

Evaluation of Residential Areas Based on Geoecosystem Unit Characteristics in Banda Aceh

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Abstract: In 2005, the residential area in Banda Aceh covered 948.5 ha. Recently, the total residential footprint has expanded significantly to 2,982.12 ha. This study aims to evaluate existing residential land use based on geoecosystem characteristics to ensure alignment with land capacity, thereby enabling the formulation of appropriate zoning for residential development. A quantitative descriptive approach was employed, utilizing spatial analysis through matching and scoring techniques. This approach characterizes each geoecosystem unit within the study area and assesses them against standard land suitability criteria for settlements. The findings indicate that among the identified geoecosystem units in Banda Aceh, coastal alluvial plains constitute the largest share at 73.5%, whereas oxbow river geoecosystems represent the smallest portion, accounting for only 0.1% of the total territory. The study concludes that coastal alluvial plains, spanning 3,947.58 ha, possess the ideal geoecosystem characteristics for residential use, making them the most suitable zones for future residential development in Banda Aceh.

Keywords: Land Suitability, Geoecosystem, Coastal Alluvial Plains, Residential Area.

Abstrak: Luas kawasan permukiman di Banda Aceh pada tahun 2005 adalah 948,5 ha. Baru-baru ini, total luas kawasan permukiman telah berkembang menjadi 2.982,12 ha. Studi ini bertujuan untuk mengevaluasi penggunaan lahan kawasan permukiman existing berdasarkan karakteristik geoekosistem guna menjaga kesesuaiannya dengan kapasitas lahan, sehingga memungkinkan formulasi zonasi pengembangan kawasan permukiman yang tepat. Metode yang digunakan dalam studi ini berupa pendekatan deskriptif kuantitatif melalui analisis spasial menggunakan teknik matching dan scoring. Pendekatan ini dapat menggambarkan karakteristik setiap unit geoekosistem di dalam wilayah studi dan menilainya berdasarkan standar kesesuaian lahan untuk permukiman. Hasil dari studi menunjukkan persentase unit geoekosistem yang diidentifikasi di Banda Aceh adalah dataran aluvial pesisir sebagai area yang terluas yaitu sebesar 73,5%, sedangkan yang area geoekosistem yang terkecil adalah geoekosistem sungai tapal kuda yang hanya sebesar 0,1% dari total wilayah di Banda Aceh. Studi ini menyimpulkan bahwa karakteristik geoekosistem yang paling sesuai untuk kawasan permukiman adalah geoekosistem dataran aluvial pantai dengan luas sebesar 3.947,58 ha, sehingga merupakan area yang paling sesuai untuk zonasi pengembangan kawasan permukiman di Banda Aceh.

Kata kunci: Kesesuaian Lahan, Geoekosistem, Dataran Aluvial Pesisir Kawasan Permukiman.

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1. Introduction

Banda Aceh, the capital of Aceh Province, is located at the northwestern tip of Sumatra Island. The city lies along the northwestern coast, with mountainous areas extending to the east and south. Geographically, Banda Aceh is situated between 5°16'15"–5°36'16" North latitude and 95°16'15"–95°22'35" East longitude.

Topographically, the city has an average elevation of 0.8 meters above sea level. Administratively, Banda Aceh covers an area of 61.36 km² and consists of 9 subdistricts, 17 mukims, and 90 villages. According to the Central Statistics Agency (BPS) of Banda Aceh (2024), the population in 2023 was 261,969, with a population density of approximately 4,269 people per km².

As the provincial capital, Banda Aceh serves as the administrative and economic center of Aceh Province. The presence of government institutions, commercial activities, and public services has increased the demand for land. Accommodating these activities requires substantial land resources, leading to intensified competition for land in a city with limited available space. Wicaksono (2011) noted that land use change in urban areas is a common phenomenon, particularly in rapidly growing cities, as a manifestation of urban development dynamics. However, such changes often deviate from established spatial planning policies and result in various adverse environmental and social impacts.

One of the major consequences of land-use change in Banda Aceh is the expansion of residential areas. Residential development can exert significant pressure on the environment, including environmental pollution, habitat and biodiversity loss, and landscape alteration. In addition, the expansion of residential areas contributes to an increase in domestic waste generation. Waste originating from residential areas frequently contaminates public water bodies, particularly rivers, and may also pose risks to public health (Sumantri & Cordova, 2011).

Over the past decade, residential development in Banda Aceh has increased substantially. Akbar et al. (2014) reported that residential land area expanded from 948.5 ha in 2005 to 1,498.65 ha in 2009 and 1,550.13 ha in 2011. Furthermore, Suhendrayatna (2019) indicated that the total residential area in Banda Aceh had reached 2,982.12 ha. This trend reflects a growing demand for housing and underscores the need for systematic evaluation of land suitability to support sustainable urban development.

This study aims to evaluate the suitability of residential areas in the geoecosystem characteristics that exist in the study area, and propose zoning directions for the development of residential areas based on the most suitable sustainable geoecosystem characteristics in Banda Aceh.

2. Method

This study was conducted in Banda Aceh, Aceh Province. The research was carried out from January to August 2024. This study employed a quantitative descriptive approach was employed, utilizing spatial analysis through matching and scoring techniques. The purpose of this approach is to describe the characteristics of each geoecosystem unit within the study area and to evaluate and compare these characteristics against established standards for residential land suitability. Furthermore, this characterization serves as the basis for assessing existing land use activities in residential areas, thereby enabling the formulation of appropriate zoning guidelines for residential development.

The data used in this study were obtained through multiple collection methods, including field observations, interviews, and literature review. Data processing and analysis involved spatial analysis techniques to examine and interpret the characteristics of each geoecosystem unit based on field observations and spatial data. The processed data were then organized and presented in the form of descriptive narratives, tables, and maps. Furthermore, data analysis was conducted using image interpretation, spatial analysis, and matching techniques to evaluate land suitability and ensure consistency between observed conditions and established criteria.

3. Results and Discussion

3.1 Residential Areas in the Study Area

A residential area is defined as an integrated unit of housing that comprises several components, including housing units, neighborhoods, and communities. It is not merely a collection of residential buildings but also includes supporting facilities such as infrastructure and public utilities that provide essential services, including transportation, communication, and recreation.

The existing residential areas in the study area were identified through a delineation process based on imagery obtained from World Imagery (Wayback, dated November 1, 2023), which is accessible via ArcGIS software. This delineation process involved updating the attribute table of the 2017 land-use map. The updates primarily consisted of revising the classification and extent of residential area attributes, as illustrated in Figure 1.



Figure 1. Residential Area Update Process

Based on the results of the study, the updated land-use distribution in the study area is presented in Table 1.

Table 1. Updated Land-Use Distribution in the Study Area

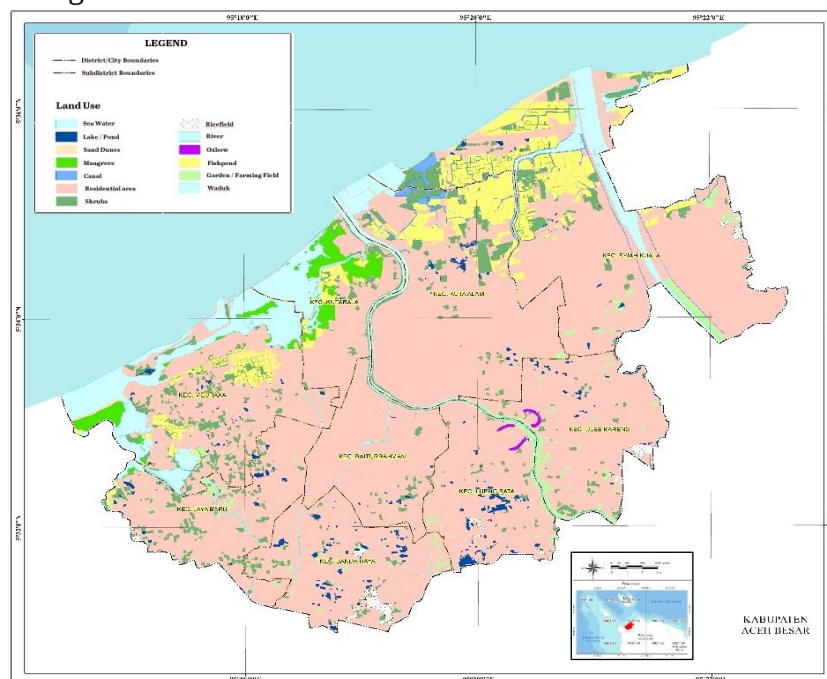
Land use	Area (ha)
Sea Water	301,10
Fishpond	59,72
Sandy Area	21,89
Mangrove Forest	97,78
Canal	45,10
Residential Area	4.220,83
Rice Field	34,86
Shrubland	363,68
River	253,59
Oxbow River	5,44
Aquaculture Pond	385,02
Dryland Farming	95,49
Reservoir	23,93
TOTAL	5.908,43

Source: analysis, 2024

3.2 Suitability of Residential Areas in the Study Area

Land suitability evaluation is the process of assessing the potential of land for specific uses through the interpretation and analysis of land characteristics, including landform, soil, vegetation, climate, and other relevant factors, in order to identify and compare appropriate land use types in accordance with the objectives of the evaluation (FAO, 1976, as cited in Karmono, 1995).

In this study, the evaluation of residential land suitability focuses on assessing the appropriateness of land for residential use based on the geoecological typologies present in the study area, with particular emphasis on existing residential areas. The evaluation was conducted for each geoecosystem unit containing residential land, allowing for a unit-based assessment of suitability. The results of the evaluation are presented in Figure 2.



Source: Analysis, 2024

Figure 2. Map of Existing Residential Areas in the Study Area

Table 3. Results of Land Suitability Evaluation for Residential Areas Based on Geoecosystem Unit Characteristics

Geoecosystem Unit	Residential Area		Residential Area Suitability							
	Yes	No	Soil Texture	Soil Permeability	Slope Gradient	Land Use Type	Groundwater Quality	Groundwater Depth	Accessibility	Disaster Vulnerability
Gisik	-	✓	Highly Suitable	Highly Suitable	Highly Suitable	Highly Suitable	Not suitable	Not suitable	Suitable	Not suitable
Lagoon	-	✓	Not suitable	Highly Suitable	Highly Suitable	Highly Suitable	-	-	Suitable	Not suitable
Mangrove Forest	-	✓	Not suitable	Highly Suitable	Highly Suitable	Not suitable	-	-	Suitable	Not suitable
Pond	✓		Suitable	Highly Suitable	Highly Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Horseshoe River	-	✓	-	Highly Suitable	Sangat Sesuai	Highly Suitable	-	-	Highly Suitable	Suitable
Coastal Alluvial Plain	✓	-	Highly Suitable	Highly Suitable	Highly Suitable	Suitable	Highly Suitable	Highly Suitable	Highly Suitable	Suitable

Source: Analysis, 2023

The gisik, lagoon, mangrove forest, and horseshoe river geoecosystem units do not contain residential land; therefore, the evaluation focuses on the pond and coastal alluvial plain geoecosystem units where settlements are present. Within the pond geoecosystem units, residential areas are located in the northern parts of Tibang and Jeulingke villages. In Tibang, the settlement has existed for a long period, with most residents working as fishermen. In contrast, Jeulingke represents a relatively new residential development established by private developers.

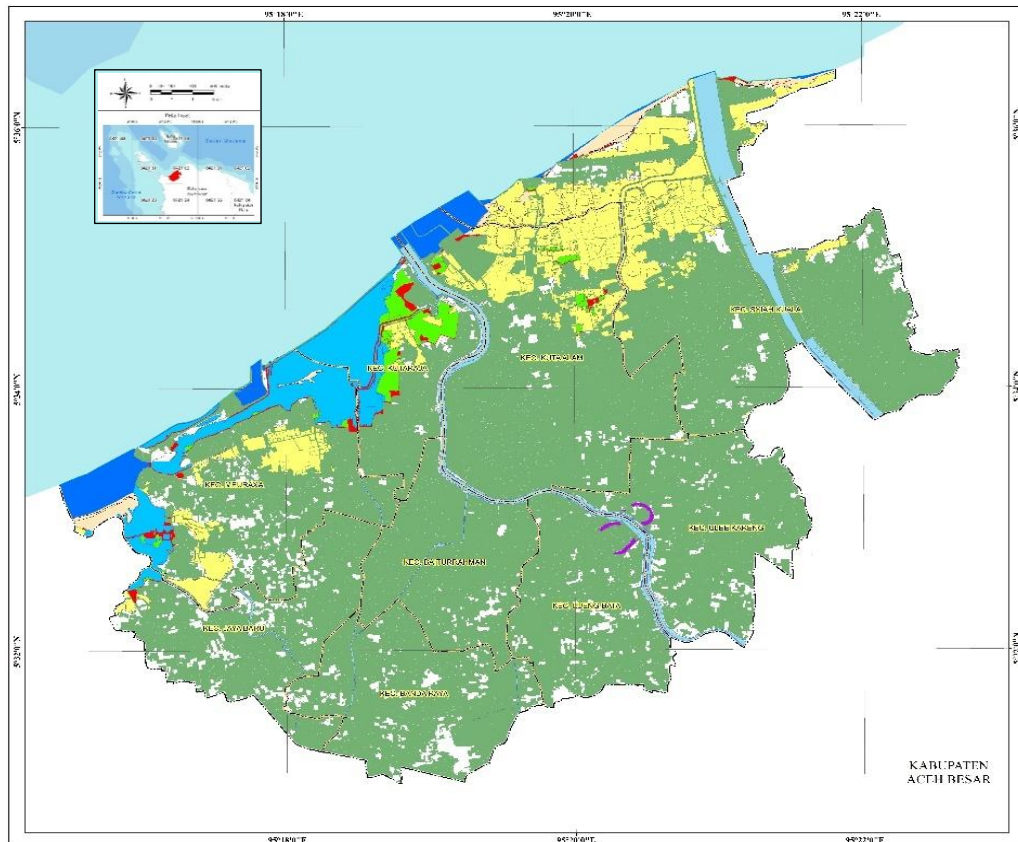
Based on land characteristics, the pond geoecosystem unit is generally suitable for residential development. However, this unit is characterized by slightly brackish groundwater, a shallow water table, and moderate vulnerability to tsunami hazards. Therefore, it is classified as moderately suitable for residential use.

The coastal alluvial plain geoecosystem unit extends from the western to the eastern parts of the study area and contains a significant proportion of residential areas. Its proximity to the city center enhances accessibility, making it a preferred location for residents, particularly those employed in the public sector.

In the eastern part of the study area, residential areas are also dominant due to the presence of major educational institutions, including Universitas Syiah Kuala and Ar-Raniry State Islamic University, as well as several other higher education institutions such as Universitas Bina Bangsa Getsempena (UBBG), Universitas Ubudiyah Indonesia, Sekolah Tinggi Ilmu Kehutanan (STIK) Pante Kulu, Sekolah Tinggi Ilmu Ekonomi Sabang (STIES), and Sekolah Tinggi Teknik Iskandar Tsani (STTIT) in Banda Aceh. This concentration of educational facilities has contributed to increasing demand for housing, particularly in the form of rental units and boarding houses. In the southern part of the study area, residential areas are also present, supported by

relatively good accessibility to the city center, although some areas, such as Pango Deah, still retain agricultural land use in the form of rice fields.

Based on physical land characteristics, the coastal alluvial plain geoecosystem unit is highly suitable for residential and urban development. This unit is characterized by moderate to low tsunami vulnerability and low flood risk. Consequently, it is classified as highly suitable for residential development. However, in areas where rice fields are present, land conversion should be carefully regulated in accordance with applicable policies to ensure sustainable urban development. More detailed information on land suitability is presented in Figure 3.



Source: Analysis, 2024

Figure 3. Map of Residential Area Suitability in the Study Area

Table 4. Suitability of Existing Residential Areas

Geoecosystem Unit	Kawasan Permukiman Eksisting	
	Suitable (ha)	Not suitable (ha)
Mangrove Forest	-	13,85
Coastal Alluvial Plain	3.947,58	
Gisik	-	3,86
Lagoon	-	15,29
Horseshoe River	1,11	-

Pond	192,9	-
Others	45,2	-
Total	4.186,79	33,00

Table 4 indicates that the total area of existing residential land in the study area is 4,186.79 ha. Among the geoecosystem units, three contain residential areas that are not compatible with their characteristics, namely mangrove forests (13.85 ha), gisik (3.86 ha), and lagoons (15.29 ha). In contrast, residential areas that are compatible with geoecosystem characteristics are primarily located within coastal alluvial plains (3,947.58 ha), horseshoe rivers (1.11 ha), ponds (192.90 ha), and other areas (45.20 ha). Residential areas located within other geoecosystem units generally consist of non-residential built-up structures, particularly coastal protection infrastructure such as seawalls along the shoreline of the study area.

3.3. Guidelines for Residential Zoning Based on Geoecosystem Unit Characteristics

Residential areas within a region constitute an integral component of the geoecosystem and should function in harmony with its processes and characteristics. The increasing demand for housing necessitates spatial planning frameworks that incorporate clear guidelines for residential development. However, this need often creates tension between development objectives and the imperative to preserve geoecosystem integrity and prevent environmental degradation.

Residential development requires supporting infrastructure, including road networks, green open spaces, drainage systems, and waste management facilities. The construction and expansion of such infrastructure inevitably alter the structure and function of the geoecosystem. When residential development is undertaken in areas that do not correspond to the inherent characteristics of geoecosystem units, it may result in environmental degradation, such as erosion, sedimentation, pollution, and increased flood risk. Therefore, spatial planning that integrates residential zoning guidelines aligned with geoecosystem characteristics is essential to ensure sustainable development. Such an approach can minimize environmental degradation, maintain ecological balance, and reduce exposure to potential natural hazards in Banda Aceh.

As discussed in the previous subsection, among the seven identified geoecosystem units, only the coastal alluvial plain and pond geoecosystem units are considered suitable for residential development. This classification is based on land suitability parameters, environmental conditions, and relatively lower disaster risk compared to other units. Accordingly, these two geoecosystem units should be prioritized in residential zoning policies. The spatial distribution of recommended residential zones based on geoecosystem characteristics is presented in Figure 4.

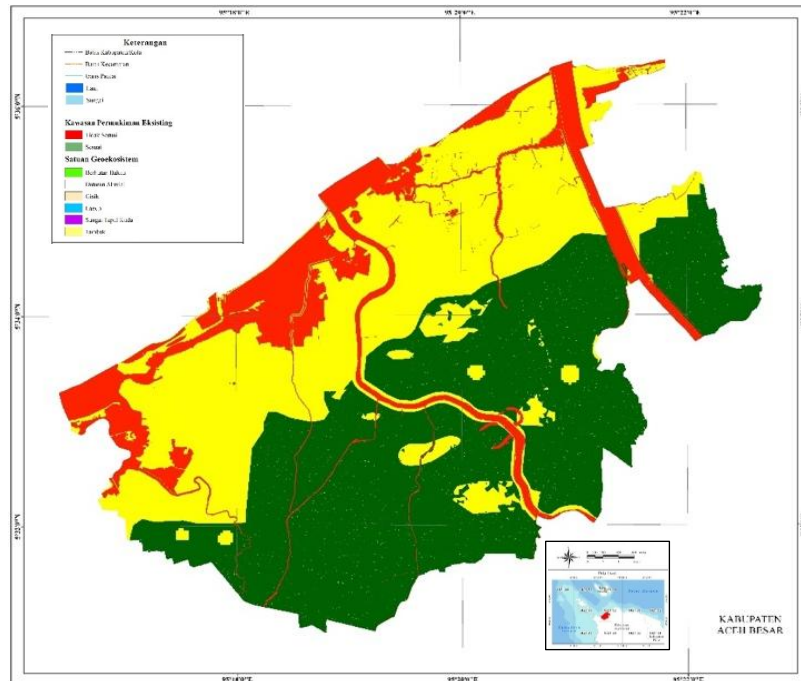


Figure 4. Zoning Guidance Map for Residential Areas in the Study Area

5. Conclusion

Based on the results of the analysis and discussion, several conclusions can be drawn. The geoecosystem units identified in Banda Aceh consist of coastal alluvial plains covering 4,338.32 ha (73.5%), mangrove forests covering 82.81 ha (1.4%), gisik covering 61.38 ha (1%), horseshoe rivers covering 6.53 ha (0.1%), fishponds covering 765.58 ha (13%), lagoons covering 272.41 ha (4.6%), and other areas totaling 142.46 ha (2.4%). The coastal alluvial plain represents the largest geoecosystem unit (73.5%), while the horseshoe river constitutes the smallest (0.1%). Residential areas that are compatible with geoecosystem characteristics are primarily located within coastal alluvial plains (3,947.58 ha), horseshoe rivers (1.11 ha), fishponds (192.9 ha), and other areas (45.2 ha). Residential areas that are not compatible with geoecosystem characteristics are found within mangrove forests (13.85 ha), gisik (3.85 ha), and lagoons (15.29 ha). The coastal alluvial plain and fishpond geoecosystem units are the most suitable areas for residential development in Banda Aceh, with the coastal alluvial plain, particularly in the southern part of the city, being the most favorable.

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