

OPTIMIZING WASTE MANAGEMENT: A REMOTE SENSING AND GIS-BASED MCDA APPROACH FOR LANDFILL SITE SELECTION

Bhavay Kothari¹, Prof. Rinni Shah²

¹ Bhavay Kothari ME Student, Dept. Infrastructure Eng. LDRP, Gandhinagar, Gujarat India

² Professor Rinni Shah, Dept. of Infrastructure Engineering. LDRP, Gandhinagar, Gujarat, India

Abstract - For urban areas to maintain public health and environmental sustainability, waste management must be done effectively. To optimize landfill site selection in City, this study suggests a novel approach integrating remote sensing, Geographic Information System (GIS), and Multi-Criteria Decision Analysis (MCDA) techniques. The purpose of this study was to locate a suitable landfill site. Nine thematic layers including elevation, slope, land value, distance from water bodies, roads, built-up areas, airport, railway, and land use and land cover (LULC) were assessed as important criteria. Weights were assigned using the Analytical Hierarchical Process (AHP) method analysis. For every parameter, the relative relevance was determined by applying Saaty's priority scale of 1 to 9. Each parameter's weighting was verified using the consistency ratio, permitting the effectiveness of the selected parameters to be justified

Key Words: Landfill Site Selection, GIS, Remote Sensing, AHP, MCDA, Solid Waste.

1. INTRODUCTION

Solid waste management is a critical global issue with significant environmental and health implications. Rapid urbanization and population growth have increased waste generation, overwhelming existing infrastructure.

In many cities, improper disposal practices like open dumping and burning pollute the environment and pose health risks. City faces similar challenges, with the dumpsite operating for many years and causing methane emissions and leachate problems.

This necessitates scientific landfill site selection using modern techniques. GIS and Remote Sensing provide spatial data on waste generation patterns, while Multi-Criteria Decision Analysis helps evaluate multiple conflicting factors systematically.

1.1 Literature review

Several studies have employed GIS-MCDA for landfill selection:

Roy et al. (2022) used AHP in Siliguri, identifying suitable waste disposal locations. Sk et al. (2020) applied eleven criteria in Durgapur City. Majid and Mir (2021) integrated GIS with MCE in Srinagar. Ali et al. (2021) combined AHP in

Memari Municipality. Hazarika and Saikia (2020) provided alternatives for Guwahati's non-compliant Boragaon site. These studies consistently validate the effectiveness of integrated GIS-MCDA approaches.

1.2 Roles of Remote Sensing (RS) and Geographic Information System (GIS) Techniques for Solid Waste Management

Through a variety of applications, geographic information system (GIS) and remote sensing (RS) techniques are essential to improving solid waste management practices. First of all, by providing comprehensive spatial data on the production of solid waste, collection locations, and disposal sites, they aid in the creation of waste maps and inventories. These maps help waste management agencies and urban planners locate high-waste-generation areas, improve collection routes, and choose the best sites for waste treatment facilities.

GIS tools also contribute to Landfill Site Selection and Management. For the best landfill siting, they aid in evaluating the topography, environmental sensitivity, and proximity to populated areas. Additionally, by tracking waste deposition, monitoring capacity, and evaluating potential risks like groundwater contamination, GIS-based decision support systems help with effective landfill management.

The integration of remote sensing and GIS techniques into waste management systems offers valuable spatial data analysis, decision support, and stakeholder engagement capabilities, leading to improved efficiency, effectiveness, and sustainability of solid waste management practices.

1.3 Objectives

- Sample/Analyze land characteristics using RS data
- Evaluate environmental suitability for landfill sites

2. METHODOLOGY

2.1 Study Area

Ahmedabad is a city in Gujarat, India, at latitude 23°01'17.83" North, longitude 72°34'46.96" East. It is the fifth-largest city and sixth-largest metropolitan area in India. According to the 2011 census, the population of Ahmedabad Metropolitan was

6,352,254. Ahmedabad was founded in 1411 AD as a walled city on the eastern bank of the river Sabarmati. It is now India's seventh-largest metropolis and the state's largest

2.2 Selection Criteria

Table -1: Criteria and Remarks

Criteria	Remarks
Slope	Low slope desirable
Elevation	Low elevation desirable
LULC	Barren land desirable
Distance from Water Bodies	High distance desirable
Distance from Roads	Low distance desirable
Distance from Airport	High distance desirable
Distance from Railways	High distance desirable
Distance from Built-up	High distance desirable
Land Value	Low value desirable

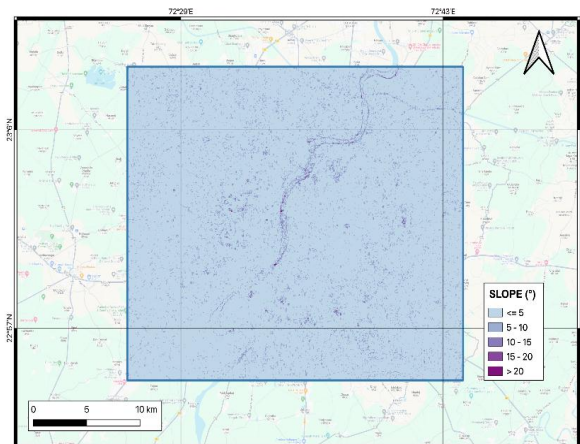


Fig -1: Thematic map of Slope

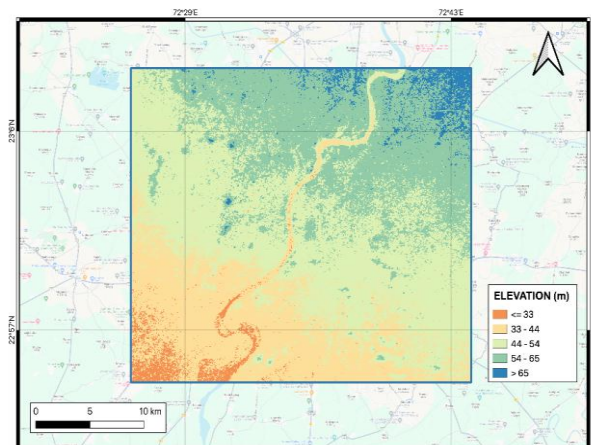


Fig -2: Thematic map of Elevation

2.3 Data Sources

NASA Earth Data (10m resolution DEM), ESRI Land Cover, property websites, DIVAGIS, and Open Street Map

2.4 Analytic Hierarchy Process (AHP)

Thomas L. Saaty created the Analytic Hierarchy Process (AHP) in the 1970s as a structured method for classifying and evaluating complicated decisions. By breaking down difficult decisions into a series of pairwise comparisons and then synthesizing the findings, it assists decision-makers in setting priorities and arriving at the best choice.

3. RESULTS AND DISCUSSION

3.1 Thematic Layers

All nine factors were mapped with different criteria using GIS software. The figures are show bellow.

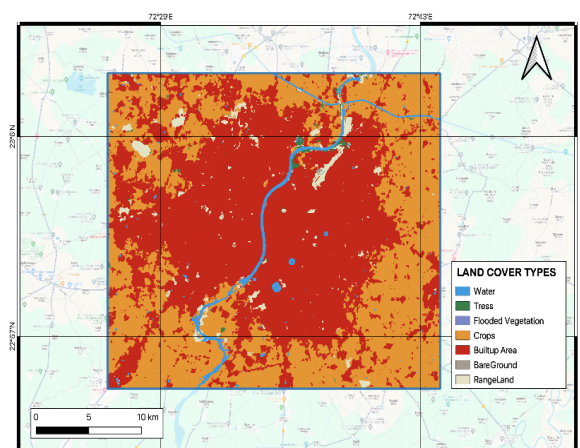


Fig -3: Thematic map of LULC

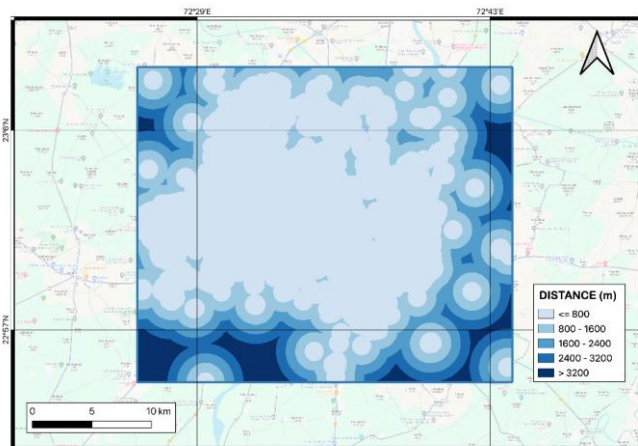


Fig -4: Thematic map of Dis. From Built-up

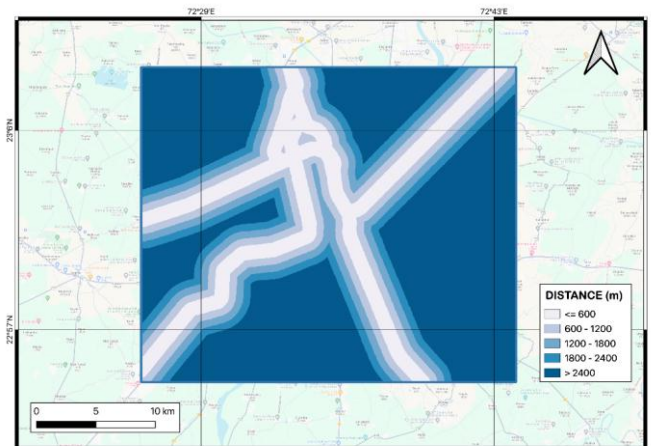


Fig -7: Thematic map of Dis. From Railways

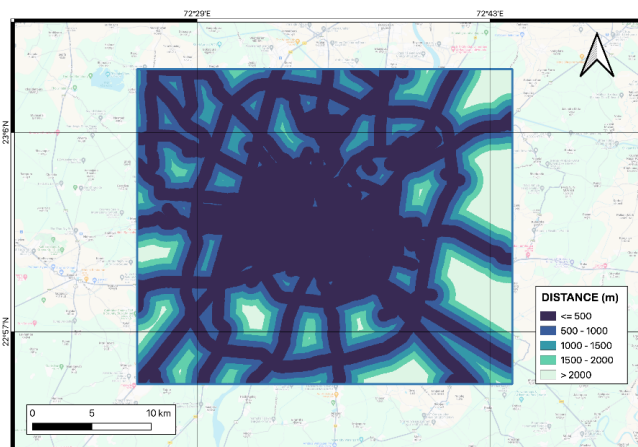


Fig -5: Thematic map of Dis. From Roads

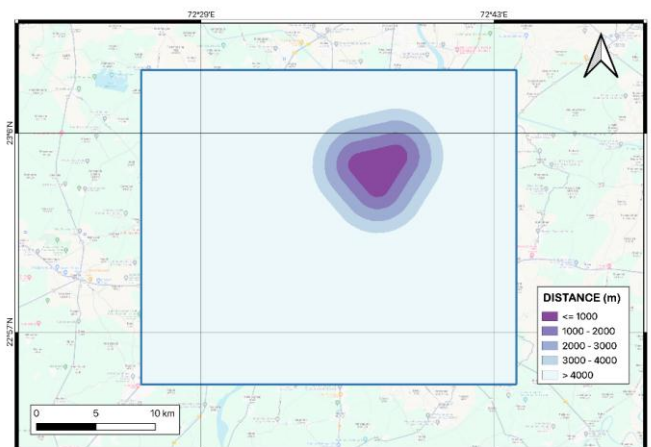


Fig -8: Thematic map of Dis. From Airport

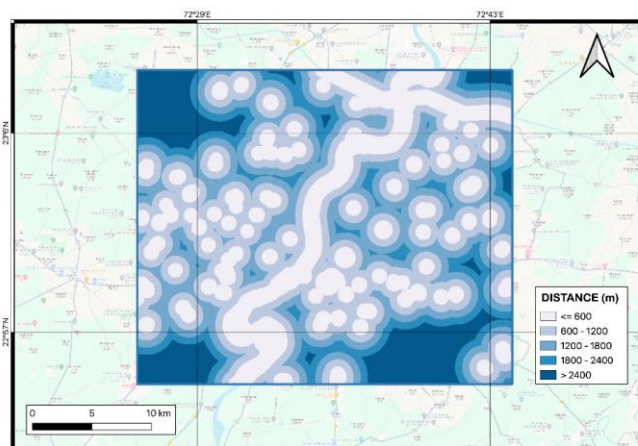


Fig -6: Thematic map of Dis. From Water-bodies

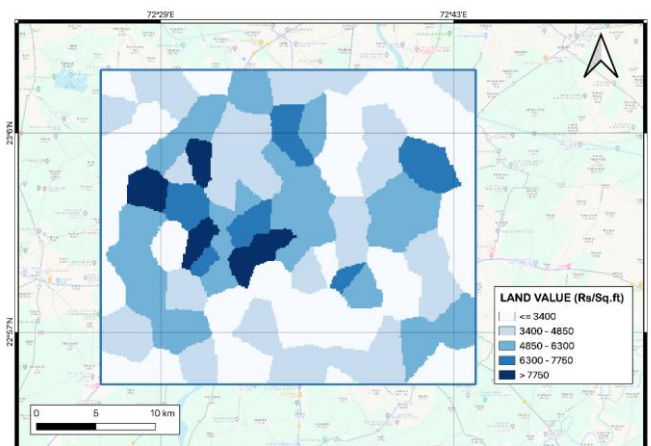


Fig -9: Thematic map of Land value

3.2 Analytic Hierarchy Process Results

Table -2: AHP Criteria Weights and Consistency

Criteria	Weighted Sum Value	Criteria weight	Principal Eigen Vectors	Lambda max	CI	CR
LULC	1.893	0.206	9.020	9.098	0.012	0.008
Dis. From Built-up	1.355	0.148	9.053			
Dis. From waterbodies	1.148	0.125	9.070			
Dis. From Roads	1.152	0.125	9.080			
Dis. From Railway	0.977	0.107	9.061			
Land Value	0.766	0.083	9.089			
Dis. From Airport	0.787	0.086	9.098			
Slope	0.600	0.065	9.085			
Elevation	0.502	0.055	9.066			

The top five criteria—LULC (0.206), Distance from Built-up (0.148), Distance from Water-bodies (0.125), Distance from Roads (0.125), and Distance from Railway (0.107)—emerged as the most influential for landfill site selection. The Consistency Ratio value of 0.008, well below the permissible cutoff of 0.10, confirmed the consistency of the findings.

3.3 Weighted Overlay Analysis

The top five criteria LULC at 0.206, Dis. From built-up at 0.148, Dis. From Water-bodies at 0.125, Dis. From roads at 0.125, and Dis. From Railway at 0.107 emerged as the most influential for landfill site selection. Conversely, Land Value at 0.083, Dis. From Airport at 0.086, Slope at 0.065, Elevation at 0.055 exhibited relatively lower impact on the selection process. The Landfill Suitability Index (LSI) is computed for the entire study area using reclassified raster layers and their respective criteria weights as per equation.

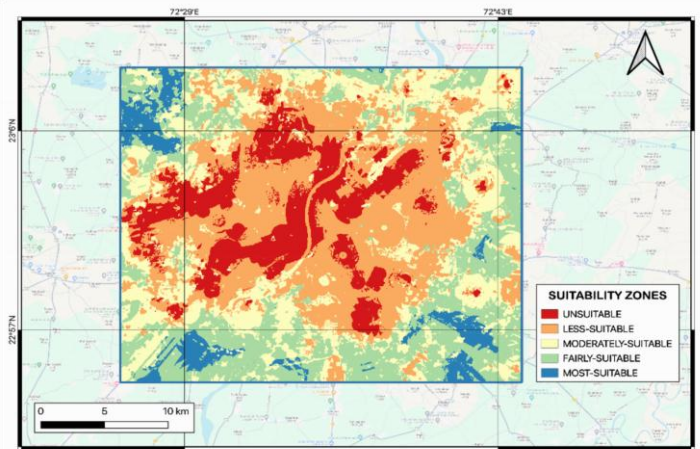


Fig -10: Landfill Suitability Index Map

4. CONCLUSIONS

The selection of new landfill sites requires scientific methods due to the urgent need to overhaul the current urban landfills in Ahmedabad city. This study successfully demonstrated an integrated Geographic Information System (GIS) and Remote Sensing approach combined with Multi-Criteria Decision Analysis (MCDA) for identifying optimal landfill locations.

Nine evaluation criteria were considered including land value, water body proximity, built-up proximity, ground elevation, ground slope, road proximity, rail proximity, airport proximity, and land use land cover (LULC). Thematic raster layers for these criteria were generated and reclassified on a 1-5 suitability scale. The Analytical Hierarchy Process (AHP), informed by expert opinions and literature, determined the relative influence of each criterion. Weighted overlay analysis was performed by combining all reclassified thematic layers with their respective AHP-derived weights to generate the Landfill Suitability Index (LSI) map (Figure 10). This map clearly delineates areas across Ahmedabad city into five suitability zones: Most Suitable, Fairly Suitable, Moderately Suitable, Less Suitable, and Unsuitable. The most suitable lands for landfill construction appear in specific peripheral areas of the city, particularly in the western and southern parts, where conditions are optimal with barren land cover, appropriate distances from sensitive features, favorable slopes, and lower land values.

The findings provide valuable scientific evidence for policymakers and urban planners to transition from conventional to systematic approaches in waste management infrastructure planning.

REFERENCES

- [1] Roy, D., et al. (2022). An assessment of suitable landfill site selection... *Computational Urban Science*, 2(1).
- [2] Ali, S. A., et al. (2021). Sanitary landfill site selection by integrating AHP and FTOPSIS with GIS. *Environmental Science and Pollution Research*, 28(6), 7528-7550.
- [3] Majid, M., & Mir, B. A. (2021). Landfill site selection using GIS based multi criteria evaluation technique. *Environmental Challenges*, 3.
- [4] Hazarika, R., & Saikia, A. (2020). Landfill site suitability analysis using AHP... *Arabian Journal of Geosciences*, 13(21).
- [5] Sk, M., et al. (2020). Optimal Sanitary Landfill Site Selection... using GIS and Multi-criteria Evaluation Technique.