

## 201. Municipal Solid Waste (MSW) landfill Site Modeling Using Geographic Information System (GIS) and Multi- Criteria Decision Analysis (MCDA): Case study of Sukkur City, Pakistan

Imtiaz Ahmed Chandio<sup>a</sup>, Mir Aftab Hussain Talpur<sup>a</sup>, Mir Ali Naqi Talpur<sup>a\*</sup>

<sup>a</sup>Department of City and Regional Planning, Mehran UET, Jamshoro 76062, Pakistan.

\*Corresponding Author: [alinaqi.talpur@admin.muuet.edu.pk](mailto:alinaqi.talpur@admin.muuet.edu.pk)

---

### Abstract

The rapidly growing Municipal Solid Waste (MSW) is a challenging problem around the world. The issue is worse in the developing countries where resources are meagre to manage the MSW. Among the different steps and methods involved in handling the MSW, landfill remains its final destination. Siting the landfill site at unsuitable locations contributes to environmental, social, and economic costs; therefore, suitable techniques are essential to identify the suitable landfill sites. The factors, like distances from roads, residential areas, water bodies, airports, and industries were decisive for suitability. Hence, this paper represents a methodological framework for finding municipal waste landfill sites in Sukkur city. The framework comprises a Multi-Criteria Decision Analysis (MCDA) approach in addition to a Geographical Information System (GIS). The GIS was utilized to create buffers so that unsuitable areas could be avoided; however, the MCDA was used to identify the potential suitable sites. Results showed that 15% of the study area was suitable for municipal landfill, 46% less suitable, and 39% was recorded as unsuitable.

© 2016 Imtiaz Ahmed Chandio; Mir Aftab Hussain Talpur; Mir Ali Naqi Talpur. Selection and/or peer-review under responsibility of Energy and Environmental Engineering Research Group (EEERG), Mehran University of Engineering and Technology, Jamshoro, Pakistan.

**Keywords:** Landfill; Geographic Information Systems (GIS); site selection; multi-criteria decision analysis.

---

### 1. Introduction

Huge amount of Municipal Solid Waste (MSW) is created in modern society. Its disposal creates serious environmental, social and economic problems. The cities rapid expansion with huge migration of population from undeveloped to urban centres has caused exponential increase in per capita of MSW generation (Awasthi *et al.*, 2014). Today many materials such as plastics that are considered as degradable and toxic materials which contains as Solid waste, primarily various types of chemical waste produced by industry. Similarly, the amount of harmful waste generated has been undergoing intense change. In addition, industrial waste is very dangerous and increases their annual discharges of toxic chemicals directly into the environment (Takele Tadesse, 2004).

The main objective of municipal solid waste management is to provide clean and healthy environment to the population, and to sustain environmental issues by- encouraging sustainable practices, which in turn would provide support to economic productivity. An appropriate solid waste (SW) disposal has been major problem in municipal environment. The use of landfill is the most environmentally and economical satisfactory method for dumping of SW all over the world (Mehdi Ahmadi, *et al.*, 2014).

In developed countries one of the main problem is the carelessness in site selection for MSW systems, existing land fill sites have not the potential to find out new waste disposal sites or their needs. One of the most critical tasks related to the landfill site selection procedure is the numerous factors that District Managements (DMs) consider to avoid both public barrier and environmental degradation in the study area (Demesouka, 2013 and suthar and Anupma, 2014).

Land-use suitability analysis based on Geographical Information System (GIS) which extends the use of the operators and overlay traditional to the consideration of DMs' preferences, the development of synergies with other multi-criteria decision analysis approaches (Demesouka, 2013 and Guiqin *et al.*, 2009). Recently, there have been different systems reported site selection for landfill such as overlaying GIS digital maps, integration of fuzzy methodology and GIS, weight linear combination (WLC) method and spatial cluster analysis (Mahini S., and Gholamalifard, M., 2006).

The combination of Multiple Criteria Decision Analysis (MCDA) methods decision model and GIS are occurred as Multi-Criteria Spatial Decision Support Systems (MC-SDSS) (Guiqin *et al.*, 2009). Discovery of suitable land fill site is one of the most critical missions in SWM. Recently Analytical Hierarchy Process (AHP) and geographic Information (GIS) System methods are used for Abadan solid waste landfill site selection nowadays (Jaafarzadeh, 2014 and Arkoc, 2013). These methods are widely used in various kind of land suitability analysis for sustainable land use planning and its activities. Allocation of appropriate landfills also play vital role in selection of suitable areas that are satisfactory for waste disposal. A type of multi-criteria evaluation (MCE) method which is called as weighted linear combination (WLC) in environment GIS to evaluate the study suitability for landfill described in present work (I.A. Salman Mahini, 2006).

It is evident that GIS is useful for this kind of preliminary studies and many criteria must be incorporated into landfill siting decisions because its ability to manage spatial data large volumes from a variety of sources. It efficiently analyses, retrieves, stores and shows information according to user defined specifications (Siddiqui, 1996).

Difficulties can decision-makers encounter with MCDA and also can handle huge bulk of complex information with MCDA. The main principle of this method is to subdivide the decision problems into smaller and more comprehensible parts, separately analyse every part and then parts are integrated in a logical manner (Malczewski, 1997).

## 2. Study area

Sukkur is a cosmopolitan city of Sindh province. Its population is increasing day by day so rate of solid waste generation is also increasing at the same time. There is no provision of municipal solid waste landfill site selection long-term statutory plan like Municipal Development Plan in Sukkur. Structure Plan provides clear guidelines and direction for at least next 10 to 20 years of future land sites.

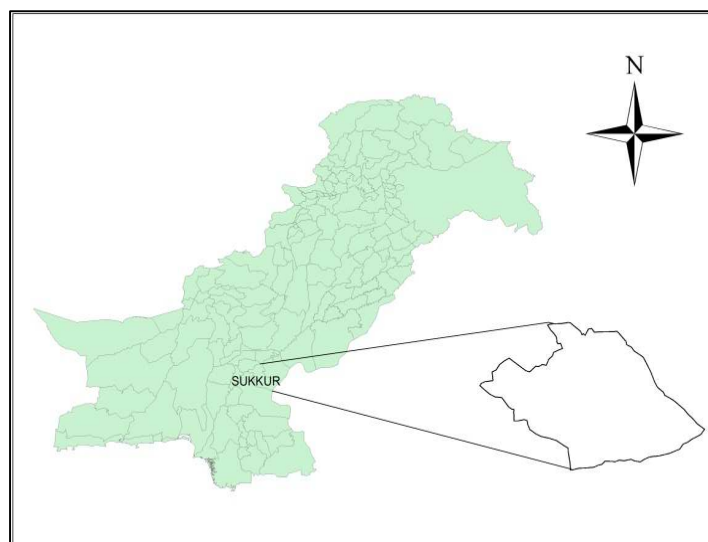


Fig. 1. Location map of Sukkur city

There are no proper planning standards for site selection of MSW land fill map and bylaws and qualified planners who develop site selection plans and implement the long-range planning according to solid waste management system that's why Sukkur is counted worst city in province in terms of management. Municipal bodies not focus in management problems which slowly destroy healthy environment. There is no single area of Sukkur city properly planned efficient system of landfill solid waste reaching the

suitable standard of environmental protection, proper sit selection for solid waste is not planned. The central targets of the research are to overview existing problems and issues and also determine the way of solution or program for analysis municipal site selection for solid waste, to clean urban environment and make it healthy for life.

### 3. Materials and methods

The data was collected through both the primary and secondary data sources. Secondary data was collected by using extensive sources i.e. literature study in published books and journals. Primary data comprises conducting field survey in order to be familiar with the land uses of study area. The data were collected from Sukkur Sindh authority and also from North Sindh Urban Services Corporation Limited (NSUSC). The gathered data was applied to revise the existing one; it was digitized into the computer compatible set-up using ArcGIS 10.1.

Weighted suitability analyse is performed on raster dataset. The raster data model is more suitable approach because the raster dataset is based on grid cell which can be easily interpreted to mark suitable sites. Raster dataset provides to the user capability to carry out a weighted overlay on numerous layers. Under a raster GIS environment scenario map were created which based on various scenarios. Located landfill site suitability for each land use was analysed. It was accomplished through Model Builder in ArcGIS 10.1.

#### 3.1 Landfill sites selection criteria

The three major factors and fourteen minor factors were identified as decisive factors in modeling landfill location. The three main criteria were environmental factors, social factors, and economic factors. The buffer zones were created around the different land uses to mark the restricted zones for landfill sites. The roads buffer is depicted in Fig. 2. The image also shows various land uses in the Sukkur city.

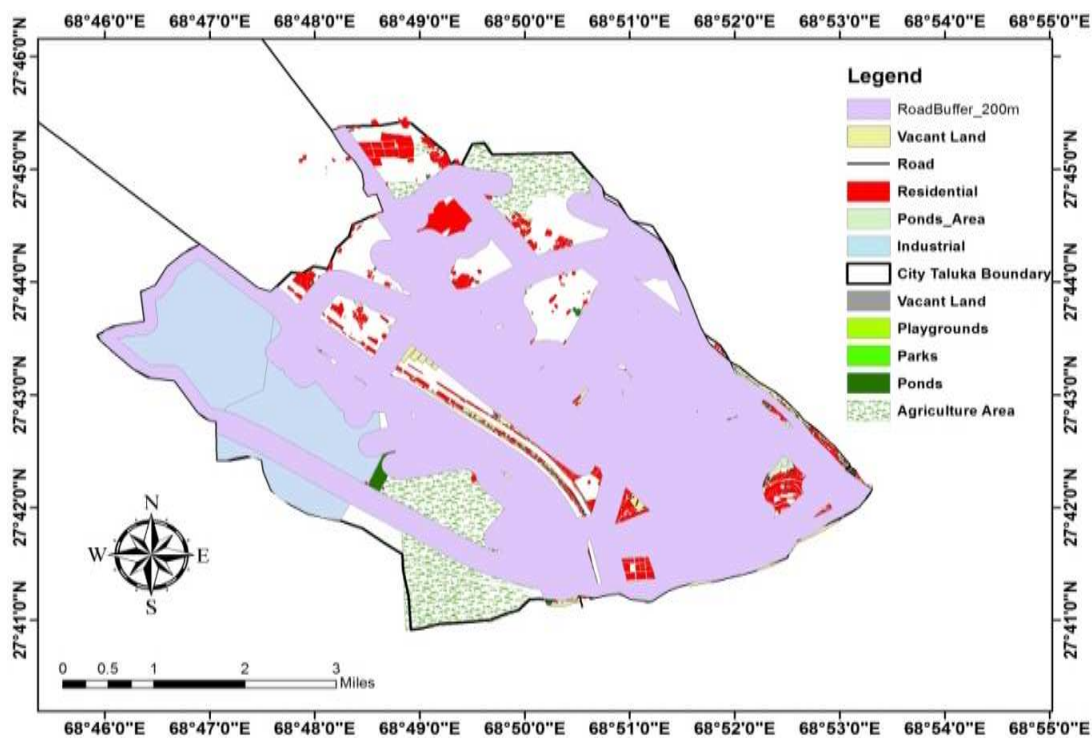


Fig. 2. Roads buffer of 200m

### 4. Results

Results showed that 15% of the study area was suitable for municipal landfill, 46% less suitable, and 39% was recorded as unsuitable. The findings are depicted in Fig. 3. It shows the potential sites for landfill. It can be observed that most of the suitable land for the landfill is where there is agricultural land. This result from the fact that the various experts consulted with during the rating phase of the

research chose to assign most points to the agricultural land. Likewise, the area around the airport is unsuitable for the landfill site.

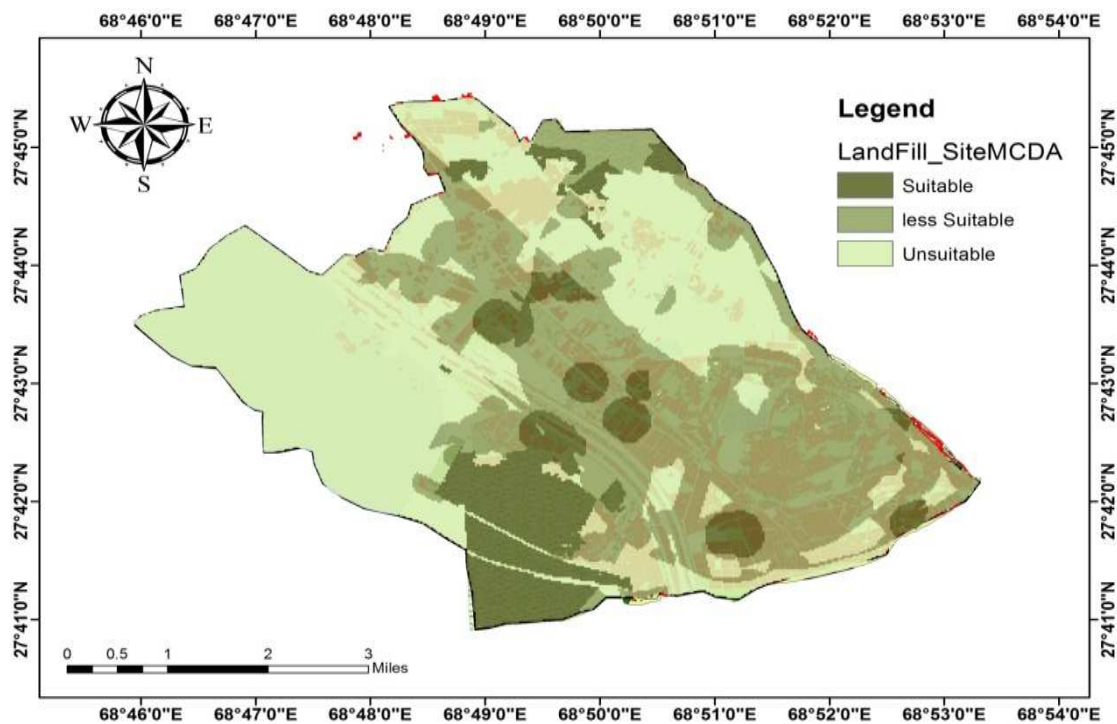


Fig. 3. Suitable potential landfill sites

## 5. Conclusion

A number of attempts have been made to site suitability for landfills, whereas factors considered inland fill site selection are: vacant land, agriculture land, residential, industrial, airport, railway, ponds, river and play ground. This study provides an integrated GIS based decision support approach towards landfill site selection at Sukkur city that can be the best possible solution to such kind of land suitability problems.

Two Simple Additive methods of MCDA are Analytic Hierarchy Process and Weighting and are used. GIS and MCDA are employed for the suitability analysis. To verify the results and check their accuracy AHP method for research study, rating method used for getting suitable site for landfill, and the declaration of the problem, the application of GIS during the study provides objective buffer areas on the basis of screening criteria and effective graphical representation.

Main advantage of this research is to investigate the absence of landfill sites for municipal solid waste. And also identify the issues and problems according to landfill sites three main factors are basic numbers to identify the reasons behind it. Through factors can determines the suitable site for landfill municipal solid waste. The remainder is illegally dumped in drains, rivers or by road side.

This automated approach will select the suitable site keeping the constraints given by the user. GIS is quite smart handling such data sets and solving such land suitability problems. Using this approach will save time and provides multiple choices to take the final decision to such land suitability problems for the stake holders. The level of severity of the existing landfills in terms of their land suitability can also be evaluated using this model by providing the coordinates of the existing landfills in the area. Remedial measures can be carried out to make the vulnerable landfills. This model will be a useful implementation tool to the practitioners and governmental officials to select the site for landfills in a robust geographical manner.

In this landfill research, all the analyses are created input data buffers. And all the buffer data gather from different papers and also from NSUSC. In the end of the analyses the numbers of potential sites are identified during the selection of the landfill siting criteria is very important but, the political restrictions

are not considered and the financial/economical very important factors constraint will be considered in the further study Among these potential sites 'suitable landfill' sites are selected. These sites generally fulfil the requirements according to suitability of landfill sites.

### **Acknowledgements**

The authors would like to acknowledge contribution from the North Sindh Urban Services Corporation Limited (NSUSC) for providing Sukkur land use data.

### **References**

- [1] Demesouka, A.V. (2013) Suitability Analysis for siting MSW Landfills and its multi criteria spatial. Waste Management. p.17.
- [2] Malczewski, J., 1997. Propagation of errors in multicriteria location analysis: a case study, in: fandel, G., Gal, T. (eds.) Multiple Criteria Decision Making, Springer- Verlag, Berlin, 154-155.
- [3] Mukesh Kumar Awasthi, Akhilesh Kumar Pandey, Jamaluddin Khan, Pushendra Singh Bundela, Jonathan W.C. Wong, Ammayappan Selvam, 2014. Evaluation of thermophilic fungal consortium for organic municipal solid waste composting, Bioresource Technology.
- [4] Tadesse, T. (2004) Solid and Hazardous Waste Management lecture notes university of Gondar.
- [5] Siddiqui, M.Z., Everett, J.W., Vieux, B.E., 1996. Landfill siting using geographic information systems: a demonstration. Journal of Environmental Engineering, 122-6, 515-523
- [6] Surindra Suthar, A.S. 2014. Rapid impact assessment matrix (RIAM) analysis as decision tool to select new site for Municipal Solid Waste Disposal. A case study of Dehradun city, India. 08.