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Determination of Suitable Landfill Site Using Geospatial Techniques: A Case study of Vasai-Virar City

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ABSTRACT

Now-a-days, as rate of generation of waste increases hence solid waste management becomes challenge for city authorities in developing country, the burden posed on the municipal budget as a result of the high costs associated to its management, the lack of understanding over a multiplicity of factors that affect the different stages of waste management and associations necessary to permit the entire handling system functioning. This study represents solution for disposal of solid waste in Vasai- Virar city in forthcoming future by signifying one potential landfill location. Our results show that 6.25% of the territory of Vasai-Virar is unsuitable for regional landfill siting. The most suitable areas cover 37.49%, suitable areas 37.49%, while areas with low and very low suitability cover 18.75 and 6.25% of the territory, respectively. Based on these findings, two sites close to two large urban groups were suggested as possible locations for a regional landfill site in Vasai-Virar. Ten factors selected as criteria/sub-criteria were recognized as most important divided into geo-natural environmental, social, & techno-economic factors. Spatial layers were overlaid into a landfill suitability map. Criteria were mapped using the GIS system and spatial analytic tools.

***Keywords: Landfill, Geographic Information System, solid waste management, overlay analysis*.**

I. INTRODUCTION

The practice of solid waste management in Vasai-Virar is mainly open dump system with only one designated site popularly known as Gokhiware site. The disposal ground started off as a tipping site in 2001 without provision of daily/frequent covering of disposed wastes.Vasai-Virar city is the fifth largest urban city in kokan region with an estimated population growth rate of 16% per year with waste generation rates of approximately 500 tons/day of which 45% is disposed off to at dumpsite,27 % of the total wastes is recycled or recovered by informal sectors and the remaining 30% is left unattended to and finally deposited to the surrounding environment by storm water and wind.

The Geographical Information System (GIS) offers reasonabledevice since many aspects such as planning and operations are highly dependent on spatial data. Not only does GIS reduce time and cost of the site selection but

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also provides digital database management system that is ideal for advanced site selection that can efficiently store, retrieve, analyze and display information according to user defined specifications.

The process of solid waste disposal management consists of collection, transportation and disposal. One way to dispose solid waste is to place it in properly designed, constructed, and managed landfills, where it is safely contained. Nevertheless, the selection of a suitable site for solid waste disposal is a daunting task, complex spatial problem, involving multiple criteria which require the use of spatial analysis models.

The present study focuses on an optimized landfill site selection which based on different parameters and geographic information system based overlay analysis. The most appropriate site has been identified for Vasai-Virar city by considering various influential parameters and factors to arrive at optimum siting decision. Factors including geology, air quality, soil types and its different properties, surface water ground water depth & its quality, slope and elevation, land use land cover etc. based on this all ten factors thematic maps were prepared within the paradigm of GIS software. A GIS-based overlay analysis was performed to identify the optimum site for the landfill, one which fulfilled all of the desired attributes.

II. MATERIALS & METHODS

2.1 Study Area

Vasai-Virar city is located between latitude 19°23’34’’N and longitude of 72°51’42’’ E. This city is located in Palghar district surrounded by 67 villages such as Sativali, Chincholi, Rajiwali, Kolhi etc. it is surrounded by Vasai creek, Arabian sea, Vaitarna river, Achole lake etc. Its west is the Arabian Sea. Vaitarna river separates Vasai Taluka from PalgharTaluka . On the north side and on the south it is separated from Thane main land by the Vasai creek. Vasai-Virar is Tehsil of Kokan division comprising most populated part of Palghar District and 5TH largest city in Maharashtra. This City has been separated from Greater Mumbai and Mira-Bhayandar City because of presence of Vasai Creek part of estuary of Ulhasriver.

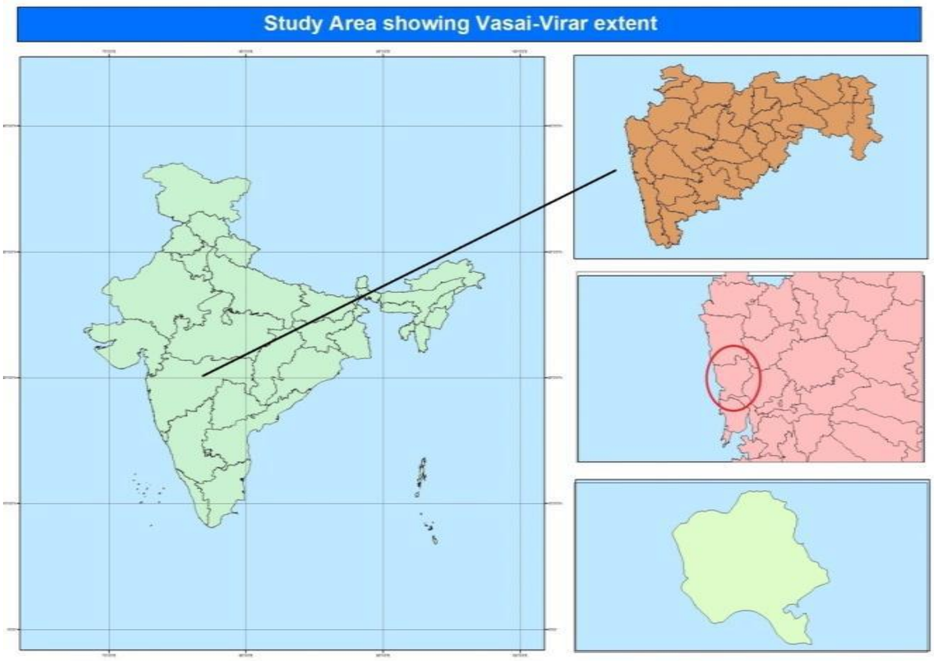

Fig. No.1: Study Area Map

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2.2 Methodology

The study depend on the existing soil data, geology/lithology data, road and rail network data, hydrology data such as underground water depth and its quality and city shape file. Some data was extracted from LANDSAT 8 OLI 30 (m) resolution image to determine land use/ land cover maps of the study area. All the above data were collected from different departments, manipulated and analyzed in GIS environment to be used for further analysis.

Suitable criteria for landfill site selection in Vasai-Virar were generated based on pre-existing information published on landfill criteria, existing environmental laws and regulatory requirements, as well as the prevailing local conditions. Ten important criteria were identified protected areas, distance to streams and water bodies, distance from transportation routes, underlying soil structure and geology and geological structures of the study area, air quality index, surface water and underground water parameters etc.

Digital Elevation Model (DEM 30*30m resolution) was used to derive slope. GIS buffering and Euclidean process were used to screen out unsuitable areas based on the defined criteria. All the constraint criterion maps were overlaid to produce the final key map. Acceptable areas were extracted from constraint maps and classified into classes of most suitable, suitable, unsuitableand moderately suitable for being used as site locations.

2.3 Criteria Used in the Analysis

Land use/land cover:

Land use/ land cover of the study area was mapped from satellite image LANDSAT 8 OLI. Image classification was done to categorize the image to different classes through supervised classification. General land cover of the area was derived and five land cover classes were identified namely: water-body, built-up, barren-land, forest, mixed vegetation, vegetation and saltpans. Solid waste disposal site should not be placed too close to settlement areas and recreation centers. Land use types such as grassland, forests, agricultural land, wet land, bush lands would be considered and assigned an appropriate index of land use suitability.

Slope and elevation: Slope is one of the key criteria in landfill siting because it can reduce or increase stability of landfills. DEM was used to derive slope and elevation. Figure 5 shows the slope suitability indicating 20% of the study area as a steep/high slope >30%. A steep slope is neither recommended due to difficulty in construction and/or leveling. In general, steeper slopes have less soil development, high erosion rates, shallow depths, and courser texture. Therefore, areas of lower slope were best considered than the areas with higher slope. For this study a slope of less than 12% was most suitable.

Air quality, underground water depth, soil type: These three types of data were collected from different departments. According to data provided, the maps were generated from the data by geocoding the location along with its value like air quality index value, depth value and soil type value. And then creating points from the geocoded value to create map and use for criteria analysis.

2.4 Euclidean Process (Buffering Analysis)

Euclidean distance is calculated from the center of the source cell to the center of each of the surrounding cells. True Euclidean distance is calculated in each of the distance tools. Conceptually, the Euclidean algorithm works as follows: for each cell, the distance to each source cell is determined by calculating the hypotenuse with

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x_max and y_max as the other two legs of the triangle. This calculation derives the true Euclidean distance, rather than the cell distance. The shortest distance to a source is determined, and if it is less than the specified maximum distance, the value is assigned to the cell location on the output raster.

The Euclidean tool is present under Spatial Analyst tool ->Distance tool -> Euclidean distance in ArcMap. Here the buffering takes place according to the distance calculated from the tool to the nearest cell value of the feature. The buffering value is calculated automatically and assigned within a range. This buffering value is taken for further processing. The Euclidean distance output raster contains the measured distance from every cell to the nearest source. Alternatively, this tool can be used when creating a suitability map, when data representing the distance from a certain object is needed.

Below description uses the method of euclidean distance which are protected areas, rail neywork and residential areas.

2.4.1 Distance from protected areas (sensitive sites), residential and railway network

Distance from protected areas (sensitive sites): A landfill must not be located in close proximity to sensitive areas or protected areas and areas gazette for special protection. Figure shows proximity map with buffering distances prepared to identify most preferable site for a landfill. Euclidean distance was used to delineate exclusionary areas from the siting process.

The ranges where approximately calculated from 0-900 m, 900-2000 m, 2000-4000 m and 4000-7000 m Areas further away from the protected areas were most preferred as opposed to those nearer these areas. A distance greater than 2000m and above was considered suitable for this study.

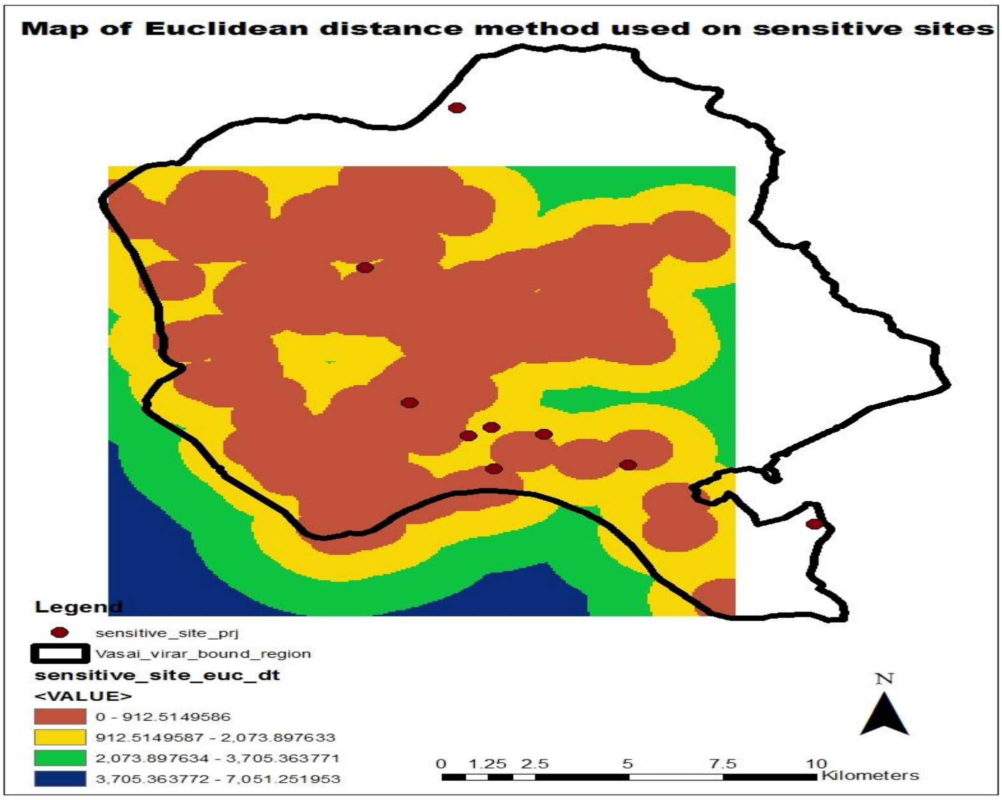

Fig. No.2: Map of Euclidean distance method used for sensitive sites.

2.4.2 Distance from rail network and residential area:

Euclidean distance for railway network was used to delineate exclusionary areas from the siting process.

The ranges where approximately calculated from 0-2500 m, 2500-5500 m, 5500-8500 m and 8500-11500 m Areas further away from the protected areas were most preferred as opposed to those nearer these areas. A distance greater than 8500m and above was considered suitable for this study.

And for residential area, the ranges where approximately calculated from 0-1750 m, 1750-3500 m, 3500-5500 m and 5500-7500 m Areas further away from the protected areas were most preferred as opposed to those nearer these areas. A distance greater than 3500m and above was considered suitable for this study.

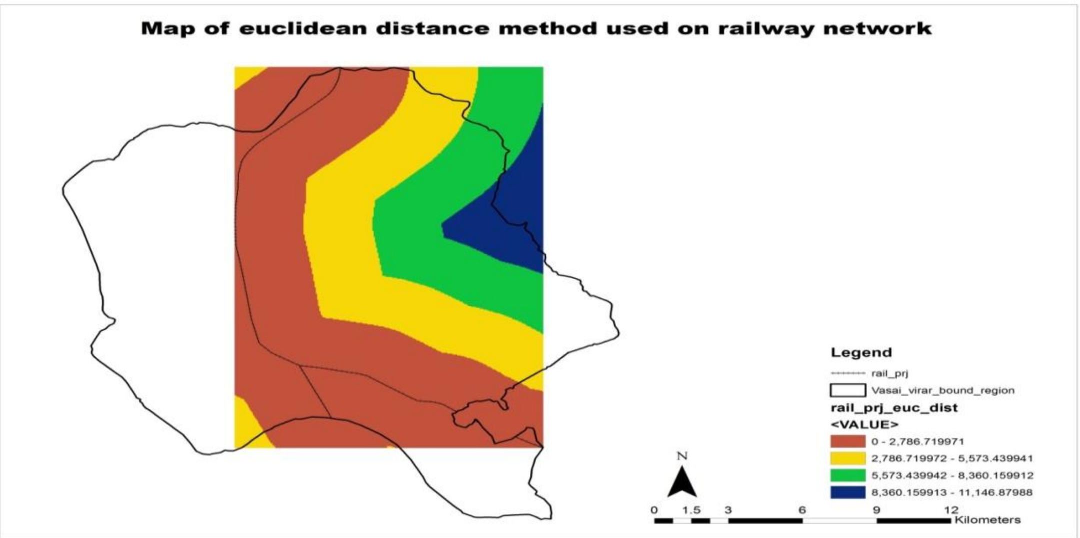

Fig.No. 3 Map of Euclidean distance method used on railway network.

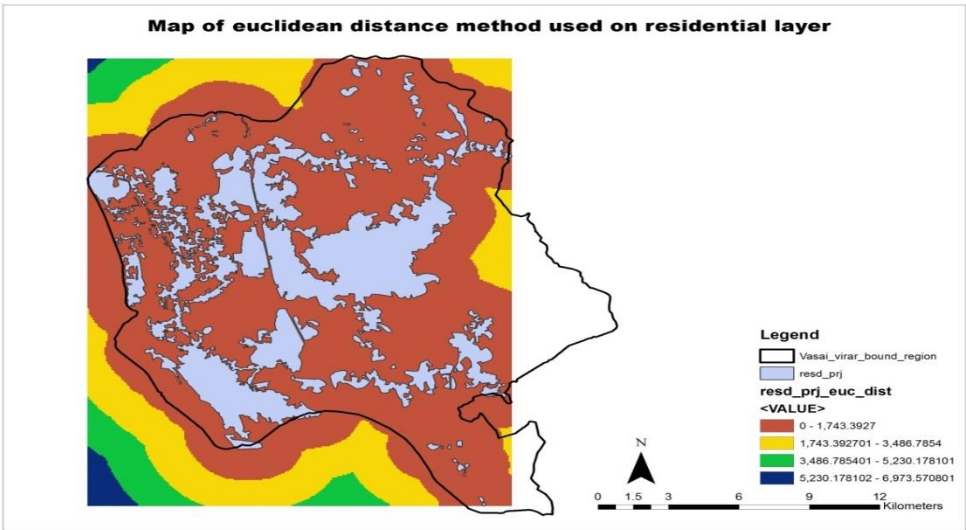

Fig.No.4 Map of Euclidean distance method used on residential layer.

Distance from roads: Landfill location must be close to roads network for accessibility and ease of transportation, consequently reducing relative costs. Minimum and maximum distance from road network for this study was established after summarizing different literatures. Most studies suggest that landfills should be

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located within a 1 km buffer from the roads and other transportation facilities. For this study Roads are segregated into different five categories which are highways, major roads, minor roads, street roads and other roads. These roads are merged together in MapInfo Professional software. Highways are given 1000 m buffering, major roads are given 700m buffering, minor roads are given 500m buffering, street roads are given 300m buffering and other roads are given 100m buffering.

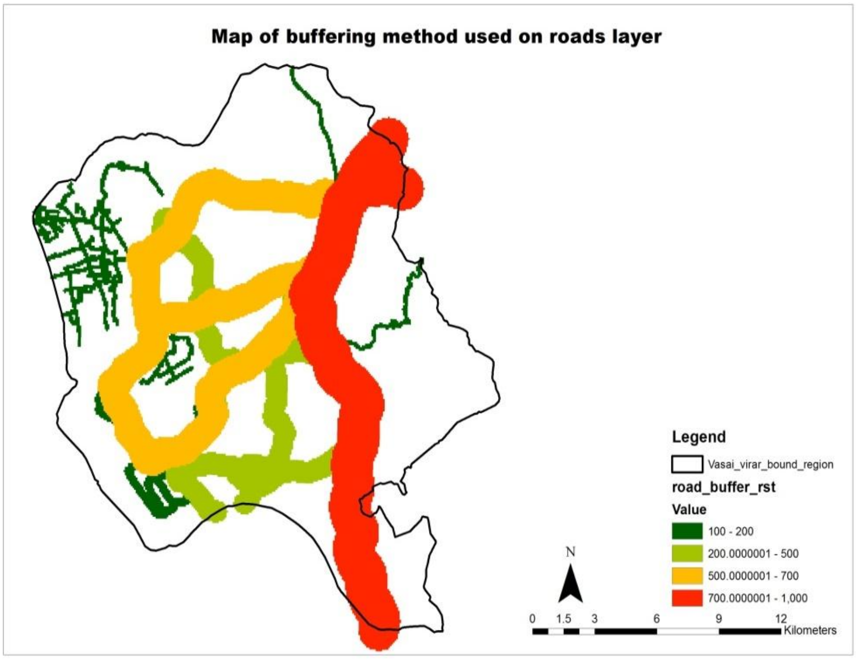

Fig.No.5 Multiple buffers to allocate exclusionary areas.

III. RESULTS AND DISCUSSIONS

In site suitability methodology, every layer has been reclassified according to their parameters using reclassify tool in Spatial Analyst tool of ArcMap. Ten layers were considered like LULC layer, sensitive site buffer layer, road buffer layer, rail line buffer layer, soil layer, water depth layer, residential buffer layer, slope layer, contour layer and air quality layer.

In ArcMap, we reclassify according to the criteria set as very low, low, moderate and high or according to their values as 1 for low and high or suitable as 4, for the layers or criteria's considered. The layers like LULC, road buffer, rail line buffer, Slope, Contour, residential buffer, sensitive site buffer, air quality layer, soil data layer and ground water depth layer are considered for site suitability which is overlaid all together according to their categories in raster calculator under Spatial Analyst tool which adds all the layer and gives overall analysis raster which would be consisting of 4 classes which would be reclassified according as poorly suitable as least followed by moderately suitable, suitable and most suitable as higher category class which would be considered for landfill sitting suitability in near future. The area calculation of suggested candidate sites by GIS was done in the attribute table of the feature. It was calculated in hectares. By interpretation of the area values, the most suitable area has the value of 5037.57 hectares. Finally location in kolhi or around Chincholi area was selected as candidate site by the visual interpretation.

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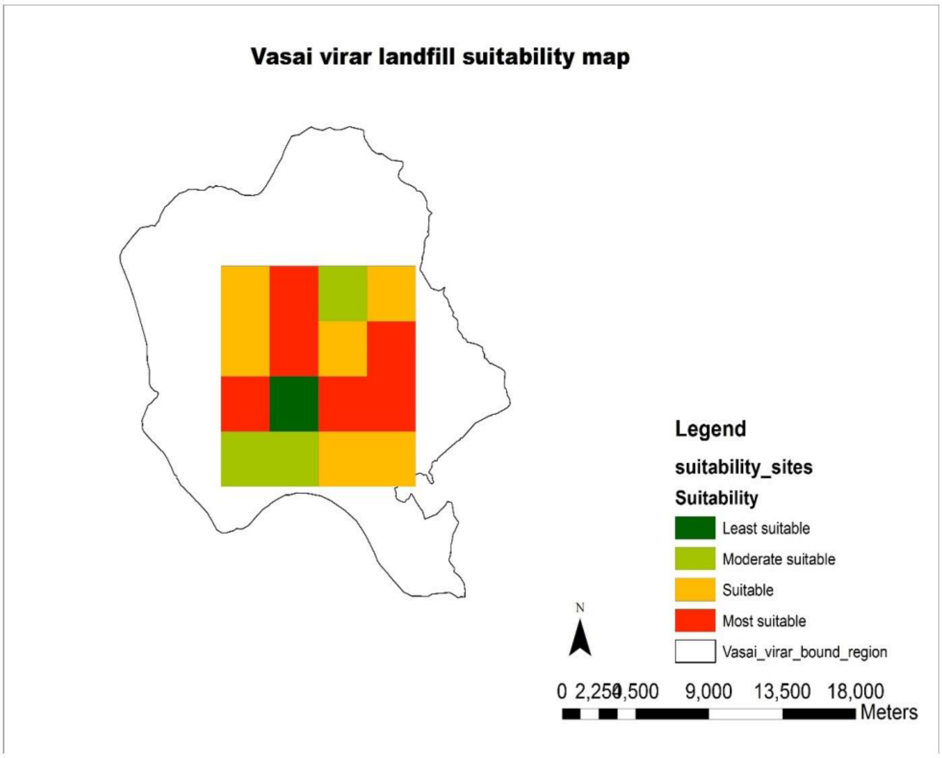

Fig. No. 6 Map of potential landfill sites

IV. CONCLUSION

Landfill site selection is a complex procedure which involves evaluating numerous factors like regulations, environmental, socio-cultural, engineering and economic factors. Using GIS for locating landfill sites is an economical and practical way as they have capabilities of producing useful, high quality maps for landfill site selection in a short period of time. During the studies, it is proved that GIS is a powerful tool in handling large amounts of data and narrowing areas of interest for potential landfill sites. Final suitability map was created showing 6 candidate sites, in Vasai-Virar city kolhi was found as potential landfill location.

V. ACKNOWLEDGEMENT

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REFERENCES

[1] Tamara ZelenovicVasiljevic, ZoricaSrdjevic (2011) GIS and the Analytic Hierarchy Process for Regional Landfill Site Selection in Transitional Countries: A Case Study From Serbia Environmental Management (2012) 49:445–458

[2] M. IrfanYesilnacara, M. LutfiSuzen (2012)Municipal solid waste landfill site selection for the city of Sanliurfa-Turkey: an example using MCDA integrated with GIS International Journal of Digital Earth, Vol. 5, No. 2, March 2012, 147_164

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

[3] BasakSener (2004) Landfill site Selection by using Geographic Information system

[4] Jess W. Everett (1996) Landfill siting using geographic information system: A demonstration journal of Environmental engineering

[5] Wang Guiqina, Qin Lib (2009) Landfill site selection using spatial information technologies and AHP: A case study in Beijing, China journal of environmental Management Elsevier 90 (2009) 2414–2421.

[6] Emilio Morelio(2008) Evaluation of a municipal landfill site in Southern Spain with GIS-aided methodology , journal of hazardous material Elsevier

[7] NadaliAlavi (2012) Municipal solid waste landfill site selection with geographic information systems andanalytical hierarchy process: a case study in Mahshahr County, Iran Waste Management and Research 31(1) 98–105

[8] JacekMalczewski (2004) GIS-based land-use suitability analysis: a critical overview, Progress in Planning 62 (2004) 3–65.

[9] O.E. Demesouka,(2013) Suitability analysis for siting MSW landfills and its multicriteria spatial decision support system: Method, implementation and case study, Waste Management 33 (2013) 1190–1206.

[10] Katerina R. Donevska (2011) Integrating multi-criteria evaluation techniques with geographic information systems for landfill site selection: A case study using ordered weighted average ,Waste Management 32 (2012) 287–296.

[11] SarikaRathi (2005) Alternative approaches for better municipal solid waste management in Mumbai, India, Waste Management 26 (2006) 1192–1200.

[12] Solomon Peter Gbanie (2012) Modelling landfill location using Geographic Information Systems (GIS) and Multi-Criteria Decision Analysis (MCDA): Case study Bo, Southern Sierra Leone, Applied Geography xxx (2012) 1-10.

[13] Mehdi Rezaeimahmoudi (2014) Application of geographical information system in disposal site selection for hazardous wastes, journal of environmental health science & engineering.

[14] Fides K. Kirimi& Edward H. Waithaka (2014) Determination of Suitable Landfill Site Using Geospatial Techniques and Multi-Criteria Decision Analysis: A Case Study of Nakuru Town, Kenya, IJSR Volume 3.