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# Towards Sustainable Waste Management: *GIS-AHP Based Landfill Suitability Assessment in Gampaha District, Sri Lanka*

Behind every piece of waste lies a story of how it impacts our environment, our health, and the communities we live in. Globally, waste management has become one of the most critical challenges faced by modern societies, and Sri Lanka is no exception. Every day, the country generates about 7,500 metric tonnes of municipal solid waste, and each citizen contributes 0.4 to 1.0 kg of waste [1].


Figure 01: Unplanned Waste Disposal Site

In the rapidly growing Gampaha District of the Western Province, this problem is magnified. The Gampaha Municipal Council alone generates about 45-50 metric tons of solid waste daily, but current collection systems manage barely half of it [2]. The rest is openly dumped, burnt, or discarded illegally. These activities pollute the air, degrade ecosystems, and endanger human lives. Addressing these impacts calls for smarter solutions. This article highlights how advanced tools like Remote Sensing, Geographic Information Systems (GIS) integrated with Multi-Criteria Decision Analysis (MCDA), and the Analytic Hierarchy Process (AHP) can revolutionize waste management by guiding the selection of more suitable solid waste disposal sites.

## Existing Methods and Related Studies

The use of GIS coupled with MCDA in identifying suitable locations for landfills has been widely reported in various countries, such as India, Iran, Thailand, and Sri Lanka. A recent study in the Kalutara Division of Sri Lanka used ten assessment criteria, namely land use, population density, schools, religious places, government offices, coastal areas, hospitals, roads, railways, and environmentally sensitive areas, applying GIS overlay and AHP weighting methods. The findings showed that the study area satisfied the suitability thresholds for landfill sites by only 9.9 % [3]. In Thailand, GIS-AHP models for municipal solid waste site selection incorporated factors such as groundwater tables, lithology, aquifer zones, and flood risk [4]. In Iran, a hybrid AHP-Fuzzy GIS approach included wind direction as a socio-economic factor to assess odour dispersion in landfill site selection [5].

Overall, the current literature shows that, despite the fact that social, environmental, and accessibility indicators are still extensively used, there is increasing interest in hydrological, geological, flood-risk, and atmospheric variables, especially wind direction. These results provide a foundation for the Gampaha District study to adopt a more comprehensive framework, including flood hazard areas, groundwater susceptibility, and odour dispersion, alongside the traditional socio-economic and accessibility parameters.

## Methodology

The study was carried out in the Gampaha District, located in the Western Province, an area of about 1,387 km$^2$ that includes both rapidly urbanizing regions and environmentally sensitive landscapes. With a population exceeding 2.4 million, the district generates a substantial volume of solid waste, underscoring the need for a systematic and spatially guided approach to identifying suitable disposal sites. Figure 02 presents the geographical extent of the study area, with its administrative boundaries.

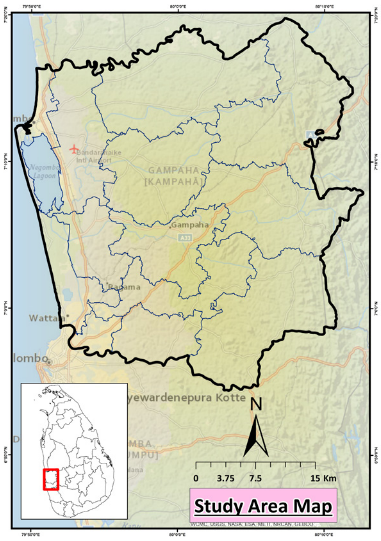


Figure 02: Study Area Map

The selection of criteria for the analysis was based on a review of existing methods and previous studies. Ten various factors were selected for landfill and waste disposal site assessment. These criteria collectively represent the environmental, hydrological, geological, and socio-economic considerations required for a comprehensive evaluation [3] [4] [5].

All datasets were preprocessed to ensure consistency before analysis. Each layer was projected to the Kandawala coordinate system, standardized to a spatial resolution of 10 × 10 metres, and converted to raster format. The reclassification procedure assigned each layer into five suitability categories, ranging from highly suitable to not suitable, enabling comparison and integration across diverse datasets.

To determine the relative importance of the ten criteria, the AHP method was applied. Pairwise comparisons were performed using Saaty's 1-9 scale to assess how strongly one factor influences site suitability relative to another. The resulting pairwise comparison matrix produced a set of normalized weights through the principal eigenvector method. The matrix was developed with the support of subject-matter experts familiar with waste management and geospatial planning, and the Consistency Ratio (CR) was calculated as 0.03, indicating excellent internal consistency and confirming the reliability of the assigned weights. These weightages reflect the contribution of each factor to the final suitability model. Table 01 summarizes the selected factors and their weights derived from AHP.

Table 01: Factors and their weightages

| Factor | Weight (%) |
|---|---|
| Land Use / Land Cover | 26.14 |
| Slope | 21.25 |
| Groundwater Depth | 16.78 |
| Environmental Sensitivity | 13.16 |
| Soil Type | 7.29 |
| Flood Frequency | 5.85 |
| Distance to Roads | 3.42 |
| Social Sensitivity | 2.49 |
| Population Density | 1.95 |
| Wind Speed | 1.67 |

The weighted overlay analysis was then carried out by combining the reclassified layers according to their AHP weights. The resulting suitability surface was examined to identify areas with values below the mean, which were considered highly suitable for waste disposal. These highly suitable zones were further analysed using high-resolution Google Earth imagery, allowing the identification of nine potential candidate locations. To evaluate possible impacts on surrounding communities and sensitive environments, a 2 km buffer was generated around each candidate point. This combined GIS and AHP approach provided a structured framework for narrowing down feasible locations for solid waste disposal within Gampaha District.

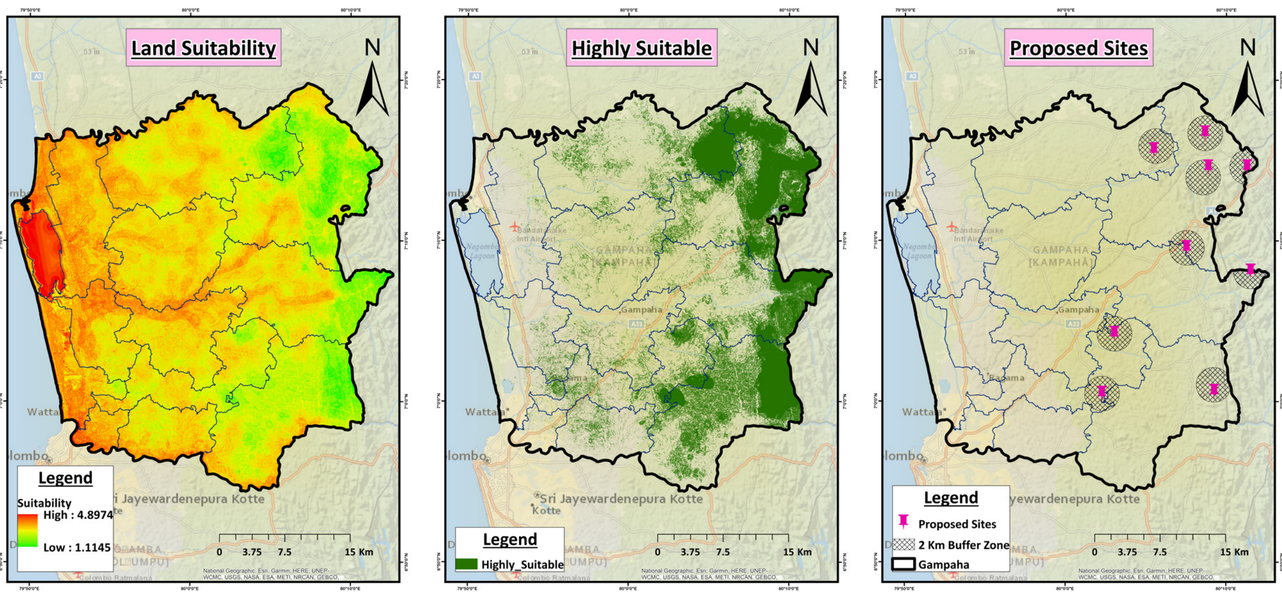


Figure 03: Suitability Map (Left), Highly Suitable Area (Middle), and Proposed Waste Disposal Sites in Gampaha District (Right)

## Results and Discussion

The suitability surface generated through the weighted overlay revealed clear spatial contrasts across the district, with the nine selected zones showing mean suitability values ranging roughly from 2.27 to 3.06, indicating varying levels of suitability among the candidate areas. When assessing potential impacts through the 2 km buffer zones, the number of buildings encountered varied substantially, from as low as about 40 to well over 2,000 structures, which highlights the differing degrees of social exposure associated with each location.

Areas with fewer surrounding buildings present lower risks of nuisance, conflict, and compensation requirements, making them appropriate for larger centralized landfill sites, while zones situated within more built-up areas may be more suitable for small-scale or transfer-station-type facilities that minimize disturbance. These variations emphasize the need for planners to interpret suitability alongside settlement density and operational scale rather than relying on the weighted output alone. Moreover, the findings reinforce the value of a multi-criteria framework, where the AHP-derived weights which were grounded in established literature and expert reasoning, combined with diverse spatial datasets offer a transparent and defensible approach. Incorporating additional layers such as groundwater vulnerability, lithology, soil permeability, and updated flood information in future analyses would help further refine the nine preliminary candidates into a smaller set of priority sites for the district.

## Conclusion

The results demonstrate that the integration of GIS and AHP provides a practical and evidence-based pathway to evaluate landfill suitability in Gampaha District, producing clear spatial outputs that can be used directly in planning processes. The identification of nine candidate areas and their corresponding impact assessments, along with the wide variation in suitability levels and surrounding building densities, provide decision-makers with a realistic understanding of trade-offs between technical feasibility, environmental risk, and social acceptability. While the weighting process relied on literature-supported expert judgement rather than field-based sampling, the internal consistency of the matrix, the coherence of spatial patterns, and the alignment with observable ground features collectively strengthen the reliability of the model. Moving forward, the inclusion of more detailed subsurface and hydrological datasets, along with targeted field validation, would enable the narrowing of the candidate set to one or two optimal long-term landfill sites for the entire district. Such refinements, combined with periodic model updates, would support a more sustainable and scientifically informed waste management strategy for Gampaha.

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