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Research Paper

Combining Analytical Hierarchy Process and Geographic Information Systems for Selection of Landfill Site Location: A Case Study of Ogan Ilir Regency, Indonesia

Dwi Vina Febrim[1], Idarwati[1], Mochammad Malik Ibrahim[1], Dede Nurohim[1*]

[1] *Geological Engineering Study Program, Faculty of Engineering, Universitas Sriwijaya, Ogan Ilir Regency, South Sumatra, 30662, Indonesia*
***Corresponding author e-mail**: dedenurohim@ft.unsri.ac.id

Abstract
Landfill site selection in Ogan Ilir Regency presents significant challenges due to escalating waste generation and the risks associated with improper landfill siting. This research identifies and maps environmentally suitable locations for landfill development in Ogan Ilir Regency, South Sumatra, Indonesia, through an integrated methodology that combines the Analytic Hierarchy Process (AHP), Geographic Information Systems (GIS), and remote sensing. Ten sub-criteria were established and categorized as physical, environmental, or socioeconomic, with each assigned a weight via pairwise comparison matrices. The resulting weighted spatial layers were analyzed using a weighted linear combination technique to produce comprehensive suitability models. The analysis classified the study area into three categories: less suitable (1.81%, 4,307.73 ha), moderately suitable (74.46%, 177,404.25 ha), and highly suitable (23.73%, 56,533.78 ha) for landfill development. The framework was validated using satellite imagery and adapted to local conditions, delivering a practical decision-support tool for regional planners and decision makers to promote effective and environmentally sustainable waste management strategies.

Keywords
Landfill Site Selection, GIS-AHP, Spatial Validation, Remote Sensing, Ogan Ilir Regency

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1. INTRODUCTION

Municipal solid waste (MSW) management in many developing countries remains severely disorganized due to inadequate planning, rapid urban expansion, and limited managerial capacity (Nanda et al., 2022). In these contexts, issues such as hunger, health, water scarcity, unemployment, and civil conflict often take precedence, resulting in waste management receiving lower priority (Chandrappa and Das, 2012). The rapid urban growth in Indonesia, coupled with rural-to-urban migration, has led to a significant rise in city populations and a corresponding increase in urban waste generation (Firda et al., 2019). Consequently, unacceptable practices-such as burning, burying, and open dumping-are commonly employed, leading to significant soil, water, and air contamination. If such practices persist, they pose serious health risks to exposed populations and contribute to long-term environmental degradation.

Landfills continue to be the primary method of solid waste disposal worldwide, largely because of their ease of implementation and cost-effectiveness (Nascimento et al., 2020). Selecting optimal landfill sites for MSW is a critical component of urban planning and is essential for promoting sustainable urban development (Barzehkar et al., 2019). This process necessitates the careful integration of socioeconomic, environmental, and physical parameters to ensure operational efficiency and minimize potential negative impacts.

Landfill site selection requires consideration of multiple factors, and spatial analysis is particularly effective for preliminary studies because it can process large volumes of spatial data from diverse sources (Sener et al., 2006). To address the complexity of decision-making, the Analytic Hierarchy Process (AHP) is often integrated with Geographic Information Systems (GIS). The effectiveness of this combined approach has been demonstrated in various geographic contexts. The use of GIS in conjunction with AHP has become increasingly prominent in research focused on analysis, evaluation, and decision support (Rahmat et al., 2017). These integrated methodologies enable planners to systematically assess multiple spatial and non-spatial criteria, facilitating transparent and reproducible site selection. GIS provides spatial analytical capabilities for mapping, overlaying, and visualizing environmental and infrastructural constraints, while AHP offers a structured framework for weighting and prioritizing decision criteria based on expert input. The integration of these tools enhances decision-making accuracy, especially in contexts characterized by data heterogeneity and diverse stakeholder preferences (Alhassan et al., 2026).

The integration of AHP-GIS and remote sensing techniques has emerged as a significant method for identifying optimal solid waste landfill sites in recent years (Ur Rehman et al., 2024). Despite its demonstrated effectiveness, this combined approach remains underutilized in Indonesia. To address this gap, the present study applies this integrated framework in Ogan Ilir Regency, a region experiencing rapid urban growth and increasing waste management challenges. The objective is to identify and map environmentally suitable sites for landfill development in Ogan Ilir Regency, South Sumatra, Indonesia, by combining the Analytic Hierarchy Process (AHP), Geographic Information Systems (GIS), and remote sensing. This research offers a structured, spatially informed methodology that can serve as a model for sustainable waste management planning in regions with similar challenges.

2. EXPERIMENTAL SECTION

2.1 Study Area

This study was undertaken in Ogan Ilir Regency, located in South Sumatra Province (Sumatra Selatan), in the southern region of Sumatra Island, Indonesia. The regency lies approximately 500 km northwest of the national capital, Jakarta (Figure 1). Geographically, it is situated between 3.032° and 3.807° South Latitude and 104.301° and 104.819° East Longitude, encompassing a total surface area of approximately 2,382.5 km^2. As of 2022, the total population of Ogan Ilir reached 431,558 inhabitants, comprising 218,652 males and 212,906 females (Khosyi'ah, 2023).

Administratively, Ogan Ilir consists of 16 districts each with varying land use characteristics, population densities, and infrastructure development levels, making it a representative case for spatially informed landfill site selection. The regency also holds development potential across multiple sectors, including agriculture, mining, industry, and tourism, which further intensifies land use competition and underscores the need for sustainable spatial planning.

2.2 Methods

Figure 2 illustrates the framework employed to depict the territorial suitability for identifying an optimal waste disposal site. The selection criteria in this study are classified into three main groups: physical, environmental, and socioeconomic. Drawing upon a detailed assessment of appropriate scientific writings and established siting guidelines from previous studies, a total of ten subcriteria were identified and systematically grouped under these categories to support the solid waste site suitability analysis (Figure 3).

A spatial analysis-based multi-criteria evaluation (MCE) approach was employed to integrate ten spatial factors: geology (lithology), proximity to fault lines, slope, elevation, land use/land cover (LULC), built-up areas, proximity to rivers, main roads, railway lines, and sensitive ecosystems. All spatial layers were georeferenced to the Zone 48S coordinate system (WGS 1984 UTM). Each criterion was reclassified according to its suitability, and the corresponding area was calculated. Subsequently, all factors were converted to raster format to enable Analytical Hierarchy Process (AHP)-based weighted overlay analysis. Standardized subcriteria were integrated using a weighting approach to generate the suitability map of waste disposal locations in the study region. Providers of geospatial information used in this analysis are listed in Table 1. The selection and classification of sub-criteria were informed by previously published scientific literature. Each sub-criterion was categorized and scored into four suitability levels: unsuitable, less suitable, moderately suitable, and highly suitable.

Table 1. Sources and Types of Spatial Data Used for Each Landfill Site Selection Criterion

Source of data	Type of Data
Rupa Bumi Indonesia (RBI)	River, road, buil-up area, sensitive ecosystem, Railway track
DEMNAS	Elevation, slope
LANSAT 8 USGS	LULC
Geological Survey of Indonesia	Geology, fault

The Analytical Hierarchy Process (AHP) serves as a systematic approach to decision-making by enabling the prioritization of various criteria according to their significance. In this technique, chosen criteria are presented in a matrix layout, where each criterion occupies both rows and columns, and descriptive information is provided for each. The Pairwise Comparison Matrix (PCM) is subsequently utilized to quantify the relative importance and preferences between criteria, assigning scores ranging from 1 to 9 (Figure 4 and Table 2). The scale, facilitated a systematic evaluation of each criterion in relation to others (Moumane et al., 2025). The validity of these comparisons is assessed through the consistency ratio (CR), with a value below 10% indicating an acceptable level of consistency. In addition, these experts were instructed to reevaluate the comparison matrices when inconsistencies are detected (Saatsaz et al., 2018). This method allowed for the creation of a hierarchical structure and made it possible to assign measurable weights to each criterion during decision-making, thus improving the systematic and robust nature of the site selection process.

The consistency ratio (CR) was obtained by dividing the consistency index (CI) from the pairwise comparison matrix by the random index (RI) assigned to a matrix with an

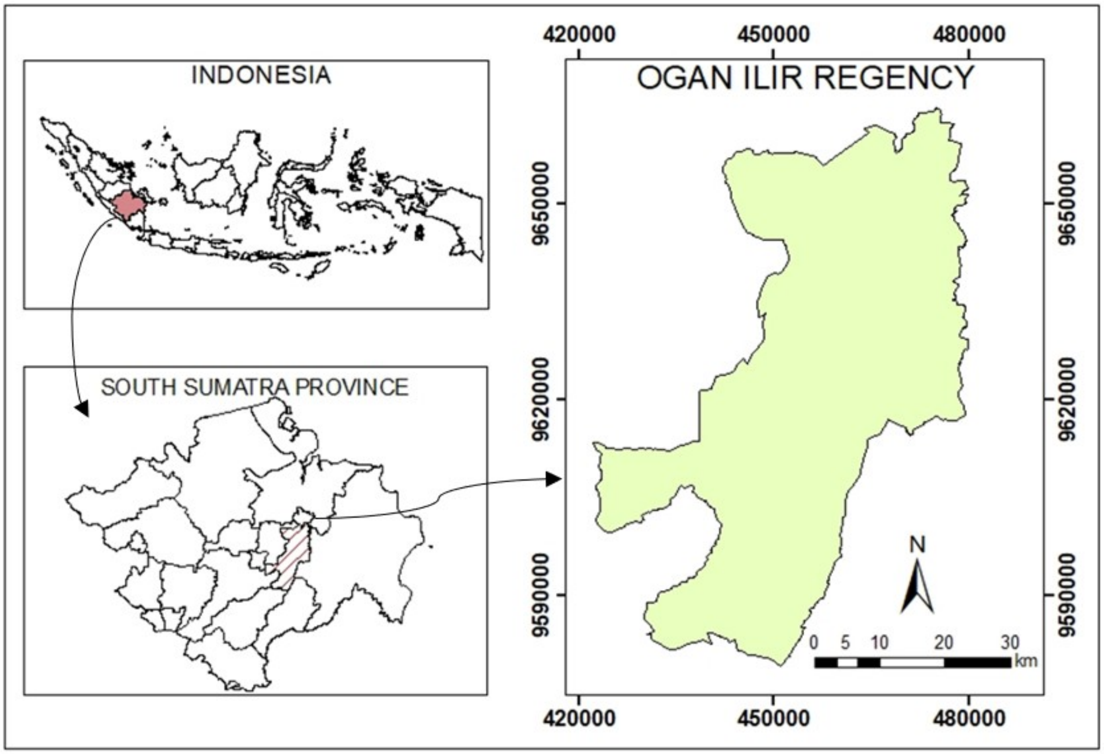

Figure 1. Conceptual Framework of the Integrated GIS–AHP Methodology Used in This Study for Landfill Site Selection in Ogan Ilir Regency

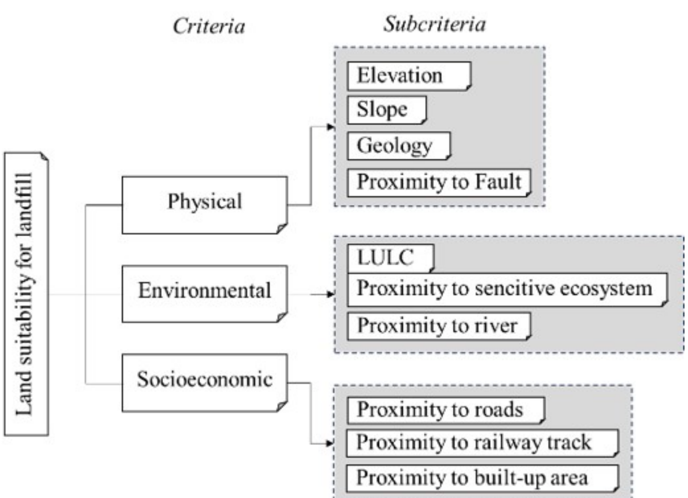

Figure 2. . Grouping of the Ten Landfill Site Selection Subcriteria into Physical, Environmental, and Socio-Economic Categories, as Used in the GIS–AHP Analysis for Ogan Ilir Regency

equivalent number of criteria (n) (Table 3) (Barakat et al., 2017). The Consistency Index (CI) is determined based on the size of the matrix ($n \times n$) and can be calculated using the following Equations (1-2):

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)} \tag{1}$$

where $\lambda_{\max}$ refers to the average of the maximum eigenvalues (average eigenvalue) calculated from the pairwise comparison matrix, and n represents the total number of criteria or subcriteria involved. Subsequently, the Consistency Ratio (CR) is obtained with:

$$CR = \frac{CI}{RI} \tag{2}$$

Here, RI stands for the Random Index, which corresponds to the number of criteria, as detailed in Table 4. The RI value reflects the average consistency index for randomly formed matrices of the same size. Calculating both CI and CR is essential for assessing the logical consistency and reliability of the expert comparisons used in the AHP process.

A weighted linear combination (WLC) technique was employed by merging standardized sub-criteria with their respective weights of importance. The reclassified layers were then integrated using the weighted overlay method based on predefined suitability thresholds (Yunis et al., 2020). Raster

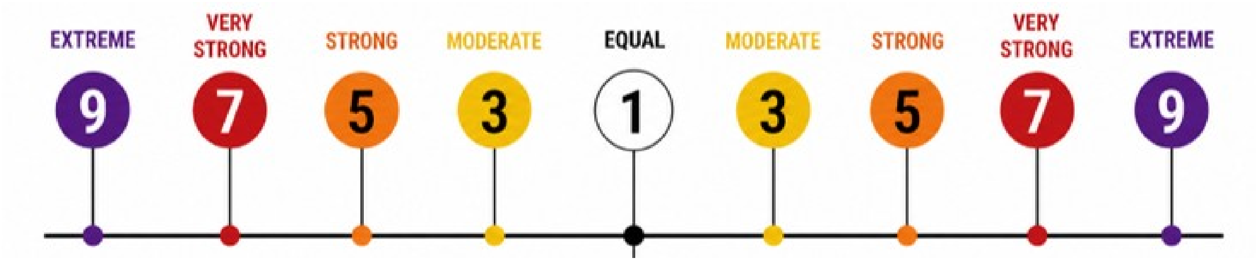

Figure 3. Saaty's Scale of Importance Intensity Used for Pairwise Comparison in the Analytical Hierarchy Process (AHP) for Landfill Site Selection

Table 2. Saaty's 1-9 Scale of Importance Intensity with Explanations Used for Pairwise Comparison in the Analytical Hierarchy Process (AHP) for Landfill Site Selection Criteria

Scale Value	Definition	Explanation
1	Same Level of Importance	Both criteria are considered equally vital
3	Moderate Importance	One criterion is slightly more important
5	Strong Importance	One factor is clearly more significant
7	Very Strong Importance	One element is strongly favored
9	Extreme Importance	One aspect is overwhelmingly preferred
2, 4, 6, 8	Intermediate Values	Values used for compromise between above judgments
1/2, 1/3, etc	Reciprocals of the Above Values	Applied when assessing the relative importance in the opposite direction between two factors

Table 3. Random Index (RI) Values for Different Matrix Sizes (n), as Proposed by Saaty (2008), Used to Assess the Consistency of Pairwise Comparison Matrices in the AHP

n	1	2	3	4	5	6	7	8	9	10	11	12	13
RI	0	0	0.525	0.882	1.115	1.252	1.341	1.404	1.452	1.484	1.513	1.535	1.555

layers for each criterion were then merged to generate the final landfill site suitability model.

To enhance the reliability of the suitability model and confirm the appropriateness of the chosen sites, validation was carried out using up-to-date Landsat 8 satellite imagery. Land cover classification was conducted using standard remote sensing techniques to identify categories such as built-up areas, agricultural land, and water bodies. The distribution of highly suitable zones was compared with the classified land cover to ensure that these areas did not overlap with environmentally sensitive, protected, or densely developed zones. Visual inspection and, where feasible, quantitative assessment were performed to confirm that the selected sites corresponded to open or less-utilized land, consistent with scientific and regulatory criteria for landfill siting. This validation process added methodological rigor and ensured that the proposed landfill sites are both environmentally appropriate and practically feasible.

3. RESULTS AND DISCUSSION

3.1 Criteria Weights and Their Influence

Sub-criteria maps were generated by applying established suitability thresholds to each thematic layer within the GIS framework. Figure 4 illustrates the reclassified maps based on the suitability thresholds presented in Table 4. The weighting of criteria in this study was performed using the Analytical Hierarchy Process (AHP), which involved pairwise comparisons of ten subcriteria based on expert judgment and the Saaty 1-9 scale. For 10 pair of subcriteria, a judgment was made regarding which one held greater importance, followed by the assignment of a numerical value to reflect the degree of preference (Table 5). Table 6 displays the weights of the subcriteria, which have been standardized and evaluated according to their impact on the effectiveness of landfill site selection in Ogan Ilir Regency. The variation in significance of the subcriteria is clarified by the amount of and differences in subcriteria used, together with contextual realities and expert knowledge (Guiqin et al., 2009).

The pairwise comparisons demonstrated acceptable consistency, as indicated by a Consistency Ratio (CR) of 7.7%, indicating acceptable consistency as it is below the 10% threshold (Table 7). The resulting weights assigned to each criterion are as follows: distance to fault (22.41%), proximity to built-up areas (18.86%), land use/land cover (13.57%), proximity to rivers (9.31%), distance to roads (7.56%), distance to settlements (6.84%), proximity to industrial areas

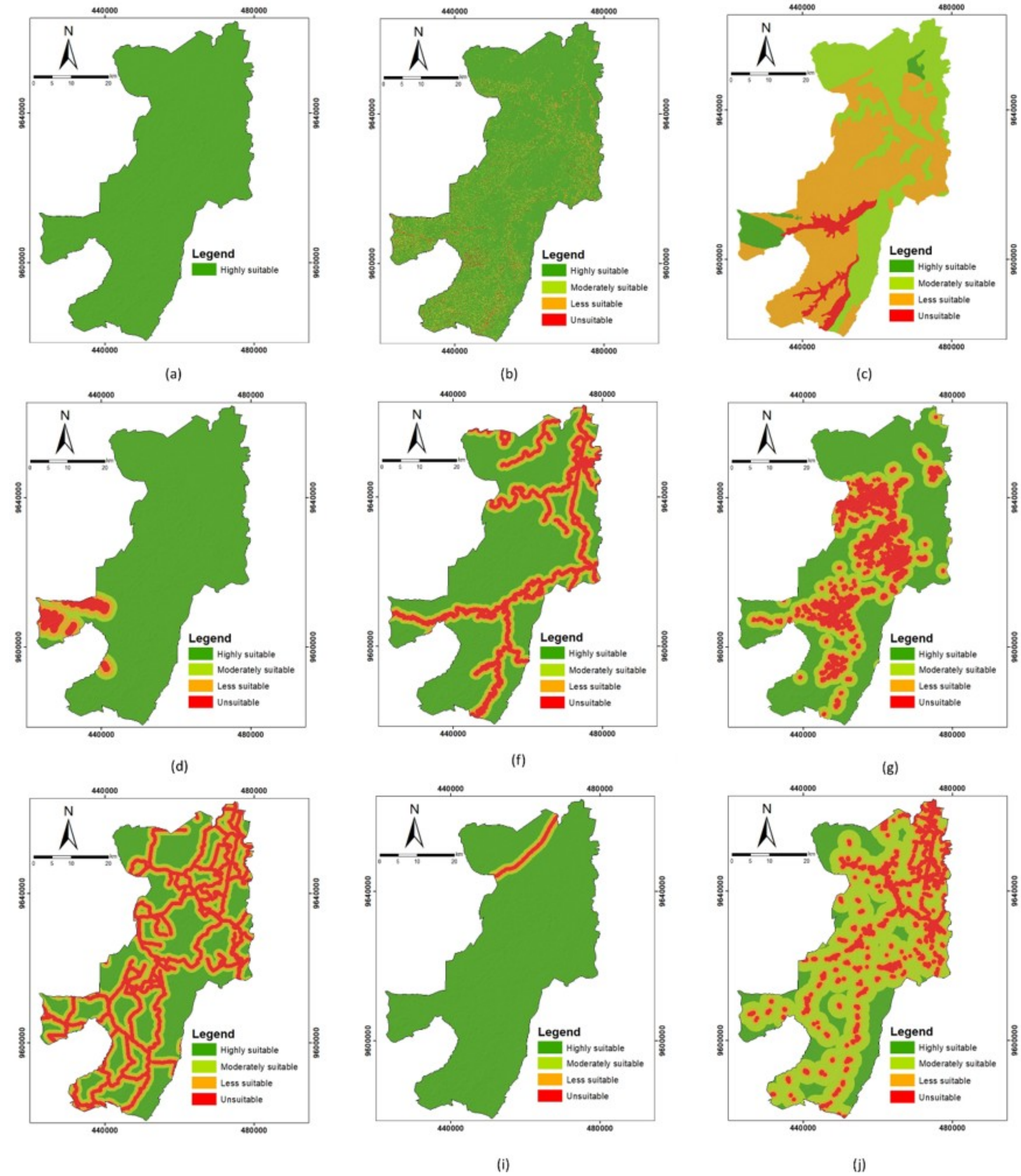

Figure 4. Spatial Distribution Maps of Landfill Site Selection Subcriteria in Ogan Ilir Regency, Including: (a) Elevation, (b) Slope, (c) Geology, (d) Proximity to Fault, (e) Land use/Land Cover (LULC), (f) Proximity to Sensitive Ecosystem, (g) Proximity to River, (h) Proximity to Roads, (i) Proximity to Railway Track, and (j) Proximity to Built-up Area

(5.22%), elevation (4.16%), soil type (3.59%), and slope (1.57%). These results highlight that geological safety (distance to fault), proximity to built-up areas, and land use are the most influential factors in landfill site selection in Ogan Ilir, reflecting the region's environmental and social priorities. The lower weights assigned to elevation, soil type, and slope indicate that these factors, while still important, play a more supportive role in the final decision. All determined weights were then applied in the GIS-based weighted overlay process to produce an overall map indicating landfill suitability within the study region.

3.2 Landfill Site Suitability Mapping

The landfill site suitability mapping in this study was carried out by integrating the weighted subcriteria, determined through the Analytical Hierarchy Process (AHP), into a GIS-based weighted overlay analysis. Each thematic spatial layer-representing physical (elevation, slope, geology,

Table 4. Landfill Site Suitability Criteria and Corresponding Area Coverage for Each Class in Ogan Ilir Regency, as Determined by the Integrated GIS-AHP Analysis

Subcri Teria	Parameter	Suitability Classes	Value	References	Area (ha)	Area (%)
Distance to river (m)	< 500	Unsuitable	1	Ng'ang'a et al. (2014)	39773.41	16.69
	500–1000	Less suitable	2		28168.26	11.82
	1000–1500	Moderately suitable	3		23829.37	10.00
	> 1500	Highly suitable	4		146476.66	61.48
Distance to road (m)	< 500	Unsuitable	1	Sisay et al. (2021)	88725.09	37.24
	500–1000	Less suitable	2		63660.94	26.72
	1000–1500	Moderately suitable	3		49128.38	20.62
	> 1500	Highly suitable	4		36733.31	15.42
Distance to railway track (m)	< 500	Unsuitable	1	Dolui and Sarkar (2021)	2441.03	1.02
	500–1000	Less suitable	2		2427.75	1.02
	1000–1500	Moderately suitable	3		2453.44	1.03
	> 1500	Highly suitable	4		230925.51	96.93
Slope (%)	> 20	Unsuitable	1	Debalke and Admas (2022)	5371.29	2.25
	15–20	Less suitable	2		7713.17	3.24
	10–15	Moderately suitable	3		19675.02	8.26
	< 10	Highly suitable	4		205486.28	86.25
Elevation (m)	< 70	Highly suitable	4	Chabuk et al. (2017)	238245.76	100.00
	> 70	Unsuitable	1		0	0
Distance to Sensitive ecosystem (m)	< 500	Unsuitable	1	Karthiheyan and Yeshodha (2016)	17498.00	7.34
	500–1000	Less suitable	2		6825.00	2.86
	1000–2000	Moderately suitable	3		11950.47	5.02
	> 2000	Highly suitable	4		201974.23	84.77
Distance to Fault (m)	< 1000	Unsuitable	1	Mussa and Suryabhagavan (2021)	5793.05	3.19
	1000–2000	Less suitable	2		6909.08	2.90
	2000–3000	Moderately suitable	3		2087.39	2.30
	> 3000	Highly suitable	4		218258.19	91.61
Geology (lithology)	Alluvium: Sand, silt, and clay	Unsuitable	1	Magoura et al. (2023)	14116.88	5.93
	Kasai Formation: Pumiceous tuff, sandy tuff and tuffaceous sandstone	Less suitable	2		127229.81	53.40
	Swamp deposits: mud, silt and sand	Moderately suitable	3		85846.43	36.03
	Muaraenim Formation: Tuffaceous claystone, siltstone and sandstone with coal intercalations	Highly suitable	4		11054.59	4.64
Distance to Built-up area (m)	< 500	Unsuitable	1	Silva López et al. (2022)	46662.03	19.59
	500–1000	Less suitable	2		43428.77	18.23
	1000–3000	Moderately suitable	3		109389.70	45.91
	> 3000	Highly suitable	4		38767.22	16.27
LULC (Class)	Water Body	Unsuitable	1	Redjem et al. (2021)	11220.08	4.71
	Built-up area	Less suitable	2		67877.02	28.49
	Agriculture area	Moderately suitable	3		159150.57	66.80

distance to fault), environmental (land use/land cover, sensitive ecosystems, proximity to rivers), and socioeconomic criteria (distance to roads, railway, and built-up areas)-was reclassified according to established suitability thresholds. All layers were converted to raster format and combined using the Weighted Linear Combination (WLC) technique in ArcGIS. The resulting landfill suitability map classified Ogan Ilir Regency into three categories: less suitable (1.81% or 4,307.73 ha), moderately suitable (74.46% or 177,404.25 ha), and highly suitable (23.73% or 56,533.78 ha) for landfill development (Figure 5). The comprehensive suitability mapping produced in this study will supports the development of environmentally responsible landfill management strategies.

Table 5. Pairwise Comparison Matrix of Landfill Site Selection Subcriteria Used in the AHP Process, Which Displays the Relative Importance Assigned to Each Subcriterion by Experts to Facilitate the Calculation of Criteria Weights

Criteria	Geology	Fault	Slope	Elevation	LULC	Settlement	River	Road	Railway Track	Sensitive Ecosystem
Geology	1.00	0.50	0.50	6.00	0.33	0.25	0.33	2.00	2.00	2.00
Fault	2.00	1.00	2.00	8.00	2.00	3.00	3.00	5.00	4.00	5.00
Slope	2.00	0.50	1.00	7.00	2.00	0.33	2.00	4.00	5.00	2.00
Elevation	0.17	0.13	0.14	1.00	0.17	0.13	0.20	0.33	0.25	0.13
LULC	3.00	0.50	0.50	6.00	1.00	0.50	3.00	4.00	5.00	3.00
Built-up area	4.00	0.33	3.00	8.00	2.00	1.00	4.00	3.00	3.00	4.00
River	3.00	0.33	0.50	5.00	0.33	0.25	1.00	2.00	2.00	2.00
Road	0.50	0.20	0.25	3.00	0.25	0.33	0.50	1.00	0.50	0.50
Railway track	0.50	0.25	0.20	4.00	0.20	0.33	0.50	2.00	1.00	0.50
Sensitive ecosystem	0.50	0.20	0.50	8.00	0.33	0.25	2.00	2.00	2.00	1.00
Total	16.67	3.94	8.59	56.00	8.62	6.38	16.53	25.33	24.75	20.13

Table 6. Normalized Pairwise Comparison Matrix and Final Weights of Landfill Siting Subcriteria Derived from the AHP Analysis

Criteria	Geology	Fault	Slope	Elevation	LULC	Settlement	River	Road	Railway Track	Sensitive Ecosystem	Criteria Weight	%	Ranking
Geology	0.06	0.13	0.06	0.11	0.04	0.04	0.02	0.08	0.08	0.10	0.07	7.09	6
Fault	0.12	0.25	0.23	0.14	0.23	0.47	0.18	0.20	0.16	0.25	0.22	22.41	1
Slope	0.12	0.13	0.12	0.13	0.23	0.05	0.12	0.16	0.20	0.10	0.14	13.53	4
Elevation	0.01	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	1.57	10
LULC	0.18	0.13	0.06	0.11	0.12	0.08	0.18	0.16	0.20	0.15	0.14	13.57	3
Built-up area	0.24	0.08	0.35	0.14	0.23	0.16	0.24	0.12	0.12	0.20	0.19	18.86	2
River	0.18	0.08	0.06	0.09	0.04	0.04	0.06	0.08	0.08	0.10	0.08	8.10	5
Road	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.04	0.02	0.02	0.04	3.59	9
Railway track	0.03	0.06	0.02	0.07	0.02	0.05	0.03	0.08	0.04	0.02	0.04	4.38	8
Sensitive ecosystem	0.03	0.05	0.06	0.14	0.04	0.04	0.12	0.08	0.08	0.05	0.07	6.90	7

Table 7. Calculation of Consistency Index (CI) and Consistency Ratio (CR) for the AHP Pairwise Comparison Matrix, Used to Assess the Reliability and Consistency of Expert Judgments in the Weighting Process

Criteria	Geology	Fault	Slope	Elevation	LULC	Settlement	River	Road	Railway Track	Sensitive Ecosystem	Weighted Sum	Criteria Weight
Geology	0.07	0.11	0.07	0.09	0.05	0.05	0.03	0.07	0.09	0.14	0.76	0.07
Fault	0.14	0.22	0.27	0.13	0.27	0.57	0.24	0.18	0.18	0.35	2.54	0.22
Slope	0.14	0.11	0.14	0.11	0.27	0.06	0.16	0.14	0.22	0.14	1.50	0.14
Elevation	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.17	0.02
LULC	0.21	0.11	0.07	0.09	0.14	0.09	0.24	0.14	0.22	0.21	1.53	0.14
Built-up area	0.28	0.07	0.41	0.13	0.27	0.19	0.32	0.11	0.13	0.28	2.19	0.19
River	0.21	0.07	0.07	0.08	0.05	0.05	0.08	0.07	0.09	0.14	0.90	0.08
Road	0.04	0.04	0.03	0.05	0.03	0.06	0.04	0.04	0.02	0.03	0.39	0.04
Railway track	0.04	0.06	0.03	0.06	0.03	0.06	0.04	0.07	0.04	0.03	0.46	0.04
Sensitive ecosystem	0.04	0.04	0.07	0.13	0.05	0.05	0.16	0.07	0.09	0.07	0.76	0.07
$\lambda max =$			11.03	$CI =$			0.11	$RI =$			1.49	$CR = 0.077$

3.3 Identified Suitable Locations

Based on the landfill suitability map generated through the GIS–AHP analysis, several specific areas within Ogan Ilir Regency were identified as highly suitable for landfill development. These locations are primarily concentrated in the northwestern and southeastern parts of the regency, where favorable geological conditions, compatible land use, and appropriate distances from sensitive receptors such as residential areas and water bodies are most evident. The selected sites are located away from major fault lines and densely populated zones, minimizing potential environmental and social conflicts. Notably, areas near Muara Kuang subdistrict, Lubuk Keliat subdistrict, and Indralaya Utara subdistrict fulfill the majority of suitability criteria, including safe distances from rivers and built-up areas, as well as convenient access via main roads. These sites are also characterized by flat terrain and suitable soil types, further supporting their appropriateness for landfill development.

To ensure the reliability of the selected landfill sites, validation was conducted using recent Landsat 8 satellite imagery (Figure 6). By overlaying the GIS–AHP suitability results with land cover data derived from Landsat 8, it was confirmed that the highly suitable areas correspond to regions with minimal environmental constraints, absence of significant development, and no overlap with protected ecosystems. The 30-meter spatial resolution of Landsat 8 enabled a comprehensive assessment, verifying that candidate sites are primarily situated in bare soil or open land, thereby minimizing biophysicochemical risks to the surrounding environment. This integrated GIS and remote sensing approach reinforces the robustness of the site selection process and provides confidence for local authorities in prioritizing these areas for further investigation and sustainable waste management planning in Ogan Ilir Regency.

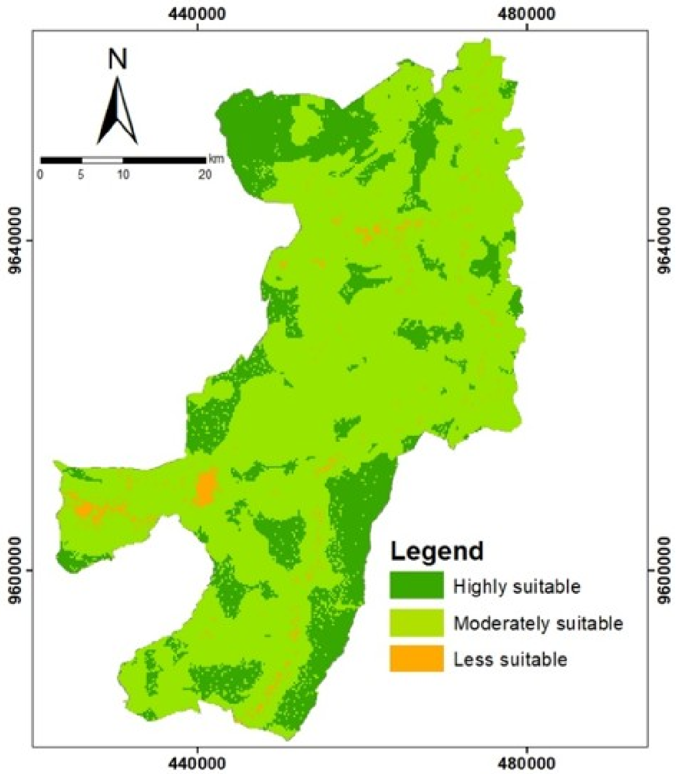

Figure 5. Final Landfill Suitability Map for Ogan Ilir Regency, Showing Less Suitable, Moderately Suitable, and Highly Suitable Zonesas Identified by the Integrated GIS–AHP Analysis

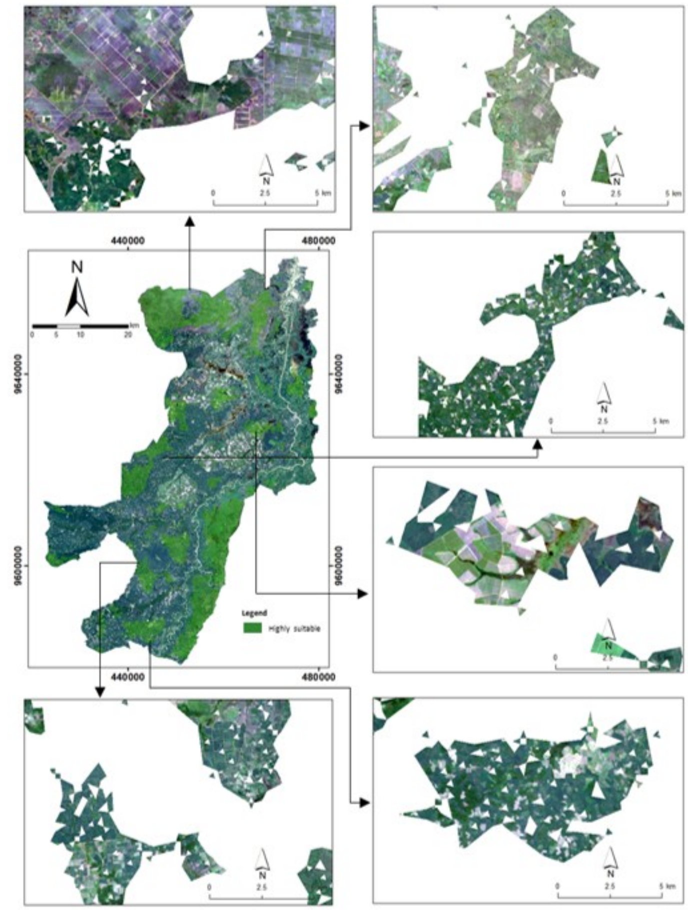

Figure 6. Aerial Imagery of Some Highly Suitable Sites for Landfill

3.4 Comparative Analysis, Practical Implications, and Study Limitations

The results of this study are generally consistent with prior research on landfill site selection utilizing GIS–AHP, both within Indonesia and internationally. Similar to previous studies, this work highlights geological safety, distance to built-up areas, and land use as the key factors influencing the suitability of landfill locations (Al-Anbari et al., 2018; Al-Hanbali et al., 2011; Asori et al., 2022). However, the specific weighting and prioritization of criteria in Ogan Ilir reflect unique local considerations, with physical criteria receiving the highest weighting, followed by environmental factors. This results in a spatial suitability pattern distinct from those observed in regions with different physical characteristics. In the Alto Utcubamba Commonwealth, Peru, by contrast, environmental criteria were given the highest priority, followed by physical criteria, highlighting a strong emphasis on environmental sustainability in that context (Santisteban et al., 2024).

Notably, this study advances the methodology by incorporating validation with Landsat 8 satellite imagery, providing an additional level of confidence in the suitability assessment and addressing a common limitation in previous GIS–AHP studies. This integration aligns with established international methodologies, such as the work of Oyedele et al. (2022) in Ado-Ekiti, South-western Nigeria, who utilized the multi-spectral capabilities of Landsat 8 to generate and validate Land Use/Land Cover (LULC) maps with a high degree of accuracy. By employing this satellite-based validation, the Ogan Ilir study confirms that candidate sites (highly suitable) are located in low-risk areas such as agriculture, thereby minimizing potential biophysicochemical risks to the surrounding ecology.

The practical implications of these findings are significant for waste management planning in Ogan Ilir Regency. The comprehensive suitability map generated through this approach offers local policymakers a robust decision-support tool for identifying and prioritizing optimal landfill sites, similar to the management frameworks proposed for developing regions. By integrating multiple criteria and validating the results with up-to-date satellite imagery, the study ensures that selected locations align with both scientific best practices and local needs, thereby supporting more sustainable and effective waste management strategies.

Despite these strengths, the study has several limitations. The selection of criteria and their corresponding weights were based on expert judgment and available data, which may introduce subjectivity-a challenge also noted in the study regarding the "low availability of cartographic data". Additionally, while Landsat 8 provides an excellent regional-scale assessment, it lacks the ultra-high-resolution detail of tools like drone photogrammetry used in other contexts to verify specific site shapes and compactness coefficients (Kc). Therefore, further field verification is recommended to confirm site conditions and community acceptance. Future research should consider incorporating additional environmental and socio-economic criteria, as well as stakeholder engagement, to enhance the comprehensiveness of the process. Integrating more advanced techniques such as machine learning, fuzzy logic, or neural networks could also improve the accuracy and robustness of landfill suitability assessments in similar contexts.

4. CONCLUSIONS

This study successfully applied an integrated GIS–AHP approach to identify and prioritize suitable landfill sites in Ogan Ilir Regency. Ten physical, environmental, and socio-economic subcriteria were established and weighted using the Analytical Hierarchy Process, with geological safety, proximity to built-up areas, and land use emerging as the most influential factors. The spatial analysis, performed through a weighted overlay in a GIS environment, produced a detailed suitability map categorizing the region into less suitable, moderately suitable, and highly suitable areas for landfill development. Validation using Landsat 8 satellite imagery reinforced the reliability of the selected sites, confirming their compatibility with scientific and environmental requirements. Comparative analysis with previous studies demonstrates that, while the GIS-AHP methodology is well established, its application in Ogan Ilir Regency provides insights into local spatial patterns and priorities. Although subject to limitations in expert judgment and data availability, this method delivers practical guidance for sustainable waste management planning. The experience in Ogan Ilir underscores the value of combining spatial analysis and remote sensing, offering a replicable framework for similar regions facing landfill site selection challenges.

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