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A Parameteric Evaluation for Sanitary Landfill Site: A Case of Indian Metropolitan City

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Abstract
In the planning process, landfill site selection in a metropolitan community is a critical issue. With the growth of urbanization, the region's economy, biodiversity, and environmental health are having a massive impact. Outsized quantities of waste are produced and every day the problem grows. As a result, selecting an optimal sanitary dump location is a challenge for city planners and solid waste managers. The site of the disposal is determined by a number of factors. Because they are frequently related to the surrounding open ground, geo-technical factors are quite significant. Furthermore, useable land that is secure and acceptable is uncommon. Surat Metropolitan City is India's densely inhabited and fastest-growing city. The purpose of the study is to conduct field experiments in order to gather data and shift facts to the best location in the GIS platform in order to create a model. The analytical hierarchical technique was used to calculate weights for each parameter based on planner expectations (AHP).
Keywords: - Urbanization, Municipal Solid Waste, GIS, analytical hierarchy process, landfill, MSW

1.0 INTRODUCTION

For soaring urban centers, municipal solid waste (MSW) is a crucial environmental issue. In low lying areas with wide open soil space, MSW was conveniently disposed of during the early period. The population contributes to the rise in the production of solid waste. The issue of trash disposal and its negative environmental consequences is a major source of worry. In India, MSW has resulted in several socioeconomic inequities. Unfortunately, environmental planning and socioeconomic factors are rarely quantified, and disposal locations are believed to be known. The scenario in India suggests a method based on fuzzy-GIS research. India's urban population is growing at the quickest rate in the world. As a result, combating urban issues and scientific development patterns is tough.A scientific decision-making approach to the disposal of MSW needs to be implemented. This research is limited to the area of Surat (Gujarat, India). The Surat region has an urban area of approximately 1000 km^2. There are four planned landfill sites in the area of Surat. Some of the problems of making spatial decisions will be discussed in this work.

A rigorous decision-making strategy is required for the disposal of municipal solid waste, where ecologically sustainable landfill site selection is crucial.Four locations have been suggested by the local government (Surat Municipal Corporation), out of four that need to be chosen as the best venue. The logical approach of MCDA-GIS has provided ranks of four proposed sites to make decisions. The Analytic Hierarchy Method (AHP) is used to test parametric weights. The town under investigation is India's fastest expanding metropolitan hub. Due to the urban area being extended to 1000 km2, it is important. This research will present some of the problems in the development of spatial analysis, a research carried out as part of the Surat City Spatial Plan.

2.0 LANDFILL SITE SELECTION CRITERIA

The placement of a sanitary landfill necessitates a thorough assessment procedure in order to find the best possible disposal site. This site must meet the needs of existing government rules while also lowering economic, financial, health, and social expenses (Siddiqui et al., 1996). Some base is a measurable and testable criterion for making a decision. Variables and constraints are two different forms of criterion. A factor is a variable that influences whether a certain alternative is suitable for the job in question. A constraint aids in the narrowing of the options being considered. A comprehensive literature review yielded 14 criteria for landfill site selection, including 11 variables and three limitations.

Input map layers have been prepared for analysis in the GIS environment for each criterion. In the UTM projection method, maps can be reported. By referencing several research papers from different national and international journals, the proposed research parameters were established. There were many parameters taken into consideration for landfill site selection depending upon the geographic conditions of different countries. Four major parameters are taken in this research work for Indian context.

A. Planning Parameters:

1. Zoning Density- The growth of landfills may be influenced by zoning regulations..
2. Distance from Collection Area- The shorter the distance travelled, the less time and energy spent getting the garbage to the dump.
3. Site Topography- The slope should be such that it aids in the transmission of garbage at

various levels.

4. Residential land use- Land use regulations should permit landfill development.
5. Size- In comparison to the amount of garbage produced and the size of the city.
6. Access to services & utilities- Important for working staff and for developing other facilities.
7. Availability of Vacant Land- Facilitate eases of development.
8. Flexibility for facility expansion- Important since both the amount of garbage generated and the population will grow in the future.

B. Environmental Parameters:

1. Soil Characteristics- Dense to moderately dense soil profile is most suitable for landfill.
2. Geological Materials– Important in determining development possibilities. Vegetation- Helps in checking the possibilities of pollution and threat to the vegetation.
3. Distance to river bed- This would help in checking the ground water pollution.
4. Environmental Nuisance- It helps in checking the accidents and possibilities of pollution and critical locations.
5. Environmental sensitive areas- Helps in checking the accidents and possibilities of any kind of threat to environment.
6. Nearness to airport- Bird strikes on aeroplanes in the area of the waste site are a possibility.

C. Geological Parameters :

1. Density- Helps to check seepage condition of soil strata.
2. Moisture content- To understand the biological processes for degradation of solid waste.
3. Permeability- To estimate leachate quantity from landfill.
4. Atterberg limit- To identify cohesive or non- cohesive soil in nature.
5. CBR- To determine percentage compaction of soil.
6. Sieve analysis- to determine grain size.

D. Socio-economic Parameters :

1. Population- People's impact is directly or indirectly important.
2. Public acceptability- to know people's perception towards development of landfill site.
3. Use of nearby areas of landfill site- Land use of surrounding areas is also important for health purpose of people.
4. Distance to nearest building- Help in assessing the impact on surrounding areas (nuisance values).
5. Property value in nearby area- Help in assessing economic values.
6. Public utility facility within 2 kms- Help in planning site infrastructure facilities.
7. Proximity to school, religious place & recreation spaces- Harmful impact can be checked by evaluating these criteria.

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3.0 RESEARCH APPROACH

The ArcGIS Spatial Analyst programme was used to conduct GIS-based analysis. It's a raster or grid-based software suite that lets you work with gridded data collections in a structured way. It was used to create suitability maps that highlighted "appropriate" geographic locations based on specified metrics generated from weighted and blended map layers.Analysis of Maps

Basically, analysis of maps includes setting the boundary of the study area, making slope maps, buffer zones, finding distance, reclassified maps and suitability maps. Raster maps are provided as constraint maps showing areas that are suitable for the location of a landfill (represented by 1) and not suitable (represented by 0). The areas that are inadequate are referred to as buffers (Kontos et al., 2003). The maps of surface water, cities, rivers, highways, railroads and land-use contain these constraints.They can also be used to represent areas that vary from low to high suitability as factor maps.

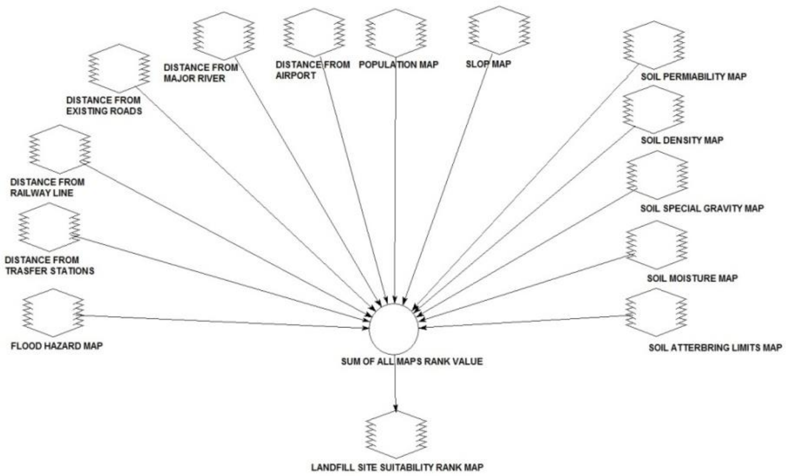

Figure 1.0 modal preparation in GIS

3.1 Study area boundary

A boundary map (base map) is created and is used for future calculations since all studies over layers have to be restricted to the extent of the study field.

3.2 Distance

The landfill should be created near or far from a given source, depending on the requirements. For layers associated with attributes that might be graded depending on their distance from the nearest source, proximity maps may be created using the 'Spatial Analyst - Distance' option. The dimensions, if this is correct, are linear interactions. Many sizes, on the other hand, are not linear connections, although they are nonetheless frequently expressed in this fashion to save time and money or because not all options are considered.

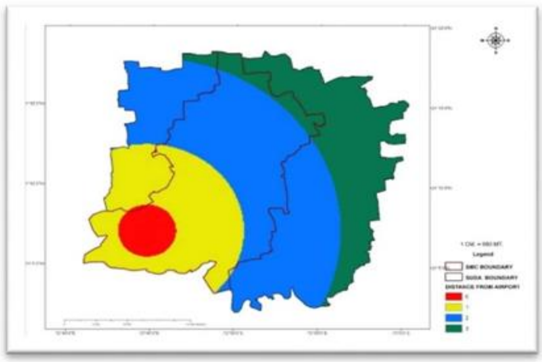

Figure 2 airport distance map

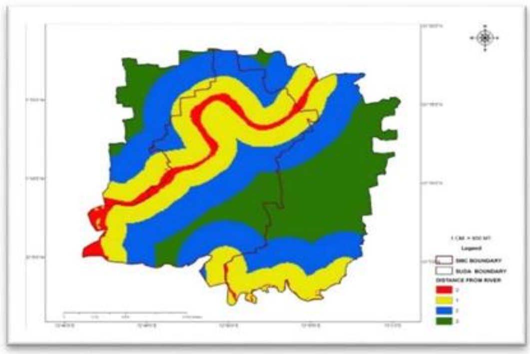

Figure 3 river distance map

3.3 Slope Map

A slope map is required by the criterion since the slope is a crucial component in the landfill's placement, and the area is a vital consideration for excavation. To track drainage, the landfill site should have a modest slope. As a result, slopes ranging from 4% to 12% are the most suitable, whereas slopes ranging from 0% to 4% are less appropriate but still acceptable. Regions with slopes more than 12% should be excluded from consideration.

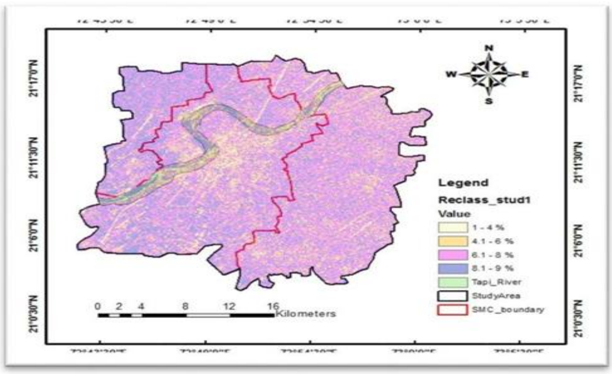

Figure 4 Slope Map

3.4 Buffer Zone

Buffer zones must be generated in order to construct binary maps for the Boolean integration process. In two groups, maps corresponding to constraints are reclassified as acceptable and unsuitable areas. They are defined, respectively, by values 1 and 0.

3.5 Reclassified Maps

Each map layer is graded according to how suitable it is for a new landfill. However, a standard scale (for example, 1-10) is utilized to combine them. More appropriate qualities are applied to higher score levels. Using the 'Reclassify' option, the score is normally allocated to each class. In the Index Overlay integration process, the layers created in this stage are utilized.

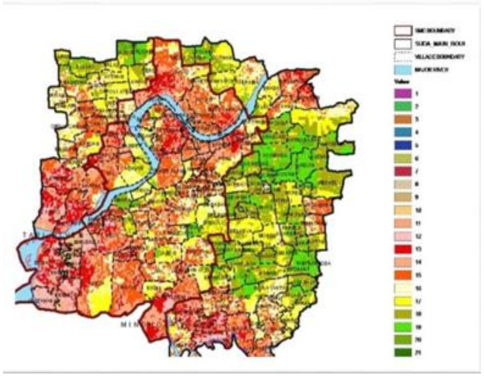

Figure 5 Site suitability map through model

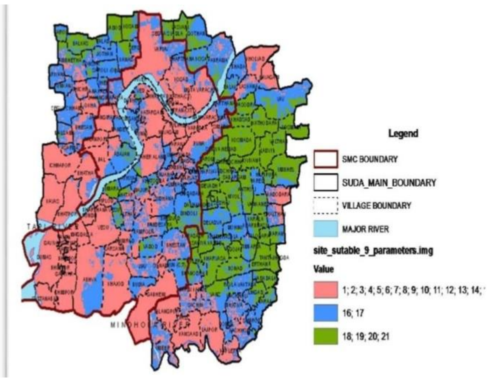

Figure 6 Categorized suitable site

3.6 Weights and combined data set

The final stage in appropriateness modelling is to evaluate each data set's relative worth. Weigh them appropriately before combining the data sets to generate a suitability map. The degree to which each data collection can impact the process results is determined by weighting the data sets.

4.0 CRITERIA WEIGHTS

Table 1.0 displays the estimation of weights according to various AHP parameters. For this analysis, it shows the pair wise value of each parameter and their weights. Land use & land cover and proximity to existing roads are very critical criteria to assess the optimal location for land fill development based on the expert's opinion of proximity to waste production centers.

TABLE 1.0 Weights calculated by AHP for various parameters

Sr. No	Parameters	**Proximity to garbage disposal facilities**	**Use of the land**	**Closeness to Roads**	**The depth of the**	**The distance between the**	**Water Bodies in Close Proximity**	**The River's**	**Closeness to the Settlement Area**	**Distance to nearby**	**The Soil Type**	**Slope**	**Weights**
1	Proximity to garbage disposal facilities	0.98	1.99	1.98	2.98	2.99	2.99	3.98	3.99	6.98	6.99	6.97	**0.235**
2	Use of the land Coverage of the	0.48	0.98	0.99	1.99	1.98	1.99	2.99	2.98	4.99	4.98	4.99	**0.148**

	Land												
3	Closeness to Roads	0.48	0.98	0.99	1.99	1.98	1.99	2.99	2.98	4.99	4.98	4.99	**0.147**
4	The depth of the groundwater	0.330	0.49	0.49	0.98	0.99	0.97	1.99	1.97	3.99	3.98	3.99	**0.092**
5	The distance between the drinking water supply well and the house	0.340	0.48	0.47	0.99	0.97	0.98	1.97	1.99	3.97	3.98	3.99	**0.090**
6	Water Bodies in Close Proximity	0.350	0.48	0.48	0.98	0.99	0.98	1.98	1.98	3.99	3.99	3.97	**0.090**
7	The River's Proximity	0.24	0.350	0.350	0.49	0.49	0.49	0.99	0.99	2.98	2.99	2.99	**0.057**
8	Closeness to the Settlement Area	0.22	0.360	0.345	0.49	0.47	0.49	0.98	0.99	1.99	1.99	1.99	**0.049**
9	Distance to nearbyAirports	0.145	0.18	0.18	0.23	0.24	0.23	0.340	0.48	0.99	0.98	0.98	**0.025**
10	The Soil Type	0.144	0.19	0.19	0.24	0.24	0.24	0.368	0.48	0.97	0.98	0.99	**0.025**
11	Slope	0.142	0.18	0.19	0.24	0.24	0.24	0.353	0.49	0.95	0.95	0.98	**0.025**

5.0 DATA ANALYSIS

The research area GIS data sets for the research region were gathered from a variety of sources and then digitized. Elevation maps were created using the LANSAT II satellite picture. The maps were digitized and reviewed using the ERDAS Imagine programme and ArcGIS Desktop 10. In this study, fourteen parameters for determining landfill appropriateness were used. The restrictions were first identified. In this paper, fourteen criteria for assessing landfill appropriateness were chosen. Second, there were clear limitations.

ArcGIS software has utilized this strategy for weighted overlay analysis. Defined numerical LSI values separated into five classes (Strictly Limited, Less Preferable, Nice, Preferable, and Most Preferable) were produced according to rules and buffer zones. The greater the score, the better the dump location. The overlay analysis of the ArcGIS Spatial Analyst tool was used to prepare the performance values of the generated maps. For the study region, LSI determined land suitability. The LSI values tested varied from 0 to 9. The relevant areas were found to be extremely high and extremely low.Acceptable pixels with a value of 0 (coloured red) were deemed to be very bad and were deleted from the alternative candidate locations for disposal. To size with maximum additional equipment, areas smaller than 90 hectares are classified as the most relevant and appropriate in the search area, as shown in the figure using the majority filter and technique. Important sites in the study area have been identified.

6.0 MODEL APPLICATION: SURAT CITY

There are four proposed sites in the study area. They are in SUDA development plan 2006. In Surat, the urban area was 112SqKm up to 2006 and it was expanded to 326 SqKm after 2006. Four sites are located at Kosad, Puna-simada, Sachin and Jahangirpura. Sachin is situated at southern part of the city. Puna-simada is in north-east, Kosad is north and Jahangirpura is in north-west part of the city. As far as the size is concerned of all four proposed sites, Puna-simada site is having highest area of 200 hectares while Sachin and Kosad are having 175 hectares area and Jahangirpura is having 150 hectares.

Table 2 Rank of proposed sites

Site	Score Value	Rank
Sachin	0.49	1st
Punasimada	0.43	2nd
Kosad	0.40	3rd
Jahangirpura	0.30	4th

As shown in table 2, Sachin (0.49) ranks number one, followed by Puna-simada (0.43), Kosad(0.40) and Jahangirpura(0.3). Jahangirpura is identified as least suitable site for landfill.

Existing site, named Khajod is to reach the capacity in near future. In case emergency proposed sites can be operated as per priority rank. Hence, it is needed to identify ideal location through GIS overlay method to construct a new landfill site apart from all proposed sites.

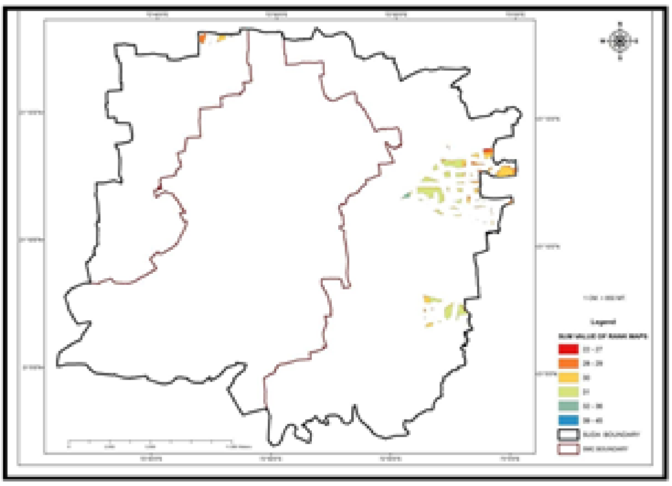

Figure 7 Appropriate site locations for Surat city

The best suitable position is defined at Saroli as shown in figure 7. It is situated on the road to Surat-Kadodara. Both major transfer stations are located within 8 km of this chosen spot. All suitable locations are solely within the SUDA cap. The best positions are in the eastern part of the city of Surat.In the northern part of the town, two sites are listed, but it is less than 100 hectares, so it is overlooked. The Saroli site has an area of approximately 200 hectares that can fulfill the requirement for at least 15 years. Saniya-hemad, Kosamadi, etc, as shown in figure 7, are other suitable locations.

7.0 Conclusion

The current study looked at 14 environmental planning, economic, and geotechnical aspects to find a viable sanitary landfill site in the Surat area. The distances from national highways, local roads, rural and metropolitan locations, railway lines, airports, rivers, power lines, water bodies, and forest areas were all factors taken into account. The slope, soil type, and flood plain zone of the site were all considered.The Analytic Hierarchy Process (AHP) is a technique for allocating weight to various criteria based on expert opinion.As per experts' opinion land use, permeability of soil, road network are observed as most governing parameters for landfill site selection specifically looking to India's urban scenario.Sachin is the most suited of the four locations, according to the findings. It receives the maximum score of 0.49. With a score of 0.43, the Punasimada site was considered the second best.While Kosad ranked third with a score value of 0.40 and Jahangirpura was the least suitable with a score value of 0.30.It is observed that quality of soil is very poor in Jahangirpura hence it is least suitable for landfill construction.Saroli, Saniyahemad, Kosamdi and Jiav villages are found to provide possible sites which are fulfilling the MoEF MSW 2016 guidelines. Under the "most suited" category, an area of around 1416 hectares has been designated for disposal. In terms of current land usage and acceptable area purchase options, these areas require additional physical verification. Surat City's solid waste disposal will require an area of around 400 hectares over the next 20 years, according to projections (SUDA-DP, 2035). As a result, the actual area required is less than one-fifth of the total area available in the most suitable category, making the acquisition and construction of sanitary landfills very simple.

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