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The data base, land use and land cover and solid waste disposal site - using remote sensing and GIS: A case study of Sakkottai – block, Sivagangai District, Tamil Nadu, India

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ABSTRACT

The problem associated with the solid waste disposal site in today's society is complex because of the quantity and diverse nature of the wastes. Rapid urbanization, limitations of funding, emerging limitations of both energy and raw materials and also add to the complexity of any waste management system. The SWM system is one of the key components of the infrastructure for a sustainable community. Therefore, solid waste will have to be managed by technologies and methods that support sustainable communities and environments. In the present study it was tried to find out the potential waste disposal sites using Remote Sensing and GIS techniques for Karaikudi Municipality. Selection of suitable sites for waste disposal is based on several factors. GIS technology using Weighted overlay analysis help to select the possible suitable solid waste disposal sites and are categorized in to three category. There are Good, Moderate and Poor. Among these categories, the sites which are in between the 4-5km buffer is selected for the disposal of solid wastes. Accordingly environmental, transportational and economic point of view suitable site is identified. On the basis of integration of various parameters IRS- P6 LISS III imagery and GIS as a tool have been found to be very useful for the interpretation and identification of solid waste disposal site. Thus with the use of these technologies management of municipal waste will no longer be a problem for city administrators.

Key words: Data base, Land use, Solid waste, Sakkottai and Remote sensing.

INTRODUCTION

Our Environment is facing potential threat from unsustainable waste disposal practices prevailing in almost all the urban centers in the country. Vast quantities of waste generation by the cities are one of the serious outcomes of unplanned development. Due to the increasing

population and industrialization, large quantities of wastes are being generated in different forms such as Solid, Liquid and Gases. Each city produces tones of solid waste daily from the Household, Hospitals, Industries, Agricultural fields, Market centers etc. Some of these are Biodegradable and some are Non-degradable and Hazardous waste. Solid wastes are directly thrown away on to the street roads, water bodies, vacant places, sewerage systems, city garbage collection sites etc. In earlier days, waste disposal did not pose problem due to negligible quantity of waste and now a days due to the lack of public awareness and erratic disposal and dumping methods problems has risen. Due to rapid urbanization and increase in domestic and industrial sectors, solid waste generation was observed in large cities. The management of this enormous waste in terms of collection, handling and disposal with conventional methods has become increasingly difficult. The proper and scientific solid waste disposal necessitates the selection of proper site, which is dependent upon several issues that have impact for site selection. Broadly, they are divided into three categories i.e., Economic, Social, and Environmental.

Remote Sensing provides an opportunity to visualize the actual ground features. The Geographical Information System (GIS) can provide an opportunity to integrate the various field parameters with population and other relevant data or other associated features, which help in the selection of sites. Site selection procedures can benefit from the appropriate use of GIS. The use of GIS in the site selection process will reduce the time and enhance the accuracy.

The study on the selection of potential waste disposal sites around Ranchi Urban complex using Remote sensing and GIS techniques have used IRS IC LISS III, (23.5 m spatial resolution), topographic maps, census data and hydrological map. They have to adopted methodology for remote sensing and GIS techniqes to identify and selection of such sites. The potential sites for the waste disposal was found out[8].

The paper on soild waste disposal site selection using image processing and GIS techniques[3] have used Analogue maps, satellite imageries and Aerial photographs. The methodology used in this study is proximity operation and Boolean operation. In this study, the criteria of the optimun sites for solid waste disposal sites has been framed.

Accurate information on land-cover changes and the forces and process behind is essential for designing a sound environmental planning and management. Land-cover analysis provides the baseline data required for proper understanding of how land was used in the past and what types of changes are to be expected in the future. Studies of land-cover changes also yield valuable information for analysis of the environmental impacts of human activities, climate change, and other forces. Such analysis is of great use to the resource manager because it provides information that would help in resolving conflicts between human use of natural resources and the function of natural systems [6].

Though landuse is mainly controlled by, various biophysical factors like soil, climate, relief and vegetation but the human activities are mainly responsible for the change of attributes of landuse modification and conversion. Continuous exploitation of natural resources beyond threshold limit of resilience of the ecosystem accelerates various geomorphic processes on the earth surface, thereby causing imbalance in natural ecosystem resulting in large-scale disaster in

present day habitation. The impact of landuse in the prevailing surface and subsurface hydrologic conditions is remarkably high. Within a basin, the dynamics of hydrologic processes are governed partially by the temporal and spatial characteristics of inputs and outputs and the landuse conditions [7]. Keeping these factors in view a full featured spatial information about the changeable landform features and related landuse (i.e. land-water-vegetation inter-relationship) on a natural unit basis is very essential for integrating the same with the related non-spatial data (e.g. demographic, socio-economic etc.) to obtain a real world feature.

GIS has been used in a number of studies in the initial screening process in order to identify suitable potential sites for new waste management facilities through a process of 'sieve mapping'. Such studies have included models that incorporate environmental, engineering, planning and economic criteria which include various siting constraints such as soil or geological type, distance from roads or urban areas, noise/nuisance, topography, hydrology and land use, etc. using GIS-based overlay techniques [1]

Land resources" concern all aspects of land that enable, support, constrain or influence present as well as potential land use [2] "Land" refers to a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface of hydrology (including shallow lakes, rivers, marshes and swamps), the near surface sedimentary layers and associated groundwater and geo-hydrological reserve, the plant and animal populations, the human settlements pattern and physical results of past and present human activities (terracing, water storage or drainage structure, roads, buildings, etc.,) LU as "A series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources". In contrast, land cover is defined as "the observed bio-physical cover on the Earth's surface"[2].

Anthropogenic changes in land use and land cover are being increasingly recognized as critical factors influencing global change[4]. While land cover and land use are often assumed to be identical, they are rather quite different. Land cover may be defined as the biophysical earth surface, while land use is often shaped by human, socioeconomic and political influences on the land[5]. Remote sensing (RS), integrated with Geographic Information System (GIS), provides an effective tool for analysis of land-use and land-cover changes at a regional level.

Aims and objectives:
The main aim of this study is to select a suitable site for solid waste disposal using Geomatics, with the view to protecting the environment and public health. With this aim the following objectives are framed for the present study

- To assess the existing problems of solid waste disposal with the perspectual study, specific to Sakkottai block.
- To analyse the information on solid waste generation, collection and transportation.
- Mapping the different Land use/Land cover categories using IRS P6 LISS III imagery by visual interpretation technique.
- Mapping of Karaikudi Municipal area with different ward boundaries and attribute data

- Creation of a GIS database for decision support system and selecting an appropriate site for the disposal of solid waste.

Database management was in need of a new style of databases to solve current database management problems. Researchers realized that the old trends of database management were becoming too complex and there was a need for automated configuration and management. Since this new development process of database management there are more possibilities. Database management is no longer limited to “monolithic entities”. Many solutions have been developed to satisfy the individual needs of users. The development of numerous database options has created flexibility in database management.

II. The study area

The present study area that comprises Sakkottai block administratively comes under Sivaganga Distict that is located in the southern part of the state of Tamil Nadu. The Sivaganga district comprises of six taluks namely, 1. Sivaganga, 2. Manamadurai, 3. Ilayankudi, 4. Devakottai, 5. Karaikudi and 6. Thirupathur. The district consists of twelve blocks and 487 Villages. As regards to the hierarchy of administrative arrangement, there are 3 municipalities, 11 town panchayats and 437 village panchayats in the District. The Sakkottai block has 36 villages, 5 town panchayats, 1 Municipality and 3 Reserved forests.

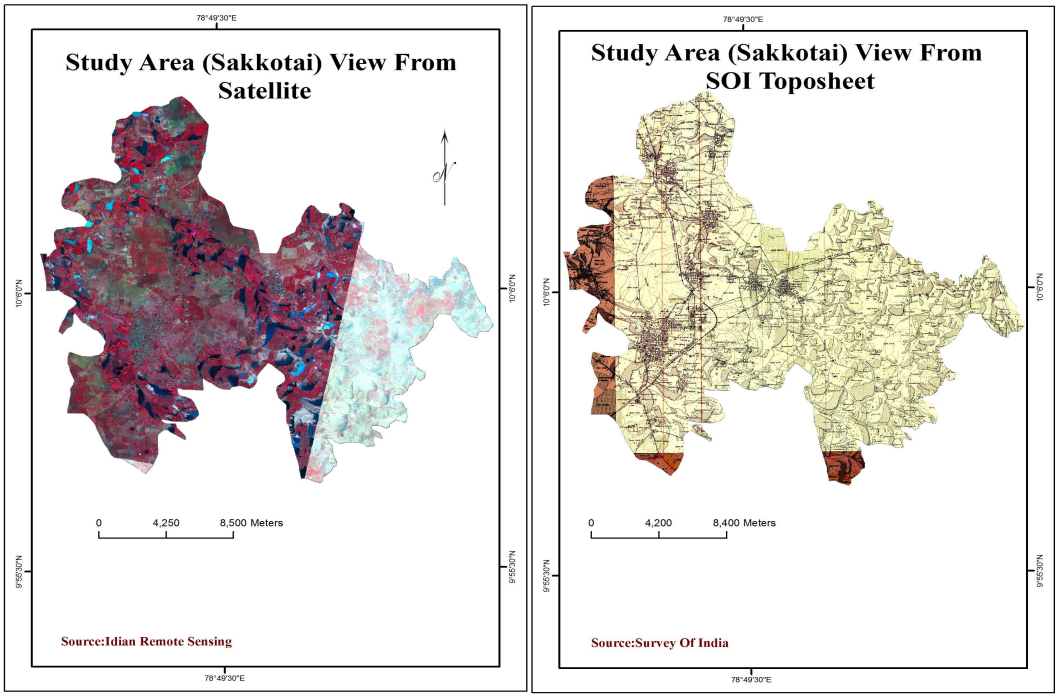

Fig.1,Topographic view and satellite view of the study area

The district of Sivaganga, extending over an area of 4,468.11 Sq.kms. is situated in the southeastern portion of the State. It is bounded on the north by portions of Tiruchirappalli and Pudukottai Districts, on the east by the district of Pudukottai and Ramanathapuram, on the south by the district of Ramanathapuram & Virudhunagar and on the west by Madurai district.

The administrative headquarters is located at Sivagangai town. The district lies between 9°61' and 10°42' north latitude and 78°12' and 79°00' east Longitude. The geographical position of Sakkottai block is between 9°59' and 10°12' North latitude and between 78°59' and 78°40' East longitude. The total areal extent of the selected block is 368.27 sq.km. The Urban movement has taken through the southwest and southeast direction. The topographic view and satellite view of the study area is shown in Fig(.1).The location of the study area is shown in Fig(.2).

The terrain of Sakkottai block is predominantly flat. The physiographic background of the present study area has been broadly discussed under the following subheads viz. Relief and Drainage, Litho units and Soil. The groundwater ranges from 2 to 20 mts below the ground level in the study area. The northwestern portion has shallow depth, whereas the central part has deep groundwater level.

The study area Sakkottai block, has a total population of 1,92,913 persons as per 2001 census. Transportation facilities in the Sakkottai block are Roadways, Railway line, and Airport.Metal and unmetalled road join with NH and SH. The railway connecting Thiruchirpalli and Thiruthuraipoondi passes through this block**.**

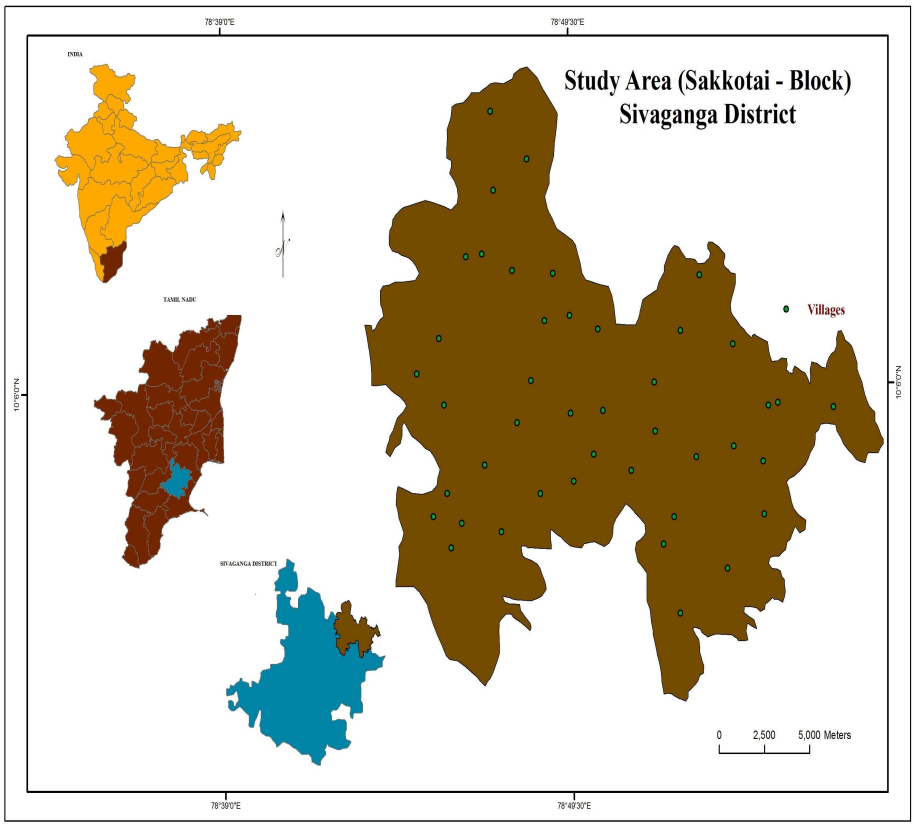

Fig.2. The location of the study area is shown

III. Research Design

The present study depends upon spatial data and non spatial data.

i) Spatial data:
a) Satellite imageries, IRS P6 LISS III acquired on August 2006 .b) Image from Google Earth
c) SOI Toposheets bearing the numbers 58 J/12, 58 J/16, 58 K/9 and 58 K/13 at the scale of 1:50,000 published in the year (1967- 1970). c) Administrative boundaries from Census of India
d) Soil, and Litho units from NATMO.

ii) Non-spatial data:
a) Existing solid waste disposal site.
b) Karaikudi municipality map with wards.
c) Nature and quantity of the waste.
d) Population census (2001), from census of India.
e) Ground water details from website.

Software used:
i) Arc GIS 9.3 version developed by ESRI and ii) ERDAS 9.2 version developed by ERDAS Inc.

i) Spatial data Preprocessing and Base Preparation
The spatial data like the satellite data, toposheets, Administrative boundaries, soil and lithounits are rectified to the same coordinate system (UTM, WGS 84). The base amp layers has been digitized and the digitization errors has been rectified. The attributes has been given and the layers are prepared in to layouts for the description of the study area. The vector layers are prepared for the overlay analysis to find out the appropriate sites for solid waste disposal.

ii) Spatial data analysis for the Selection of Solid waste Disposal Site
The present study of solid waste disposal site selection using geomatics techniques adopted the method for Weighted overlay analysis. The parameters like Land use, Road, Ground water depth, soil, relief, Litho units are considered and weightages are given in accordance to its importance to the favorable sites for disposal. All the above parameters have been extracted from the toposheets, satellite imageries, and websites. All the parameters has been generated as a single layer in vector format. The Karaikudi Municipality Office has been plotted with reference to the toposheet, Google earth imagery and also field visit experience. The buffer 5 and 4 km distance from Municipality office has been created in Arc GIS Toolbox. The above parameters are extracted with this 5 km buffer in study area. All these vector layers are converted into a Raster format. All the parameters are given different weightages for a total of 100%. Each parameters has different categories and the weightage ranks for the separate category has been allotted based on its influence to the selection of solid waste disposal sites.

IV.Analysis

a)Data base:

1)Population and Growth rate
Karaikudi is the largest city in Sivaganga district. As of 2001 India census, Karaikudi had a population of 86,422 persons(Fig.3). Males constitute 50% of the population. Karaikudi has an average literacy rate of 79%, higher than the national average of 59.5%; in which male literacy is 84%, and female literacy is 74%. In Karaikudi, 11% of the population is under 6 years of age. The estimated population of Karaikudi urban agglomeration in 2004 is 132,294 persons. This is also termed as the best place to live among the other places in the same district. Karaikudi is a

selection grade municipality with an area of 14.42 Sq. km consisting of 36 wards. The decadal growth rates had shown a gradually increasing trend until the year 1971 and then decreased. In 2001, Karaikudi has shown a growth of about 20.33 percent. This growth rate is due to increase in the educational facilities in and around the town. The municipality is experienced with inward migration.

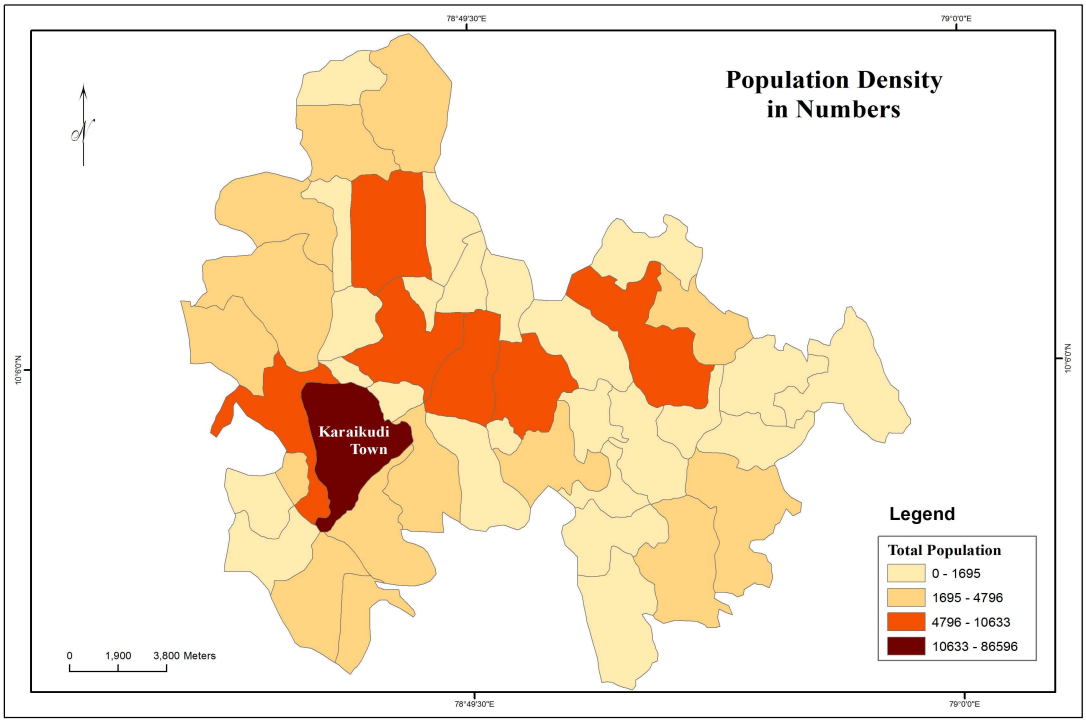

Fig.3.Population density

Linkage and Transportation

Karaikudi is situated towards north of Sivagangai district and is about 90 Km from Trichy and 450 Km from Chennai. It is well connected by rail and road transport. NH 210, SH 28 and SH 35 passes through the town. While NH 210 connects Trichy and Rameswaram, SH 28 & 35 connects Tanjavur, Sayalkudi and Dindigul with Karaikudi. Karaikudi is a junction on the southeast Railway division. The meter gauge line connecting Trichy, Manamadurai and Rameswaram passes through the town .

Road accessibility:

The highly accessible area within < 1 km distance from the roads is seen in major parts of the area. To the north, west and east region of municipality office has accessible area within 1- 2 kms and finally north-west region has accessible area greater than 2 kms.

Ground water depth

In the buffer zone north-west zone has the ground water depth is 2- 5 m. bgl. The northern portion of the municipality office area are Aarumuganagar, Subramanyapuram and western

region Manikandapuram, Naganathapuram has the category of 5-10 bgl. In the south-west region of Sathyamoorthy nagar has the 10- 20 m. bgl. (Fig.4).

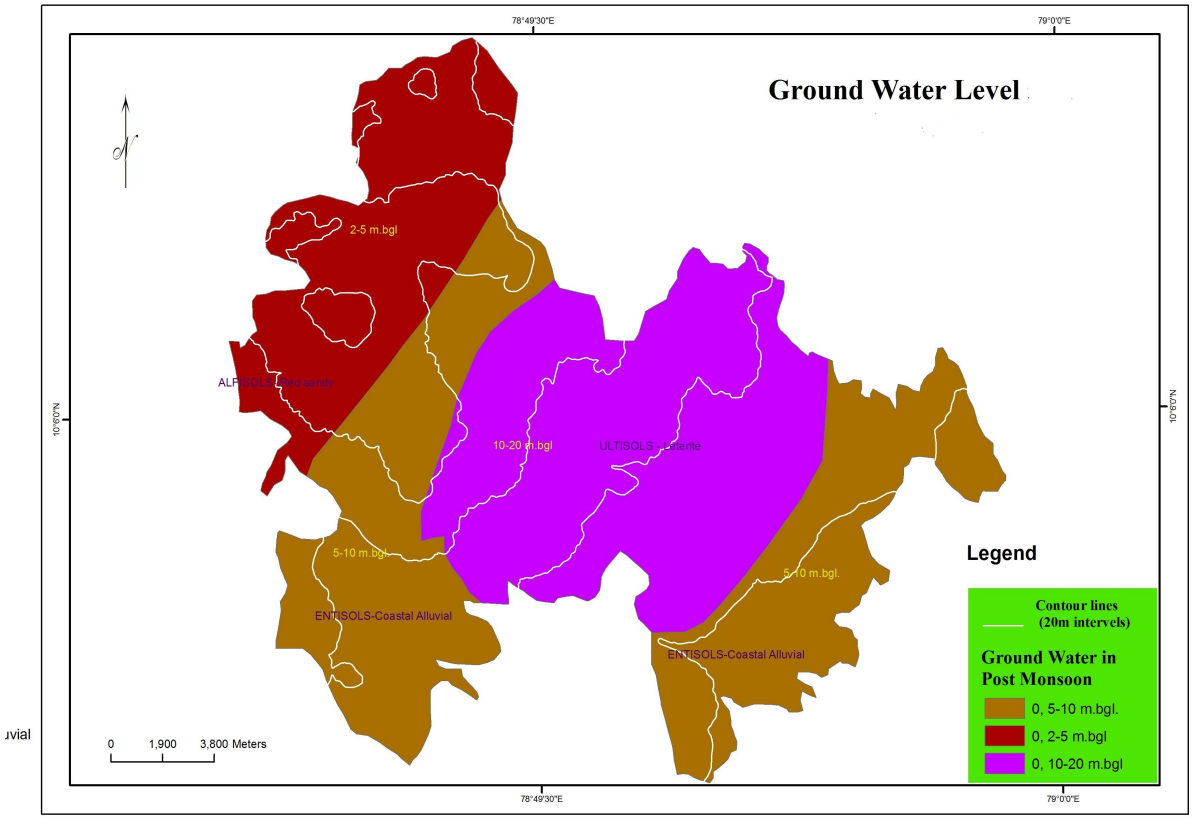

Fig.4.Ground water depth

Soil:

The soils of Sakkottai block are of three broad groups viz. Laterite (Ultisols), Red sand (Alfisols) and Coastal Alluvium (Entisols). The laterite type of soil is found predominant in the study area. The red soils are seen towards the western portion whereas the coastal alluvium is seen distributed towards the southern portion. The spatial distribution of the soil types is showing the (Fig.5). The areal extent of the types of soil is shown in Table 1.

Table 1. Areal extent of the soil types in Sakkottai Block

Soil Type	Area in Sq.Km
Laterite	293.34
Red sandy	12.38
Coastal Alluvium	62.55

a) Laterite:

Laterite is a kind of vesicular rock composed essentially of mixture of hydrated oxides of aluminum iron with small percentage of other oxides such as manganese and titanium. There is no fixed relation between the principal oxides (iron and aluminium), and this variation is responsible for the occurrence of laterite in a number of varieties.

b) Red sandy:
These are mainly residual type of soils that have been formed due to decomposition of ancient crystalline rocks like granites and gneisses and also other rocks rich in iron and magnesium bearing minerals.

c) Coastal Alluvial:
It is a group of soils spread out by streams along their banks on the flood plains during repeated floods. These are made up of fine material and are clearly stratified. In view of their heterogeneous composition, fine size and negligible leaching these soils are often very fertile.

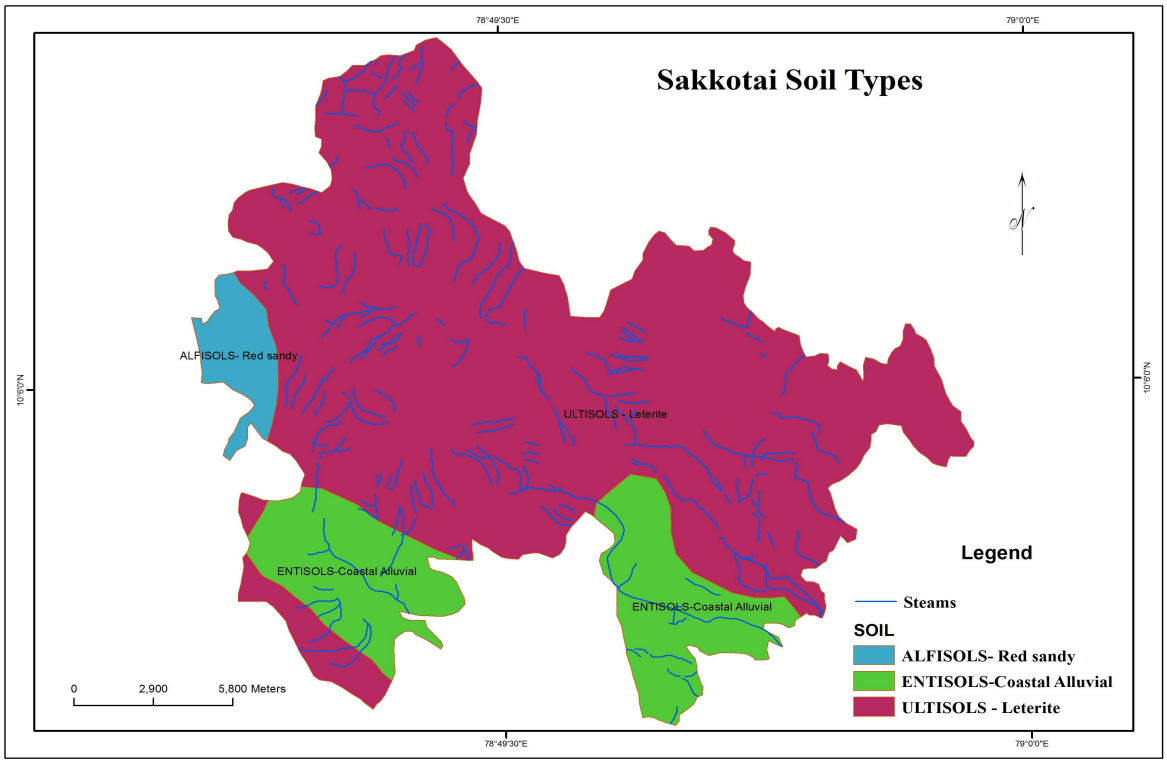

Fig.5. Spatial distribution of the soil types

Relief:
The north direction of the city like Arumuganagar, Subramanyapuram has the values greater than 100 mts above mean sea level. The center portion of the city like Manikandapuram has heights of about 80 – 100 mts above mean sea level. The southern zone like Naganathpuram, Sathyamoorthy nagar has the less than 80 mts above mean sea level.

b)Land use /Land cover.
The buffer zone has different types of LU/ LC viz. Settlements, Crop land, Tanks, Waste land and other lands. In the present study area, Settlements are present in the central part of the buffer zone. In the peripheral area the Crop land is seen. In the city northwest, south and south west region the waste lands are present. The tanks are widely spread in the surroundings of the city.

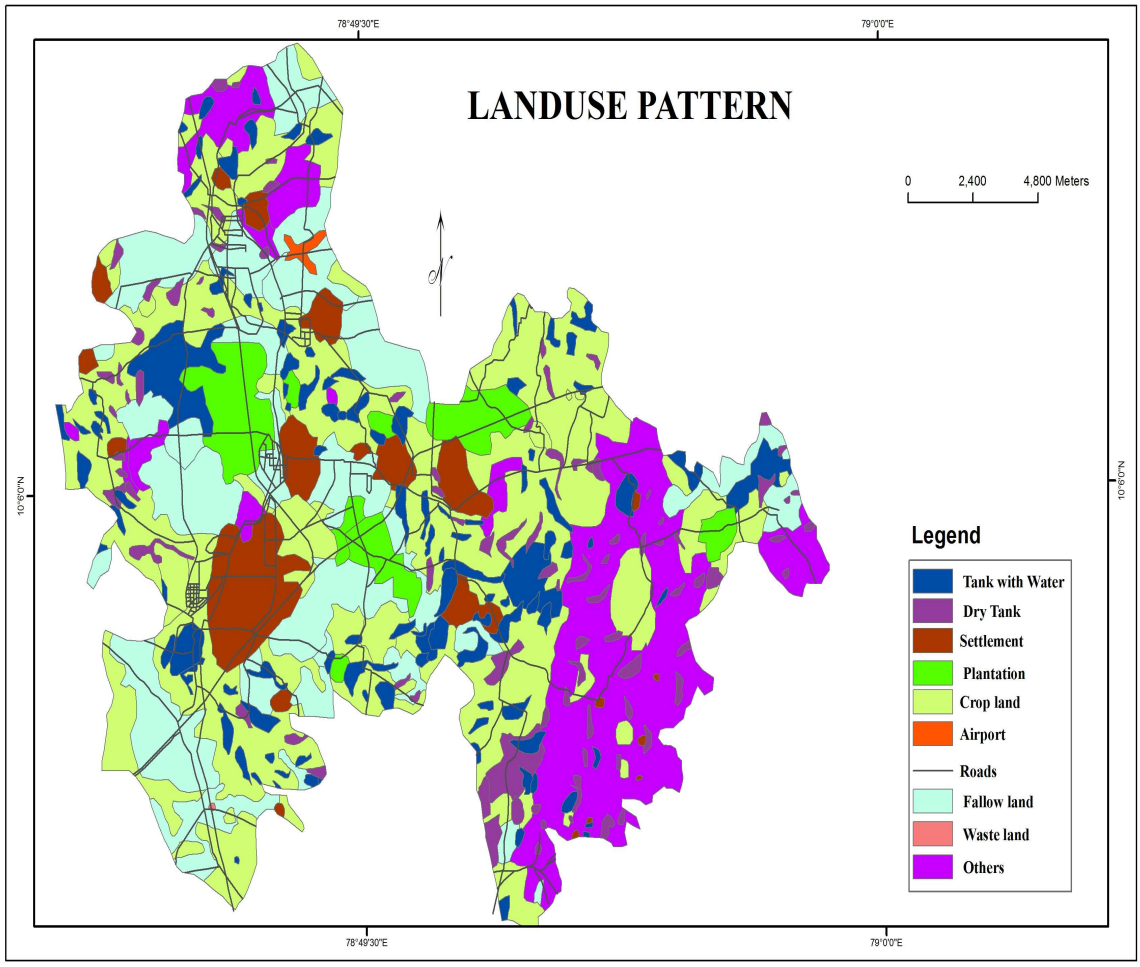

Fig.6. Land use /Land cover

Table 2. Areal extent of Land use/ Land cover classes in Sakkottai block.

Sl. No	Land use / Land cover	Area (sq.km.)	Area (%)
1	Settlement	24.72	6.71
2	Airport	0.81	0.22
3	Crop land	130.6	35.46
4	Plantation	19.92	5.41
5	Fallow land	84.76	23.02
6	Water surface	20.46	5.56
7	Tank bed	2.82	0.76
8	Dry tank	18.11	4.72
9	Waste land	5.24	1.42
10	Others	60.83	16.52

The present study area of Sakkottai block of Sivagangai District covers an area 368.27 sq.km. which has the different types of land use / land cover that was delineated from IRS P6 LISS III satellite images. There are Settlements, Airport, Crop land, Plantation, Fallow land, Water surface, Dry tank, Tank bed vegetation, Waste land and Other lands. The Spatial distribution of

the various land use / land cover types are shown in the (Fig.6) and the areal extent in sq.kms is given in the table (2).

c)Solid waste management:

Karaikudi municipality has 36 wards. The total garbage bins are 72. The characteristics and quantity of solid waste generated in the town primarily Influence the disposal options. Nearly 40% of the waste generated in Karaikudi is organic in nature. In terms of the quantity, around 41.51 tons of waste is generated every day and is expected to go up 53.32 tons by the year 2026. This necessitates the need for suitable solid waste disposal site.

Generation of municipal solid waste

Solid waste is generated in association with almost every activity of man depending upon the nature of his life and living – both quantity and kind. Wastes are generated with every process beginning with the collection of raw materials. Thereafter, solid wastes are generated at every stage and every process, during the conversion of raw materials into consumable goods. There are derived from different origins such food, paper, metals, plastics, glass, textiles, chemicals, furniture, garden, construction materials, factory cutoffs, bio – degradable and hazardous organic matter (Table .3).

Table 3. Types of Soild Waste generated in Karaikudi Municipality

Sl. No	Source	Storage of segregated waste	
		Bio-Degradable	Non- Bio-Degradable
1	Households	10-15 liters plastic/reinforced plastic/LDPE/metal bin with lid	A bin or Bag of suitable size
2	Hotels,Restaurents	60 liters capacity-LDPE/HDPE	A bin or Bag of suitable size
3	Shops,Offices,Institutions	Suitable container not exceeding 60 liters.	A bin or Bag of suitable size
4	Market stalls	40-60 liters bin-LDPE/HDPE	A bin or Bag of suitable size
5	Function halls	Bin/skip matching to Municipal collection system	A bin or Bag of suitable size
6	Hospitals,Nursing homes	60 liters capacity bin for non-infectious bio –degradable waste	Store waste as per Bio-medical waste Mgmt handling Rules :1998
7	Construction/Demolition waste		Store with in premises and deposit in the notified site by the local body or to the municipal Vehicle
8	Garden wasre	Store with in premises	Deposit in large community bin or to the municipal vehicle

Existing situation of solid waste Management

Efforts to improve the solid waste management in the town were made by the health department. The town is divided into 8 zones and the waste generated is collected and disposed at the site located on Devakottai road in an area of 13.70 acres. The site is about 5 km from the town. The total quantity of solid waste generated in the town is 41.51 tons per day and around 30 tons of the waste generated per day is collected with a collection efficiency of 72 percent as per the estimates of the municipality.The detail of municipal waste generation is illustrated(Table 4).

Table 4. Details of Generation of municipal waste

Type	Quantity 2002-03	Percentage	Quantity 2005-06	Percentage
	Tones		*Tones*	*Tones*
Domestic	12.57	36.4	16.52	39.8
Comercial	4.32	12.5	5.32	12.8
Industrial	3.82	11.1	3.81	9.2
Markets	2.29	6.6	4.29	10.3
Street sweeping	10.00	28.9	10.00	24.1
Drain Cleaning	12.57	4.2	1.44	3.5
Hospital waste	0.13	0.4	0.13	0.3
Total	**34.57**	**100.00**	**41.57**	**100.00**

Source: Karaikudi Municipality & Analysis.

Per capita waste generation in Karaikudi is 461 grams/day and is on the higher side for a town of similar size. Solid waste generated in Karaikudi is mainly organic in nature. The other major components being inert material mixed with paper and plastic. Apart from these, bio-medical waste also mixes with the domestic solid waste generated by the city.

Categories of wastes:

1)Domestic, Commercial and Markets: - Domestic waste per household varies from area to area in the town and on an average, ranges between 250 to 500 gram. About 16.52 tons of domestic waste is generated per day. The commercial waste includes the waste from hotels and eating establishments, shops, small time street traders, etc. There is one daily market and one weekly market run by the municipality. The daily waste generated by these markets is roughly around 4.29 tons. Market waste, generally organic in nature is planned to use for composting.

2)Industrial: - About 3.81 tons of industrial waste per day is generated mainly from the looms and household industries in the town. Out of this only 9.2 percent of the total waste generated. The waste mainly consists of cloth, plastic carry bags, paper bags, glass bottles etc.

3)Bio-medical waste: Bio Medical Waste of about 0.13 T is generated every day. They consist of recyclable types of bottles etc as well as non-recyclable types of tissues, dressing left-outs, needles etc. These are from the private hospitals, nursing homes, medical Laboratories etc. At present, a separate area is being planned at the compost yard to handle this waste through incineration plant to be provided by the support of the Indian Medical Association and Local Medical Practitioners Association.

Collection of waste:

Primary Collection & Street Sweeping:

Door to Door collection has been implemented in all 36 wards. Privatization of solid waste collection has been implemented in 7 wards and 18 important streets, which is entrusted with collection of about 25 percent of the total waste generated in the town. The municipality handles another 70 percent of the waste collection through door-to-door collection process. The municipal health workers collects wastes from the doorstep use 100 handcarts with compartments with total capacity of 0.1T. These tricycles cover the entire population of the town. The system of primary collection followed is cleaning, sweeping, scrapping and collection of MSW by tri-cycle/ handcarts and transfer to secondary collection points. In the other wards

where door-to-door collection is yet to be introduced waste is collected from the community dustbins.

Secondary Collection: - The municipality has 5 sanitary inspectors, 9 sanitary supervisors, and field assistants under the supervision of the Municipal Health Officer to monitor the solid waste management system in the town. At present there are 215 workers engaged in collection of waste across the eight zones of the town. The approximate road length per sanitary worker in the town works out to be 720 meter. Waste collected through primary collection is transported from the secondary collection points to the disposal site. About 13.7 acres of land is available for treatment and disposal of waste. The disposal site is about 5 km. from the town. At present, no scientific method of disposal is followed. The area available is sufficient to meet the disposal requirement till 2026. At present private sector is involved in the transportation of solid waste to the disposal site. The main roads in the core areas of the town including New Bus Stand to Periyar Statue, Rajai Bus Stand to Sekkalai road junction are currently vested with the private sector.

Solid waste disposal site selection:

Any unplanned disposal of waste causes adverse impacts not only on the ecosystem but also on the human environment in viz. the solid waste disposal site suitability analysis can be easily solved with the aid of GIS. In the present study the weighted over lay analysis has been adopted and potential sites has been selected. In this analysis, a buffer of 5 km distance area from the Municipality Office are extracted and the suitable parameters viz. LU/LC, Road, Ground water Depth, Soil and Litho units has been considered. The 5 km buffer zone covered the whole city and nearest villages and adjacent block. The Urban development has already rapidly grown in north part of the city and it may possibly grow in the east, west and finally in the southwestern region.

Solid waste disposal potential sites:

The potential sites for solid waste disposal are identified in three classes. The good potential sites are seen in the southern portion near Naganathapuram and Illuppakudi in the western portion of Kalanivasal and in the eastern portion of Subramanyapuram. The moderate potential sites are found towards eastern side of the municipality. The poor potential sites are seen towards north western side. The solid waste disposal sites have been overlayed on google earth image. Solid waste disposal sites need not be placed within a distance of 4kms from the settlements and not beyond 5 kms away from the Municipality Office. So the first appropriate site is the southern portion of Illuppakudi and the second site can be selected anywhere in the 4-5kms buffer arc, which might be suitable from environmental, transportational and economic point of view.

CONCLUSION

The problem associated with the solid waste disposal site in today's society is complex because of the quantity and diverse nature of the wastes. Rapid urbanization, limitations of funding, emerging limitations of both energy and raw materials and also add to the complexity of any waste management system. The SWM system is one of the key components of the infrastructure for a sustainable community. Therefore, solid waste will have to be managed by technologies and methods that support sustainable communities and environments. In the present study it was

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On the basis of integration of various parameters IRS- P6 LISS III imagery and GIS as a tool have been found to be very useful for the interpretation and identification of solid waste disposal site. Thus with the use of these technologies management of municipal waste will no longer be a problem for city administrators.

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