Site Suitability Analysis for Location of Sewage Treatment Plant

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Abstract: Site selection or suitability analysis is investigation that is done with help of geographic information system G.I.S to determine the best place or site for a project. Potential sites that are generally used in suitability analysis include the location of a new hospital, shopping complex or educational institute among many others. Site suitability evaluation for waste management is becoming a major criterion for defending the environmental degradation. If proper location for the treatment plant is not selected then it may lead to soil degradation and ground water pollution. The study area is situated in Hyderabad, India that is currently experiencing high rates of population growth and economic development. By following a systematic procedure a suitable site for a Sewage Treatment Plant has been found. Potential sites for the sewage treatment plant have been evaluated using suitability score based on planning and design constraints, including ground slope, land-use pattern, and distance to river and roads.
Keywords: G.I.S, suitability analysis, waste management, environmental degradation, land-use pattern

I. INTRODUCTION

Site suitability analysis in a GIS context is a geographic or GIS-based process used to determine the appropriateness of a given area for a particular use.

The basic premise of GIS suitability analysis is that each aspect of the landscape has intrinsic characteristics that are to some degree either suitable or unsuitable for the activities being planned. Suitability is determined through systematic, multi-factor analysis of the different aspect of the terrain. Model inputs include a variety of physical, cultural, and economic factors. The results are often displayed on a map that is used to highlight areas from high to low suitability.

A GIS suitability model typically answers the question, "Where is the best location?"-whether it involves finding the best location for a new road or pipeline, a new housing development, or a retail store. For instance, a commercial developer building a new retail store may take into consideration distance to major highways and any competitors' stores then combine the results with land use, population density, and consumer spending data to decide on the best location for that store.

II. GEOGRAPHIC INFORMATION SYSTEM (GIS)

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyse, and understand patterns and relationships.

With GIS technology; people can compare the locations of different things in order to discover how they relate to each other. For example, using GIS, the same map could include sites that produce pollution, such as gas stations, and sites that are sensitive to pollution, such as wetlands. Such a map would help people determine which wetlands are most at risk. GIS can use any information that includes location.

The location can be expressed in many different ways, such as latitude and longitude, address, or ZIP code. Many different types of information can be compared and contrasted using GIS. The system can include data about people, such as population, income, or education level. It can include information about the land, such as the location of streams, different kinds of vegetation, and different kinds of soil. It can include information about the sites of factories, farms, and schools, or storm drains, roads and electric power lines.

III. WHY GIS?

A geographic information system (GIS) lets us visualize, question, analyse, and interpret data to understand relationships, patterns, and trends.GIS benefits organizations of all sizes and in almost every industry. There is a growing interest in and awareness of the economic and strategic value of GIS.
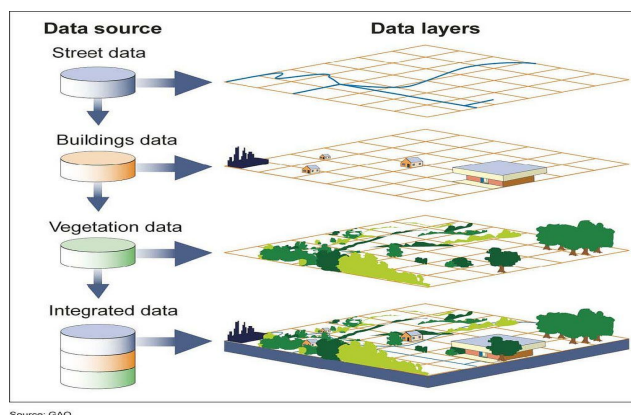
Fig. 1 GIS allows multiple layers of information to be displayed on a single map

A. Cost Savings from Greater Efficiency

GIS is widely used to optimize maintenance schedules and daily fleet movements. Typical implementations can result in a savings of 10 to 30 percent in operational expenses through reduction in fuel use and staff time, improved customer service, and more efficient scheduling.GIS helped the City of Woodland refine its fleet scheduling, saving fuel and labour.

B. Better Decision Making

GIS is the go-to technology for making better decisions about location. Common examples include real estate site selection, route/corridor selection, evacuation planning, conservation, natural resource extraction, etc. Making correct decisions about location is critical to the success of an organization. This GIS-based disaster decision support system helps Taiwan plan for and respond to typhoons.

C. Improved Communication

GIS-based maps and visualizations greatly assist in understanding situations and in storytelling. They are a type of language that improves communication between different teams, departments, disciplines, professional fields, organizations, and the public. Michels Corporation improved collaboration and communication with GIS.

D. Better Record Making.

Many organizations have a primary responsibility of maintaining authoritative records about the status and change of geography. GIS provides a strong framework for managing these types of records with full transaction support and reporting tools. ROI on Montana's GIS-based state-wide cadastral system is more than $9 million annually.

E. Managing Geographically

GIS is becoming essential to understanding what is happening and what will happen in geographic space. This new approach to management—managing geographically—is transforming the way organizations operate. Kuwait University used GIS to design and build a multibillion-dollar expansion.

IV.METHODOLOGY

For a particular area, a Land Use – Land Cover analysis has to be done in order to analyse land usage pattern and land coverage areas and hence obtain all the vacant land available or the open sites available, which may be used for construction of a Sewage Treatment Plant. To do so, a toposheet was acquired from Survey of India and was also scanned.

This scanned copy of toposheet has to be geo referenced, digitized and then analysed. Typically the steps include

1) Geo referencing.
2) Digitizing roads and other features.
3) Giving Symbology.
4) Calculating each feature's area.
5) And hence finally arriving at the left out available vacant land.

A. Area of Interest

The area that has been considered for this work is Ibrahimpatnam region where most of the Engineering colleges are located. The topography if this particular region is almost flat with not much variations and the type of soils available at this region are Red-Chelka soils. Toposheet number is E44M12 (56K/12)

B. Georeferencing

Georeferencing is defined as aligning geographic data to a known coordinate system so it can be viewed, queried, and analysed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting or ortho rectifying the data.

The following procedure had been done to georeference the toposheet.

1) The toposheet was dragged on to the data view. Georeferencing toolbar was enabled by right clicking on the empty space and checking on the drop down menu.
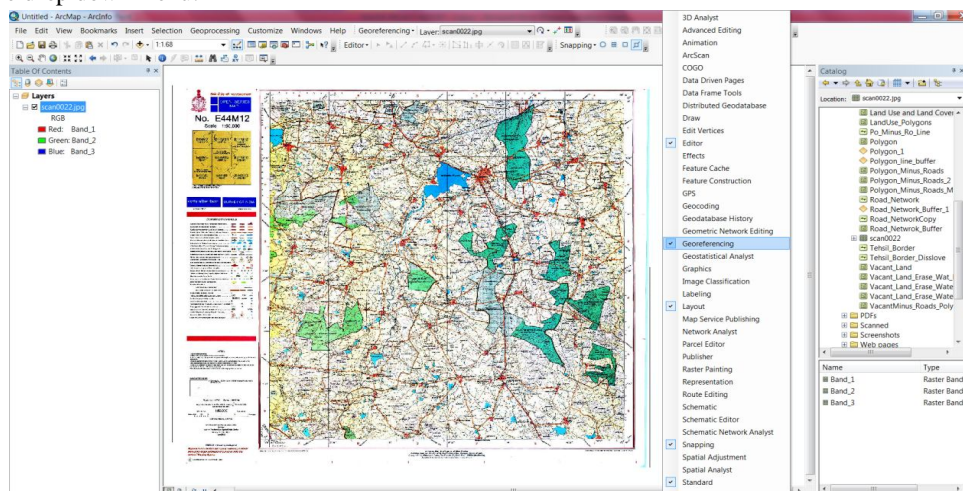
Fig. 2 Toposheet onto the dataview and enabling Georeferencing toolbar

2) From the Georeferencing toolbar 'Auto Adjust' option was disabled.
3) 'Add Control Points'icon from the Georeferencing tool bar was selected. See figure 3.2.

Fig. 3 Georeferencing toolbar

4) Required location was zoomed, it was right clicked and X and Y coordinates were given. See figure 3.3.
5) After the control points were added. The image was zoomed and 'Rectify' option was selected from Georeferencing menu. See figure 3.4.
6) And then 'Update Georeferencing' was selected.
7) The image got brighter and more precise than the original image.
8) Then the "Auto Adjust' option was enabled.
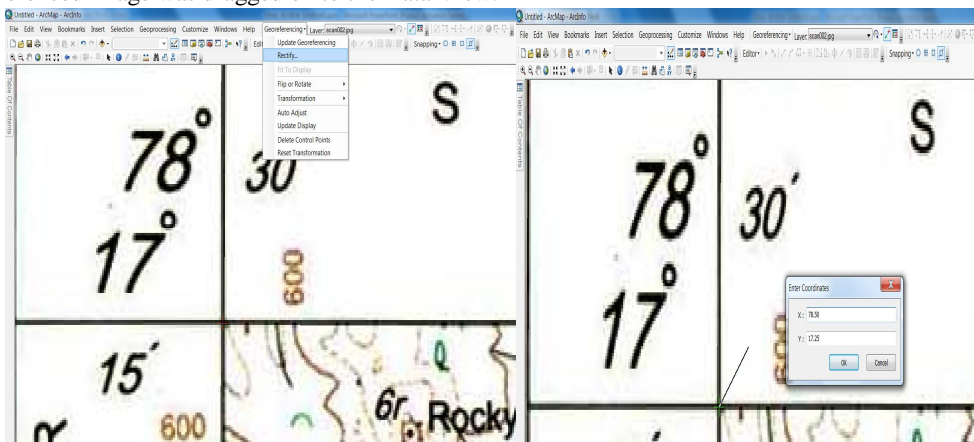9) The georeferenced image was dragged on to the Data View.

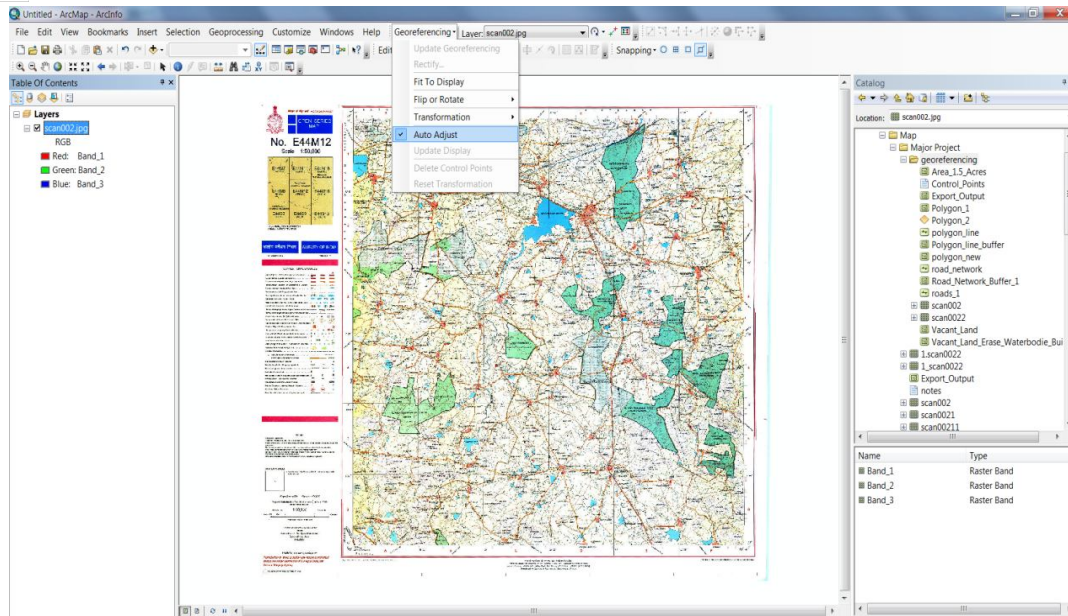Fig 4 Add control points   Fig. 5 Selecting 'Rectify

Fig. 6 Rectified image

C. Projection

Once the toposheet was georeferenced, it has to be projected

Projection may be defined as a method by which the curved surface of the earth is portrayed on a flat surface. This generally requires a systematic mathematical transformation of the earth's graticule of lines of longitude and latitude onto a plane.

Some projections can be visualized as a transparent with a light bulb at its casting lines of latitude and longitude onto a sheet of paper. Generally, the paper is either flat or placed tangent to the globe. Every map projection distorts distance, area, shape, direction, or some combination thereof. Here in the work, suitable projection to convert the units of toposheet to required units i.e., decimal degrees to meters is used.

The following procedure has been performed to project the georeferenced toposheet.

1) Georeferenced toposheet was dragged on to the data view.
2) Data Management tools was selected from the Arc toolbox.
3) Projections and Transformations was selected and the option Define Projection was selected.
4) The file that had to be projected wasselected and the units into which it had to be projected were also selected.
5) 'Apply' option was selected and hence the projected image was obtained.
6) Projected image was dragged on to the data view to continue the procedure.

D. Creating a Shape file

Shapefile may be defined as a vector data storage format for storing the location, shape, and attributes of geographic features. A Shapefile is stored in a set of related files and contains one feature class.

The following procedure was followed to create a Shapefile.

1) It was right clicked on the folder in the Catalog window and the option New Shapefile was selected.
2) The required feature i.e., either, Point, Polyline or Polygon was selected.
3) Coordinate system was then given.

In this paper it was concentrated on creating roads and polygons

E. Roads

1) A Shapefile was created and was named as Roads. Its feature was selected as Polyline.
2) The Projected image's coordinates ware given to the shape file.
3) The option 'Start Editing' was enabled from the Editor Toolbar.
4) Then from the Create Feature window, the feature to be digitized was selected.
5) Then points were placed along the roads of the toposheet until their ends.
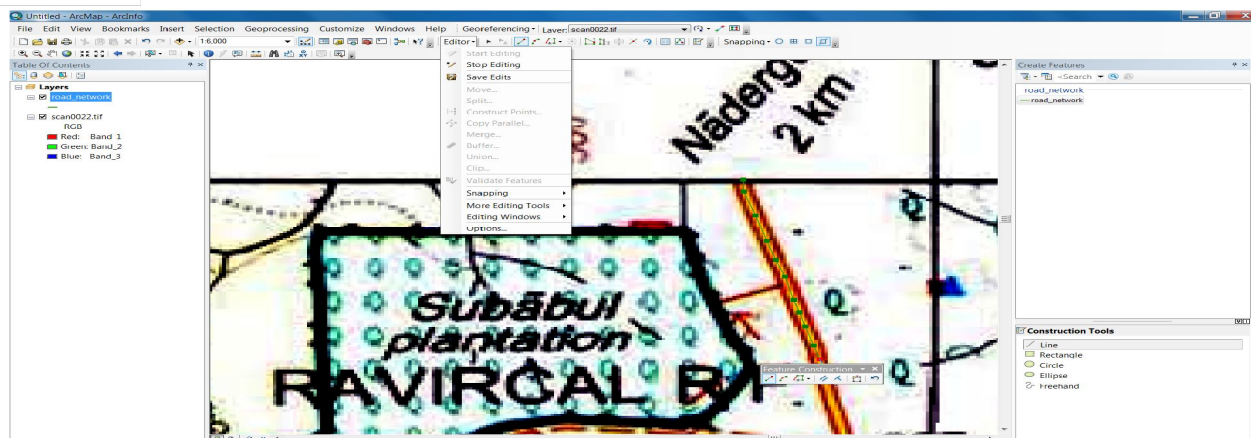6) Finish sketch or F2 key was pressed after all the points were placed on the toposheet.

Fig.7 Creating road Shapefile

F. Polygons

1) A Shapefile was created and was named as Polygons and its feature was selected as Polygon.

2) The Projected image's coordinates were given to the shape file.

3) The option 'Start Editing' was enabled from the Editor Toolbar.

4) Then from the create feature window, the feature to be digitized was selected.

5) Points have been placed along the perimeter of polygon.

6) Finish sketch or F2 key was pressed after the points were placed on the toposheet.

This is the process of digitizing the roads and polygons or any feature on a toposheet

G. .Land use – Land Cover Analysis

Land use-Land cover is all about differentiating a given land into various entities such as built-up, agricultural land, water bodies, vacant land etc.In this paper the major classification used for the land is built-up area, agricultural land, water bodies, vacant land, forest area and rocky knobs.

3.5.1 Giving symbology to the digitized features

The following procedure was followed in order to give symbology to a feature:

1) It was right clicked on the layer file and the option Properties was selected.

2) From the properties dialog box, Symbology was selected.

3) In Symbology dialog box the option 'Categories' was selected and the unique values were given.

4) Then the required land cover and their respective Id numbers were entered.

5) Suitable colour for each land cover was selected as shown below

Table 1 Symbology

Land cover	Colour or Symbol
Built up	Rose
Agricultural land	Green
Water bodies	Lake
Forest areas	Mangrove
Plantations	Orchids
Roads	Black
Vacant land	Grey

6) Once their respective symbols or colours were given, 'Apply' and 'Ok' were selected and the image with various land use and land cover was obtained.

H. Measuring the road widths

The following procedure was followed in order to measure the width of the roads:

1) The road shape file was dragged on to the data view.

2) It was right clicked on the layer file and the attribute table was opened.

3) All the edits done so far were saved and stopped.

4) Two fields i.e., width and Half width were added to the attribute table.
5) The icon 'Measure' was selected from the tool bar and the width of the roads was measured and its respective value was entered in the attribute table. See figure 3.11.
6) Once the widths were entered, the entire Half width Column was selected and right clicked on it and the option Field Calculator was selected.
7) A dialogue box appeared in which formula for Half width i.e., Half width= [width]/2, was given.
8) After the values were obtained, they were saved.
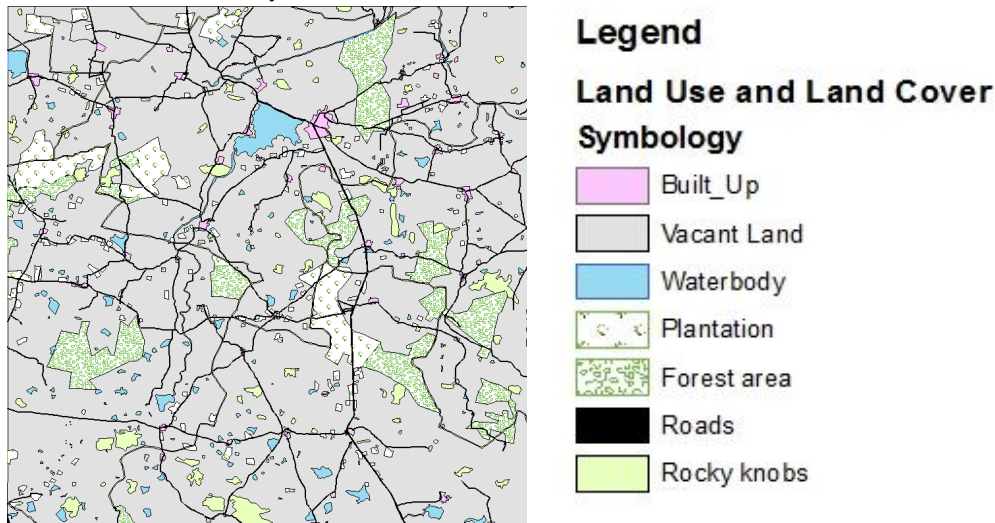
Fig. 8 Land Use – Land Cover
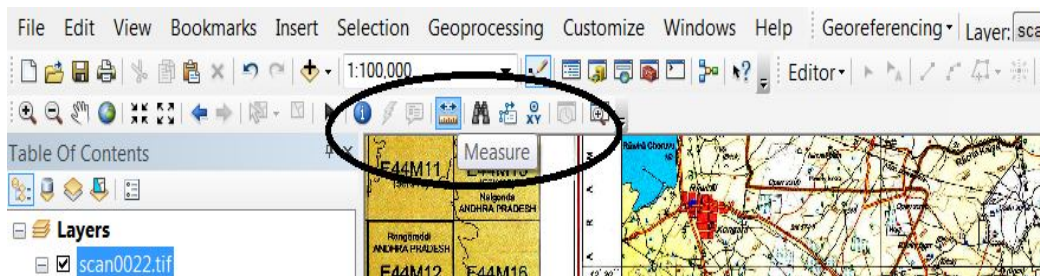
Fig9. Measure icon
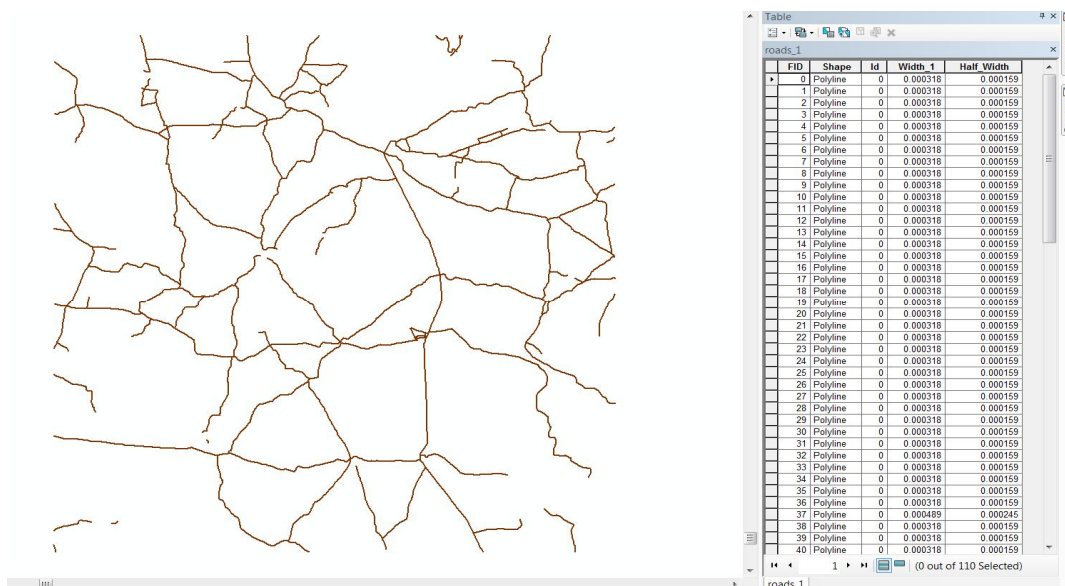
Fig. 10 Assigning road width

I. Road buffer

Once the widths and half-widths were obtained the roads were buffered to their half widths. The following procedure was followed to perform the buffer operation.

1) From the Geoprocessing tool bar, the option 'Buffer' was selected.
2) The file which was to be buffered was given as the input.
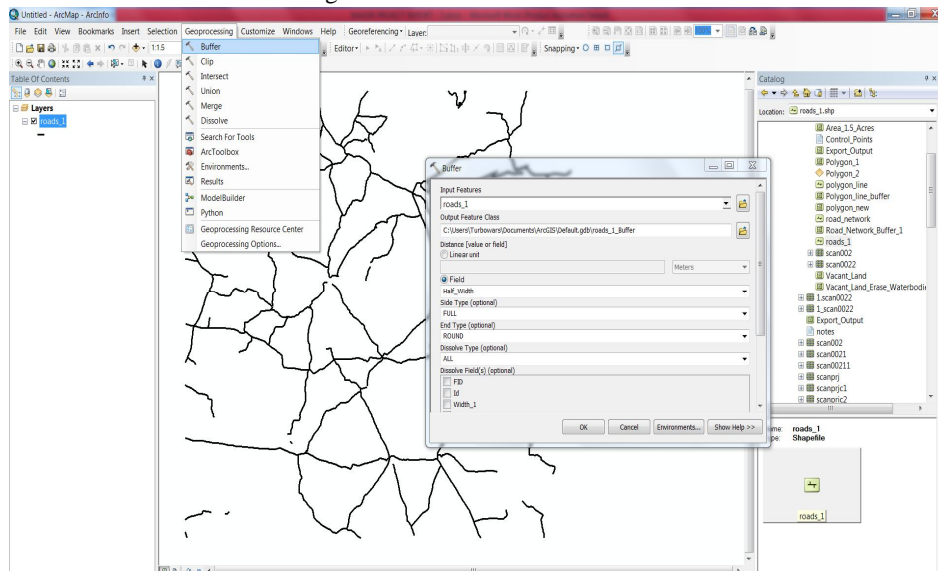3) The output location and the field units were given.
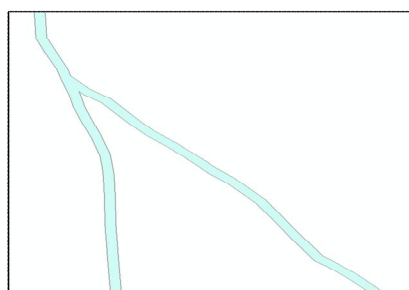

Fig. 11 Geoprocessing menu – Buffer

Fig. 12 Road buffer

J. Map polygon

A polygon covering the entire toposheet was created.

The following procedure was followed to create such a polygon.

1) A new shape file was created and feature type Polygon was selected.
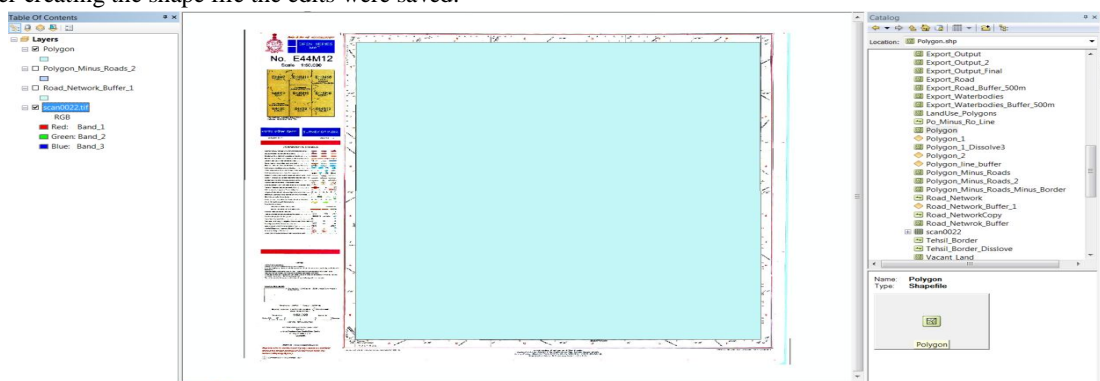*2)* After creating the shape file the edits were saved.

Fig 13 Map Polygon

K. Erasing road buffer from the map polygon

Now the road buffer was erased from the map polygon

The following procedure was followed to erase the road buffer from the map polygon.

1) 'Analysis tools were selected from the Arc tool bar.
2) Overlay was selected.
3) From Overlay the option 'Erase' was selected.
4) Now the feature which was to be erased and the feature from which the roads buffer was to be erased were given.
5) Apply and Ok were selected.
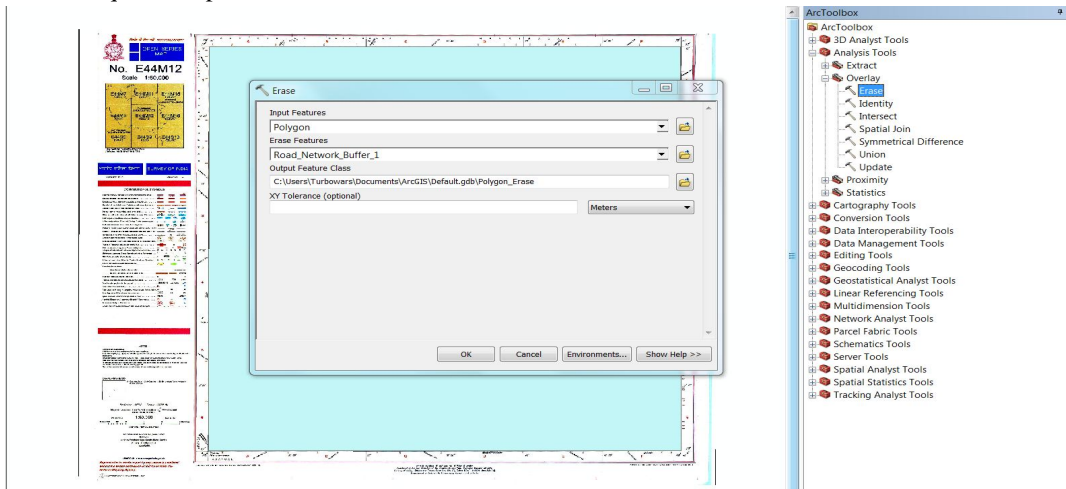6) Therefore the required map without the roads was obtained.
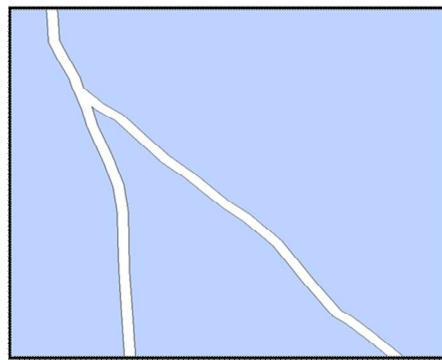

Fig. 14 Erasing buffer

Fig 15 Map polygon after erasing road buffer

After the roads buffer was erased from the map polygon, similarly the polygons were also erased. Therefore a map containing only vacant land was obtained as shown in figure 3.18.
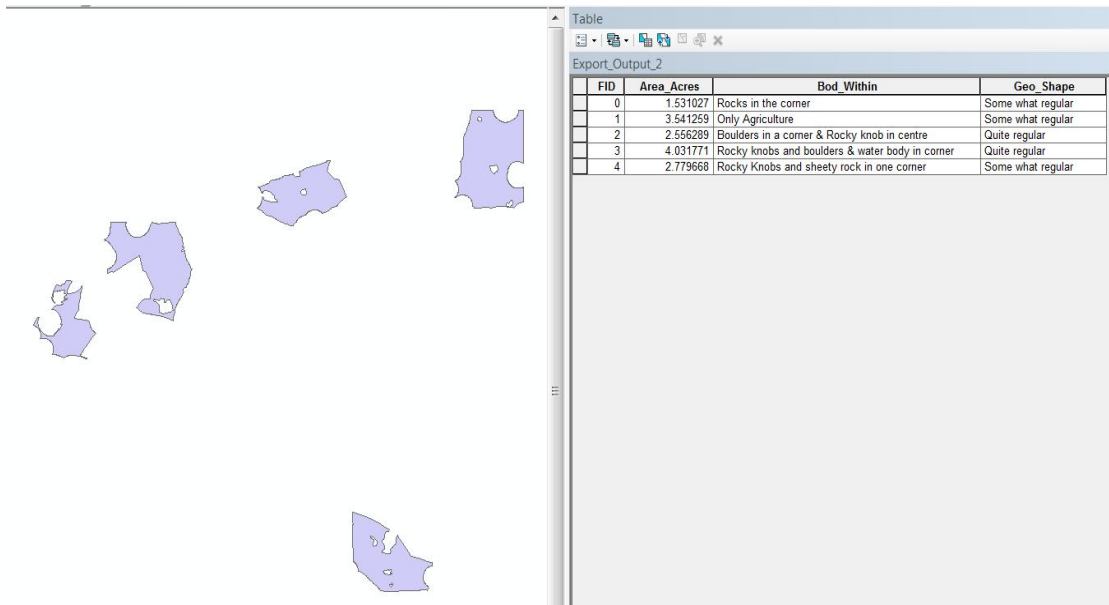

Fig 16 Vacant land
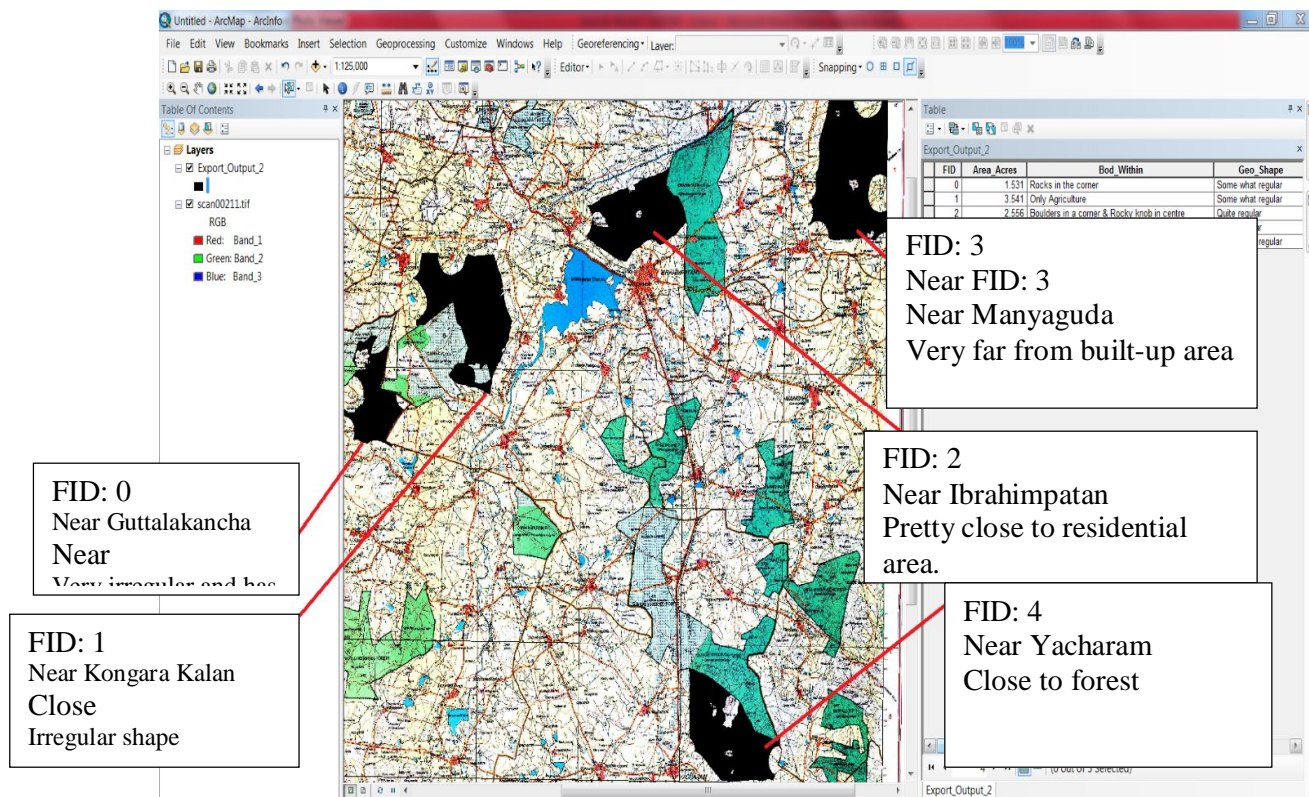
V. RESULTS

Fig. 17 Suitable sites

Fig. 18 Suitable sites' details

Table 2 Discussion of results

Site No.	FID	Site Location	Advantages	Disadvantages
1	0	Near Guttalakancha	Far from settlements	Very irregular and has the least area of all
2	1	Near Kongara Kalan	Comparatively bigger area and has stony waste towards a corner	Irregular shape

3	2	Near Ibrahimpatan	Has comparatively regular shape and greater area	Closer to settlements and has stony area at its centre
4	3	Near Manyaguda	Far away from settlements, most regular shape, greatest area	Small stony waste area at its centre
5	4	Near Gungal Reserve Forest	Somewhat regularly shaped	Lesser area, is mostly covered by stony area

Site number 1 – Near Guttalakancha

As seen from the figure 4.10, it can be observed that the site is close to plantation and far from settlements but, is very irregularly shaped. It also has the least area of all (1.53 acres). Hence this site is rejected.

VI. CONCLUSIONS

It was discussed in the previous chapter about the various sites obtained by using site suitability analysis.

Analysing all the pros and cons of all the candidates, one can conclude that site number 4 is the most suitable site for establishing a Sewage Treatment Plant and site number 2 stands at second place to it.

A. Most suitable site number 1

This site has been selected as the most suitable site, as it has maximum regular area being far away from residential, water bodies and other agricultural areas though having stony wastes at its centre. This disadvantage is negligible as its area is far less and wouldn't cause any drastic effect on the overall cost.
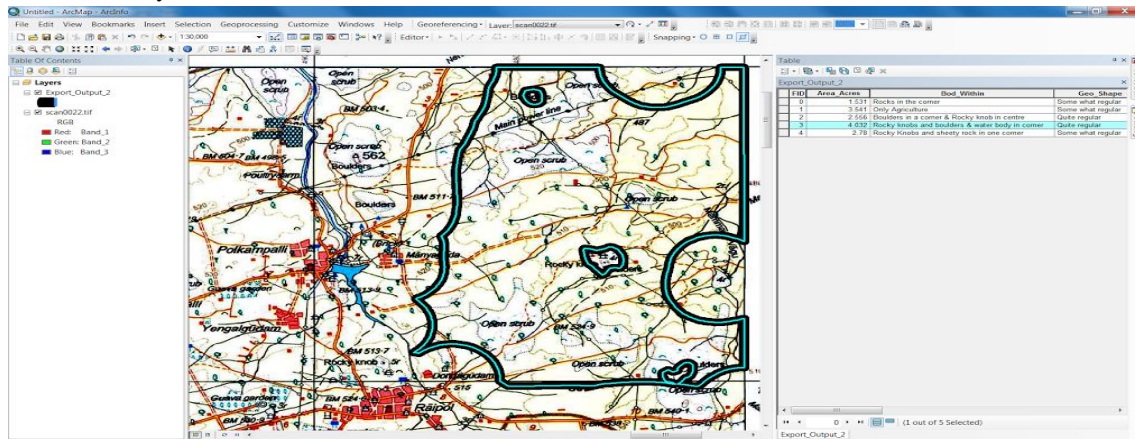

Fig Most Suitable Site-1

B. Most Suitable Site Number 2

Though it also has more area, it has been given 2nd priority as it has bigger area of stony waste at its corner, with which the chances of construction costs rising are high, It is also require more or less a regular area in order to place the equipment therefore it was chosen.
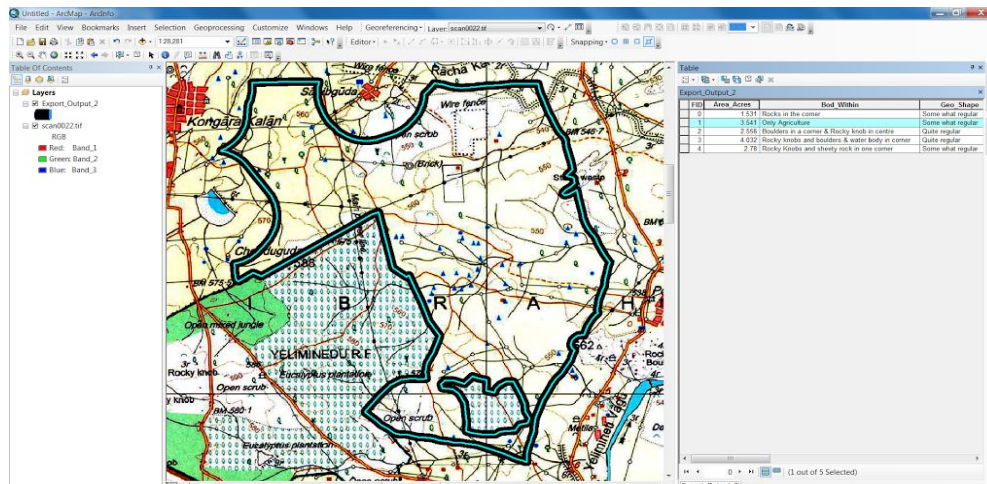

Fig Most Suitable Site-2

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