Selection of suitable sites for solid waste disposal for Manur block of Tirunelveli district using GIS techniques

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Abstract: Solid waste is the term used to describe non-liquid waste materials arising from domestic, trade, commercial, agricultural, industrial activities and from public services. There has been a significant increase in municipal solid waste generation in India in the last few decades. This is largely because of rapid population growth and economic development in the country. Solid waste management has become a major environmental issue in our country. Waste disposing is an important part of waste management system, which requires much attention to avoid environmental pollution. The disposal of solid wastes can be carried out by several methods such as composting, verminculture, recycling, incineration and land filling. Sanitary land filling is the most acceptable and flexible method for ultimate disposal of solid waste. A suitable disposal site must satisfy environmental safety criteria and attributes that will enable the wastes to be isolated. The present study has been undertaken for demarcating the suitable solid waste disposal sites for the Manur block of Tirunelveli district, Tamil Nadu using GIS techniques. The suitability criteria for locating the solid waste disposal sites were demarcated based on GIS based weighted index overlay analysis. The different solid waste disposal sites were categorized into highly suitable, moderately suitable and less suitable.

Keywords: Solid waste, composting, GIS, weighted index overlay analysis, land filling

1.Introduction

Solid waste comprises of all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwarranted. Rapid growth in population, industrialization and urbanization are responsible for huge amounts of solid wastes being generated every day. Waste disposing is an important part of waste management system, which requires much attention to avoid environmental pollution. The solid waste disposals can be carried out by composting, vermiculture, recycling, incineration and land filling methods. A solid waste disposal site is a land disposal site for non-hazardous solid wastes at which waste is spread in layers, compacted to the smallest practical volume, and covered with materials. Geographical Information System (GIS) can be used as a decision support tool for planning waste management. Manual methods adopted for analysis of many factors would be a lengthy and tedious work. GIS is used in this study to create various maps, data analysis and for creating site suitability maps. GIS is a fundamental part of modern geography and it is extensively used by environmental planners (Kontos et al., 2003). Spatial analyst tool of ArcView 3.2a software has been used for the selection of suitable waste disposal sites.

2. Materials and methods

2.1 Study area

Manur block of Tirunelveli district, Tamil Nadu has been selected for the present study. This block is located in the Eastern side of the Tirunelveli district. The study area covers an area of 620.60 km^2. The study area is situated between 8°40’33’’N to 8°57’43’’N latitude and 77°33’13’’E to 77°49’27’’E longitude. The study area has a population of 1,55,432 as per 2001 census. Average annual rainfall of the study area is 485 mm. Thamiravaruni and Chittar rivers are flowing through Manur block. Thamiravaruni river flows in the southeastern side of Manur block. Chittar river flows in the northeastern side of the study area. The location map of the study area is shown in Figure 1.

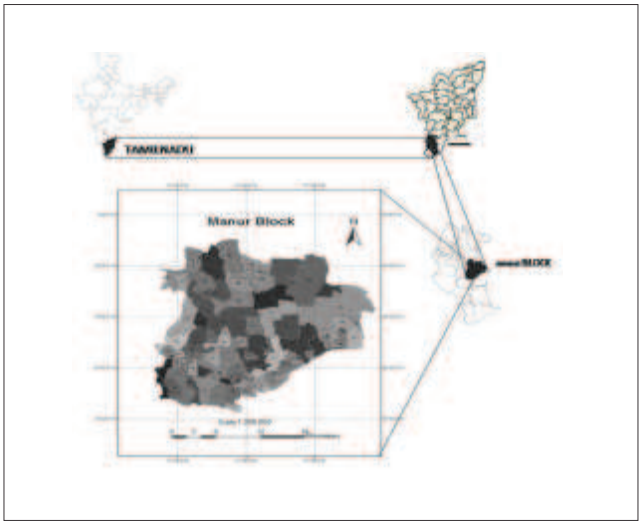

Figure1: Location map of the study area

2.2 Acquisition of spatial and non spatial data

Data acquisition involves with the collection of maps, rainfall data and population census data for the study area. The spatial data of study area such as hydrological soil group, land use pattern, geology, geomorphology, lineament and village map were collected in the form of maps in the same scale of

1:50,000. These maps were collected from Institute of Remote Sensing, Anna University, Chennai. The non-spatial data such as rainfall was collected from the Public Works Department, Tirunelveli and population data was collected from Tirunelveli Municipal Corporation, Tirunelveli.

2.3 Software used

The GIS software used for digitization and spatial analysis in the present study are ArcGIS 9.2 and ArcView 3.2a. ArcGIS 9.2 is raster based software with multiple map analysis capabilities. It is used for geo-referencing, creation of attribute table and digitization of the collected map. ArcView 3.2a is a vector based GIS package and is capable of accessing large amount of spatially varying data. It is used to create the spatial database, analysis and produce the outputs for the present study.

2.4 Thematic map preparation

Thematic maps are an important source of GIS information. These are tools to communicate geographical concepts such as climate, forests, land use pattern, soil type, roads and political boundaries etc. Thematic map displays the spatial pattern of a theme or series of attributes (Akbari et al., 2008). The thematic maps such as hydrological soil group, land use pattern, geology, geomorphology, lineament, road network and village map were prepared for the present study.

2.5 Weighted index overlay analysis

The various thematic maps such as hydrological soil group, land use pattern, geology, geomorphology, lineament and village map were overlaid using weighted index overlay analysis in the present study. In this method, weights have been assigned to various classes of different themes like geology, geomorphology, land use pattern, soil type and population. The weightage of each criterion was finalized on the basis of the ranges of the maximum and minimum values within each theme. Total weightages were divided into different solid waste disposal zones such as highly suitable, moderately suitable and less suitable depending on the final weight values assigned to polygons in the final layer. The maps exhibiting the zones of highly suitable sites are considered as favorable sites for solid waste disposal. The road map is superimposed over the weighted overlaid map and used to identify site-specific mechanism for solid waste disposal for Manur Block. The decision rules used to delineate solid waste disposal sites are listed in Table 1.

3. Results and discussion

The thematic maps such as hydrological soil group, land use pattern, geology, geomorphology, lineament, road network and village map were derived using ArcGIS software. The spatial distribution of these thematic layers and their distribution of areas are as follows.

Table 1: Weightage for different criteria's for selection of suitable solid waste disposal sites

Sl. No.	Criteria	Classes	Rank	Weightage
1	Geology	Quartzite	3	22
		Hornblende Biotite Gneiss	1	
		Alluvium	3	
2	Geomorphology	Pediment and Pediment Inselberg complex	1	10
		Buried Pediment Shallow	2	
		Buried Pediment Deep, Residual Hill, Flood plain and Structural Hill	3	
3	Hydrological Soil Group	Class C and Class D	1	18
		Class B	2	
		Class A	3	
4	Land use	Waste land	1	25
		Built-up land	3	
		Water bodies	3	
		Agricultural areas	3	
5	Lineaments	Absent	1	10
		Present	3	
5	Population	0-2000	1	15
		2000-4000	2	
		4000-6575	3	

3.1 Hydrological soil group

Hydrological soil group A, B, C and D were identified in the study area. The Hydrological soil group B covers major portion of the study area. The areas under various hydrological soil group of the study area are shown in Table 2. Hydrological soil group map of the study area is shown in Figure 2.

Figure 2: Hydrological soil group of study area

Table 2: Hydrological soil group present in the study

Sl. No	Hydrological soil group	Area (km^2)
1	A	64.70
2	B	434.52
3	C	86.57
4	D	34.81
	Total Area	**620.60**

3.2 Land use pattern map

The major portion of the study area is under agricultural area. Based on the land use pattern existing in the study area, it was reclassified into four major categories such as waste land, water bodies, agricultural area and built up land. The areas under various land use patterns of the study area are shown in Table 3. The land use pattern map is shown in Figure 3.

Table 3: Land use classification present in the study

Sl. No.	Land use classification	Area (km^2)
1	Waste land	26.10
2	Water bodies	48.16
3	Agricultural area	527.73
4	Built-up land	18.61
	Total Area	**620.60**

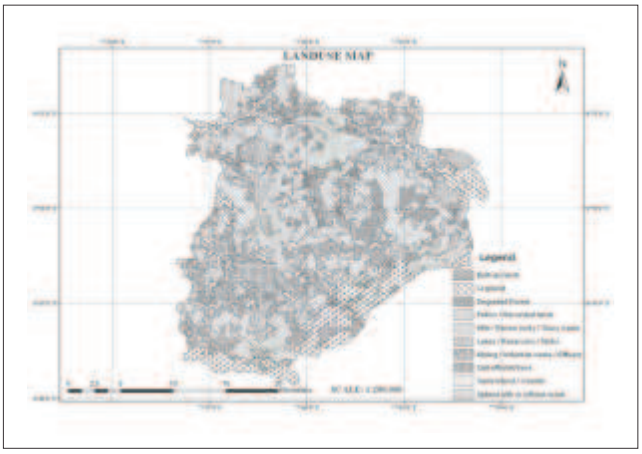

Figure 3: Land use map of study area

3.3 Geology

The geology of the study area has been divided into three categories such as Hornblende Biotite Gneiss (HBG), Quartzite (Q) and Alluvium (ALL). The Hornblende Biotite Gneiss covers major portion of the study area. The areas under different types of geology of the study area are shown in Table 4. Geology map of the study area is shown in Figure 4.

3.4 Geomorphology

The major geomorphic units identified in this study area are Pediment-Inselberg Complex (PI), Buried Pediment Shallow (BPS), Buried Pediment Deep (BPD), Flood Plain (FP), Pediment (P), Residual Hill (RH) and Structural Hill (SH). The Buried Pediment Shallow covers major portion of the study area. The areas under different types of geomorphology of the study area are shown in Table 5. Geomorphological map of the study area is shown in Figure 5.

Table 4: Geological classification present in the study

Sl. No.	Geological classification	Area (km^2)
1	Alluvium	127.97
2	Hornblende Biotite Gneiss	481.10
3	Quartzite	11.53
	Total Area	**620.60**

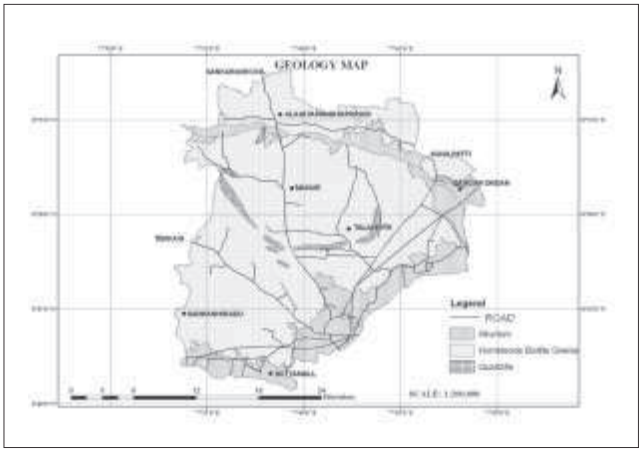

Figure 4: Geology map of study area

Table 5: Geomorphological classification present in the study area

Sl. No.	Geomorphological classification	Area (km^2)
1	Pediment-Inselberg Complex	4.25
2	Buried Pediment Shallow	348.83
3	Buried Pediment Deep	78.24
4	Flood Plain	123.95
5	Structural Hill	11.53
6	Pediment	52.50
7	Residual Hill	1.30
	Total Area	**620.60**

Figure 5: Geomorphology map of study area

3.5 Lineaments

Lineaments are present in the central part of the study area and are shown in Figure 6.

Table 6: Area of different categories of solid waste disposal sites

Sl. No.	Solid waste disposal zones	Area (km^2)
1	Highly Suitable	5.66
2	Moderately Suitable	541.86
3	Less Suitable zones	73.08
	Total Area	**620.60**

Figure 6: Lineaments map of study area

3.6 Road network and details of village

The study area has various major roads, minor roads, unmetalled roads and rail route. Road map of study area is shown in Figure 7. Village map of the study area shows different Taluk boundary, village boundary and block boundary. Village map of the study area is shown in Figure 8.

Figure 7: Road map of study area

3.7 Selection of suitable sites for solid waste disposal

To demarcate the solid waste disposal sites all the thematic layers were integrated into a weighted index overlay process. Based on this method, weightage have been assigned to various classes of different themes like hydrological soil group, land use pattern, geology, geomorphology, lineament and village map. Finally all these thematic maps have been converted into grid with related weightage supporting suitable disposal sites and the entire model is run in Model builder tool of ArcView 3.2a software. The suitable solid waste disposal map of the study area has been generated after the model run and is shown in Figure 9. The different solid waste disposal sites were categorized into highly suitable, moderately suitable and less suitable zones. The areas of different categories of solid waste disposal sites are shown in Table 6. There are four highly suitable sites are demarcated in the study area and the sites are located in the villages namely Sethurayanpudur, Sanganhiradu, Pillaiyarkulam and Tachanallur. Then the Road network map was overlaid over the final integrated weighted overlay map. The accessible zones of the highly suitable areas were assessed for the study area and finally the villages namely Sethurayanpudur and Tachanallur were identified as the highly suitable zones for disposing solid waste and are most accessible sites of the study area.

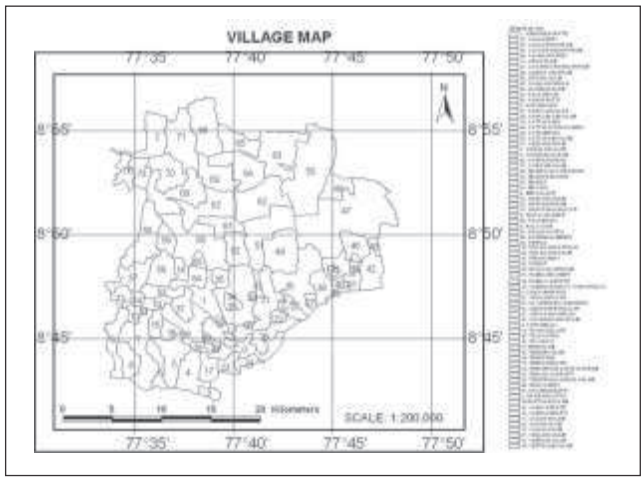

Figure 8: Village map of study area

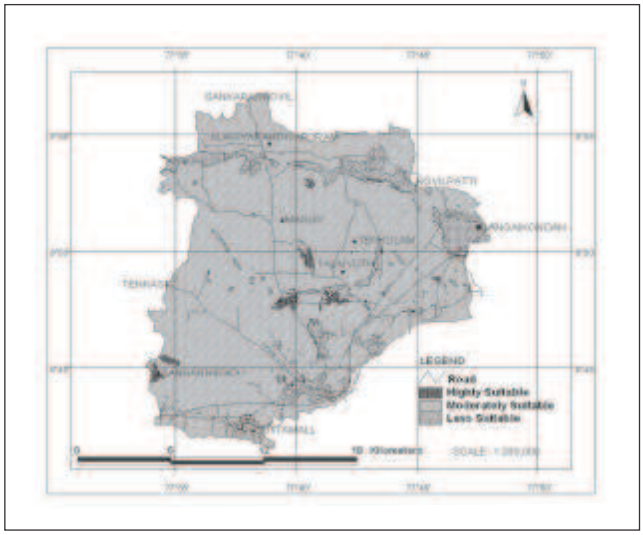

Figure 9: Suitable solid waste disposal site map of study area

4. Conclusions

Solid waste consists of highly heterogeneous mass of discarded materials from residential, commercial, industrial and mining activities. Solid waste management is of great concern to all, as improper collection and distribution will leads to health problems. Selection of disposal sites for solid waste generated in the urban area has always remained big task, as the selected site should not affect the environment negatively. The present study has been carried out to demarcate suitable solid waste disposal sites using GIS. The data integration, management and visualization in GIS environment were relatively efficient. The result of suitability map indicates that most part of the area in Manur block is having moderately suitable to less suitable for solid waste disposal. The application of the GIS for selection and demarcation of solid waste disposal sites was clearly visualized, not only in its accurate prediction but also easy handling of any changes in the space or domain under consideration.

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