International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 6, June - 2014

Determination of Suitable Site for Solid Waste Disposal using Remote Sensing and GIS Techniques in Allahabad Municipality Area

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***Abstract*: City waste management is a global environmental problem in today's world. There is an increase in commercial, residential and infrastructure development due to the population growth and this has negative impact on the environment. 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 location of dumping site in unsuitable areas. This paper deals with determination of suitable sites for the disposal of waste generated from Allahabad city surrounding areas using GIS techniques. Remote sensing and Geographical information analysis was used in this study to find out suitable site of waste disposal. Land use Land cover mapping, geology mapping, geomorphology mapping, Lithology mapping, slope mapping, road and rail network, and drainage mapping was done using on screen visual interpretation of landsat data 2011. Attribute is given to all the classes. After attributing the data base map was created and there after various thematic maps like geomorphology, lithology, drainage, slope, streams, populations and road map were created and weightage allocate to them based on the key parameter. All thematic vector layers were integrated and introduced in to overlaying and weightage analysis to carry out Site Suitability Index (SSI) using spatial analyst tool in Arc GIS 9.3 to target potential sites for waste disposal. Potential site for waste disposal have been evaluated from the analysis of geospatial data using computerized GIS soft ware by following analysis; Selection of sites for waste disposal was based on different criteria, such as landuse, landcover, geology, Lithology, DEM, Infrastructure. Ranking (order of priority) was done based on the knowledge of study area to select the best sites for waste disposal. Outcome generated through the GIS analysis shows that 0.98 km^2 area is highly suitable, 3.43 km^2 area is moderately suitable, 464.01 km^2 area is less suitable, 291 Km^2 area is come under not suitable and 186.16 km^2 unspecified for waste disposal. The studies illustrate the importance of RS and GIS technology in the present days.**

1. INTRODUCTION

In spite of the increasing stress towards the waste reduction at the source, as well as recovery and recycling of the solid waste, disposal of solid waste by land filling remain the most commonly employed method. Landfill incorporates an engineered method of disposal of solid waste on land in a manner that minimizes environmental hazards by spreading the solid waste in thin layers, compacting the solid waste to the smallest practical volume and applying a cover at the end of the operating day. However, with the increased population density and urban infrastructure, several key considerations are required to be taken into account to ensure its overall su Advancement in recent technological innovations, ease and accessibility has made the application of environmental criteria in national planning and waste management achievable. stain ability, especially those associated with its economics, optimized siting and operation.

Remote sensing is one of the excellent tools for inventory and analysis of environment and its resources, owing to its unique ability of providing the synoptic view of a large area of the earth's surfaces and its capacity of repetitive coverage. Its multispectral capability provides appropriate contrast between various natural features where as its repetitive coverage provides information on the dynamic changes taking place over the earth surface and the natural environment. Technological development in computer science has introduced geographic information system (GIS) as an innovative tool in landfill process. GIS combines spatial data (maps, aerial photographs, satellite images) with the other quantitative, qualitative and descriptive information databases. This technology offers an analytical frame work for data synthesis that combines a system capable of data capture, storage, management, retrieval, analysis and display. When

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remotely sensed data are combined with other landscape variables organized with in a GIS environment provide an excellent frame work for data capture, storage, synthesis, measurement and analysis. For assessing a site as a possible location for solid waste land filling, several environmental and political factors and legislations should be considered. The GIS aided methodology presented here utilizes to create the digital geo database as a spatial clustering process and easily understood way for landfill process in Allahabad town area.

In recent years, GIS has emerged as a very important tool for land use suitability analysis. GIS can recognize, correlate and analyze the spatial relationship between mapped phenomena, thereby enabling policy-makers to link disparate sources of information, perform sophisticated analysis, visualize trends, project outcomes and strategize long-term planning goals **(Malczewski, 2004)**. GIS has often been employed for the siting and placement of facilities **(Church, 2002)**. The pioneering work in this field was initiated by **(McHarg, 1969)** who enunciated the basic mapping ideas for site suitability analysis; especially those that involve delineating the best route connecting two points or identifying the best location for a specific function. GIS has been found to play a significant role jin the domain of siting of waste disposal sites. The potential advantage of a GIS-based approach for siting arises from the fact that it not only reduces time and cost of site selection, but also provides a digital data bank for long-term monitoring of the site.

The present study focuses on an optimized land use site selection based on multi-criteria decision analysis and geographic information system based (GIS) overlay analysis. The most appropriate landfill site has been identified for Allahabad city of India. Several important factors and criteria were considered to arrive at the optimum siting decision including the pre-existing land use, location of sensitive sites, infiltration, water bodies, water supply sources, air quality, geology. Thematic maps of the selected criteria were developed within the paradigm of standard GIS software. Subsequently, weightings were assigned to each criterion depending upon their relative importance, and ratings in accordance with the relative magnitude of impact. A GIS-based overlay analysis was performed to identify the optimum site for the landfill, one which fulfilled all of the desired attributes.

2. MATERIALS AND METHODS

2.1 Study Area Characteristics

2.1.1 Geographical Location: Allahabad is a major city of east Uttar Pradesh State , situated at 25°.27 N, 81°.50 E in the southern part of the Uttar Pradesh at an elevation of 98 meters (322 f). It is about 627 km from Delhi and about 815 km from Calcutta. Allahabad is an ancient city of India, because it is built on the confluence (Sangam) of the rivers Ganga, Yamuna and Saraswati (Tourism Department, 1989). The city has a population of about 5,959,798 inhabitants (AMC, 2011)

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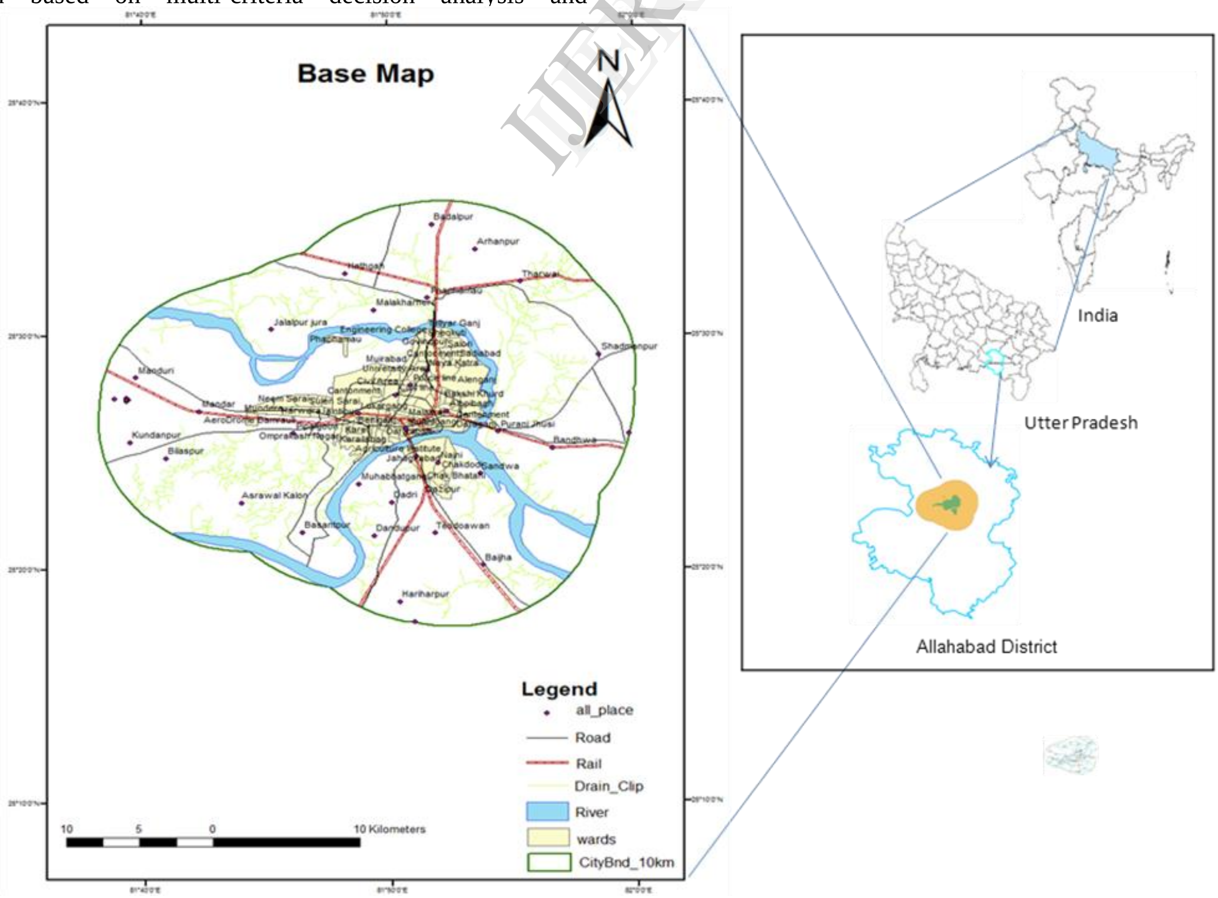

Fig: 1 Location map of the study area

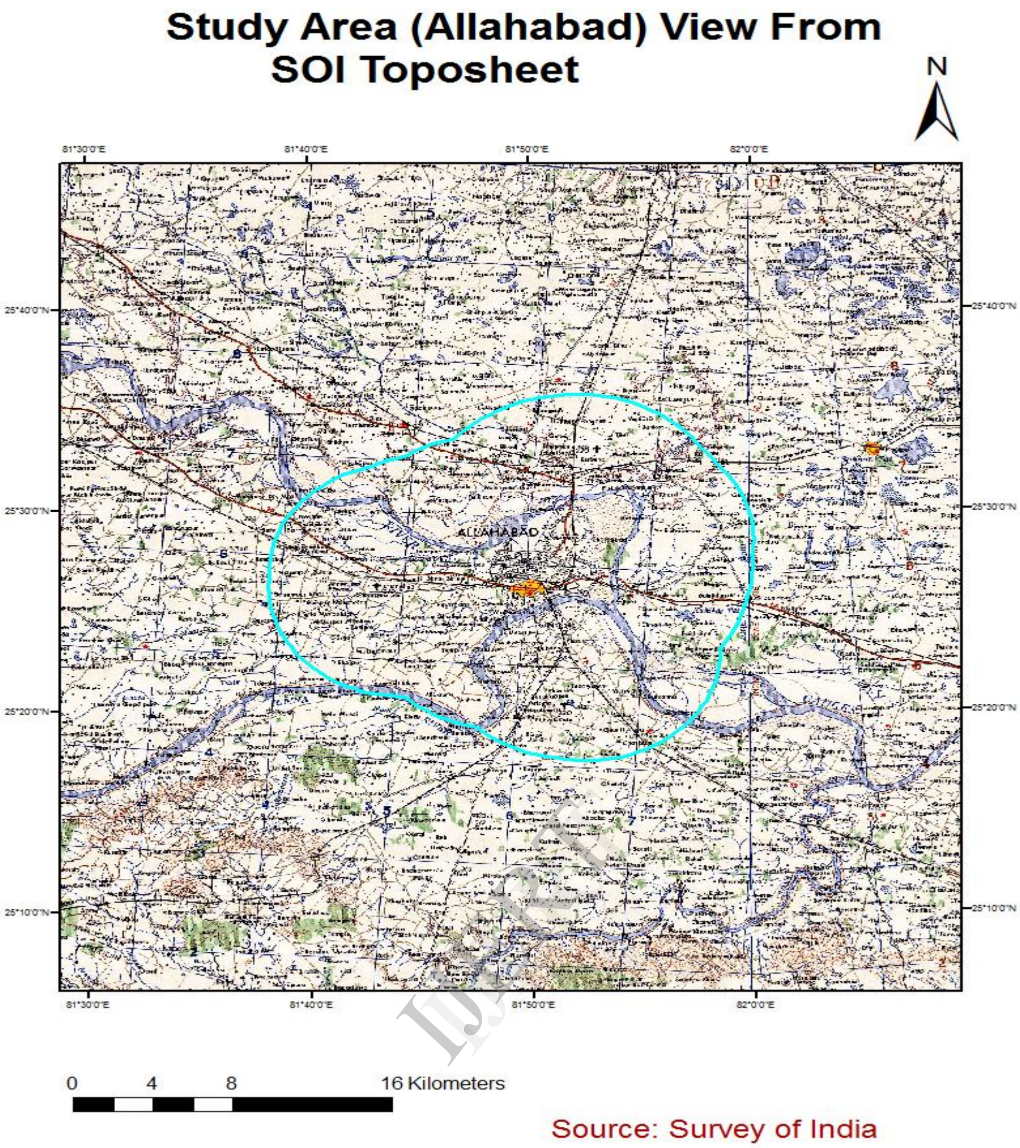

Fig: 2 Topographic view of the study area

2.1.2 Soil: The land of Allahabad district that falls between the Ganga and Yamuna is just like the rest of Doab dominant with alluvial (Entisols), fertile but not too moist. The non-doabi parts of the district, the southern part and eastern part of the district are somewhat similar to those of adjoining Bundelkhand and Bagelkhand, dry and rocky.

2.1.3 Demography: Allahabad City have a population of 1,042,229 as per the 2001 census. It lists as the 32nd most populous city in India and 3rd fastest growing cities of Uttar Pradesh after Lucknow and Agra. Allahabad has an area of about 7000 km^2 (2700 sq mi).

2.1.4 Climate: Allahabad experiences all four seasons. The summer seasons are from April to June with the maximum temperatures ranging between 40^{0}C to 48^{0}C. Monsoon begins in early July and lasts till September. The winter seasons falls in the month of December, January and February. Temperatures in the cold weather could drop to freezing with maximum at almost 12^{0}C to 14^{0}C. The lowest temperature recorded, -2^{0}C and highest 48^{0}C. Rainfall and humidity are varies.

2.1.5 Population: In 2011, Allahabad had population of 5,959,798 of which male and female were 3,133,479 and 2,826,319 respectively. In 2001 census, Allahabad had a population of 4,936,105 of which males were 2,626,448 and remaining 2,309,657 were females. The initial provisional data released by census India 2011, shows that density of Allahabad district for 2011 is 1,087 people per sq. km. In 2001, Allahabad district and density at 901 people per sq.km. Allahabad district administers 5,481 square kilometers of areas.

2.1.6 Hydrogeology: Ground water in the district occurs both in alluvium and in the weathered & jointed sandstones areas which are underlain by hard rocks. In the unconsolidated or alluvial formation ground water occurs under unconfined to confined conditions in the shallow and deeper aquifers respectively and depth to water ranges between 2 to 20 meters during pre-monsoon period, while in the post monsoon period it stands between 1 to 18.00 meters (Wikipedia).

2.2. Data Used

2.2.1 Remote Sensing Data: Landsat ETM$^+$ sensor data were used for this study. Since the study area was covered in many paths of Landsat satellite data acquisition (each path is covered separately in a different day as per orbital calendar), cloud free data was acquired in different time windows depending upon the overpass of satellite. Each scene was ortho corrected; geo-referenced and suitable Image enhancements are applied to facilitate the delineation and interpretation of different thematic information. Characteristics of Land sat data is shown in Table 1.

Table: 1 satellite remote sensing data specification

Remote sensing Data	Landsat Satellite Data
Sensor	Enhanced Thematic Mapper Plus (ETM$^+$)
Temporal Resolution	16 Days
Spatial Resolution	30 m X 30 m
Spectral Range	0.45 - 12.5 µm
Image Size	183 km X 170 km
Sensor type	Opto-mechanical
No. of Bands	8
Swath	183 km
Path	142, 143, 144
Row	42, 43, 44

Topographical maps

Survey of India toposheets of 1: 250000 and 1:50000 scales were used for preparation of the base maps for geometric correction of satellite data and for remote sensing data interpretation. Detail of toposheet used in the present study is shown in Table 2. Further, irrigation command area maps were collected from Water Resources Department, Government of Utter Pradesh.

Table: 2 Details of SOI Maps

SOI Map No.	Scale	Purpose
63K, 63G, 64 G,	1:250,000	Geo-referencing of satellite data, Study area boundary extraction
63G/15, 63G/16, 63G/11, 63K/4 64G/14	1:50,000	Ground truth & mapping

2.2.2 Methodology

The Survey of India (SOI) toposheet (1978) were mosiaced and georeferenced. The mosaiced toposheet covers the study area. Georeferenced toposheets provides the information about the features prevailing in the area and details of latitude /longitude for Allahabad district as well as Allahabad city. The observed Lat/Long was further used to search and download the Landsat satellite imagery of the study area. Land Sat ETM$^+$ 2011 was used to identify the land use land cover, lithology, geology, road network etc to identify the suitable site for waste disposal. ERDAS IMAGING 9.2 and Arc GIS 9.3 Software were used to carry out the analysis

Table 3: The Criteria and sub criteria used in development of GIS database

Physical Criteria	Lithology Geomorphology Slope Drainage
Social economical criteria	Population Distance from major roads Distance from river Distance from drainage

Various shape files were created and these were converted in to coverages for doing further works in Arc GIS 9.3. After converting the shape files in to coverages topology creation started. Topology is the mathematical relationship built between objects and it makes an explicit bond between geographic features in the data base. After attributing the data base map was created and there after various thematic maps like geomorphology, lithology, drainage, slope, streams, populations and road map were created and weightage allocate to them based on the key parameter. The weightage assigned for different themes are shown the table 4. For getting a suitable site for the disposal of solid waste 2 km buffer zones were created around the Municipality area. Various coverages in these themes were assigned a suitability score and converted in to raster format using Spatial Analyst in the Arc Map

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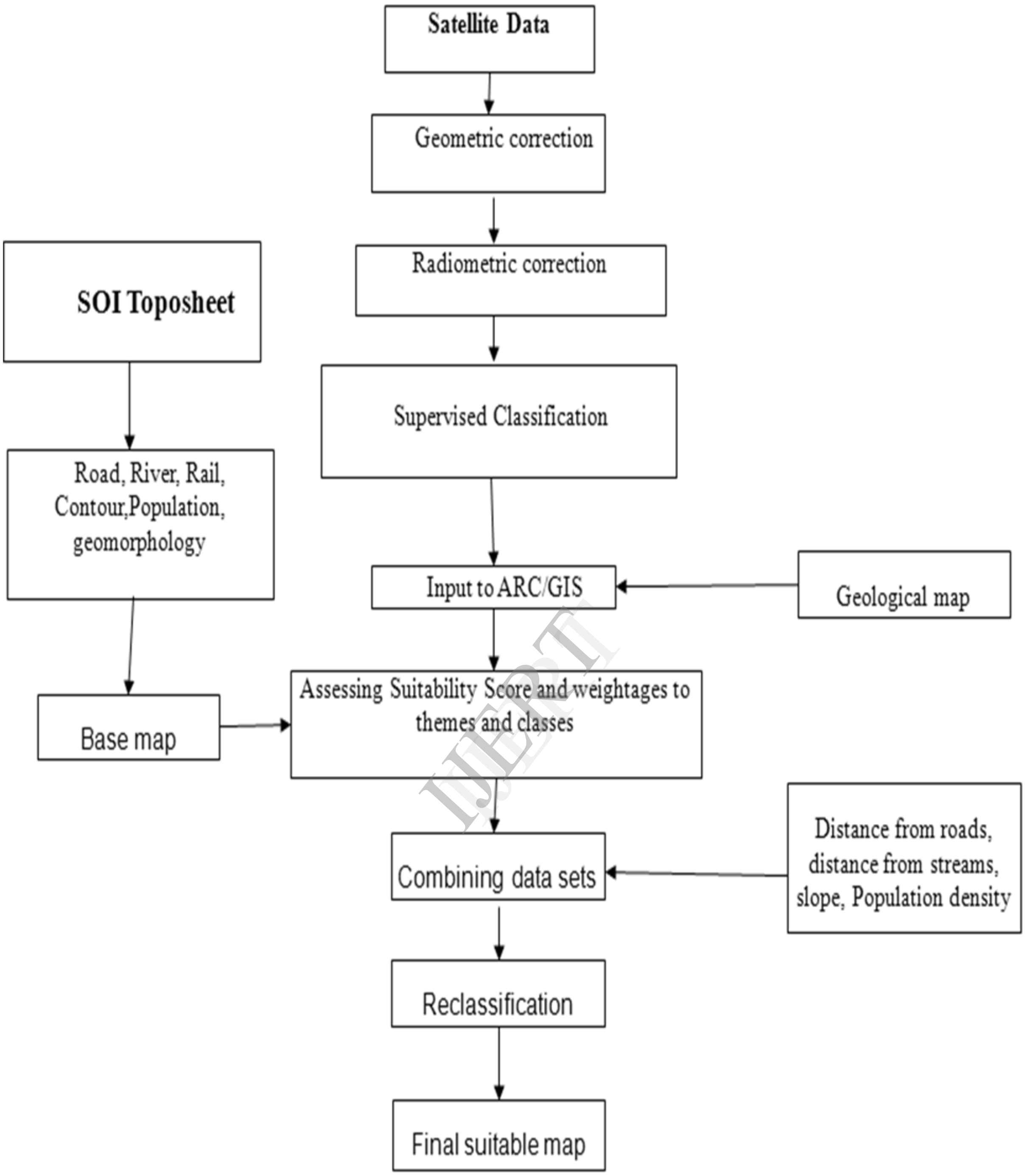

Fig: 3 Diagrammatic representation of research methodology

2.2.3 Overlapping of all the layers

All thematic vector layers were integrated and introduced in to overlaying and weightage analysis to carry out Site Suitability Index (SSI) using spatial analyst tool in Arc GIS 9.3 to target potential sites for waste disposal. Potential site for waste disposal have been evaluated from the analysis of geospatial data using computerized GIS soft ware by following analysis; Selection of sites for waste disposal was based on different criteria, such as landuse, landcover, geology, Lithology, DEM, Infrastructure. Ranking (order of priority) was done based on the knowledge of study area to select the best sites for waste disposal.

For each of the criteria allocated 5 weightage points, respectively, were given which sums up to a total of 40 weightage points. A procedure for calculating site-suitability index (SSI) based on the above criteria was designed in order to quantify subjectivity of the regulatory guidelines and other related parameters used in the selection process.

3. RESULT AND DISCUISON

3.1 Geomorphology mapping

When urban areas are in a period of very dynamic development, besides many other problem demanding urgent solutions, first of all it is necessary to analyze the nature support of the antropogen activity that is the relief. In the last decades urban area of Indian city has grown significantly that causes the lots of city waste in area. In such circumstance the importance of the role of geomorphology is increasing. Now-a-days, Land use planning is important task for local and government authority to provide suitable land for human activities in the study area so it is realized that land use planning need to be developed in an integrated and comprehensive manner based on geomorphic study. In this study, Remote Sensing and GIS, tools and techniques are used to identify landform, geomorphic units and area mapping because geomorphology is the base of land use planning.

The satellite data was transformed into thematic geomorphology map using on screen visual interpretation. The satellite data of 2011 was classified into various classes. The geomorphology map of the study area is shown in figure 5. Statistics of different classes of study area has been calculated and shown in table 5.

3.2 Geomorphology statistics

Allahabad city consist of 9198.02 ha out of which 3423.78 ha is settlement Area. In this respect, the settlement area covers about 37.22% of the total area. It has also been found that about 2533.4ha (27.76%) of area is covered by Plantation. The Agriculture land comprises of 2497.15ha (27.14%). The area covered by Riverbed water is 375.03 ha (4.08%) and that of the Deep water is 201.51 ha (2.19%). The area covered by shallow water is 167.13 ha (1.82%). Table 5 shows the area distribution of the various geomorphology map of Allahabad city.

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Table 5: Area Statistics of Geomorphology of Allahabad city

Class	Area(ha)	Area (%)
Alluvial plain	13962.706	36.39
Flood plain	9119.591	23.77
Habitation mask	15174.735	39.55
Water body mask	114.191	0.300
Total	38371.223	100

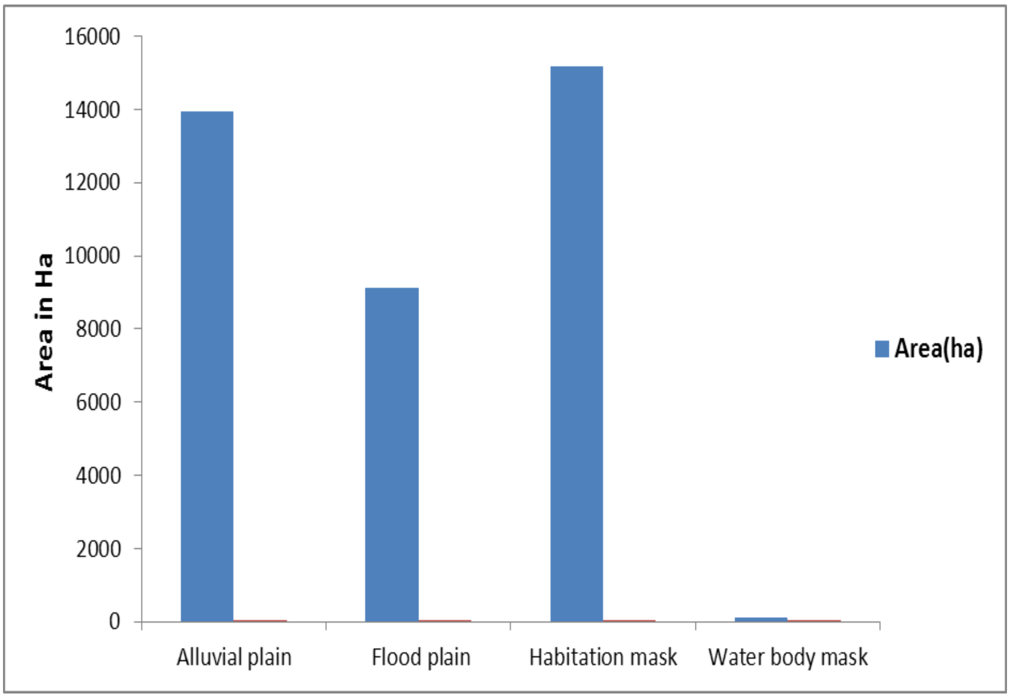

Fig. 4 Area Statistics of Geomorphology of Allahabad city

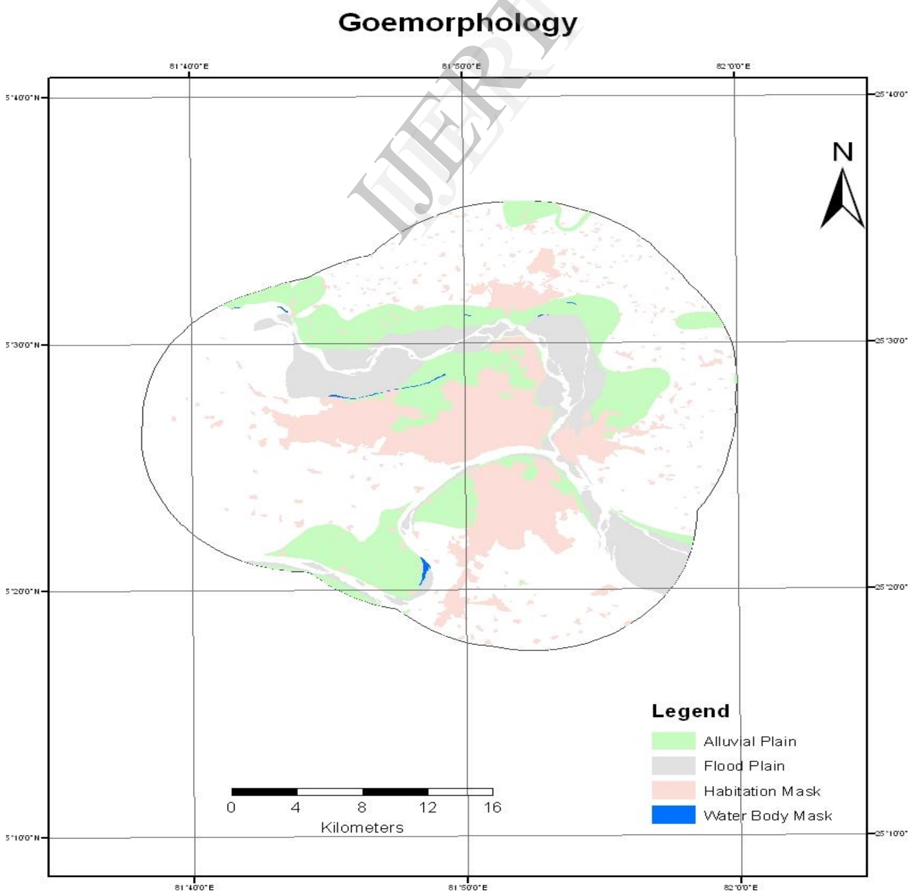

Fig: 5 Geomorphology map of the study area.

Table 6: Suitability scores given for geomorphology

Type of Geomorphology	Suitability Score
Alluvial Plain	3
Flood Plain	1
Habitation Mask	2
Water Body Mask	1

3.3 Lithology mapping

Geological structures have great importance in ground investigation, clay regions, silt, sand and rock to find out the degree weathering and fracture, as well as locate groundwater of the study area is shown in figure 7. Statistics of study area has been calculated and shown in table 7.

3.4 Lithology statistics

Allahabad city consist of 9198.02 ha out of which 3423.78 ha is Settlement Area. In this respect, the Settlement area covers about 37.22% of the total area. It has also been found that about 2533.4ha (27.76%) of area is covered by Plantation. The Agriculture land comprises of 2497.15ha (27.14%). The area covered by Riverbed water is 375.03 ha (4.08%) and that of the Deep water is 201.51 ha (2.19%). The area covered by Shallow water is167.13 ha (1.82). Table 7 shows the area distribution of the various land use/land cover and the land use / land cover imagery of Allahabad city area.

Table 7: Area Statistics of Lithology of Allahabad city

Class	Area(ha)	Area (%)
Clay with sand/Silt parting	0.005	0.00
Clayey sand	45915.639	52.46
Graval/ Sannd, silt	9542.879	10.90
Habitation mask	15173.743	17.35
Sandy clay	13196.799	15.09
Water body	3688.470	4.21
Total	87517.535	100

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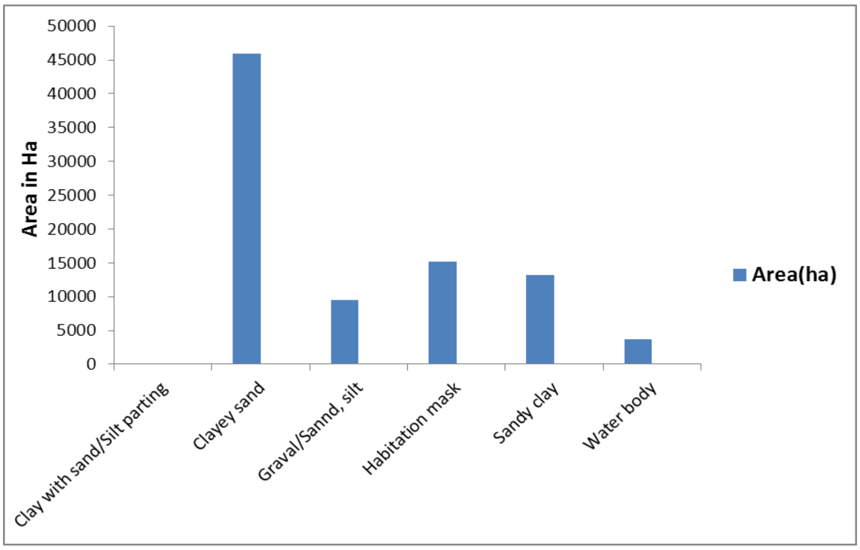

Fig: 6 Area Statistics of Lithology of Allahabad city

Table 8: Suitability scores given for Lithology.

Type of Lithology	Suitability Score
Clay with sand/Silt porting	4
Clayey sand	3
Gravel/Sand, silt	2
Habitation mask	2
Sandy clay	2
Water body	1

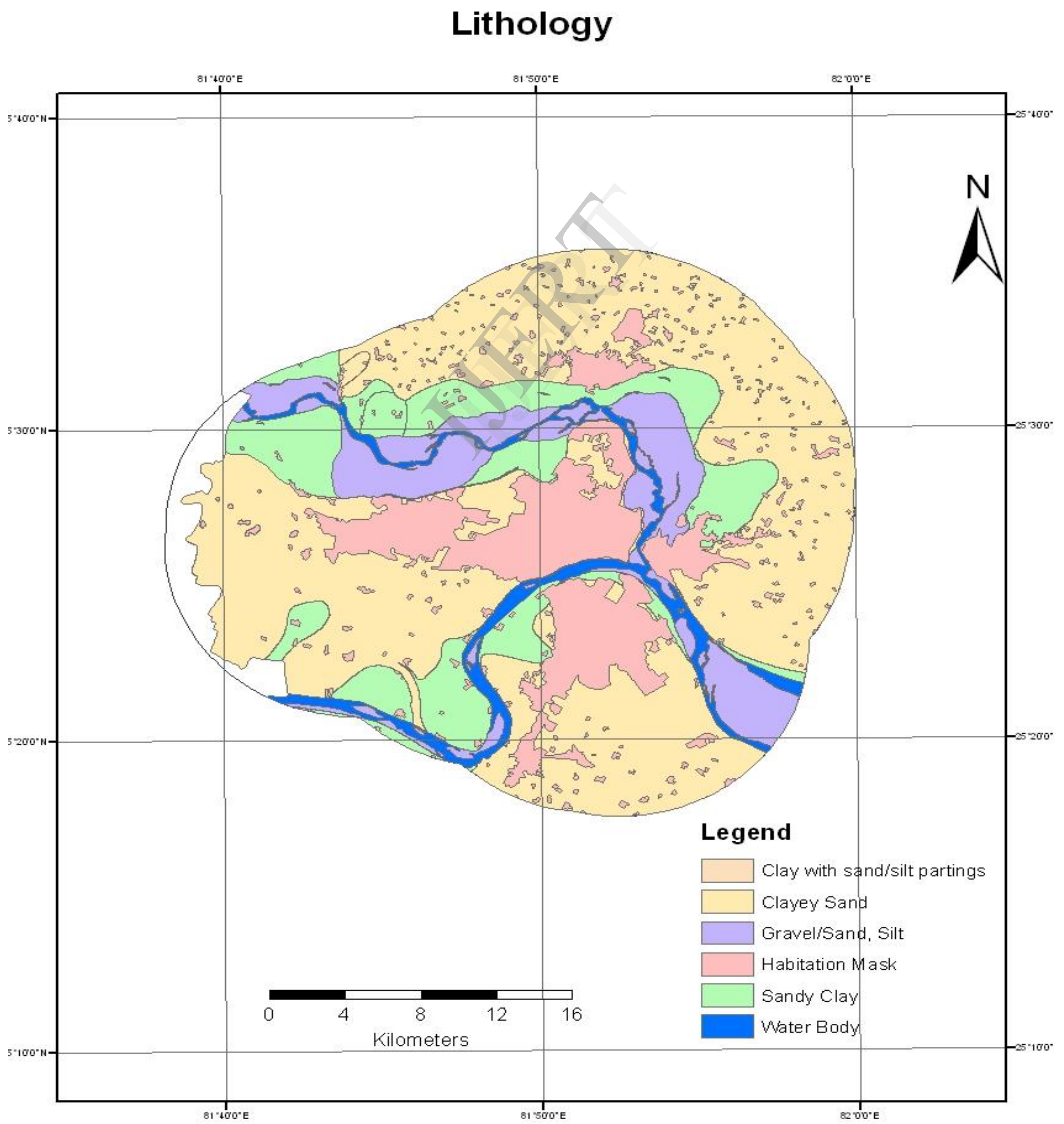

Fig: 7 Lithology map of the study area.

ISSN: 2278-0181
Vol. 3 Issue 6, June - 2014

3.5 Slope mapping

The aim of this study is to utilize the remotely sensed data and GIS techniques for slope assessment for site suitability of waste management of Allahabad district. Study area has found to be only two type of slope one is level to very gently slop area and other is mainly river bed.

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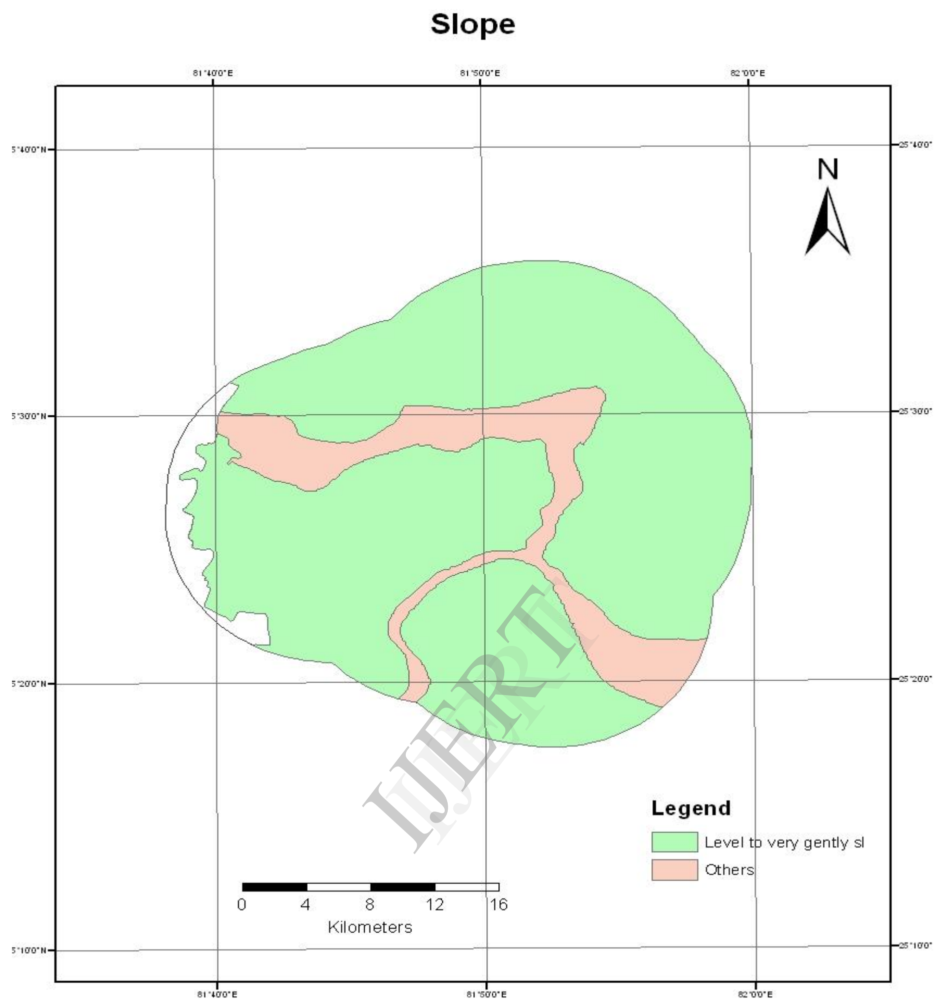

Fig: 8 Slope map of the study area.

Table 9: Suitability scores given for slope.

Type of Geomorphlogy	Suitability Score
Level to very gently slope	2
Others	1

3.6 population

According to the 2011 census the population of the municipality of the city of Allahabad is 5,959,798, which is high compared to some neighboring cities. Given the demographic map and relevance due to area residents in Figure 4.8 and total area of Allahabad city is 9066.12 ha and having average population density 134 persons per Ha .In this way Allahabad is the seventh most populous city in Uttar Pradesh, with an estimated population of 1.74 million living in the city and district area. In 2011, it was ranked the world's 130th fastest growing city. This demographic pattern can be used for identifying Wards for implementing future development schemes in the region. The unprecedented growth of population has put tremendous stress on management of housing water and environmental sustainability, which can be gauged by the magnitude of waste produced. The city generates 5,34,760 kg of domestic solid wastes every day, while per capita generation of waste is 0.40 kg per day. Wastes generated by domestic, commercial and industrial activities are often indiscriminately disposed and unscientific management of such wastes further leads to serious environmental and health problems.

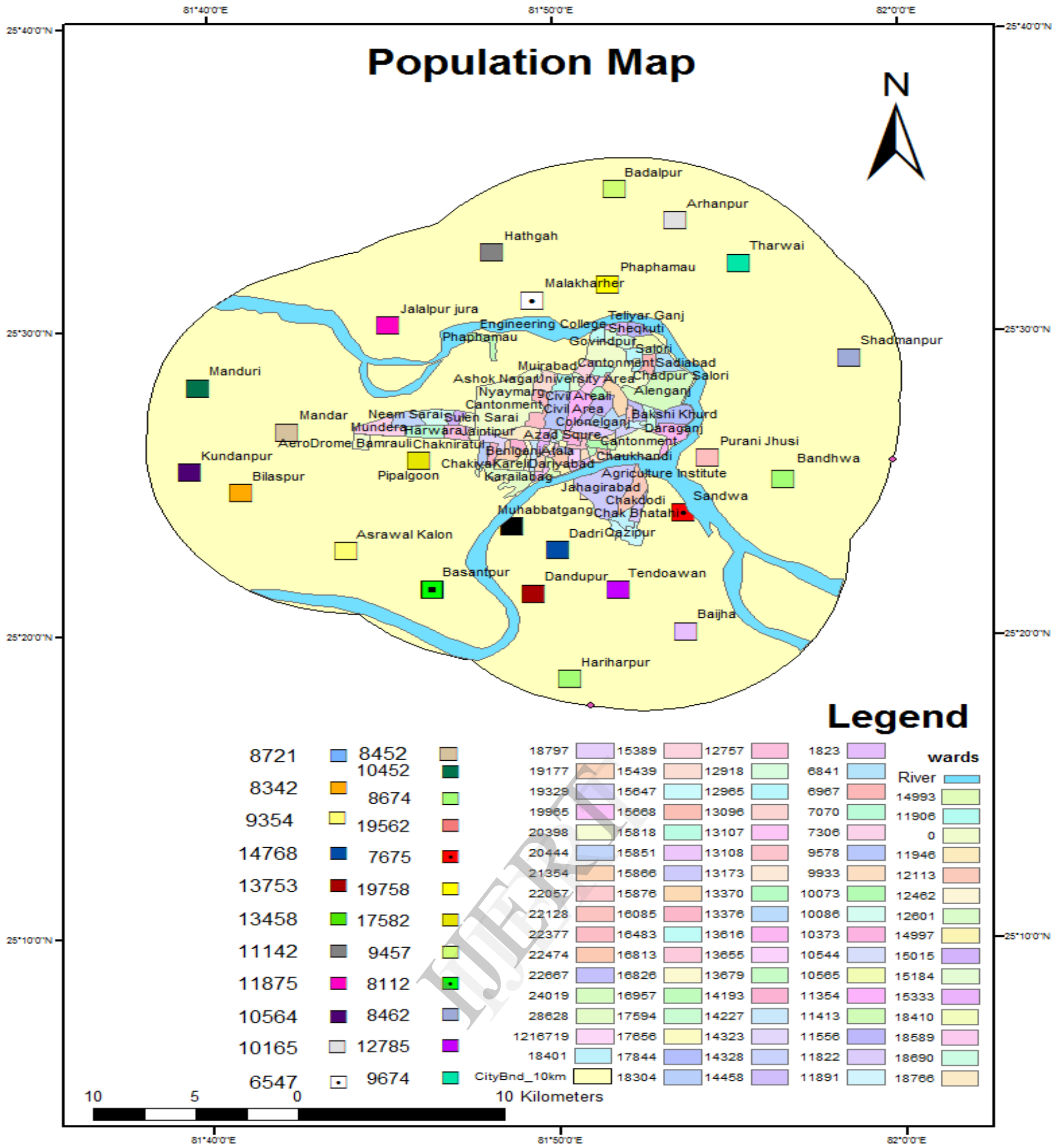

Fig: 9 Population map of the study area.

Table: 10 Suitability areas given for population (based on 2001 population)

Location	Population	Suitability score
Malakherher	6,547	5
Sandwa	7,675	4
Basantpur	8,112	3

3.7 Road mapping

The Road network was prepared from toposheet and satellite data. Considering the road network five buffer zone was created which is shown in figure 10. This buffer zone helps to find out the waste disposal site where road network is existing

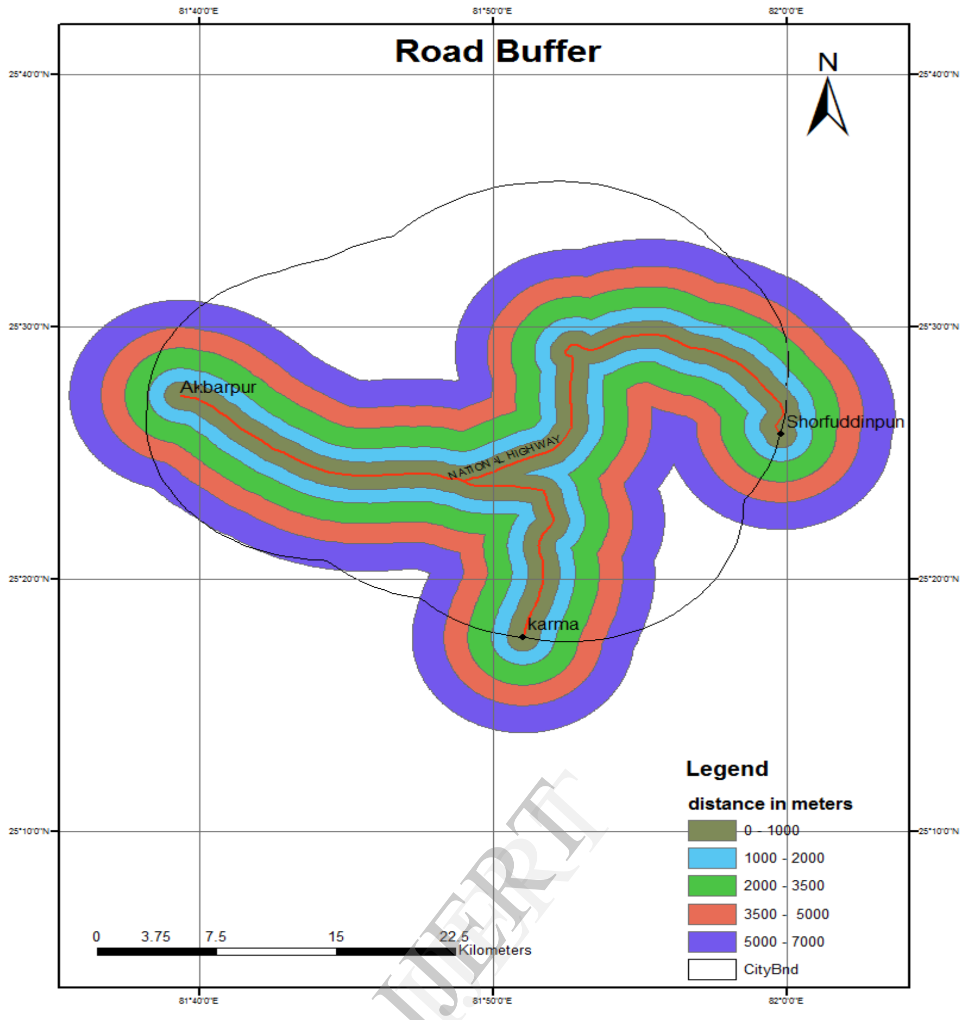

Fig: 10 Distance from major road map of the study area.

Table: 11
Suitability scores given for distance from Major Roads.

Road distance meter	Suitability score
0-1000	1
1000-2000	2
2000-3500	4
3500-5000	3
5000-7000	1

3.8 River mapping

The river map was prepared from the topographic maps with additional inputs from the satellite images. Four buffer zone was created which is shown in the figure 11

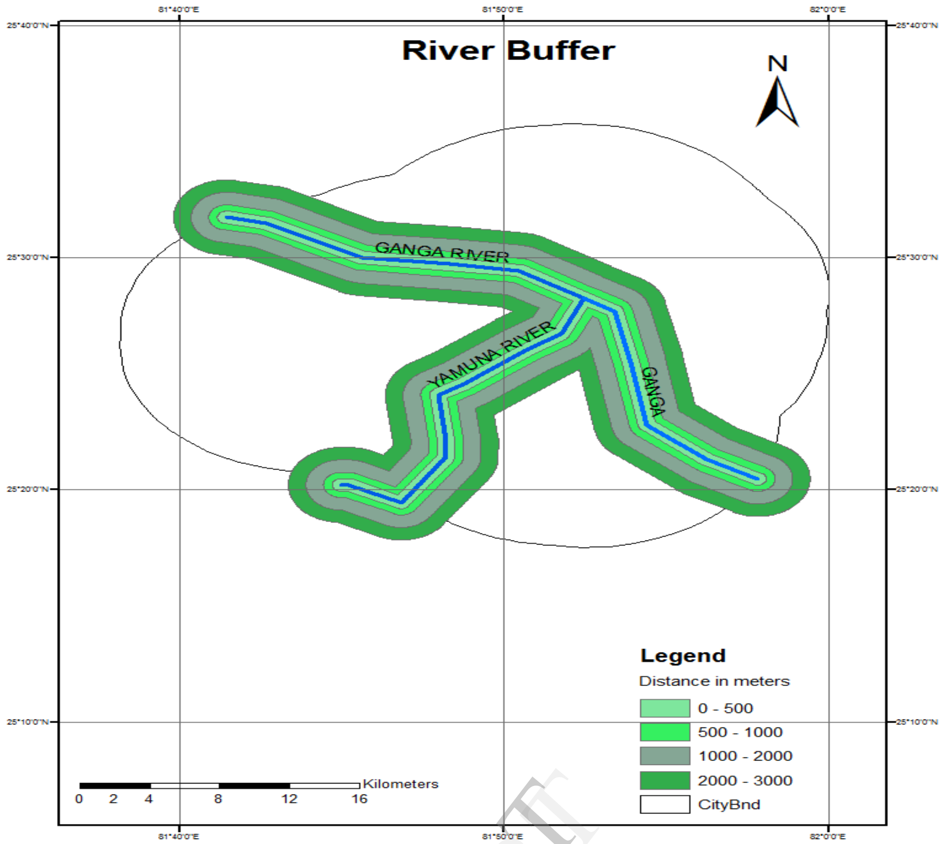

Fig: 11 Distance from River map of the study area.

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Table: 12 Suitability scores given for distance from River.

Road distance meter	Suitability score
0-500	1
500-1000	2
1000-2000	3
2000-3000	4

3.9 Drainage mapping

The drainage map was prepared from the topographic maps with additional inputs from the satellite images. Five buffer zone was created which is shown in the figure: 12

Table: 13 Suitability scores given for drainage.

Drainage distance in meter	Suitability score
0-500	1
500-1000	2
1000-2000	3
2000-3000	4
3000-5000	5

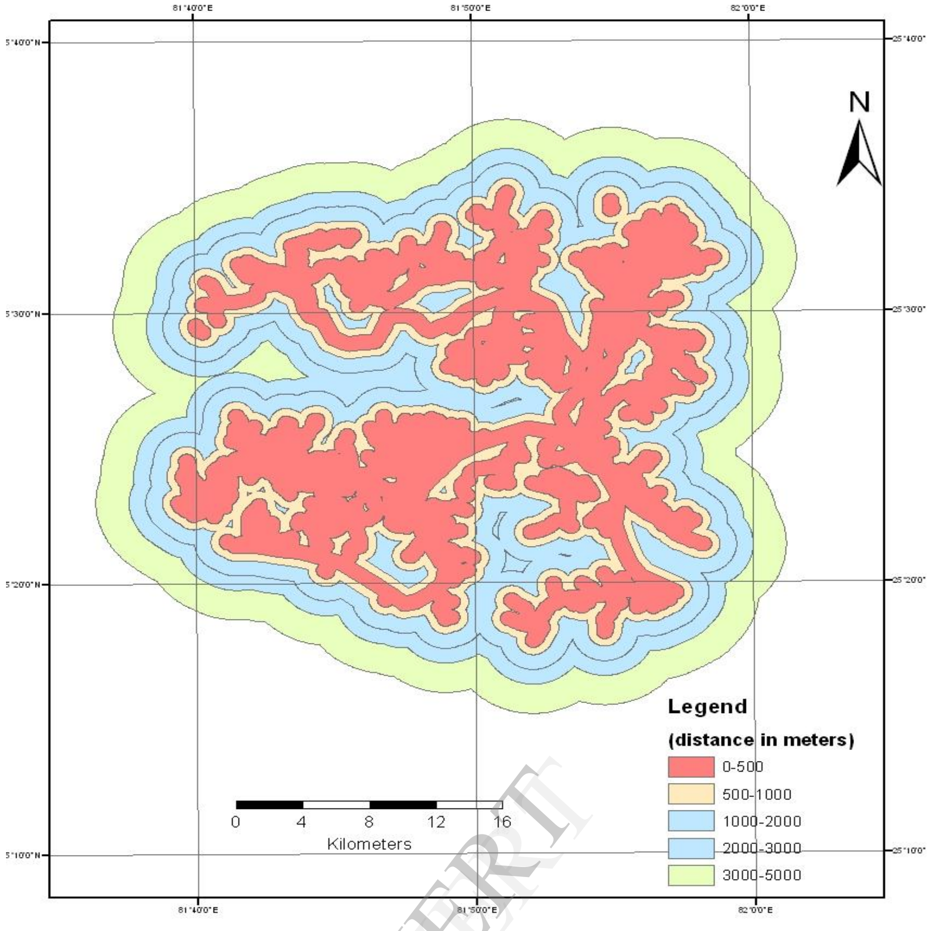

Fig: 12 Drainage map of the study area.

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3.10 Suitable site mapping

Maps like distance from major roads, distance from river, distance from streams, distance from drainage and their suitability scores are given in the figures 10, 11, 12 and table 11, 12, 13 respectively. After projection and topology creation all feature classes like geomorphology, slope, lithology, drainage, stream and road were converted to raster files and separate datasets were created using weightage and rank. For the analysis all the raster datasets for different layers having different score were over layed and the scores of each composite class were added using raster calculator tool of spatial analyst extension of Arc GIS 9.3. The final scores were reclassified to generate the output map showing various classes of suitable site for waste dumping.

Table: 14 Suitable area Analysis.

Class	Area Covered (Sq km)
Highly Suitable	0.98
Moderately suitable	3.43
Less Suitable	464.01
Not suitable	291.57
Unspecified	186.16

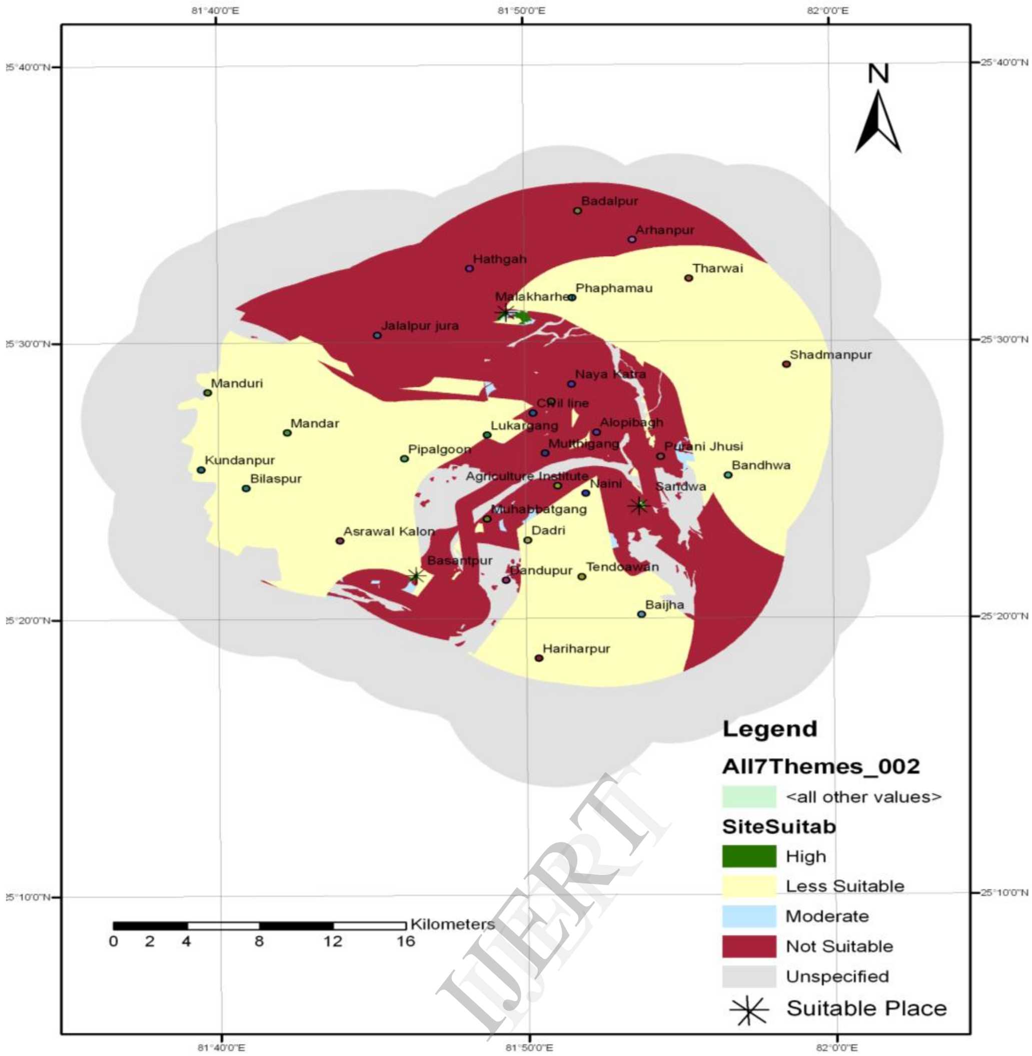

Fig: 13 Suitability map

Table: 15 Characteristics of Suitable land area

	Location	Geo morphology	Distance from main road	Distance from drainage	Distance from river	Land cover types	Slope	Rock Type	Area (sq km)
Site1	SE side of study area	Alluvial Plain	1000m	2000m	5000m	Scrubland	Level To very gentle slope	Sandy soil	0.16
Site 2	N side of study area	Alluvial Plain	1000m	3000m	7000	Scrubland+Rabi crop land	Level To very gentle slope	Sandy soil	0.67
Site3	SW side of study area	Alluvial Plain	1000m	3000m	5000m	Scrub land	Level to very gentle slope	Sandy soil	0.15

.After the analysis of using all thematic layer total area in our study including buffer zone covers 946.15Km^2. The results shows that 0.98km^2 area is very highly suitable, 3.43km^2 area is moderately suitable, 464.01km^2 area is less suitable, 291Km^2 area is come under not suitable and 186.16 km^2 unspecified for waste disposal. Suitable area obtained in the analysis is shown in the table 15 and the suitability map is shown in the figure 13.

Three sites were selected as the most suitable west disposal site located at south east side, North side, south west side of the study area. They were located in area comprised of scrub land; the slope is level to very gentle slope, and sandy soil. All the three sites are very close to mail road and connected to branch road. Also after the field visit, all three sites were found to be suitable for waste disposal

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Diagrammatic representation of the decision making process is shown in Fig 14.

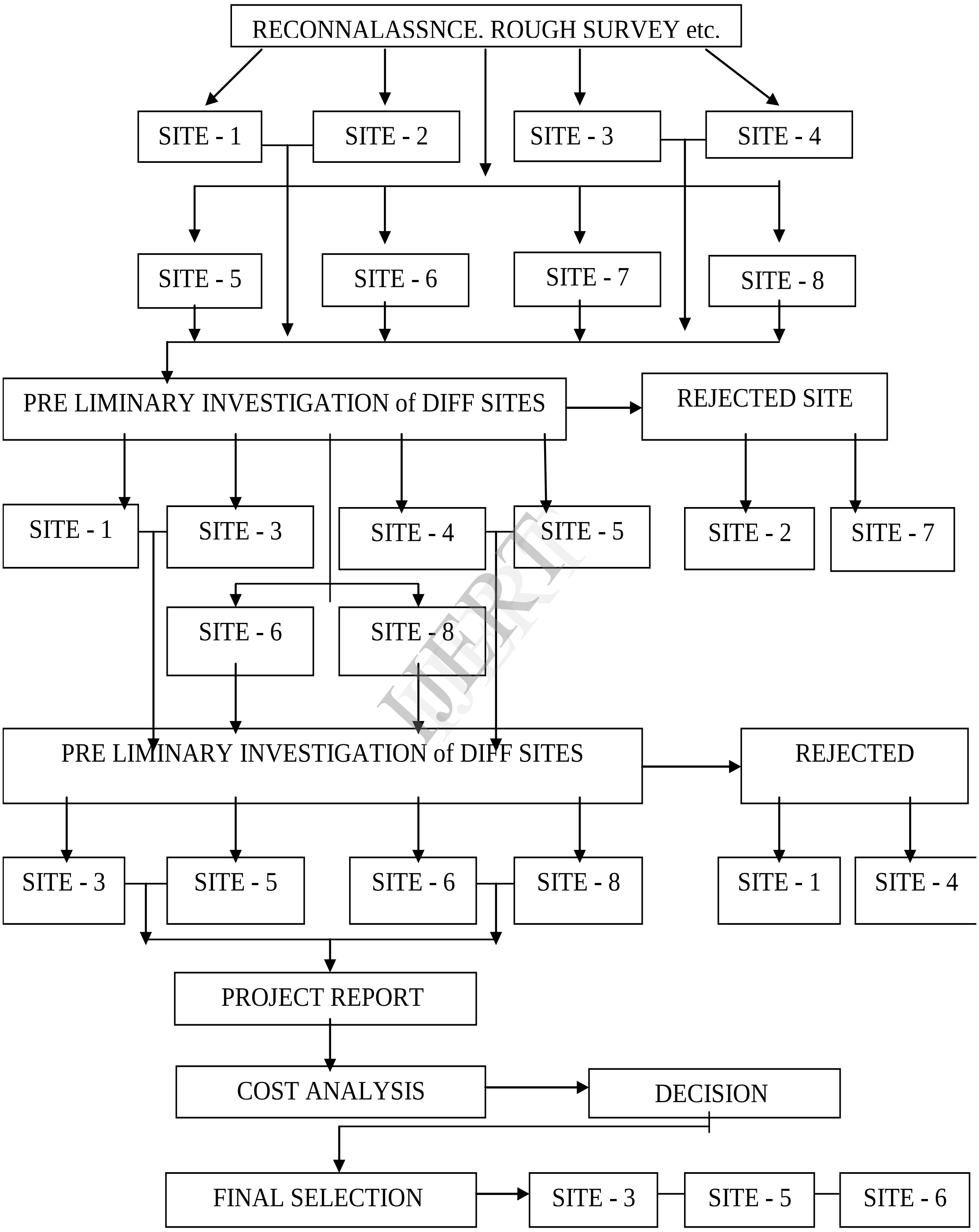

Fig: 14 Showing chart for site selection

4. CONCLUSION

The Present study examines an approach for identifying the site for waste disposal using Geospatial technology in a typically urbanizing city. A multi criteria approach was employed in conjunction with GIS-based overlay analysis to identify the most suitable site for waste disposal. The study was based upon a set of key criteria, which were selected based upon the already available knowledge from research literature as well as the pre-existing local level factors of the area. After the analysis and result different conclusion was take out from this study. After the analysis using GIS software and field cheek three (3) potential suitable sites were identified in different location. Outcome generated through the GIS analysis shows that $0.98km^2$ area is very highly suitable, $3.43km^2$ area is moderately suitable, $464.01km^2$ area is less suitable, $291Km^2$ area is come under not suitable and $186.16km^2$ unspecified for waste disposal. The studies illustrate the importance of RS and GIS technology in the present days.

RS and GIS technology, as an information tool, has helped in the acquisition of recent land use information study aimed at solving environmental problems. Information on different aspects for this study like land use land cover, geomorphology, Lithology, slope, road, rail, drainage etc has been derived using this techniques. Further integrating this data using GIS has helped in the analysis of the study, which would have been otherwise been difficult to do manually using the conventional method. However, GIS based methodology is highly sophisticated or developed or standard one but it is success depend on the proper and careful application on it. Thus with the use of these technologies management of municipal waste ill no longer be a problem for city administrators. Determination of suitable sites for the disposal of urban solid waste is one of the major problems in developing countries where the industrial development and migration of people from village to town is adversely affecting the environment. The proposed method may be used for site selection processes in other conditions and locations where the intensity of introduced parameters shows discrepancies.

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REFERENCE

1. Abhishek Mishra1, Sateesh Karwariya and Sandeep Goyal (2012). Land use / Land cover Mapping of Chhatarpur District, Madhya Pradesh, India Using Unsupervised Classification Technique, Vol.2, P. 51-56.
2. Adel Shalaby and Ryutaro Tateishi (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt, Applied Geography Vol. 27 P.28–41.z
3. Allen,A.(2001). Containment landfills: the myth of sustainability, *Engineering Geology*, 60:3-19.
4. Allahabad Municipal Corporation (AMC), 2003. Allahabad Nagar Nigam, Uttar Pradesh, India, unpublished data.
5. Church, R.L. (2002). Geographical information systems and location science, *Computers & Operations Research*, 29:54-562.
6. Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview, Progress in Planning, 62:3-65.
7. Gil1,A., Catarina,F., Agustín, L. and Calado, H. (2012). Linking GMES Space Component to the development of land policies in Outermost Regions – the Azores (Portugal) case-study. European Journal of Remote Sensing – vol.,45.p. 263-281 doi: 10.5721/EuJRS20124524
8. Ian L. McHarg, (1967). An Ecological Method for Landscape Architecture, Landscape Architecture 57, January 1969): 105-7.
9. Vimla Singh and Alok Dubey (2012). Land Use Mapping Using Remote Sensing & GIS Techniques in Naina - Gorma Basin, Part of Rewa District, M.P., India, International Journal of Emerging Technology and Advanced Engineering Vol. 2, P. 151-156.