovão, & Hengeler Antunes, 2021). The beginning of the emergence of this method was only as a statistical analysis which in its development included spatial aspects into the method (Widayani & Yuliantari, 2017). SMCA is usually complemented by weighting analyzes such as weighted sums or weighted overlays. Both of these methods in the same concept require scores and weights in multi-criteria analysis, then the variables will overlap from the statistical and spatial aspects. In research that examines suitability, it is more appropriate to use the Weighted Sum because this analysis method is a raster-based analysis that is suitable for simple and non-complex factors. This analysis can minimize biased calculations, and improve optimal experimental conditions (Sojobi, Xuan, Li, Liu, & Poon, 2021). Regarding the accuracy of the values of 4 soil classes for evaluation of forest areas in Bogor Regency, SMCA with raster analysis is superior in spatial modeling because it is mathematical and can produce ideal results because it avoids generalizing data as is done by vector analysis. Studying variables one by one can increase the sharpness of research analysis. For example, the analysis of soil type variables on the suitability of forest area functions is a study that can be discussed in detail and in-depth compared to using variables that only complete the theoretical requirements in making a suitability map. The discussion mentions that the research objective is to provide information for processing spatial data with GIS technology and the advantages of using the SMCA method based on raster analysis. On the soil type map (figure 4), a new form of problem-solving can be synthesized, namely recommendations for very careful land management because wrong management can accelerate land degradation (Harjadi, 2018).

CONCLUSION

From the discussion of the results of the research conducted, it can be concluded that Bogor Regency has 5 types of soil. And after the reclassification of the raster analysis using the 1994 RLKT pattern guideline, 4 soil classes were produced that represent soil type variables based on the level of sensitivity to the suitability of forest area functions. From the total area of the research area, which is 299.432,12 ha, Rather Sensitive class ranks first because it has the largest area of 170.497,33 ha and the Low Sensitive class is the area with the smallest area, which is 7.050,68 ha. The sensitive class itself has an area of 96.019,21 ha. Soil sensitivity determines the physical properties of the soil against erosion, infiltration rate, and soil resistance. Furthermore, the soil type will be combined with other supporting variables such as slope, rainfall and spatial patterns with the same method so as to produce a map of the suitability of the function of forest areas in Bogor Regency for recommendations for decision-making interests for policy makers related to problem solving.

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