GIS-Based Suitability Analysis of Landfill Sites in Davao City, Philippines

Gerome Kevin T. Argao [1], Vinz Adrian O. Crisostomo [1], Van Ulrich G. Delos Santos [1], Alexis Richard C. Claridades [1]

[1] Department of Geodetic Engineering, University of the Philippines Diliman, Quezon City, Philippines - {gtargao, vocrisostomo, vgdelossantos, acclaridades}@up.edu.ph

Keywords: GIS, MCDM, Sanitary Landfill, Site Suitability, Solid Waste Disposal, Weighted Overlay Analysis

Abstract

The continued rise in solid waste generation in Davao City has placed significant pressure on its existing landfill infrastructure, with the lone operational facility in New Carmen reaching full capacity. Existing studies have highlighted the advantages of using Geographic Information Systems (GIS) in site suitability analysis, owing to their capacity to integrate multiple spatial factors and provide evidence-based decision support; this method can be useful for identifying a new landfill location. In response, this study investigates the spatial suitability of current, proposed, and alternative landfill locations through a GIS-based multi-criteria method grounded in the standards set by the DENR-NSWMC Resolution No. 64, Series of 2013. Spatial datasets corresponding to environmental, geological, infrastructural, and regulatory criteria were evaluated through a weighted overlay analysis, with priority coefficients of parameters derived from expert-based pairwise comparisons under the Analytical Hierarchy Process framework. The assessment revealed that both the existing and the proposed adjacent landfill locations generally fall within the "less suitable" classification, failing to meet several critical spatial and environmental thresholds. In contrast, a previously unconsidered site located in Barangays Callawa and Riverside met all key suitability conditions, including the minimum required area, and demonstrated full regulatory compliance to all parameters. This study underscores the importance of evidence-based spatial planning in addressing urban waste challenges and offers a replicable framework for identifying sustainable landfill locations in rapidly growing cities.

1. Introduction

Solid waste is an inevitable byproduct of modern life. While individual initiatives help, effective management requires coordinated community and government action to ensure proper handling and disposal. According to the World Health Organization (WHO), negligent and irresponsible waste disposal practices contribute to pollution of the environment and pose significant health risks. Landfill sites have been established globally to manage waste safely.

As stated by the United States Environmental Protection Agency (US EPA, 2024), landfills are facilities specifically designed for solid waste disposal. These are selected based on criteria set by environmental authorities such as the Department of Environment and Natural Resources (DENR) as the main governing body in the Philippines. Particularly, the National Solid Waste Management Commission (NSWMC) under DENR oversees the policy implementation in managing solid waste. The NSWMC established landfill site selection parameters in 1998, which were expanded in 2013. Despite these guidelines, many landfills remain in unsuitable areas, raising environmental and health concerns (Sadie et al., 2022).

Technological advancements have significantly shaped modern waste management practices, with Geographic Information Systems (GIS) playing an important role. GIS provides a platform to study complex relationships between different geographic factors with the use of spatial data (Dempsey, 2024). Its significance lies in its capacity to integrate multiple datasets into a single analytical framework. In the context of managing solid wastes, GIS supports identification of landfill site by providing a data-driven evaluation of multiple criteria. This evaluation enhances the selection of sites that minimize adverse effects on communities and ensure adherence to environmental and technical standards.

Davao City exemplifies the challenges of solid waste management in urban areas. The city generates approximately 700 to 800 tons of solid waste daily, with this amount increasing to as much as 1,000 tons during special events (City Government of Davao, 2023). The New Carmen Landfill, covering seven hectares, is currently the only operational sanitary landfill serving the city, but it was projected to reach capacity by 2023 (Colina IV, 2022). Although a potential site adjacent to the current landfill was identified (City Government of Davao, 2023), no comprehensive GIS-based evaluation has been conducted to determine its suitability according to the standards outlined in DENR-NSWMC Resolution No. 64.

This research addresses this gap by developing and applying a GIS-based workflow to analyze landfill site suitability in Davao City. It integrates the criteria specified in DENR-NSWMC Resolution No. 64 to create a landfill site suitability map for selection, assess the suitability of the existing New Carmen Landfill and the proposed adjacent site for long-term solid waste disposal, and identify and propose alternative landfill site(s) that meet the established criteria.

In addition to addressing solid waste management challenges, this study supports key UN Sustainable Development Goals (SDGs) relevant to sustainable urban development. It advances SDG 9 (Industry, Innovation, and Infrastructure) by integrating GIS and MCDM frameworks, showcasing innovative technology use in urban planning and waste management. This enhances the development of resilient, sustainable landfill infrastructure to meet Davao City's needs. The study also contributes to SDG 11 (Sustainable Cities and Communities) through evidence-based landfill site identification that prioritizes environmental safety and minimizes community impacts. Lastly, it supports SDG 12 (Responsible Consumption and Production) by promoting efficient, sustainable solid waste management that reduces environmental impact and fosters responsible resource use.

The remaining sections of the paper follow the structure: Section 2 offers a review of related studies on solid waste management, the selection of landfill sites, and suitability assessments using GIS. Section 3 describes the research methodology employed, while Section 4 details and analyzes the findings, comparing the current landfill, a proposed adjacent site, and potential alternative site. Lastly, Section 5 summarizes key conclusions and suggests directions for future studies and policy improvements.

2. Related Studies

In recent years, researchers have focused on managing landfill sites with an emphasis on data-driven decision-making. For instance, Macalam et al. (2023) analyzed optimal landfill locations in Butuan City, Philippines, using NSWMC guidelines and GIS-based spatial analysis. Their study classified site suitability into three categories—moderately suitable, highly suitable, and very highly suitable—while considering only sites that met the minimum recommended landfill size. By aligning their analysis with barangay boundaries, they facilitated administrative integration and identified Barangay Tungao and Barangay Florida as the most highly suitable areas. However, they noted limitations from insufficient detailed spatial data and recommended on-site investigations for future research. Building on this approach, the present study develops a continuous suitability map for the entire Davao City boundary, thereby avoiding the potential administrative fragmentation of barangay-based analysis. It also reclassifies suitability into three categories—most suitable, less suitable, and not suitable—in line with NSWMC Resolution No. 64.

The GIS-based methodology of Macalam et al. can be enhanced through multi-criteria decision-making (MCDM). Sadie et al. (2022) used a Fuzzy Multi-Criteria Analysis for landfill site selection in Quezon City following the Payatas Landfill closure. By assigning weights to parameters, they ranked factors by relative importance and identified 26 potential sites, with three standing out for their proximity to key urban areas. They recommended adding factors such as wind direction and site development costs, highlighting the need for a comprehensive, context-specific framework. In contrast, this study applies expert-based parameter prioritization and vector overlay analysis instead of fuzzy methods, enabling systematic integration of multiple criteria within Davao City's jurisdiction. It also aims to identify one alternative landfill location that meets national standards and remains near the existing site, considering the proposal to establish a new landfill adjacent to it.

Hazarika and Saikia (2020) utilized Analytical Hierarchy Process (AHP) in Guwahati, India to evaluate site suitability for landfill, categorizing sites into five levels of suitability from the most suitable to the least suitable areas. Their quantitative breakdown, 7.5%, 22.8%, 43.8%, 22.2%, and 3.6% respectively, enabled clear visualization of suitable areas, identifying five viable relocation sites for the city's landfill. Similarly, this suitability analysis for Davao City employed AHP through pairwise comparison to systematically evaluate parameter importance. However, this study uses a three-category classification: most suitable, less suitable, and not suitable. The classification is based on adherence to at least one critical parameter or full compliance with all criteria, thus facilitating focused comparison while aligning with national standards.

Arabeyyat et al. (2024) also utilized AHP to evaluate landfill site selection in Al-Balqa Governorate, Jordan by applying pairwise comparison to integrate technical, environmental, and economic factors. Their approach demonstrated the effective integration of multiple parameters, providing a comprehensive framework for identifying optimal landfill sites. The current study similarly employs AHP to assign priority coefficients to various parameters, ensuring systematic and transparent evaluation of landfill site suitability within the area of interest.

The 2024 report by the Davao City Government provides valuable insights into landfill site selection processes specific to Davao City. This report describes the selection of Barangay New Carmen as the proposed landfill site, a decision informed by recommendations and evaluations conducted by local agencies and consultants. Additionally, the report outlines the anticipated impacts of the landfill's construction, highlighting both potential benefits, such as increased employment opportunities, and potential drawbacks, including traffic congestion. This study seeks to complement this local government initiative by providing a data-driven, GIS-based analysis of landfill site suitability. The analysis aims to address waste management concerns systematically and provide an objective foundation for landfill site selection and management.

3. Methodology

3.1 Study Area

Davao City is found in the southeastern area of Mindanao, Philippines. It lies within Region XI (Davao Region) and serves as the region's economic and administrative center. Figure 1 presents Davao City's location in the Philippines.

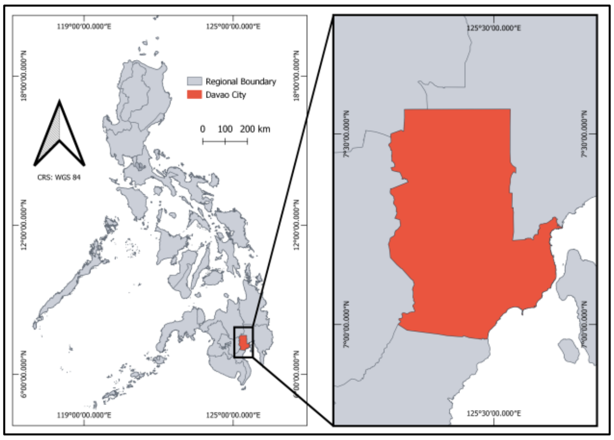

Figure 1. Geographical location of Davao City in the Philippines.

The National Economic and Development Authority (NEDA) reported that it is the only highly urbanized city in the region and holds the distinction of being the country's largest city by land area, covering 2,444 km². Based on the 2020 census done by the Philippine Statistics Authority (PSA), its population stands at 1,776,949. Furthermore, a steady increase in the volume of collected garbage over the years has been recorded by the City Environment and Natural Resources Office (CENRO). The annual garbage collected from years 2020-2022 is shown in Table 1.

Year	Garbage collected (tons)
2020	223, 431
2021	254, 750
2022	258, 829

Table 1. Garbage collected from 2020 to 2022 in Davao City.

Presently, Davao City operates a single seven-hectare sanitary landfill located in Barangay New Carmen. However, this facility reached its maximum capacity in 2023 (Colina IV, 2022). With the continuous increase in population and economic activities,

https://doi.org/10.5194/isprs-annals-X-5-W4-2025-59-2026 | © Author(s) 2026. CC BY 4.0 License.

the volume of generated waste has exceeded the landfill's designed capacity. Consequently, a new landfill site has been proposed adjacent to the existing facility.

3.2 Methodological Framework

This study utilized an MCDM strategy integrated into a GIS environment to identify suitable landfill sites. Figure 2 illustrates the methodological framework, outlining the sequential geospatial processes—data acquisition, preparation, analysis, and interpretation—that informed the suitability assessment of landfill sites in Davao City.

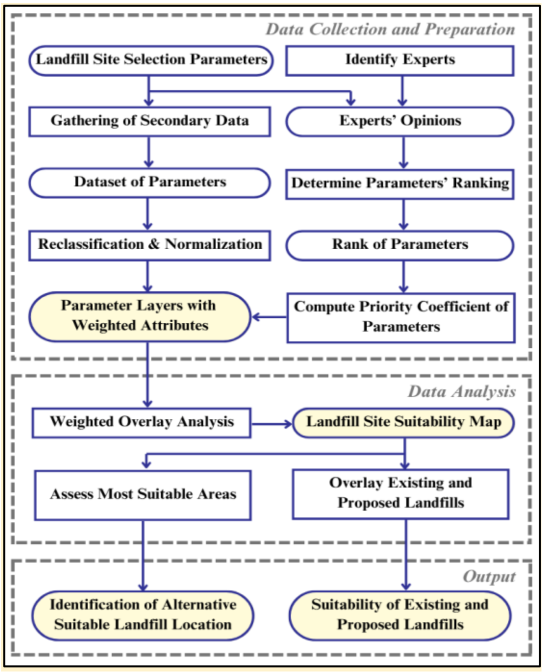

Figure 2. Geospatial framework for suitability analysis of landfill site in Davao City.

The framework provides a systematic approach to landfill site identification based on the NSWMC Resolution, comprising three phases: Data Collection and Preparation, Data Analysis, and Output. In the first phase, key parameters influencing landfill suitability are identified and weighted through expert opinion. Secondary data are then collected, normalized, and reclassified to create parameter layers with computed priority coefficients. In the Data Analysis phase, these layers are integrated using a vector overlay technique in a GIS environment, producing a landfill suitability map cross-referenced with existing and proposed sites to detect overlaps and conflicts. Finally, the Output phase identifies alternative suitable sites and evaluates existing and proposed sites against the established criteria.

3.3 Review of the NSWMC Resolution No. 64 Criteria

The National Solid Waste Management Commission (NSWMC) Resolution No. 64 sets out regulatory guidelines for identifying appropriate landfill sites. It defines a range of environmental, physical, and socio-economic factors that must be considered to ensure landfills are safe and compliant with national standards. Table 2 provides a summary of these spatial parameters.

Parameter	Criteria	Consideration
Proximity to Groundwater Resources (PGR)	not within 0.5 km	not within 1 km
Proximity to Perennial Surface Waters (PPW)	not within 0.3 km	not within 1 km
Local Geological Conditions (LGC)	not located on porous rock formations	not within 0.3 km of porous rock formations
Seismic Conditions (SC)	not within 0.075 km of active faults	not within 0.5 km of active faults
Soil Properties (SP)	not located on unstable, very soft, and unsettling soils	not within highly permeable soils
Topography (T)	not within areas with ground slope >50%	not within areas with ground slope >20%
Vulnerability to Flooding (VF)	not located in swampland, marshes, wetlands, and highly susceptible to flood	not in locations that could experience washout or flooding during a major flood event
Proximity to Residential Areas and Other Sensitive Land Uses (PRS)	not within 0.25 km	not within 1 km
Proximity to Ecologically Sensitive or Environmentally Critical Areas (PEC)	not within 0.5 km	
Consistency with Current or Proposed Land Use Classification (CPL)	not be sited in areas designated for housing, commerce, industry, or agriculture, and should steer clear of major roads, waterways, and key utility or communication corridors	
Proximity to Airports (PA)	not within 1.6 km	not within 13 km
Landfill Area and Lifespan (LAL)	expected landfill service area = 2.6 ha/100,000 population for 0.5 kg/person/day	
Haul Distance, Accessibility and Road Conditions (HAR)	within 30 km from roadways	

Table 2. Spatial criteria and considerations for the parameters outlined in the NSWMC Resolution No. 64.

3.4 Data Collection and Preprocessing

Secondary data for the parameters were sourced from multiple platforms (Table 3), including the Humanitarian Data Exchange (HDE), DIVA-GIS, PhilGIS, VSU GIS, Geoportal, OpenTopography DEM, Phil-LiDAR LiPAD, OpenStreetMap (OSM), PSA, and the Local Government of Davao Project Description for Scoping Report (LGD PDSR). Each dataset was reclassified according to the criteria and considerations as detailed in Table 2.

Parameter	Data Type	Format	Source
PGR	Point	Vector	HDE
PPW	Line	Vector	DIVA-GIS
LGC	Polygon	Vector	PhilGIS

This contribution has been peer-reviewed. The double-blind peer-review was conducted on the basis of the full paper.
https://doi.org/10.5194/isprs-annals-X-5-W4-2025-59-2026 | © Author(s) 2026. CC BY 4.0 License.

SC	Line	Vector	VSU GIS
SP	Polygon	Vector	Geoportal
T	Digital Elevation Model	Raster	OT DEM
VF	Polygon	Vector	Phil-LiDAR LiPAD
PRS	Polygon & Point	Vector	Geoportal
PEC	Polygon	Vector	Geoportal
CPL	Polygon	Vector	Geoportal
PA	Polygon	Vector	Digitized (OSM)
LAL	Tabular	Compu-tational	PSA
HAR	Line	Vector	OSM
Base Map	Polygon	Vector	HDE
Existing Site	Polygon	Vector	Digitized (OSM)
New Site	Tabular	CSV	LGD PDSR

Table 3. Parameters and their data type, format, data source, and spatial processing used.

Proximity to groundwater resources was critical due to the risk of contamination from landfill leachate. Areas within 500 meters of groundwater sources were classified as not suitable, and those within 1 kilometer as less suitable, recognizing that contamination risks extend beyond immediate proximity. Similarly, areas within 300 meters of perennial rivers were considered not suitable, with the 1-kilometer buffer beyond this zone marked as less suitable to protect downstream ecosystems.

Geological characteristics were evaluated for their influence on leachate migration. Highly porous recent sedimentary deposits were not suitable, moderately porous unconsolidated non-sedimentary materials were of less suitable, and stable consolidated formations, being least porous, were most suitable for landfill containment. Fault lines were included due to seismic hazards. Areas within a 75-meter buffer of active faults were deemed not suitable, while a 500-meter buffer was considered less suitable to account for extended risk.

Soil type is important for its permeability and compaction properties. Permeable soils such as sandy clay loam and silty clay loam were less suitable. More compact soils like clay and clay loam were better at preventing leachate infiltration, hence most suitable. Topography, evaluated through slope gradients derived from a digital elevation model, was considered for stability and feasibility. Slopes above 50% posed high erosion and instability and were not suitable; slopes between 20% and 50% were less suitable; and slopes below 20% were most suitable.

Flood susceptibility was factored in to avoid waterlogging and contamination spread. Highly susceptible areas were rated not suitable, moderately susceptible zones less suitable, and low-susceptibility areas are most suitable. Proximity to residential and commercial zones was considered to protect public health and minimize land use conflicts. Areas within 250 meters were not suitable, while those within 1 kilometer were less suitable.

Ecologically sensitive areas, particularly Mount Apo Natural Park, were protected by designating sites within 500 meters as not suitable to preserve biodiversity and ecosystem integrity. Land cover data was analyzed to exclude developed or high-conservation areas such as built-up zones, forests, fishponds, water bodies, mangroves, and perennial crops (not suitable). More open land types like brush/shrubs, grasslands, and barren areas were deemed suitable for development.

Proximity to airports was assessed to prevent conflicts with aviation safety. Areas within 1.6 kilometers of Davao International Airport were not suitable, and those within 13 kilometers were less suitable due to potential operational hazards.

Population data were used to compute the expected landfill area requirement through Equation 1:

$$A = (2.6)\frac{p}{100{,}000} \tag{1}$$

where A = minimum area of the landfill site
p = population of the study area
2.6 is in hectares

Given the city's population of 1,776,949 (PSA, 2020), the required minimum landfill area is 46.201 ha.

Lastly, accessibility was evaluated based on proximity to major road networks in Davao City. It was determined that any location on the study area is located within a distance of 30 kilometers from these roadways, ensuring that they are adequately accessible for efficient landfill operations.

3.5 Weighted Overlay Analysis

To determine the relative importance of the parameters used in site identification, a pairwise comparison technique was applied through a structured questionnaire administered to five selected experts. Each expert contributed their professional expertise and specialized knowledge to the evaluation process, ensuring a well-rounded prioritization of selection parameters.

Expert 1 (E1), an economist, discussed economic feasibility and governance. Expert 2 (E2), an assistant professor in environmental and water resource management, provided technical insights on environmental and hydrological impacts. Expert 3 (E3), a lawyer and environmental advocate, contributed legal and policy perspectives. Expert 4 (E4), an environmental researcher, addressed geological and ecological factors. Expert 5 (E5), an architect and environmental planner, discussed land use and community integration in landfill siting. Table 4 presents the raw parameter rankings provided by the experts.

Parameter	**Ranking**				
	E1	**E2**	**E3**	**E4**	**E5**
PGR	12	7	6	8	3
PPW	13	1	5	10	4
LGC	9	10	7	7	5
SC	4	8	8	5	6
SP	8	9	13	6	7
T	5	2	11	11	9
VF	1	3	10	4	8
PRS	7	4	3	2	2
PEC	10	5	1	1	1
CPL	11	6	12	3	13
PA	2	11	4	13	10
LAL	3	12	2	9	11
HAR	6	13	9	12	12

Table 4. Parameter ranking of the experts.

The experts evaluated the parameters by systematically comparing each one against the others to determine which was more significant for landfill site identification. Comparative

https://doi.org/10.5194/isprs-annals-X-5-W4-2025-59-2026 | © Author(s) 2026. CC BY 4.0 License.

judgments were recorded using binary scoring, assigning a score of one (1) to the parameter deemed more important and zero (0) to the less important one. The resulting pairwise comparison data were aggregated across all expert responses to generate a composite score for each parameter, which served as the basis for the final ranking before applying the AHP in the subsequent analysis phase.

All experts were given equal importance in the evaluation process. The pairwise comparison scores were summed to obtain the cumulative score for each parameter, which were then ranked, with rank 1 assigned to the highest cumulative score and rank 13 to the lowest. Parameters with identical cumulative scores were assigned average ranks. The average rank for each parameter was computed using Equation 2.

$$\bar{R} = \frac{rank_1 + rank_2 + \cdots + rank_n}{n} \tag{2}$$

where $\bar{R}$ = average rank of the parameter
$rank_n$ = rank provided by expert "n"
n = total number of experts

The average ranks were then utilized to obtain the final priority coefficient for the parameters through the Equation 3:

$$P_i = \frac{1}{m}\Sigma\frac{1}{\bar{R}} \tag{3}$$

where P_i = priority coefficient
m = total number of parameters
$\bar{R}$ = average rank of the parameter

Table 5 shows the results. The priority coefficients computed from this process were utilized to calculate the suitability scores of identified locations. This facilitated the comparison of different landfill sites based on the established criteria.

Parameter	Ave. Rank	Final Rank	Priority Coefficient
HAR	10.4	13	0.0318
CPL	9	12	0.0477
SP	8.6	11	0.0582
PA	8	10	0.0662
T	7.6	8.5	0.0749
LGC	7.6	8.5	0.0749
LAL	7.4	7	0.0823
PGR	7.2	6	0.0863
PPW	6.6	5	0.0898
SC	6.2	4	0.0930
VF	5.2	3	0.0958
PRS	3.6	1.5	0.0997
PEC	3.6	1.5	0.0997

Table 5. Final rank and priority coefficients of the parameters. Lower numerical rank value signifies higher importance.

The parameter coefficients derived from the priority coefficients were integrated into a composite landfill suitability map through vector overlay. When summed, these coefficients yield a maximum score of 1.00, representing the most suitable areas in the study. Suitability classification multipliers were then applied to the priority coefficients, with values of 1 for most suitable areas, 0.5 for less suitable areas, and 0 for not suitable areas, to systematically reflect varying levels of suitability.

Each parameter layer was classified into suitability classes based on established thresholds and criteria, with appropriate GIS symbology applied to enhance interpretability. The final suitability map was generated by combining the reclassified parameter layers, weighted according to the parameter coefficients. The aggregated weighted values produced a continuous surface representing overall suitability for landfill site selection, which was subsequently categorized into most suitable, less suitable, and not suitable classes. This map provides a spatially explicit decision-support tool for identifying optimal landfill locations within the study area.

3.6 Sensitivity Analysis of Parameter Priority Coefficients

To address the subjectivity in deriving parameter priority coefficients from expert opinions, a sensitivity analysis was conducted using the raw rankings from the survey. Sensitivity analysis compares the original results with those obtained under varying conditions, often using the one-at-a-time (OAT) approach, where one input is altered while others remain constant (Chen et al., 2010).

In this study, the rankings of one expert were randomly changed using a random number generator to eliminate individual bias, while others remained unchanged. New parameter priority coefficients were computed from these modified rankings using Equations (2) and (3). The standard deviation between the original and modified coefficients was then calculated to quantify sensitivity. This process was repeated for each expert, and the overall average standard deviation was determined using Equation (4).

$$\overline{SD} = \frac{SD_1 + SD_2 + \cdots + SD_n}{n} \tag{4}$$

where $\overline{SD}$ = overall average standard deviation
SD_n = standard deviation of expert n
n = total number of experts

A linear regression analysis was also performed to assess the correlation between the original and randomized coefficients, serving as a visual measure of dataset similarity.

3.7 Assessment of the Existing and Proposed Landfill Locations

The existing and proposed landfill locations were evaluated against the established suitability criteria by overlaying their locations onto the generated suitability map, enabling spatial comparison between their footprints and the corresponding suitability classes. This spatial analysis systematically assessed each site's degree of compliance with the defined criteria.

Suitability scores for the existing and proposed sites were quantitatively derived using the parameter coefficients. For each site, parameter scores were calculated and summed to obtain the total suitability score. If a site covered multiple suitability classes, the scores were averaged based on the parameter coefficients and corresponding classification multipliers, as described in Section 3.5. These computations, combined with spatial query techniques in the GIS environment, allowed for precise determination of whether each site aligned with its respective suitability classification.

3.8 Identification of Alternative Landfill Location

Using the suitability map, areas classified as most suitable were extracted through spatial querying and polygon delineation, representing potential locations meeting the study's multi-criteria requirements. These alternative sites were analyzed for spatial contiguity and size sufficiency. Since the plan aimed to expand or site a landfill adjacent to the current facility, priority was given to areas near the existing landfill. Sites satisfying both suitability and operational requirements were prioritized as alternatives for future landfill development.

4. Results and Discussion

4.1 Suitability Map of Landfill Site in Davao City

The suitability map was developed by integrating the reclassified weighted vector layers of the parameters using vector overlay analysis. This is shown in Figure 3.

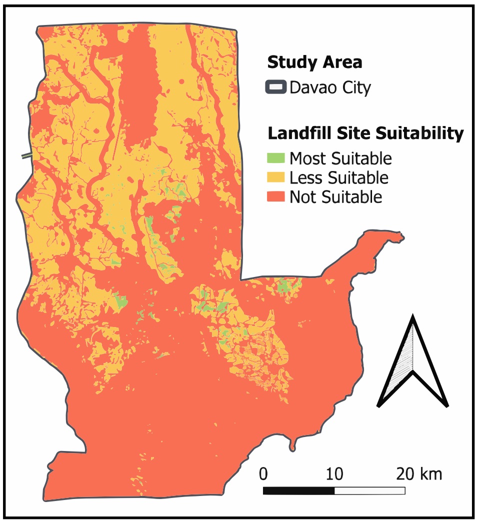

Figure 3. Suitability map of landfill site of Davao City.

Areas classified as most suitable were shown in green, with a suitability score of 1.00, indicating full compliance with all regulatory requirements and technical standards. Areas scoring 0 in at least one parameter, signifying a direct violation of a restrictive criterion, were classified as not suitable and displayed in red. Areas with partial compliance, scoring between 0 and 1, were classified as less suitable and shown in orange, meeting minimum standards but not fully conforming to all recommended criteria.

4.2 Sensitivity Analysis of Parameter Priority Coefficients

Sensitivity analysis was done on the parameter priority coefficients with a total of five (5) iterations to account for the five (5) experts. Table 6 presents the obtained standard deviation values and R^2 obtained from the performed analysis.

Randomized Expert	SD	Average SD	R^2
1	0.012	0.012	0.92
2	0.008		
3	0.014		
4	0.012		
5	0.014		

Table 6. Sensitivity analysis standard deviations and R^2.

The result indicates that variations in expert rankings exert minimal influence on the priority coefficients, as evidenced by the low standard deviation values. This confirms that the priority coefficients derived from expert opinions maintain stability even when individual responses are modified. Furthermore, the linear regression in Figure 4, with an R^2 value of 0.92, reflects a strong correspondence between the original and adjusted coefficients. These findings demonstrate that the assigned priority coefficients are not highly sensitive to changes, and that subjectivity in expert evaluations does not materially affect the overall MCDM results.

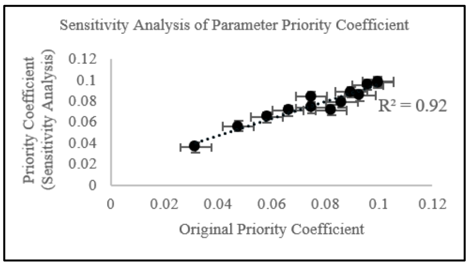

Figure 4. Scatter plot of the original priority coefficient and derived from the sensitivity analysis.

4.3 Suitability Assessment of the Existing and Proposed Landfill Locations

Figure 5 presents the assessment that both the existing landfill site, shown in blue, and the proposed landfill site, shown in pink, predominantly fall within areas classified as less suitable. These findings indicate that these sites, while not violating any exclusionary parameters, do not fully satisfy the strict criteria required for optimal landfill siting.

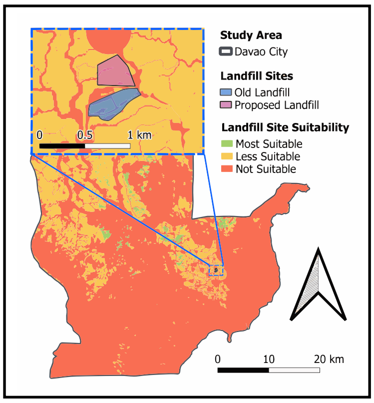

Figure 5. Less suitable existing and newly proposed landfill sites in Davao City.

The suitability scores of both the existing and proposed sites were calculated by applying the final priority coefficients derived from the pairwise comparison. These computed scores provide a quantitative assessment of each site's level of compliance with the NSWMC Resolution No. 64 criteria, confirming the results from the overlay analysis.

Parameter	Existing landfill	Proposed landfill
HAR	0.0318	0.0318
CPL	0.0291	0.0291
SP	0.0239	0.0239
PA	0.0331	0.0331
T	0.0375	0.0749
LGC	0.0624	0.0375
LAL	0.0088	0.0208
PGR	0.0863	0.0863
PPW	0.0898	0.0898
SC	0.0465	0.0465
VF	0.0479	0.0479
PRS	0.0748	0.0872
PEC	0.0997	0.0997
Suitability Score:	**0.6715**	**0.7085**

Table 7. Suitability scores of the existing and proposed landfill sites in New Carmen, Davao, City.

This contribution has been peer-reviewed. The double-blind peer-review was conducted on the basis of the full paper.
https://doi.org/10.5194/isprs-annals-X-5-W4-2025-59-2026 | © Author(s) 2026. CC BY 4.0 License.

Table 7 indicates that the existing landfill site meets the criteria for suitability in terms of parameters HAR, PGR, PPW, and PEC. However, it is classified as less suitable for the remaining parameters. The proposed landfill site demonstrated a similar pattern of results, except that it additionally satisfies the T parameter. The proposed landfill yielded a slightly higher overall suitability score of 0.7085 compared to the existing landfill's 0.6715, yet both remain classified under the "less suitable" category.

4.4 Identification of Alternative Landfill Location

Alternative landfill sites were identified from the suitability map by selecting areas that achieved the most suitable classification. Figure 6 presents the potential alternative sites. Given that the original plan involves the expansion or establishment of a landfill site adjacent to the existing facility, the proximity of potential sites to the existing landfill was also considered. Consequently, priority was given to sites located closest to the existing landfill.

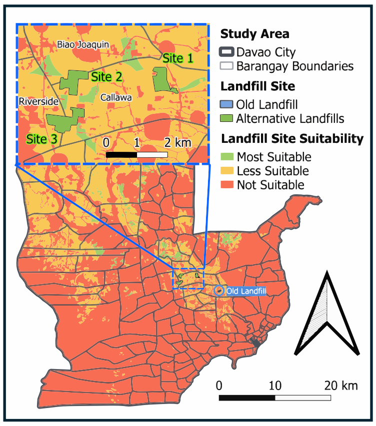

Figure 6. Three potential alternative landfill sites for Davao City.

Landfill Site	Area (ha)	Distance from old landfill (km)	Jurisdiction
Site 1	36.095	4.883	Brgy. Callawa
Site 2	41.552	7.319	Brgy. Callawa & Biao Joaquin
Site 3	51.650	7.443	Brgy. Callawa & Riverside

Table 8. Comparison of area, distance from existing landfill, and jurisdiction of the three potential alternative landfill sites.

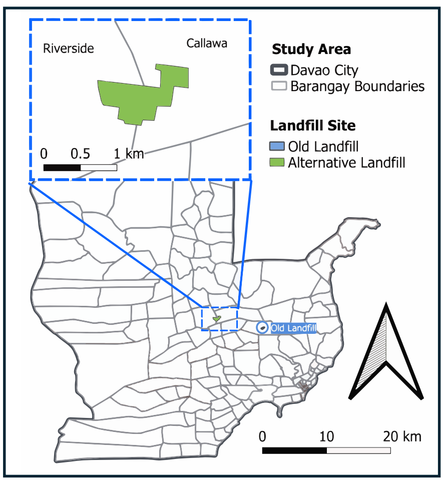

Figure 7. Proposed alternative landfill site within Barangays Callawa and Riverside, Davao City.

Three candidate sites were identified from the most suitable areas Each site was then evaluated for compliance with the minimum area requirement of 46.201 hectares. As presented in Table 8, Site 3 emerged as the most feasible option among the identified sites, with a total area of 51.650 hectares and located approximately 7.443 kilometers from the existing landfill. This site falls within the jurisdiction of Barangays Callawa and Riverside as seen on Figure 7. The other two alternative sites fall short in the minimum required area.

4.5 Discussion

The landfill site suitability analysis reveals a critical insight: both existing and proposed landfill sites fall short of fully meeting the regulatory and technical criteria of NSWMC Resolution No. 64, despite being operationally feasible in terms of accessibility and proximity. This indicates a planning gap in the current siting process, where minimum standards are met but optimal suitability, important for long-term environmental protection and efficient solid waste management, is compromised. The identification of Site 3 as the most feasible alternative landfill site presents a valuable opportunity to address this gap. Its compliance with both the minimum area requirement and proximity considerations ensures that it can accommodate the increasing solid waste demands of Davao City while minimizing logistical challenges associated with waste transport.

Establishing a new landfill site in a most suitable area, as identified through GIS-based analysis, aligns with the provisions of the DENR Administrative Order No. 2006-10, which mandates that landfill siting must consider factors such as topography, land use compatibility, and environmental impacts. This approach not only supports regulatory compliance but also contributes significantly to the long-term sustainability of Davao City's waste management system by ensuring that environmental safeguards are upheld.

In addition, using GIS-based multi-criteria analysis to determine suitable landfill sites reinforces the evidence-driven planning approach endorsed by Republic Act No. 9003, also known as the Ecological Solid Waste Management Act of 2000. This Act underscores the need for scientifically informed decision-making processes to ensure environmentally sound waste management practices. In the broader context, establishing a landfill in a highly suitable area could substantially reduce environmental risks like water contamination, flooding, and negative impacts on ecologically sensitive zones. This proactive approach is important as Davao City continues to grow, requiring an efficient waste management system that aligns with SDGs.

The key findings promote the necessity of transitioning from landfill sites that merely fulfill minimum requirements to those that comprehensively meet suitability criteria. This shift is essential to advancing Davao City's responsibility for a sustainable and efficient waste management system, thereby ensuring that future landfill development is operationally viable, environmentally sound, and socially responsible.

5. Conclusions and Recommendations

A GIS-based analysis using an AHP-aided MCDM was employed to develop a landfill suitability map for Davao City, guided by the technical and environmental standards of NSWMC Resolution No. 64, Series of 2013. Pairwise comparisons were used to assign priority coefficients, which were then applied to compute composite suitability scores across the study area. Results indicate that both the existing landfill in New Carmen and the proposed adjacent expansion fall within areas classified as "less suitable," as they do not meet minimum area requirements and are affected by limiting factors that hinder full regulatory compliance.

In response to the city's development plan, three alternative sites were evaluated based on suitability and proximity. Among these, Site 3—measuring 51.650 hectares in Barangays Callawa and Riverside and located 7.443 kilometers from the existing site—emerged as the most feasible option.

The study faced several limitations including data constraints that required simplifying parameters such as development costs and hazard vulnerability, and the lack of detailed descriptions for certain criteria, which limited the depth of analysis. Future studies should integrate more comprehensive parameters, including detailed cost assessments, hazard analyses, and refined criteria descriptions, and consider alternative methods such as raster-based or fuzzy multi-criteria decision analysis to enhance evaluation. While the GIS-based suitability map provides valuable preliminary insights, it should be supplemented by field validation and rigorous legal and administrative reviews to ensure compliance with regulatory standards.

Although focused on Davao City, the methodology can be applied to other areas of the Philippines, as the spatial and analytical datasets used have nationwide coverage. Methodological variations may occur due to differences in expert input and the extent of prior local studies, but the approach remains grounded in the national standards of NSWMC Resolution No. 64.

Overall, the study underscores the potential of integrating GIS-based methodologies with multi-criteria decision-making techniques as effective tools for landfill site selection. By applying Resolution No. 64, it identifies both challenges and opportunities for improving waste management infrastructure, emphasizes the need to reassess current and proposed sites, and points to alternative locations that better align with environmental and technical requirements. This approach supports sustainable solid waste management and offers a replicable framework for other localities seeking to balance development with environmental stewardship.

References

Arabeyyat, O. S., Shatnawi, N., Shbool, M. A., & Shraah, A. A., 2024. Landfill site selection for sustainable solid waste management using multiple-criteria decision-making. Case study: Al-Balqa governorate in Jordan. *MethodsX*, 12, 102591. doi.org/10.1016/j.mex.2024.102591.

Colina IV, A., 2022. Sanitary landfill in Davao City completely full in 2023. *Manila Bulletin*. mb.com.ph/2022/09/17/sanitary-landfill-in-davaocitycompletely-full-in-2023/ (29 May 2024).

Chen, Y., Yu, J., & Khan, S., 2010. Spatial sensitivity analysis of multi-criteria weights in GIS-based land suitability evaluation. *Environmental Modelling & Software*, 25(12), 1582–1591. doi.org/10.1016/j.envsoft.2010.06.001

Davao City Local Government, 2023. Davao City Gov't Develops New Lot Near New Carmen Sanitary Landfill Site to Address Mounting Waste Volume. Davao City Local Government. davaocity.gov.ph/solidwastemanagement/davao-city-govt-develops-new-lot-nearnewcarmen-sanitary-landfill-site-to-address-mountingwastevolume/ (29 May 2024).

Davao City Local Government, n.d. Davao City. National Economic and Development Authority. nro11.neda.gov.ph/davao-region/davao-city/ (29 May 2024).

Dempsey C., 2024. Inroduction to GIS. *Geography Realm*. geographyrealm.com/what-is-gis/ (6 June 2025).

Department of Environment and Natural Resources (DENR), 2006. Administrative Order No. 2006-10: Guidelines on the Categorization of Final Disposal Facilities. nswmc.emb.gov.ph/wp-content/uploads/2018/01/DAO-10_pdf.pdf (6 June 2025).

Hazarika, R. & Saikia, A., 2020. Landfill site suitability analysis using AHP for solid waste management in the Guwahati Metropolitan Area, India. *Arab J Geosci* 13, 1148. doi.org/10.1007/s12517-020-06156-2.

Local Government of Davao, 2024. New Sanitary Landfill Facility Barangay New Carmen, Tugbok District, Davao City. Environmental Management Bureau. r11.emb.gov.ph/wpcontent/uploads/2024/02/NewSanitary-Landfill-FacilityPDS_compressed.pdf. (29 May 2024).

Macalam, F., et al., 2023. Landfill Site Suitability Assessment Using Geographic Information System (GIS) and Analyti Hierarchy Process (AHP) in Butuan City, Philippines. *Journal of Environmental & Earth Sciences*, 5(1), 95-107. doi.org/10.30564/jees.v5i1.5381.

National Solid Waste Management Commission (NSWMC), 2013. Resolution No. 64, Series of 2013: Adoption of modified guidelines on site identification criteria and suitability assessment procedure for sanitary landfills. Department of Environment and Natural Resources, Philippines.

Philippine Statistics Authority, 2023. Age and Sex Distribution in Davao City (2020 Census of Population and Housing). rsso11.psa.gov.ph/content/age-and-sex-distributiondavao-city-2020-census-population-andhousing?fbclid=IwAR0mojKNBYoI04sYayI5TQHYIMa8u93XxolXoHfsrnPfjM9VdzTXTXyjD8 (29 May 2024).

Republic of the Philippines, 2000. Republic Act No. 9003: Ecological Solid Waste Management Act of 2000. *Official Gazette of the Republic of the Philippine*s. officialgazette.gov.ph/2000/01/26/republic-act-no-9003/ (6 June 2025).

Sadie, N. T., Tanchuling, M. A. N., & Blanco, A. C., 2022. Landfill site suitability mapping using fuzzy multi-criteria decision analysis and GIS case of Quezon City, Philippines. *Philippine Engineering Journal*, 43(1).

United Nations Department of Economic and Social Affairs, n.d. THE 17 GOALS | Sustainable Development. sdgs.un.org/goals (6 June 2025).

United States Environment Protection Agency, 2024. Municipal Solid Waste Landfills. epa.gov/landfills/municipalsolid-waste-landfills. (29 May 2024).

World Health Organization, n.d. *Guidance on solid waste and health*. WHO. who.int/tools/compendium-onhealth-andenvironment/solid-waste (29 May 2024).