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Application of remote sensing and GIS for identifying suitable sites for solid waste disposal in Erode Corporation, Tamil Nadu, India

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This investigation focuses on the selection of suitable sites for solid waste dumps in Erode Corporation, Tamil Nadu using Spatial Multi-Criteria Evaluation (SMCE) with the help of Topographical map and Landsat-8 satellite data for the generation of road, water bodies, rivers and drainages, land use/land cover, landforms, geology and soil, slope maps. Use of remote sensing and GIS for distinguishable proof of the sensible objectives of solid waste dumped depends on the overlaying of datasets and spots that fulfill the site suitability criteria. The datasets and spots join the spatial examination devices given by GIS to arrange and survey in order to choose possible waste areas. Finally, in Erode city Municipal Corporation an appropriate dumping zone and few locations for dumping of solid waste are created. A set of twenty-one (21) sites is found to be the most favorable locations for dumping of solid waste. Indeed, SMCE is found to be the best method for the present work.

[**Keywords**: Erode Corporation, Geology, Landsat-8, Remote sensing & GIS, Slope, Soil]

Introduction

Phenomenal increase in population and extension of urban areas in recent years are the main reasons for dumping municipal solid waste, which has become an alarming situation globally. The people started visualizing the diminishing environmental resources in satisfying the needs of their comfort living with the invention of emerging technologies. The demands of people affect the eco balance which results in breaking the mutual relationship between living and non-living factors and it becomes threat to the environment. The economic growth of any country can be raised by meeting the demands for sustainable development in coherence with fulfilling environmental needs.

Waste disposal can be done either as it is or after sustaining some thermal processing methods like combustion, pyrolysis, gasification or physical processing method[1,2]. However, because of low level of technology, low income, high level of illiteracy in developing countries, open dumps are in preponderance. The processing method is thermal when open dumps are set on fire not minding the effect of pollution on the air and the environment. This is peculiar with dry season period; in the rainy season, the solid wastes are dumped indiscriminately causing major natural issues presenting dangers to the lives of human beings.

Remote sensing and GIS approach is used for the Spatial Multi-Criteria Evaluation (SMCE) analysis of the acquired data with the view of obtaining the best site for the waste disposal[3,4]. GIS is a computerized technology for data collection, storage assimilating, employing, evaluating, examination and exhibiting data, which are spatially referred to the Earth[5,6]. The present solid waste dump yard is located at Vendipalayam in an area of about 19.46 acres and volume of existing dumps is around 5 lakh cubic metres. The major challenge found in the present site is the pollution generated from composting and it demands transportation of solid waste from all parts of the city to the existing dump yard. Hence, isolation of dump sites at various locations vicinity to the collecting wastes could be the appropriate solution to address the above problem.

Materials and Methods

Study area

The present study region shown in Figure 1 is 10 km radius (Buffered zone) of Erode municipality covering an area of about 109.52 km^2 which is located between 11°11’47.994” and 11°32’0.13” North

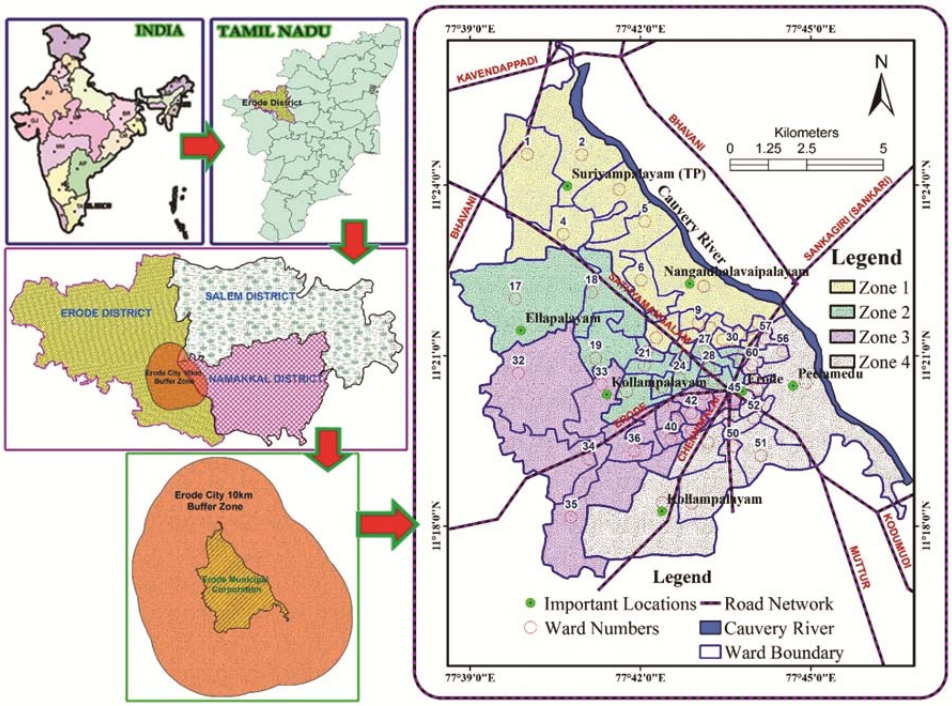

Fig. 1 — Key map of the study area

latitudes and 77°33'5.416" and 77°33'5.416" East longitudes and 103 m and 397 m above mean sea level. It is positioned in the northwest part of Tamil Nadu. The 10 km radius boundary is combined together with the three districts such as Erode (80.38 %), Namakkal (16.47 %) and Salem (3.14 %). The population of Erode Corporation as per 2011 census is 4,98,121. The zone has a tropical environment with the most extreme and least temperature recorded in May and January independently are 36 and 27 °C, respectively. The precipitation of this region depends essentially on the Northeast rainstorm season. The major industries situated in Erode district are tanneries, paper industries, co-operative processing mills, dairy project, sugar and chemical factories.

Methodology

The method adopted in the current study involves the acquisition of data, data preparation and SMCE analysis of the data prepared for obtaining the appropriate sites for disposal of solid in Erode Municipal Corporation. The feature data classes created in Arc GIS 10.5 version are carefully selected and digitized from the georeferenced image of the area concerned. Further, the elevation model of the area is generated by digitizing contour lines from the georeferenced topographical map. Using SMCE analysis in ArcGIS environment, the most suitable sites for waste disposal are obtained[7].

Data/ Equipment needed

Landsat-8 satellite data used for the study include those downloaded from www.earthexplore.usgs.gov website and Topographical sheets No. 58E/10, E/11, E/12, E/15 and E/16 at scale of 1:50,000. Likewise, the Equipment used include Personal computer with ArcGIS 10.5 version software and Global Positioning System (GPS).

Data preparation

Toposheets are registered before digitizing the thematic layers using existing latitude and longitude values. Satellite image, District resource map and District soil map are registered with the help of toposheets and GPS points are used for the georeferencing in GIS platform.

Two types of data are used in the present research: Spatial information of maps and their related attribute information. Both the data are created in ArcGIS environment. Creation of feature classes is done using Arc Catalog portion. A New Personal Geodatabase is developed and from the Personal Geodatabase (PGDB), a feature dataset is created named as FR data. Further, XY coordinate system that refers to Geographic coordinate system is selected as World WGS 1984 and projected coordinate system is

selected as UTM WGS 1984, UTM 44N zone. From the feature dataset, feature data classes are created as drainage, water bodies, road network, geology, soil, land use/land cover, landforms, lineaments and slope. For each of these data classes, the type of feature stored is selected e.g. line for road, lineaments, drainages and polygon for geology, soil, land form, land use/land cover and slope. Interpretation of satellite imageries are used for lineament extraction and ERDAS software (ERDAS IMAGINE 9.0) is used for lineament densities on further processing. False color composite (FCC) images are used to derive the geomorphology and land use/land cover maps in the band combination of 4 (red), 3 (green), and 2 (blue) using Landsat 8 data with 30-m resolution. The thematic layers created using SMCE overlay analysis are utilized to find an appropriate site in erode city Municipal Corporation for solid waste dumping. Detailed methodology flowchart is given in Figure 2.

Results and Discussion

A serious level of environmental problem occurs with the solid waste dumping process in the world. The leachates generated from the dumping area affect the soil and the groundwater properties. In addition, the air pollution is caused by the gas (Biogases) emissions from the solid wastes. The present research deals with locating suitable sites for disposing municipal solid waste in and around the Erode municipal corporation.

Suitability of soil types

Soil is different from its parent rock sources as it is altered by multifarious interactions among the lithosphere, hydrosphere, atmosphere and the biosphere. The predominant types of soil found in the study area are red non-calcareous, red calcareous, alluvial, black and brown soils. The spatial reference map given in Figure 3 shows that the majority of the portions are distributed as red non-calcareous soil followed by red calcareous and alluvial soil. This study considers the red calcareous and non-calcareous soils and Brown Soil that are more highly suitable than the land with alluvial and black soil portions. Alluvial soil is found all along the river courses. Therefore, the region along the river courses is not a suitable place for disposal of solid waste.

Suitability of slope

Present study region is a vast stretch of rolling plain. It reflects that low slope portions are the suitable sites for dumping the solid waste. Slope map given in Figure 4 is classified into seven types to give the rank based on making seven classes of interval. Distinctive research demonstrates that territories with deep slants are highly dangerous sites for dumping. Most of the investigation territories fall near to surface and very gentle slope of 0-3°; it is 98.35 % of the complete examination region. The slope that is less than 3° is profoundly appropriate for solid waste dumping[8,9]. Depending on the larger part of the study area, possible sites are identified for solid waste.

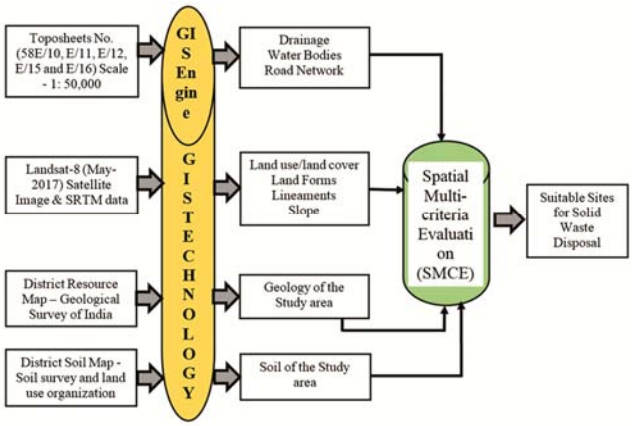

Fig. 2 — Methodology of the present research

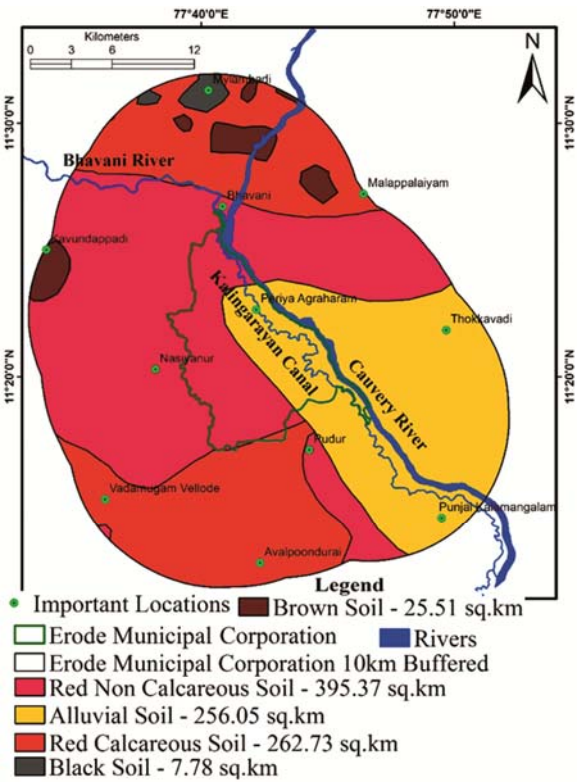

Fig. 3 — Spatial map of soil

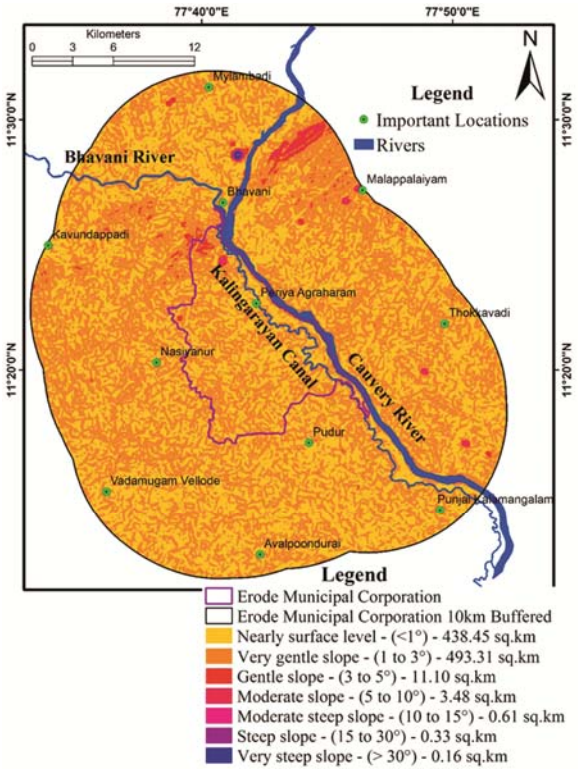

Fig. 4 — Spatial map of slope

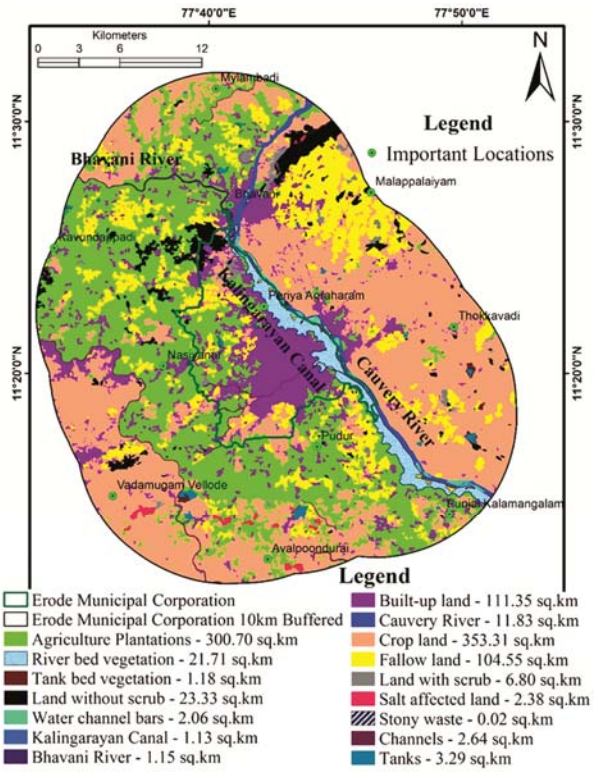

Fig. 6 — Spatial map of land use/land cover

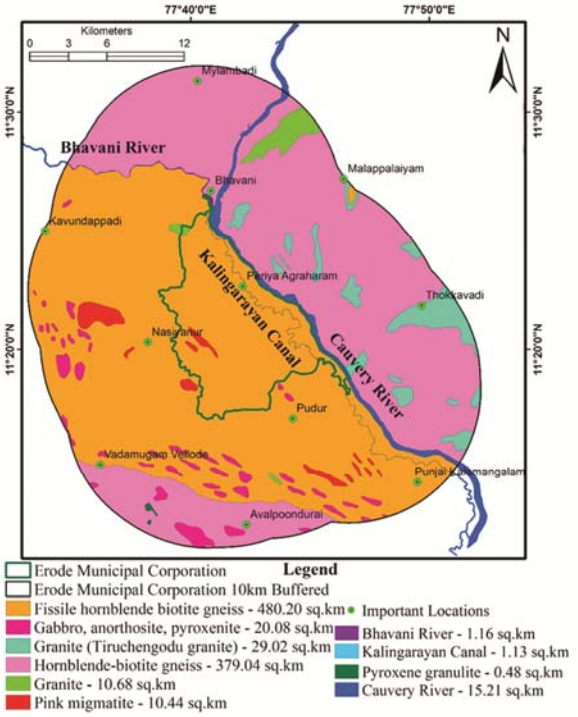

Fig. 5 — Spatial Map of geology

Suitability of geology

The Geological condition at the present study region is shown in Figure 5. It is observed that the rocks are classified as Archaean crystalline group of rocks. The fissile hornblende gneisses and hornblende gneisses (Peninsular gneiss-younger phase) of Bhavani group covers 90.69 % out of the entire region. The Cauvery river flows from north to south direction. These rocks are very low permeable due to less degree of weathering and fracture and thus have a high suitability for solid waste disposal siting.

Suitability of land use/ land cover

Land utilization describes how a land is distributed for cultivation, settlements or industry. However land cover insinuates the materials, for instance, vegetation, river and water bodies that are available on the earth surface. Land use is the expression of typical anthropogenic activities of the region.

Most of the present study region falls under agriculture lands like crop, fallow, plantations and built-up land that covers 80.06 % and 11.75 %, respectively of the total study area. Subsequently, 1 km distance away from the residential area is more class that is suitable. Wastelands like land with scrub and land without scrub area about is 0.7 % and 2.46 %, respectively as shown in Figure 6. Gray and dark shadings indicate the suitable portions for solid waste disposal sites.

Suitability of geomorphology

Decision has to be made both locally and regionally by giving importance to geomorphology. Figure S1 represents the importance of Geomorphology in the solid waste dump related planning processes. Pediplain canal command area is a dominant feature. It is not a suitable area for solid waste dumping. The suitable landforms such as shallow buried pediplain and moderately buried pediplain area are about 38.54 % is indicated by the blue and red shading as in Figure S1. These are the suitable portion for solid waste disposal sites.

Suitability of river, drainage and water bodies

Surface water resource like running stream, river, pond or lake is a gift to plants and animals and microorganism by nature. The characteristics of the polluted surface water are the key factor for the present research work.

In Erode Municipal Corporation, the river Cauvery flows from north to south and river Bhavani from west to east direction. Hence, to keep up the natural strength of these water sources, a minimum distance of 500 m is maintained. Consequently, two different regions are specified considering relative distance from river, drainage and water bodies as in Figure S2. By considering the river and drainage, the white portions are the most relevant sites for solid waste disposal.

Suitability of road network

The general thought is that the solid waste dumps would not be situated inside 100 m distance from national highway, state highway and other roads. The sites must be of minimum 1 km distance from all types of roads. The present investigation reveals more than 2 km distance from all types of roads as given in Figure 7. The result exhibits that 6.43 % from the above 2 km buffered zones is highly suitable for solid waste disposal sites of this study.

Spatial multi-criteria evaluation (SMCE) analysis for solid waste disposal sites

The solid wastes have a significant role in environmental pollution. The disposal of solid waste material includes materials from human and animal activities, which are not useful to human life and can sometimes be dangerous. It includes industrial wastes, agricultural waste, sewage treatment materials, garbages, rubbish, ashes, and dead animals. Hence, in view of involvement and likely effect on surrounding environment, suitable weightages are allotted to all

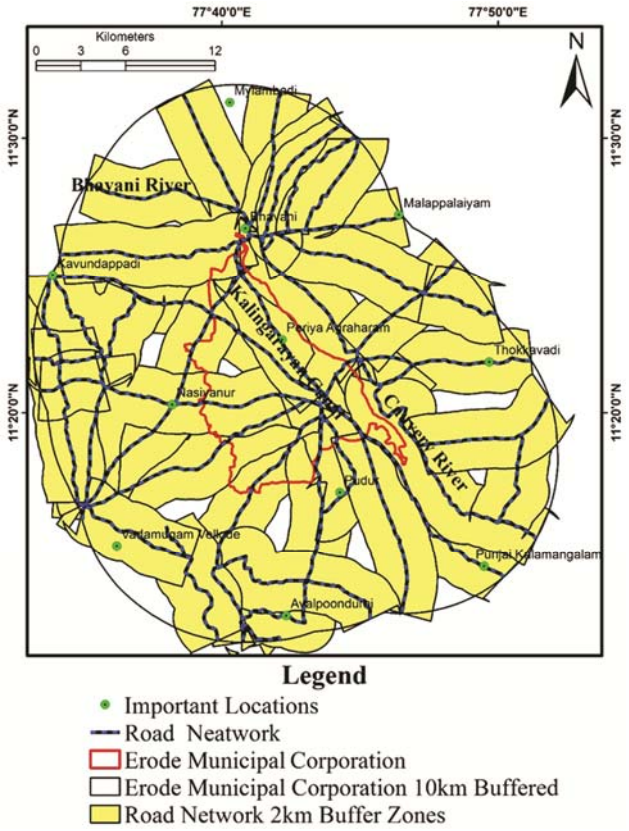

Fig. 7 — Spatial Map of road network 2 km Buffer zone

the parameters. The higher weightages indicate that they are more suitable for solid waste disposal[10].

Weightages have been allotted to each feature of all thematic maps for GIS Spatial SMCE overlay study[11]. A scale of 1 to 10 (value < 9 = unsuitable (restricted), value > 9 = suitable) is followed commonly for combining all overlay analysis for standardizing all data involved. The suitable weightages are given in Table 1[ref. 12,13]

All the thematic maps are integrated with the help of suitable ranking[14]. The output map given in Figure 8 shows that the suitable sites are located away from the Erode municipal corporation area and distribution of 6.43 % (60.88 km^2) falls under this category.

Results of suitable solid waste disposal sites are given in Table 2 based on level of suitability. Among the 21 suitable sites the following three sites such as Jambai, Salangapalayam and Pungampadi which is located at a distance of 22, 20 and 14 km respectively, were found to be more highly suitable for the reasons like consumption of less time for transportation, less impact on residents around and feasible geographical conditions.

Table 1 — Weightages ranking for suitable site selection of solid waste disposal followed by [12,13]

S. No	Site Selection criteria	Types / Nature	Weight Factor	S.No	Site Selection criteria	Types / Nature	Weight Factor
1	Soil	Red Non calcareous soil	9	6	LULC	Agriculture plantations	3
		Alluvial soil	7			Bhavani river	0
		Red calcareous soil	9			Built-up land	0
		Black soil	7			Kaveri river	0
		Brown soil	9			Crop land	3
2	Slope	Nearly surface level	10			Fallow land	3
		Very gentle slope	9			Kalingarayan canal	0
		Gentle slope	8			Land with scrub	10
		Moderate slope	7			Land without scrub	10
		Moderate steep slope	5			River bed vegetation	1
		Steep slope	4			Salt affected land	7
		Very steep slope	3			Stony waste	8
3	Geology	Fissile hornblende biotite gneiss	9			Tank bed vegetation	0
		Hornblende biotite gneiss	9			Tanks	0
		Gabbro,anorthosite, pyroxenite	9			Channels	0
		Granite (Tiruchengode Granite)	8			Water channel bars	0
		Granite	8	7	Geomorphology	Pediplain canal command	4
		Pink migmatite	6			Shallow buried pediplain	8
		Pyroxene Granulite	8			Moderate buried pediplain	9
		Kalingarayan canal	0			Pediment/ valley floor	6
		Kaveri river	0			Shallow flood plain	1
		Bhavani river	0			Inselberg	3
4	Drainage and river	Buffer in < 500mts	2			Linear Ridge/ Dyke	2
		Buffer in > 500mts	9				
5	Road Network	Buffer in < 2 km	2				
		Buffer in > 2 km	9				

Table 2 — Results of suitable solid waste disposal sites

S. No	Name of the villages	Suitability
1	Jambai	
2	Pungampadi	Highly Suitable
3	Salangapalayam	
4	Mylambadi	
5	Appakudal	
6	P Mettupalayam	
7	Tenmugam	
8	Punnam	
9	Vettaiperiyapalayam	Moderate
10	Tayinpalayam	
11	Pallapalayam	
12	Thuyyampoondurai	
13	Avalpoondurai	
14	Thanathampalayam	
15	Katteri	
16	Emappalli	
17	T. Kavundampalayam	
18	Pirithi	Suitable
19	Perundalaiyur	
20	Ellapalayam	
21	Pallakkapalaiyam	

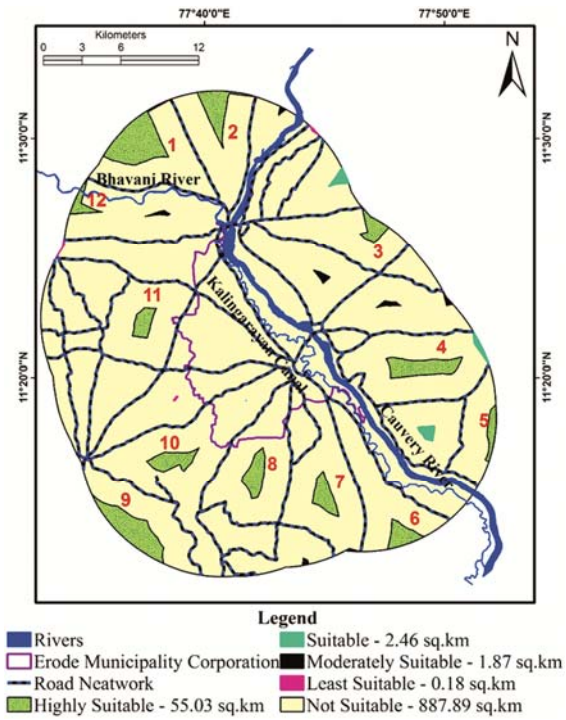

Fig. 8 — Suitable solid waste dumping site map

Conclusion

Thus, the present work involves the usage of GIS and Remote Sensing integration. It serves the purpose of locating the most appropriate sites for dumping of solid waste material. It has focused on the decision of dumping solid waste in optimal sites at Erode Corporation, Tamil Nadu using SMCE.

From the 21 suitable solid waste dump sites, three sites are suggested as highly suitable. The suitability of sites helps in improving the solid waste management system for Municipal Corporation. The isolation of dump sites near to the collecting area greatly increases the efficiency of the system. The extensive coverage of erode district beyond the radial distance of 10 km could be the scope for future research.

Supplementary Data

Supplementary data associated with this article is available in the electronic form at http://nopr.niscair.res.in/jinfo/ijms/IJMS_49(08)1479-1485_SupplData.pdf

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Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

KV proposed the objective of the study and developed the SMCE analysis and KE contributed in writing of manuscript.

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