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Application of GIS and Remote Sensing in Solid Waste Management

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Abstract: In today's world, handling solid waste is a global environmental issue. The population growth has led to an increase in the production of industry, residential and services and this has a negative environmental impact. The disposal of urban solid waste is known as one in developing countries ' municipalities ' most serious environmental problems. The placement of the dumping site in unsafe places has one of these consequences. The aim of this paper is to create a suitable site for the disposal of urban solid waste generated in and around Aurangabad through GIS technology. Based on analysis of Landsat satellite data, the urban area over the last three decades was increased by more than 240%, mostly south and southwest, apart from the nearby villages where the increase was in the east and northeast. Ultimately three sites, taking the environmental, biophysical and economic variables implemented in the GI-based WLC study into account, were proposed as alternatives to the current waste disposal sites.

Keywords: Remote Sensing, GIS, MSW, Solid waste management, Routing.

INTRODUCTION

Rapid population growth and urbanization decreases non-renewable energy and indiscriminately eliminates waste and toxic waste, which are major environmental issues threatening human existence. Allen et al. Misuse of solid waste mainly includes transmission of disease, fire hazards, odour, atmospheric and water pollution, esthetic nuisance and economic losses. Over the years, solid waste generation in India has increased significantly from 100 gm/person/day in towns and to 500 gs/person / day in large towns. Most of the urban solid waste is actually disposed of unscientifically in India. Municipal solid waste usually collected and disposed of in sanitary sites attracts rats, mice, and fleas to the waste disposal site and produces unhygienic conditions. The degradation of the solid waste contributes to CO2, methane (CH4) and other trace gases being released. The non-scientific landfill will lower the drinking water quality and cause disease such as yellowing, nausea and asthma. The goal of this study is to identify a suitable site for the disposal with remote sensing and GIS techniques of urban solid waste produced in and around the municipality of Aurangabad. Solid waste management is one of the dilemmas facing towns and cities in Maharashtra and the serious problems facing urban centers in Maharashtra is to find a suitable landfill area [1].

GIS ' position in the management of solid wa ste:

Remote sensing, due to the unique ability to provide a synopsis of a large surface area and its capacity to repetitively cover, is one of the excellent methods for inventory and study of the environmental and resources. The multi-spectral capacities contrast the natural characteristics in which it provides frequent reporting details on dynamic changes over the earth's surface and the natural environment. Geographical Information System (GIS) has been introduced as an innovative tool for the waste disposal process in computer science. The GIS integrates geographic data

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with other quantitative and concise data bases. GIS contains maps, aerial photos, and satellite images [2], [3]. The technology incorporates a device capable of gathering, processing, controlled, restoring, analyzing and showing data, offering an analytical platform for data synthesis. Once data with remote sensing is combined with other GIS-organized landscape variables, an excellent system for data collection, storage, processing, measures and analysis is achieved. Many environmental and political considerations and regulations should be weighed in order to evaluate the site as a possible location for solid waste landfill. The GIS helped methodology presented here utilizes the digital geo-database as a tool for spatial clustering and easily understand the method of deposition in the municipality of Aurangabad [4].

Study Area:

The Municipality of Aurangabad is a town in the western part of the state of Maharashtra. Around 19.8762° N, 75.3433° E. The municipality's overall area is 54.4km^2. It has more than 2,00,000 households and a number of companies, offices and educational institutions. Paithan and Kannad is situated at the municipality boundaries with Panchayat (North), Panchayat (East), Panchayat (South) and Panchayat (West) and Sillod. Municipality of Aurangabad is the headquarters of the district of Aurangabad; therefore it has a large population floating as well. As a result of all this, the city produces most solid waste [5].

Methods and Materials used for the study:

In solid waste management, the role of Geographic Information Systems (GIS) is very important as many aspects of their planning and operation are very dependent on spatial data. GIS is a tool that not only reduces site selection time and costs, but also provides a digital database to monitor the site in the future. The approach uses GIS to analyze the entire region based on some measurement criteria for the study of site appropriateness. Such parameters are divided into two major categories including information concerning physical and social economics. The criteria have been selected based on local characteristics of the study areas. Lithology, geomorphology, slope, drainage, population, distance from major highways, the distance from major streams and distance from drainage constitute the main sub-criteria for spatial analysis. Table 1 indicates the requirements and sub-criteria used for creating a GIS database. Table 1.Criteria and sub-criteria for GIS database creation[2], [6].

Table.1: The Criteria and Sub-Criteria Used in Development of GIS Database

Social economic criteria	Population
	Distance from major roads
	Distance from streams
	Distance from drainage
Physical Criteria	Lithology
	Geomorphology
	Slope
	Drainage

With the help of satellite image IRS1B, the geomorphologic map was produced from a scale of 1:50,000 on the topo sheets 58C/6 and 58C/10. Different form files have been generated and translated to coverage in the Arc GIS 8.3. The development of topology began after the conversion of the form files into topology. Topology describes the mathematical relation between objects and specifically connects geographical characteristics in the database. After attributing the data basis map, different thematic maps were produced and assigned according to the key parameter, including geomorphology, lithology, drainage, pathways, streaming, population and road map. Table 2 indicates the weighting applied to various topics [7]. A 5 km buffer zones were established in the municipality for the disposal of solid waste. A suitability score has been assigned and converted with the Spatial Analyst in the Arc Map for different coverage's in these topics [2], [3], [7], [10]. The research methodology covers many sequential steps; the comprehensive methodology is outlined graphically in Figure 1.

Table.2: Assigned Weightage for Each Theme

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Themes	Weightage
Geomorphology	8
Lithology	8
Slope	7
Drainage	6
Stream	6
Population	5
Road	4

RESULTS

Figure 2 shows the drainage map of the study area. Sandstone, gritty gneiss biotite, cordierite gneiss, brown sand and shoreline sand are all research area lithology. Figure 2, 3, 4, 5 shows the lithology chart for the study area, and Table 3, 4, 5 shows the appropriateness ranking. The important geomorphic units found in the study area are denudational hills, residual hill slopes, denudational slopes, floodplains and water bodies, based on their picture characteristics. The hill is formed because of the varying erosion and weathering, so that the formation or the intrusion of mountains or hills is more robust. In the central area of the municipality of Aurangabad, surrounded by denudational hill, there is a Denudational Hill [10]. On the western part of the research area the flood plain is mainly found in Paithan, Kannad and in part in Panchayat Sillod. Residual hills are found in Paithan, Kannad and Waluj Panchayat, in the eastern part of the study area.

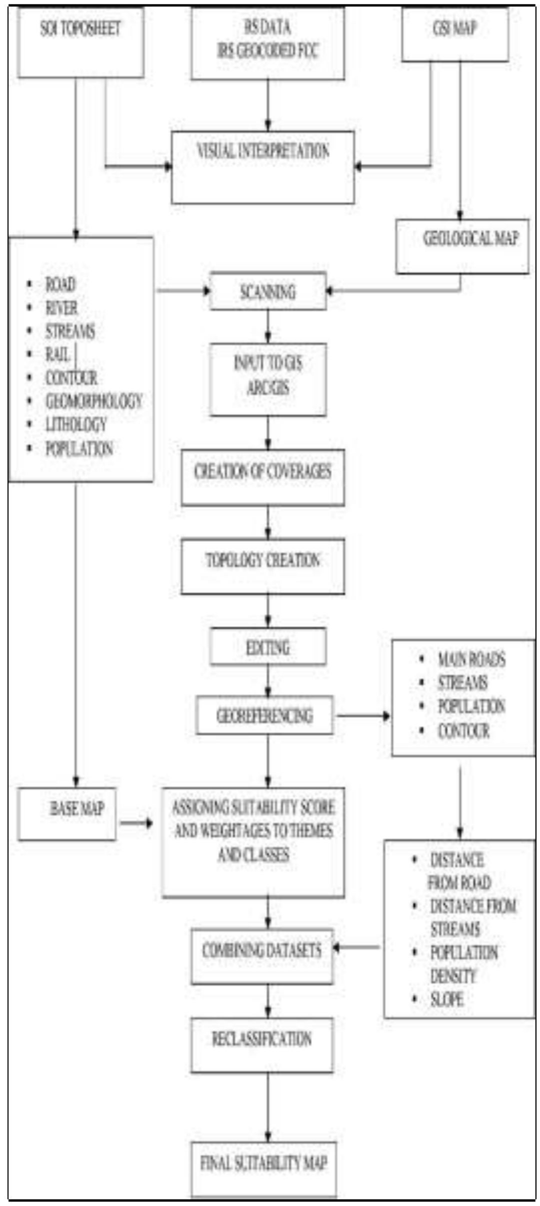

Figure 1: Flowchart of the methodology adopted

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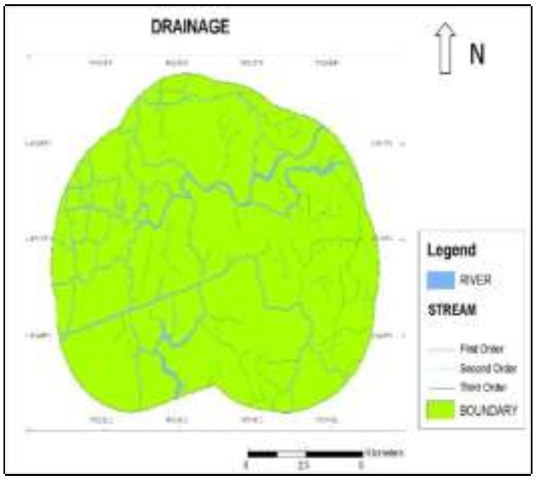

Figure 2: Study Area's Drainage.

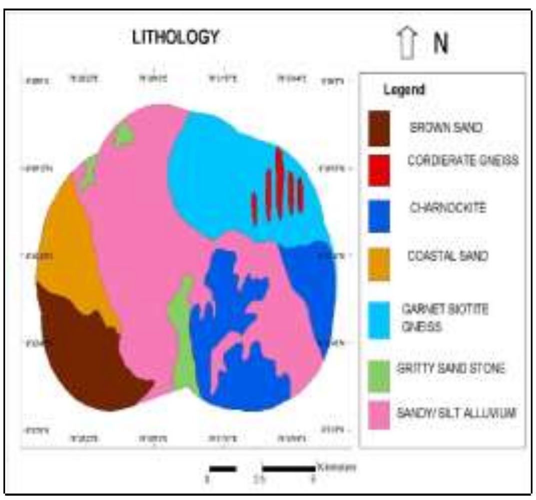

Figure 3: Study Area's Lithology Map

Table.3: 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

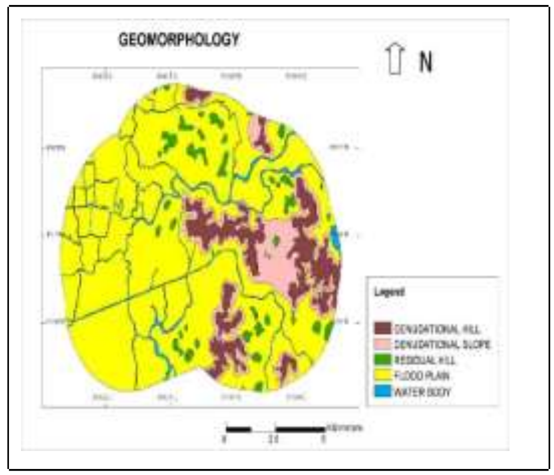

Figure 4: Geomorphology Map of the Study Area.

Table.4: 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

Figure 5: Study Area's Slop Map.

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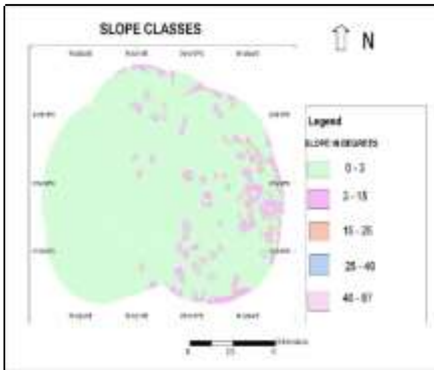
Slope in degree	Suitability score
0-3	1
3-15	8
15-25	7
25-40	2
40-87	1

Table.5: Suitability Scores Given for Slope

According to 2011 census population in the Aurangabad municipality is 11.8 lakhs which is quite high as compared to its neighboring Panchayat. The population map and the suitability score given for population zone is given in the figure 6 and table 6 respectively. And Table 7 shown the scores for drainage and table 8 for major roads.

Table.6: Suitability Scores Given for Population

Location	Population	Suitability score
Paithan	34,556	8
Kannad	40,759	7
Sillod	58,230	6
Waluj	20,220	6
Gangapur	25,053	5
Khultabad	12,794	4
Aurangabad	11,72,878	1



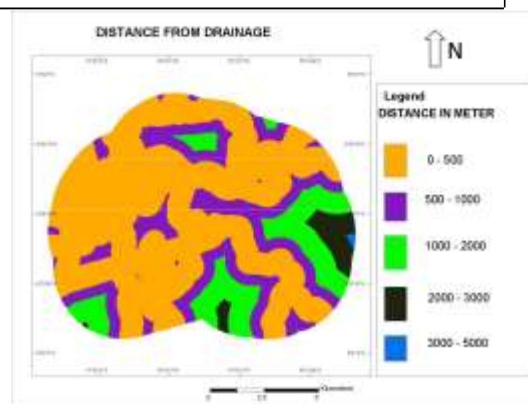


Figure 6: Distance from Drainage Map of the Study Area.

Table.7: Suitability Scores Given for Drainage

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

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Figure 7: Distance from Major Road Map of the Study Area.

Table.8: Suitability Scores Given for Distance from Major Roads

Road distance meter	Suitability score
0-1000	1
1000-2000	2
2000-3500	8
3500-5000	7
5000-7000	2

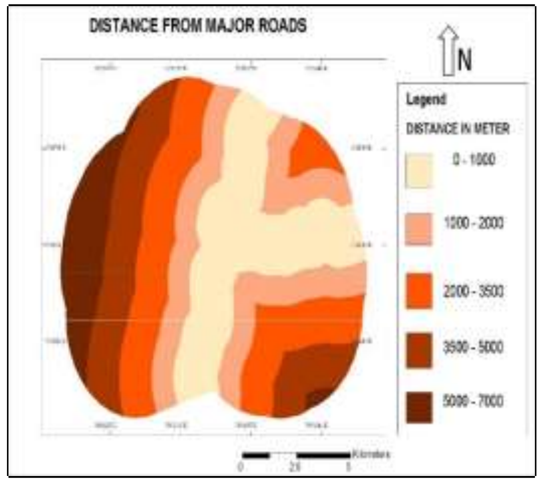
Figure 8: Distance from Stream Map of the Study Area.

Table.9: Suitability Scores Given for Distance from Streams

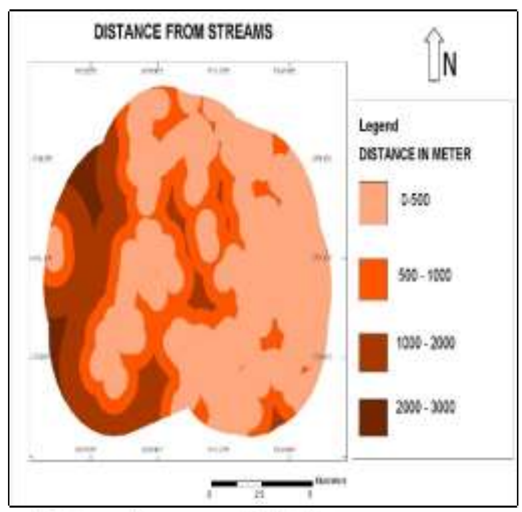
Stream distance meter	Suitability score
0-500	1
500-1000	3
1000-2000	6
2000-3000	7

The figures 7, 8, 9 and Tables 7, 8 and 9 indicate maps such as distance of drain, distance from major roads, distance from streams and suitability scores respectively. All feature classes such as geomorphology, pitch and lithology have been transformed into raster data after projection and topology development, weightage and rank have been used to generate a raster and separate data settings. All raster datasets were applied to the study for different layers of different quality, adding raster calculators for the extension of Arc Map to each composite level [11]. In the final scores, the performance map was reclassified indicating different classes of acceptable dumping place. Table10 lists the rules governing the quest for suitable land.

Table.10: Decision Rules for Finding Suitable



Land Area



Criteria	Suitability class		
	Highly Suitable	Moderately Suitable	Less Suitable
Geomorphology	Denudational Hill	Denudational slope and Residual hill	Flood plain
Lithology	Charnockite and Cordierate Gneiss	Garnet biotite Gneiss and Brown sand and Sandy slit Alluvium	Coastal sand, Gritty sand stone and
Slope	3^0-15^0 and 15^0-25^0	25^0-40^0	0^0-3^0 and 40^0-87^0
Distance from drainage in meter	3000-5000 and 2000-3000	1000-2000	0-500 and 500-100
Population density	33,074 and 23,538	29,413 and 34,986	1,72,878
Distance from major roads in meter	2000-3500 and 3500-5000	1000-2000 and 5000-7000	0-1000 and
Distance from streams in meter	2000-3000 and 1000-2000	500-1000	0-500

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CONCLUSION

This section addresses the results produced by the GIS study. Our project includes a total area of 24.61536Km^2 including a buffer zone. The results showed that an area of 4,2909 km^2, which is 14,1833 km^2, is very less suited to dumping, 3,90096 km^2, and an area of 1,5824 km^2, which is very suitable for dumping, are very suitable and an area of 0,65773 km^2 is less suitable. The correct area reached in the study is shown in Table 11.

Table.11: Suitable Area Analysis

Suitability	Area in Km^2	Area %
Very High	0.65773	2.6820
High	1.58244	6.4287
Medium	3.90096	15.8446
Low	14.18333	57.6197
Very Low	4.29094	17.4250
Total	24.61540	100

In the area between Paithan and Kannad and also in Waluj, the appropriate categories are high and very high. The establishment of appropriate waste disposal sites is one of the major problems in developing countries with adverse environmental effects for industrial development. In the disposal of hazardous solid waste, the biggest environmental concern needs to be considered is the location of the land filling. In other conditions and locations where the intensity of the criteria applied indicates inconsistencies, the proposed approach can be used for site selection processes.

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