

Application of Remote Sensing and GIS in Solid Waste Management: A Case Study of Surroundings of River Yamuna, India

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Abstract

Water resource development has taken place all over the world. There is a tremendous amount of pressure for defending the water resources available in the country. River Yamuna which is one of the largest tributaries of River Ganga and one of the most prominent rivers of our country is getting deteriorated due to various human activities, unfortunately certain stretches of River Yamuna are much polluted due to deposition of solid wastes from various sites. This is the prime reason for worsening of water quality. The solid waste disposal depends upon selection of proper site and several issues like environmental sustainability and socially acceptable. This paper deals with Hydromorphogeological study and determination of suitable site for the solid waste. The key elements of Hydromorphogeology are hydrology, geomorphology and geology and these have been focused on the interface and association of them. LANDSAT-TM satellite imagery and open source DEM image is use for this study. Open source SRTM DEM is used as an elevation data which deals with Hydrological and morphometric parameters like flow direction, flow accumulation, stream link, stream ordering, watershed boundary, slope, aspect and contour line. The study area falls in the surroundings of River Yamuna it covers 783.682445 Square Miles area lying between 27°11'N to 27°34'N and 77°33'E to 78°24'E. Results clearly show that the site suitability analysis using remote sensing and GIS identified 17 favourable location that occupy 3.902% of total area which can be use as the best suitable area for solid waste.

Keywords: Solid waste; Site selection; Water resource development; Hydrogeology; Remote sensing and GIS.

1. Introduction

Water pollution in the river Yamuna is severely caused due to the solid wastes, that is disposed into the river through various sites in the cities. Wastes being solid in state are non biodegradable which cannot be decomposed by the micro organisms. Hence these wastes lead to water pollution in the river. Waste remains in water forever until it is separated out by any physical process. Hence it is prime need of time to stop deposition of solid wastes in the river. Due to rapid increase in the production and consumption processes, societies generate as well as reject solid materials regularly from various sectors agricultural, commercial, domestic, industrial and institutional. The considerable volume of wastes thus generated and rejected is called solid wastes. Solid wastes are the organic and inorganic waste materials encompass both a heterogeneous mass of wastes from the urban community as well as a more homogeneous accumulation of agricultural, industrial and mineral wastes. Methods of waste reduction, waste reuse and recycling are the preferred options when dealing with solid waste. There are many environmental benefits that can be derived from the use of site suitability for solid waste. They reduce the release of pollutants, conserve resources, save energy.

Hydromorphogeological investigation are imperative for all activity of interaction and linkage of hydrologic processes with landforms or earth materials and it is the interface of geomorphic processes with surface and subsurface water in temporal and spatial dimensions (Sidle et al. 2004). Remote sensing is one of the incomparable tools for sensing the earth surface to make the interface of object property and measurement analysis of environment and its resources, and have a unique ability of providing the synoptic view of a large area with the capacity of repetitive coverage (Nishanth.T, et al. 2010) The methodology utilizes GIS to estimate the entire region based on certain estimation criteria for the analysis of landfill site suitability (Ozeair Abessi et al. 2009) The Geographic Information Systems in solid waste management is very large with GIS technology people can evaluate the locations of different things in order to ascertain there relation in term of spatial attribute and its planning and operations are dependent on spatial data. GIS is technique which is deal with the time and cost of the site selection also provide spatial data related to positions from different things so people can more easily find out the criteria for site suitability, (Miles S.B et al; 1999). The present study intend to find out a suitable site for the disposal of urban and rural solid waste with the help of Remote sensing and GIS techniques.

2. Study Area

Study area is located in the western part of Uttar Pradesh state which is the surroundings of Yamuna River. Study area covers some parts of three big cities Agra, Mathura, Firozabad (Figure 1).



Figure 1: Study Area.

3. Data Used and Methodology

Visual interpretation LANDSAT-TM imagery is done using Google earth and image interpretation elements like tone, texture, association, shape, size, pattern and different erosion characteristics. According to these features, images are digitized according to the various themes. In this study, methodology is divided into three parts i.e. hydrology (Figure 4.), geomorphology and land use Land cover classification (Figure 2.). Application of GIS and remote sensing techniques in the field of waste management using a multicriteria decision making technique provides the organized approach for assessing and integrating the impact of various factors as indicators of suitability. It would be chosen according to the opinion and information related to the study field area. The weightage assigned for different themes are shown in the table 1. Buffer zones were created for getting suitable site. Site suitability criteria of solid waste is mainly focused on two categories physical and socially (Ozeair Abessi et al.2009).

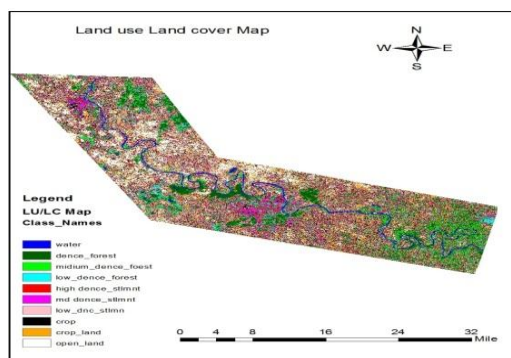
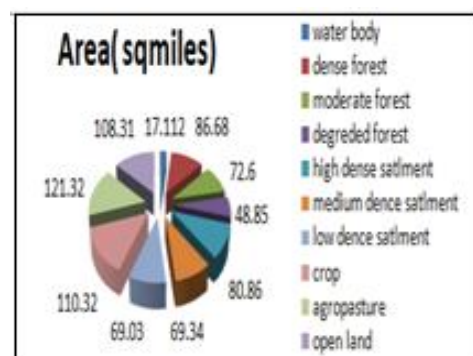
Table 1: Weightage assigned for each categories.

Criteria	Themes	Weighted
1.Physical	Slope	6
	Drainage	7
	Settlement	8
2.Social	Road	6
	River	7
	Crop	5
	Forest	4

In these categories different input map layers including drainage, watershed, roads, settlements, forests, crops, barren land and weightage are allocated to them based on the different parameters. Scores of the criteria are given on the different scales. Solid waste management process use methods of waste reduction, waste reuse and recycling these processes are required a particular site.

3.1. Land use land cover

Land use land cover refers to the type of material present on the land space, what people do on land surface and the pattern of the change. Information of the area land use land cover can be get from the satellite image (Fig 1.) and topographical map. Land use land cover map (Figure 2.) is generated through the ERDAS IMAGING 10 software using supervise classification method with 10 signature file used here seven classes.

**Figure 2:** Land use land cover map**Figure 3:** Study area classification.

3.2. Hydrological analysis

Extraction of hydrological parameter (Figure 4.) of the study area find out from SRTM DEM 30m*30m grid cell size were using Arc Map-10 hydrological tool (Hosseinzadeh S. R. et al. 2011).

- Flow direction shows the direction in which water will flow out of each cell of a filled elevation raster (Freeman et al 1991).
- Flow accumulation raster records how many upstream cells will contribute drainage to each cell .A flow accumulation raster tabulates for each cell the number of cells that will flow to it.(O'Callaghan et al. 1984.).
- Sink is surrounded by higher cell. It can artificially terminate streams by trapping flow. It is caused by possible error in the elevation data and needs to be removed before attempting hydrology analysis.
- Filling sink is an iterative process. Sink cell values are changed to equal neighbouring elevation values.
- Con is used to create a drainage network of details by choosing the appropriate volume value here 380 is used .this value can be arbitrary, it should be corresponding to the high resolution topographical maps of filed Maps.
- Stream link is a unique value assigned to the stream raster line and associated with a flow direction.
- Stream order is a numeric order to the stream link that can use true or false ordering methods. (Horton.R.E. et al.1932.), (Figure 6.).

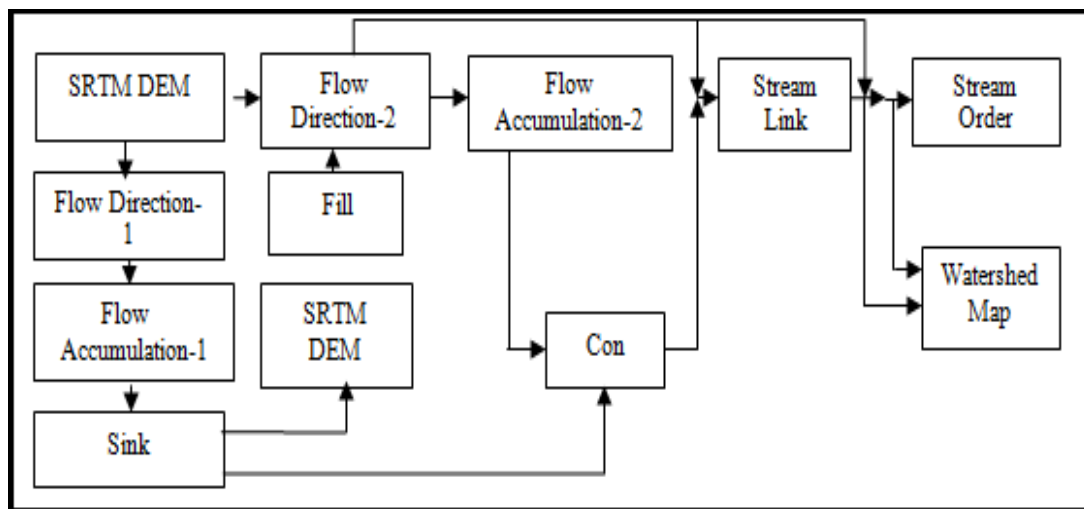


Figure 4: Flow chart of hydrological process.

3.3Morphometric analysis

It is a quantitative description and topographical expression of land attributes analysis that is accomplished in geomorphology that may be useful to the particular kind of land former or to drainage basins and large region.Morphometric analysis of the drainage basin and network plays an essential role to identify the geology and geomorphology of the area (Strahle et al. 1952). Morphometric study of an area provides a quantitative measure of altitude, slope, aspect, contour (Dury et al. 1952.)

and valuable information for ground water condition of drainage basin with spatio temporal variation. Morphometric analysis of the study area is carried out using SOI Topographical map and SRTM DEM. Altitude, stream length (S.L), stream number (S.N), stream area, slope, aspect, contour (figure 7.), area of water shed, mean stream length (M.S.L), drainage density(D.D), bifurcation ratio (B.R) these parameter has been generated for morphometric analysis (Horton 1945) shown in table 2. Sub watersheds' drainage characteristics and hydrological behavior of drainage area can easily understand by the substantial value of these morphometric parameters.

Table 2: Morphometric parameters.

B.A (Sq mile)	D.D	S.O	S.N	S.L(K.m)	B.R	M.S.L
783.682	0.40	1st	1658	400.11	3.05	0.241
		2nd	542	184.70	3.08	0.340
		3rd	176	167.19	2.619	0.94
		4th	37	64	-	-
		5th	-	-	-	-

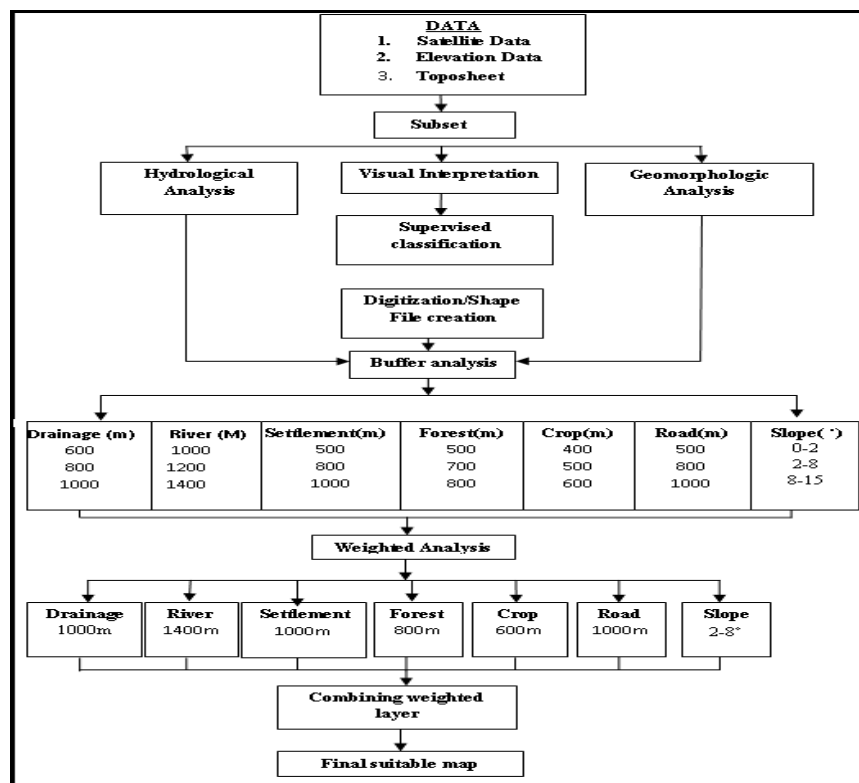
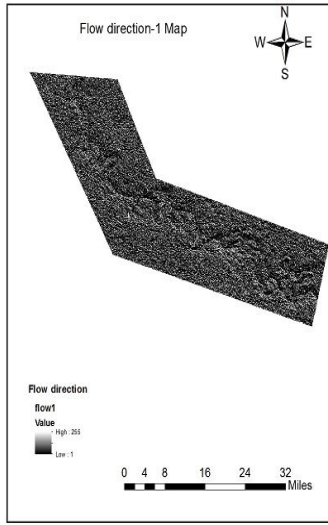
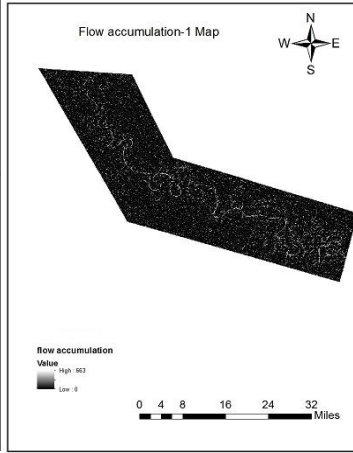


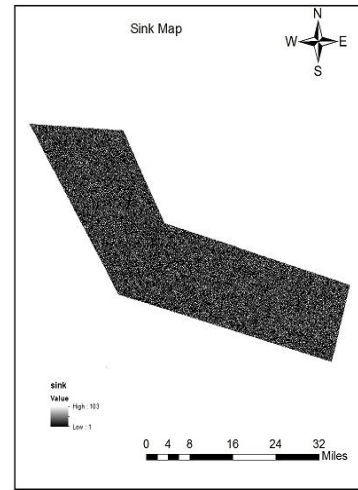
Figure 5: Flow chart of overall methodology.



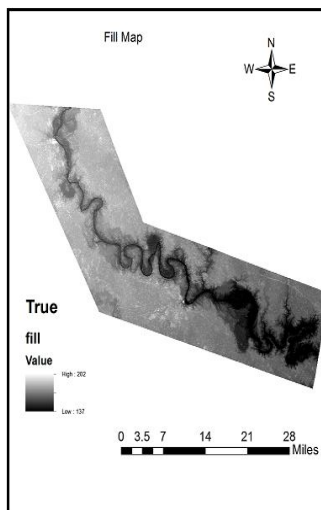
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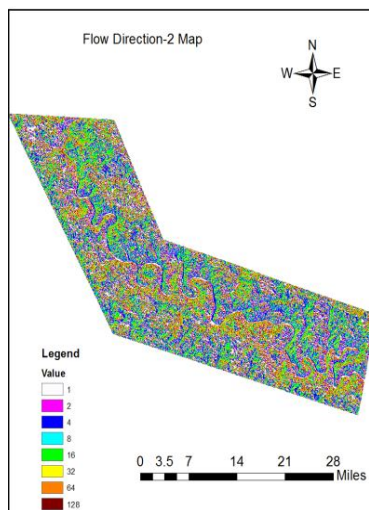
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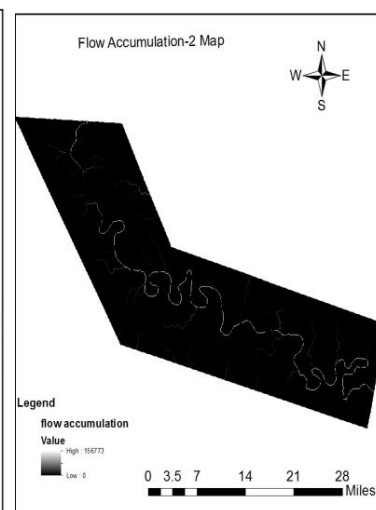
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(d)



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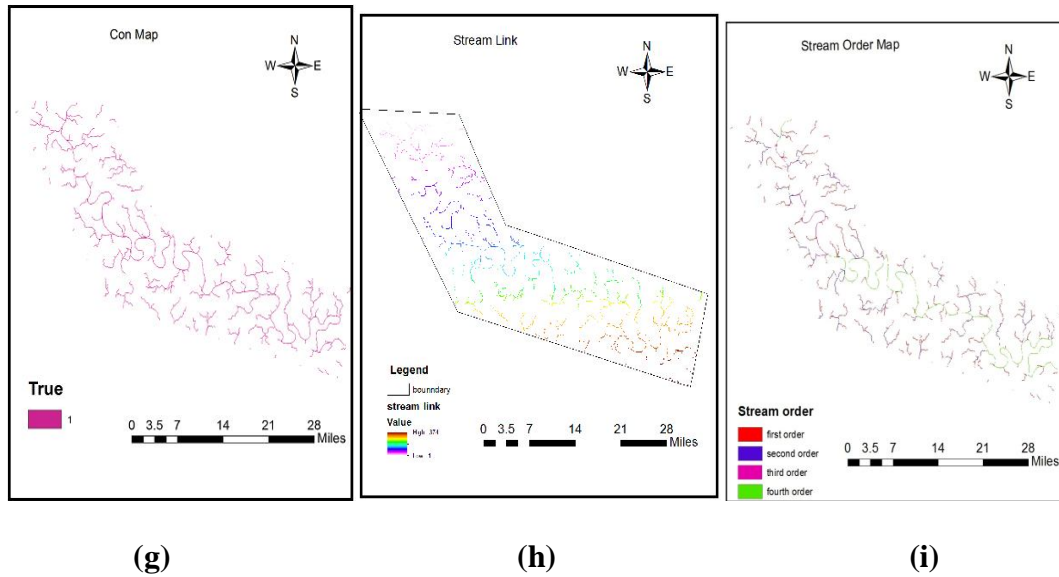
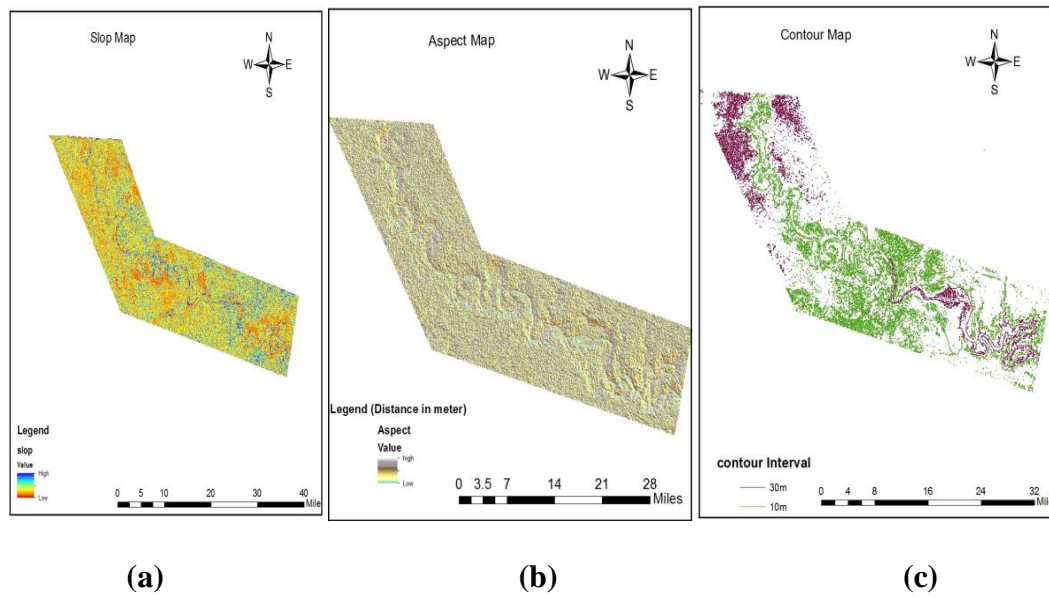
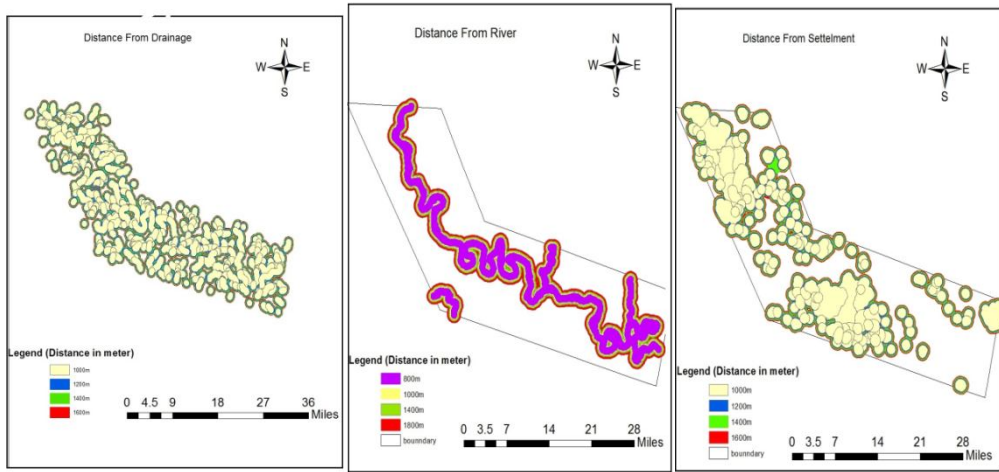


Figure 6: Hydrological Maps; (a) Flow direction-1, (b) Flow accumulation-1, (c) Sink. (d) Fill, (e) Flow direction-2, (f) Flow accumulation-2, (g) Con, (h) Stream link, (i) Stream order.

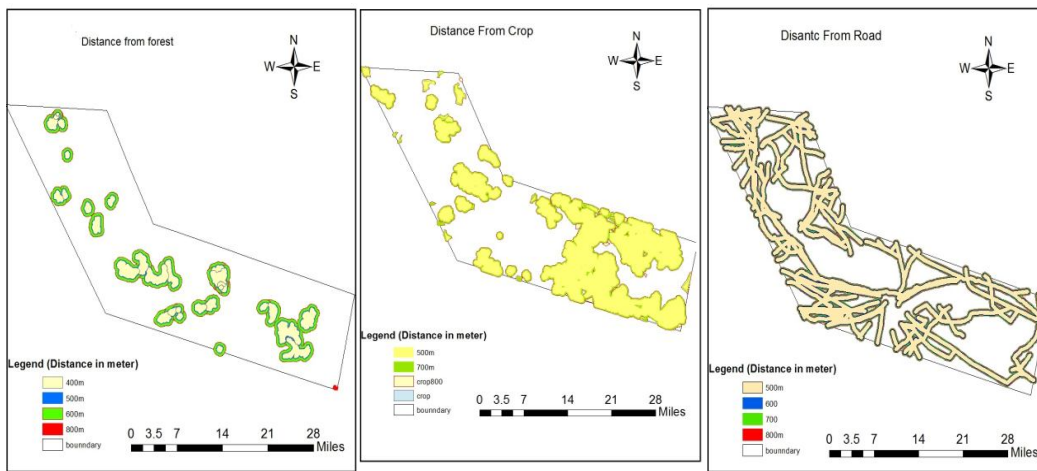




(d)

(e)

(f)



(g)

(h)

(i)

Figure 7: Morphometric parameters; (a) Slope Map. (b) Aspect Map. (c) Contour Map. , Buffer analysis; (d) Drainage. (e) River. (f) Settlement. (g) Forest. (h) Crop. (i) Road.

4. Result and Conclusion

By the process of hydrology, morphology and buffer analysis with the weighted criteria of land use land cover map give 17 suitable sites for solid waste in which one site found 13.5 Km away from Taj Mahal in east direction .Study area falls among three big cities. Buffer analysis has much significance in field of site suitability. According to the hydrological analysis of the study area, stream order was generated

which is used in morphometric analysis and consider as a essential parameter for site suitability analysis. There were Five stream orders generated with the specific length. Buffer creates a new coverage area around the polygon line or point according to the specified input coverage parameter and specific measurements. Buffer tool is used to identify or define an area within the specified distance around the feature. In this study buffer layers were created on the different criteria (Figure 7.) that will assign through the weighted analysis. Weighted analysis defines the suitable site 1000m from drainage,1400m from river, 1000m form settlement, 800m from forest, 600m from crop, 1000m from road and 2-8° from slope on the basis of area(Figure 5). With this process founded sites were categorized in 3 classes according to the weight. Highly suitable class were found 5 locations, medium suitable class were found 6 locations and low suitable class were found 6 locations with a particular area as shown in the following table 3.and map show in (Figure 8.)

Site suitability for solid waste management is a large procedure in which many social and physical criteria are involved. Remote sensing techniques and GIS application in the field of site suitability gives the considerable outputs. According to the hydromorphogeological analysis hydrology and morphometry of the study area can be used in the suitable site determination of solid waste.

Table 3: Suitable Area analysis.

Suitability	Location	Area(Square miles)
High	5	8.532
Medium	6	4.92
Low	6	2.59

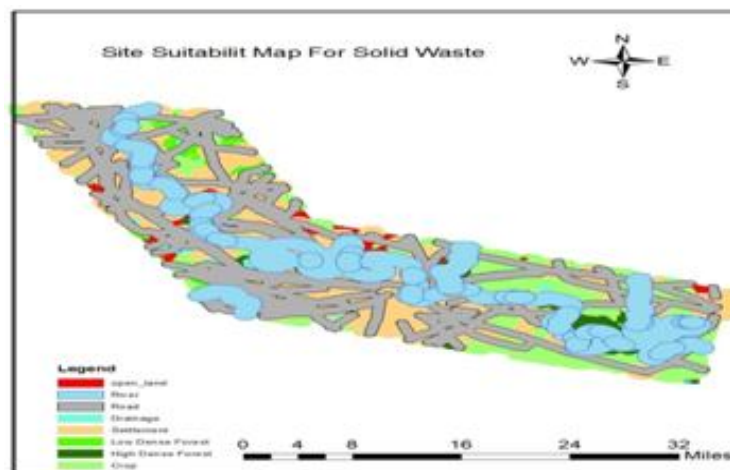


Figure 8: Final Site Suitability Map.

Final site suitability map results 16.56 square mile area which is shown in red color (Figure 8.). 90 % pollution in river Yamuna is due to the solid waste materials according to this study solid waste are not found in the buffer of 1400m sq area so the site suitability is used as the water pollution control mechanism to improve the quality of river water. Therefore it is advisable that site suitability should be adopted and incorporated as a part of the waste management plan.

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