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Land Suitability for Settlement in the Coastal Area of Bolaang Mongondow Utara Regency

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Abstrak

Penelitian ini bertujuan untuk mengevaluasi kesesuaian lahan bagi pengembangan permukiman di wilayah pesisir Kabupaten Bolaang Mongondow Utara. Pendekatan analisis spasial berbasis Sistem Informasi Geografis (SIG) digunakan dengan menerapkan teknik seperti buffering, overlay, dan pembobotan untuk menilai parameter kesesuaian. Parameter yang dievaluasi meliputi kemiringan lereng, jenis tanah, aksesibilitas (jarak terhadap jalan utama), penggunaan lahan, kedekatan dengan garis pantai, dan kedekatan dengan sungai. Hasil analisis spasial menunjukkan bahwa sebagian besar wilayah studi tergolong cukup sesuai untuk permukiman (18.619,35 ha atau 55,73%), sementara area yang sangat sesuai mencakup 1.847,10 ha (36,05%). Temuan ini memberikan wawasan penting bagi perencanaan wilayah oleh pemerintah daerah dalam pengelolaan pengembangan permukiman pesisir.

Abstract

This study aims to evaluate the land suitability for residential development in the coastal areas of Bolaang Mongondow Utara Regency. A spatial analysis approach based on Geographic Information Systems (GIS) was employed, utilizing techniques such as buffering, overlay, and scoring to assess the suitability parameters. The evaluated parameters include slope, soil type, accessibility (Distance to Main Road), land use, distance to coastline, and distance to river. The spatial analysis results indicate that the majority of the study area is categorized as marginally suitable for settlement (18,619.35 ha or 55.73%), while highly suitable areas account for 1,847.10 ha (36.05%). These findings provide important insights for regional planning by the local government in managing coastal residential development.

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INTRODUCTION

(Calisto 10), Before : 0, After : 0, Multiple : 1,04)

The use of land for settlements continues to increase in demand along with population growth in both urban and rural areas. This is no exception in coastal areas which are widely used by the community for settlements. This is not only caused by limited land but also by the lives of these communities which depend on the sea. According to (Rachmah et al., 2018), Limited land availability has resulted in many residential developments on unsuitable land. (Risdayanti et al., 2017) stated that careful decision-making in land use is necessary because land resources are limited.

Several researchers concluded that there are various problems in the management and development of residential areas. According to (Umar et al., 2017), rapid population growth drives changes in land use. According to (Dien et al., 2018), Population growth that is not balanced with land availability causes the development of settlements on unsuitable land. According to (Da Costa et al., 2019), the growing population leads to increased land use. (Sakarov & Fahik, 2019) concluded that limiting physical factors in the form of topography, geology, and hydrology are often problems in settlement development. According to (Setyowati, 2007), residential areas developed in unsuitable areas can endanger both the environment and humans. (Pradana et al., 2013) concluded that land use incompatibility will have an impact on land productivity. (Kadriansari et al., 2017) stated that changes in land use need attention because they will affect human life.

Factors such as land limitations, increasing land needs, and problems in land use make land management need serious attention from local governments as spatial planning regulators. (Andina & Taufik, 2015), stated that management studies for sustainable resource utilization are very important in land resource management. According to (Deris & Ramli, 2019), development should pay attention to environmental sustainability.

There are various methods and models in land management, including land capability analysis and land suitability analysis. (Ratnawati & Djojomartono, 2020) stated that land suitability analysis is an effort to protect land functions. (Ambarwulan et al., 2022) stated that land suitability evaluation examines the potential of land for a particular use based on certain criteria. Land management needs to consider various aspects so that environmental sustainability is maintained and the potential for conflict in the community is minimized.

Based on (Syam et al., 2018), land use for settlements needs to consider aspects of ecological balance. (Ndun et al., 2021) stated that land use planning needs to consider the physical aspects of the land. According to (Laia et al., 2020), the selection of residential area locations needs to consider physical factors, accessibility, socio-economics, existing land use, and others. (Khansa et al., 2022) linked it to the disaster aspect and concluded that settlements located around the coastline are at risk of tsunami disasters. Meanwhile, (Tanjung et al., 2021) added the LP2B aspect to the analysis of residential land suitability. (Amir et al., 2020) concluded that the basic principles of settlement placement are clean water, flood vulnerability, accessibility, land availability, and availability of public facilities.

(Padungo et al., 2024) stated that spatial planning and land suitability evaluation are crucial aspects in designing coastal area development. Research on the suitability of residential land on the coast of Bolaang Mongondow Utara Regency is very important to do. This is because all sub-districts in Bolaang Mongondow Utara Regency have coastal areas. The purpose of this research is to analyze the suitability of residential land on the coast of Bolaang Mongondow Utara Regency. This research considers the physical aspects of the land, accessibility, disaster potential, and existing land use. This research uses a scoring method for land suitability parameters. Data analysis is carried out spatially using GIS.

METHOD

This research was conducted in the coastal area of Bolaang Mongondow Utara Regency, North Sulawesi Province. The study adopted a spatial analysis approach utilizing Geographic Information Systems (GIS) to evaluate the suitability of land for residential development in coastal regions. The analysis was guided by spatial planning principles and considerations of environmental vulnerability. The data used in this

research were obtained through primary data collection in the field and the use of secondary data. The spatial analysis involved multiple stages, including attribute data scoring to assign weight values to each parameter based on its influence on settlement suitability. Proximity analysis was conducted using buffer techniques to measure the distance from physical features such as coastlines, rivers, and road networks. Overlay analysis was employed to integrate multiple spatial layers. Finally, the composite index was calculated by combining all parameter scores using a weighted linear combination method. The results were then categorized into different land suitability classes using a classification system based on standard criteria.

The parameters and scores that determine the suitability of coastal residential land are shown in Table 1.

Table 1. Land Suitability Criteria for Residential Settlements in Coastal Area

No	Parameter	Criteria	Score
1.	Slope	0 – 8%	5
		8 – 15 %	4
		15 -25 %	3
		25 -45 %	2
		>45 %	1
2.	Soil Type	Alluvial, clay soil, planosol, grey hydromorphic, lateritic groundwater soil	5
		Latosol	4
		Brown forest soil, non-calcic brown, mediteran	3
		Andosol, lateric, grumusol, podsol, podsolic	2
		Regosol, litosol, organosol, renzina	1
3.	Distance to Main Road	0-500 m	5
		500-1000 m	4
		1000-1500 m	3
		1500-2000 m	2
		>2000 m	1
4.	Distance to Coastline	>3000 m	5
		1501-3000 m	4
		1001-1500 m	3
		501-1000 m	2
		0-500	1
5.	Distance to River	>500 m	5
		301-500 m	4
		201-300m	3
		101-200	2
		0-100	1
6	Land Use	Open land, Built-up Land (Settlements)	5
		Dryland Farming, Fields, Rice Fields	4
		Shrubland	3
		Forest, Plantation, Ponds	2
		Water Body	1

Source: (Taufiqurrahman, 2015), (Faiqoh et al., 2013), and Fersely as cited in (Prayoga, 2017) with several modifications.

RESULTS AND DISCUSSION

The land parameters considered in this research include slope, soil type, accessibility, distance to coastal, distance to river, and existing land use. This land suitability research is spatially based. Spatial data for each parameter were analyzed using GIS software for buffer analysis, scoring, map overlay, total score calculation, and land suitability classification.

Slope is a key physical factor in determining settlement locations. Slope affects accessibility, connectivity, disaster potential, and ease of building construction. The slope data is presented in Table 2, while the slope map is shown in Figure 1.

Table 2. Slope in Bolaang Mongondow Utara Regency

No	Slope	Area (ha)	%
1.	0-8 %	8032.22	24.04
2.	8-15%	3298.89	9.87
3.	15-25%	6068.52	18.16
4.	25-45%	12169.03	36.42
5.	>45%	3840.48	11.50
	Total	**33409.13**	**100**

Table 2 shows that Bolaang Mongondow Utara Regency is dominated by slopes of 25–45%, covering an area of 12,169.03 hectares (36.42%), followed by flat slopes (0–8%) covering 8,032.22 hectares (24.04%). Moderately steep slopes (15-25%) cover 6,068.52 hectares (18.16%), and very steep slopes (>45%) occupy 3,840.48 hectares (11.50%). Gently sloping (8-15%) areas cover 3,298.89 hectares (9.87%).

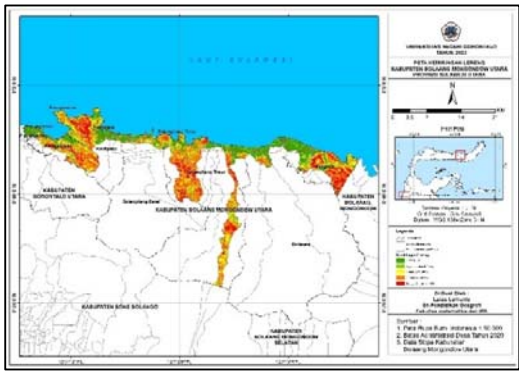

Figure 1. Slope Map of the Coastal Area in Bolaang Mongondow Utara Regency

Figure 1 illustrates the slope distribution across the coastal area of Bolaang Mongondow Utara Regency. It can be observed that flat areas with a slope of 0–8% are predominantly located near the coastline, making them potentially more favorable for settlement development. Meanwhile, steeper slopes ranging from 25–45% dominate the inland areas, presenting challenges for residential construction due to the higher risks of landslides, erosion, and accessibility issues. This slope distribution serves as a fundamental parameter in assessing land suitability for settlements in the region.

Soil types in the coastal area of Bolaang Mongondow Utara Regency are dominated by latosol soils, covering 14,157.95 hectares (42.10%), and podsolic soils, covering 12,450.03 hectares (37.02%). Full data on other soil types are available in Table 3. The soil type map is shown in Figure 2.

Table 3. Soil Types in the Coastal Area of Bolaang Mongondow Utara Regency

No	Soil Types	Area (ha)	%
1.	Regosol	267.83	0.80
2.	Podsol	1158.42	3.44
3.	Latosol	14157.95	42.10
4.	Glei Humus	4870.36	14.48
5.	Aluvial	726.30	2.16
6.	Podsolik	12450.03	37.02
	Total	**33630.89**	**100**

Figure 2. Soil Type Map of Bolaang Mongondow Utara Regency

Figure 2 presents the spatial distribution of soil types in the coastal area of Bolaang Mongondow Utara Regency. The map shows that latosol soils are widely distributed across the region, particularly in the inland areas, while podsolic soils are also significantly present. Other soil types such as glei humus and alluvial soils appear in smaller, localized zones. The varying soil characteristics across the coastal landscape influence the suitability of land for settlement, particularly in terms of soil stability, drainage, and construction feasibility.

Accessibility is an important factor in determining settlement areas. Areas with high accessibility generally have more developed economies and better access to public and social facilities. The accessibility aspect was analyzed using a buffer analysis of the road network map. Data on classification of the research area based on distance to the road network can be found in Table 4. The map of distance classification from road networks is presented in Figure 3.

Table 4. Distance from Road Networks in the Coastal Area of Bolaang Mongondow Utara Regency

No	Distance to Main Road	Area (ha)	%
1.	0-500 m	6860.56	20.40
2.	500-1000 m	4895.70	14.56
3.	1000-1500 m	3638.21	10.82
4.	1500-2000 m	2623.54	7.80
5.	> 2000 m	15614.55	46.43
	Total	**33632.57**	**100**

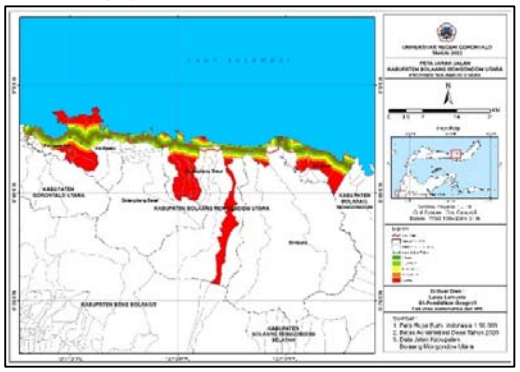

Figure 3. Road Network Map of Bolaang Mongondow Utara Regency

Figure 3 displays the spatial distribution of distance to main road in the coastal area of Bolaang Mongondow Utara Regency. Areas located within 500 meters of major roads are concentrated mainly around existing settlements and administrative centers, offering higher accessibility for development. In contrast, regions located more than 2,000 meters from main roads are widespread in inland and forested areas.

In determining land suitability for settlement, distance from the coastline and distance from rivers are considered disaster-related factors. The closer an area is to the coastline, the higher its risk from tsunamis and other coastal hazards. The research area is dominated by areas more than 3,000 meters from the coastline, covering 13,297.10 hectares (39.54%). The results of the coastline buffer analysis in Bolaang Mongondow Utara Regency are shown in Table 5, with spatial distribution shown in Figure 4.

Table 5. Results of the Buffer Analysis on Distance to the Coastline

No	Distance to the Coastline	Area (ha)	%
1.	0-500m	6064.35	18.03
2.	501-1000m	4115.44	12.24
3.	1001-1500m	3626.35	10.78
4.	1501-3000m	6529.34	19.41
5.	>3000m	13297.10	39.54
	Total	33632.58	100

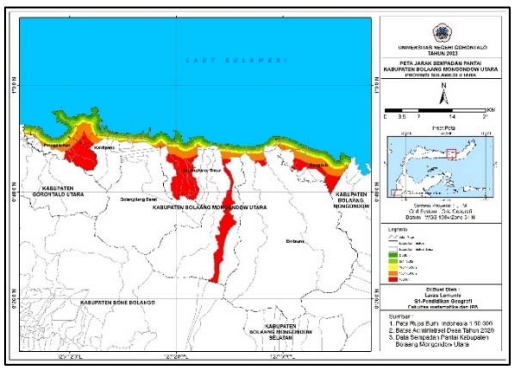

Figure 4. Map of Coastline Distances in the Coastal Area of Bolaang Mongondow Utara Regency

Due to the disaster potential associated with areas near coastlines and riverbanks, the assessment of land suitability must also be aligned with national regulations that govern setback zones. Law No. 27 of 2007 on the Management of Coastal Areas and Small Islands mandates a minimum coastal setback of 100 meters from the highest tide line toward the land. This regulation aims to reduce the risk of disasters, especially those related to earthquakes and tsunamis, while ensuring environmental protection and maintaining public access to coastal areas (Law of the Republic of Indonesia Number 27 of 2007 Concerning the Management of Coastal Areas and Small Islands, 2007). Likewise, the Regulation of the Minister of Public Works and Public Housing No. 28/PRT/M/2015 concerning the Establishment of River and Lake Setback Lines requires the delineation of buffer zones along riverbanks, in order to limit the destructive impact of river water on the surrounding environment (Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 28/PRT/M/2015 of 2015 Concerning the Establishment of River and Lake Setback Lines, 2015).

Figure 4 illustrates the spatial pattern of distances from the coastline in the coastal area of Bolaang Mongondow Utara Regency. The map shows that areas within 500 meters of the coastline are scattered along the shorelines, reflecting zones that are more vulnerable to coastal hazards such as tsunamis, erosion, and tidal flooding. Meanwhile, inland areas located more than 3,000 meters from the coast dominate the region and are relatively less exposed to direct coastal risks.

In addition to the distance from the coastline, distance to the river proximity is an equally significant factor in land suitability assessments. Rivers in coastal areas not only influence local hydrology but also present potential risks such as flooding, especially in low-lying zones. The research location is also dominated by areas more than 500 meters from river boundaries. The calculation of distance to the river aims to assess flood disaster potential. The results of the river buffer analysis in the coastal area of Bolaang Mongondow Utara Regency are shown in Table 6, with the map presented in Figure 5.

Table 6. Results of the Buffer Analysis on Distance to the River

No	Distance to the River	Area (ha)	%
1.	0-100m	1598.09	4.75
2.	101-200m	1092.12	3.25
3.	201-300m	1076.16	3.20
4.	301-500m	2200.65	6.54
5.	>500m	27665.57	82.26
	Total	33632.59	**100**

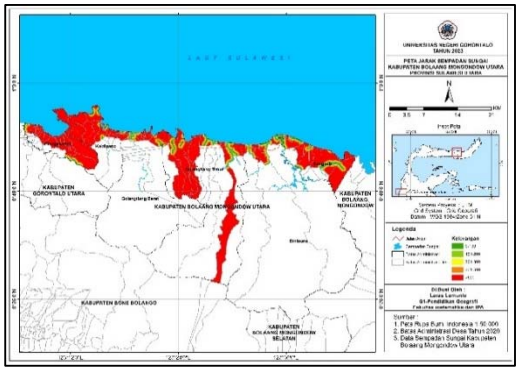

Figure 5. Map of River Distances in the Coastal Area of Bolaang Mongondow Utara Regency

Land use is a critical parameter in land suitability analysis because it reflects the current utilization and biophysical condition of the area, which directly influences the feasibility of new land uses such as residential development. In the context of the coastal area of Bolaang Mongondow Utara Regency, land use is predominantly characterized by forest cover, occupying 20,166.05 hectares (59.96%), and agricultural land, covering 10,667.49 hectares (31.72%). Land use data in the research area are shown in Table 7. The land use map in the coastal area is shown in Figure 6.

Table 7. Land Use Data in the Coastal Area of Bolaang Mongondow Utara Regency

No	Land Use	Area (ha)	%
1.	Water Body	362.65	1.08
2.	Forest	20166.05	59.96
3.	Settlement	853.88	2.54
4.	Plantation	10667.49	31.72
5.	Pond	1581.43	4.70
	Total	**164317.80**	**100**

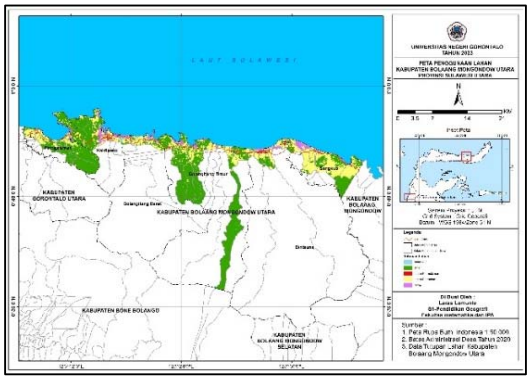

Figure 6. Land Use Map of Bolaang Mongondow Utara Regency

After analyzing each individual parameter, a comprehensive land suitability classification was performed by integrating all evaluation criteria. The combined scoring approach provides a holistic assessment of the suitability of land for residential development in the coastal area. The classification of land for settlements is determined based on the total score from each land suitability parameter.

The classification was derived using a range-based interval method by subtracting the lowest total overlay score (10) from the highest score (29), and dividing the result by the number of suitability classes. This resulted in an interval width of 4.75, and the land was classified into four suitability classes: Highly Suitable (29–25), Moderately Suitable (24–20), Marginally Suitable (19–15), and Not Suitable (14–10), as presented in Table 8.

Based on the calculations, four classes of coastal land suitability for settlements were identified: Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), and Not Suitable (N). Based on the parameters of slope, soil type, distance to main road, land use, distance to the coastline, and distance to the river, the results of land suitability analysis for coastal settlements in Bolaang Mongondow Utara Regency are shown in Table 9. The land suitability map is presented in Figure 7.

Table 8. Land Suitability Classification for Settlement Based on Total Overlay Scores

No	Suitability Class	Total Score Range
1.	Highly Suitable	29 – 25
2.	Moderately Suitable	24 – 20
3.	Marginally Suitable	19 – 15
4.	Not Suitable	14 – 10

Table 9. Land Suitability for Settlement in the Coastal Area of Bolaang Mongondow Utara Regency

No	Category	Area (ha)	%
1.	Highly Suitable	1847.10	36.05
2.	Moderately Suitable	12042.51	5.53
3.	Marginally Suitable	18619.35	55.73
4.	Not Suitable	898.53	2.69
	Total	**33407.49**	**100**

Table 9 shows that the coastal area of Bolaang Mongondow Utara Regency is mostly marginally suitable for settlement, covering 18,619.35 hectares (55.73%). The area that is highly suitable for settlement covers 1,847.10 hectares, or 36.05% of the total research area.

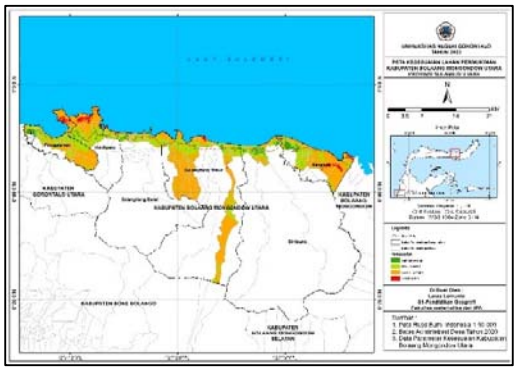

Figure 7. Land Suitability Map for Settlement in the Coastal Area of Bolaang Mongondow Utara Regency

Figure 7 presents the spatial distribution of land suitability for settlements in the coastal area of Bolaang Mongondow Utara Regency. The map indicates that areas located near the coastline are predominantly classified as marginally suitable (S3) for coastal development. This is attributed to their close proximity to the coast, which heightens their vulnerability to coastal hazards such as tsunamis, erosion, and tidal waves. Conversely, highly suitable areas (S1) tend to be located farther inland, where environmental and physical conditions are generally more favorable. The results of this research can serve as input for the Bolaang Mongondow Utara Regency Government in planning residential areas along the coast.

Several previous studies have also applied GIS-based land suitability analysis for settlement planning in coastal or geographically constrained regions. (Ambarwulan et al., 2022) conducted a spatial multi-criteria analysis to identify suitable settlement zones in earthquake-prone areas of Sukabumi Regency, highlighting the importance of integrating physical vulnerability with land potential. This study highlights the importance of spatial-based land suitability analysis for settlement planning in coastal regions. By incorporating physical, accessibility, and disaster risk factors into a GIS-based evaluation, the findings offer a comprehensive reference for local governments in formulating sustainable coastal settlement development strategies. Future research should consider integrating socio-economic and climate change factors to enhance the robustness of land suitability assessments in dynamic coastal environments

CONCLUSION

Based on the results, the coastal area of Bolaang Mongondow Utara Regency is dominated by marginal land suitable for settlements, which is 18619.35 Ha (55.73%) and areas that are very suitable for settlements covering an area of 1847.10 Ha (36.05%). The land suitability map for settlements on the coast of Bolaang Mongondow Utara Regency illustrates that the areas around the coastline are marginally suitable for settlement development. The results of this research can be a recommendation for the Regional Government of Bolaang Mongondow Utara Regency in arranging settlement areas in the coastal areas of Bolaang Mongondow Utara Regency.

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