International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Site Suitability Analysis for Municipal Solid Waste Disposal in Mangalore City Corporation, Karnataka - Using Geospatial Technology

Sandipta Das[1], Dasharatha P. Angadi[2]

[1]Research Scholar, Department of Geography, Mangalore University

[2]Associate Professor & Research Guide, P .G. Department of Geography, Mangalore University, Department of Geography, Mangalagangothri-574 199

Abstract: ***Solid waste dumping is a challenging issue now-a-days in urban extent. The solid waste produced in municipality areas (ULB) of Indian cities which impacts on health as well as the surrounding environment. The first requirement to dumping urban solid waste in our Indian cities is a suitable land site. Mangalore taluk is a second populated taluk of Dakshin Karnataka, side by it is being a fast developing city where solid wastes generating average 220 (TDP) tons per and* 0.35kgs/capita/day *which is also facing challenges to dumping to a suitable place. The objective of present study was the urban solid waste dumping site selection using the geospatial techniques for Mangalore City Corporation area. Remote Sensing and GIS multi-criteria analysis (MCA) methods were used to identifying the suitable site for disposal urban solid waste. Landsat ETM+ and SRTM DEM data were used for present paper. Estimation of buffer distance analysis and overlay weightage procedure was used for this study. The finding result has been indicates that only 6.45 km^2 (3.93%) area is suitable for solid waste dumping; otherwise 17.289 km^2, 77.31 km^2 and 62.95 km^2 area are fall under unsuitable, less suitable and moderate suitable with 10.54%, 47.13% and 38.39% respectively.***

Keywords: Solid waste Generation; Suitable Dumping site; GIS and Remote Sensing;

1. Introduction

Solid waste is annoying ingredients which made from collective domestic, residential, industrial and commercial actions in a particular area. Solid waste generation in India has been increasing over the years from 100 grams per person per day in small towns to 500 grams per persons per day in large towns (Jaybhaye, Mundhe, & Bhalachandra , 2014). It's put major impacts on human health and surrounding environment due to the improper and instinctive solid waste dumping. The ground water quality, drinking water purity has been reduces due to unscientific landfill site and its causes the disease like nausea, jaundice, asthma etc. (Bean et al., 1995). Increasing population in urban extend due to rural to urban migration which leads to increase solid waste generation in smaller to bigger cities in India. Solid waste disposal is an important part of waste management to protect the surrounding environment. According to the Municipal Solid Wastes (MSW) rules, 1999 every municipal authority has to take in charge for collection, segregation, stores, transportation processing and disposal of municipal solid waste. It comes under some schedule i.e., (i) implementation schedule, (ii) collection, separation, storage, transportation, assembled and disposal of municipal solid waste, (iii) identified for land filling, suitable site selection, prevention of pollution, water quality monitoring, ambient air quality monitoring and post care and (iv) processing and composting. MCC has been generates Municipal Solid Waste is about 220 TDP (tons per day) and collection is about 200 TDP, 0.35kgs/capita/day. In three major ways solid waste is generated in MCC like municipal, biomedical, hazardous industrial waste .There are two ways to collect solid waste in Mangalore City Corporation. One is primary collection and another is secondary collection. Primary collection is mostly deals with door to door collection and street sweeping. As per CSP of MCC report, corporation has collected waste by door to door 56.4% of total house hold population in 2011 and 12% from slum house hold. Slum residents are used to practice throw waste directly on road site bin and open drainage. Solid waste collection report of Corporation reveals that amount of Domestic waste generated 88.87 TDP; commercial area generated 45.50 tons per day; construction and street sweeping waste generated 1, 27.27 TDP respectively. Monthly wise waste generated of MCC are 3300, 2190, 540, 60,0 and 90 MT from domestically, commercial, Street sweeping, Slaughter, Houses, Industries and Construction. To find the suitable solid waste disposal site of municipal areas, it is an important to considered some basic parameters like physical, socio-economic and land use factors for people safety even though limited land resources in urban areas. The collection of waste system from Slum areas and non-slum areas are more or less 'Good; only 10% to 12 % are 'Bad'. Remote sensing and GIS techniques are a new kind of aid that can solve out problem of cost effectively. This technique supports to selecting a suitable site for dumping waste considering all the necessities criteria. The present study discussed about the selecting suitable site for disposal of municipal solid wastes in Corporation area using Multi Criteria Analysis of GIS techniques based on physical, socio-economic parameters. The rule is used to give rank wise alternatives under the consideration. The ranking depends upon the decision maker is preference. Eight parameters have been taken into consideration to build suitability dumping site in Mangalore City Corporation. Create buffer distance from each parameters using multiple buffer tools and again reclassify of it using spatial analyst tools in ArcGIS and finally suitability site map has been detect on the based on raster calculation of each parameter.

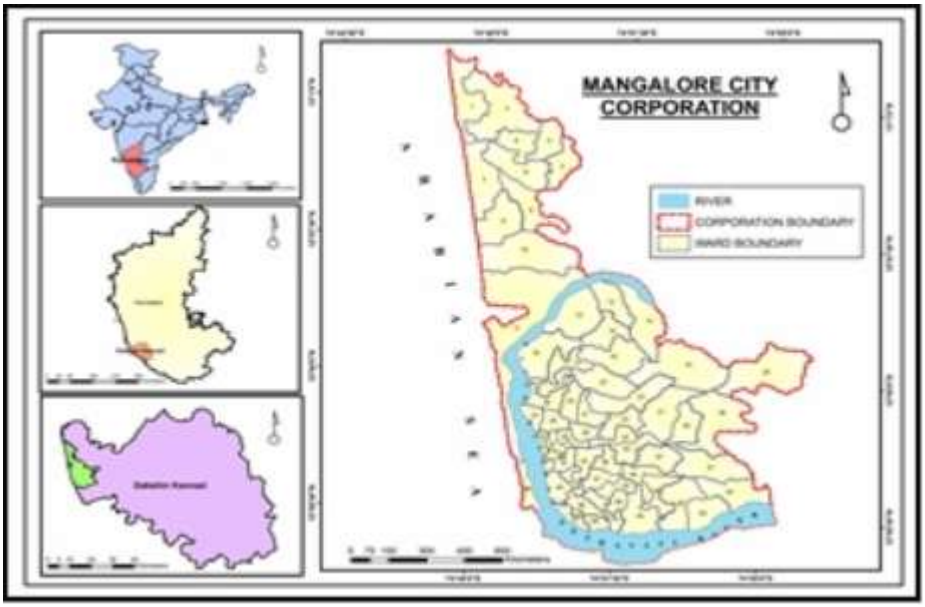

Figure 1: Study Area

2. Study Area

Mangalore City Corporation lies in west coast of Dakshin Karnataka district of Karnataka state (Figure no.1). The latitudinal and longitudinal extension of the city is 12°50′30″ N to 13°01′00″N and 74°48′0″ E to 74°55′00″ E. The Mangalore City Corporation established in the year of 1865, and it has 60 wards. MCC area (165 km2) is sharing its boundary with Arabian Sea on West, Kerala state on south, on the north with Udupi district and on the east with Bantval taluk. Mangalore is district headquarters of Dakshin Kannada as well as it is a largest coastal urban centre of the district along with an administrative, industrial, commercial and educational institute. The average temperature varies from 17oC to 37oC and faced heavy rainfall in monsoon period. The elevation is varies from 0 meter to 120 meters because of extension from coastal to hill topography of the city. Geologically it lies over the lateritic soil and sandy soil along the sea coast.

3. Methodology

Based on primary and secondary data, the whole methodology has been prepared to fulfill the objective of the present work. Primary data were collected by using GPS to locate the field over the surface. The secondary data were collected from different government organization, literature survey, journals, books etc. The administration and ward boundary were collected from the MCC (Mangalore City Corporation). To create the population density map, data obtained from census of India, 2011. Satellite imagery (Landsat ETM+ and SRTM DEM) data were used to prepare the land use land cover map, elevation and slope topography map of the study area. Road, water bodies, airport map were equipped by using digitization process from Google Earth. For the present study, we used Landsat ETM+ and Shuttle Radar Topographic Mission data which was downloaded from USGS earth explorer website. After that, Landsat data rectified and classified into different land uses using supervised classification methods using software ERDAS 2014. DEM data were used to classify into different elevation and slope classes using software ArcGIS 10.3. Fundamentally the present work used a Multi-criteria analysis (MCA) technique to find out the suitable site for dumping of municipal solid waste which is the classification of various layer based on weights and values of ranking ranging from suitable to unsuitable (Wiley and Sons,2009). Here used the multiple buffer ring distance method to prepared zonation map on different parameters in ArcGIS software. After that, all vector layers have been converted into raster images. Then again all raster images have been reclassified according to weightage ranking of suitability score of preference. Finally overlay techniques were applied over the all parameters to get potential suitable site for disposal of solid waste within the study area (Figure No.2).

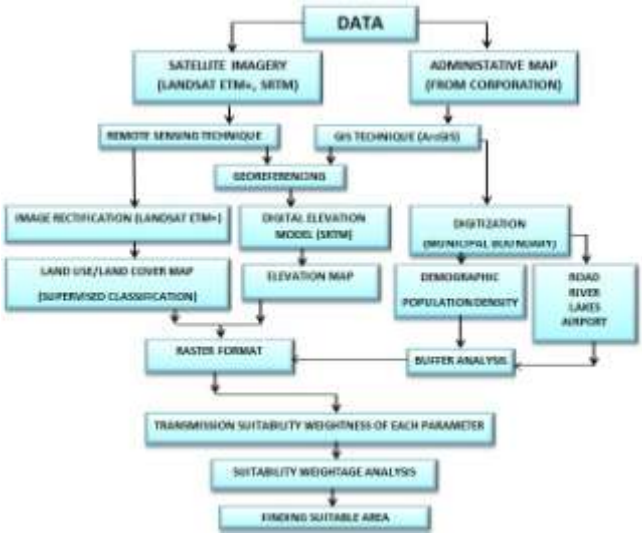

Figure 2: Flow diagram of Methodology

4. Result and Discussion

Increasing population trend has been a challenging in urban areas. With this growth rate it is also challenging to manage municipal solid waste in a proper way. Huge quantities of solid waste are generated in urban areas per day which leads

to environmental problems. As per Central Pollution Control Board (CPCB) report 1,43,449 tons per day (TDP) of MSW was produced in India During 2014-2015 with an average waste of 0.11 Kilogram (kg/capita/day), 80% MSW was collected while only 22% was processed and treated. Swachh Bharat Mission (SBM) has been launched by Ministry of Urban Development in 2014 to give encourage of municipal solid waste management in cities. The main aim of SBM is to manage of municipal solid waste in systematic order. According to MCC report, approximately 300 tones waste are produced from the all ward. Ward no. 41 is generated maximum waste (15.8 tons) because it's a central market ward, because of huge population pressure other wards are followed by 10, 44, 45, 30 with 10.8, 7.5, 6.5, 6.5 tons waste generating respectively. The minimum waste generated wards are 14, 54, 57, 58, 59, 49, 50, 51, 4, 5, 6 with average 3 tons per day (Figure no. 3 and 4).

Figure 3: Solid Waste Generate

Figure 4: Solid Waste Generate

Mangalore City Corporation has collected waste annually 3583 tons and used it to land fill the whole amount in 2016. It was 95% and 98 % for land fill in 2014 and 2015 correspondingly. Within the corporation area, there are one solid waste dmsing site near Pachanadi.

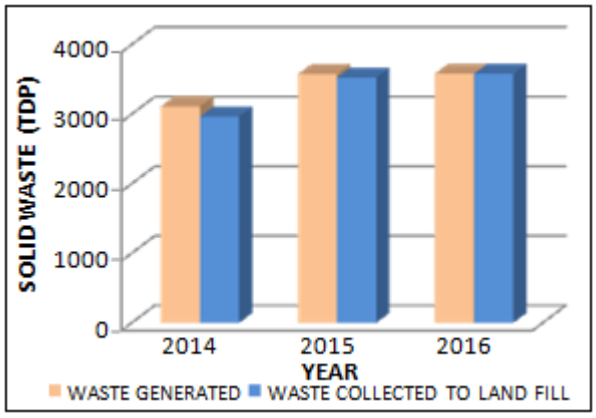

Figure 5: Year wise Waste Generate and Land fill

4.1. Selected criteria/ factors for waste disposal site selection of Mangalore City Corporation

To evaluation for the suitability site of disposal of waste, the basic physical and socio-economic factors or criteria are needed to be considered as per the rules of CPCB. There are eight parameters, which were taken into concern while considered the right landfill in given study area. These are elevation, slope, River, land use/ Land cover, population density, major road, wet land, airport etc. (Table No. 1).

Table 1

Physical Criteria	land use/ land cover
	Distance from River
	Elevation
	Slope
Socio-economic Criteria	Population
	Distance from major road
	Distance from wet land
	Distance from airport

Land Use/Land Cover Map

Land use Land Cover map is very an important parameter to study of the changes of land surfaces at particulate period of time. Land use and Land cover map has been prepared for assigning suitable land fill site over corporation area. Landsat ETM+ data of USGS was used to make LULC map. Here, five types of LULC were made to give ranking of suitability for solid waste dumping. Solid waste should not dump near surface water bodies, urban built up areas and agricultural land. It should be disposed near the fellow land and open vegetation land; it must have to take distances from most valuable land of livelihood (Jaybhaye, Mundhe, & Bhalachandra , 2014) .Ranking of suitability level was given as 1, 2, 3, 4 to prefer unsuitable to suitable areas. 13.84 % area are covered by natural vegetation, 40%, 8.37%, 14.52% and 23.22 % area are followed by agricultural land, surface water, fellow land and built up areas. Fellow land is assigned as suitable land while Surface water land is allocated as most unsuitable land (Table no.2 and Figure no. 6).

Table 2

Criteria	Land Use Type	Ranking	Level of Suitability
Land Use Land Cover	Surface Water	1	Unsuitable
	Agricultural land/ Built up areas	2	Less suitable
	Vegetation	3	Moderate suitable
	Fellow Land	4	Highly Suitable

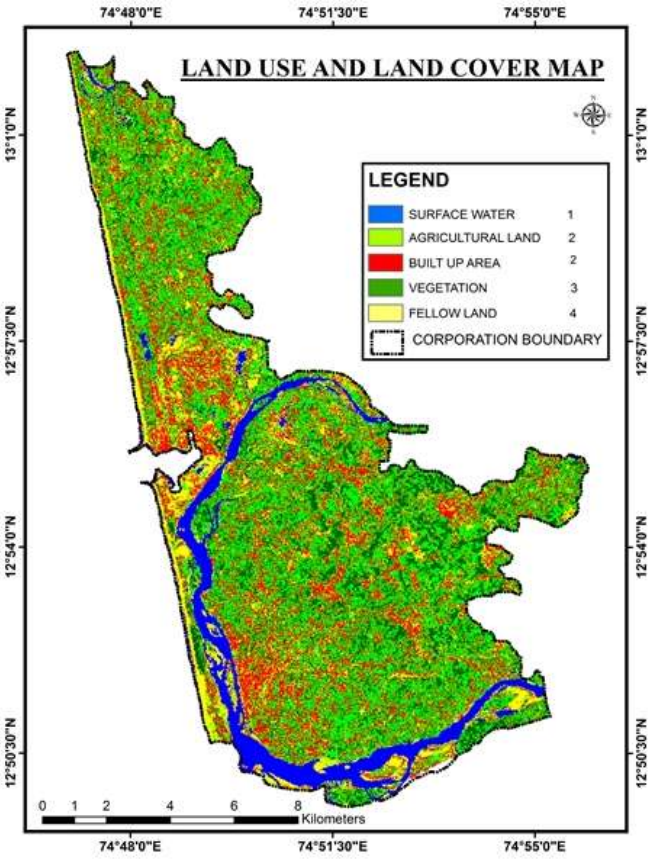

Figure 6: Land Use Land Cover Map

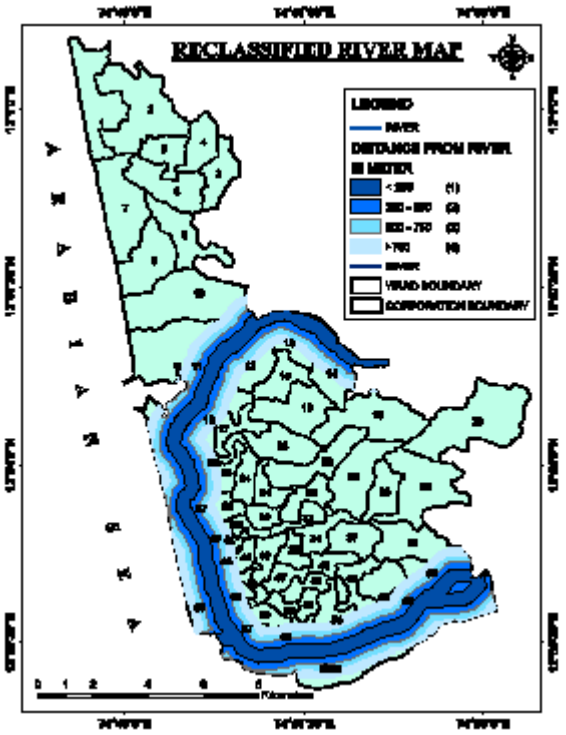

Figure 7: Reclassified River Map

Distance from River

Mangalore city is situated along the confluence of river Nethravathi and Gurpur. Corporation supplies Nethravathi River's water for domestic purpose. According to CPCB, Rivers and water bodies are prohibited to dispose solid waste. Dumping site should not be constructing near river and surface water land (Paul, 2012). Multiple ring buffer method were applied to create distance of 250m, 500m, 750m and 1000m from the river and allocated each buffer ring as a rank of weights or preference 1, 2, 3, 4, from unsuitable to suitable (Table no 3 and Figure no.7). Increasing distance as increases preference of suitable land.

Table 3

Criteria	Distance from river	Ranking	Level of Suitability
River	0m - 250m	1	Unsuitable
	250m - 500m	2	Less suitable
	500m - 750m	3	Moderate suitable
	> 750m	4	Highly Suitable

Elevation

Elevation map has been prepared by using Shuttle Radar Topographic Mission (SRTM) DEM data of USGS. The elevation range of MCC varies from 0 meter to 120 meters. According to preference of suitability level, lower elevated land is more suitable while higher elevated is unsuitable for putting waste. It is observable that along coast line, western part is low elevated land (-4m to 27 m) and as a part of Western Ghats, the eastern part is high land (89m to 120m) of corporation area. The suitability ranking scores were given 1, 2, 3, 4 from high to low land (Table no 4. and Figure no.8). In this study 55.44% area is as low land area, only 3.4% is high elevated land of total area. Moderate and less moderate zone of elevation land are followed by 10.41% and 30.73% of total area.

Table 4

Criteria	Height from Msl	Ranking	Level of Suitability
Elevation	0m – 27m	4	Highly Suitable
	27m – 58m	3	Moderate suitable
	58m – 89m	2	Less suitable
	89m – 120m	1	Unsuitable

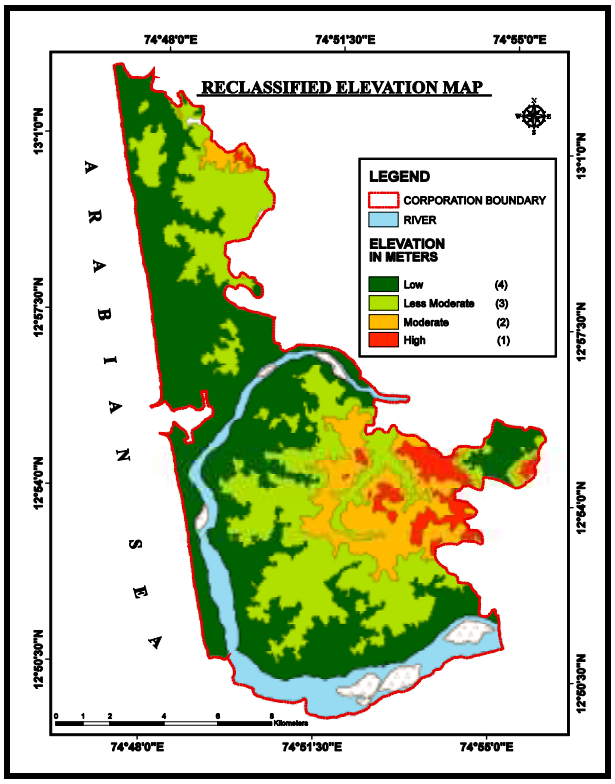

Figure 8: Reclassified Elevation Map

Slope:

Slope is calculation of the ratio of the perpendicular change to the parallel change between two different points on a line. In this study area, low degree slope areas are suitable than high slope land area for waste disposal (Ebistu et al., 2013). Slope were classified into four classes i.e., 0-2 degree (40% area covered), 3-6 degree (35% area covered), 7- 10 degree (18% area covered) and 11- 47 degree (6%). According to preferences of suitability ranking score, increases slope as decreases suitability of place of waste dumping. Most of the area comes under within 0-2 degree which is low degree slope with high suitability. Only 6% area is fall under 11- 47 degree slope which is unsuitable (Table no 5. and Figure no.9).

Table 5

Criteria	Slope in Degree	Ranking	Level of Suitability
Slope	0 – 2	4	Highly Suitable
	3 – 6	3	Moderate suitable
	7 – 10	2	Less suitable
	11 – 47	1	Unsuitable

Distance from roads

Road network is essential for city development. In MCC Corporation the main transport network is road because it connects to different part of the country with city. NH-17, NH-48, NH-13 are linking Mangalore with Panvel, Bangalore and Sholapur. According to (Bhambulkar, 2011) solid waste should be sited more than 250m distance from road site. Multiple ring buffers were applied to create distance zonation map of suitability from main road. According to priority, distances of 250m, 500m, and 750m, above 750m are allocated from unsuitable to suitable (Table no.6 and Figure sno.10).

Table 6

Criteria	Distance from Road	Ranking	Level of Suitability
Road	0m - 250m	1	Unsuitable
	250m - 500m	2	Less suitable
	500m - 750m	3	Moderate suitable
	> 750m	4	Highly Suitable

Population Density

As per report of Census data population of MCC is 463300 persons and density is approximately 2807 person/sq km. there are total 60 wards. Most densely populated wards are 43, 44, 29, 42 with 14837, 11803, 10245, 10220 persons/sqkm whereas low populated ward are 11 and 36 with population 731 and 852 persons/sqkm. High to low populated wards are referred to build suitability ranking of solid disposal. In this paper, high populated wards are low unsuitable, low populated wards are more suitable (Table no. 7and Figure no.11).

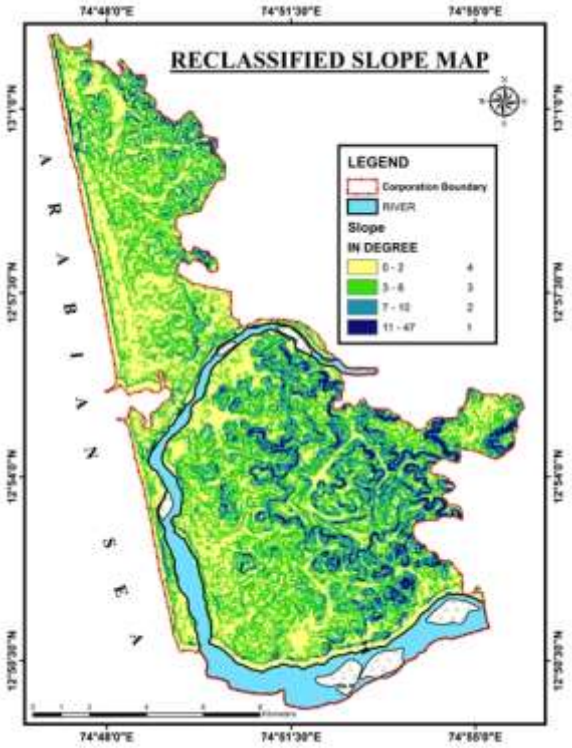

Figure 9: Reclassified Slope Map

Table 7

Criteria	Population Density (persons / sqkm)	Ranking	Level of Suitability
Population Density	731-4258	4	Highly Suitable
	4259-7784	3	Moderate suitable
	7785-11311	2	Less suitable
	11312-14837	1	Unsuitable

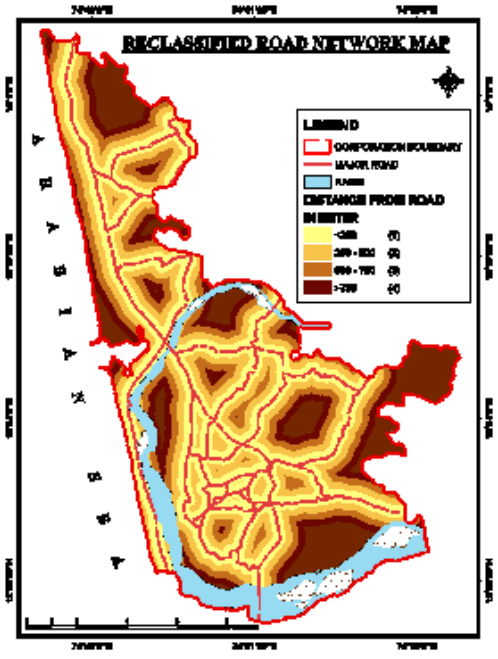

Figure 10: Reclassified Road Network Map

Distance from Wet land

River, lakes, water bodies are prohibited to fill solid waste (Jaybhaye, Mundhe, & Bhalachandra , 2014). In MCC area, there are some water bodies and creek adjacent wet land which is used as agricultural purpose. These wet land patches are reclassified based on distances by using multiple buffer analysis. Distance increasing from the wet lands of 250m to above 750m is considered as unsuitable to suitable criteria (Table no 8. and Figure no. 12).

Table 8

Criteria	Distance from Wet Land	Ranking	Level of Suitability
Wet Land	0m - 250m	1	Unsuitable
	250m - 500m	2	Less suitable
	500m - 750m	3	Moderate suitable
	> 750m	4	Highly Suitable

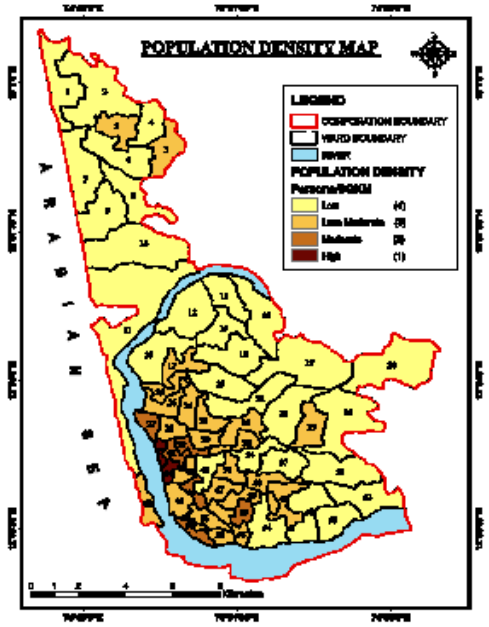

Figure11: Population Density Map

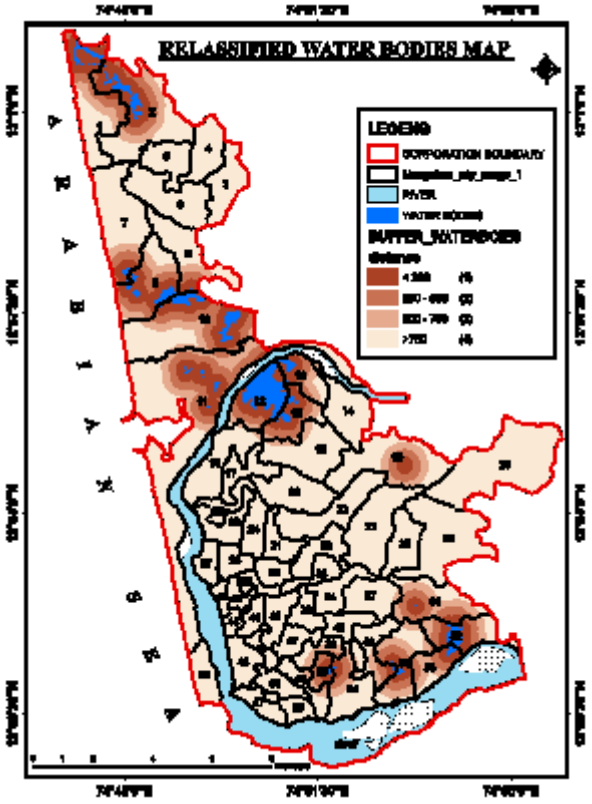

Figure 12: Reclassified Water Bodies Map

Distance from Airport

Airport is considered as socio- economic parameters of selecting suitable dumping site. Mangalore international airport are situated in Mangalore taluk, it's near to Mangalore Corporation of 13 and 14 no ward. Considering its locational importance, multiple buffer distances were created to assign suitability ranking from below 500m to above 1500m for waste dumping station of airport. Below 500m was unsuitable, 500m to 1000m distances was considered as less suitable rank, 1000m to 1500m was given as moderate suitable and finally above 1500m is suitable place to fulfill the criteria. (Table no 9. and Figure no.13).

Table 9

Criteria	Distance from Airport	Ranking	Level of Suitability
Airport	<500m	1	Unsuitable
	500m – 1000m	2	Less suitable
	1000m – 1500m	3	Moderate suitable
	> 1500m	4	Highly Suitable

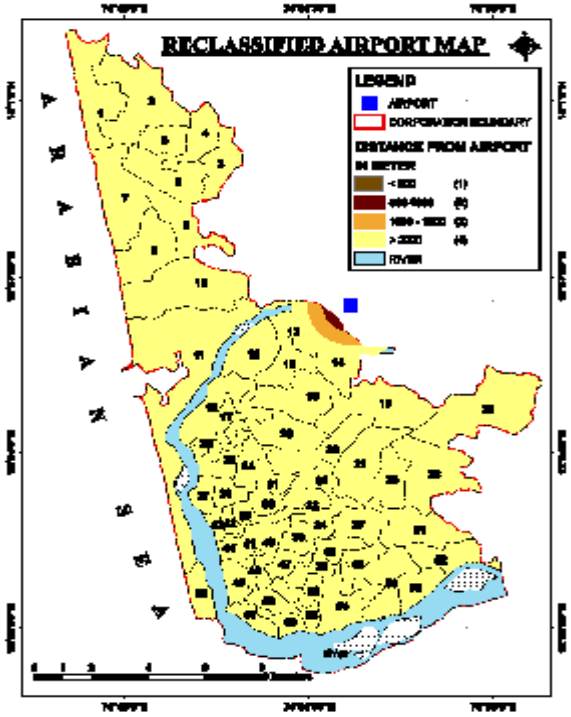

Figure 13: Reclassified Airport Map

Based on multiple criterial Analysis, suitable dumping site has been selected within Mangalore City Corporation. The overlay method was used over the factors to detect the landfill site using the Raster calculation of ArcGIS software (Table no 10. and Figure no.14). The suitable land has been classified into four classesi.e., less suitable to highly suitable land (table no.10).

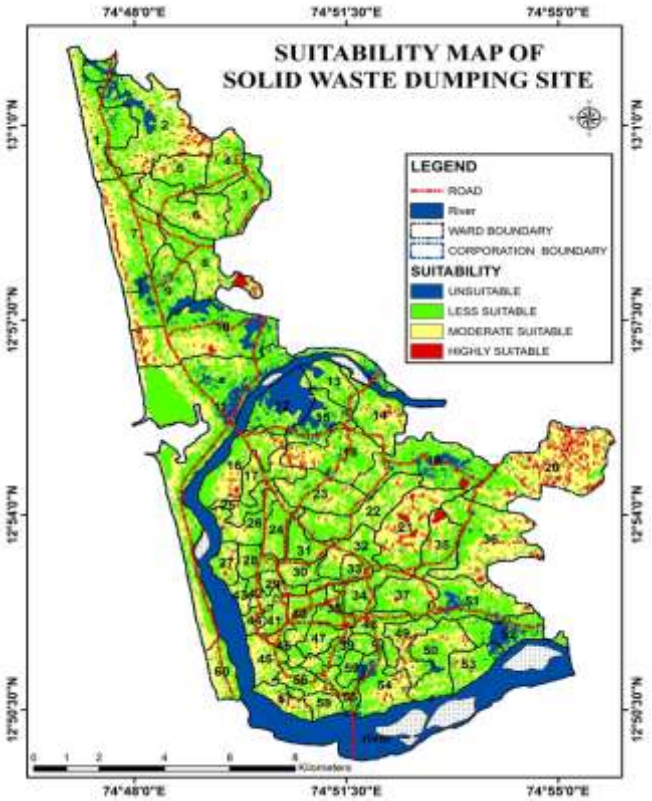

Figure No. 14: Reclassified Airport Map

Table 10

S no.	Suitability Classes	Area (KM^2)	Area (acres)	Area (%)
1	Unsuitable	17.289	4272.20	10.54
2	Less Suitable	77.31	19103.71	47.13
3	Moderate Suitable	62.954	15556.27	38.39
4	Highly Suitable	6.45	1593.83	3.93
Total		164.003	40526.01	100

It is finding that in the whole Corporation area, only 6.45 km^2 (3.93%) area is suitable for solid waste dumping; otherwise 17.289 km^2, 77.31 km^2 and 62.95 km^2 area are fall under unsuitable, less suitable and moderate suitable with 10.54%, 47.13% and 38.39% respectively. In this paper, it has been find out that there are five potential sites are considered as suitable site; these are in ward no 8, 19, 21 and 35 with area of 28.02, 18.53, 23.22, 3.45 and 10.13 acres. Near pachanadi there is one dumping landsite of under Mangalore City Corporation area; rest of other four sites are located near Kulai, near Sakti Nagar and Bikarnakatte Kaikamba(Table no 11. and Figure no.15).

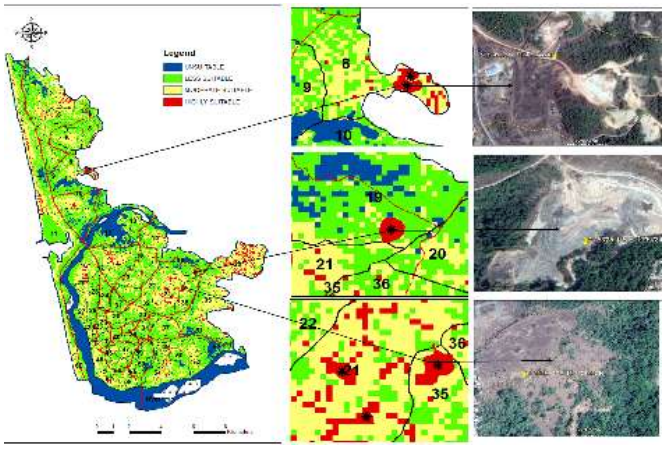

Table 11

S no.	Potential suitable site	Area (KM^2)	Area (acres)	Ward No.
1	Near kulai	0.1134	28.02	8
2	Near Pachanadi	0.075	18.53	19
3	Near Sakti Nagar	0.094	23.22	35
4	Bikarnakatte Kaikamba	0.014	3.45	21
5	Bikarnakatte Kaikamba	0.041	10.13	21

5. Conclusion

It is observable that, the solid waste management has not been archived at satisfactory level in our Urban Local Bodies areas; where the population pressure and growth of slums are increase as well as its producing much solid waste day by day. The GIS approach and methodology has been adopted to find out some potential solid waste dumping site of corporation area. There are various factors which considered to selecting disposal site but in this study some important factors has been taken to fulfill the methodology and it would be a useful for further decision planning of corporation. But in case of GIS technology which is most useful tool to taking planning decision environmentally and economically. As per finding result the most potential 5 site which are far from

water resources and other considered parameters as per CPCB rules.

References

[1] Swachh Bharat Mission-Municipal Solid *waste; Part I: An Overview*. New Delhi: Central PublicHealth and Environmental Engineering Organisation(CPHEEO)-Ministry Of Urban Development. 2016
[2] Bean, E., Rovers, F., & Farquhar, G. (1995). Solid WasteLandfill Engineering and Design. *Prentice Hall, NJ. 380.*
[3] Bhambulkar, A. (2011). Municipal Solid Waste Collection Routes Optimized with ArcGIS Network Analyst. *International Journal of Advanced Engineering Sciences and Technologies.*, 202-207.
[4] CPHEEO, 2000: Manual on Municipal Solid Waste Management. http://moud.gov.in/swm_manual.
[5] Census of India 2011: Karnataka; DIstrict Census Hand Book , Dakshin Karnataka. http://censusindia.gov.in.
[6] Central Pollution Control Board, 2000: A Support Manual for Municipal Solid Waste (Management and Handling) Rules.
[7] City Sanitation Plan.-Karnataka: Draft Report Mangalore.
[8] Jaybhaye, R., Mundhe, N., & Bhalachandra , D. 2014;Volume 3, Issue 1; Site Suitability for Urban Solid WasteDisposal Using Geoinformatics: A Case Study of PuneMunicipal Corporation, Maharashtra, India. *InternationalJournal of Advanced Remote Sensing and GIS*, pp. 769-783
[9] Paul, S. (2012). Location Allocation for Urban Waste Disposal Site Using Multi-Criteria Analysis: A Study on Nabadwip Municipality, West Bengal, India. *InternationalJournal of Geomatics and Geosciences.*, 74-87.
[10] *Solid Waste Management in Mangalore City-Documentation.* Mangalore: Mangalore City Corporation.
[11] Wiley, J., & Sons, L. (2009). Essential Image Processingand GIS for Remote Sensing. *Imperial College London, UK.*