Site Selection for Urban Solid Waste Disposal Using Remote Sensing and Open Source GIS In Krishnagiri District, Tamil Nadu

P.N. Karthiheyan
PG Student
Department of Civil Engineering
Adhiyamaan College Of Engineering

Dr. L. Yeshodha
Professor
Department of Civil Engineering
Adhiyamaan College Of Engineering

Abstract

The solid waste materials in cities are the natural outcome of human activities. Solid waste management is a global environmental problem in today's world and is the key component of the infrastructure for a sustainable community. Urban solid waste management is considered as one of the most serious environmental problems confronting municipal authorities in developing countries. One of these impacts is due to improper location of dumping site in unsuitable areas. 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. Hence potential sites will have to be managed by technologies and methods that support sustainable communities and environment. Selection of suitable sites for waste disposal is based on several factors. Due to the different parameters involved, deciding upon a suitable location is also very complicated, costly and time consuming. Remote Sensing and Geographic Information System (GIS) allows users to view, understand, question, interpret and visualize spatial and non-spatial data in many ways that reveals relationships, patterns and trends in the form of maps, reports and charts. This paper deals with determination of suitable site for the disposal of waste generated from Krishnagiri district where the greatest protection for environment is provided using Remote Sensing and GIS techniques. This study that has been carried out involved analysing the existing solid waste disposal site initially and later land use land cover, geology, geomorphology, soil, road network and drainage mapping was done using on screen visual interpretation of the IRS P6 LISS-IV satellite imagery for identifying the sites for solid waste dumping. All thematic vector layers created were analysed by the theme wise suitability of different classes in the study area by giving them weightage scores using spatial analyst tool in Q-GIS to target the potential sites for waste disposal.

Keywords: Remote Sensing, Geographical Information System (GIS), Visual interpretation

I. INTRODUCTION

Our Environment is facing potential threat from unsustainable waste disposal practices prevailing in almost all the urban centres 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. The rapid growth of population and urbanization also decreases the non-renewable resources and disposal of waste matter and toxic waste haphazardly are some of the major environmental issues posing threats to the existence of human being. The most common problems associated with improper disposal of solid waste include diseases transmission, fire hazards, odour nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses. There has been a significant increase in solid waste generation in India over the years from 100 gram per person per day in small towns to 500 grams per persons per day in large towns. Source reduction, recycling and waste transformation are methods widely used to manage solid waste. However, in all these methods there is always a residual matter to be disposed of even after the recovery process. The technique of getting rid of these wastes in an economic and environmentally friendly approach is called Solid waste disposal. Hence waste disposing is an important part of waste management system, which requires much attention to avoid environmental pollution.

Landfill site selection is a complex process involving social, environmental and technical parameters as well as government regulations which requires the processing of a massive amount of spatial data. Waste management issues should be confronted in a more generalized manner, which means that new strategies need to be designed considering diverse and variable urban models. In addition, site selection of new landfills for municipal solid waste disposal is a great concern for the urban government as old landfill sites are being filled-up and demand for new sites is increasing. This demonstrates the necessity of developing integrated, computerized systems for obtaining more generalized and optimal solutions for the management of urban solid waste. Geographic Information System (GIS) and Remote Sensing are such computerized systems that can be integrated to get optimal solutions for efficient and effective solid waste management planning. It is a tool that allows users to analyse spatial information, edit data, maps, and present the results of any spatial and non-spatial based analysis.

II. STUDY AREA

Krishnagiri district is bounded by Vellore and Thiruvannamalai districts in the East, Karnataka state in the west, State of Andhra Pradesh in the north Dharmapuri District in the south. Its area is 5143 sq kms. It is located between 11º 12'N to 12º 49'N Latitude, 77º 27'E to 78º 38'E Longitude. Krishnagiri district has two municipalities namely the Krishnagiri and Hosur municipality and is comprised of 352 village panchayats and 636 revenue villages. The total population according to 2011 census is 18, 83,731. This district has a network of National Highways converging. Apart from this state highways and district highways are linking almost all the towns and villages of the district. Eastern part of the district experiences hot climate and western part has a contrasting cold climate. The average rainfall is 830 mm per annum.

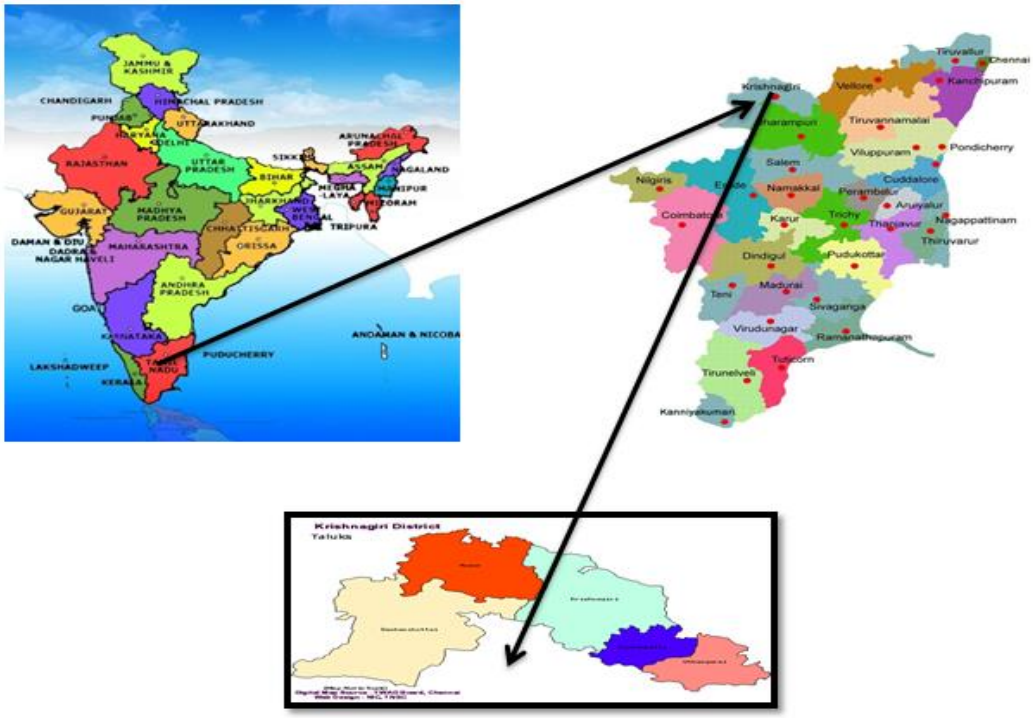

Fig.1: Study Area

III. MATERIALS AND METHODOLGY

A. Data and Software Used:

- First edition-2011 Survey of India (SOI) Toposheets (D43X10, D43X11, D43X12, D43X13, D43X14, D43X15, D43X16, D44S1, D44S2, D44S3, D44S6, D44S7, D44S8, D44S11, D44S12)
- IRS P6 LISS IV satellite image of Krishnagiri district with 5.2 resolution (2012 data)
- Q-GIS for map creation and composition
- ILWIS for image processing.

B. Methodology:

The role of Geographic Information Systems (GIS) in solid waste management is very large as many aspects of its planning and operations are highly dependent on spatial data. GIS is a tool that not only reduces time and cost of the site selection but also provides a digital data bank for future monitoring program of the site. The toposheets were first scanned and then incorporated into the software for further processing. The toposheets were then opened in ILWIS software where each toposheet was geocorrected individually. The geocorrected toposheets were then combined together for getting the image of entire study area by the process of mosaicking. Land Use Land Cover map, Drainage map, Geology map, Geomorphology map, Road network map and soil map was created using the Q-GIS software by digitising the satellite imagery and the toposheets.

IV. RESULTS AND DISCUSSION

A. Existing Solid Waste Disposal Site:

Presently most of the municipal solid waste in Krishnagiri is being disposed unscientifically and are mostly found on the outskirts of the urban areas where there are water bodies, crop filed, settlement, around road, etc. Inappropriate disposal of solid

waste can be manifested by soil contamination through direct waste contact, air pollution by burning of wastes, spreading of diseases by different vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste. The unscientific landfill may reduce the quality of the drinking water by contamination of surface and ground water through leachate and causes diseases like jaundice, nausea, asthma. Therefore, locating proper sites for solid waste disposal and selecting appropriate landfill site far from residential areas, environmental resources and settlement is very important for the management of solid waste. One way to dispose solid waste is to place it in properly designed, constructed, and managed landfills, where it is safely contained. The present condition of the dumping sites in Krishnagiri district is shown in Fig: 2.

Fig. 2: Present Condition of the Disposal Site

B. Thematic Maps Generated:

The thematic maps such as land use land cover, geomorphology, geology, road network, soil and drainage map were derived from the satellite image and toposheets procured using Q-GIS software.

C. Land Use Land Cover and Geomorphogy Maps:

The land use / land cover pattern of a region is an outcome of both natural and socio-economic factors and their utilization by man in time and space. The land use/land cover of the present study area was analysed from IRS P6 LISS - IV data for the solid waste dumping site selection. The dumping site should not be selected close to the built up area to avoid adversely affecting land value and future development and to protect human being from environmental hazards created from dumping sites (Clark et al., 1974). It should be selected at a suitable distance farther from the residential area. Scrub land and barren land are most suitable for the dumping site. Rivers and lakes, canals, built-up, vegetation, agricultural land, scrub land and fallow land are major land use/land cover classes in the present study. Geomorphology may also help in identifying the various geomorphic units. Pedi plain and dissected hills and valleys are the dominant landforms found all over the study area. Pedi plains are the result of denudation landforms. The thickness and intensity of these land forms vary depending upon the slope and structural disturbance of the area.

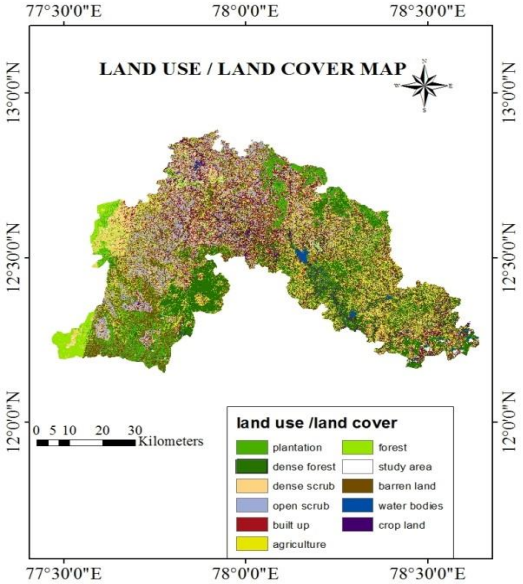

Fig. 3: Lu/Lc Map

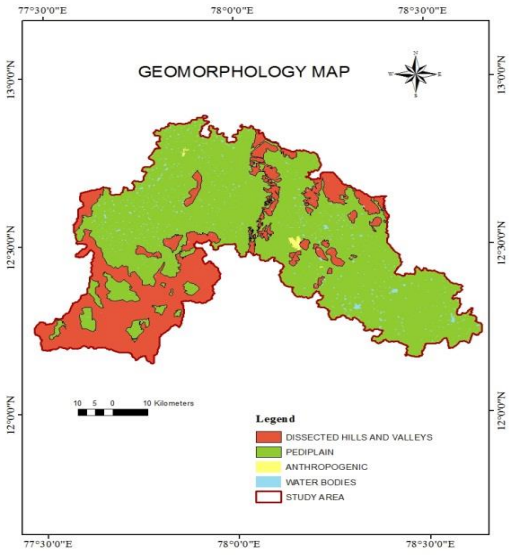

Fig. 4: Geomorphology Map

D. Road and Drianage Maps

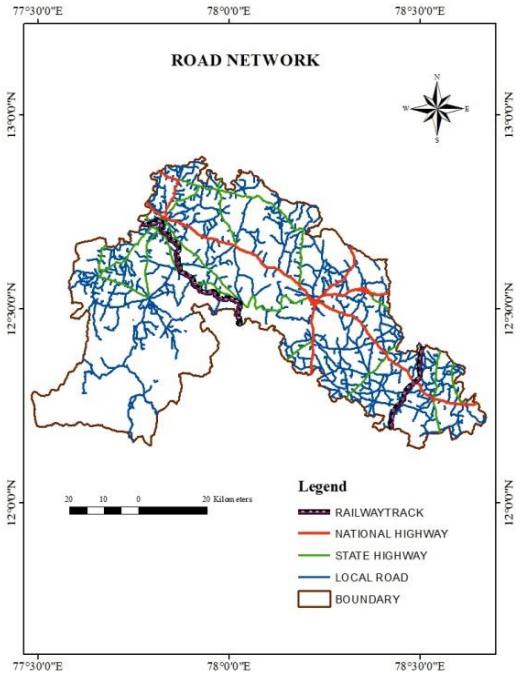

Fig. 5: Road Map

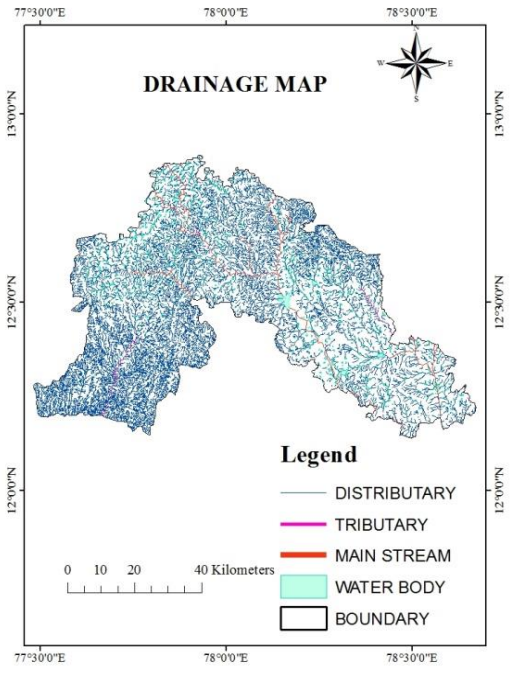

Fig. 6: Drainage Map

The road network comprises of the railway network, national highway, state highway and other local roads that almost link all the towns and villages of the district while the drainage network consists of the major river – South Pennar river as it cuts across the study area and the surrounding tributaries. From the drainage map we can perceive that the drainage density is very high at Hosur, Krishnagiri taluk and Denkanikottai while at some parts like Pochampali, Uthangarai and the region joining Hosur and Krishnagiri taluk has a comparatively low drainage density. Apparently region having high drainage density is not suitable for considering the site for solid waste disposal as it exploits the surface and ground water through the process of leachate. Hence a region with low drainage density is preferable. The road and drainage networks of Krishnagiri district are shown on map in Fig.5 and 6 respectively.

E. Geology and Soil Maps:

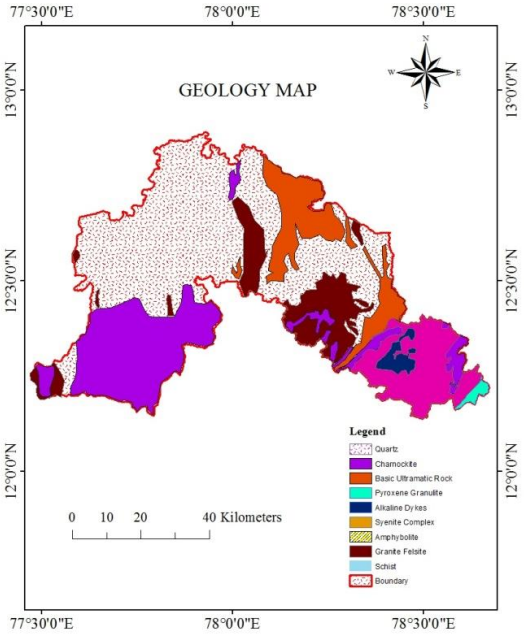

Fig. 7: Geology Map

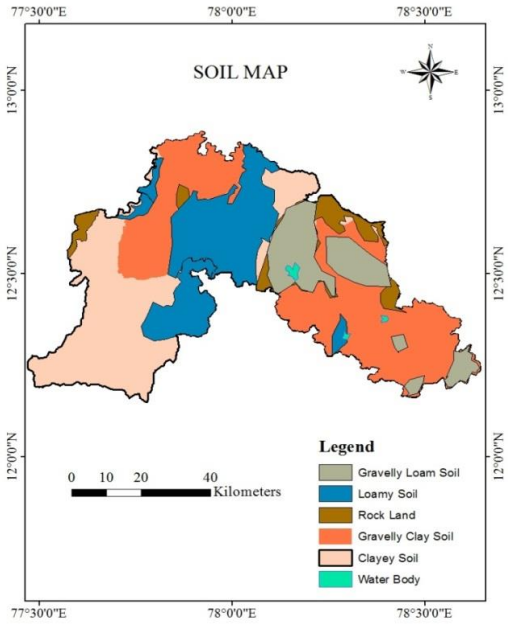

Fig. 8: Soil Map

Geological structures have great importance in ground investigation. The geology of the study area has quartz that covers the major portion of the study area. Other major geological features observed in Krishnagiri district were charnockite, basic ultramatic rock, alkaline dykes and granite felsite. Geology map of the study area is shown in Figure 7.

The soils of Krishnagiri district are broadly grouped into loamy soil, clayey soil, gravelly clay soil, gravelly loam soil and the rock land. The gravelly clay type of soil is found predominant in the study area. The clayey soil is found towards the western portion whereas the loamy soil is seen distributed on the centre portion of the study area.

F. Slope Map

Elevation is an important parameter in the identification of landfill site. In the method used here, the land morphology was evaluated using the grading of the slope and specified in degrees format. The slope map was generated from the digital elevation model (ASTER-DEM) that was obtained from the USGS portal. The areas with high slopes are not ideal for solid waste disposal and flat areas are not ideal either. The preferred areas for waste disposal are those with medium slope of not more than 22°. The slope map is shown in Fig 9.

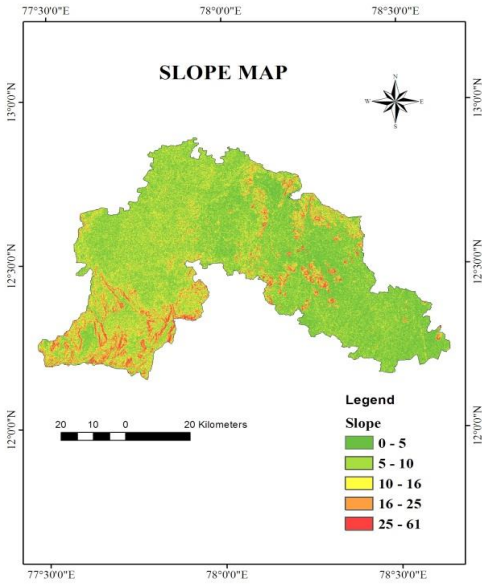

Fig. 9: Slope Map

G. Weightage:

Weights have been assigned to each class of all thematic maps for GIS analysis. Weights range from 0 to 10 in which 0 stands unsuitable while 10 stands suitable. There are more than 9 classes in the thematic layers of geomorphology and land use/land covers are considered most suitable classes (Table 1).

Table - 1
Features in Each Theme and Weight Factors

THEME	*IDENTIFIED FEATURE*	*SOURCE*	*WEIGHT*	*SITE SUITABILITY*
Geomorphology	*Dissected Hills and Valleys*	*Satellite Data IRS P6 LISS-IV Imagery*	*6*	*Unsuitable*
	Pedi plain		*9*	*Suitable*
	Anthropogenic		*3*	*Unsuitable*
	Water Body		*0*	*Unsuitable*
Drainage	*Main Stream*	*SOI Toposheets*	*Buffer in mts 500*	*Sites away from the buffer zones were selected*
	Tributary			
	Distributary			
Network	*National Highway*	*SOI Toposheets*	*Buffer in km*	*Sites away from the buffer zones were selected*
	State Highway		*2-3 Km*	
	Local Road		*0.5-2 Km*	
	Railway Track			
Land Use Land Cover	*Built Up*	*Satellite Data IRS P6 LISS-IV Imagery*	*0*	*Unsuitable*
	Barren Land		*10*	*Suitable*
	Agriculture		*4*	*Unsuitable*
	Open Scrub		*8*	*Unsuitable*
	Dense Scrub		*7*	*Unsuitable*
	Forest		*2*	*Unsuitable*
	Dense Forest		*0*	*Unsuitable*
	Plantation		*3*	*Unsuitable*

	Crop Land *Water Bodies*		*4* *4*	*Unsuitable* *Unsuitable*
Geology	*Quartz* *Charnockite* *Basic Ultramatic Rock* *Pyroxene Granulite* *Alkaline Dykes* *Granite Felsite* *Syenite Complex* *Amphibolite* *Schist*	*GSI Map*	*9* *10* *8* *8* *6* *8* *6* *5* *8*	*Unsuitable* *Suitable* *Unsuitable* *Unsuitable* *Unsuitable* *Unsuitable* *Unsuitable* *Unsuitable* *Unsuitable*
Soil	*Loamy Soil* *Gravelly Loam Soil* *Clayey Soil* *Gravelly Clay Soil* *Rock Land*	*District Soil Map*	*7* *7* *8* *7* *10*	*Unsuitable* *Unsuitable* *Unsuitable* *Unsuitable* *Suitable*

H. Final Suitability Map

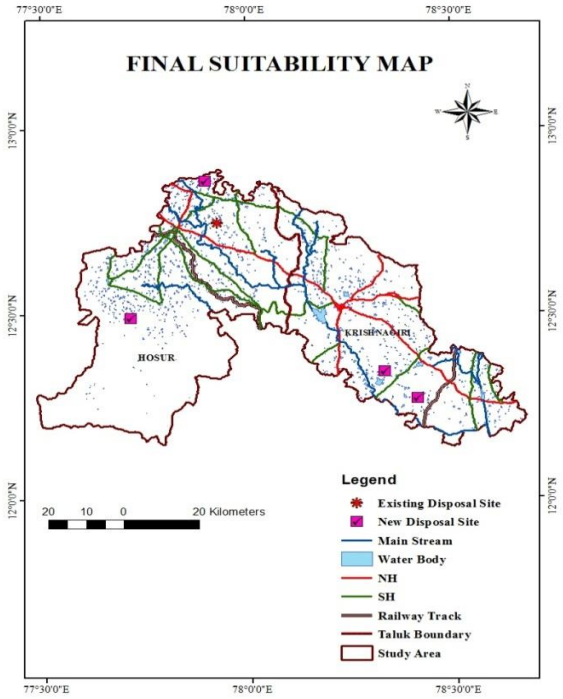

Fig. 10: Final Suitability Map

The study area is one of the fast developing townships in Tamil Nadu state. At present the urban solid waste is being discarded at a site in a village called Dasaripalli which is an eleven year old dump yard. The site is almost filled with solid waste and it may not be able to accommodate any further. Similarly, several constructions have come up near this site in recent years which is a violation. In this study seven thematic maps, the land use land cover, geology, geomorphology, soil, slope, drainage, road network map were prepared using the Q-GIS software. To demarcate the solid waste disposal sites all the thematic layers were integrated into a weighted index process. Based on this method weightage was assigned to various classes of the different themes and this analysis helped in categorizing the entire study area into suitable or unsuitable based on the weightage assigned. Finally, four sites were selected for the management of solid waste in the study area located in the villages namely Karamdapalli, Devvapalli in Hosur municipality and Guttapatti, Jainikkallu Modu in Krishnagiri municipality. The selected sites were checked for accessibility by overlaying the road network map and were found to be the most accessible sites in the study area. The research has also shown that siting criteria can be modified based on local constraints.

V. CONCLUSION

Solid wastes consist of highly heterogeneous mass of discarded materials from residential, commercial and industrial activities. Selection of disposal sites for solid wastes generated in the urban area has always remained a big task as the selected site should not affect the environment negatively. The methodology employed in this study described the GIS and weighted index process

techniques for the selection of suitable sites for the disposal of municipal solid wastes in Krishnagiri district. The study shows the ability of GIS as an authentic tool for decision support. The techniques considered a number of siting criteria ranging from accessibility, land use to natural factors which are very important in identifying sites which possess minimum or no risk to the environment. Finally, four sites were selected for the management of solid waste in the study area which were identified to be the ideal and the most accessible site. Most of the data available and collected were in the analogue format hence most of the information was derived using the GIS techniques. The study also demonstrated the efficacy of GIS in the site identification and selection process and can therefore be applied elsewhere for siting purposes.

REFERENCE

[1] Adeofun C. O. "Application of Remote Sensing and Geographic Information System for selecting Dumpsites and Transport Routes in Abeokuta, Nigeria" Proceedings of the Environmental Management Conference, Federal University of Agriculture, Abeokuta, Nigeria, 2011.
[2] Ahmad Al-Hanbali. "Using GIS-Based Weighted Linear Combination Analysis and Remote Sensing Techniques to Select Optimum Solid Waste Disposal Sites within Mafraq City, Jordan" Journal of Geographic Information System, 2011, 3, pp. 267-278.
[3] Mohammedshum. "Application Of Geographic Information System And Remote sensing In Effective Solid Waste Disposal Sites Selection In Wukro Town, Tigray, Ethiopia" The International Archives Of The Photogrammetry, Remote Sensing And Spatial Information Sciences, Volume Xl-2, 2014 PP. 115 – 119.
[4] Nishanth.T. "Suitable Site Determination For Urban Solid Waste Disposal Using GIS And Remote Sensing Techniques In Kottayam Municipality, India" International Journal Of Geomatics And Geosciences Volume 1, No 2, 2010, PP. 197 – 210.
[5] Subhrajyoti Choudhury. "GIS and Remote Sensing For Landfill Site Selection- A Case Study on Dharmanagar Nagar Panchayet" Journal of Environmental Science, Toxicology and Food Technology Volume 1, Issue 2 (Sep-Oct. 2012), PP 36-43.
[6] Suman Paul. "Location allocation for urban waste disposal site using multi-criteria analysis: A study on Nabadwip Municipality, West Bengal, India" International Journal of Geomatics and Geosciences Volume 3, No 1, 2012 PP 74 – 88.
[7] Tirusev Ayisheshim. "Solid Waste Dumping Site Suitability Analysis Using Geographic Information System (GIS) And Remote Sensing For Bahir Dar Town, North Western Ethiopia" African Journal Of Environmental Science And Technology, Vol.7 Issue 1, Pp. 976 – 989.
[8] Yogeshwar singh. "SWM of Kolar Municipality Using Remote Sensing and GIS Techniques" International Journal of Advance Technology & Engineering Research Volume 2, Issue 1, January 2012.
[9] Clark, R.M., and Gillean, J. Systems Analysis and Solid Waste Planning. Journal of the Environmental Engineering Division. 1974. 7-25.