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Spatial Analysis of the Suitability of Residential Area Development to the Regional Spatial Plan of Ambon City, Indonesia, Based on the Slope Factor

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Abstract
This study examines the suitability of land for the development of residential areas in Ambon City, based on the slope factor. The methods used include spatial analysis by utilizing Digital Elevation Model (DEM) data and the Ambon City Regional Spatial Plan (RTRW), as well as satellite image interpretation to identify suitable and unsuitable areas for residential development. The results show that more than 56% of the total planned land area is in the highly suitable category, while areas with steep slopes have a high potential for landslide risk. The discussion emphasizes the importance of settlement development focusing on safe and suitable areas, and the need for strict regulations to protect communities from disaster risks. The findings provide a strong basis for policy makers to formulate spatial planning strategies that are sustainable and responsive to the geographical conditions of Ambon City.

Abstrak
Penelitian ini mengkaji kesesuaian lahan untuk pengembangan kawasan permukiman di Kota Ambon, berdasarkan faktor kemiringan lereng. Metode yang digunakan meliputi analisis spasial dengan memanfaatkan data Digital Elevation Model (DEM) dan Rencana Tata Ruang Wilayah (RTRW) Kota Ambon, serta interpretasi citra satelit untuk mengidentifikasi area yang sesuai dan tidak sesuai untuk pembangunan permukiman. Hasil penelitian menunjukkan bahwa lebih dari 56% dari total luas lahan yang direncanakan berada dalam kategori sangat sesuai, sementara area dengan kemiringan lereng yang curam berpotensi tinggi terhadap risiko tanah longsor. Hasil penelitian ini menekankan pentingnya pengembangan permukiman yang berfokus pada area yang aman dan sesuai, serta perlunya regulasi yang ketat untuk melindungi masyarakat dari risiko bencana. Temuan ini memberikan dasar yang kuat bagi pengambil kebijakan dalam merumuskan strategi perencanaan tata ruang yang berkelanjutan dan responsif terhadap kondisi geografis Kota Ambon.

Kata Kunci : Ambon, Analisis spasial, Kesesuaian lahan, Kemiringan lereng, Pengembangan permukiman

INTRODUCTION

Residential areas are an important aspect of spatial planning, especially in growing urban areas. In Ambon City, rapid population growth and high urbanization have made the need for proper residential areas increasingly urgent (BPS, 2023; Latue et al., 2023). However, the development of residential areas cannot be done carelessly, especially in areas that have complex geographic characteristics, such as steep slopes (Salakory & Rakuasa, 2022). Therefore, land suitability analysis becomes very important to ensure that settlement development is carried out in safe and sustainable locations. Slope is one of the factors that affect land suitability for settlement development (Amir et al., 2020). Steep slopes have the potential to cause various problems, such as landslides, erosion, and difficulties in accessibility (Hehanussa et al., 2024). Previous research shows that many residential areas are built in areas with high slopes, which can increase the risk of natural disasters. Therefore, it is important to conduct an in-depth analysis of the suitability of residential areas based on slope in Ambon City.

In the context of the Regional Spatial Plan (RTRW), land suitability analysis should consider various factors, including slope, soil type, rainfall, and disaster potential. Ambon City's RTRW needs to accommodate the need for safe and sustainable settlements, and protect the community from disaster risks (Muin & Rakuasa, 2023). Thus, spatial analysis of the suitability of residential area development based on slope can provide valuable information for decision makers in formulating better spatial policies (Sihasale et al., 2023). The Spatial Multi-Criteria Analysis (SMCA) method can be used to evaluate land suitability based on various criteria, including slope (Rakuasa & Somae, 2022). Using this

method, analysis can be conducted comprehensively and systematically, resulting in a suitability map that can be used as a reference in planning residential areas. This map will assist in identifying areas that are most suitable for settlement development, as well as areas that need to be protected from development.

Ambon City has unique geographic characteristics, with many areas having varying slopes. Therefore, it is important to conduct an analysis that is specific to local conditions. This research aims to provide a clear picture of the suitability of residential areas in Ambon City based on the slope factor, and provide recommendations for the development of safer and more sustainable residential areas. By conducting a spatial analysis of the suitability of residential area development against the Ambon City RTRW, it is expected to create residential areas that not only meet the needs of the community, but are also safe from disaster risk. This research is expected to be a reference for the government and stakeholders in formulating better spatial policies, as well as increasing public awareness of the importance of choosing settlement locations that are in accordance with environmental conditions.

METHOD

This research was conducted in Ambon City, which is the capital of Maluku Province, Indonesia. Administratively, Ambon City consists of the sub-districts of Sirimau, Nusaniwe, South Leitimur, Ambon Bay, and Ambon Baguala Bay. This research uses Digital elevation model (DEM) data with a spatial resolution of 8 meters obtained from the Geospatial Information Agency, Ambon City Regional Spatial Plan 2011-2031 data obtained from the Ambon City Regional Development Agency, Ambon City settlement data in 2024 obtained from the interpretation of Landsat 8 satellite images. The entire analysis process was carried out in Arc GIS 10.8 software.

This research uses a spatial analysis approach to evaluate the suitability of developing residential areas in Ambon City based on the slope factor. The method used is Spatial Multi-Criteria Analysis (SMCA), which allows researchers to consider various criteria in determining the level of land suitability (Prabandari & Wibowo, 2024). Slope data is obtained through Digital Elevation Model (DEM) data processing that provides accurate topographic information. The slope classification is divided into several categories, namely flat (0-8%), gentle (8-15%), moderately steep (15-25%), steep (25-45%) and very steep (>45%), which are classified based on Minister of Public Works Regulation 41/PRT/M/2007 on Guidelines for Technical Criteria for Cultivation Areas (Prabandari & Wibowo, 2024).

After the slope data is classified, the next step is to analyze land suitability by considering other relevant criteria. Each criterion is given a weight based on its level of importance in determining land suitability for settlement development. Land suitability in the study was classified into 5 classes, namely highly suitable, suitable, moderately suitable, unsuitable, highly unsuitable (Prabandari & Wibowo, 2024). This process involved collecting secondary data from various sources, including statistical data, RTRW maps, and other relevant information. Subsequently, analysis was conducted using GIS software to produce suitability maps showing the most suitable and unsuitable areas for residential development. The results of the analysis of the suitability of settlement land based on the slope factor of Ambon city were then overlaid with the 2024 settlement data and the 2011-2031 RTRW settlements.

RESULT AND DISCUSSION

Slope

The results show that the distribution of slope in Ambon City varies, with the total area analyzed reaching 32,562.57 hectares. The most extensive slope class is in the 15-30% category, covering 9,004.28 hectares or 27.65% of the total area, followed by 30-45% slope with an area of 7,888.24 hectares (24.22%) and >45% slope covering 6,830.80 hectares (20.98%). Meanwhile, the flat (0-8%) and gentle (8-15%) slope classes have an area of 6,036.89 hectares (18.54%) and 2,802.37 hectares (8.61%) respectively. This finding indicates that most areas in Ambon City have fairly steep slopes, which can affect the suitability of land for residential development. The results of this study indicate that areas

with steeper slopes (>30%) are potentially exposed to disaster risks, such as landslides, especially if developed for settlements (Ullah et al., 2022). Therefore, it is important to consider this slope factor in spatial planning. This research recommends that the development of residential areas be focused on areas with lower slopes (0-15%), which are safer and more suitable for housing. The spatial extent of slope can be seen in Figure 1.

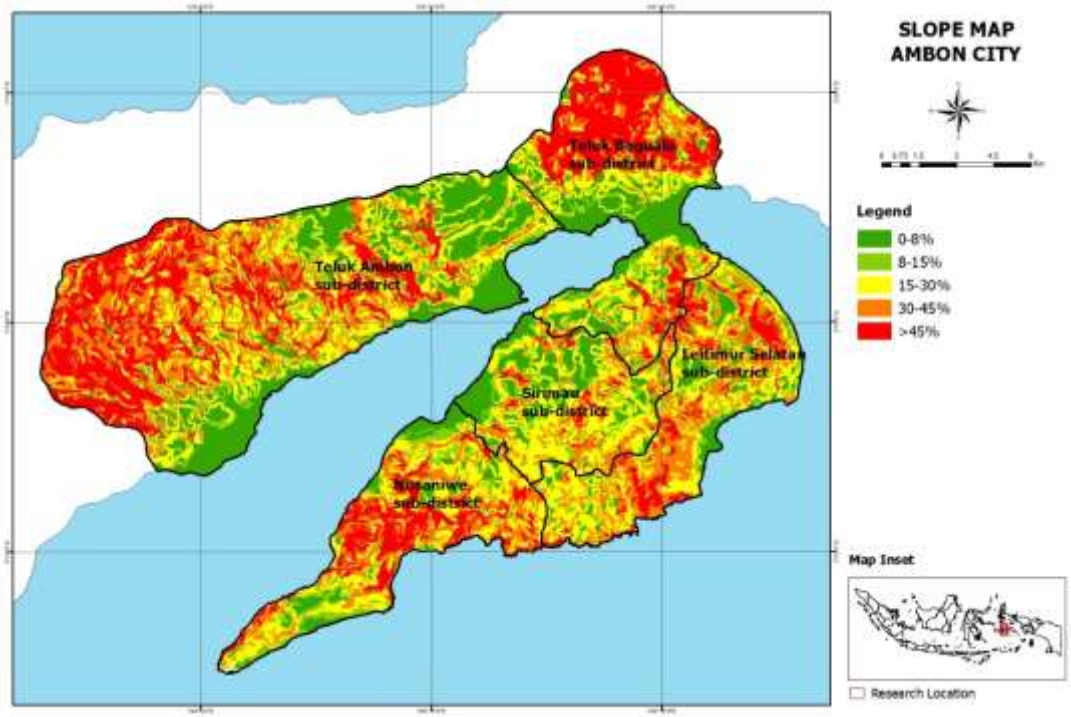

Figure 1. Slope Map Ambon City

Land Suitability Based on Slope

The results show that there are significant variations in the development potential of residential areas in each sub-district. Teluk Ambon sub-district has a highly suitable area for settlement development of 2,862.41 hectares, making it the area with the best potential. On the other hand, Teluk Baguala sub-district also shows a highly suitable area of 1,252.74 hectares, but has a highly unsuitable area of 1,932.57 hectares. This suggests that while there is good potential, there are challenges to be faced in developing settlements in the area. The results further reveal that sub-districts with steeper slopes tend to have more unsuitable and highly unsuitable areas for settlement development. For example, the sub-districts of Leitimur Selatan and Nusaniwe show a moderate to unsuitable proportion of areas, with significant areas in these categories. The "unsuitable" and "highly unsuitable" categories in Kecamatan Nusaniwe reached 1,240.17 hectares and 970.66 hectares, while in Kecamatan Leitimur Selatan, the unsuitable area reached 1,597.08 hectares. This finding emphasizes the importance of considering the slope factor in spatial planning, so that the development of residential areas can be carried out in a sustainable and safe manner. The full results can be seen in Table 1 and Figure 2.

Table 1. Area of suitability of residential areas based on slope of Ambon City

Sub-district	Classification of Land Suitability Based on Slope (ha)				
	Very suitable	Appropriate	Moderately Suitable	Not Suitable	Very Unsuitable
Sirimau	933,38	414,28	1.456,08	731,93	166,79
Nusaniwe	471,38	565,41	1.425,27	1.240,17	970,66
Leitimur Selatan	516,98	425,54	1.613,23	1.597,08	598,15
Teluk Baguala	1.252,74	495,20	1.385,12	1.009,48	1.932,57

Teluk Ambon	2.862,41	901,94	3.124,59	3.309,58	3.162,62
Total Area	6.036,89	2.802,37	9.004,28	7.888,24	6.830,80

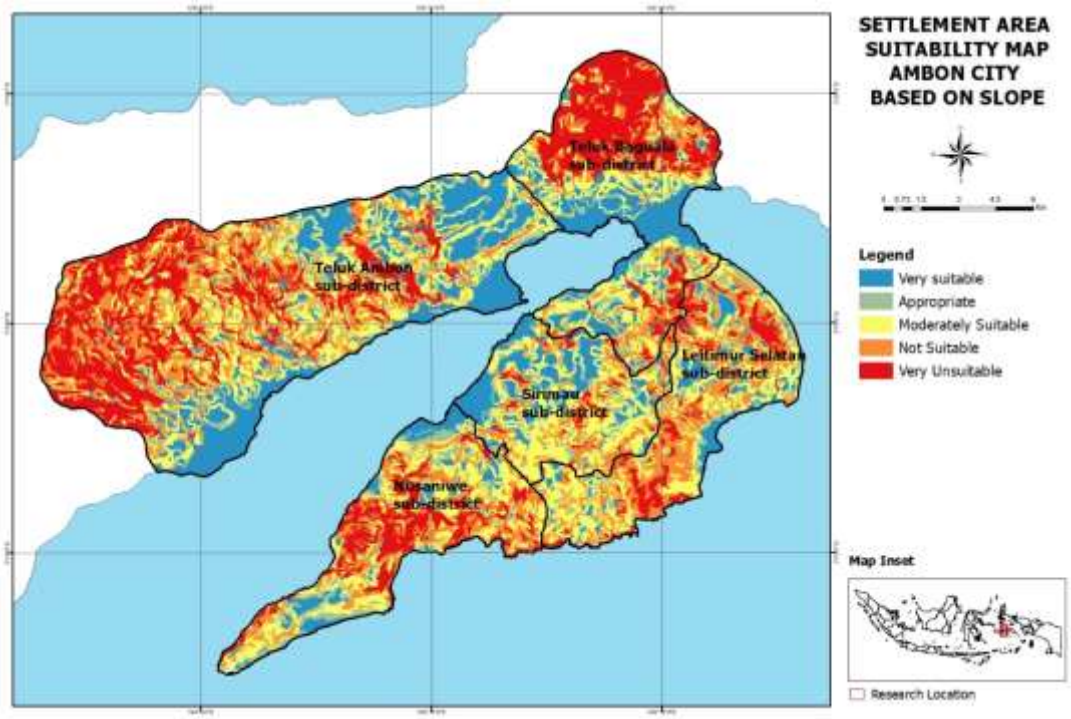

Figure 2. Settliment Area Suitabilty Map Ambon City Based on Slope.

The recommendation from this research is that the development of residential areas should be more focused on highly suitable and suitable areas, and avoid development in high-risk areas to reduce potential disasters and negative impacts on the environment. Thus, good spatial planning should consider the physical characteristics of the land, including slope, to ensure that settlement development not only meets housing needs, but is also safe and sustainable for the community (ROHAENDI et al., 2021). This research provides a strong basis for policy makers to formulate development strategies that are more effective and responsive to the geographical conditions of Ambon City.

Land Suitability in Settlement Areas in 2024

Based on the results of the classification of land cover in 2024 Ambon City, it is known that built-up land has an area of 4,418.63 ha. The results of this area are then overlaid with the land suitability map based on the slope of Ambon City. The results of the overlay of settlement land with the suitability of residential area development in Ambon City show that most of the areas planned for settlements are in the suitable category for development. Of the total area of 4,418.63 hectares, more than half, namely 2,497.27 hectares (56.52%), is categorized as highly suitable. This indicates that the spatial plan for Ambon City has considered the ideal physical conditions for settlement development, so that it can support sustainable growth (Lestari et al., 2020). In addition, suitable and moderately suitable areas also contributed significantly, totaling 1,738.51 hectares (39.35%), indicating that the majority of land planned for settlements has good potential. However, the overlay analysis also identified unsuitable and highly unsuitable areas for settlement development, covering 160.30 hectares (3.63%) and 22.55 hectares (0.51%) respectively. Although the percentage of unsuitable areas is relatively small, it is important to pay attention to and manage these areas to avoid high-risk development. This research emphasizes the need for evaluation and adjustment in spatial plans to ensure that the development of residential areas not only focuses on highly suitable areas, but also considers risk factors in unsuitable areas.

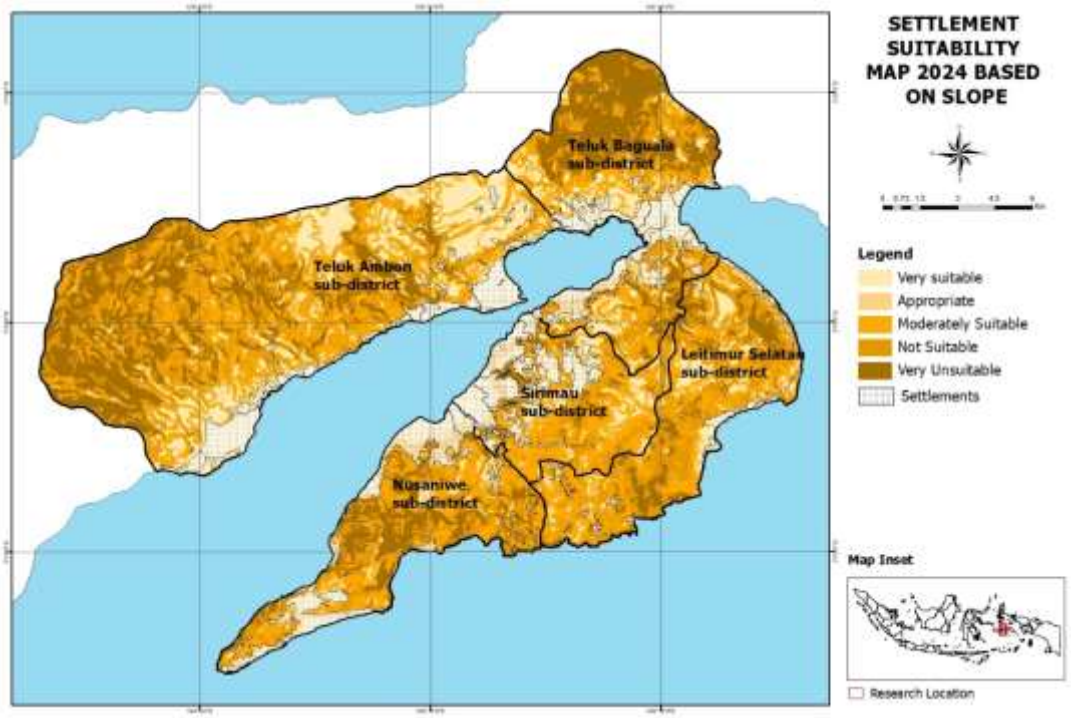

Figure 3. Settement suitability map 2024 based on sloper

Land Suitability in 2031 Residential Area Planning (RTRW 2011-2031)

The results of land suitability based on slope gradient were then overlaid with data from the Ambon City spatial plan (settlements), 2011-2031. The results of this overlay show that there is significant potential for settlement development in Ambon City. Of the total area of 6,583.35 hectares, approximately 2,729.64 hectares (41.46%) is categorized as highly suitable, indicating that this area has ideal conditions for settlement development. In addition, there are also 969.18 hectares (14.72%) categorized as suitable, and 1,834.76 hectares (27.87%) categorized as moderately suitable. This indicates that more than 80% of the total area analyzed has good potential for development, providing positive opportunities for sustainable settlement planning in the future. The results also revealed the presence of unsuitable and highly unsuitable areas for settlement development, with an area of 727.52 hectares (11.05%) and 322.25 hectares (4.89%) respectively. Although the percentage of unsuitable areas is relatively small, it is important to pay attention to the factors that cause such unsuitability, such as disaster risk or unfavorable physical conditions. The results of this study emphasize the need for careful planning strategies to maximize the use of suitable land and minimize risks in unsuitable areas. Thus, planning for residential areas in Ambon City can be carried out effectively and safely, in line with the vision of sustainable development until 2031 (Figure 4).

Based on the results of the research on land suitability for residential development in Ambon City, it is recommended that residential development be focused on areas that have been identified as highly suitable and suitable. This is important to minimize the risk of disasters, such as landslides, which can occur in areas with steep slopes (Latue et al., 2023). Policy makers need to establish strict regulations to prohibit development in high-risk areas, as well as develop supporting infrastructure in safer locations (Hehanussa & Rakuasa, 2024). Thus, the development of residential areas can be carried out with the safety and welfare of the community in mind. In addition, it is important to increase public awareness regarding the selection of settlement locations that are suitable for environmental conditions. Education and socialization programs can be conducted to provide information on the risks associated with development in unsuitable areas. In addition, spatial data integration in spatial planning should be strengthened to produce more accurate suitability maps (Haris et al., 2022). Regular monitoring and evaluation are also needed to assess the effectiveness of the policies implemented, so that adjustments can be made according to changes in environmental and social conditions in Ambon City. With these

measures, it is expected that the development of residential areas can take place in a sustainable and safe manner.

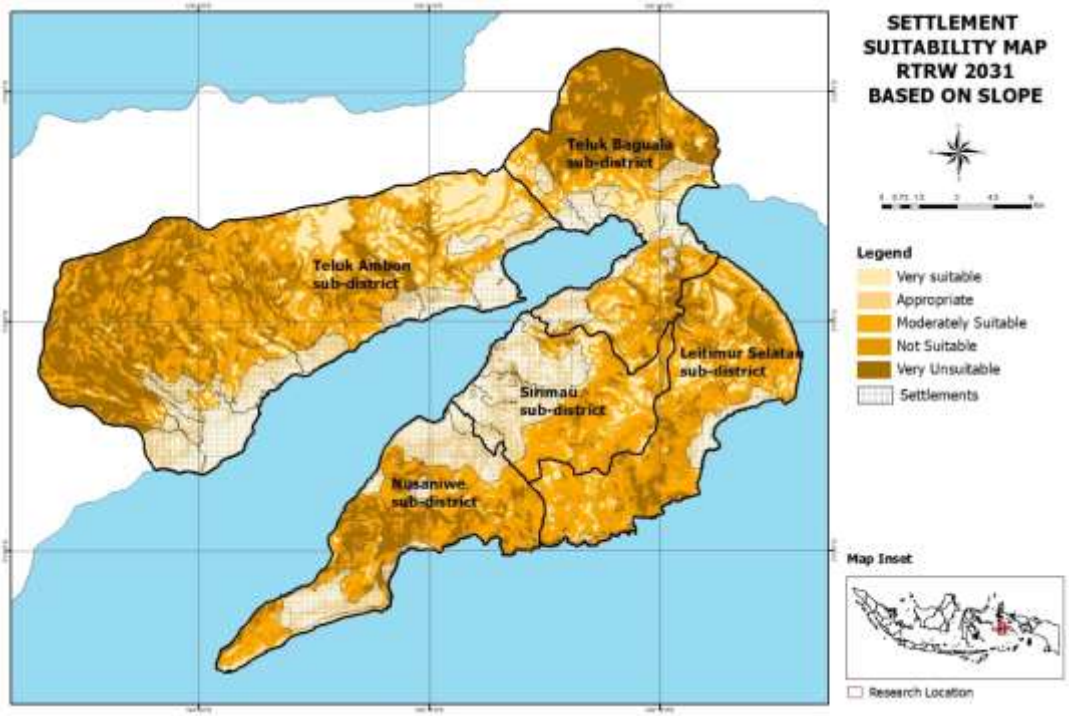

Figure 4. Settliment Suitabilty Map RTRW Ambon City 2011-2031 based on sloper

CONCLUSION

The results of this study indicate that land suitability analysis for the development of residential areas in Ambon City is essential to ensure sustainability and residential safety. The results indicate that most of the areas planned for settlements are in the highly suitable category, while areas with steep slopes should be avoided to reduce disaster risks. Therefore, recommendations to focus on development in suitable areas, careful management of risky areas, and increased community awareness are key in formulating effective spatial planning strategies. Thus, this research provides a strong basis for policy makers to create safe, sustainable and responsive residential areas to the geographical conditions of Ambon City.

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