IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
ISSN: 2319-2402, ISBN: 2319-2399. Volume 1, Issue 2 (Sep-Oct. 2012), PP 36-43
www.iosrjournals.org

GIS and Remote Sensing For Landfill Site Selection- A Case Study on Dharmanagar Nagar Panchayet

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ABSTRACT: *Municipal landfill siting is becoming increasingly difficult due to growing environmental awareness, decreased government and municipal funding and extreme political and social opposition. The increasing population densities, public health concerns, and less land available for landfill construction are also the difficulties to overcome. This paper deals with determination of suitable site for the disposal of urban solid waste generated from Dharmanagar Nagar Panchayet and surrounding areas using GIS and Remote Sensing. For this study 5 Km. of buffer area of Dharmanagar Nagar Panchayet has been considered for selection of proper landfill site.*
Keywords - GIS, Remote Sensing, Solid waste management.

I. INTRODUCTION

Waste management issues are coming to the forefront of the global environmental agenda at an increasing frequency, as population and consumption growth result in increasing quantities of waste. In the context of the above mentioned challenge a New Paradigm for waste management has emerged, shifting attention to resources efficiency and minimization of environmental impacts throughout the life cycle of waste management, from waste prevention to safe disposal.

Technically, GIS is a set of software tools that is used to input, store, manipulate, analyze and display geographical information. Strategically, GIS may be a philosophy, a way of making decisions within an organization where all information is held centrally and is related by its location. Technological development in computer science has introduced geographic information system (GIS) as an innovative tool in landfill process. GIS combines spatial data (maps, aerial photographs, satellite images) with the other quantitative, qualitative and descriptive information databases.

Remote sensing is one of the excellent tools for inventory and analysis of environment and its resources, owing to its unique ability of providing the synoptic view of a large area of the earth's surfaces and its capacity of repetitive coverage. Its multispectral capability provides appropriate contrast between various natural features where as its repetitive coverage provides information on the dynamic changes taking place over the earth surface and the natural environment.

When remotely sensed data are combined with other landscape variables organized with in a GIS environment provide an excellent frame work for data capture, storage, synthesis, measurement and analysis. For assessing a site as a possible location for solid waste disposal, several environmental and political factors and legislations should be considered. The GIS aided methodology presented here utilizes to create the digital geo database as a spatial clustering process and easily understood way for landfill process for Dharmanagar Nagar Panchayet.

II. ABOUT THE STUDY AREA

Dharmanagar is a district town and a Nagar Panchayat in the North East of India and the North Tripura district of the state of Tripura, India. It lies between 92^0 08' 42.60" E 24^0 21' 43.40" N and 92^0 10' 52.3 "E 24^0 24' 14.42" N. The area has an altitude of 20 meters.

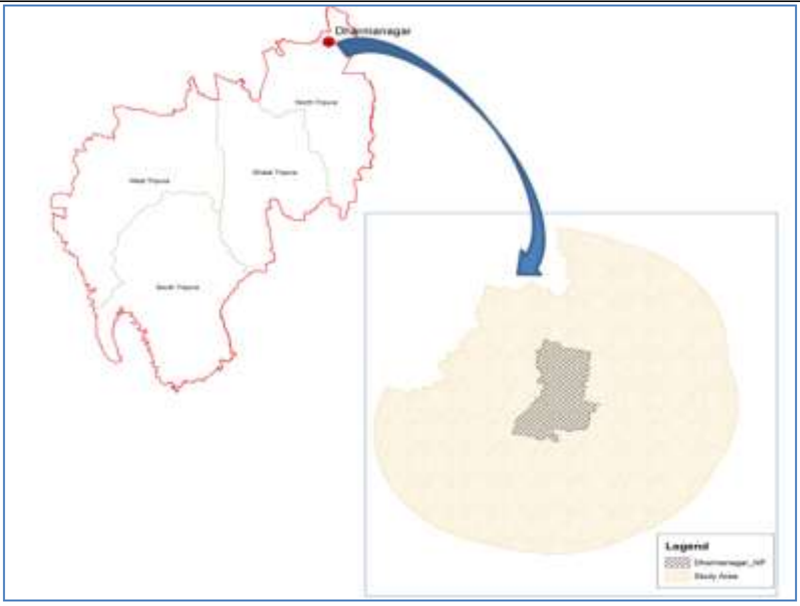

Figure 1. Locational map of the study area

III. MATERIALS AND METHODS USED

It is evident that, many factors must be incorporated into landfill siting decisions and GIS is ideal for this kind of preliminary studies due to its ability to manage large volumes of spatial data from a variety of sources. It efficiently stores, retrieves, analyzes and displays information according to user defined specifications. The methodology utilizes GIS to evaluate the entire region based on certain evaluation criteria for the analysis of landfill site suitability. The criteria were selected according to study areas local characteristics.

The principal sub criteria that used for spatial analysis are:

a. Lithology
b. Geomorphology
c. Slope
d. Drainage
e. Population
f. Distance from major Roads
g. Distance from major Streams
h. Distance from Drainage

Various vector files in .shp format were created. After attributing the database, map was created and thereafter various thematic maps like Geomorphology, Lithology, Slope, Drainage, Streams and road map were created and weightage were allocated to them on the basis of key factors. The weightage value for different themes is shown in the Table 1.

Table1: Weightage assigned for each theme.

Themes	Weightage
Geomorphology	8
Lithology	8
Slope	8
Drainage	6
Stream	6
Population	5
Road	4

In that multi-criteria analysis system, the comparative evaluation of the alternative scenarios, is taking place in 2 steps: (i) criteria groups are defined, each one consisting of a series of individual criteria and the weight factor of each group is defined based on the experience of the working group, and on any potential data from relevant applications. Based on the defined criteria groups and the relative weight factors, the proper cumulative function is extracted based (ii) the Criteria Groups (CG) are getting extracted into their individual evaluation criteria (IC), where by using the appropriate weight factors, their own relative significance is defined, within each criteria group.

i. Geological Criteria

The geology of an area will directly control the soil types created from the parent material, loading bearing capacity of the landfill's foundation soil, and the migration of leachate. Rock and its structure type will determine the nature of soil and the permeability of the bedrock. Geologic structure will influence the movement of leachate. Comparing extreme permeability rates, unfractured crystalline rocks will transmit little (if any) fluids whereas poorly cemented sandstones will allow rapid transport of fluids. Due to higher permeability rates, sandstone is less suitable as landfill bedrock than other sedimentary rocks such as limestone and shale. Limestone is more suitable than other shale due to susceptibility of the carbonate rocks to dissolution from low pH leachate, and is commonly associated with discontinuities and karsts features such as collapses, sinkholes and caverns. Shale formations are well suited for landfill sites since shale commonly act as a retarding bed slowing or confining the transmission of fluids.

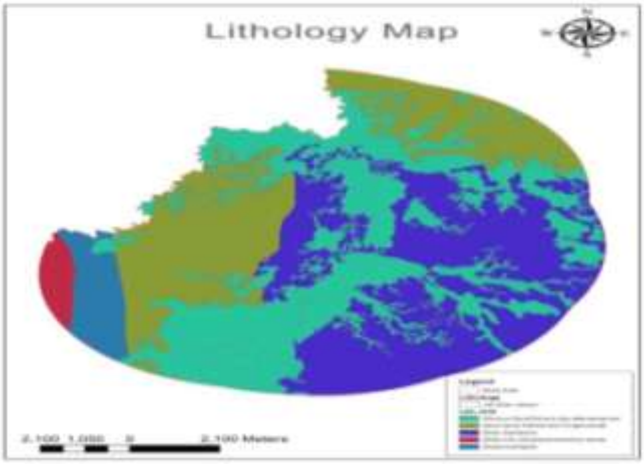

Figure 2. Lithology map of the study area.

Table 2: Suitability scores given for lithology

Type of Lithology	Suitability score
Charnockite	8
Cordierate Gneiss	7
Garnet biotite Gneiss	5
Brown sand	5
Coastal sand	1
Gritty sand stone	1
Sandy/ slit Alluvium	1

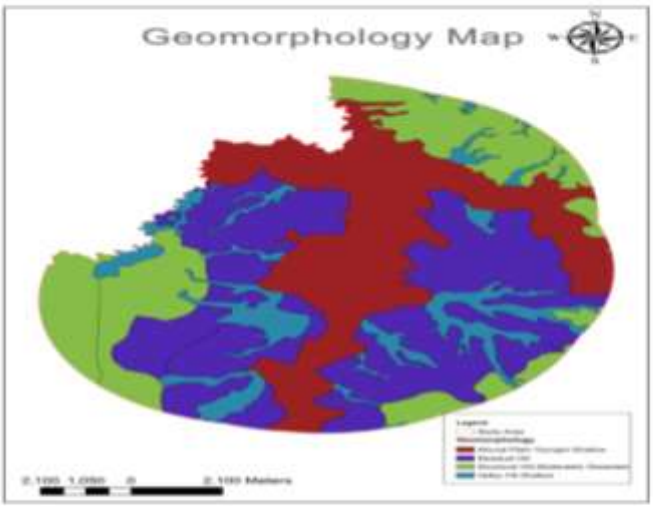

Figure 3.Geomorphology map of the study area.

Table 3: Suitability scores given for Geomorphology

Type of Geomorphology	Suitability score
Denudational hill	7
Denudational slope	5
Residual hill	3
Flood plain	1
Water body	No data

ii. ***Topographical Criteria***

The topography of an area is an important factor on site selection, structural integrity, and the flow of fluids surrounding a landfill site because it has important implications for landfill capacity, drainage, ultimate land use, surface and groundwater pollution control, site access and related operations. Deciding the type of landfill design (area-, trench-, and depression-type landfills) is directly related to topography of a site.

Flat and gently rolling hills that are not subjected to flooding are the best sites for (area- and trench-type landfills. However, this kind of topography is also suitable for other land uses like agriculture, residential or commercial development that lead to higher land prices.

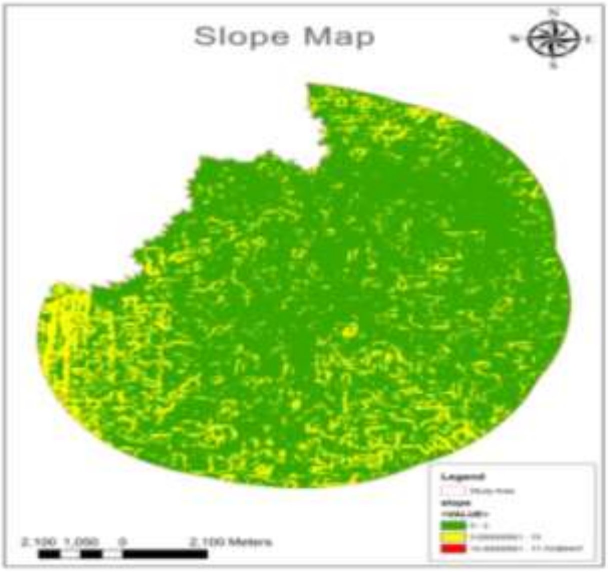

Figure 4.Slope map of the study area.

Table 4: Suitability scores given for slope

Slope in degree	Suitability score
0-3	1
3-15	8
15-19	7

iii. ***Hydrologic/Hydro-geologic Criteria***

The landfill site should not be placed within surface water or water resources protection areas to protect surface water from contamination by leachate. Safe distances from meandering and non-meandering rivers should be achieved to prevent waste from eroding into rivers and major streams. A landfill should not be located within 100 feet (30.48 m) of any non-meandering stream or river, and at least 300 feet (91.44 m) from any meandering stream or river. Large ponds, lakes, and reservoirs should have a buffer zone of land to prevent blown debris and runoff from harming aquatic habitats. Large bodies of water (greater than 20 acres (80937.45 m2) of surface area) should be at least 100 feet (30.48 m) from any landfill site. If the regional drinking water is supplied by surface water impoundments, it may be necessary to exclude the entire watershed that drains into the reservoir from landfill sites (Bagchi, 1994). Since major rivers have a higher discharge and greater downstream influence, no landfill should be sited within the floodplains of major rivers (Bagchi, 1994). The construction of a landfill within the 100-year flood stage of a minor river or stream is not safe.

A high groundwater level or a nearby high river level will cause more risk to pollute the groundwater or river water. The potential landfill location with the lowest groundwater or river level is more suitable for a landfill.

Figure 5: Drainage map of the study area.

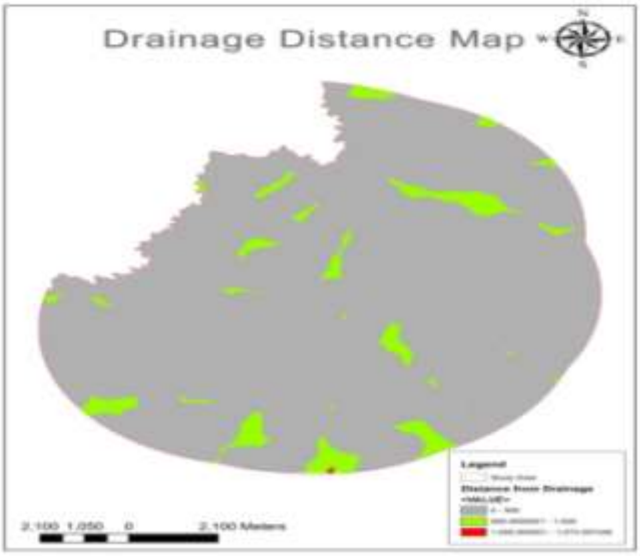

Figure 6: Distance from Drainage map for the study area.

Table 5: Suitability scores given for distance from drainage

Drainage distance in meter	Suitability score
0-500	1
500-1000	3
1000-2000	6
2000-3000	7
3000-5000	8

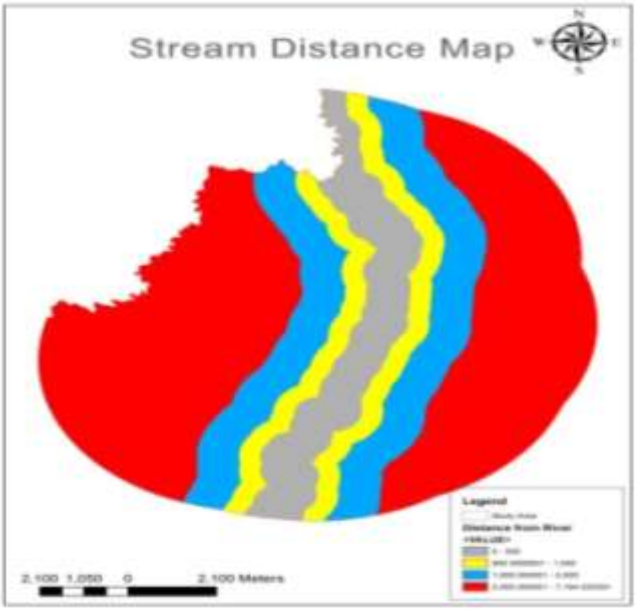

Figure 7: Distance from Stream Map

Table 6: Suitability scores given for Distance from Streams.

Stream distance in meter	Suitability score
0-500	1
500-1000	3
1000-2000	6
2000-3000	7

iv. Socio-economical Criteria

Landfills may not be constructed on sites within the settlements according to regulation on solid waste control.

Public Amenities

If the location of the new landfill come across with existing infrastructural provisions such as cables, roads or existing plans for drainage, it is very difficult to make the location suitable for the use as a landfill.

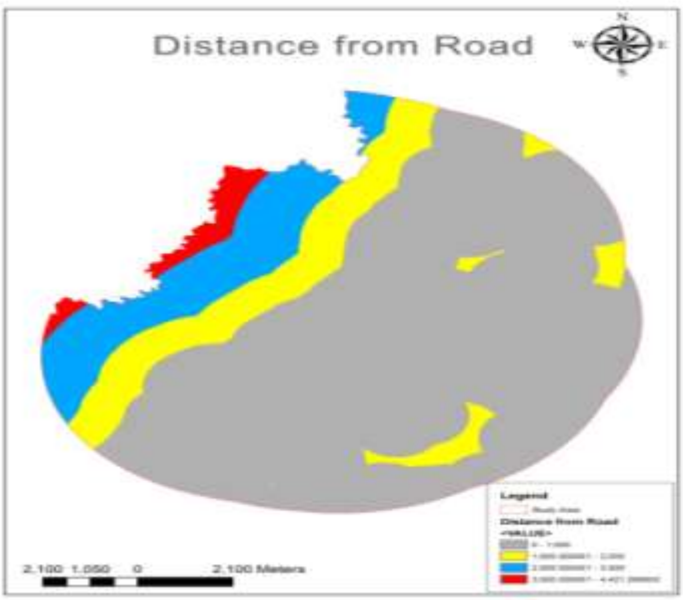

Figure 8: Distance from Major Roads

Table 7: Suitability scores given for distance from Major Roads.

Road distance in meter	Suitability score
0-1000	1
1000-2000	2
2000-3500	8

Population

According to 2011 census population at Dharmanagar is 1, 89,998 which is quite high as compared to its neighboring Revenue Villages. The population map and the suitability score given for population zone is given in the table 8.

Figure 9: Population Zone Map of the Study area.

Table 8: Suitability scores given for Population Zone

Population Range	Suitability Score
1,319 - 1,631	1
1,631- 2,285	2
2,285 - 2,924	3
2,924 - 3,257	4
3,257 - 4,577	5
4,577 - 6,618	6
6,618 - 8,478	7
8,478 - 13,314	8

After projection and topology creation all feature classes like geomorphology, slope, lithology, drainage, stream, population and road were converted to raster files and separate datasets were created using weightage and rank. For the analysis all the raster datasets for different layers having different score were over layed and the scores of each composite class were added using raster calculator tool of spatial analyst extension of Arc Map.

The final scores were reclassified to generate the output map showing various classes of suitable site for waste dumping.

IV. SUMMARY AND CONCLUSION

The outcome generated through the GIS analysis is discussed in this section. Total area in our project including buffer zone covers an area of 203.96Km^2. The result shows that 55.08 Km^2 areas is very less suitable, 76.45 Km^2 area is less suitable, 49.49 Km^2 area is moderately suitable, 16.72 Km^2 area is highly suitable and 6.22 Km^2 area is very highly suitable for dumping waste. The suitability study shows that the Balidhum revenue village area shows the maximum concentration of very highly suitable to highly suitable area. The Paschim Halflong revenue village also shows good concentration of both the classes. Suitable areas obtained in the analysis are shown in the suitability map.

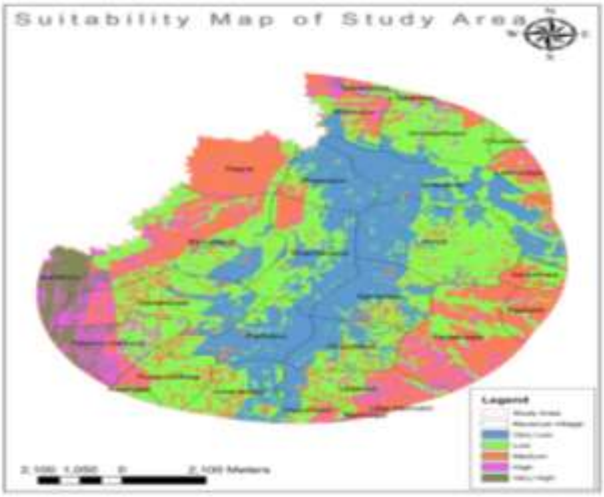

Figure 10: Suitability Map of Study Area

Table 9: Suitable Area Analysis

Suitability	**Area in** Km^2	**Area %**
Very Low	55.08	27.01
Low	76.45	37.48
Medium	49.49	24.26
High	16.72	8.2
Very High	6.22	3.05
Total	**203.96**	**100**

One of the serious and growing potential problems in most large urban areas is the shortage of land for waste disposal. Although there are some efforts to reduce and recover the waste, disposal in landfills is still the most common method for waste destination. An inappropriate landfill site may have negative environmental, economic and ecological impacts. Therefore, it should be selected carefully by considering both regulations and constraints on other sources.

V. Acknowledgements

The authors express their deep sense of gratitude to Tripura Space Applications Centre, Agartala, Tripura (West) for providing all facilities to carry out the study. The authors are also grateful to NRSC, Hyderabad for providing support for this study.

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