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A Geo-Spatial Multi-Criteria Evaluation Approach for Solid Waste Landfill Site Selection in Gampaha, Sri Lanka

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I. Introduction

Solid waste management has become one of the most critical and challenging issues worldwide, and Sri Lanka is no exception. In Sri Lanka, the municipal solid waste production is estimated to be 7,500 metric tons per day, and a person generates 0.4 to 1.0 kg of waste per day [1]. As a result, a significant amount of waste that has not been collected is being openly disposed of, burnt, or disposed of illegally, thus contributing to environmental pollution, ecological degradation, and increasing health risks. The aim of this study is to select suitable waste landfill sites for the country's rapidly urbanizing Gampaha district, in the Western Province.

Remote Sensing and Geographic Information Systems (GIS) play an important role in spatial decision-making for waste management, as they allow comprehensive analysis of diverse environmental, social, and infrastructural data layers over large geographic extents. These tools provide a systematic approach to the assessment of site suitability when combined with Multi-Criteria Decision Analysis (MCDA). The Analytical Hierarchy Process (AHP) method is widely applied due to its ability to assign weights to criteria through pairwise comparisons, reflecting expert judgment. This integration of RS, GIS, and AHP-based MCDA has been successfully used in landfill site selection studies worldwide, and it offers a systematic and transparent approach for identifying suitable waste landfill sites in Gampaha District.

II. Literature Review

Selection of suitable waste dump or landfill sites using GIS integrated with MCDA has been widely employed across different contexts, including India, Iran, Thailand, Sri Lanka, and other countries. In Sri Lanka, a study conducted in the Kalutara Division using ten different criteria to select a suitable location for waste dump via AHP weighting and GIS overlay. They found that only 9.9% of the area was suitable for waste dumping based on strong comparison among criteria [2]. In Thailand, a study on the selection of municipal solid waste site using GIS-AHP model, considered some important criteria including groundwater table, lithology, aquifer zones in their model, and the significance of flood risk in site suitability [3]. In Iran, a hybrid AHP-Fuzzy GIS approach was employed for the landfill site selection. In their criteria, they considered the wind direction as a socio-economic component. That inclusion is a novel criterion to assess odour dispersion [4].

In general, the literature shows that, despite the regular use of social, environmental, and accessibility criteria, there is a noticeable tendency towards the inclusion of hydrological, geological, flood-risk, and atmospheric factors, especially the wind direction. These above gaps provide an opportunity for the Gampaha District study to adopt a more comprehensive approach to the methodology by integrating flood hazard zones, groundwater susceptibility, and odour dispersion alongside conventional socio-economic and accessibility factors.

III. Materials and Methods

A. Study Area

Fig. 1 shows the study area, which is the Gampaha District, located in the Western Province. The total area of the district is approximately 1,387 km². It is the second most populated district in the country, with around 2.44 million people, ranking second after Colombo. Due to this high population and high waste generation, it is essential to conduct a study in Gampaha District to identify the most suitable waste landfill sites.

B. Factor Identification

Ten mostly relevant criteria were identified based on existing literature, to assess suitable sites for the landfill. These factors represent the key environmental, social, and infrastructural considerations required for landfill site

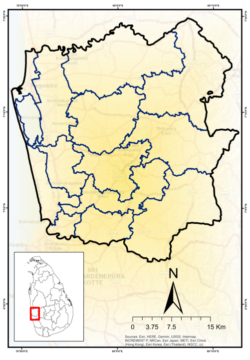

Fig. 1. Study Area Map - Gampaha District

selection. All datasets were compiled for the year 2024. The list of identified factors are land use/land cover, slope, distance to roads, distance to environmentally sensitive areas, distance to socially sensitive areas, flood frequency, soil type, population density, groundwater table depth, and wind speed.

C. *Preprocessing and Reclassification*

All the selected criteria were preprocessed and standardised into raster format with a consistent spatial resolution of 10×10 metres, and each dataset was projected to the Kandawala coordinate system to ensure spatial compatibility across layers. Then, each raster was reclassified into five suitability classes, ranging from Class 1 (Highly Suitable) to Class 5 (Not Suitable).

D. *Analytical Hierarchy Process (AHP)*

The AHP was used to assign the relative importance of all selected ten criteria. This was done with the help of experts. A pairwise comparison matrix was generated by comparing factors one to other on a scale of 1 to 9, developed by Saaty, that measures the apparent influence of one criterion on another. The obtained Consistency ratio (CR) is 3% reflects strong internal consistency between comparisons.

E. *Suitability Layer and Proposing Zones*

Using AHP-derived weightages, each resulting raster was reclassified into standard suitability classes, ranging from Class 1 to Class 5, representing highly suitable to not suitable areas, respectively. Based on this classification, areas above moderately suitable (Class 1 and Class 2) were selected as highly suitable areas for waste disposal.

Subsequently, three points were visually identified within the highly suitable areas using Google Earth. Around each candidate point, three buffer zones were generated at distances of 500 m, 1,500 m, and 3,000 m. Within each zone, the socially important points (school, hospital, railway station, etc.) and buildings within a certain distance were calculated to estimate the impacts on the surrounding environment and communities. According to that, most appropriate zone for the solid waste landfill site in Gampaha was determined.

IV. Results and Discussion

Fig. 2 represents the solid waste landfill suitability map of the study area and three zones proposed in a highly suitable area. The highly suitable area (Class 1 and Class 2) covers 40.16% of the total study area, approximately 568.01 km². The results of distance-based impact assessment show the clear differences in exposure and potential community impact. Zone 1 records minimal influence, with only a few socially important locations in the 500-1,500 m range and no buildings within 1,500 m. In contrast, Zone 2 shows significantly higher settlement density, with 425 buildings within 1,000 m and nearly 2,900 buildings within the 3,000 m boundary, accompanied by 24 socially important locations, indicating substantial potential for disturbance. Zone 3 also contains a considerable number of buildings as distance increases, but fewer socially important points. These differences indicate that suitability does not work alone; The scale of operation also should be considered for the final site selection. Zone 1 is more appropriate to a larger landfill, whereas Zone 2 or Zone 3 might be possible with strict mitigation measures. The analysis also highlights the need for more refined datasets (e.g., groundwater vulnerability, forest cover, heritage and protected area buffers) to strengthen exclusion rules and

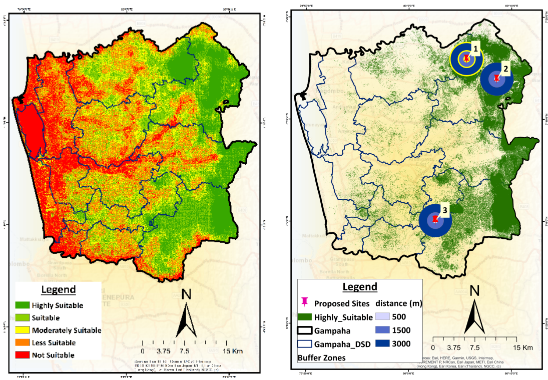

Fig. 2. Waste landfill site suitability map and proposed sites for solid waste landfill site

reduce conflicts with culturally or environmentally sensitive sites.

V. Conclusion

This study used a GIS-based multi-criteria analysis through AHP to identify suitable locations for solid waste landfill sites in Gampaha District. According to the ten environmental, social, and infrastructural criteria, approximately 568 km² of the district was classified as highly suitable. Three candidate locations were proposed, and the buffer zone-based impact assessment clearly indicated that Zone 1 poses the least risk to communities and socially sensitive locations. Zones 2 and 3 remain technically suitable but require careful planning and mitigation because of the presence of higher settlements. So, the findings demonstrate that GIS-AHP provides a structured, evidence-driven workflow that can directly support practical landfill planning.

Although the method is technically robust, the study has some limitations. Some constraints relate to the availability and completeness of social and environmental sensitivity data, and further refinement of protected-area buffers, groundwater vulnerability layers, and cultural heritage zones would improve accuracy. Practical implementation barriers such as community acceptance, regulatory compliance, and potential environmental objections must also be considered before final site approval. Future research should incorporate field validation, stakeholder engagement, and environmental impact assessments to strengthen decision-making and help narrow the recommended sites to one or two optimal, long-term waste disposal locations for the district.

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