DEVELOPMENT OF DECISION SUPPORT SYSTEM

9.1 GENERAL

Geographical Information System (GIS) is an ideal tool to use, analyze and solve multiple criteria problems. The advantages of GIS include their capability to combine spatial and non-spatial information, ideal data viewing capabilities allowing efficient and effective visual examinations of solutions, user interactive to perform sensitivity analysis and spatial query and analytical capabilities such as measurement of area, distance measurement, overlay capability and corridor analysis. But, GIS fall short of the goals of a Decision Support System (DSS) for a number of reasons. Analytical modeling capabilities often are not part of a GIS, many GIS databases have been designed solely for cartographic display of results while, DSS goals require flexibility in the way information is communicated to the user, the set of variables or layers in the database may be insufficient for complex modeling, data may be at insufficient scale or resolution and GIS designs are not flexible enough to accommodate variations in either the context or the process of spatial decision-making. In such cases, a DSS provides a framework for integrating analytical modeling capabilities, database management systems, graphical display capabilities, tabular reporting capabilities and the decision-maker's expert knowledge.

Hence Decision Support System is defined as a computer-based system that share several key characteristics including:

- Assisting users in their decision making in a flexible and interactive manner
- Solving all classes of problems, including ill-structured ones
- Having a powerful and user-friendly interface
- Having a data analysis and modeling engine
- Enabling the user to combine models and data in a flexible manner

9.2 VISUAL BASIC

Visual Basic (VB), an extension of the BASIC programming language combined with a graphical user interface, is an ideal programming language for developing sophisticated professional applications for Microsoft windows. It makes use of Graphical User Interface
for creating robust and powerful applications. The GUI as the name suggests, uses illustrations for text, which enable users to interact with an application. This feature makes it easier to comprehend things in a quicker and easier way.

The Visual Basic IDE is made up of a number of components like:

- Menu bar
- Tool bar
- Project Explorer
- Properties Window
- Form layout Window
- Toolbox
- Form Designer
- Object Browser

9.2.1 Creating a Program in Visual Basic

VISUAL BASIC is a VISUAL and events driven Programming Language. These are the main divergence from the old BASIC. In BASIC, programming is done in a text-only environment and the program is executed sequentially. In VISUAL BASIC, programming is done in a graphical environment. Since users may click on a certain object randomly, each object has to be programmed independently to be able to respond to those actions (events). Therefore, a VISUAL BASIC Program is made up of many subprograms, each has its own program codes, and each can be executed independently and at the same time each can be linked together in one way or another.

Creating event-driven programs in Visual Basic requires a different approach than that used in procedural languages. If you are experienced with procedural programming, the approach may seem unusual at first. Both types of programming require logic and order, but Visual Basic requires a different type of logic and order. For example, to create an interface in Visual Basic, you draw the objects and controls on a blank form. Compared to the programming effort required to produce graphical objects in most procedural languages, the actual coding needed to provide functionality in Visual Basic is minimal.
9.2.2 Creating an Application in Visual Basic

Creating an application in Visual Basic involves the following eight basic steps.

1) Create a design plan: The design plan should be like a road map showing the path that should be used when creating an application. Before writing any code, time should be spent to design the application that will be built. Although Visual Basic provides tools to help quickly develop a solution, having a clear understanding of the user needs and initial feature set will help to be more efficient in development efforts. This will also help save time by minimizing the potential for recoding because of a poor or nonexistent design plan.

2) Create the user interface: To create the interface for an application, controls and objects are placed on a form by drawing or painting them in the Form Designer.

3) Set the properties of interface objects: After adding objects to a form, their properties are set at design time, or code statements can be used to set properties at run time.

4) Write code for events: After setting the initial properties for the form and its objects, a code is added that runs in response to events. Events occur when different actions are performed on a control or object. For example, a command button’s Click event occurs when the user clicks it with the mouse.

5) Save the project: Next, the project is saved, giving it a unique and descriptive name. The project should be saved frequently as and when a code is added to it. Saving a project also saves its forms and code modules.

6) Test and debug the application: As the code is added to the project, the application is run to view its behavior. Visual Basic offers numerous tools for debugging the application.

7) Make an executable file: Upon completion of the project, an executable file is created. By doing this, the various files that make up the program are compiled into a stand-alone executable file.

8) Create a Setup application: To run an application, the user usually needs other files, such as any DLL files or custom control.ocx files that are used to create the application. Visual Basic provides the Package & Deployment Wizard, which automates the creation of the Setup program and ensures that the user has all of the necessary files.
9.3 DEVELOPMENT OF A DECISION SUPPORT SYSTEM (DSS)

The attribute and collateral data obtained and collected during fieldwork and the spatial data prepared during the study (maps obtained) are together related in a user-friendly manner in the form of a decision support system using VB software. This system named as a Decision Support System, is a user-friendly system in which the end user can access the information and make a decision by mere clicking the options. The system is designed in Integrated Development Environment (IDE), a term commonly used in the programming world to describe the interface and environment that is used to create the application we need and can function on a desktop computer.

The utilities of this system are:

1) It gives the detailed information about the study area with respect to different parameters like population, solid waste generation rates, collection points, transfer stations, etc., displayed in the form of both maps and data.
2) It helps in decision-making e.g. querying and in analytical hierarchy measurements
3) Helps in report generation
4) Updating with the data from time to time can be made possible
5) Can be used by any user without having any prior knowledge about the software (user friendly).

This decision support system consists of the login page and home page from which different windows open. The design of these pages is discussed below.

9.3.1 Login Page
The login page is designed with username and password buttons, through which only authenticated users can enter into the project main page to view and update the data (Fig. 9.1).

9.3.2 Home Page
From home page all the operations of the application can be performed like viewing the maps and field photographs, updating the data, report generation etc. via main menu and
sub-menus. This page displays the information on location, area, population, climate and the waste generation details of the study area i.e. Hyderabad city (Fig. 9.2).

![Fig. 9.1 Login Page](image)

![Fig. 9.2 Home Page displaying the main menu](image)
9.3.3 Main Menu

The main menu of the DSS consists of

- File
- Statistics
- Landfill Site Selection (LSS) tool
- Route analysis tool
- Photo gallery

For each main menu there exists their corresponding submenus, which are discussed in the following sections. The figures of these main menu and submenu are shown below.

9.3.3.1 File

Through the file menu, there is an access to the satellite imagery, an important input for the preparation of thematic maps of the study area. There is an exit button provided in this menu by which the user will quit the project.

9.3.3.2 Statistics

The statistics menu is composed of two sub-menus viz., population statistics and solid waste statistics.

a) Population sub-menu: It provides information on population details of Hyderabad from the year 1921 to 2001 and the corresponding increment. The population forecast values for the years 2006, 2011, 2016 and 2021, calculated using geometric progression method are also incorporated. The population density map of the entire study area including Hyderabad district and parts of Ranga Reddy, Nalgonda and Medak can also be accessed through this sub-menu.

b) Solid waste sub-menu: This displays the solid waste generation details of the years 1981, 1991 and 2001. The calculated quantities of solid waste that can be generated in the future years i.e. 2011 and 2021 are also included in this sub-menu. Map showing the
circle-wise waste collection points and transfer stations in Hyderabad can be viewed from this sub-menu.

9.3.3.3 Landfill Site Selection (LSS) tool

The Landfill Site Selection (LSS) tool of the DSS consists of six sub-menus (Fig. 9.3).

- **Identification of criteria and constraints:** It displays the preliminary criteria that are considered for landfill site selection which are categorized into exclusionary and non-exclusionary criteria (Fig. 9.4).

- **Creation of maps:** All the non-exclusionary criteria in the form of maps are accessed through this sub-menu. The topographic, thematic and derived maps can be accessed individually from this sub-menu (Fig. 9.5).

- **Creation of database:** The area statistics of each of the spatial maps generated can be accessed through this sub-menu both as statistics and graphical representations.

- **Structuring of criteria into hierarchy:** This sub-menu when selected displays the decision hierarchy structure developed for site selection. An access to the calculation of weightage factors indicating the importance of one criterion over the other is provided. The user can enter his own weightage value at each level of hierarchy to get the final suitability index value (Fig. 9.6 to Fig. 9.10).

- **Map analysis:** This sub-menu displays the results of GIS data analysis and is categorized into buffer, binary and overlay maps.

- **Suitability maps:** This menu simply provides an access to the final site suitability maps (sites including the scrub forest and sites excluding the scrub forest) that are obtained as a result of data analysis in GIS (Fig. 9.11).
Fig. 9.3 Landfill Site Selection (LSS) Tool

Fig. 9.4 Landfill Site Selection Criteria
Fig. 9.5 Tool Displaying the Maps Generated
Fig. 9.6 Decision Hierarchy Structure and AHP Tool

Fig. 9.7 AHP Tool at Level II
Fig. 9.8 AHP Tool at Level III

Fig. 9.9 AHP Tool at Level IV
Fig. 9.10 AHP Tool Displaying Geology at Level IV

Fig. 9.11 Tool Displaying the Suitability Maps
9.3.3.4 Route analysis tool

This menu when selected opens a window with the origin points (from where the waste has to be transported) on one side of the window and the destination points (to where the waste has to be transported for its disposal) on the other side. When a user selects a particular origin and destination point, a map showing the optimal routes from the origin to the destination is displayed (Fig. 9.12). The user at any given point of time can select only one origin and one destination point.

Fig. 9.12 Route Analysis Tool
9.3.3.5 Photo gallery

This menu provides an access to the photographs taken during the fieldwork. The photographs include the waste transportation vehicles, landfill sites, compactors, waste processing plant etc (Fig. 9.13).

Fig. 9.13 Photo Gallery
SUMMARY AND CONCLUSIONS

10.1 SUMMARY

The enormous generation, improper storage and unscientific disposal of solid waste can affect air and water quality, land use, and public health. As it may take years to identify improper disposal practices that affect public health and the environment, it is imperative that accurate, thoughtful methods be used to locate waste sites so that their impact on the environment and public is minimized. The major problems faced are evaluating the impact of existing facilities and identifying economically practical and environmentally safe sites for future waste disposal. In both cases, volumes of multi-disciplinary information must be collected, stored, and analyzed. One approach particularly well suited to the management of such database is the Geographic Information System (GIS). A GIS is a digital data base management system designed to accept large volumes of spatially distributed data from a variety of sources. It efficiently stores, retrieves, analyzes, and displays the accumulated information according to user-defined specifications.

Keeping this in view, the present study is carried out with an objective of identifying a suitable site for disposal of municipal solid waste generated in Hyderabad city using GIS and Analytical Hierarchy Process (AHP). According to the existing records of the Municipal Corporation of Hyderabad (MCH), the total solid waste generated in Hyderabad is about 2200 MT/day of which 1500MT is disposed by landfilling and the remaining 700MT is utilized for power generation. With the Autonagar dumping site being closed in 2005, there exists only one site operating at present located at Jawaharnagar for disposing this waste. Keeping in view the need for disposal sites, an attempt has been made in this study to identify potential sites for disposal of solid waste generated in Hyderabad. For achieving this objective, GIS is used to analyze the existing spatial relationships between various geologic, topographic, hydrologic and environmental characteristics of the area as they relate to the investigation of identifying suitable landfill sites. For this purpose, various input spatial map layers including settlements, roads, topography, geology, land use, geomorphology, soil, aquifers and surface water are prepared using the Survey of India toposheets, IRS-ID PAN.
& LISS-III merged satellite data, ground data and collateral data with the help of ARC/INFO GIS.

Siting criteria were defined using the standards related to land use, geology, watercourses, roads, etc. The adopted criteria are applied to the integrated data using if-then queries, buffering capacities, and overlays. Maps satisfying the defined criteria were obtained and a composite map representing the overlay of these maps was derived. The weightage factors are estimated for each criterion using the Analytic Hierarchy Process (AHP) and an overall suitability index is produced for each candidate site allowing comparison and best site selection.

Optimal route analysis in terms of travel distance from each of the three existing transfer stations to the disposal site is carried out using Network Analyst extension of ArcView GIS software. The various factors that are considered during selection of an optimal route are type of road, traffic flow, volume of traffic etc. A Decision Support System (DSS) incorporating the spatial and attribute database generated for the study, landfill site selection tool and the route analysis tool was developed using Visual Basic software. The DSS developed is a user-friendly system in which the end user can access the information and make a decision by mere clicking the options. The system is designed in Integrated Development Environment (IDE), a term commonly used in the programming world to describe the interface and environment that is used to create the application we need and can function on a desktop computer.

The significance of the project lies in the development of a coherent set of criteria for siting solid waste landfills, and establishing a robust methodology for analyzing the necessary data in a relatively quick and reliable manner using GIS.

10.2 CONCLUSIONS
1. Based on the suitability index values obtained by aggregating the relative importance weightage values (RIW) of each element at every level of decision hierarchy, entire area is categorized into five suitability classes as excellent, good, moderate, poor and very
poor with respect to landfill siting. Higher the suitability index, the more suited is the site for waste disposal and lower the value, lower is the suitability. Two suitability maps are generated in the present study based on the presence of scrub forest. One map depicts all the suitable sites excluding the areas under scrub forest and the other depicting the sites which include the areas with scrub forest.

2. Attribute evaluation viz., distance from the point of waste generation, area covered, distance to nearest road or water body, population density surrounding the site etc. of all the sites identified resulted in the short-listing of the sites. Five best sites possessing the best compromise of features were selected within excellent, good and moderate suitability class.

3. Some of the excellent sites including the area with scrub forest are identified near Kuntlur and Annaram, Marpalliguda and Adilabad, Ankshahpur and Aushapur, between Pocharam and Yemnampet villages towards east of Hyderabad and near Yadawaram, Turkapallli and Masjidpur villages towards northeast of Hyderabad. Excellent sites excluding the area under scrub forest were identified near Lakdaram towards northwest of Hyderabad, near Kisara, Peddaparvatapuram and Bhogawaram towards northeast of Hyderabad and near Pratapasingaram, Koremalla and Choudariguda villages located towards east of Hyderabad.

4. Good sites including the scrub forest were identified between Nerapalli, Polkampalli and Manyaguda villages, between Seriguda and Turka Yemjal and near Upparpalli and Tumukunta villages towards southeast, between Narapalli and Kachwani Singaram towards east and between Puduru, Munirabad and Yemjal towards north of Hyderabad. Apart from the above, site located between Ismailkhanguda and Pocharam villages towards southeast of Hyderabad is identified as a good site excluding area with scrub forest.

5. Sites located near Yadagiripalli and Kisara, between Kondapuram, Charlapalli and Ghatkesar villages and between Kisara, Bhogawaram and Peddaparvatapuram towards
east of Hyderabad, between Srirangam, Dablipur and Girmapuram towards north and between Wailal, Kishtapalli and Jinnawaram villages towards northwest are few of the moderate sites (including the scrub forest) identified. Apart from the above, one site located near Madhawaram, Gandigudem and Kazipalli villages towards northwest of Hyderabad is identified as moderate site excluding the area with scrub forest.

6. From the optimum route analysis carried out with transfer stations as origin points and sites identified as destination points it can be concluded that the waste collected at Imliban transfer station can be transported and disposed to sites located near Kuntlur, Marpalliguda and Adilabad villages belonging to excellent class; to sites near Narpallli and Seriguda of good category; and sites near Yadagiripalli and Kisara of moderate category. The waste from TBT can be transported to sites located near Kuntlur, Pocharam, Kisara and Marpalliguda of excellent class; to sites near Narapalli, Upparpalli, Puduru and Ismailkhanguda of good class; and to sites near Kondapuram and Srirangaram of moderate class. The waste from YZT can be transported to site near Lakdaram of excellent class; to site near Wailal and Madhawaram of moderate class.

7. The decision support system (DSS) developed using visual basic incorporates the entire spatial and attribute database generated in the present study. The database is related in a user-friendly manner in which the end user can access the information and make a decision by mere clicking the options. The Integrated Development Environment (IDE) used in designing DSS provides a framework for integrating analytical modeling capabilities, database management systems, graphical display capabilities, tabular reporting capabilities and the decision-maker's expert knowledge.