ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
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APPLICATION OF GIS FOR URBAN PLANNING IN ETHIOPIA WITH PARTICULAR REFERENCE TO ABATTOIR SITE SUITABILITY ANALYSIS FOR KULITO TOWN: AN EXPLORATION

A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements for the degree of masters of science in information science

BY
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DEDICATED to :

My mother Ytaish Mihrete

My late father Melese Wubshet

My brothers and sisters

and

My spiritual friends at Genete Tsige Sunday School of

St. George Parish Church

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List of Abbreviations

CAD	Computer Aided Drafting
DBMS	Database Management Systems
DEM	Digital Elevation Model
EMA	Ethiopian Mapping Authority
EPA	Environmental Protection Authority
GIS	Geographic Information Systems
GPS	Geographic Positioning Systems
LMA	Livestock Marketing Authority
NUPI	National Urban Planning Institute
ORAAMP	Office for the Revision of Addis Ababa Master Plan
PMGE	Provisional Military Government of Ethiopia
UTM	Universal Transverse Mericator
WHO	World Health Organization

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ABSTRACT

In Ethiopia certain urban functions, particularly abattoirs even though their siting is a critical environmental issue (EPA, 2002), are frequently observed being located incompatibly with the surrounding geographic features. As a result, abattoirs pose environmental hazard to their surrounding, and they are also affected by some nearby activities.

The implication is that each fiscal year NUPI, which is the chief urban development plan making arm of the Federal Government of Ethiopia, would be confronted with problems of these kind to which appropriate solution should be sought. However, it is admitted that the manual method NUPI is currently using is not sufficient enough to cope with the increasing demand for siting abattoirs. It is rather slow, error prone and laborious.

In an attempt to address such problems, the present study specifically explores the potentiality of applying GIS for abattoir site suitability analysis, by taking a selected town of Ethiopia (Kulito) as a case. A model for the analysis has been developed by working closely with knowledgeable experts of NUPI in the problem area as well as reviewing relevant documents. The model was then implemented using Arc View GIS Version 3.1. Based on the comments of NUPI's experts, the result was proved satisfactory and the method could be used for the designation of suitable abattoir site for other towns with some modifications if necessary.

CHAPTER ONE
INTRODUCTION

1.1. BACKGROUND

Cities and towns in most developing countries experience a growing pressure of population on finite resources and a lack of modern economic organization, which might help relieve this pressure (Harris, 1990). The implication on the environment and the quality of life is thus far-reaching. This fact holds for Ethiopia, as well (Tegegn, 2001).

Urban planning takes place in a spatial context. Much of this planning has to do with the use of land and how the different types of land uses relate to one another. This means that urban planning must contend with many conflicting goals and circumstances. A desire to provide an amendable and efficient urban environment conflicts with the need to conserve resources. The anticipation of rapid growth calls for the provision of facilities which may not be needed at once. Provisions for the future will require a degree of foresight which is difficult to achieve in a dynamic and uncertain environment (Harris, 1990).

Furthermore, most investments in buildings, factories and infrastructures have their physical location in towns and cities. These investments have a long life span and depend for their functioning and efficiency on the urban area to which they belong (Bruijn, 1990).

Harris (1990) stresses that the mixture of problems which must all be resolved together, covering several types of land uses and a lot of public facilities which illustrate the natural complexity in urban planning creates a situation in which many alternatives must be tried, combined, improved, and tested by analysis, by experiment and by public discussion.

Bruijn (1990) also emphasizes that the interdependency between investments and their environment, and the need to integrate all groups of inhabitants in urban society under decent living conditions, make urban planning at all level of government a prime concern. Such urban planning exercise is no exception in Ethiopia (Solomon, 1999).

Nowadays, urban planning activities are supported by computer-based systems. Specifically, GIS plays a major role in solving problems related to urban planning activities.

As a result, throughout the world, governments, utilities and businesses are investing billions of dollars on computer systems that store, manage, and analyze maps and geographic information (Antennuci, et al, 1990). The increasing interest in geographic information technology can be attributed to technological improvements (in terms of increasing power with declining cost) in computers in general, and to advances in geographic information technology and related fields in part.

The key feature of Geographic Information Systems (GIS) is that they are systems with powerful capability to analyze spatially referenced data in order to produce new information that could be used for new set of purposes or applications (Parent, 1988, cited in Antennuci, et al, 1990).

GIS has vast potential, recognized but not fully realized, for solving environmental and human management problems (Antennuci, et al, 1990); its application is limited only by the imagination of those who use it (ESRI, 2001). This is why a GIS application for solving real-world problems, where geographically-referenced data is needed, is recognized as an important research area of the field (Worboys, 1994).

In the context of urban planning, activities which can be supported with GIS range upwards in complexity and difficulty from quick fixes, all the way to City-wide strategic plans.

On a small scale, GIS is used for site selection for many different lands of single facilities with unique locational requirements, for which the implications as to traffic, pollution, displacements of other activities, functionality of the new facility, and so on can be explored (Harris, 1990; Brail, 1990; Bruijn, 1990).

A different set of problems arises when the present and future location of systems of facilities are considered. Here, all the questions at single facility level arise, but in addition the facilities compete and supplement each other, so that no two facilities must be too close together, and no client needing service should be too far from the nearest facilities (Harris, 1990).

The effective use of GIS depends on the purposes for which it is applied and the context in which that application takes place (Ibid). Furthermore, a better understanding of GIS technology by users, managers, and decision makers is crucial to the appropriate use of the technology (Aronoff, 1989).

1.2. STATEMENT OF THE PROBLEM AND JUSTIFICATION

The Government of Ethiopia, with the intention of tackling the problems and challenges of urban planning, has established NUPI in 1987 (PMGE, 1987). Among other things, NUPI is concerned mainly with aspects of urban studies and planning. One such major task of NUPI is the creation of a strategy for overall urban development and preparation of plans (master plans/development plans) and documents that should guide major investments in the urban area, maintain a balanced environment, and create acceptable living conditions for all segments of the population (Ibid).

Among those important urban functions or services studied by NUPI related mainly to appropriate location are abattoirs. These are livestock processing industries, located near the population they serve (for Ethiopian case, usually within the municipal boundary of the corresponding cities and towns). The activities involved in abattoirs pose environmental hazard to the neighbouring areas. These are manifested in the form of (EPA, 2002; WHO, 1984).

- **Liquid wastes** which are characterized by effluent salinity and bacterial contamination.
- **Storm water contamination.** Storm water gets contaminated when it becomes in contact with the different parts within the slaughterhouse area and can have detrimental environmental effect on the surrounding ecosystem.
- **Solid wastes**. These include manure generated from animal holding area and materials not suitable for rendering, such as unwanted carcasses.
- **Airborne wastes**. These mainly include disagreeable odours which may be generated from waste effluent treatment plants, material drying areas, waste disposal techniques burning dead stock, holding of carcasses before disposal, odour from skin handling and skin sheds, etc.
- **Diseases.** In abattoirs there is a large potential for the transmission of zoogenic diseases such as Q-fever and anthrax to humans.
- **Noise.** In abattoirs noise can be generated by several sources, including animals, processing activities within the slaughterhouse, plant machinery, etc.

On the contrary, abattoirs could also be affected by certain nearby incompatible activities. Examples are industrial activities that emit smoke and dust. Other relevant issues associated with the proper functioning of abattoirs include availability of basic infrastructure.

The discussion so far provides a general overview of varied characteristic of abattoirs necessitating unique locations that comply with environmental and land use policies. However, a number of examples in different towns of Ethiopia can be mentioned which portray the existence of serious problems in this regard. The most notable ones include:

- in many cases the sites lack a reasonable time dimension so that they are soon encroached by other urban land uses (housing and commercial activities). Ultimately, the abattoirs become subject to relocation earlier than expected. Furthermore, abattoirs are sometimes found near waste disposal site being exposed to pollution. Typical example is Teppi town (NUPI, 1999c).
- In some places such as Durame town, abattoirs are found being constructed within the central business center, indicating a serious problem of incompatibility (NUPI, 1999a).
- In other situations such as in Gimbi town, abattoirs are noted being built so close to water supply dams that the liquid waste disposed of joins the water, representing serious hygienic hazard (NUPI, 1999b), and more other similar problems are encountered.

The implication is that each planning team of NUPI would be confronted with problems of these kinds to which appropriate or optimal solutions should be sought. In attempting to designate suitable abattoir sites for the towns/cities under study, a set of local criteria are used.

As can be noted, like most spatial decision making problems, the land allocation problem associated with abattoirs is multicriteria in nature, involving economic, social, environmental and political dimensions. To make things clear, the site characteristics for an abattoir are evaluated (using a manual procedure) based on various suitability aspects including:

- **Planning suitability**, which refers to whether a site is suitable and appropriate for the intended land use. The data needed for evaluation incorporate site capacity, present land use, planned land use (zoning and restriction), ownership/land control, and environmental impact.
- **Physical suitability**, which relates to the physical characteristics that influence the suitability of the site for development. Data is required on general topography, slope, flood hazard, etc.
- **Infrastructural suitability** which is associated with existing and supplementary physical infrastructure that are important for the proper functioning of the abattoir and include access road, electric power and water supplies.
- **Locational suitability** which refers to the distance from the intended site to certain geographic features such as rivers/streams, residences, high tension electric lines, airports, etc., and
- **Financial suitability**, which relates to the financial consequences of development of the site. Relevant data comprise acquisition and compensation costs, site development cost, etc.

The large number of factors necessary to identify and consider in making spatial decisions (such as that of designating appropriate site for an abattoir) and the extent of the interrelationship among these factors causes difficulties in decision making (Malczewiski, 1999), particularly in terms of timeliness, being error free, and labour requirement (both intellectual and physical).In other words, this non-computerized searching or decision making procedure, practiced by NUPI, could be described as one that is error-prone, time-consuming and laborious. The most difficult cases are when the town is characterized by high population density and a lot of physical constraints.

In line with this argument, Janssen and Rietveld (1990) mention two basic reasons why urban planning problems (such as land allocation decisions) are often difficult to solve:

- Large amount of data are required, due to the number of spatial units involved or the range of phenomena taken into account, and
- Political conflicts between spatial units or between policy objectives are intense.

Furthermore, the investment climate in the livestock sector indicates that private investors are currently showing an increasing interest to be involved in meat and meat product venture (LMA, 2000). Consequently, according to the same source, export abattoirs are expected to flourish in the country in the near future. It follows that the conventional method mentioned above will not be sufficient enough to accommodate the increasing demand for abattoirs' sites. This implies that a new method for supporting the spatial decision making process is, thus, essential.

The use of a GIS to support such decision-making problems is best justifiable. Geographic information systems have been designed to contribute to the solution of such planning problems. For this purpose, GIS systems have been supported with various facilities for analysis, modeling and forecasting (Janssen and Rietveld, 1990). Otten (1990) also stresses that GIS can be employed for all research that involves land-based spatial analyses and modeling. He further asserts that especially for area monitoring, regional potential and feasibility analyses and site selection studies, GIS offers good functionalities.

Basically, technology in general and geographic information technology in particular is a means to make many types of work more efficient and workers more effective; it enables better decision, based on better information (Antennuci, et al, 1990). The ability to manipulate the spatial data and corresponding attribute information and to integrate different types of data in a single analysis and a higher speed are unmatched by any manual methods (Aronoff).

The immediate contribution of the present study particularly to NUPI is notable for the following reasons:

- NUPI is about to start using GIS for urban planning purpose; a preliminary draft proposal for GIS project organization has been prepared and as an example an attempt has been made to develop a GIS database for Woreta town using MapInfo professional GIS software. The present study contributes to this initiation by employing GIS for solving a specific urban planning problem; and

- GIS provides the functions for spatial analysis but the techniques of its use may not be explicit in the package's user interface or documentation (Miller, 1990). Consequently, users unfamiliar with GIS techniques or the nature of geographic information can just as easily conduct invalid analyses as valid ones (Aronoff, 1989). As an example of what might be done, the present study could demonstrate how to employ the spatial analysis capabilities of GIS for solving land allocation problems.

Finally, it should be noted that the literature on previous works related to abattoirs generally focuses on the preparation of guidelines for the siting and construction of abattoirs, slaughtering activities and other internal operations as well as hygienic and environmental issues (WHO, 1984; EPA, 2000). The siting task is accomplished by a manual method.

1.3. THE STUDY AREA

This account on the study area is based on the data collected by NUPI as part of the development plan preparation of the town of Kulito

The study area, Kulito town, is found in the Southern Nations, Nationalities and Peoples Regional State, 60 Kilometers West of Shashemene town on the Shashemene-Sodo-Arba Minch Regional Road. It is administrative center for Alaba Special Woreda and is considered as market center for its hinterland. In the global grid system, the study area is located at 7^0 17' North latitude and 38^0 06' East longitudes coordinate. The town has a total area of 473 hectares with a total population of 20,524.

Furthermore, it lies in the lower western escarpment of the lakes region physiographic unit of the Ethiopian Rift Valley. The maximum slope gradient is nearly 10 per cent (indicating flatness of the town), with average altitude of 1, 812 meters above sea level. The town is characterized by subtropical (" Weina Dega") thermal condition (moderate temperature), with mean annual value of 19^0c. The mean annual rainfall is about 1090.8mm.

It would be worth mentioning here that Kulito town is chosen as a study area for the following reasons:

- preparation of the development plan for Kulito town is currently underway by NUPI. A multi-disciplinary team had already conducted field survey. It would be, thus, convenient for the researcher to have access to all relevant data which otherwise would be difficult and time-consuming to acquire within the permissible research period;

- AutoCAD drawing file of the topographic map of the town is available. This reduces the total cost that will be incurred in getting the entire mapped data digitized; and
- again, since the plan is underway, the researcher will have the opportunity to take part in the project's team discussion sessions.

1.4. OBJECTIVE OF THE STUDY

1.4.1. General Objective

The general objective of the study is to explore the potential of GIS for urban planning purpose in Ethiopia in general and experiment its application by developing a site suitability model for abattoir to a selected town (Kulito), and to make recommendation on further activities to urban planning.

1.4.2. Specific Objectives

In line with achieving the general objective, the study seeks to deal with the following specific objectives:

- to review related literature in the area of GIS application for urban planning;
- to review local land use and environmental policies pertaining to urban land use planning;
- to explore the land use pattern and geographic features of the study area;
- to review literature on the locational requirements and environmental qualities of abattoir;

- to develop a prototype GIS database for the study area, focusing on the specific problem area; and
- to develop a site suitability model in order to select the most suitable site for abattoir in Kulito town.

1.5. METHODS

1.5.1. Method of Data collection

1.5.1.1. Literature Review

Reviewing literature provides the researcher with theoretical framework about the problem. In order to have ideas and views of others, a thorough review was made on materials relevant to the problem area under investigation.

A GIS-based site suitability analysis requires one to acquire geographically referenced data about the specific site of interest. To that end, land use and environmental policies related to abattoir were reviewed. Furthermore, master plans and development plans (with accompanying documents) of different towns of the country were explored.

1.5.1.2. Discussion

Discussions were held with experts of NUPI in identifying abattoir site selection criteria and finding out the buffer distance that an abattoir should be separated from relevant geographic features. Additional discussions were made particularly with those experts, who are involved in the development plan preparation of Kulito town, in order to acquire some appreciation of the study area. In particular, the following experts working at NUPI were interviewed: Ato Andualem Getinet, Ato Belachew Kale Kiristos, Ato Nega Haile Maryam, Ato Fitsum Haile, Ato Yalem Tsega Tiruneh, and Ato Zelalem Fanta.

1.5.1.3. Site Visit

As already stated, the preparation of a development plan for Kulito town is underway. This means that a wide variety of data including socio-economic, physical, demographic, geologic and spatial data related to the study area have already been collected by NUPI. After investigating these data, a site visit of the study area was required in order to complement some missing data and to have a general feel of the study area.

1.5.2. Development Methods

1.5.2.1. Data Acquisition

The information (data layers) needed for database development has been extracted from topographic map of the study area (scale 1:5,000), which is available in AutoCAD drawing file.

Such mapped data contains the built up area and other geographic features. The elevation points for slope analysis were also obtained in dat-file format.

1.5.2.2. Data Input and Storage

Arc View GIS Version 3.1 software has been used for developing the prototype database for the study area. Furthermore, a CAD reader extension program has been used to convert the original mapped data (in CAD drawing format) into a GIS format. Arc View GIS Version 3.1 has been used since it has been designed, among other things, to solve land allocation problems. Furthermore, it is equipped with user-friendly facilities and is convenient to use.

1.5.3. Conducting Abattoir Site Suitability Analysis

For the purpose of conducting abattoir site suitability analysis, a site selection model has been constructed. The model was then implemented using Arc View GIS Version 3.1.

1.6. SCOPE AND LIMITATION

The scope of this study is to explore the potential of using a GIS for abattoir site suitability analysis. The study focuses mainly on municipal abattoirs since they are the dominant types in most towns of the country. The site selection criteria were formulated based mainly on NUPI's experience. As to export abattoirs, such requirements should be modified based on the guidelines recently provided by the Livestock Marketing Authority.

Because of the specific features of the study area, some of the criteria are not incorporated in the abattoir site suitability model. This mainly includes airport. Furthermore, due to shortage of time and financial resources, the model has not been tested for other towns.

1.7. ORGANIZATION OF THE THESIS

This thesis is divided into six chapters. The first chapter provides an introduction to the study, which consists of different sections: background, statement of the problem and justification to conduct the research, objectives and methodology to carry out the research, and its scope and limitations. The second chapter dwells on review of related literatures on geographic information systems, about its theoretical framework, architecture and application in the area of urban development planning.

The third chapter is devoted to background information on the current urban development practices undertaken in Ethiopia. Furthermore, abattoirs are discussed as important urban functions including their basic features, undesirable environmental problems they pose and basic facilities they require to properly function.

In chapter four, the site selection criteria are identified, based on which a prototype database for the study area has been created. Furthermore, the same chapter contains the design of abattoir site suitability model. Chapter five is about discussion of the analysis result, while the last chapter provides conclusion and recommendations.

CHAPTER TWO

GEOGRAPHIC INFORMATION SYSTEMS

2.1. INTRODUCTION

Computers have been applied in urban planning almost since their inception, but only recently with the development of graphics, distributed processing, and network communications has software emerged. At the basis of these developments are geographic information systems (Batty and Densham, 1997).

A GIS is designed for the collection, storage and analysis of objects and phenomena where geographic location is an important characteristics or critical to the analysis. The number and type of applications that can be performed by a GIS are as large and diverse as the available geographic data set (Aronoff, 1989).

2.2. THEORETICAL FRAMEWORK

Basically, GIS is recognized as a tool that links attribute databases with digital maps. However, in light of its powerful features and capabilities, this definition would seem an oversimplification. Different authors in the field of GIS have proposed different definitions for GIS. Most of these definitions share in common the fact that GIS not only provide users with a variety of facilities for handling and linking attribute and spatial data, but also they are characterized by more advanced features including advanced modeling functions, tools for design and planning, and advanced imaging capabilities. Some of these capabilities also exist in other types of systems; however, GIS are unique in their emphasis on providing users with a representation of objects in a cartographically accurate spatial system and on supporting analysis and decision making (Mennecke, 1997).

Foote and Lynch (1996a, cited by Malczewski, 1999) identify three important features of GIS systems:

1. GIS may be thought of as a general-purpose digital database in which case having a common spatial coordinate system is a necessity for storing and accessing data and information. With GIS systems one can perform a variety of functions by employing both the spatial and attribute data stored within them. Among other things, this feature of GIS distinguishes it from other information management systems.

2. GIS represents an integration of a number of technologies. For example, remote sensing, global positioning system, computer-aided design, and automated mapping and facility management.

3. GIS is considered as a kind of decision support system in which spatially referenced data are integrated in a problem solving environment.

2.3. BASIC COMPONENT FUNCTIONS

The functionality of a GIS can be subdivided into four main components subsystems (Aronoff, 1989; Malczewski, 1999). These are: data input, data storage and management, data manipulation and analysis, and data output (see Figure 2.1). A review of the major GIS functions, techniques, and concepts follows here below.

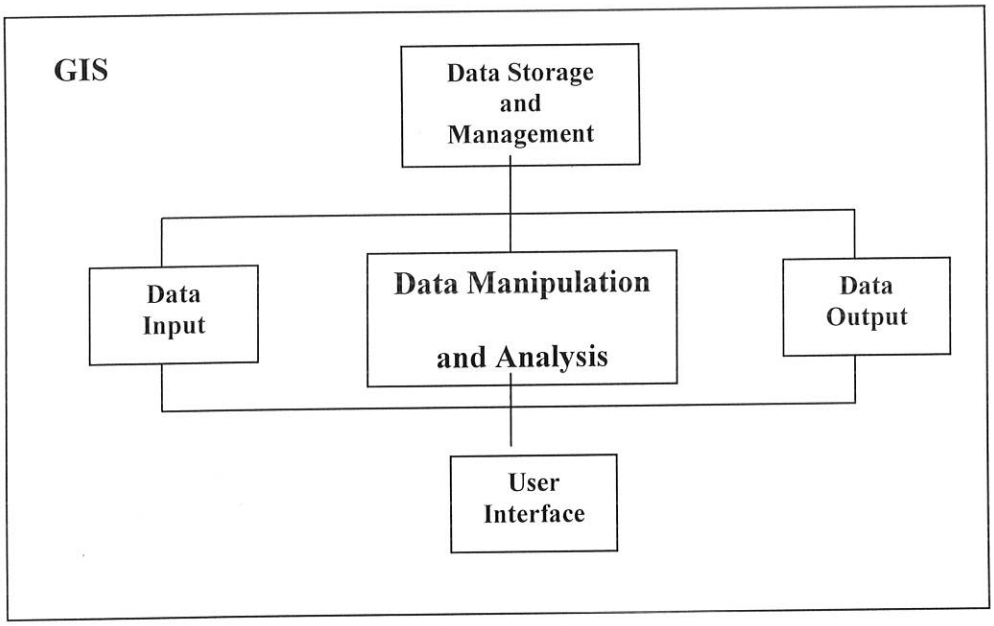


Figure 2.1. Structures of a GIS

2.3.1. Data Input

Data input refers to the process of identifying and gathering the data required for specific application, thus involving acquisition, reformatting, geo-referencing, compiling, and documenting the data (Malczewski, 1999). The data input component converts data from their existing form into one that can be used by the GIS.

2.3.1.1. Data Sources for GIS

The data to be used in a GIS may be available in different formats including paper maps, tables of attributes, electronic files of maps and associated attribute data, aerial photos, satellite images and other sources in digital format. One important virtue of a GIS is its efficient capability of integrating different data in different format acquired from a wide range of data sources into compatible format (Malczewski, 1999; USGS, 2001)

2.3.1.2. Data Entry Systems

A GIS system provides alternative data entry systems including keyboard entry, coordinate geometry, manual or semi-automated digitizing, scanning, and translation of existing digital files.

Keyboard Entry. Attribute data are commonly input by keyboard. Separately entered data can be dumped later into the GIS database. This is usually more efficiently handled by entering the attributes with a code to indicate the spatial element that they describe. The attribute file is subsequently linked to the spatial data (Aronoff, 1989; Antenucci, et al, 1990).

Coordinate Geometry. Coordinate geometry procedures are used to enter land record information. The procedures involve a quite different technique in order to create digital map data. That is the geometric descriptions of map features (such as bearings and distances with respect to a predefined point of origin) are entered on the keyboard. The resulting coordinates are then determined by employing mathematical algorithms. The coordinates are stored, subsequently to generate graphic displays of the map images. The method ensures the production of more accurate cartographic data than is practical with conventional manual digitizing of existing maps (Antenucci, etal, 1990).

Manual Digitizing. Manual digitizing is the most widely used method for entering spatial data from maps. This approach uses a digitizing table and mouse with a cursor to trace and record points, lines, and polygons needed for a particular data set. This method is used when existing maps are available but cannot be scanned.

Scanning. Scanning technology emerged as a solution to the drawbacks of manual digitizing. This approach uses an optical laser or other electronic device to convert analog source document (hard-copy maps or graphics) into digital raster. Since most GIS applications require a vector version of the data and attachment of attributes, additional raster-to-vector conversion processing is required. In GIS, Scanning is used for entering map and photo information. Scanning works best with maps that are very clean, simple, and do not contain extraneous information, such as text or graphic symbols (Aronoff, 1989; Antenucci, et al, 1990; Malczewski, 1999).

Remote Sensing. Remote sensing has long been used in map production. Most of the spatial data used in a GIS are produced with remote sensing technology (Aronoff, 1989).

The process of remote sensing involves collecting data about the surface of the Earth and the environment from a distance, usually by aircraft or space sensors (Jensen, 1996, cited by Malczewski, 1999). The data obtained from the orbiting satellites is subject to processing (which involves reduction/simplification) before it can be integrated with a GIS. It is worth noting that remote sensing is increasingly being recognized as one element of an integrating GIS environment rather than simply as an important data source for GIS (star, et al, 1997, cited by Malczewski, 1999). A fully-fledged GIS typically has a module to convert raw, remotely sensed imagery into maps.

Global Positioning System The other type of geographical information technology that is of importance for data input is the global positioning system (GPS.) This technology uses satellites which transmit signals that can be decoded by specially designed receivers to determine positions precisely (Antennuci etal, 1990). Data from GPSes can be used in association with existing spatial databases (or GIS), both for update and for a range of applications in spatial decision making (Malczewski, 1999).

2.3.2. Data Output

The data output component of GIS provides a way to see the data or information in the form of maps, tables, diagrams, and so on. The results may be output in hard-copy, soft-copy, or electronic format. Maps and tables are commonly output permanently in hard copy format. The hardcopy output takes longer to produce and requires more expensive equipment. However, it is permanent and easily transported and displayed. A large map can be shown at whatever level of detail is required by making the physical size of the output larger. Outputs in electronic formats, on the other hand, consist of computer-compatible files. They are used to transfer data to another computer system either for additional analysis or to produce a hardcopy output at a remote location (Aronoff, 1989; Malczewski, 1999).

Different output devices are used including display monitors, pen plotters, electrostatic plotters, laser printers, line printers, and dot matrix printers and plotters. Output functions (useful to add legend, title, north arrow, scale bar, colour modification, symbology adjustment) are determined by the user's needs (Malczewski, 1999).

2.3.3. Data Storage and Management

The data storage and management component of a GIS incorporates those functions concerned with the storage and retrieval of data from the database. The methods employed to implement these functions affect how efficiently the system performs all operations with the data (Aronoff, 1989). Most GIS systems are database oriented, which can be thought of as representation or model of real world geographical system (Malczewski, 1999).

2.3.3.1. The Nature of Geographic Data

The information for a geographic feature has four major components: its geographic position, its attributes, its spatial relationships, and time (Aronoff, 1989).

Geographic Position. Geographic data are basically a form of spatial data. Each feature has a location that must be specified in a unique way. For geographic data, locations are recorded in term of a coordinate system like the Latitude/Longitude, UTM, or State Plane coordinate systems. In some cases the coordinates of one system can be mathematically transformed into the coordinates of the other.

Attributes. The second characteristics of geographic data are their attributes. These attributes are also called non-spatial attributes to indicate that they do not in themselves represent locational information. They are representations of the characteristics, qualities, or relationships of map features and geographical locations.

Spatial Relationships. Spatial relationships are numerous, may be complex, and are important. For a computer-based GIS, relationships must be expressed in a computer-usable manner. Since it is difficult to store all possible spatial relationships, only some are explicitly defined in the GIS, and the remainder is either calculated as needed or is not available.

Time. Geographic information is referenced to a point in time or a period of time. Knowing the time when geographic data were collected can be critical to using those data appropriately. Historical information may also be a valuable component of a GIS database. The representation of time in a GIS is an added level of complexity that is difficult to handle.

As stated earlier, geographic data are inherently a form of spatial data. They can be represented on a map or in a geographic information system as point, line, or area features (Aronoff, 1989; Antenucci, et al, 1990; Malczewski, 1999).

Points are used to represent the location of geographic phenomena at a point or to represent a map feature that is too small to be shown as an area or a line. The location of a city (on small scale map), a mountain peak, or an airstrip could be represented by a point element.

A **line** feature consists of an ordered set of connected points. Lines are used to represent line features that are too narrow to be represented as an area or features that theoretically have no width, such as a political boundary. A shoreline, a contour line, roadways, or an administrative boundary are examples of line features.

An **area** feature is a region enclosed by line features. The geographic extent of a city, a forest stand, or a lake could be represented by an area element. Area elements in GIS are often represented as polygons. (A polygon is a closed plane figure bounded by straight lines. By making the straight-line segments small, curved boundaries can be closely approximated. The polygon shape is produced from curvilinear boundaries when the geographic information is entered into the GIS).

2.3.3.2. Managing Spatial Data

There are two fundamental approaches to the representation of the spatial components of geographic information: the vector model and the raster model (Aronaff, 1989; Burrough, 1990; Malczewski, 1999).

2.3.3.2.1. Raster Data Model

Data in raster format are stored in two dimensional matrix of uniform grid cells (Pixels), normally square or at least rectangular, on a regular grid. The spatial unit is represented using homogeneous units, which are the cells. The area within a cell is not subdivided and the cell attribute applies to every location within the cell. Areas are made up of continuous pixels with the same value (see figure 2.2). Lines are made by connecting cells into a one-pixel-thick line. Points are single cells, which means that all the area represented by that cell becomes unavailable for other spatial entities. Because positions are defined by the cell row and cell column numbers, the position of geographic features is only recorded to the nearest cell. Unlike those of the vector model, the units of the raster model do not correspond to the spatial entities they represent in the real world. The spatial entities or units in the raster data model are not the objects we conceptualize: they are the individual cells. The size of the grid can vary, and therefore the spatial resolution of the data is determined by the grid size. The higher the level of resolution, the greater the detail that can be distinguished on an image.

2.3.3.2.2. Vector Data Model

In the vector model, objects in the real world are represented by the points and lines that define their boundaries, much as if they were being drawn on a map. The spatial entities correspond more or less to the spatial entities that they represent in the real world. In the vector approach, the homogeneous units are the points, lines, and polygons. Relative to the raster approach, these homogeneous units are relatively few in number and variable in size. The positions of these homogeneous vector units are defined using a nearly continuous range of coordinate values. This method provides a much more flexible and usually more precise coordinate position than the row and column positioning used in the raster approach.

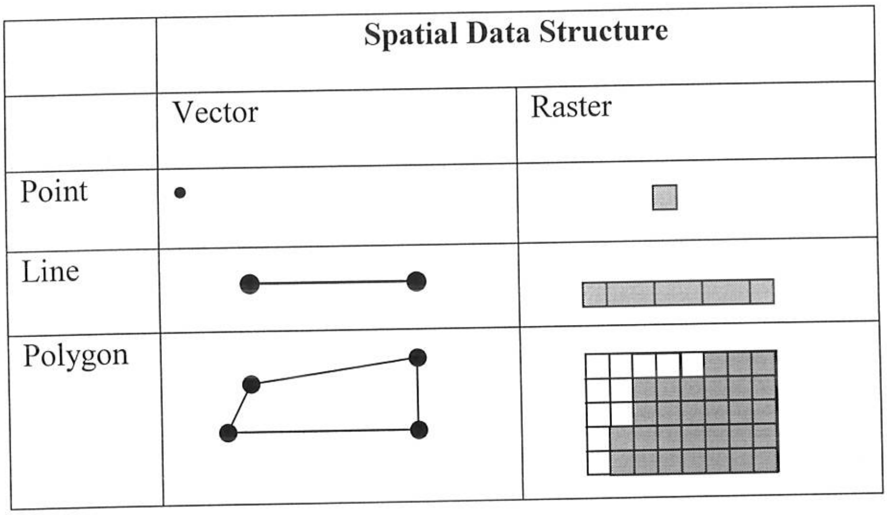


Figure 2.2. Vector and Raster Representation of Points, Lines, and Polygons.

2.3.3.2.3. Raster versus Vector Data Models

These two different approaches have their advantages and disadvantages. The major trade-offs are summarized in Table 2.2. Each approach tends to work best in situations where the spatial information is to be treated in a manner that closely matches the data model. Where the geographic phenomenon of concern is characterized by continuous varying data, then the raster model is generally applied. Where the information of interest is the distribution of objects in space or the conditions that apply to an area feature, then the vector approach tends to be better suited (Aronoff, 1989; Malczewski, 1999).

Table 2. 1 Comparison of Raster and Vector Data Models

Raster Model	Vector Model
Advantages: 1) It is a simple data structure 2) Overlay operations are easily and efficiently implemented 3) High spatial variability is efficiently represented in a raster format **Disadvantages:** 1) The raster data structure is less compact. Data compression techniques can often overcome this problem. 2) Topological relationships are more difficult to represent. 3) The output of graphics is less aesthetically pleasing because boundaries tend to have a blocky appearance rather than the smooth lines of hand-drawn maps. This can be overcome by using a very large number of cells, but may result in unacceptably large files.	**Advantages:** 1) It provides a more compact data structure than the raster model 2) It provides efficient encoding of topology, and, as a result, more efficient implementation of operations that require topological information, such as network analysis 3) The vector model is better suited to supporting graphics that closely approximate hand-drawn maps. **Disadvantages:** 1) It is a more complex data structure than a simple raster 2) Overlay operations are more difficult to implement. 3) The representation of high spatial variability is inefficient 4) Manipulation and enhancement of digital images cannot be effectively done in the vector domain.

Source: Aronoff, 1989.

2.3.3.2.4. Topology

In the vector representation, the spatial elements exhibit a definite spatial relationships called topology. Topology is a method used to define spatial relationships. The basic logical entity, in a topological model (see Figure 2.3), is the arc, which consists of a series of points that start and end at a node. A node represents an intersection point where two or more arcs meet. A node can also occur at the end of an arc that is not connected to another arc. A polygon constitutes a closed chain of arcs that represents boundaries of the area.

The basic point behind topology is that it allows a GIS to perform spatial analysis functions on geographical data.

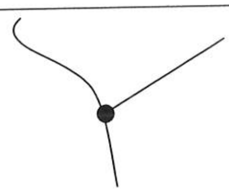
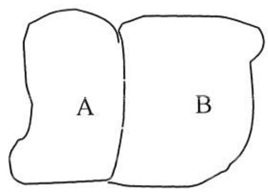
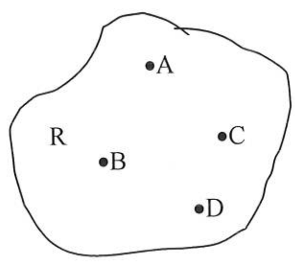
	Spatial Relationships
Connectivity	 Node N connects Chains A,B and C
Adjacency	 Polygon A is adjacent to polygon B
Containment	 Polygon R contains points A,B,C and D

Figure 2.3. Selected Spatial Relationships

There are three basic spatial relations (Figure 2.3):

Connectivity. This refers to interconnected pathways or networks that transport something. Lines are connected at nodes.

Containment. In this case, one spatial entity may contain another entity. For example, one polygon can contain another as an "island".

Topology can be stored as part of the map representation in the database table or built from the coordinates of each entity. It is worth nothing that it is only cells adjacency that is the only topology existing in the raster data structure.

Another important vector-based topological data model is the **Triangular Irregular Network or TIN**. A TIN is used to represent terrain surface as a set of inter-connected triangular facets. For each of the three vertices, the XY coordinates (geographic location) and the Z coordinate (elevation) values are encoded. One important advantage of a TIN is that extra information is encoded for areas of complex relief without requiring a large amount of data to be collected from areas of simple relief. (Aronoff, 1989).

2.3.3.3. Databases for GIS: Managing Spatial and Attribute Data Together

Fundamental to the description of geographical objects are locational data (which associate the objects to their location in geographical space) and attribute data (which provide description of the properties of the objects other than their locations). GIS typically employs DBMS strategies to handle these two types of data.

The **relational model** is the most popular database used to organize data in GIS (Malczewski, 1999). Maguire (1995, cited by Malczewski, 1999), conveniently distinguishes three categories of GIS data models: file processing, hybrid, and extended or integrated DBMS.

File processing design model. The file processing design model involves storing all the files in a flat files (which is a simple method for storing data). This type of database is a simple collection of records (representing entities) for which there are identical categories of data (attributes) associated with each record. The virtues of this approach include simplicity, easy-to-understand data structure, and fast retrieval speed. However, it is characterized by low flexibility and responsiveness. (Antenucci, et al, 1990; Malczewski, 1999).

Hybrid data model. The hybrid data model is based on the assumption that data storage approaches that are efficient for spatial data are inefficient for attribute data, and vice versa.

Spatial data are stored in a set of direct-access operating system files for speed of input-output, while attribute data are usually stored in a standard DBMS. The GIS software manages links between the spatial data files and the DBMS during different map-processing operations. While a number of different approaches to the storage of the spatial data are used, the linking mechanism to the database is basically the same. It involves unique identifiers stored in the database table of attributes that allows them to be tied to individual map (Malczewski, 1999).

Extended data model. The extended data model is also a spatial database management system which employs GIS for the purpose of query processing situated at the top of the database itself. Currently the implementations are dominantly of vector-topological type. Relational tables hold map coordinate data for points/nodes and line segments, together with other tables containing topological information. Attributes may be stored in the same tables as map feature or in separate tables accessible via relational joins (Maguire, 1995, cited by Malczewski, 1999).

2.3.4. Data Manipulation and Analysis

The art and science of using a GIS is to know how to combine the analysis functions available on a particular system to provide the required information using the available data. The quality of the information produced from a GIS depends on the intelligent use of a systematic analysis approach (Aronoff, 1989).

2.3.4.1. Organizing Geographic Data for Analysis

Geographic information are organized within a GIS so as to optimize the convenience and efficiency with which they can be used. The form of organization chosen will be influenced by the types of data to be used, the types of analyses to be performed, and the methods used to encode the data (Ibid).

Organizing geographic data for analysis involves putting the different types of thematic information into different map layers and (where necessary) partitioning the coverage area into tiles.

Map layers. A map layer is a set of data describing a single characteristic of each location within a bounded geographical area. Only one item of information is available for each location within a single layer. A single layer may represent a single entity type or a group of conceptually related entity types. A map layer can be displayed, manipulated, and analysed individually or in combination with other map layers stored in a GIS database (Malczewski, 1999).

Partitioning the coverage area. When a GIS must handle a large amount of data, the coverage area may be subdivided into smaller units called tiles. In general, tile boundaries should be chosen in such a way that they will be stable for the life of the database and enhance the performance and use of the system (Aronoff, 1989).

2.3.4.2. A Classification of GIS Analysis Functions

Aronoff (1989) attempts to conveniently group GIS analysis functions into four major categories, each with several subdivisions. The first level of classification incorporates:

(a) Maintenance and analysis of the spatial data,

(b) Maintenance and analysis of the attribute data,

(c) Integrated analysis of spatial and attribute data, and

(d) Output formatting.

2.3.4.2.1. Maintenance and Analysis of the Spatial Data

Maintenance and analysis functions are used to transform spatial data files, edit them, and assess their accuracy. They are primarily concerned with the spatial data and require little reference to the associated non-spatial attribute information. The functions included in this category are:

Format Transformation: This involves transformation of source data into the data structure and file format used internally by the GIS.

Geometric Transformations: These refer to the assignment of ground coordinates to a map or data layer within the GIS or to adjust one data layer so it can be correctly overlaid on another of the same area. The procedure used to accomplish this correction is called registration.

Transformation between Geometric Projections: The spherical surface of the earth is represented on a flat 2-dimensional map through mathematical transformation. This process is called map projection. The transformation assigns to each location on the spherical surface a unique location on the 2-dimensional map.

The data layers that are to be used in a GIS should all be represented using the same coordinate system. To that end, a GIS commonly support several projections and has software to transform data from one projection to another. Where more than one projection is to be used, then appropriate projection transformations should be provided (Aronoff, 1989).

Conflation. This is the procedure of reconciling the positions of corresponding features in different data layers so that they overlay precisely. This is important when data from several data layers are to be used in the analysis.

Edge Matching. This is used to reconcile the position of features that extend onto an adjacent map but are not correctly aligned at the map boundary. Edge matching must be done for the geographic information from several adjacent maps to be represented as a single continuous data layer.

Editing Functions. These are use to add, delete, and change the geographic position of features.

Line Coordinate Thinning. This function is used to reduce the number of coordinate pairs that must be stored in the GIS. Often, more coordinate are entered (during digitizing or scanning operations) than are actually needed to define a geographic feature. The procedure will tend to improve system performance.

2.3.4.2.2. Maintenance and Analysis of the Non-spatial Attribute Data.

This group of functions is used to edit, check, and analyse the non-spatial attribute data. Included in this group are: attribute editing functions and attribute query functions.

Attribute Editing Functions. These functions allow the attributes to be retrieved, examined, and changed.

Attribute Query Functions. These are used to retrieve records according to conditions specified by the user.

2.3.4.2.3. Integrated Analysis of Spatial and Attribute Data.

The power of a GIS lies in its ability to analyse spatial and attribute data together. It is these capabilities that most distinguish a GIS from automated and computer aided drafting systems (Arnoff, 1989; Antenucci et al, 1990; Malczewski, 1999). The range of analysis procedures included in this group of functions is diverse, and is subdivided into four categories:

retrieval/classification/ measurement, overlay, neighbourhood, and connectivity or network functions.

Retrieval, Classification and Measurements

Retrieval operations on the spatial and attribute data involve the selective search manipulation, and output of data without the need to modify the geographic location of features or to create new spatial entities.

Classification refers to the procedure of identifying a set of features as belonging to a group. Classification is one of the important functions of GIS for it assists in defining patterns.

Spatial measurements supported by a GIS include distances between points, length of lines, perimeters and areas of polygons, and the size of a group of cells with the same class.

Overlay operations may be arithmetic, logical, probabilistic or fuzzy. Arithmetic operation involves addition, subtraction, division and multiplication of each value in a map layer by the value in the corresponding location in a second map layer. Overlay operations can also be performed on map layers containing probabilities of events. Another class of overlay operation is based on fuzzy logic, which is a superset of Boolean logic that has been extended to handle the concept of partial truth, that is, the truth between "completely true" and "completely false". Logical operations are based on Boolean algebra. They involve finding those area where a specified set of conditions occur (or do not occur) together.

The data model used affects the performance of these functions. Raster-based systems are in general more efficient than vector-based systems with regard to overlay operation performance. This is because the regular subdivision of space makes an overlay operation easy to implement in the raster domain (Aronoff, 1989; Malczewski, 1999).

Neighbourhood Operations.

Neighbourhood operations evaluate the characteristics of an area surrounding a specified location. Operations included in this category incorporate search, Line-in-Polygon and Point-in-Polygon, Thiessen Polygons, interpolation and contour generation. (Aronoff, 1989; Malczewski, 1999).

Search Operation. This operation requires that the target locations and the neighbourhood be specified. Given these two parameters, an algebraic or statistical operation is applied to the locations within the window. The resulting value is assigned to each location in the neighbourhood(Ibid).

Point/Line-in-Polygon. These operations can be considered as a class of neighbourhood functions in vector-based GIS. They determine whether points/lines are inside or outside a polygon boundary. The attributes of these points/lines identified as being within the polygon can then be processed for analysis by display on a map, computing statistics of attribute values, listing attribute values in tabular form, and so on. Point/line-in-polygon operations are typically performed by topological overlay procedures (Malczewski, 1999).

Topographic Functions. These relate to the calculation of surface characteristics of an area such as slope and aspect from a digital elevation model. The two most commonly used terrain parameters are the slope (the rate of change of elevation measured in degrees or percentages) and aspect (the direction in which a topographic slope faces expressed in terms of degrees from North). Conceptually, the calculation of the slope can be thought of as fitting a plane to the elevation values of the neighbouring points (Aronoff, 1989; Malczewski, 1999).

Thiessen Polygons. These define individual areas of influence around each of a set of points. It is an approach to extending point information which assumes that the best information for locations with no observations is the value at the closest point with a known value (Aronoff, 1989).

Interpretation. This involves a procedure for estimating unknown values using the known values at neighbouring locations. The known values may be associated with points, lines, or areas (Malczewski, 1999).

Contour Generation. Contour lines represent surface relief as a set of lines that represent points of the same value. Contour lines, in topographic map, represent points of the same elevation value. Contour functions make use of interpolation for estimating missing values (Aronoff, 1989).

Connectivity Functions

The distinguishing feature of conectivity functions is that they accumulate the values over the area being traversed. The connectivity functions include such operations as contiguity measures, proximity, network and spread visibility.

Contiguity Measure. These evaluate characteristic of spatial units that are connected. A contiguous area consists of a group of spatial units that share one or more specified characteristics and for a unit. Commonly used measures of continguity are the size of the contiguous area and the shortest and longest straight-line distances across the area (Ibid).

Proximity. Proximity operations generate concentric equidistant zones around a specified location or a set of locations (Berry, 1993, cited by Malczewski, 1999). The proximity operations require four parameters: the locations of target objects, unit of measurement, a function to calculate proximity and the area to be analyzed (Aronoff, 1989; Malczewski, 1999)

Network Functions. Networks are commonly used for moving resources from one location to another. A GIS is used to perform three principal types of network analyses: Prediction of network loading, route optimization, and resource allocation (Aronoff, 1989).

Spread. Spread operation is an extension and generalization of the proximity procedure. In spread operation the distance between a given cell and the target objects is measured in terms of the minimum number of cells that must be traversed to move from that cell to the nearest target. The spread operation can be used to identify travel time between specified locations(Aronoff, 1989; Malczewski, 1999).

2.3.4.2.4. Output Formatting

This relates to the preparation of analysis result for output. Output devises include pen plotters, electrostatic plotters and photographic devises. Some of the most common types of output formatting functions incorporate:

- **Map annotation**, which include titles, legends, scale bars and north arrows,

- **Text labels**, which are placed within the map area and interspersed with the map information,
- **Texture patterns and line styles**. Texture patterns are generated by most output devices. Line widths and colours are used to portray attribute of lines, and
- **Graphic symbols**, which are used to represent map objects. Symbols used to designate a city; a mountain peak and a bridge are common examples.

2.4. GIS and Decision Support

The ultimate goal of GIS is to provide support for making spatial decisions. Particularly, GIS is linked with other systems such as decision support systems and expert systems to complement its spatial analytical tools (Batty and Densham, 1997; Malczewski, 1999).In any case, the aim is to improve the performance of decision makers and managers when they are confronted with semi-structured spatial decision making problems. Central to the concept of spatial decision support systems is the interaction of user(s) with a computer-based system containing a set of tools for analyzing spatial and attribute data and modeling spatial decision problems (Malczewski, 1999).

2.5. APPLICATION OF GIS FOR URBAN DEVELOPMENT PLANNING

The number and type of application that can be performed by a GIS are as large and diverse as the available geographic data sets (Aronoff, 1989). As far as urban development planning is concerned there are many possibilities for the application of GIS. From broader perspective, GIS can be used for planning, analytical, policy-making and management tasks. More specifically, GIS could be applied nearly for all research that involves land-based spatial analysis and modeling (Ottens, 1990).

2.5.1. GIS for Allocation of Land for Housing

The use of geographic information systems for land allocation decision may be well appreciated by exploring the experience of other countries. In the Netherlands, the National Physical Planning Agency, which is responsible for the preparation of spatial policy framework, has been actively involved in developing plans for implementing the policies. The policy framework stretches a broad outline for physical planning of the Netherlands from 1988 to 2015. The intention was to use GIS to translate the broad policy statements into concrete location decisions.

One important goal of the policy was the construction of large number of dwelling units in an already densely populated areas. To that end, a user friendly GIS application has been developed which serve as a tool to allocate and evaluate new building sites in terms of criteria derived from general goal stated in the policy framework and in various other reports, concerned with the spatial aspects of economical, housing, environmental, recreational and rural areas. The selection and the translation of general goals into criteria and appropriate GIS map layers is, of course, influenced by the presence, quality and accessibility of data. A preliminary assessment of the pilot study indicated that it had been a successful application of a GIS (Geertman, 1990).

2.5.2. GIS for Evaluating Public Services

A survey was carried out in the Florencio Valela District of Buenos Aires (in Argentina) to assess the general level of public services related to health maintenance and assistance. The purpose was to identify the specific areas in which public utilities (water and gas supply, sewage) and health services are most urgently needed. The use of a GIS made it possible to provide a comparison of the supply and demand of utilities and services which indicated various degrees of severity and vulnerability, generally conforming with population density (Rodriguez and Aguglino, 1990).

2.5.3. GIS for Identifying Areas for Restoration

GIS has also been used in establishing restoration suitability of the historic center of Havana (in Cuba). Because of its historical and architectural significance, UNESCO as "patrimony of the world" declared Havana in 1982. Since then great effort has been made to preserve and restore this living monument. The planners, architects and other specialists involved in the restoration required a proper automated tool to help them in assigning restoration priorities. A GIS was used to identify those areas in most urgent need of restoration, not only in a detailed graphic database (parcel map) but also in an aggregate graphic database (block map). These attributes, needing urgent restoration, could then be selected and shown by the system from attribute combinations
specified by the user (Machado, 1990).

CHAPTER THREE

URBAN PLANNING IN ETHIOPIA

3.1 GENERAL INFORMATION

3.1.1. Urban Development Planning Exercise in Ethiopia

Virtually all Ethiopian towns and cities were established without proper plans (Tadesse, et al, 1997). It was only in the late 1950's that Ethiopia first started giving attention to urban development planning by formulating appropriate development strategies (Solomon, 1999). This means that the history of urban development planning in Ethiopia can be estimated to be only half a century old. The emphasis at that time was largely on the issue of land use control. A series of three different types of 5-year plans were prepared between 1958 and 1974. The focus of these plans in general was (Solomon, 1999):

- Development of infrastructure,
- Expansion of agriculture and manufacturing industry, and
- Maximization of growth and attainment of better standard of living.

In 1964 the first huge planning project with the aim of preparing master plan for forty towns of the country was commenced and completed in 1967. The responsible government arm was Ministry of Interior and the contract was given to three Italian Companies (Tadesse, et al, 1997).

Later the development and planning aspect of the urban sector was handled by the Ministry of Urban Development and Housing, which was established through proclamation No. 126/1977. The various plans prepared, however, were not responsive as expected due mainly to lack of integration of the various aspects of urban development planning (such as social, economic, cultural and physical concerns of the towns). Neglect of the interactions of the towns with their corresponding immediate hinterlands was also important factor (Ibid).

As urban problems in the country got more and more complex, the concern of the government and the importance of having sound urban planning practice became notable. To that end, the Military Government of Ethiopia established the present National Urban Planning Institute (NUPI), in 1987 (PMGE, 1987). The proclamation empowers the institute:

- to prepare different types of plans for towns and cities of the country based on appropriate study and research;

- to prepare plans for regional urbanization, metropolitan area and urban centers; and

- to recruit the required manpower necessary for executing the above mentioned responsibilities.

The traditional planning power of the central government was decentralized to Regional and Local authorities following government change in 1991. Regional governments have been given power to prepare and implement urban plans under their jurisdiction (TGE, 1993). However, for reasons associated with lack of appropriate technical manpower, and equipments, regional governments would still require technical and other assistances from the central government in preparing, monitoring and implementing urban development plans (Tadesse et at, 1997; Demissew, 1996; Solomon, 1999).

Because NUPI is not adequately strengthened, it does not still exercise all its power except for the preparation of urban plans (Demissew, 1996). The Ministry of Works and Urban Development has also the responsibility of conducting socio-economic studies related to urban areas, preparing master plans for them and providing technical assistance to regional governments during implementation (TGE, 1993). This means that the main actors engaged in urban development planning in Ethiopia are Ministry of Works and Urban Development, NUPI (Tadesse et al 1997; Demissew, 1996) and some regional governments (to minor extent).

3.1.2. Current Planning Practice Undertaken by NUPI

NUPI, the chief plan preparation agent of the Federal Government, has been employing three fundamental approaches to urban plan preparation (for various town of the country). The approaches include master planning, development planning and action planning.

In light of the planning practice adopted by NUPI, these basic planning types possess much similarity in essence. The differentiating features, though not sound, are related to the time dimensions the plans are expected to serve, the composition of the professionals involved, the scope and content the plans dwell on. Currently, however, NUPI has almost completely abandoned preparing master plans (Belachew, 2001) for reasons to be clarified shortly. The basic traits of these plan types are briefly discussed here below.

3.1.2.1. Master Plans

Basic attributes of and major activities involved in master plans include (Tadesse et al, 1997; Belachew, 2001):

- embrace multidisciplinary planning team;

- involve production of maps with accompanying textual documents, specifying land use categories, road structure, and other physical standards;
- usually provide a city-level guidance for development activities; and
- provide long-term(a twenty-year) framework. Such plans, however, are subject to review every five-year (though this has been done for no town by NUPI).

According to Belachew (2001), NUPI has terminated (as mentioned a bit earlier) preparing master plans merely in favour of shorter plans apparently to facilitate investment and settlement programmes across centers in the country. He further identifies the following drawbacks related to master plans:

- take long time to prepare;
- lack estimate of cost of development;
- assumptions are not based on realistic evaluations of economic potentials and likely population growth;
- are characterized by longer time perspective, and proposals are aimed at being implemented over longer time period. This makes the plans rather rigid and inflexible to the extent that it would be difficult to control socio-economic dynamics.

3.1.2.2. Development Plans

Development Plans are medium-term plans intended as an attempt to alleviate the drawbacks inherited in master plans. They are more detailed and relatively more efficient (i.e., in NUPI's context) than master plans. Development plans focus on areas which should be developed and redeveloped. Specifically, they define the sites of proposed roads, buildings and open spaces, allocate land for agricultural, industrial and other uses. They also provide the ground for development coordination. Their drawbacks incorporate the level of detail they propose and definition of broad strategies inherited from master plans (solesbury, 1974; Belachew, 2001).

Development plans are not merely implemented immediately once prepared. Instead, NUPI applies further division upon them, resulting in three distinct components. These are district, action area and subject plans that are intended to serve as implementation tools within a broader framework of a citywide structure.

3.1.2.2.1. District Plans

District plans provide comprehensive planning of relatively large areas in which change is expected to take place largely in piecemeal fashion and at a relatively slow and uneven pace. Provision of greater detail to specific proposals and strengthened ground for development control are some of the opportunities provided for the planning agent to expound the objective of the development plan. Any firm proposals, conforming generally with the structure plan, may be included whether or not it is for early executive action or will produce a major change in the area, and policies to be applied within the whole or parts of the area through the time period of the structure plan can be expressed (Ibid).

3.1.2.2.2. Action Area Plans

These are also comprehensive planning exercises, but for areas which have been indicated in the development plans or district plans as those in which intensive and relatively rapid change by redevelopment, development or improvement by public or private agencies seems certain to happen within short period of time extending from one to three years (Solesbury, 1974).

Action area plans might be used to secure coordination of projects between a local authority, other public agencies and private developers in developing new housing area, redeveloping a town center or inserting new roads and associated redevelopment in built-up areas (Ibid).

These types of plans are detailed, usually prepare in the scale of 1: 2000-1: 500. This means that they can be manipulated at plot parcellation level, indicating all types of urban activities. They are tools for implementing development plans (Belachew, 2001).

3.1.2.2.3. Subject Plans

The subject plan is essentially a device for bringing the characteristics of development plans to topics of limited areas not as part of a comprehensive plan. Examples may be landscaping of motorway corridor or the recreational use of a certain area (Solesbury, 1974).

3.1.2.3. Action Plans

These types of plans emerged in situations where either some urban problem inexplicably persisted or where changes were too fast for analytical planning to positively respond (Tadesse, et al, 1997). Consequently, action plans are implementation-oriented and are prepared with a short-term perspective (usually intended to serve a 5-year period).

Action plans, however, are characterized by some pitfalls. Belachew (2001) summarizes the following drawbacks in the action planning process:

- Urban land (which may well serve beyond the implementation period of the action plan) may be compromised. Belachew associates this problem with possible misconception on the part of plan implementers to consider these areas as left over vacant lots; and

- The level of financial and managerial commitment being invested may hinder the smooth implementation of the action plan.

3.2. ABATTOIRS AS IMPORTANT URBAN FUNCTIONS

3.2.1. Basic Features

Though not accomplished by all, the major activities involved in the operation of an abattoir are :

- receiving and holding of livestock;
- slaughter and carcass dressing of animals;
- chilling of carcass product;
- carcass boning and packaging;
- freezing of finished carcass and cartooned products;
- rendering processes;
- drying of skins;
- treatment of wastewater;
- transport of processed material

The ultimate purpose or importance of establishing abattoirs is, thus, (LMA, 2000; ORAAMP, 2001):

- to provide cleaner and hygienic animal slaughtering services;
- to ensure proper utilization of animal by-products including hide, skin, horns, bones and so on.
- to establish and control standards, and to generate income for the services rendered;
- to ameliorate impact on the environment by controlling the waste disposal system.

3.2.2. Environmental Problems Associated with Abattoirs

The characteristics of abattoirs are such that they can pose serious problems to the environment unless these problems are adequately appreciated and appropriate measures are taken. The issue could be discussed in terms of liquid wastes, solid wastes, airborne wastes, diseases and noise (EPA, 2002).

3.2.2.1. Liquid Wastes

One basic trait of abattoirs, among other things, is that they consume large amount of water in their animal processing operation mainly for hygienic reasons. Such situation produces large amount of wastewater which must be treated. In general, the effect of liquid wastes could be explained in terms of effluent salinity and wastewater as well as storm water qualities.

3.2.2.1.1. Effluent Salinity

Effluent generated from dry salting skin preservation method is highly saline and has a very high biochemical oxygen demand. It contains high levels of fluoride. This may lead to salinity problems if the effluent is used for irrigation, and also to fluorosis problems with vegetation.

3.2.2.1.2. Wastewater

Wastewater produced in animal slaughter areas typically has a high biochemical oxygen demand. It is also very saline and has high levels of nutrients, suspended solids and bacterial contamination.

3.2.2.1.3. Stormwater

There is a chance for stormwater to get contaminated when it comes into contact with animial holding pens, sludge. Stockpile and treated wastewater irrigation area. This contaminated stormwater can have detrimental environmental effects on the surrounding eco-system.

3.2.2.2. Solid Wastes

Solid wastes generated from within an abattoir may have different sources including animal holding areas, slaughterhouse and processing areas, waste treatment plant, unwanted hide or skin and pieces, and unwanted carcasses and carcass parts.

3.2.2.3. Airborne wastes

Airborne wastes can refer to odours, dust and fuel burning emissions.

3.2.2.3.1. Odours

Potential sources of disagreeable odours in abattoir operation consist of the cooking and rendering process, water effluent treatment plants, slaughterhouses, product storage and handling areas, material drying areas, waste disposal techniques such as burning dead stock, animal holding pens, livestock transport vehicles, holding of carcass before disposal, odours from skin handling and odours from skin sheds.

3.2.2.3.2. Dust

Potentials sources of dust emissions at an abattoir include unsealed roads, paddocks, saleyards and holding pens, stockpiled products and materials, and construction activities.

3.2.2.3.3. Fuel Burning Emissions

Fuel burning leads to atmospheric emissions. Materials burned at an abattoir incorporate coal or gas fuel for boilers and steam production, diseased animals, sludge, packaging and unusable skins.

3.2.2.4. Diseases

In abattoirs there is a large potential for the transmission of zoogenic diseases such as Q-fever and anthrax to humans.

3.2.2.5. Noise

In an abattoir noise can be generated from different sources including animals, processing activity within the slaugherhouse, plant machinery, and service vehicles.

3.2.3. Utilities for Abattoirs

New sites for abattoirs are usually located on vacant undeveloped area. In such cases, it is important that the necessary infrastructure, facilities and utilities are provided for the proper functioning of an abattoir. The discussion below is based on the guideline provided by LMA (2000).

3.2.3.1. Water Supply

As already discussed, the various operations occurring in an abattoir involve the use of large amount of water. Most of the time such water requirement are satisfied from the corresponding municipal town's water supply system. However, where such water supply system is inadequate or absent, deep wells should be boreholded.

3.2.3.2. Electric Supply

Among other things, laboratory activities are conducted in an abattoir. In order for the laboratory to provide regular service, there ought to be an interruptible electric supply. For meat examination, the intensity of the light should be 540 lux and in other working places it could be 220 lux or 110 lux depending on the situation.

3.2.3.3. Road Accessibility

Access roads to abattoirs should be at least compacted gravel road as per the Ethiopian Road Authorities rural road standard (RR10). The provision of such facility, of course, depends on the financial capacity of the corresponding municipality.

3.2.3.4. Waste Disposal and Drainage Systems

It is recommended that for efficient waste disposal and drainage system, the topography of the abattoir site preferably be gentle slope.

3.2.4. Planning Issues

Studies of the causes and effects of soil, water, and air pollution and of noise nuisance and risk reveal increasingly that the land use planning should play an important role in the prevention of pollution (Velden, et al, 1990). Almost every pollution problem has both a spatial and a temporal dimension. Therefore, appropriate land use planning, taking into account the prevention and solution of environmental problems is essential (Velden, etal, 1990; EPA 2002).

As far as abattoirs are concerned, land use planning could help, among other things, in designating appropriate sites and provision of buffer zones.

Site selection is the critical environmental issue for abattoirs (EPA, 2002). Careful site selection can greatly reduce the environmental nuisance. Relevant Site information should include (NUPI, WHO, LMA, 2000; ORAAMP, 2001; EPA, 2002):

- the closeness to existing and future housing developments, and to land zoned to permit housing or other land uses not compatible with proposed development.
- Conformity with civil aviation free corridor regulation.
- the site hydrology: flood liability, site drainage and closeness to water courses and ground water resources used for domestic, agricultural or town water supply.
- the prevailing wind conditions
- the land form and the likely direction of draft of odour or effect of noise
- direction of major cattle supply inlets and proximity to cattle market.
- the adequacy of the land area to house all projected activities.
- the erosion hazard
- the local road network
- corridors for power and other services
- suitability of the site for possible disposal.

CHAPTER FOUR

DESIGN OF ABATTOIR SITE SUITABILITY MODEL

4.1. INTRODUCTION

A main concern of urban land use planning is the designation of suitable sites for the appropriate land uses. The selection of suitable site for abattoir must be based on a set of local criteria to ensure that the maximum cost-benefit ratio for a community is attained. The suitability of a site for an abattoir is influenced by the various characteristics of the site. However, each characteristic only reflects an aspect of the overall suitability for the specific land use.

Furthermore, when a site is found suitable for an abattoir it does not automatically ensure a maximum benefit for the community to assign the site for such a use. Several land uses may compete for the same site. The necessary choices are the subject of the overall urban development planning or the master plan of an area (Hofstee, 2000).

A GIS- based site suitability analysis requires that the site selection criteria should be identified and integrated into a GIS database in the form of map layers with associated attributes. Consequently, a set of criteria for abattoir site selection has been identified based on literature review and relevant experts' opinion.

Virtually all the selection criteria identified are geographic in nature in the sense that they can be referenced to a particular location. The various data sources (mapped data available in paper, CAD and dat-file format) used to generate map layer equivalent of the criteria. These map layers, with their attribute data, used to construct abattoir site suitability model, the implementation of which on Arc View GIS Version 3.1 yielded suitable sites for the abattoir. Figure 4.1 provides an overview of the general procedure followed.

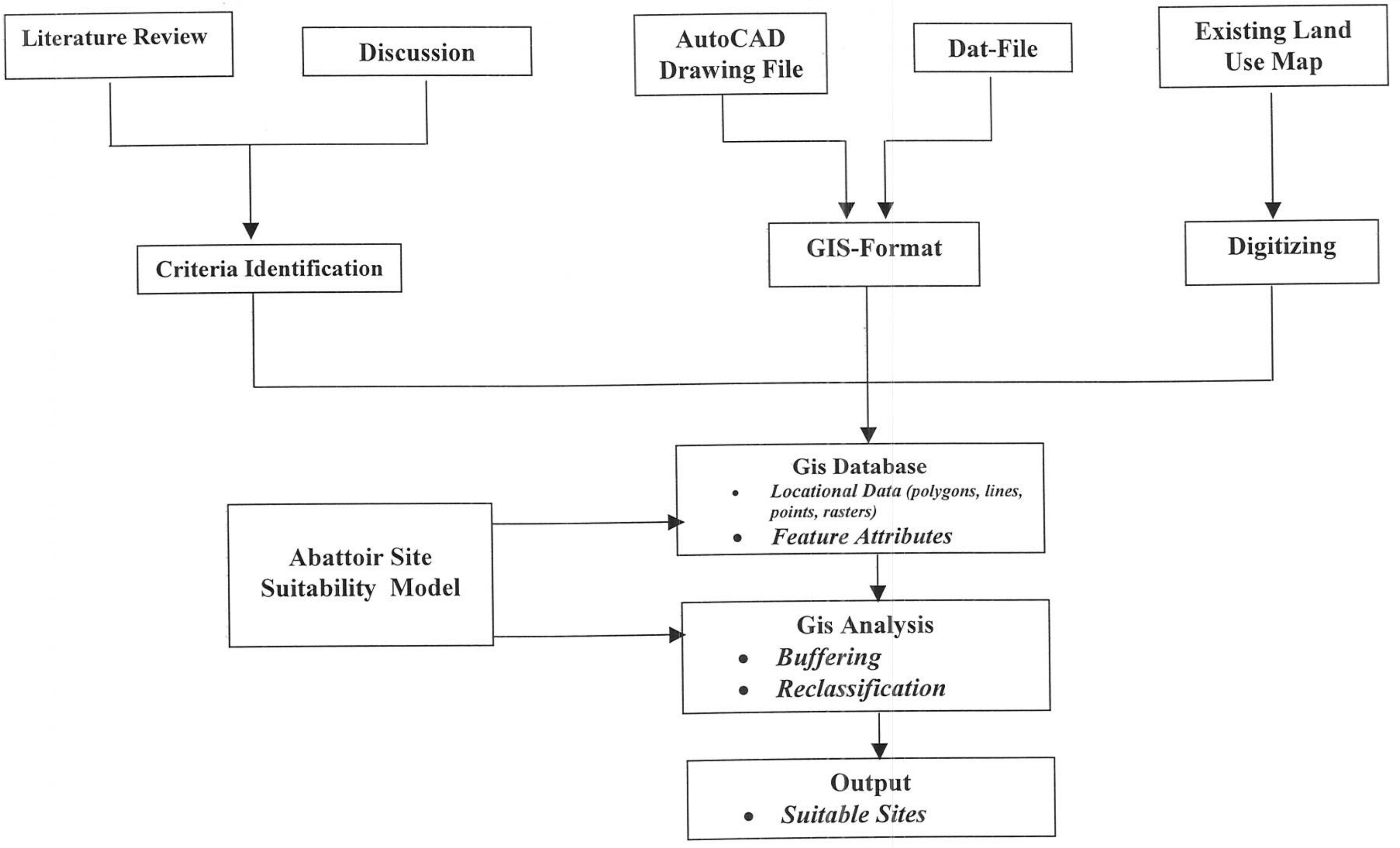


Figure 4.1. A Diagram Indicating the General Procedure for Selecting Suitable Abattoir Site

4.2 . IDENTIFYING THE CRITERIA

Before discussing the issue of site selection criteria, it would be worth mentioning here the experience of NUPI as far as site selection for abattoirs is concerned. NUPI conventionally uses a list of criteria for the selection of abattoir's site for a given town under study. Because of administrative and service problems associated with the financial and material capacities of the respective municipalities, abattoirs are located within the municipal boundary. The data on the distance between the abattoir and the various spatial entities is obtained from NUPI. Some figures are also obtained from other organizations through literature review.

As a spatial decision making problem, site suitability analysis involves several steps or procedures. Among other things, identifying site selection criteria is a critical step. Figure 4.2 portrays a diagram that provides a convenient structure of the site selection criteria. The structure could serve as a framework for better understanding of the various specific objectives and spatial entities involved in the overall suitable site designation process for abattoir.

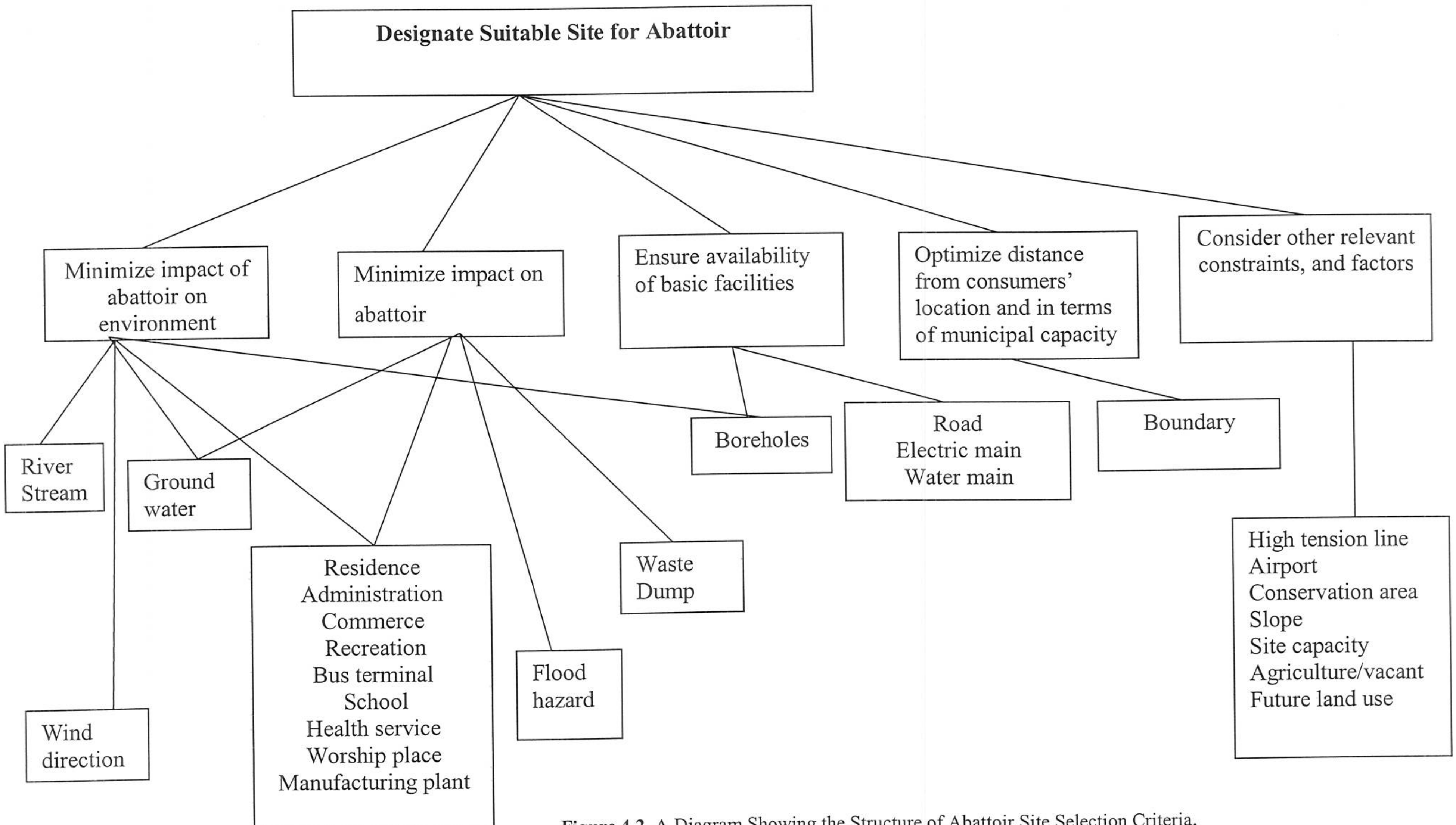


Figure 4.2 A Diagram Showing the Structure of Abattoir Site Selection Criteria.

As can be noted from the figure, the overall objective (the goal) is to designate suitable site for an abattoir. Towards fulfilling this objective, the following more specific objectives are considered:

- Minimize impact of abattoir on the surrounding environment,
- Minimize impact of nearby activities on the abattoir,
- Ensure availability of basic facilities that are necessary for the proper functioning of the abattoir,
- Optimize distance from consumers' location and in terms of municipal capacity, and
- Consider other relevant constraints, factors and targets.

Once the set of objectives has been identified, measures for achieving those objectives are specified to provide an indication of the degree of attaining an associated objective.

The performance of the first objective (i.e. minimizing impact of abattoir on environment) is assessed in terms of eleven features: residential, administration, commercial and recreational areas, bus terminal, school, health service, worship place, rivers/streams, wind direction or influence and boreholes. All (except wind direction) are measured in distance units (meters). The focus is on alleviating possible negative impacts that the abattoir can pose on the surrounding environment and vise versa. The impact that the abattoir poses may manifest in the form of liquid wastes (characterized by effluent salinity and bacterial contamination), airborne wastes (mainly disagreeable odours), large potential for the transmission of zoogenic diseases, noise, traffic congestion, attraction of animals (such as hyenas) and big birds, etc. Much of such environmental problems can greatly be reduced through appropriate siting of the abattoir (EPA, 2002; Veldon, et. al, 1990). The difference between distances attached to the various land use categories emanates from the specific or unique features of some spatial entities which necessitates further consideration. For example, one can find a number of big trees within compounds of churches. If the abattoir is not separated from such churches with sufficient distance, one could imagine the severity of potential problems that can be created by big birds hovering around the abattoir.

A minimum of 250 meters of distance is thus considered to separate the abattoir from residential and administrative areas, and commercial places. Furthermore, the following recommendations are provided:

- The abattoir should be located at least 300 meters from schools, health services, worship places, recreational places and bus terminals.

- In order to avoid possible contamination of the river/ stream and to prevent the abattoir from being flooded, the site should not lie within 100 meters of rivers/streams. Proneness to frequent flooding, not only incurs additional cost but also affects the sanitary condition, both within the abattoir compound and the downstream localities. Furthermore, if abattoirs are constructed near rivers, septic tanks (if not properly lined) may get filled with ground water and ground water pollution may occur, as well.

- According to LMA (2002), on average, a 300-meter distance should be kept between an abattoir and boreholes in order to protect them from being contaminated through ground water flow.

- Furthermore, in order to alleviate the impact of wind in spreading bad odour generated from some activities of the abattoir, the site should be provided with a buffer of 150 to 200 meters radius.

To minimize the impact of neighbourhood activities upon the abattoir, at least two activities are considered. These are waste dump and polluting industries. Waste dump is considered mainly from hygienic point of view; particularly, dust and smoke emitting industries can produce chemical and other form of pollution. Abattoir should be located at least 500 meters from waste dump site and 300 meters from dust emitting industries.

The objective concerned with ensuring availability of basic facilities nearby is assessed in terms the following utilities: roads, electric mains, water mains and boreholes. These are facilities needed for the proper functioning of the abattoir.

Boreholes are to be seen bi-directionally. That is they are facilities required by the abattoir in case the water supply of the town is not adequate and they are also spatial entities subject to contamination if located near the abattoir. For this reason their minimum location from the abattoir should be 300 meters as stated earlier.

The other three issues are important in terms of site development. The closer the site to such facilities the better it is. In this study, it is assumed that electric and water mains are equally available throughout the town. According to data collected by NUPI, this is so since the town is currently beneficiary of hydroelectric power, served by fifteen step-downing transformers, which are spatially fairly distributed from the point of view standard distance (or radius) they are expected to serve.

The performance of the fourth objective (optimizing distance from consumers' location) is assessed in terms of municipal capacity (both financial and material) and the location of consumers. In most towns of the country, poor road conditions and traditional mode of transport dominate. The carcass from the abattoir is transported to consumers under such conditions, usually horse drawn carts on gravel road being exposed to any local environmental harm. To minimize exposure to such harms and also to ensure a timely delivery of the meat (particularly in the morning), the location of the abattoir should be optimal with respect to the location of the consumers. It is, therefore, a usual practice to locate an abattoir within the municipal boundary.

The final objective can be assessed in terms of a package of miscellaneous factors, consisting of high-tension lines, airport, conservation areas, slope, site capacity and agricultural/ vacant land use.

- High tension line. In order to alleviate or avoid possible accidents that could be encountered because of big flying birds (e.g. scavengers) hovering over the abattoir, the site should be at least 500 meters from high tension lines.
- Air Port. An abattoir must not be located within 6 kilo meters of an air port

- Conservation areas. The site should be out of areas needing conservation measure. Such areas should also be protected with a 10-meter buffer.

- Slope. Slope is associated with building cost. Building the abattoir is less expensive on low slopes. The slope is also closely related to surface drainage characteristics of the site. Desirable slope for abattoir site is suggested to be gently slopping area (LMA, 2000), which ranges from 2 to 10 per cent. Slope values below 2 per cent are not suitable from safe drainage point of view.

- Site Capacity. Nearly one hectare of land should be found to accommodate all the necessary components of the abattoirs (LMA, 2000).

- Agricultural / Vacant land use. The site should preferably lie on agricultural/ vacant land use for the purpose of reducing site acquisition cost.

- Future land use. The suitability of a candidate site for abattoir will finally be evaluated taking into account the future intended land use of the area.

To summarize, the criteria so far discussed are of two types: constraints and factors. Constraints are those Boolean criteria that constrain, or limit the areas for abattoir site. In this case, the constraints differentiate areas, or alternatives that one can consider suitable for abattoir site, or alternatives that are not suitable. Factors, however, are criteria that define some degree of suitability for all geographic regions. They define areas or alternatives in terms of a continuous measure of suitability and in fact enhance or detract from the alternatives under consideration outside the areas that have been constrained.

4.3. CREATING THE DATABASE

The method employed for database creation involves first of all designing the database, which involves, among other things, identifying the spatial data needed, determining the feature attributes and map projection.

4.3.1. Designing the Database

4.3.1.1. Identifying the Spatial Data Needed

Each criterion defined in section 4.2 will require a data layer which are to be used for creating the database. The layers are then the representations of the corresponding geographic features (which are the spatial data needed) that are spatially related with the abattoir. Table 4.1 below provides a summary of the relevant spatial data, their layer name assignment, querying attributes and the corresponding criteria (or decision rules). Instead of creating a layer of map for each land use category, they were kept in a single layer i.e., land use layer, so that they can be easily retrieved by formulating a simple query as shown in Table 4.1(column 4). In other words, such land use categories are stored in a single table (labeled attribute table of land use layer). Note that each parcel or block is represented in the table as a polygon, which is actually a record. Other spatial data such as boreholes, waste dump, river/ stream, and road are provided with a layer for each, with accompanying attribute table.

Table 4. 1 Profile of Spatial Data (With Associated Criteria) Required for Database Creation and Spatial Analysis for the Selection of Abattoir Site.

SN	Spatial Data	Layer Name	Querying Attribute	Criteria
1	Residential areas	Residence	LandUse	250 m away from Residence
2	Administrative areas	Administration	LandUse	250m away from Administration
3	Commercial areas	Commerce	LandUse	250m away from Commerce
4	Recreational areas	Recreation	LandUse	300m away from Recreation
5	Schools	School	LandUse	300m away from School
6	Health Service	Health	LandUse	300m away from Health
7	Worship place	Worship	LandUse	300 m away from Worship
8	Industrial area	Industry	LandUse	300m away from Industry
9	Conservation areas	Conservation	LandUse	10m away from conservation
10	Cemeteries	Cemetery	LandUse	100m away from cemetery
11	Boreholes	Borehole	N/A	300m away from Borehole
12	Waste Dump Site	Waste Dump	N/A	500m away from Waste Dump
13	Rivers and Streams	River/Stream	N/A	100m away from River/Stream
14	High Tension Line	High/Tension Line	N/A	500m away from High/Tension Line
15	Vacant or Agricultural Land	Vacant/ Agriculture	Landuse	Select Vacant/ Agriculture
16	Slope	Slope	Slope in percent	Between 2-10 per cent slope
17	Road Network (streets)	Road	N/A	Between 20 and 400 m from existing Road
18	Prevailing Wind direction	Wind	N/A	Provide buffer zone (150 to 200m)
19	Future Land use	Future Landuse	Landuse	Prioritize
20	Site Capacity	Site Capacity	Area in hectare	Greater than or equal to one hectare
21	Boundary/Town Area	Boundary	N/A	Within municipal boundary

NB: N/A = Not Applicable; Layer Name includes both factors and constraints identified in section 4.2

4.3.1.2. Determining Feature Attributes

Most of the attribute data needed for the data layers are related to the geometric properties of the corresponding geographic features. Such features have a set of required fields that are necessary to record the state of any particular feature. These required fields are automatically created when a new feature is created. Such fields incorporate shape, area and perimeter (for polygon features) and length (for line features). Where necessary relevant fields are added for the tables associated with the corresponding spatial features. In this case, some settings for the fields are specified, including field type and the maximum size of the data that can be stored in the fields. All fields have properties such as default value, domain, alias, and allow nulls. Domain can also be set, which is a valid set or range of values that can be stored in the field. The detail is presented in Table 4.2. Furthermore, sample attribute values for the land use layer of the study area is provided in Annex 3. Note that the land use layer includes a lot of features (residence, administration, commerce, etc., as indicated in Table 4.1.

Table 4.2 Profile of Attributes of spatial features Used for Abattoir Site Selection

Layer Name	Attribute Domain Name	Constraint	Meaning	Domain Definition	Description
Land use	Shape		Geometric shape of the feature(polygon).	Automatic	
	ID	Primary key	Unique numbers assigned to each land use block	Character: Size 4	ID number
	Area		Possible values of area in area unit	Float: 6 digit	Area
	Perimeter		Possible values of perimeter in linear unit	Float: 5 digit	Perimeter
	LU_code		A set of codes assigned to a single or a group of block(s) of the same type	Character: Size 5	Land use code
	Buf_dis		Possible buffer distance values	Integer: 3 digit	Buffer distance
Waste Dump	Shape		Geometric shape of the feature (polygon).	Automatic	
	ID	Primary key	Unique numbers assigned to waste dump site	Character: Size 1	ID number
	Area		Possible values of area in area unit	Float: 5 digit	Area
	Perimeter		Possible values of perimeter in linear unit	Float: 3 digit	Perimeter
	Type		Possible types of waste dumps	Character: Size 10	Type
	Buf_dis		Possible distance values	Integer: 3 digit	Buffer distance

Table 4.2: Continued

Layer Name	Attribute Domain Name	Constraint	Meaning	Domain Definition	Description
Borehole	Shape		Geometric shape of the feature(point)	Automatic	
	ID	Primary key	Unique numbers assigned to each borehole	Character: Size 2	ID number
	type		Possible type of borehole	Character: Size 10	Type
	Buf_dis		Possible buffer distance values	Integer: 3 digit	Buffer distance
River/Stream	Shape		Geometric shape of the feature(polyline).	automatic	
	ID	Primary key	Unique numbers assigned to each river/stream	Character: Size 1	ID number
	Length		Possible values of length in linear unit	Float: 5 digit	Length
	Type		Possible types of river/stream	Character: Size 10	Type
	Buf_dis		Possible buffer distance values	Integer: 3 digit	Buffer distance

Table 4.2: Continued

Layer Name	Attribute Domain Name	Constraint	Meaning	Domain Definition	Description
High Tension Line	Shape		Geometric shape of the feature(polyline).	automatic	
	ID	Primary key	Unique numbers assigned to high tension line	Character: Size 1	ID number
	Length		Possible values of length in linear unit	Float: 5 digit	length
	Type		Possible type of electric power lines	Character: Size 6	HTL
	Buf_dis		Possible buffer distance values	Integer: 3 digit	Buffer distance
Boundary	Shape		Geometric shape of the feature(polygon).	automatic	
	Area		Possible values of area in area unit	Float: 5 digit	Area
	Perimeter		Possible values of perimeter in linear unit	Float: 3 digit	Perimeter

Table 4.2: Continued

Layer Name	**Attribute Domain Name**	**Constraint**	**Meaning**	**Domain Definition**	**Description**
Road	Shape		Geometric shape of the feature(polyline).	automatic	
	ID	Primary key	Unique numbers assigned to each road type	Character: Size 4	ID number
	Length		Possible values of length in linear unit	Float: 5 digit	Length
	Type		Possible type of roads	Character: Size 10	Type
	Buf_dis		Possible buffer distance values	Integer: 3 digit	Buffer distance
Slope	Shape		Geometric shape of the slope category (polygon)	automatic	
	ID	Primary key	Unique numbers assigned to slope elements	Character: Size 4	ID number
	Grid code		System generated codes assigned to slope categories	Float: 5 digit	Area

4.3.1.3. Map Projection

Most of the time NUPI obtains topographic maps for project towns from EMA). However, sometimes NUPI itself prepares topographic maps for small towns from scratch whenever there is no base map. The reason is, for such cases, that the mapping process by the EMA is rather costly and time taking (taking on average a year while NUPI can prepare the maps in a month). However, such maps prepared by NUPI are based on local grids. The surveyors at NUPI simply establish grids at their convenience and carry out topographic survey.

In this study such type of map (in CAD drawing format) has been used. Attempt has been made to link the map to the national grid. However, it was not possible to get reference features (on the already obtained map and on a-50000 scale map obtained from EMA). Of course, as an alternative GPS was to be used for that purpose, but the researcher could not find a GPS.

In any way, it is important to note that the map units of the spatial data used are already in meters. It is thus not important to get involved to choose a map projection.

4.3.2 Automating and Gathering Data for the Database

The major activities undertaken in this section include:

- Converting data from other systems and formats,
- Digitizing, and
- Verifying the data and correcting errors.

The mapped data of the study area was already available in CAD-format. It was, therefore, used to extract almost the entire map layers required for creating the database to be used for abattoir site suitability analysis. However, prior to that, CAD-reader extension program loaded on ArcView GIS Version 3.1 was employed to convert the CAD-file to a GIS- data format. The so obtained mapped data has been used for creating a land use layer for the study area (Figures. 4.3, 4.4 and 4.5). Figure 4.3 indicates the major land use categories from which the required data layers are extracted as shown in Figure 4.4. Some of the spatial data layers are presented in isolation for the purpose of clarity (Figure 4.5).

Fig. 4.3 Land Use Data Layer of the Study Area

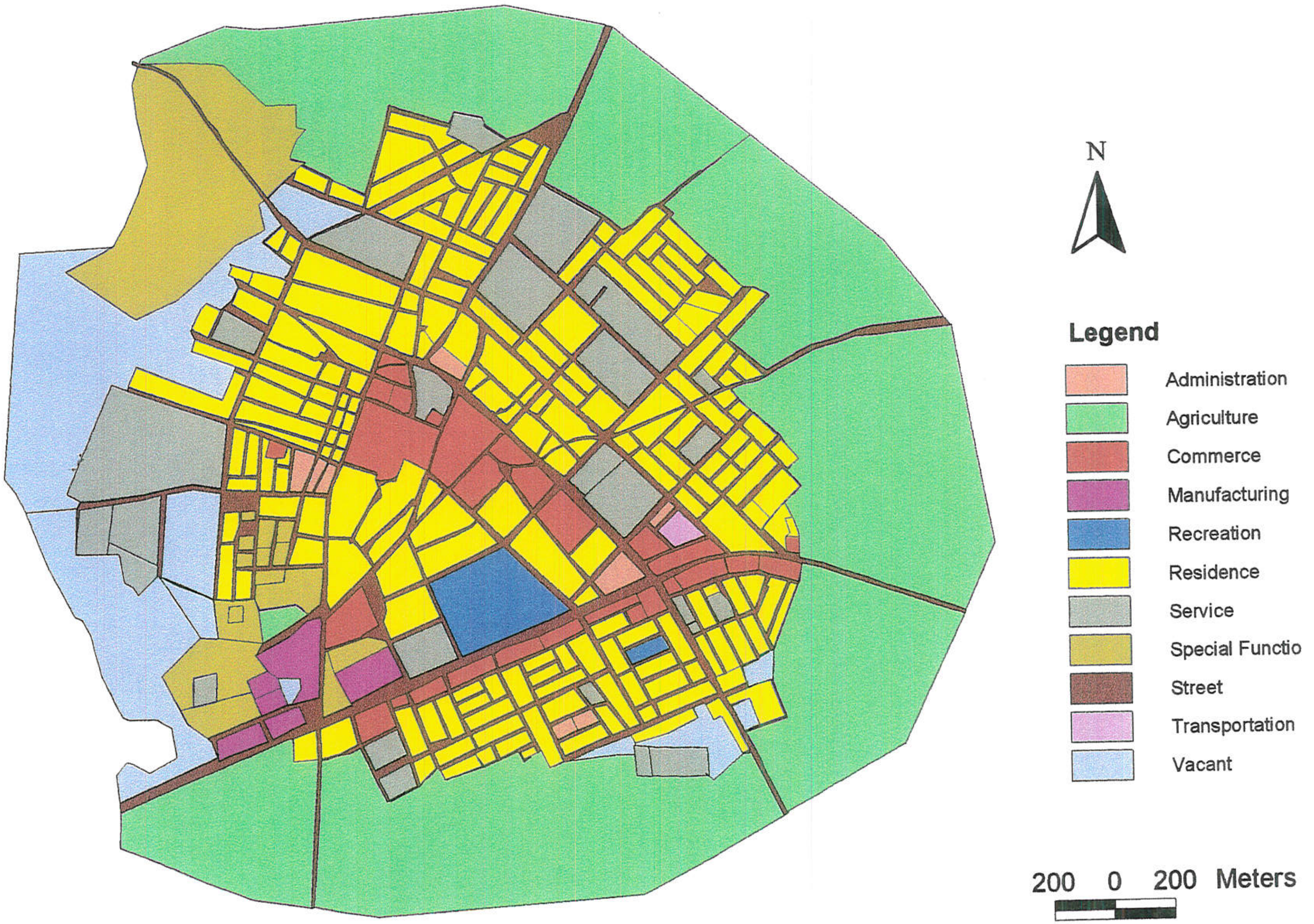


Fig. 4.4 Spatial Data in the Land Use Data Layer

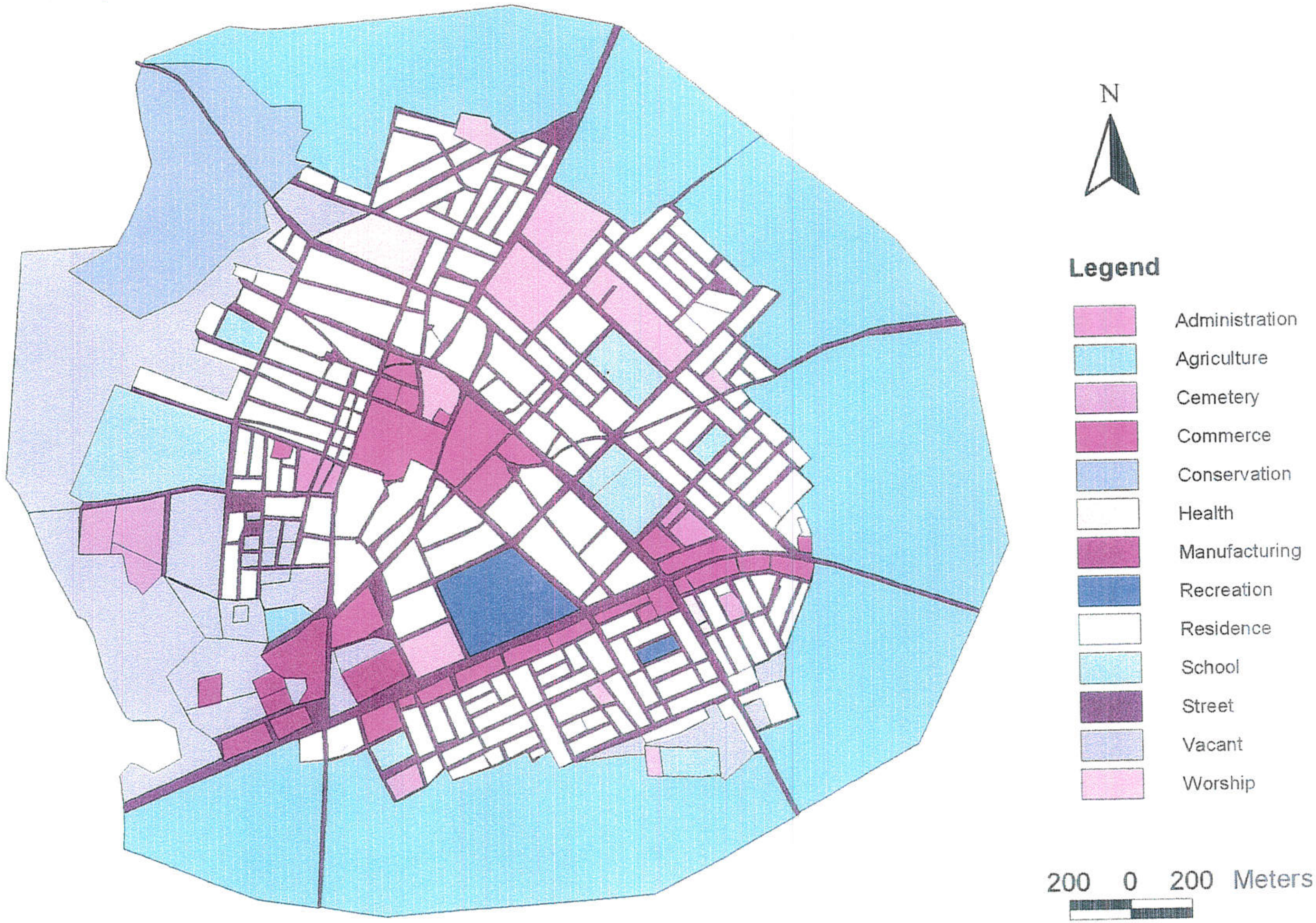
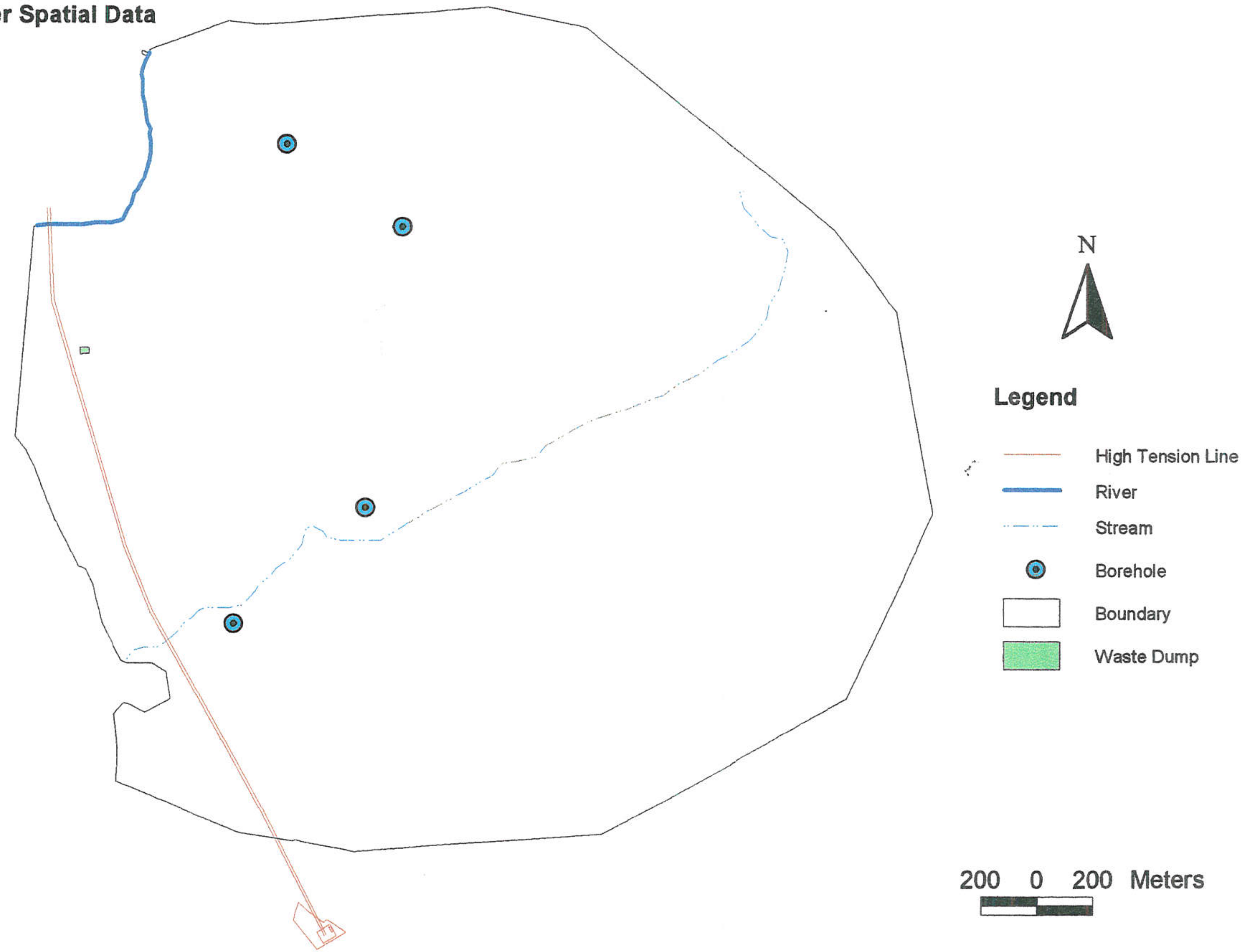


Fig. 4.5 Other Spatial Data



The elevation points for performing slope analysis were also available in text dat-file format. A spatial analyst extension program was used to convert the text dat-file to a GIS compatible format. In the process, DEM was first created from the text dat-file, then a slope map was generated from the DEM, and finally the slope map was reclassified into suitable (2-10 per cent) and unsuitable slope class. Once the required mapped data have been converted to a GIS format, the data are edited by a combination of manual and computerized processes. In this regard, there were at least two basic defects with the mapped data imported from AutoCAD 2000:

- each of the various components of the land use were not kept in a separate layer; everything was maintained rather in a single layer.

- the parcels and blocks were formed in polylines. Thus, it was important to convert the polylines into polygons. XTools extension program was used for that purpose.

Furthermore, the editing process involved on-the-screen digitizing as well as digitizing some features from the paper land use map using the digitizing tablet.

4.4. ABATTOIR SITE SUITABILITY MODEL

The general method used to develop abattoir site suitability model is based on examples given on the various manuals provided by ESRI The examples consist of finding the best site for stores, banks and so on. The steps involved in this study includes:

1. Delineating the areas within which the abattoir should not fall

This involves: -

- Organizing those data layers which are identified to be constraint. These include the following layers: Residence, Administration, Commerce, Recreation, School, Health, Worship, Industry, Conservation, Cemetery, Borehole, Waste Dump, River/Stream, and High Tension Line (see Table4.1 and Annex 1).

- Buffering each of such layers with the corresponding buffer distance to produce constraint maps.
- Combining all the constraint maps to yield the overall constraint map.
- Considering targets to designate suitable sites map. The targets are agricultural or vacant areas.

2. Designating the areas within which the abattoir should fall

This also involves:

- Organizing those data layers that are identified to be factors. Such layers mainly refer to slope and road.
- Buffering each of such layers with the corresponding buffer distance to produce factor maps.

3. Designating highly suitable sites by combining the results of (1) & (2)

That is:

- Combining suitable sites map derived in (1) with the factor maps derived in (2)
- Considering future land use and the influence of wind to yield highly suitable sites. Figure 4.6 portrays a general schematic diagram of the procedure mentioned above. The detailed abattoir site suitability model which is implemented on ArcView GIS Version 3.1 is epicted in Figures 4.7.a, 4.7.b, and 4.7.c.

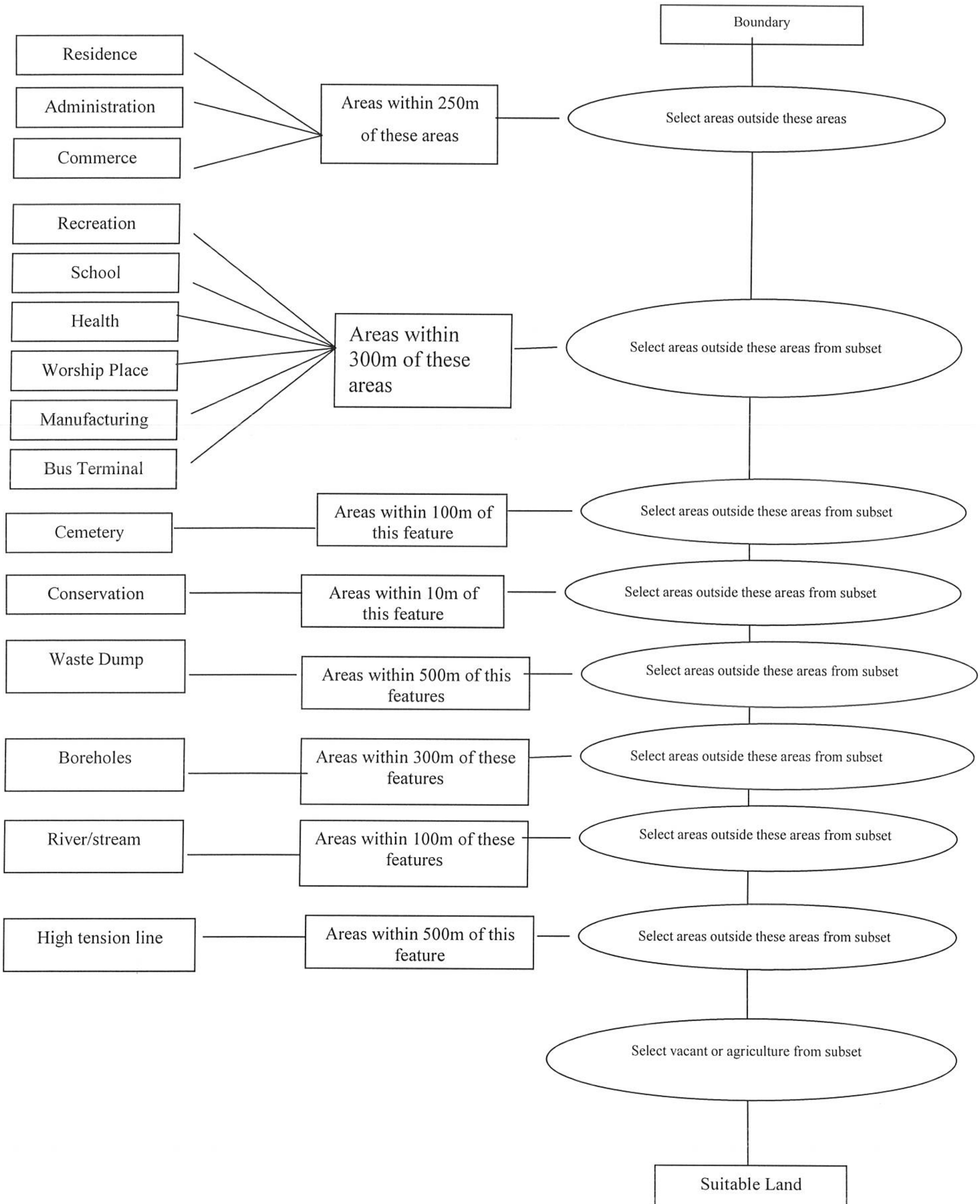


Figure 4.6 A Schematic Diagram of the Analysis Process for Abattoir Site Selection

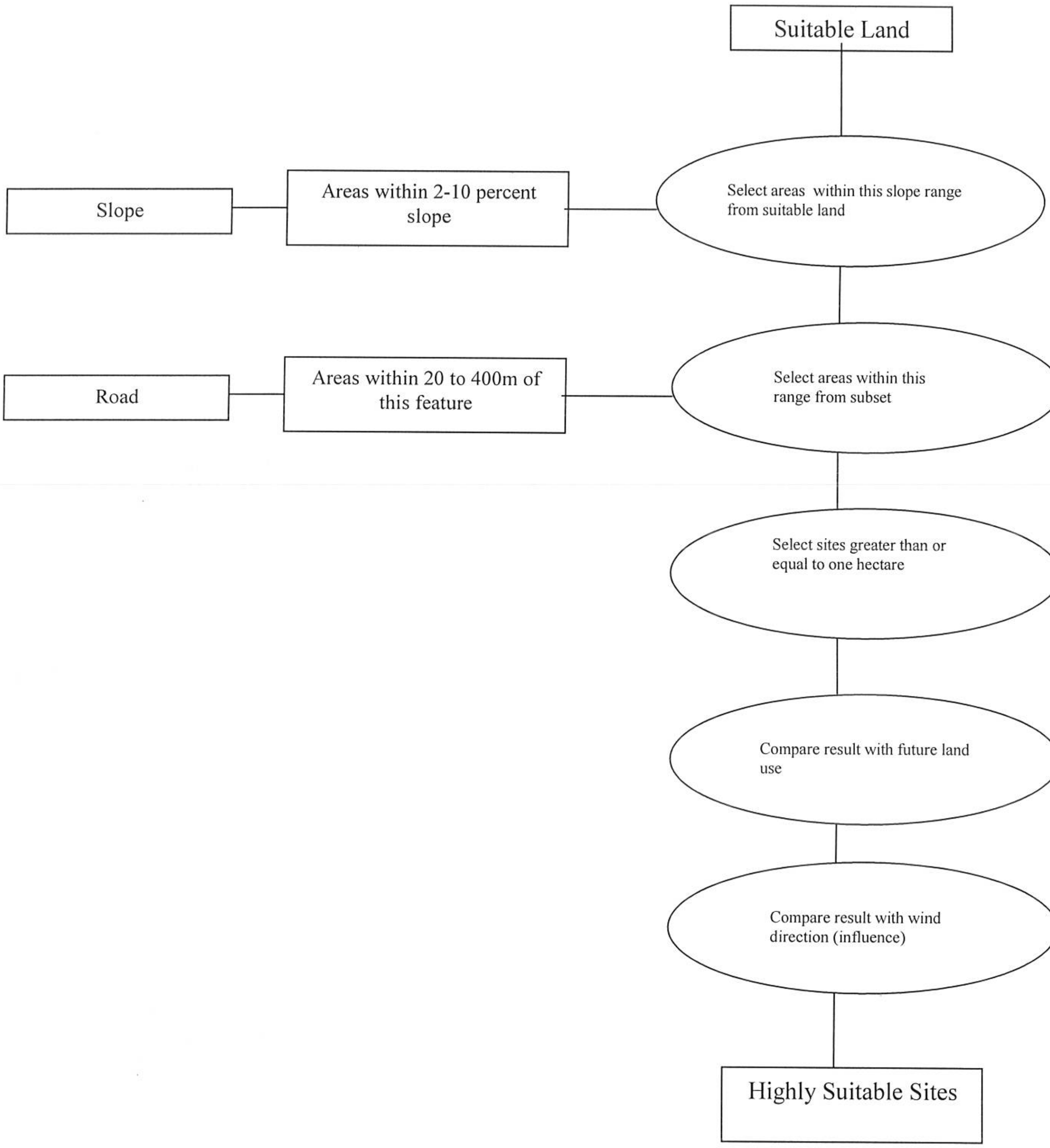


Fig 4.6 Continued

In all cases map layers are indicated as rectangles, any process applied on the map features is represented as ellipses and intermediate process output maps are depicted in the form of parallelograms.

Figure 4.7.a shows the data layers identified as constraints, the corresponding process applied upon them and the resulting constraint maps associated with each map layer. One could see that in all cases the buffer command is commonly applied, while the first four elements involve querying the land use layer table in order to retrieve them and apply the buffer command.

Figure 4.7.b. portrays a model for the process of combining the constraint maps obtained in Fig. 4.7.a into an overall constrain map by applying a series of overlay procedures (that is the union command).

Figure 4.7c depicts a model for the combination of the factor maps and constraint map. In this procedure, the road factor was first buffered with 20 to 400 meters and then was forced to be confined within the boundary by applying the identity command which is loaded on the XTools extension program. The result is shown in the model as "Roadbuf_in". Note that the final output labeled "Suit_Slope_Road_FLandUse" is the highly suitable site which will be provided with a-200 meter buffer in order to minimize the influence of wind.

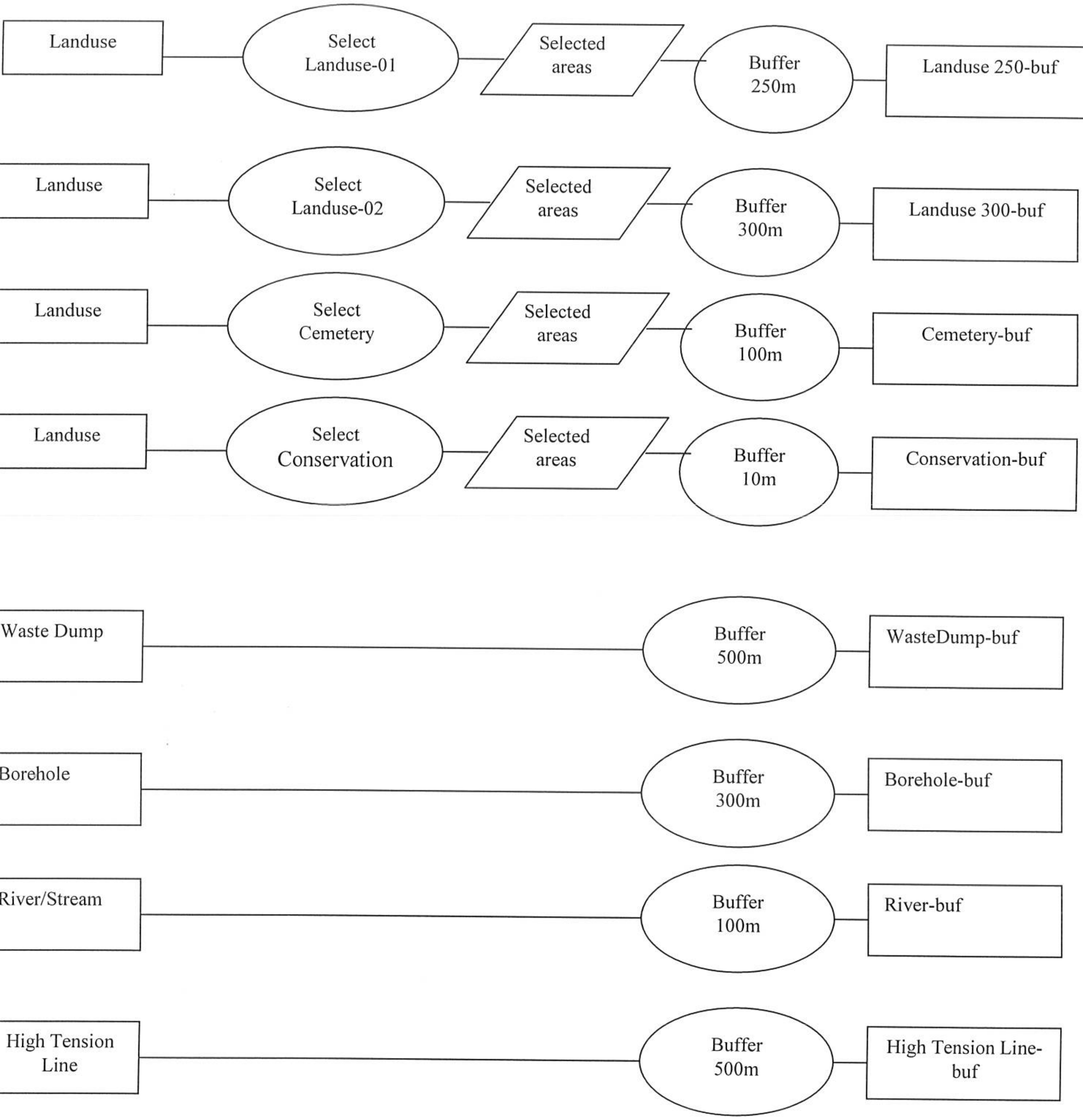


Figure 4.7a A Model Showing Constraint Maps

NB:

Landuse-01= Residence, Administration, Commerce

Landuse-02= Recreation, School, Health, Worship, Industry, Bus Terminal

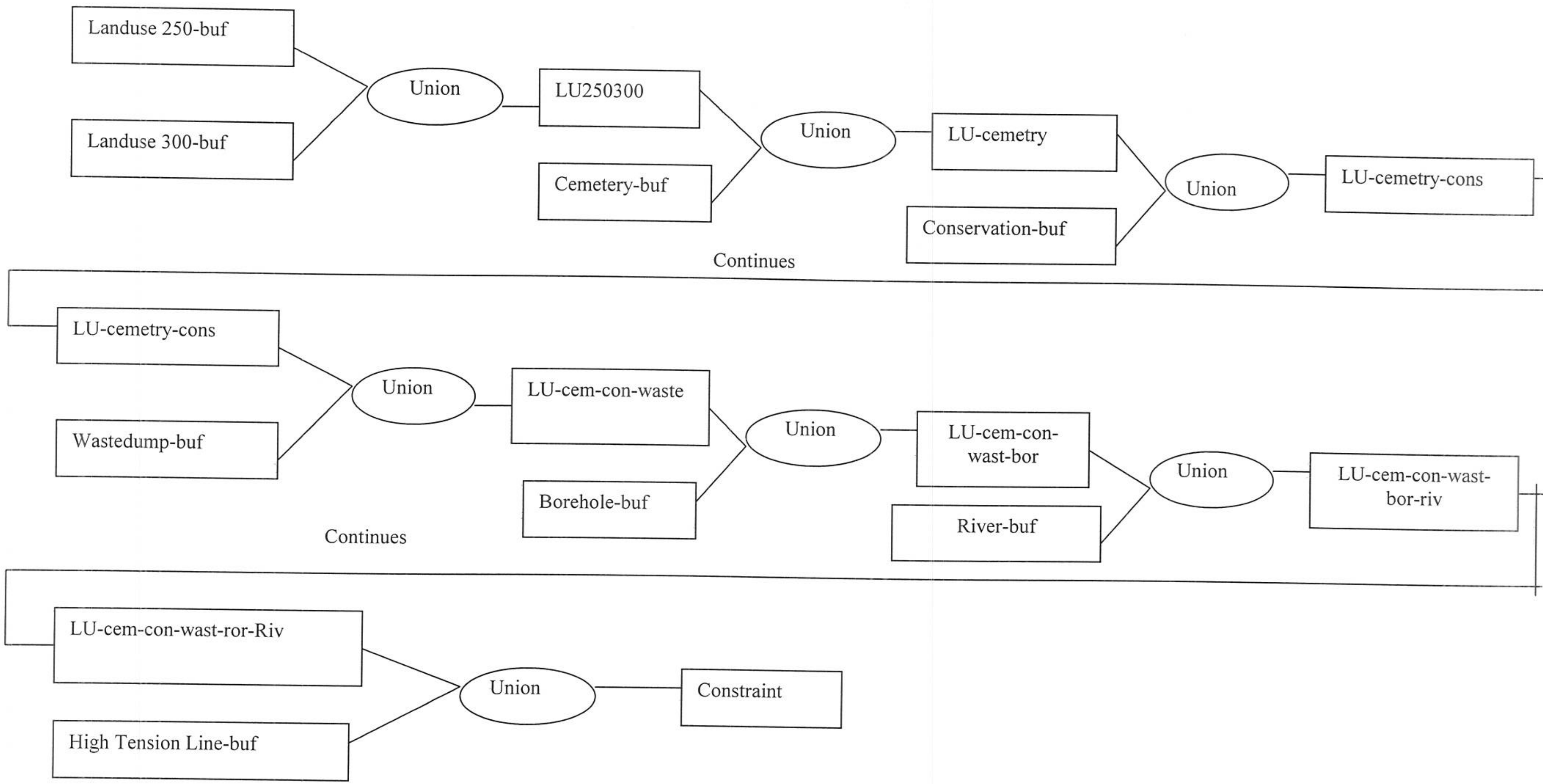


Figure 4.7b A Model Depicting how the Overall Constraint Map is Generated from the Individual Constraint Map Layers Derived in Fig 4.7a.

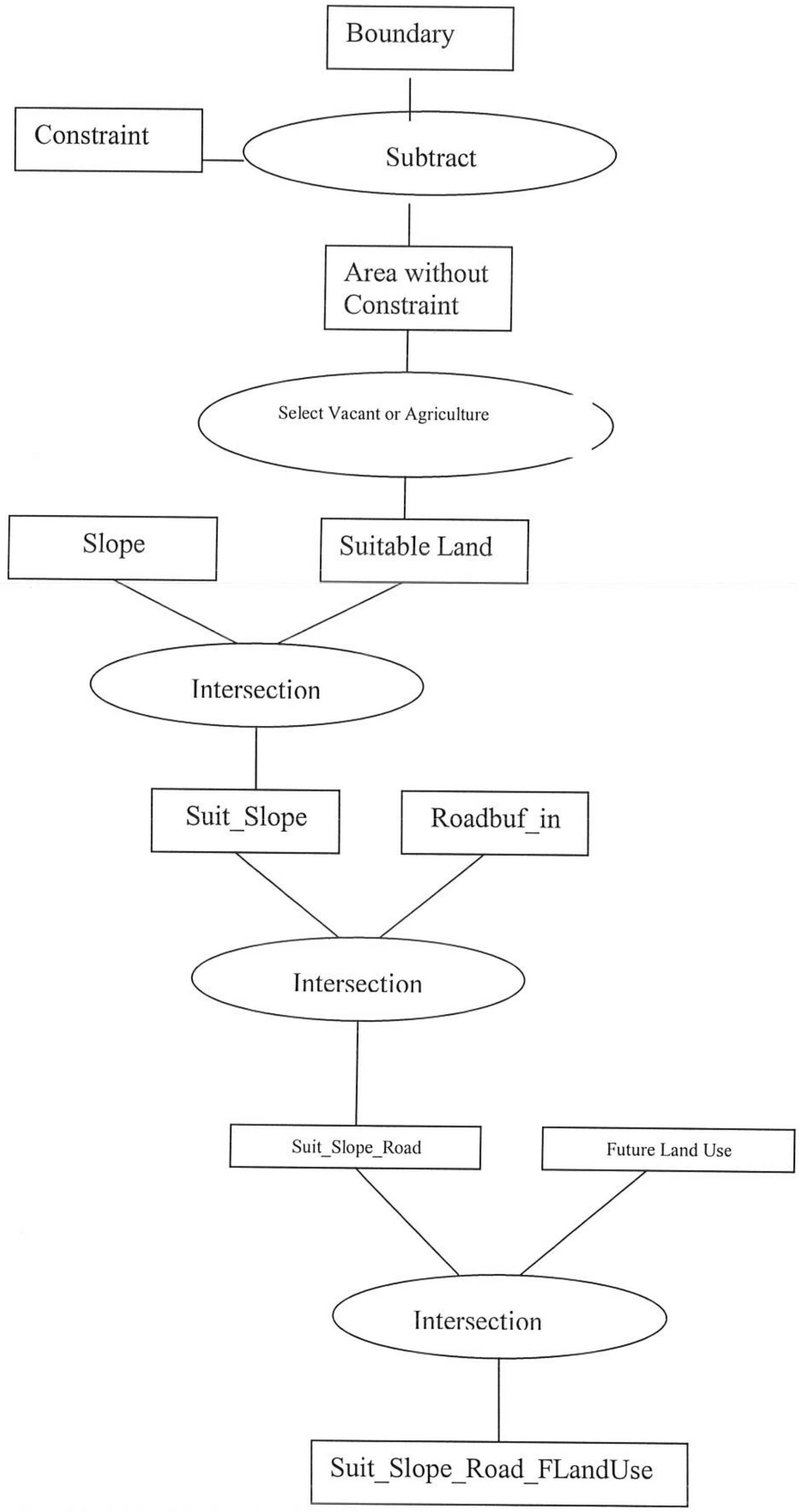


Figure 4.7c A Model Showing the Combination of Constraints and Factors to Yield the Composite Suitability Map

CHAPTER FIVE
RESULTS AND DISCUSSION

5.1. INTRODUCTION

In the preceding chapter, the criteria for abattoir site selection were first identified. The majority of these criteria were then taken as map layers in the database created. In order to select the best site for the abattoir, a site suitability model was built. This chapter thus provides a discussion on the results of the analysis.

5.2. CONSTRAINT MAPS

The overall effect of the constraint maps (Fig.5.1) indicates the extent of the study area which is designated as suitable and not suitable for siting the abattoir. Conversely, excluding the area taken up by the unsuitable area from the study area and then selecting target land uses (vacant/ agricultural land) would yield possible suitable areas that are characterized by varying degree of suitability for siting the abattoir. It should be noted that, as far as NUPI's planning exercise in urban development planning is concerned, the existence of such possible suitable area holds in most cases. This is so since land allocation for abattoir (like other similar urban functions) is usually handled when a development plan is prepared. This type of plan envisages a 10-year perspective of a given town under study. The amount of land that would be required to accommodate all the demand for land will be estimated based on demographic and other relevant factors. Consequently, the boundary of the town under study will be redefined, usually at expense of the surrounding agricultural lands. Thus, this additional area is incorporated and analysed with the original area in the process of site allocation for abattoir. This is the case with this study, as well.

Other obviously possible sites are highly constrained by the existence of the high tension electric line within the boundary of the study area. It should be remembered (section 4.2) that the incompatibility of an abattoir to be located close to such electric line emanates from its characteristics to attract big flying birds, which could be a cause for possible accidents on the high tension line. In any way, there is still large amount of area whose relative suitability for siting the abattoir needs to be assessed by combining it with the factor maps (i.e., slope factor map and road factor map).

At this stage, it is important to note the combined effect of having the overall constraint map and considering the target land uses (mentioned above) in fulfilling some of the specific objectives established from the outset, as a structure of the general objective of designating suitable site for abattoir (section 4.2). Such effect includes:

- minimizing impact of the abattoir on the surrounding environment, and
- alleviating possible impact of neighbouring activities on the abattoir.

Fig. 5.1 Constraint Map

5.3. FACTOR MAPS

The factor maps (slope factor map and road factor map) indicate the relative suitability of the area for siting abattoir, based mainly on costs associated with the site development. The slope factor map differentiates the area with respect to slope requirements. The areas delineated by the slope requirement (Fig.5.2) indicate those areas that are characterized by optimum slope, which ensure safe drainage of liquid waste generated from the abattoir. Furthermore, such area does not incur much cost in shaping or excavating the ground surface for construction purpose. The slope threshold between 0 and 2 per cent represents areas not suitable from safe drainage point of view.

The road factor map (Fig.5.3), on the other hand, portrays the relative accessibility of the area from existing road network as far as abattoir site is concerned. For the purpose of the analysis, largely all-weather roads that cross the boundary of the study area are considered. Areas delineated based on the road accessibility requirement, in addition to possessing optimal accessibility, are characterized by being less susceptibility to dust attack. As it is known, most of Ethiopian towns have road networks not paved with asphalt material. As a result, dust problem prevails depending on the local vehicle traffic density and the intensity of the wind. In order to alleviate the impact of the former on the abattoir, a depth of 20 meters from an existing road is incorporated in the road factor threshold. The overall factor map thus implicitly reflects the integration of the characteristics of the entire factor maps discussed above.

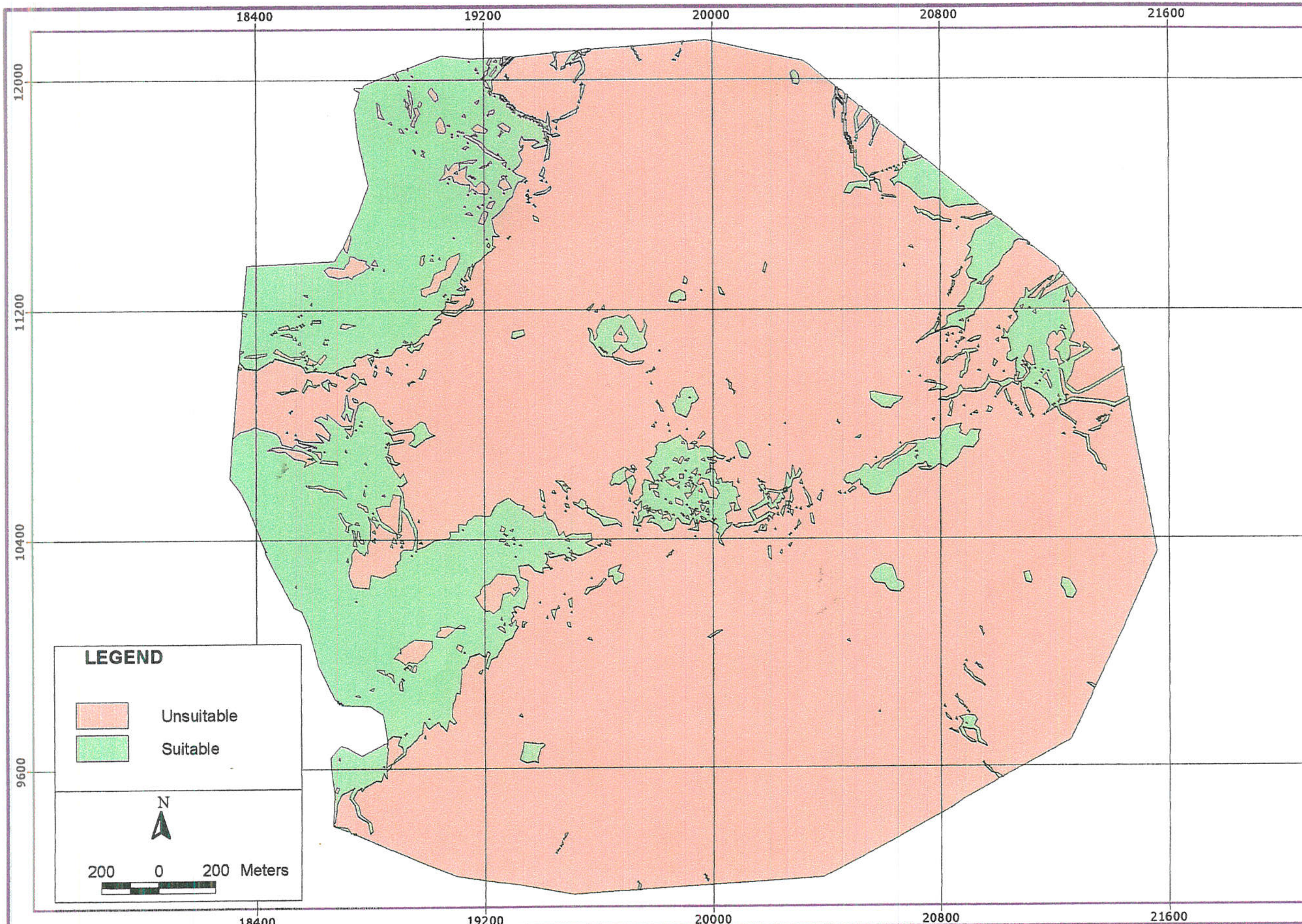


Fig. 5.2 Slope Factor Map

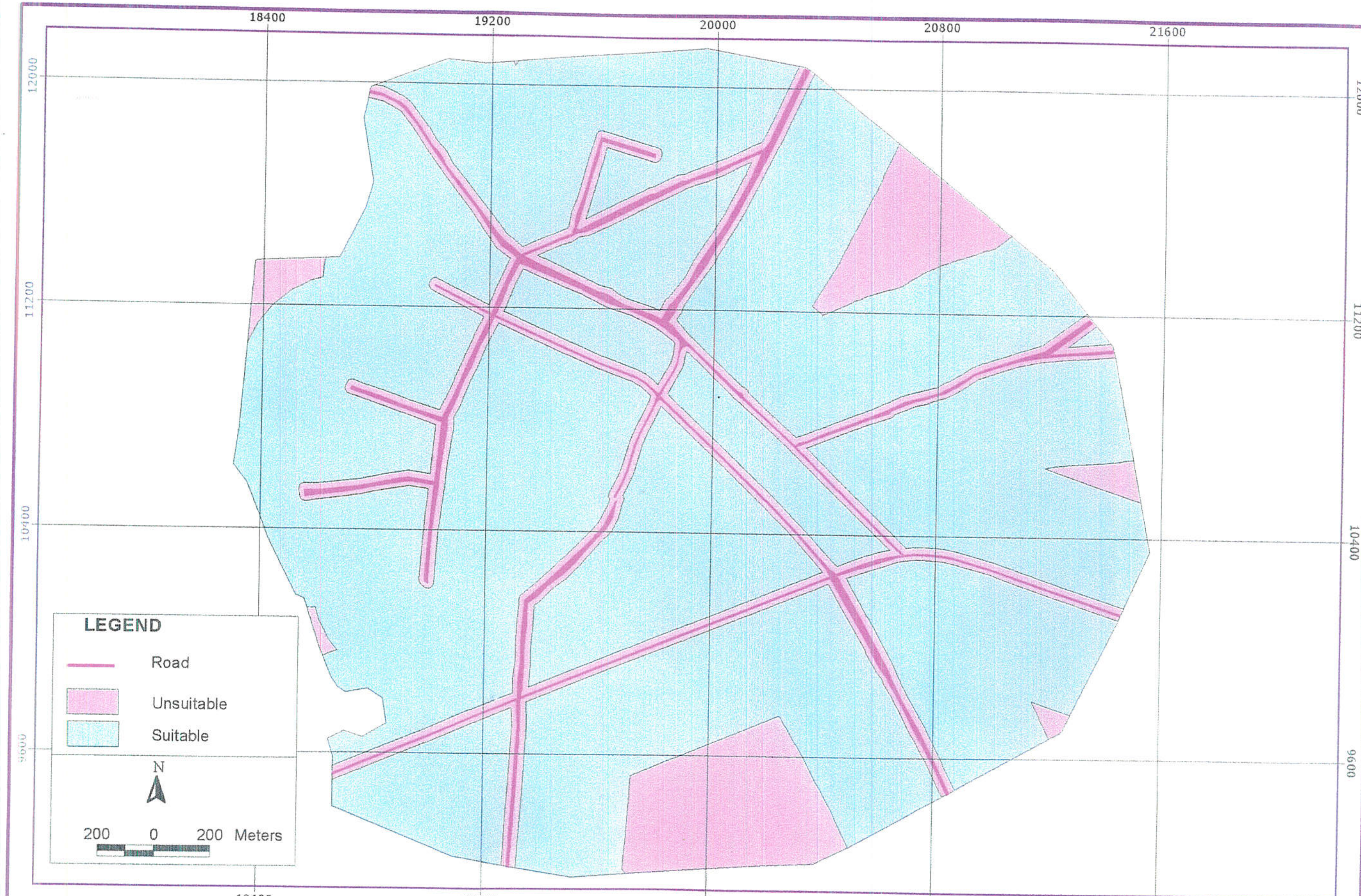


Fig. 5.3 Road Factor Map

5.4. THE OVERALL SUITABILITY MAP

Figure 5.4 shows the composite suitability of the constraint map and the factor maps.

Partial view of the content of the associated table is depicted in Annex 5.Note that the alternative sites have a value of 1 (last column) indicating that they are chosen as suitable candidate sites. The slope and the road factors have differentiated the area designated possible suitable (indicated in Fig. 5.1) into areas of increased suitability. In other words the search space is highly reduced by the slope and road factors. The resulting sites selected are labeled **S1**, **S2** and **S3**. It is still possible to make further suitability differentiation among these areas. This could be accomplished by altering threshold values of the slope and\or road factors. Obviously, those parts of the selected areas that are near the existing roads are more suitable than those located farther, as far as only the road factor is considered. In this study is, it will not be important to make further differentiation of suitability of the area using the slope criteria since the study area is dominated by flat areas (about 83 per cent of the study area has slope value less than 2 per cent), the maximum slope being nearly 10 per cent.

It should be noted that unlike the factor criteria, the constraints are not to be altered. The constraints are usually regulations (environmental, land use etc), which are legal constraints in essence. For example, the local building regulation forbids the construction of an abattoir within 100 meters distance of rivers or streams. Obviously this is a constraining criterion that immediately limit the specified area for development. That is, such constraining criteria are deemed as legal constraints and cannot be compromised. Thus the likelihood of getting alternative abattoir site by altering the constraining criteria is not promising.

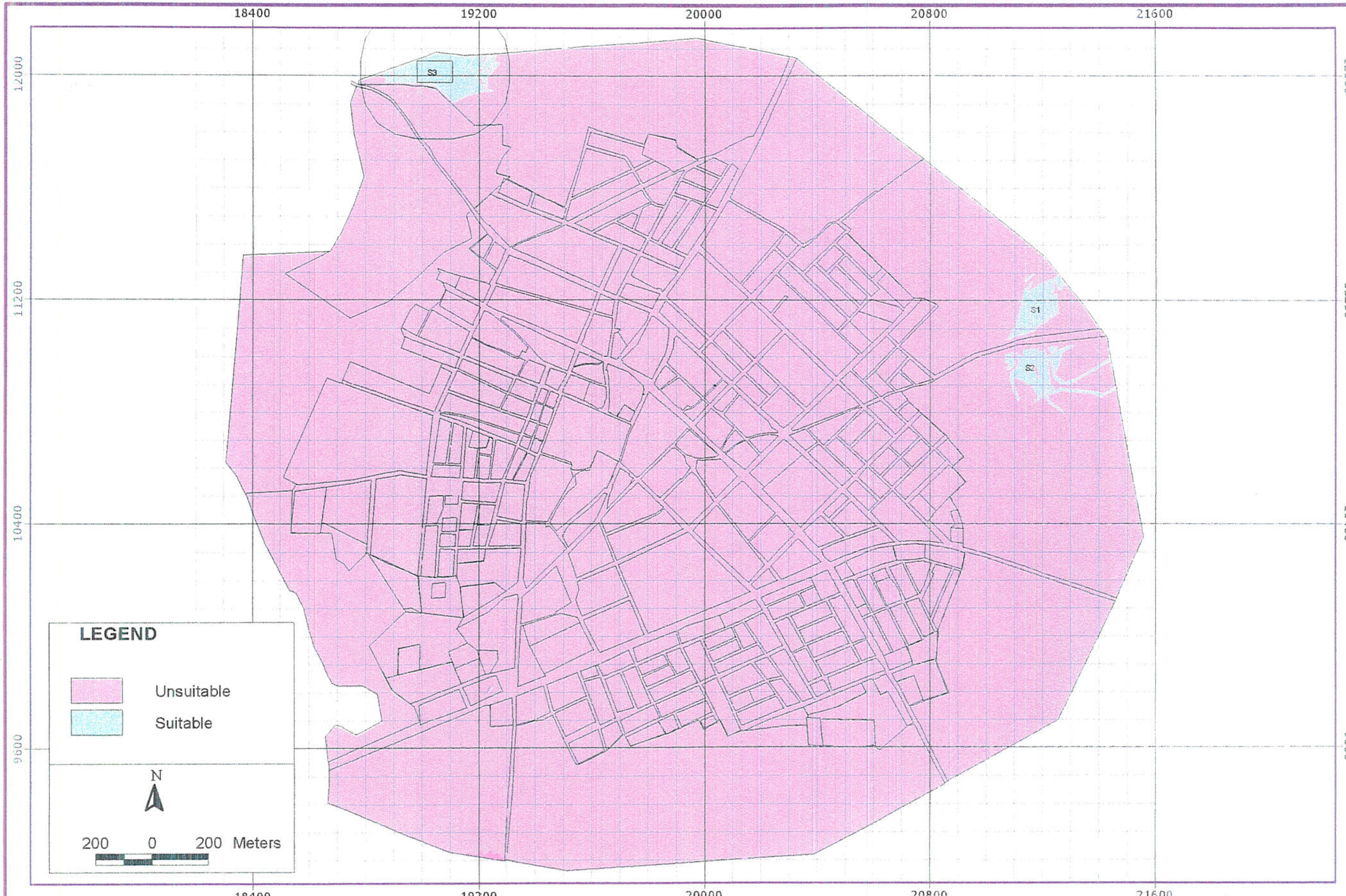


Fig. 5.4 Overall Suitability Map

Now, referring back to Figure 5.4, a final decision has to be made among the alternative sites (**S1**, **S2** and **S3**) based on the remaining criteria – future land use priority and the influence of wind (direction). As stated elsewhere, the development plan of the study area, which is being undertaken by NUPI, is still underway and the future land use proposal has not been completed, yet. A discussion was thus held with relevant experts to prioritize the future land uses of the three alternative sites. The result is that **S1** and **S2** are relatively more suitable for residential development than for siting an abattoir. If the abattoir is sited either within **S1** or **S2,** the likelihood that it will be relocated earlier than expected (because of residential pressure or encroachment) would be greater. The third site, **S3**, on the other hand, is less suitable for residential development and hence it is selected as the best site for the intended abattoir. This site is located at the boundary of the town and is also bounded in the west, south and south west by the preserved conservation area which could not be used for urban land use purpose. It can be therefore observed that, being located within this site, the abattoir will have prolonged life time before it can be relocated. Finally, in order to mitigate the odour pollution that could be generated from some activities within the abattoir, a 200 meter buffer is provided. Based on the suggestion of experienced urban planners, within this buffer, the following activities that are compatible with the abattoir can be undertaken so as to minimize wastage of urban land:

- Municipal fuel wood plantations to supplement the fuel wood and construction wood requirements of the residents of the town;
- Cattle market: cattle markets are usually recommended to be located close to abattoir so that purchased cattle could immediately be taken to the abattoir without having to cross the town. This reduces possible traffic problems that would otherwise be created; and

- Cattle fattening lots: this type of investment activity exists in most towns of the country. The cattle are usually fattened to be sold later. Thus it is compatible both with the abattoir and the cattle market.

To summarize, the characteristics of the site (**S3**) are such that the specific objectives set at the beginning are satisfied. In other words, locating the abattoir within this site ensures:

- minimized impact of the abattoir on the surrounding environment;
- reduced impact of the nearby activities on the abattoir;
- minimized wastage of urban land; and
- a relatively less probability of being relocated earlier than expected.

Finally, it would be worth mentioning that based on NUPI's experts comments, the output of this study suggests the promising potentiality of using GIS not only for abattoirs site suitability analysis, but also for solving other similar land allocation problems under Ethiopian condition. The general procedure followed by the experts to assess the result includes:

- Examining the various component parts of the abattoir site suitability model, particularly the site selection criteria. These were investigated in terms of (1) comprehensiveness (unambiguity and understandability as well as whether they cover all aspects of the decision problem), (2) operationality (whether they can be used meaningfully in the decision making process), and (3) nonredundancy (ensuring that they are not considered more that once).
- Evaluating the output with respect to the selection criteria, taking also into account the specific conditions of the study area.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSION

Abattoirs are important urban functions that provide livestock processing services to the towns and/or cities they serve. The ultimate purpose of establishing abattoirs is to provide cleaner and hygienic slaughtering services, to ensure proper utilization of animal by-products, to establish and control standards, to generate income for the services rendered, and to alleviate impact on the environment by controlling the waste disposal system.

Abattoirs have some basic features that necessitate the search of unique location for them. Such location ought to satisfy some specific objectives including minimizing the undesirable impacts that the abattoir can pose on the surrounding environment and vise versa, ensuring the availability of basic facilities necessary for the proper functioning of the abattoir and so on.

However, in a number of towns of Ethiopia, abattoirs are observed posing environmental hazards (NUPI, 1999a, 1999b, 1999c). Much of such problems can largely be reduced by a careful siting of the abattoir (Velden, et al, 1990; EPA, 2002).

NUPI, as the chief urban development plan preparing arm of the Federal Government of Ethiopia, is confronted with problems of these kind to which appropriate solution should be sought. In light of the present and expected demand for siting abattoirs, and the diversity and complexity of the factors involved in the abattoir site selection, the present manual method NUPI is using is not adequate. It is rather slow, error-prone and laborious.

In attempting to solve the problem, the use of a GIS has been proved justifiable since GIS has been designed to contribute to the solution of such planning problems (Janssen and Rietvelt, 1990). The present study is, therefore, made in an attempt to design abattoir site suitability model for a selected town of Ethiopia (Kulito), which could assist urban planners in abattoir site selection decision making process. The site selection criteria were identified based on the opinions of NUPI's experts. Relevant manuals, guidelines and policy documents have also been reviewed.

The database has been created based on the criteria identified. The criteria are represented as map layers in the database. A model was developed for conducting the analysis for abattoir site selection. Arc View GIS Version 3.1 was then employed to implement the model.

Based on the comments of NUPI's experts, the result of the study has demonstrated the potentiality and applicability of GIS not only in supporting abattoir site selection decision making problems but also the possibility of using it in other similar land allocation problems under Ethiopian context.

6.2 RECOMMENDATIONS

In this study an attempt is made to develop a model for conducting abattoir site suitability analysis for a selected town of Ethiopia (i.e., Kulito). The study shows that the use of a GIS for land suitability analysis is appropriate and a necessity in urban development planning under Ethiopian context. For further undertaking of the system, the following recommendations are given:

1. Because of the specific characteristics of the study area, certain geographic features (such as airport) are not included in the model. Where such features are present, they need to be incorporated in the analysis.

2. The decision rules used for the built-up land use features in the study are deemed more appropriate to the specific condition of the study area. Particularly, for bigger towns, the decision rules should be proportionally altered (increased) by relevant knowledgeable experts.

3. The abattoir site suitability model developed in this study has been intended to be used for towns requiring one abattoir. Where more than one abattoir is required, additional factors, particularly in relation to the spatial distribution of the abattoirs, have to be considered.

4. This study has been intended to serve for solving the locational problems associated with municipal abattoirs. For Export abattoirs, which are expected to flourish in the country in the near future, some additional factors will probably be required to be considered, depending on the nature and complexity of such abattoirs.

5. The method used for the analysis in this study involves, among other things, a series of overlay operations. However, as the number of criteria to be considered increases, such

technique gets difficult to keep track of the various datasets, processing procedures, parameters, and assumptions made. To avoid such difficulties and also gain additional virtues, appropriate modelbuilde may be used. A modelbuilder is a tool for creating and managing spatial models that are automated and self-documenting. A spatial model in a modelbuilder is easy to build, run, save, modify, and share with others. With a modelbuilder the same model can be applied to different geographic areas by changing the input data. Furthermore, the model could easily be modified to explore "what if" scenarios and obtain different solutions (ESRI, 1996).

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Annex 1 The Detail Aspect of Abattoir Site Selection Process

Delineating the Area within which the Abattoir should not be Located

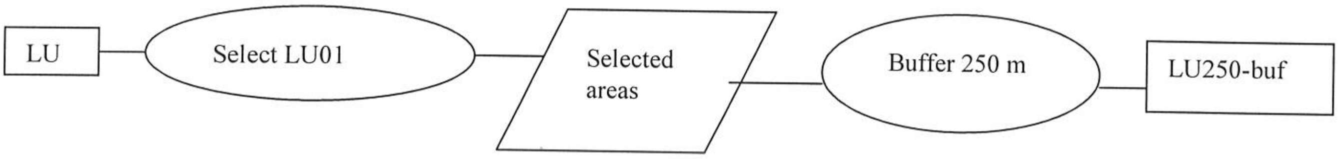
This part of the analysis involves a lengthy process to delineate the areas within which the abattoir site should not lie. These areas include:

1. Areas within 250 meters of residential areas, administrative areas and commercial areas;
2. Areas within 300 meters of recreational areas, bus terminal, schools, health services, and industrial areas (dust and smoke emitting ones);
3. Areas of within 500 meters of liquid waste dump site;
4. Areas within 100 meters of cemeteries;
5. Areas within 100 meters of rivers and streams;
6. Areas within 10 meters of conservation areas;
7. Areas within 250 meters of high tension electric lines; and
8. Areas within 300 meters of boreholes.

Each case (from 1 to 8) is treated separated and then combined. The first case involves the following steps:

- Select residential, administrative and commercial areas (labeled LU-01) from the land use layer.
- Buffer the selected areas to 250 meters using the buffer command.

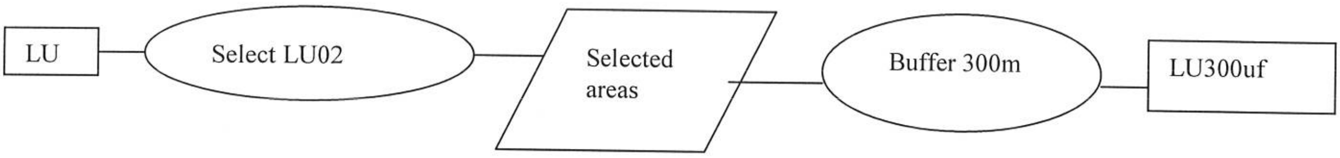
Here is the process model



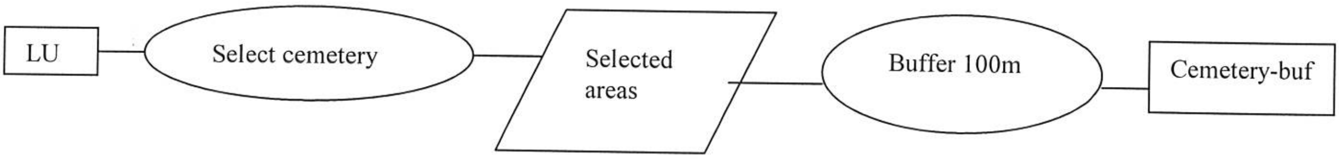
The second case involves the following steps:

- Select recreational areas, bus terminal, schools, health services, and industrial areas (labeled LU-02) from the land use layer.
- Buffer the selected areas to 300 meters.

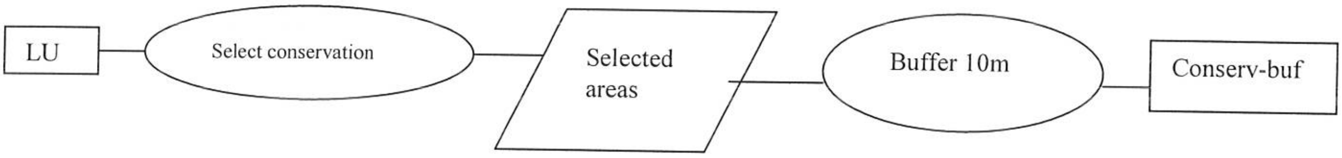
The process model s indicated below:



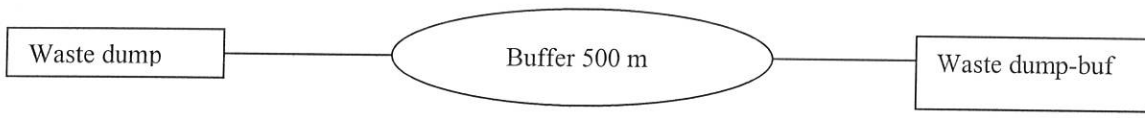
The third case (shown below) involves selecting cemeteries from the land use layer and then providing a buffer distance of 100 meters using the buffer command.



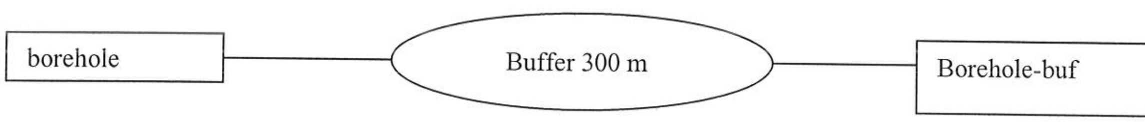
Similarly, the fourth case involves querying conservation area from the land use layer and buffering the result with 10 meters.



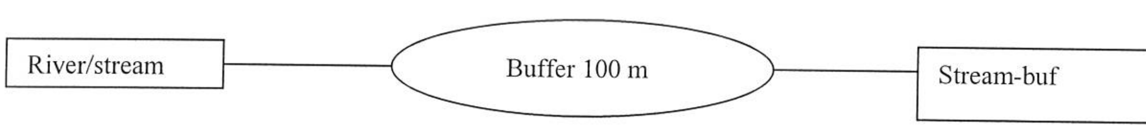
The fifth case involves buffering the waste dump with a 500 meter distance . The process model is shown below.



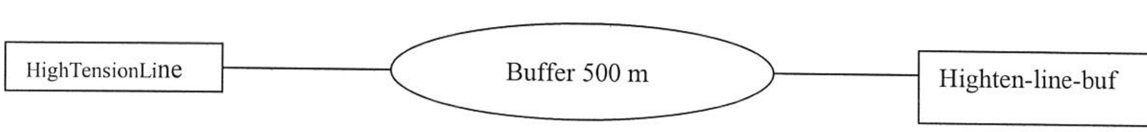
The sixth case involves buffering boreholes with a 300-meter distance. The process model is shown below.



The seventh case involves buffering rivers and streams with 100 meter distance. The process model is indicated below.



The eighth case involves buffering high tension electric line with a buffer distance of 500 meters. The model is indicated below.



Aggregating the Constraints

The next step is to combine all the processes indicated 1 to 8 above by making use of the overlay procedure (i.e., the union command or addition). The procedure involves adding the first two buffer layers, again adding the resulting buffer layer with the third layer and so on until the eighth one. This process model is clearly indicated in Figure 4.3a. The final output of such procedure is the "constraint" which represents the areas within which the abattoir site should not lie in relation to those that are suitable.

Delineating the Areas within which the Abattoir should Fall (explanation to Figure 4.3c)

- Delineating the area of interest for locating the abattoir also involves consideration of other factors, in this case slope and road factors. The process involves:
- Differentiating the whole area based on required slope threshold (i.e., 2-10 per cent).
- Combining the result with the suitable land which has been derived by selecting agricultural or vacant land from the area excluding the constraints. Note that the subtract command has been applied to exclude the constraints from the overall area of the study area. Note also that the intersection command has been applied to aggregate slope suitability and areas designated suitable. The result (suit_slope) indicates further differentiation of the suitable land based on slope, which is now characterized by increased suitability.
- Combining suit_slope and Roadbuf_in by applying the intersection command. Note that the road feature was first buffered with a distance threshold of 20 to 400 meters and then clipped to confine its extent within the study area boundary. For that purpose the identity command has been used.

- The result (Suit_slope_Road) was then integrated with the future land use again through the intersection command. This yielded suit_slope_Road_FlandUse which also need to be assessed based on the influence of wind direction.

Annex 2 Questions used during discussions

1. What are the criteria employed for abattoir site selection?
2. What are the spatial buffer distances required to separate municipal abattoir from different geographic features (such as residential areas, rivers, boreholes etc.)?
3. What are the justifications for the buffer distances provided in (2) above?
4. How are these criteria treated for different towns with different size?
5. What problems are faced both at field and at office in searching appropriate site for abattoirs?
6. How would you assess the site selected using GIS taking into account all the appropriate criteria and the specific conditions of the study area?

Annex 3 Land Use Classification used by the National urban planning Institute

NO.	LAND USE CLASSIFICATION	CODE
1	RESIDENCE	R
	Existing Residential	R1
	Existing Residential (Pure)	R11
	Proposed Residential	R2
	Proposed Residential(Pure)	R21
	Proposed Residential (Mixed)	R22
2	ADMINISTRATION	AD
	GOVERNMENTAL INSTITUTIONS	AD1
	Sectoral Department Offices	AD11
	Local Area Administration	AD12
	Municipal Office	AD13
	Police	AD14
	Justice Courts	AD15
	Prison	AD16
3	COMMERCE and TRADE	CO
	Commercial Activities	CO1
	(Small shops, groceries, shopping centers, supermarkets, hotels,	
	restaurants, etc.	
		CO2
	Market Place	CO21
	General Market(Open, Covered	
	Cattle Market	CO22
	Local Market(Gullits)	CO23
	Financial Institutions	CO3
	Banks, Insurance, etc....	CO31
4	SERVICES	S
	EDUCATION	S1
	Pre-School Education	S11
	Elementary School	S12
	Elementary + Junior Secondary School	S13
	Secondary School	S14
	Research Center	S15
	HEALTH	S2
	Health Post (Clinic)	S21
	Health Center	S22
	Veterinary Clinic	S23
	Hospital	S24
	CIVIC and CULTURAL CENTRS	S3
	Multi Purpose Hall	S31
	Library	S32
	Theater/ Cinema Hall	S33
	Community Center (KG, Health, Post, Sport, Field, Public Bath, etc	S34
	PUBLIC WORSHIP	S4
	Christian (Orthodox) Church	S41
	Christian (Non- Orthodox) Church	S42

NO.	LAND USE CLASSIFICATION	CODE
	Mosque	S43
NO.	LAND USE CLASSIFICATION	CODE
	UTILITIES	
	Water Pump House	S51
	Reservoir	S52
	EEPCO Substation	S53
	Telecommunication	S54
	Postal Service	S55
	CEMETRY	S6
	Christian (Orthodox) Cemetery	S61
	Christian (Non Orthodox) Cemetery	S62
	Muslim Cemetery	S63
	Municipal Cemetery	S64
	MUNICIPAL SERVICE	S7
	Garbage Collection & Disposal	S71
	Slaughter House	S72
	Public Bath and Shower	S73
	Fire Brigade	S74
	SOCIAL WELFARE	S8
	Homes for the Aged, Orphanage, Handicapped, Rehabilitation Center etc....	S81
5	MANUFACTURING and STRORAGE	M
	MANUFACTURING	M1
	Manufacturing Plant	M11
	Processing Plants (Coffee, Oil, Grains, etc...)	M12
	STORAGE	M2
	GARAGES and WORSHOPS	M3
	Filling Station and Auto Service	M31
	Garage	M32
	Workshops, Repair and Maintenance	M33
	Generator, Transformer, Power Plant etc...	M34
	BUILDING MATERIAL PRODUCTION	M4
6	TRANSPORTATION	T
	Air port	T1
	Bus Terminal	T2
	Freight Terminal	T3
7	RECREATION and ENTERTAINMENT	RE
	OPEN SPACE	RE1
	Play Ground	RE11
	Sport Field	RE12
	Sport Center (Stadium)	RE13
8	AGRICULTURE	A
	Animal Husbandry	A1
	Horticulture	A2
	Grazing and Other Farming Activities	A3

9	FOREST	F
10	SPECIAL FUNCTIONS	SF
	Reserved Area	SF1
	Water body	SF2
	Swampy area	SF3

Annex 5 Partial View of the Attribute Table for the Abattoir Site Suitability Analysis

ArcView GIS Version 3.1

File Edit Table Field XTools Window Help

0 of 907 selected

Attributes of Theme78.shp

Shape	F_sui	Sui	Area	Perimeter	Hectares	Suitable
Polygon	1	1	39347.947	1667.446	3.935	1
Polygon	1	1	48988.144	4025.962	4.899	1
Polygon	1	1	58.707	35.854	0.006	0
Polygon	1	1	84.299	40.945	0.008	0
Polygon	1	1	25.000	20.000	0.003	0
Polygon	1	0	25.000	20.000	0.003	0
Polygon	1	1	88.596	41.177	0.009	0
Polygon	1	1	33.746	28.369	0.003	0
Polygon	1	0	16.010	18.749	0.002	0
Polygon	1	0	224.569	64.794	0.022	0
Polygon	1	1	240.944	84.742	0.024	0
Polygon	1	1	77.192	39.994	0.008	0
Polygon	1	1	82.012	44.287	0.008	0
Polygon	1	1	11.758	16.171	0.001	0
Polygon	1	1	25.000	20.000	0.003	0
Polygon	1	1	18.480	17.490	0.002	0
Polygon	1	0	5.149	11.536	0.001	0
Polygon	1	1	7.492	13.307	0.001	0
Polygon	1	1	25.000	20.000	0.003	0
Polygon	1	1	25.000	20.000	0.003	0
Polygon	1	0	17.116	18.864	0.002	0
Polygon	1	0	17.116	18.864	0.002	0
Polygon	1	0	58.670	35.363	0.006	0
Polygon	1	1	25.000	20.000	0.003	0

DECLARATION

This thesis is my original work and has not been submitted for a degree in any other university

Aysheshim Melese Wubshet

June 2002

This thesis has been submitted for examination with our approval as university advisors

Workshet Lamenew

Teferra Sileshi