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College of Graduate Studies

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A thesis submitted as a partial fulfillment to the admission of the degree of Master in Geodesy and GIS

Design of Digital Re-planning Model for Informal Settlements Using Geographic Information Systems

تصميم نموذج اعادة التخطيط الرقمي للمناطق العشوائية باستخدام نظم المعلومات الجغرافية

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ABSTRACT

The process of re-planning settlements is a complex process, governed by technical foundations, legal regulations, procedures and practical steps, in order to improve and develop these settlements to be at a perfect planning level, with minimum possible damages. Execution of this process manually leads to slow down the solution with disconnected procedures and sometimes increases the complexity of the problem by losing time, effort, cost and decrease the accuracy .In this research a new method had been proposed depending on digital systems to execute re-planning process by analyzing the foundations and regulations that governs the re-planning process and design the required digital solutions for its implementation applying the analysis tools of geographic information systems softwares together with its capabilities of input and processing of spatial data and their attributes in one digital database which enables its efficient integration, quick retrieval, ease of analysis and presentation. This method contributes in making re-planning process easy, quickly, secured, precise and of low cost.Aerial photo
graphs had been used as a source of spatial data, non spatial attributes had been collected from the field using forms designed for this purpose and ArcGIS software had been used to execute the steps of the process in the study area.

المستخلص

عملية إعادة تخطيط المستعمرات السكنية من العمليات المعقدة المحكومة بأسس و ضوابط فنية، لوائح قانونية وإجراءات وخطوات عملية لتحسين وتنمية هذه المستعمرات بتخطيطها بالصورة الصحيحة وتقليل الأضرار بقدر الإمكان. إجراء هذه العملية بالطرق اليدوية يؤدى إلى تأخير حلها وعدم ترابط الإجراءات المطلوبة وأحيانًا يساهم فى زيادة تعقيد المشكلة بضياع الزمن، الجهد والتكلفة المالية ويقلل من الدقة. فى هذا البحث تم إقتراح طريقة جديدة تعتمد على الأنظمة الرقمية لتنفيذ عملية إعادة التخطيط وذلك بتحليل الضوابط واللوائح التى تحكم عملية إعادة التخطيط وتصميم الحلول الرقمية اللازمة لتطبيقها بإستخدام أدوات التحليل الخاصة ببرامج نظم المعلومات الجغرافية مع إمكانياتها فى إدخال ومعالجة البيانات المكانية وخصائصها فى قاعدة بيانات رقمية واحدة تمكن من فاعلية تكاملها وسرعة إسترجاعها وسهولة تحليلها وعرضها. هذه الطريقة تساهم فى جعل عملية إعادة التخطيط سهلة وسريعة وآمنة ودقيقة وقليلة التكلفة.تم إستخدام الصور الجوية للحصول على المعلومات المكانية والمعلومات الوصفية (غير المكانية) تم جمعها من الحقل (منطقة الدراسة) بنماذج خاصة مصممة لهذا الغرض وبرنامج ArcGis لتنفيذ خطوات العمل فى منطقة الدراسة.

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It is my pleasure to acknowledge you, O you who knowing herself, without calling her name. I'm eager to see your smile. I'm sure you will come.

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Finally, I must express my very profound gratitude to my parents and to my brothers for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Harith W. Elsadig

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CHAPTER ONE

INTRODUCTION

1.1 General review

Mankinds since the first ages try to deal with the surrounding environments to make their life more easy and comfortable. There is no doubt; there are some essential requirements that may make people looking for them in order to live comfortably. For instance, roads help people who live in inaccessible areas to participate in society and improve their quality of life.

"No matter how large or small your community, as a planner you deal with spatial information such as parcels, zoning, land use, addresses, transportation networks and housing stock. You also monitor multiple urban and regional indicators, forecast future community needs, and plan accordingly to help improve the quality of life in your community." (Milton Ospina, ESRI)

Planners use geographic information system (GIS) technology to research, develop, implement, and monitor the progress of their plans. GIS provides planners, surveyors, and engineers with the tools they need to design and map their neighborhoods and cities. Planners have the technical expertise, political savvy, and fiscal understanding to transform a vision of tomorrow into a strategic action plan for today, and they use GIS to facilitate the decision-making process.

1.2 Problem Statement

Application of re-planning process depending on digital systems without a clear plan to show the sequence of the steps leads to lack of:

- Selection of appropriate data.
- Connectivity between different participants of planning process.

- Standards of physical structure of digital data (different files' format, organization of required layers).
- Coordinate system (Geo-reference) and coordinates (E, N) or (φ,λ).

In fact all that is not commensurate with the nature of the spatial data which need to be carefully organized and a well arranged to reap optimal results.

1.3 Thesis Objectives

This thesis aim to:

- Automation of re-planning process to increase the efficiency and reduce the effort.
- Guarantee a correct link between the owner from Form 1(figure 4.1) and the parcel Parcel layer(figure 4.3) through common parcel number (unique identifier) which preserves rights and properties.
- Design of flowchart to show the sequence of different steps of the re-planning process.
- Creation of a complete database, suitable for different services utilities: electricity, water, Communications, statistics, etc.).
- To avoid double work, high cost, different technical standards and different coding which minimize effort, cost and errors.

1.4 Thesis layout

This thesis consists of six chapters, Chapter one contains an introduction. Chapter two reviews Geograpich Information Systems (definitions, component, fancanalites, Spatial analyses and toolboox and model builder).Chapter three explains the Urban Planning (definitions, types of planning, urban planning and GIS and replanning of informal settlement) .Chapter four illustrate the Methodology and steps of design of the proposed digital model. Chapter five presente results and analysis. Finally, conclusion and recommendations state in chapter six.

CHAPTER TWO

GEOGRAPHIC INFORMATION SYSTEMS

Geographic information systems are an important product of the revolution of information technology. Which allow us to use and analyze spatial information in conjunction with connected socio-economic information, and therefore it's an ideal basis for the planning and management. There are many definitions for GIS depending on its components and functions. The U.S Federal Interagency Coordinating Committee (1988) definition stated that a GIS is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced data for solving complex planning and management problems. Shoba and Ra sappan (2013: 1) also describe GIS as: A computer tool for capturing, storing, querying, analyzing and displaying spatial data from the real world for a particular set of purposes. GIS has capability of efficient storage, retrieval, integration, manipulation, updating and changing, managing and exchanging, combining, analyzing, and presenting of geographical and non-geographical information. GIS technology can be used for scientific investigations, resources management, asset management, environmental impact assessment, urban planning, cartography, criminology, history, sales, marketing, and logistics, etc.

2.1 Components of GIS

Actually GIS is quoting its power and comprehensiveness from its strong components, mainly it's have five components, which are: hardware, software, data, people, and procedures.

2.1.1 Hardware

GIS needs many types of hardware to satisfy some of its main functions such as data collection, storage, manipulation, and presentation. The heart of GIS is the computer which can be a personal computer (PC) or a workstation depending on the volume of the GIS projects and the organization. Input units mainly the keyboard and the mouse, the output units such as the monitor. Many types of devices are attached to the computer as input devices such as scanners, cameras, digitizers, and many others. Also printers and plotters of different sizes are attached to the computer as output devices. Networks hardwares, such as modems, cables, hubs, bridges and other networks devices, are utilized in GIS to share data, software, and hardware.

2.1.2 Software

Several comprehensive software systems are developed and fully support GIS applications. GIS has benefited greatly from the rapid, continuous development in the software systems, Many organizations and companies concerned with GIS had developed softwares to satisfy different functions of GIS such as those developed by The Environmental Systems Research Institute (ESRI): Arcview, Arcinfo and ArcGis. ArcGis is composed of many modules such as ArcMap, ArcCatalogue, ArcToolbox, ArcReader, ArcGlobe, and ArcScene. These modules are functioning in a integrating manner for capturing, managing, manipulating, displaying, and analyzing spatial data. There are many other GIS softwares such as IDRISI which had been developed by the Graduate School of Geography at Clark University, Geographic Resources Analysis Support System (GRASS) which had been developed by U.S Army Construction Engineering Research Laboratories (USACERL). Also Intergraph's Modular GIS Environment (MGE) and many other systems.

2.1.3 Data

The efficiency of any GIS scheme depends on the quantity and the quality of data. The expected results of analysis are affected directly by the availability, accessibility, reliability, validity, integrity, and completeness of data. Data must be classified in several classes and all data of a particular level of classification, such as roads or vegetation type are grouped into layers or coverages. Layers can be combined to each other in various ways to create new layers that are a function of individual ones. Data collection and processing is the most expensive part of GIS. There are two main types of GIS data: spatial or geographical data and non-spatial data or attributes:

2.1.3.1 Spatial Data

Spatial data describes the absolute or relative location of geographic features, it is the graphical representation of the geographic locations in a digital form, and it can be classified into two basic data models: raster data model and vector data model. Raster data model, known also as a grid model is: a mathematical model. it is a set of grid of uniform, regular cells. The cell is called pixel which refers to a picture element usually it is rectangular or square but it may be triangular or hexagonal. The main sources of raster data models are satellite imageries, aerial photographs and digital image scan of existed maps. Vector data model is: representation of the geographical phenomena in terms of the spatial components, consisting of points, lines, areas, surfaces and volumes and each layer in the vector data model must be composed of only one component. The point is an object of zero dimensions called node or vertex. Line is the link between two points which has one dimension called link or arc, while area has two dimensions and composed of at least two arcs called polygon or face. The geometrical relationships and connections between objects are controlled by Topology independent of their coordinates. Topology model is based on mathematical graph theory that deals with the geometrical properties and employs nodes and links.

2.1.3.2 Attributes

Attributes are non-graphic data that describe properties of the geographic features or elements represented on the map. Attributes are stored in a table in a manner that each record or row in the table corresponds to geographic object on the map, whereas each property is stored in a column or a field. Each object must have an identity (ID) or access key. The number of columns representing the properties is not limited, but is optionally selected due to the available attributes. The number of columns may be extended by joining several tables automatically using a common field. The first line or row in the attributes table contains the name of the field which must not exceed ten characters, the data of each field must be of the same type of characters and the type can be short integer, long integer, float, double, text and date.

2.1.4 People

Different levels of people from different disciplines are involved to establish GIS project or organization. People involved in GIS team depend on the capacity of the organization and the nature of the GIS project, GIS team may include GIS experts, who advise and solve problems for end users, cartographers, system analysts, computer specialists and people specialized in the field of the project in question e.g. geologists, agriculturists, engineers. GIS team also include end users, who seek problem solutions and see final products only in the form of maps and reports, GIS operators of low level of experience who understand the functions of specific system so as to manipulate data and data compilers, who understand the data but not the system.

2.1.5 Procedures

Procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output. The procedures are the step taken to answer the question needs to be resolved. The ability of a GIS to perform spatial analysis and answer these questions is what differentiates this type of system from any other information systems. The transformation processes includes such tasks as adjusting the coordinate system, setting a projection, correcting any digitized errors in a data set, and converting data from vector to raster or raster to vector (Carver, 1998).

2.2 Functionalities of GIS

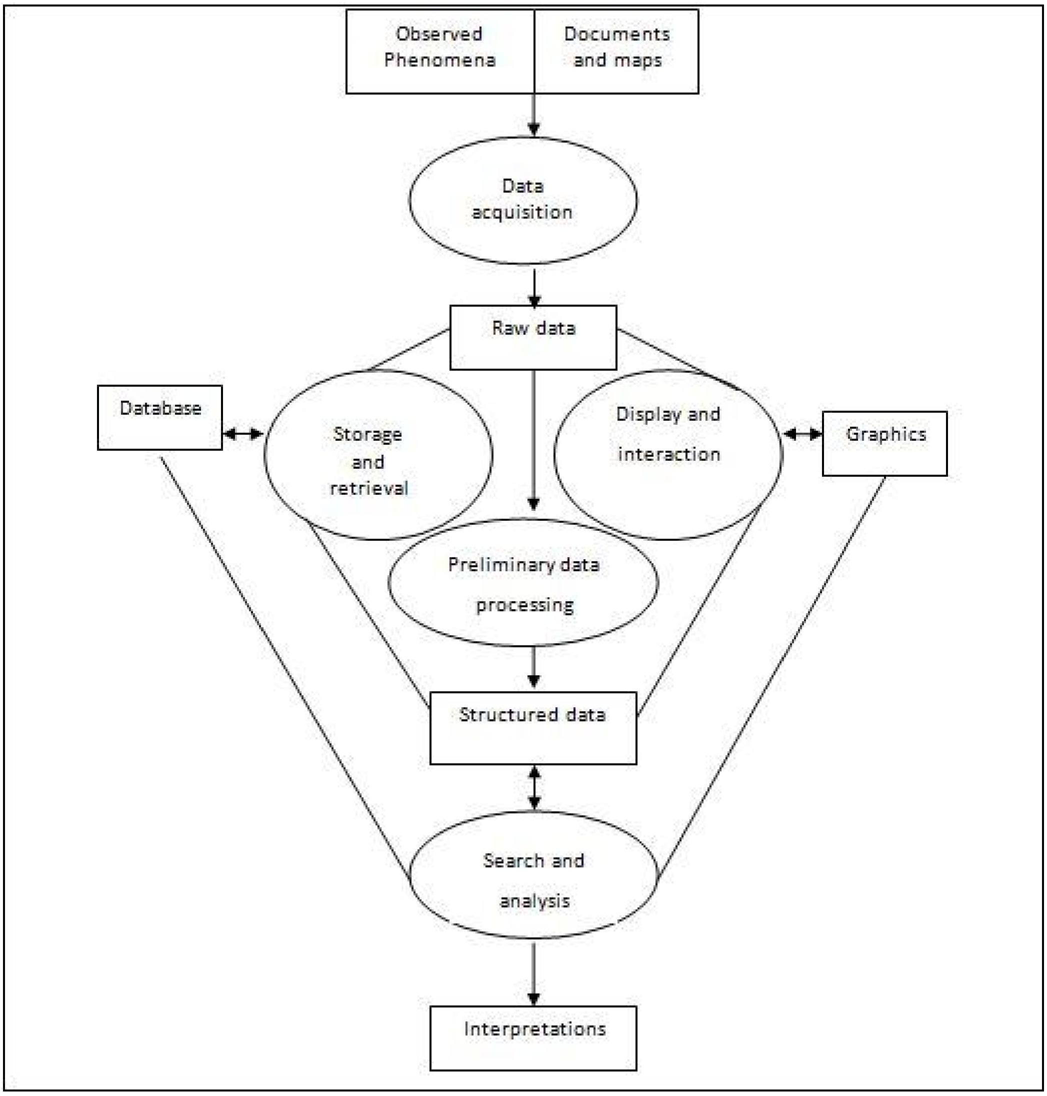


Figure 2.1: Relationship between GIS functions
(Christopher B. Johns 1988)

Most GIS packages provide functions and tools to enable the execution of different operations necessary for GIS project. There are main five functions as shown with their relationships in figure 2.1 and can be categorized in:-

2.2.1 Data acquisition

All data that needed for GIS project must be transferred from their original source form to the digital form to satisfy the basic requirements of GIS. Data can be obtained from primary data acquisition techniques such as direct ground survey techniques, whether in a digital form or in a hard copy form. Data in hard copy maps which are secondary data acquisition sources are transformed to the digital form by digitization or scanning and the resulting format depends on the employed technique. Satellite imageries and aerial photographs are important source of spatial data which can be obtained directly in digital form or scanned from hard copies. Aerial photographs provide spatial data of high accuracy which is suitable for creation and updating of large scale topographic maps while the accuracy of the spatial data obtained from remote sensing depend on the ground resolution. Data acquisition is a critical, time consuming and expensive stage in many geographical information tasks.

2.2.2 Preliminary data processing

Preliminary data processing includes creating topologically structured data, classification of remotely sensed data, change of structure of data, coordinate systems and map projections transformation and conversion from raster to vector or vice versa according to the type of analysis tools. The required conversion to a raster data model from a vector data model can be done straight forward by rasterization algorithms while vectorization of raster data is more complicated. Data of unknown coordinate system can be forced by rubber sheet transformation to fit into known coordinate system data of the same location. Data processing involves the creation of surface models by interpolation techniques to generate contour maps, triangular irregular network (TIN) or any other relief representation method. Acquiring data from different sources may cause the problem of using two or more classification or coding referring to the same phenomenon, re-coding must be applied to solve this problem by reclassification to combine several classes to form a generalized less-detailed class.

2.2.3 Data storage and retrieval

The manner by which the data is stored depends on the data model. The storage of vector data model consist of the spatial data or the map and the attributes tables, where every record in the attributes table corresponds to a spatial object or a feature in the map and the fields of the table are the attributes of these spatial objects. Each spatial object must have a unique identifier or access key to link the spatial object to its attributes in the table. The raster data is saved in the computer memory in the form of two dimensional arrays, the coordinates of grid cells, or pixels, are implicit within the row and column ordering of the matrix. The property of this type of storage from a retrieval point of view, that each element can be referred to or addressed directly in terms of the row number and the column number.

2.2.4 Spatial search and analysis

The objective of any GIS project is to use the stored data to make decisions and to solve problems in a particular application. GIS has utilizes of many functions to carry out searches and analysis to satisfy these objectives which can be summarized in:-

2.2.4.1 Containment search within a spatial region

This is a straight forward spatial analysis to find features or part of features that lie within a given region of space. A rectangular window can be defined to find spatial objects that lie within it.

2.2.4.2 Proximal search

There are many types of proximal search. One of them may be regarded as an extension of the spatial containment search, where a zone of specified distance from a particular object is defined. This object can be point, line or area and this zone is called buffer in the case of vector model and spread in raster based systems.

2.2.4.3 Phenomenon based search and overlay processing

This type of search may be based on a single phenomenon irrespective of other phenomena or a search for regions that are defined by combinations of phenomena.

2.2.4.4 Interpolation and surface modeling

Interpolation functions are performed in sample points taken in a regular distance interval forming a regular grid, the values of the known sample points are used to estimate the unknown values by analysis of the correlation function between the sample values and the distance.

2.2.4.5 Best path analysis and routing

Network data models or raster data models are used to find the best route in terms of cost, length or other criteria. Network data models are used to select a path from already existed paths such as roads and rivers while raster data models are used when the problem is to find a path across terrain that may not have any predefined path.

2.2.4.6 Spatial interaction modeling

Spatial interaction modeling is used for identifying optimal locations of facilities that satisfy particular requirements or criterion.

2.2.4.7 Correlations, associations, patterns and trends

GIS analysis is useful to integrate information within spatial region to search for links between events. This type of analysis can be applied to find factors that cause a certain phenomena for example to find correlation between environmental factors and diseases.

2.2.4.8 Map algebra with grided data

GIS analysis is useful to integrate information within spatial region to search for links between events. This type of analysis can be applied to find factors that cause a certain phenomena for example to find correlation between environmental factors and diseases.

2.2.5 Graphical display and interaction

GIS has the capability to represent the results of analysis and queries on maps, for example by choosing each country which its area is less than one million squared kilometers and its population is more than 100 million from the layer of world countries. Many cartographic facilities are available to modify map features and change the graphical variables of map symbols and text such as colour, shape, size, patterns, orientation, font size and orientation of text. Many GIS packages also include facilities for changing datums and map projections for example by changing the datum of a particular layer by using define projection in the data management tools of ArcToolbox. Animation facilities also are provided by some GIS packages for the presentation of maps to show changes over time. An important facility for some GIS applications is the capacity to view three dimensional (3D) scenes from different viewpoints in order to evaluate aspects of the landscape with regard to their appearance and their visibility from different locations.

2.3 Spatial analysis

The strongest capability of GIS which differentiate it from other spatial technologies is the advanced spatial analysis. Spatial analysis is a general term to encompass the manipulation of spatial data to examine the location, attributes, and relationships of geographic features to gain information. "…the purpose of geographic inquiry is to examine relationships between geographic features collectively and to use the relationships to describe the real-world phenomena that map features represent." (Clarke, 2001).There is three types of spatial relations: Proximity, Directional and Topological. Also, there are three Fundamental Questions Regarding Spatial Relationships; how can two (or more) spatial distributions be compared with each other? How can variations in geographic properties over a single area or data set be described and/or analyzed? How can we use what we have learned from an analysis(es) to predict future spatial distributions? Spatial Analysis can cover the spectrum implied by these questions.

2.3.1 Basic concepts in spatial analysis

2.3.1.1 Spatial Dependency

Spatial dependency is a key concept on understanding and analyzing spatial phenomena. Such notion stems from what Waldo Tobler calls the first law of geography: "everything is related to everything else, but near things are more related than distant things.” Or, as Noel Cressie states that “the [spatial] dependency is present in every direction and gets weaker the more the dispersion in the data localization increases.” Generalizing we can state that most of the occurrences, natural or social, present among themselves a relationship that depends on distance.

2.3.1.2 Spatial Autocorrelation

The computational expression of the concept of spatial dependence is the spatial autocorrelation. This term comes from the statistical concept of correlation, used to measure the relationship between two random variables. The preposition “auto” indicates that the measurement of the correlation is done with the same random variable, measured in different places in space. We can use different indicators to measure the spatial autocorrelation, all of them based on the same idea: verifying how the spatial dependency varies by comparing the values of a sample and their neighbors’.

2.3.2 Data types in spatial analysis

The most used taxonomy to characterize the problems of spatial analysis considers three types of data:

- Events or point patterns: phenomena expressed through occurrences identified as points in space, denominated point processes. Some examples are: crime spots, disease occurrences, and the localization of vegetal species.
- Continuous surfaces: estimated from a set of field samples that can be regularly or irregularly distributed. Usually, this type of data results from natural resources survey, which includes geological, topographical, ecological, phitogeographic, and pedological maps.
- Areas with Counts and Aggregated Rates: means data associated to population surveys, like census and health statistics, and that are originally referred to individuals situated in specific points in space. For

confidentiality reasons these data are aggregated in analysis units, usually delimited by closed polygons (census tracts, postal addressing zones, municipalities).

2.3.3 Capabilities of GIS in spatial analysis

GIS is a tool with unique capabilities, they can use in spatial analysis; these capabilities are;

- Handle geographically-referenced data.
- Spatial/attribute data entry/update capabilities.
- Data conversion functions.
- Storage and organization of a variety of spatial and attribute data.
- Manipulation of spatial and attribute data.
- Presentation/display capabilities, and
- Spatial analysis tools (many tools may be used in combination).

2.3.4 Characteristics of spatial analysis and required skills

Spatial analysis is an artistic and a scientific endeavor; it requires:

- Knowledge of the problem and/or question to be answered.
- Knowledge about the data (how it was collected, organized, coded, etc.).
- It requires knowledge of GIS capabilities.
- It may require knowledge of statistical techniques.
- It requires envisioning the results of any operation, and the combination of any operations.
- It is not completely objective, in fact some argue that it is completely subjective, Many times there is more than one way to derive information that answers a question.

2.4 Analysis tools in GIS

The Analysis toolbox contains a powerful set of tools that perform the most fundamental GIS operations. With the tools in this toolbox, you can perform overlays, create buffers, calculate statistics, perform proximity analysis, and much more. Whenever you need to solve a spatial or statistical problem, you should always look in the Analysis toolbox. In ArcGIS the Analysis toolbox has four toolsets; each toolset performs specific GIS analysis of feature data.

Toolsets	Description
Extract	GIS datasets often contain more data than you need. The Extract tools let you select features and attributes in a feature class or table based on a query (SQL expression) or spatial extraction. The output features and attributes are stored in a feature class or table.
Overlay	The Overlay toolset contains tools to overlay multiple feature classes to combine, erase, modify, or update spatial features, resulting in a new feature class. New information is created when overlaying one set of features with another. There are six types of overlay operations; all involve joining two existing sets of features into a single set of features to identify spatial relationships between the input features.
Proximity	The Proximity toolset contains tools that are used to determine the proximity of features within one or more feature classes or between two feature classes. These tools can identify features that are closest to one another or calculate the distances between or around them.
Statistics	The Statistics toolset contains tools that perform standard statistical analysis (such as mean, minimum, maximum, and standard deviation) on attribute data as well as tools that calculate area, length, and count statistics for overlapping and neighboring features.

Table 2.1: Analysis toolbox tools

2.4.1 Extract toolset

GIS datasets often contain more data than you need. The Extract tools let you select features and attributes in a feature class or table based on a query (SQL expression) or spatial extraction. The output features and attributes are stored in a feature class or table.

Tool	Description
Clip	Extracts input features that overlay the clip features.
Select	Extracts features from an input feature class or input feature layer, typically using a select or Structured Query Language (SQL) expression and stores them in an output feature class.
Split	Splitting the Input Features creates a subset of multiple output feature classes. The Split Field's unique values form the names of the output feature classes. These are saved in the target workspace.
Table Select	Selects table records matching a Structured Query Language (SQL) expression and writes them to an output table.

Table 2.2: Tools in the Extract toolset

Use clip tool to cut out a piece of feature class using one or more of the features in another feature class as a cookie cutter. This is particularly useful for creating a new feature class—also referred to as study area or area of interest (AOI)—that contains a geographic subset of the features in another, larger feature class.

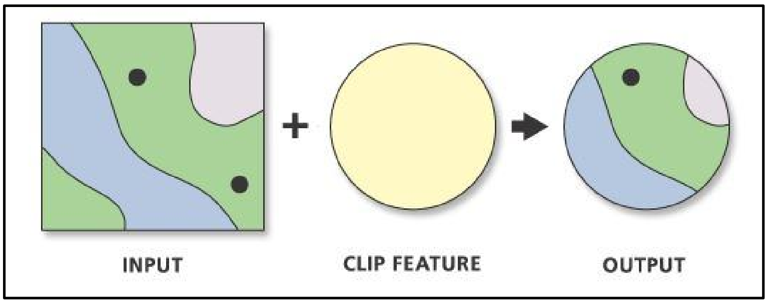


Figure 2.2: Clip feature tool

Splitting the Input Features creates a subset of multiple output feature classes. The Split Field's unique values form the names of the output feature classes. These are saved in the target workspace.

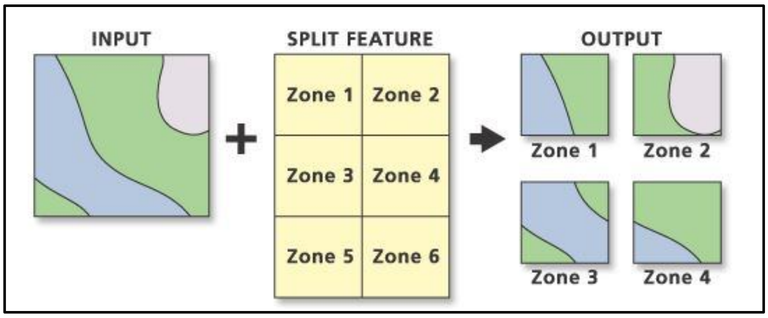


Figure 2.3: Split feature tool

2.4.2 Overlay toolset

One of the most basic questions asked of a GIS is "What's on top of what?" these questions are answered with the use of overlay tools. The Overlay toolset contains tools to overlay multiple feature classes to combine, erase, modify, or update spatial features, resulting in a new feature class. New information is created when overlaying one set of features with another. There are six types of overlay operations; all involve joining two existing sets of features into a single set of features to identify spatial relationships between the input features.

Tool	Description
Erase	Creates a feature class by overlaying the Input Features with the polygons of the Erase Features. Only those portions of the input features falling outside the erase features outside boundaries are copied to the output feature class.
Identity	Computes a geometric intersection of the input features and identity features. The input features or portions thereof that overlap identity features will get the attributes of those identity features.
Intersect	Computes a geometric intersection of the input features. Features or portions of features which overlap in all layers and/or feature classes will be written to the output feature class.
Spatial Join	Joins attributes from one feature to another based on the spatial relationship. The target features and the joined attributes from the join features are written to the output feature class.
Symmetrical Difference	Features or portions of features in the input and update features that do not overlap will be written to the output feature class.
Union	Computes a geometric union of the input features. All features and their attributes will be written to the output feature class.
Update	Computes a geometric intersection of the Input Features and Update Features. The attributes and geometry of the input features are updated by the update features in the output feature class.

Table 2.3: Tools in the Overlay toolset

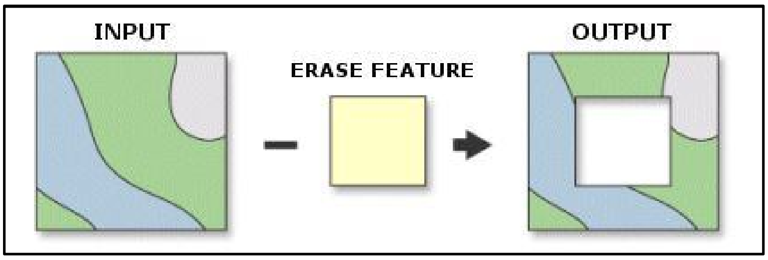


Figure 2.4: Erase tool

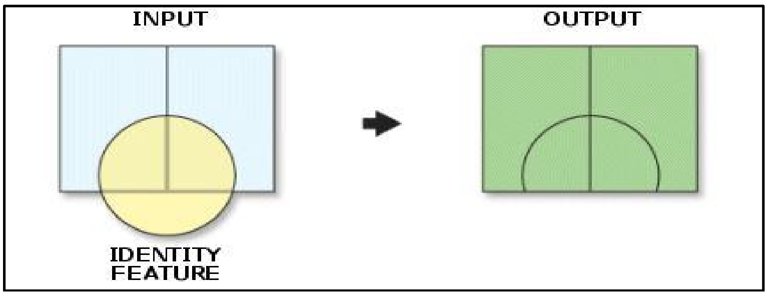


Figure 2.5: Identity tool

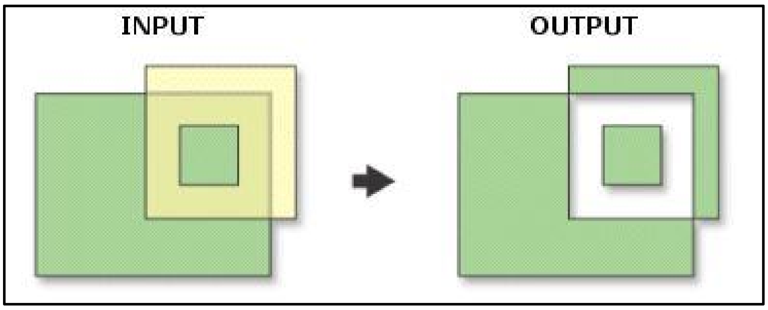


Figure 2.6: Symmetrical difference tool

2.4.3 Proximity toolset

The Proximity toolset contains tools that are used to determine the proximity of features within one or more feature classes or between two feature classes. These tools can identify features that are closest to one another or calculate the distances between or around them.

Tools	Description
Buffer	Creates buffer polygons around input features to a specified distance.
Create Thiessen Polygons	Creates Thiessen polygons from point input features. Each Thiessen polygon contains only a single point input feature. Any location within a Thiessen polygon is closer to its associated point than to any other point input feature.
Multiple Ring Buffer	Creates multiple buffers at specified distances around the input features. These buffers can optionally be merged and dissolved using the buffer distance values to create non-overlapping buffers.
Generate Near Table	Determines the distances from each feature in the input features to one or more nearby features in the near features, within the search radius. The results are recorded in the output table.
Near	Determines the distance from each feature in the input features to the nearest feature in the near features, within the search radius.
Point Distance	Determines the distances from input point features to all points in the near features within a specified search radius.

Table 2.4: Tools in the Proximity toolset

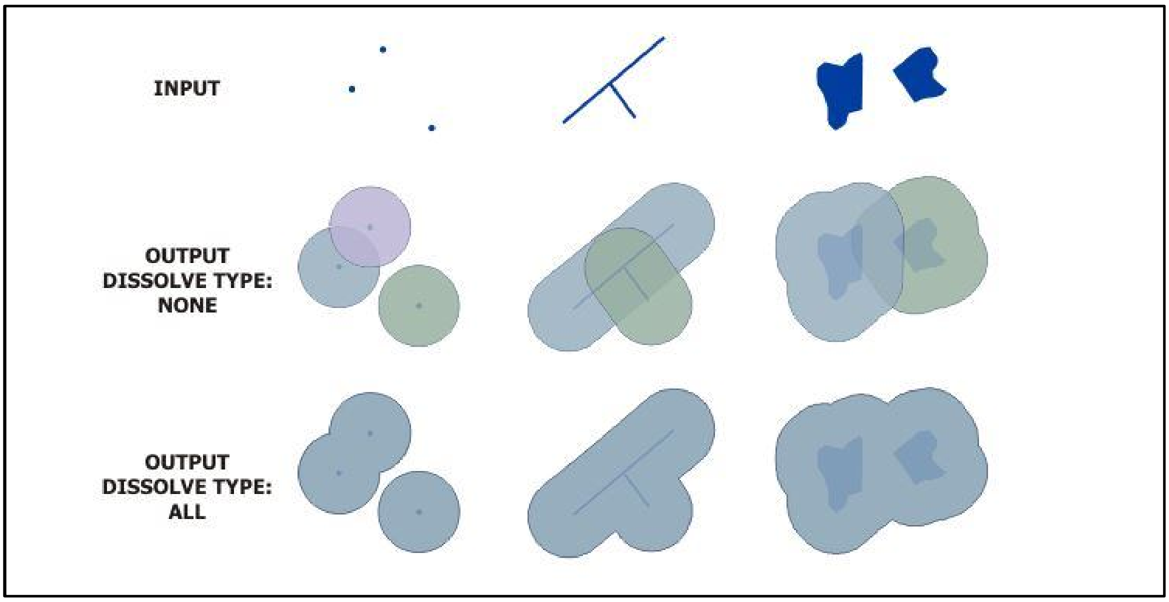


Figure 2.7: Buffer tool

2.4.4 Statistics toolset

The Statistics toolset contains tools that perform standard statistical analysis (such as mean, minimum, maximum, and standard deviation) on attribute data as well as tools that calculate area, length, and count statistics for overlapping and neighboring features.

Tool	Description
Frequency	Reads a table and a set of fields and creates a new table containing unique field values and the number of occurrences of each unique field value.
Polygon Neighbors	Creates a table with statistics based on polygon contiguity (overlaps, coincident edges, or nodes).
Summary Statistics	Calculates summary statistics for field(s) in a table.
Tabulate Intersection	Computes the intersection between two feature classes and cross-tabulates the area, length, or count of the intersecting features.

Table 2.5: Tools in the Statistics toolset

2.5 Model builder

ModelBuilder is an application use to create, edit, and manage models. Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input. ModelBuilder can also be thought of as a visual programming language for building workflows. Design of workflow of planning process with fixed tools and variable data.

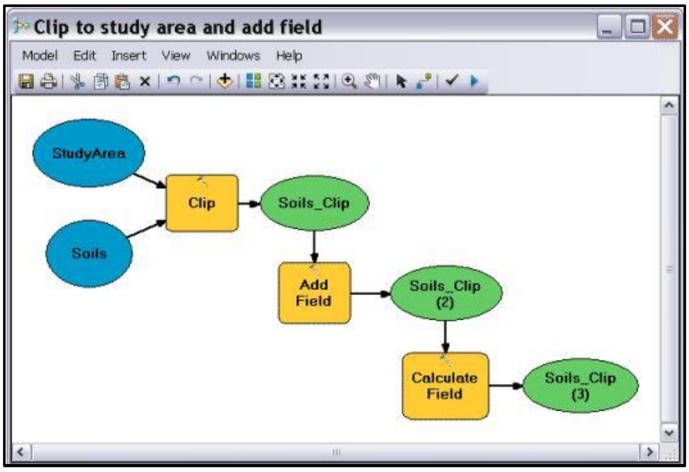


Figure 2.8: Simple model builder

While ModelBuilder is very useful for constructing and executing simple workflows, it also provides advanced methods for extending ArcGIS functionality by creation and sharing the models as tool. ModelBuilder can even be used to integrate ArcGIS with other applications. An example is Figure 2.9.

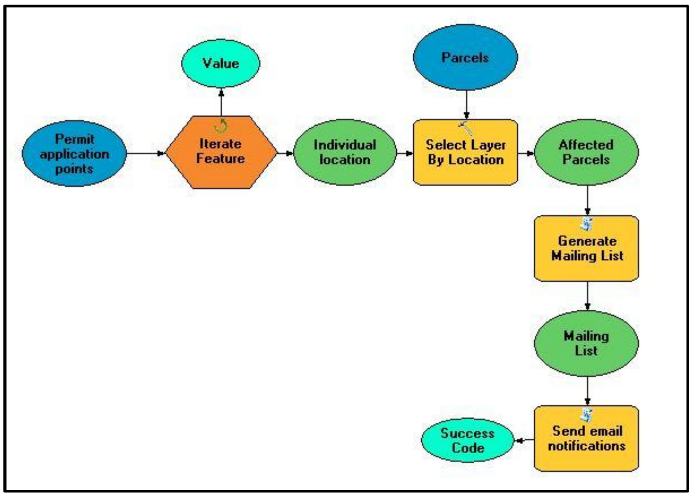


Figure 2.9: Advanced model builder

2.5.1 Benefits of modelBuilder

The benefits of ModelBuilder can be summarized as follows:

- ModelBuilder is an easy-to-use application for creating and running workflows containing a sequence of tools.
- You can create your own tools with ModelBuilder. Tools you create with ModelBuilder can be used in Python scripting and other models.
- ModelBuilder, along with scripting, is a way for you to integrate ArcGIS with other applications.

2.5.2 Model elements

Model elements are the basic building blocks of models. There are three types:

2.5.2.1 **Tools:** Geoprocessing tools are the basic building blocks of workflows in a model. Tools perform various operations on geographic or tabular data. When tools are added to a model, they become model elements.

2.5.2.2 **Variables:** Variables are elements in a model that hold a value or a reference to data stored on disk. There are two types of variables:

- **Data:** Data variables are model elements that contain descriptive information about data stored on disk. Properties of data that are described in a data variable include field information, spatial reference, and path.
- **Values:** Value variables are values such as strings, numbers, Booleans (true/false values), spatial references, linear units, or extents. Value variables contain anything but references to data stored on disk.

2.5.2.3 **Connectors:** Connectors connect data and values to tools. The connector arrows show the direction of processing. There are four types of connectors:

- **Data:** Data connectors connect data and value variables to tools.
- **Environment:** Environment connectors connect a variable containing an environment setting (data or value) to a tool. When the tool is executed, it will use the environment setting.
- **Precondition:** Precondition connectors connect a variable to a tool. The tool will execute only after the contents of the precondition variable are created.
- **Feedback:** Feedback connectors connect the output of a tool back into the same tool as input.

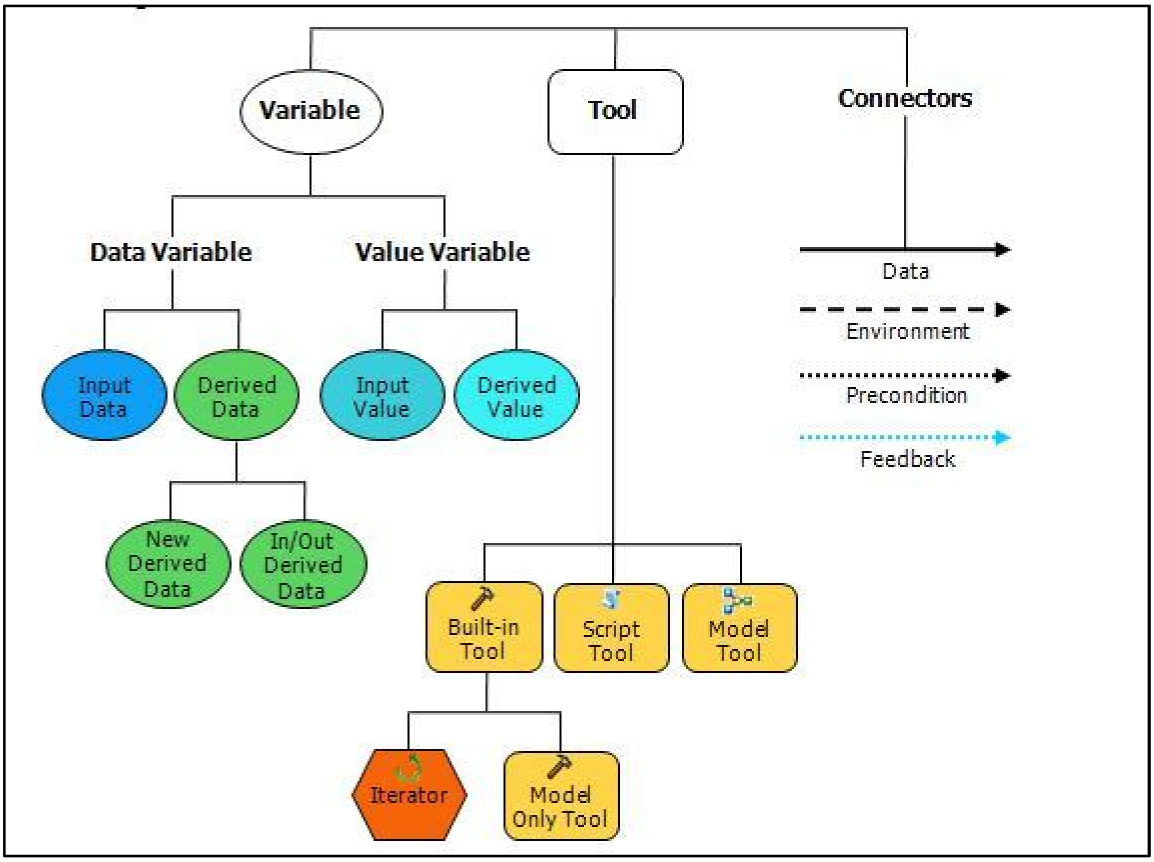


Figure 2.10: how model elements are classified in ModelBuilder

CHAPTER THREE
URBAN PLANNING

3.1 Introduction

There is a widely varied opinion among scholars about the definition of planning. No matter the divergent opinions, planning consists of goals and means. The goals contained in a plan must be explicit and coherent and there must be a means available for achieving the goals. Planning from this perspective can be defined as a consciously directed activity with pre-determined goals and means to carry them out (Agrawal and Lal, 1980). However, Hall (1974) defined planning as an ordered sequence of operations, designed to lead to the achievement of either a single goal or to balance between several goals‘. This implies that the goal may be designed to achieve one objective or the other in the future.

3.2 Types of planning

Planning can be classified according to the nature of the field on which it is applied

3.2.1 Physical Planning

Physical planning is concerned with the orderly spatial arrangement of man-made structures and the activities so as to create healthy environment for living, working circulation and recreation. It also involves development of a new town or village, renewal of decay city core and re-planning of shanty settlements in the urban fringe. It is also called Spatial Planning and this is what we need to discuss in this thesis.

3.2.2 Economic Planning

Economic planning is concerned with centrally directed allocation of resources to primary, secondary, and tertiary sectors of the economy. It aims at increasing the gross national product, agricultural production, industrial output, savings, and investments. Economic planning is also called Sectoral Planning.

3.2.3 Development or Innovative Planning

Development planning is a process of formulating consistent social policies, economic programmes and institutional reforms that are capable of putting the economy on the path of progress.

3.2.4 Indicative and Imperative Planning

Indicative planning is a process of laying down policy guidelines that the government agencies, private companies and investors will follow in their day-to-day activities. Government rarely intervenes in the affairs of private industries as long as they function within the framework of the economic policies formulated. Directly, this type of planning co-ordinates the policy-making of government within a coherent whole. Indirectly, the rest of the economy is steered along the guidelines of the government policy.

3.2.5 Fixed or Rolling Planning

Fixed planning is a process of preparing a plan for a rigidly fixed period of time. A plan may be for five years say 2005-2010, it therefore mean that the programmes and policies contained in the plan will not change between 2005-2010. Thereafter, another 5-year plan, starting from the year 2010-2015 will be formulated and implemented. Fixed plan show the uni-direction of government policy to investors, but fails to incorporate certain unforeseen changes and developments such as shortfall in crude oil revenues, that may arise within the planned period.

3.3 Urban Planning

Urban Planning involves the planning of the physical and social development of a city through the design of its layout and the provision of services and facilities Urban or city planning, is the unified development of cities and their environs. For most of its history, urban planning deals primarily with the regulation of land use and the physical arrangement of city structures, as guided by architectural, engineering, and land-development criteria. In the mid-20th century it had been broadened to include the comprehensive guidance of the physical, economic, and social environment of a community. Elements characteristic of urban or city planning include:

- general plans that summarize the objectives of (and restraints on) land development;
- zoning and subdivision controls that specify permissible land uses, densities, and requirements for streets, utility services, and other improvements;
- plans for traffic flow and public transportation;
- strategies for economic revitalization of depressed urban and rural areas;
- strategies for supportive action to help disadvantaged social groups; and
- Guidelines for environmental protection and preservation of scarce resources.

3.3.1 Urban planning and GIS

Urban planning is one of the main applications of GIS. Urban planners use GIS both as a spatial database and as an analysis and modelling tool. The applications of GIS vary according to the different stages, levels, sectors, and functions of urban planning. The users which were considered as friendliness had became familiar with GIS together with the appreciated decrease in the cost of GIS software and hardware, GIS is an operational and affordable information system for planning. Nowadays GIS is considered as an important spatial decision support systems for planning . Recent advances in the integration of GIS with planning models, visualisation, and the Internet will make GIS more useful to urban planning. The main constraints in the use of GIS in urban planning today are not technical issues, but the availability of data, organisational change, and people.

3.3.2 The use of GIS in urban planning

GIS is just one of the formalized computer-based information systems capable of integrating data from various sources to provide the information necessary for effective decision-making in urban planning (Han and Kim 1989). Other information systems for urban planning include database management systems (DBMS), decision support systems (DSS). GIS serves both as a database and as a toolbox for urban planning. In a database-oriented GIS, spatial and attribute data can be stored and linked using the File geo-database. Current GIS support efficient data retrieval, spatial analysis, and mapping. When combined with data from other tabular databases or specially conducted surveys, geographical information can be used to make effective planning decisions. As a toolbox, GIS provides planners with comprehensive tools to perform spatial analysis using such as map overlay, connectivity measurement, and buffering (See 2.4). Of all the geoprocessing functions, map overlay is probably the most useful tool. Urban planners use GIS both as a spatial database and as an analysis and modeling tool. The applications of GIS vary according to the different stages, levels, sectors, and functions of urban planning. Database management, visualization, spatial analysis, and spatial modeling are the main uses of GIS in urban planning (Levine and Landis 1989). GIS is used for the storage of land use maps and plans, socioeconomic data, environmental data, and planning applications. Planners can extract useful information from the database through spatial query. Mapping provides the most powerful visualisation tools in GIS. It can be used to explore the distribution of socioeconomic and environmental data, and display the results of spatial analysis. Spatial analysis and modelling are used for spatial statistical analysis, site selection, identification of planning action areas, land suitability analysis, land use transport modelling, and impact assessment. Interpolation, map overlay, buffering, and connectivity measurement are the most frequently used GIS functions in spatial analysis and modelling. The use of the above functions varies according to different tasks and stages of urban planning.

There are many benefits in using GIS in urban planning include:

- Improved mapping – better access to maps.
- Improved map currency, more effective thematic mapping, and reduced storage cost.
- Greater efficiency in retrieval of information.
- Faster and more extensive access to the types of geographical information important to planning and the ability to explore a wider range of 'what if' scenarios.
- Improved analysis.

3.3.3 Re-planning of informal settlement

Due to the lack of development, many of the residents of village and rural, migrate to the big cities in search of basic services and employment opportunities. Most of those cannot afford housing within the city, so they resort to create informal settlements on the edge of cities. Informal settlement has been defined in various ways depending on the planning and legal framework of a country where it exists. Informal settlements may contain a few dwellings or thousands of them, and are generally characterised by inadequate infrastructure, poor access to basic services, unsuitable environments, uncontrolled and unhealthy population densities, inadequate dwellings, poor access to health and education facilities and lack of effective administration by the municipality**.**

Re-planning of informal settlement as a solution for these illegal settlement needs to lay the foundations and technical standards, as well as the enactment of laws, for optimal results.

3.3.3.1 The technical perspective

Prior starting to prepare the outline for these settlements must study relation site schemes and neighboring facilities in order to clarify the following:

- Quality and service locations existing or approved network facilities, streets, and the impact on the design of the settlement.
- Relation to the natural environment surrounding the settlement.

As for this thesis discuss Physical Planning Department Guidelines in Khartoum state, Guidelines for schemes proposed to regulate villages in Khartoum state prepared by the Technical Committee for Urban Planning: -

- All the roads and paths which cross villages must be continuous.
- Provide major streets (internal) with minimum width 15 meters, and connect it to a highways network and surrounding the village (provide more than street).
- Short streets (internal) and impassable, minimum width not less than 8 meters.
- Provide minimum services (basic schools - mosques - and open spaces) as much as possible.
- Villages which bordering the Nile are reviewed in accordance with the Guidelines interfaces Nilotic (water), and the visions of the structural plan of urban of the state.

In addition to other general guidelines and conditions like: the edge of residential parcel which faced the street must be not less than 10m.

3.3.3.2 The legal perspective

The most important characteristic of informal settlements, it lack of a legal record. To carry out the planning process must study the legal status of the area firstly, and then apply the law of the land registration. In order to facilitate the process of grants to the beneficiaries and treated as urban settlement in terms of taxation and revenue.

For the Sudan, it applied the law of the land registration for the year 1925 revised of 1985, which regulates the process of registration of public and private land, agricultural and residential. In this thesis, it must be point out to the paragraph which states that prevents the registration of any residential land with an area of less than 200 square meters.

CHAPTER FOUR

METHODOLOGY

This chapter explains the proposed automation of re-planning process as an alternative to the current used system.

4.1 Study area

The study area is AL-Oshara district, which is located south east of Omdurman city, 1km west of White Nile, surrounded between coordinates (440330 & 441486)E and (1720112 & 1721125)N, WGS84 Datum, UTM Projection Zone 36N.

4.2 Source of data

Aerial photograph had been used as a primary source of spatial data with the following specifications:

Produced by: Khartoum State Survey Department.

Date of Photography: 2008.

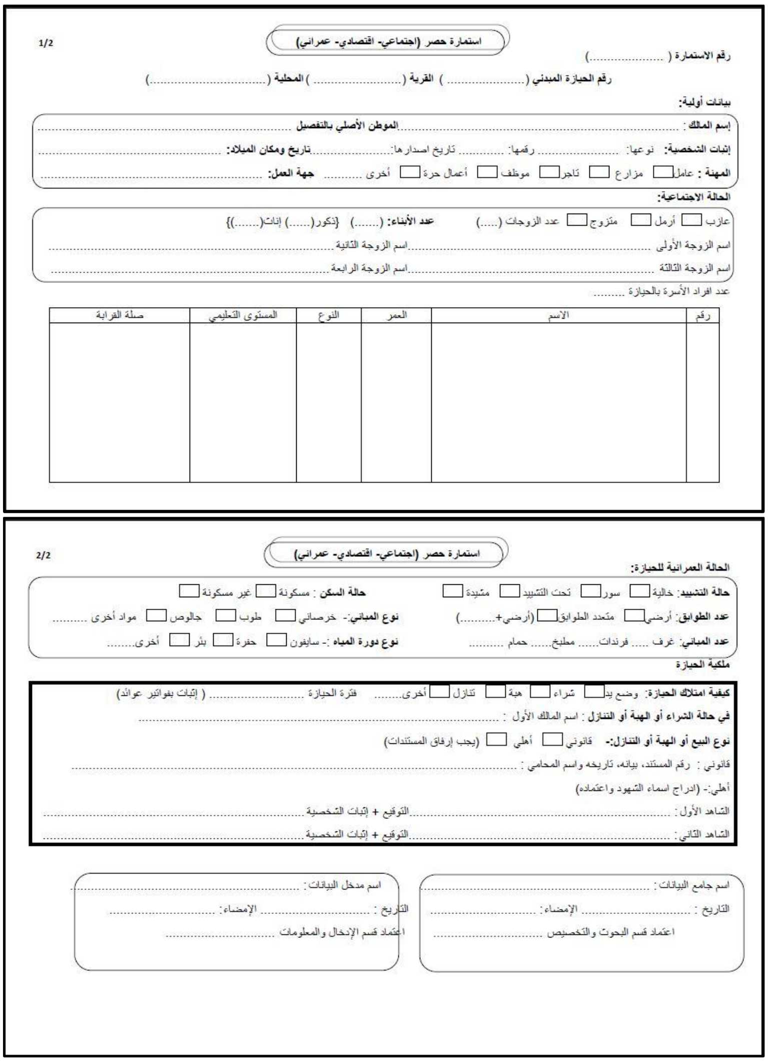
Resolution: 10cm

Datum: WGS84.

Projection: UTM, Zone 36N.

Sudanese Law of Land registration 1925 modified 1985. And Physical Planning Department Guidelines of Khartoum state had been taken as references of laws and planning regulations.

A Form had been designed to collect the attribute data about parcels in the study area containing: basic identification information of the owner such as: name, name(s) of wife(s), names of children, status of ownership.etc. See figure 4.1



1/2

استمارة حصر (اجتماعي- اقتصادي- عمراني)

رقم الاستمارة (......................)

رقم الحيازة المبدني (......................) القرية (......................) المحلية (..............................)

بيانات أولية:

إسم المالك : ....الموطن الأصلي بالتفصيل ....

إثبات الشخصية: نوعها: .... رقمها: .... تاريخ اصدارها: ....تاريخ ومكان الميلاد: ....

المهنة : عامل ☐ مزارع ☐ تاجر ☐ موظف ☐ أعمال حرة ☐ أخرى .... جهة العمل: ....

الحالة الاجتماعية:

عازب ☐ أرمل ☐ متزوج ☐ عدد الزوجات (.....) عدد الأبناء: (.......) {ذكور(......) إناث(......)}

اسم الزوجة الأولى ....اسم الزوجة الثانية ....

اسم الزوجة الثالثة ....اسم الزوجة الرابعة ....

عدد افراد الأسرة بالحيازة ....

رقم	الاسم	العمر	النوع	المستوى التعليمي	صلة القرابة

2/2

استمارة حصر (اجتماعي- اقتصادي- عمراني)

الحالة العمرانية للحيازة:

حالة التشييد: خالية ☐ سور ☐ تحت التشييد ☐ مشيدة ☐ حالة السكن : مسكونة ☐ غير مسكونة ☐

عدد الطوابق: أرضي ☐ متعدد الطوابق ☐ (أرضي+.........) نوع المباني:- خرصاني ☐ طوب ☐ جالوص ☐ مواد أخرى ....

عدد المباني: غرف ..... قرندات...... مطبخ...... حمام .... نوع دورة المياه :- سايفون ☐ حفرة ☐ بئر ☐ أخرى.......

ملكية الحيازة

كيفية امتلاك الحيازة: وضع يد ☐ شراء ☐ هبة ☐ تنازل ☐ أخرى....... فترة الحيازة .... (إثبات بفواتير عوائد)

في حالة الشراء أو الهبة أو التنازل : اسم المالك الأول : ....

نوع البيع أو الهبة أو التنازل:- قانوني ☐ أهلي ☐ (يجب إرفاق المستندات)

قانوني : رقم المستند، بيانه، تاريخه واسم المحامي : ....

أهلي:- (ادراج اسماء الشهود واعتماده)

الشاهد الأول : ....التوقيع + إثبات الشخصية ....

الشاهد الثاني : ....التوقيع + إثبات الشخصية ....

اسم جامع البيانات : ....

التاريخ : .... الإمضاء: ....

اعتماد قسم البحوث والتخصيص ....

اسم مدخل البيانات : ....

التاريخ : .... الإمضاء: ....

اعتماد قسم الإدخال والمعلومات ....

Figure 4.1: Form No1

ArcGIS 10.2 software has been used to automate the re-planning process and design a model with perfect database for spatial data linked to attribute data, which is ready to use for storage, analyses and editing at any time.

4.3 Steps of the design of the proposed model

Main steps for the creation of the proposed model:

4.3.1 Data collection

Aerial photograph (see 4.2) of the study area had been input to ArcGIS software, ArcMap interface.

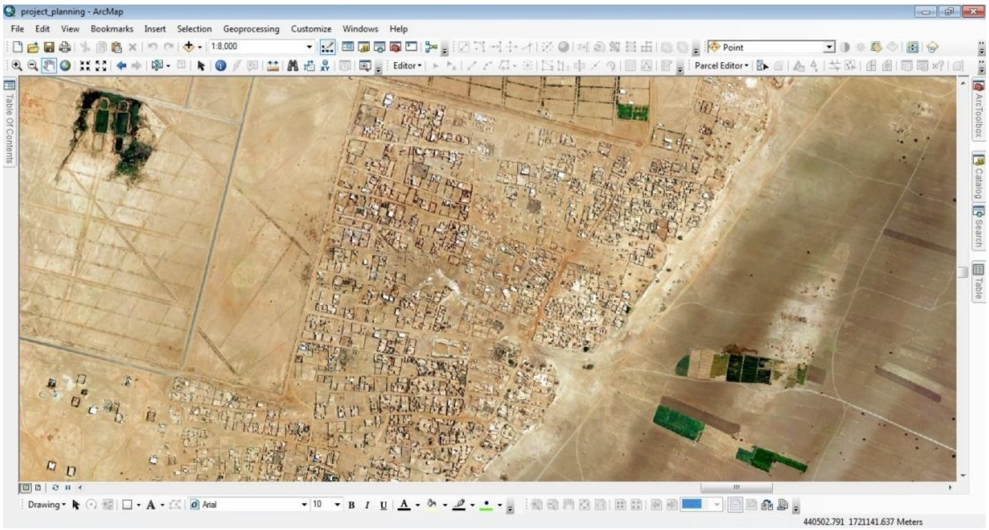


Figure 4.2: Preparing Image using ArcMap

A form (figure 4.1) had been filled with the attribute data about parcels from the study area.

4.3.2 Data processing

Many steps had been followed to process the data.

4.3.2.1 Creation of the layers

Using ArcCatalog interface the required layers had been created as follows:

- File Geodatabase named Planning, contain all the feature classes of layers used in the model.
- Parcel layer of polygon feature class with the fields: district name(text field), Block No(integer), Parcel No (integer), Area (Double) area field had been created automatically on the feature class in (Shape Area) or can be easy to calculate on attribute table, using calculate geometry.
- Street layer of polyline feature class with the fields: Name (text), Width (integer), Class (text).
- Study Area layer of polygon feature class: representing the total area of study.

4.3.2.2 Digitizing and making a parcel layer

Parcel layer had been digitized from the aerial photograph (image) at (parcel) feature-class using ArcMap tools.

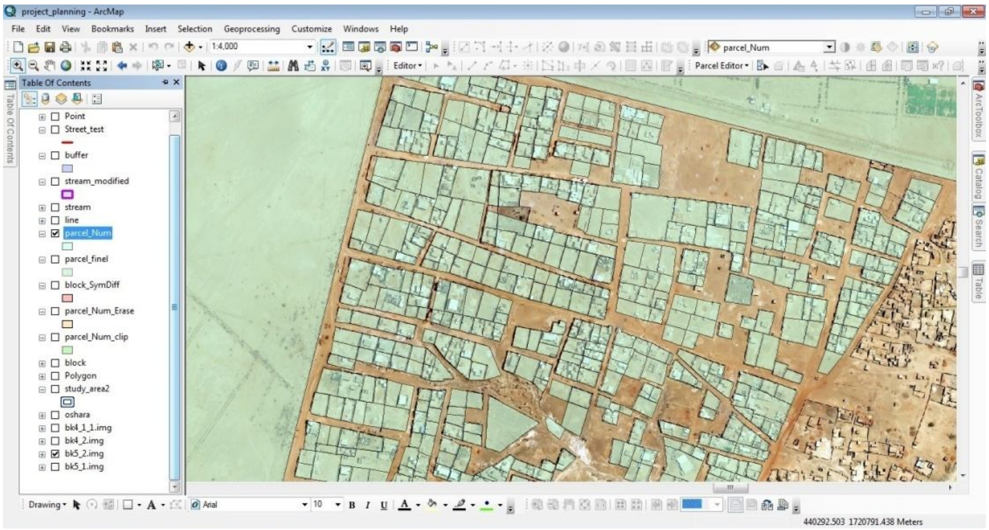


Figure 4.3: Parcel feature class

The attribute table of the parcel layer had been filled with unique number and recorded at field (Parcel No) then automatically GIS software calculate the area of parcels at Field (Shape-Area) or it can be easy to calculate the value of area using calculate geometry in Field (Area). Without need of site work

4.3.2.3 Filling the Form1and linking it with parcel layer

Form (1) had been filled by the required data at the study area; the database of the study area had been built in the attribute table depending on the collected data, containing: economical, social and structural data. (See figure 4.1) Necessary basic data compatible for the purpose of the research is the following attributes:

(Parcel No – Owner –Building Type – Housing Situation – Land Use – Area – Notes)

The attribute data (Form 1) had been linked to spatial data (parcel layer), Parcel-No field had been used as Id number (key field).

4.3.2.4 Creating and classifying the roads

Re-planning process starts with Study the status of the roads, in terms of: width, connecting to the main roads network, importance, services etc, referring to the existing image (figure no. 4.2), the roads had been created at Street layer, the roads had been classified into three type according to their width (Main 15m, medium 10m and internal 8m) and had been recorded in the attribute table in the field (width). Streets' design must consider condition and terms of Planning (See 2.3.3.1) to satisfy public transportation, and general services.

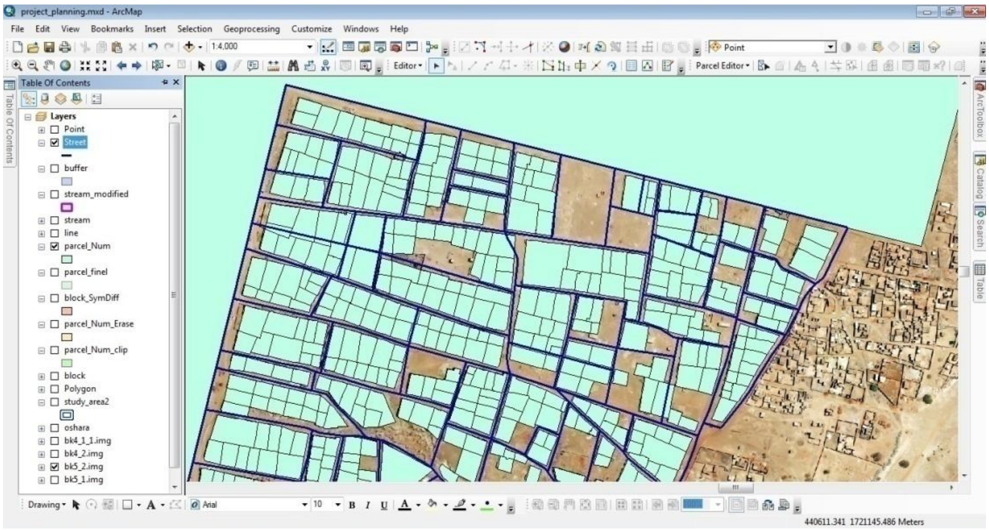


Figure 4.4: Street feature class

4.3.2.5 Buffering the streets

Depending on width's roads, a new layer had been produced named (buffer street), by using ArcToolsBox buffering by field tool using (Width) field, see (2.4.3)

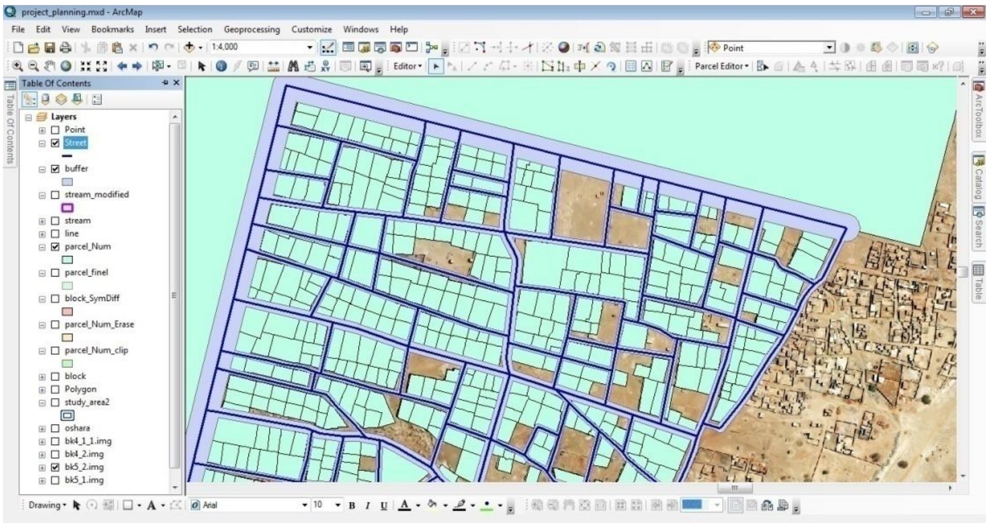


Figure 4.5: Buffering of street layer

4.3.2.6 Clipping and erasing the parcels using streets' buffer

After preparing streets' buffer, the parts of any parcels lie within the buffer area had been deleted to satisfy the required road's width, by using Erase tool (see 2.4.1) and the output is (Parcel Erase) layer, a layer of the omitted parts had been created using Clip tool (see 2.4.2), and the output is (Parcel Clip) layer, using (parcel) layer as a source layer and (buffer street) as clip or erase layer.

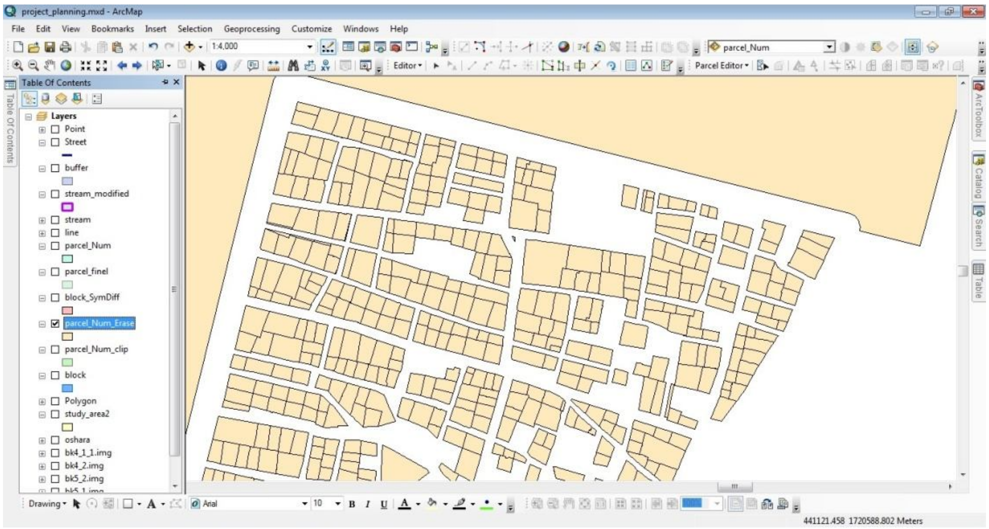


Figure 4.6: (Parcel Erase) layer after using Erase tool

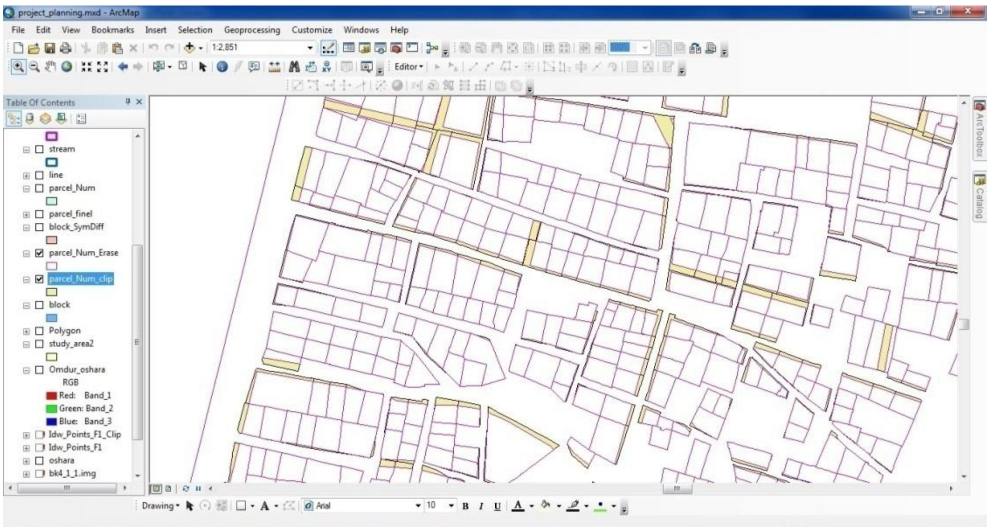


Figure 4.7: (Parcel Clip) Layer after Using Clip tool

4.3.2.7 Detecting the vacant areas and reshaping the blocks

Actually, within re-planning process vacant areas had been shown as empty area between parcels, to gain these areas: firstly figure out the new shape of blocks or the boundaries of blocks as fallow: drawing a great polygon representing a study area (Figure 4.8), then Erasing the Study area polygon by using (Buffer Street) layer, the output is a group of polygons representing new blocks layer (Block) after re-planning.

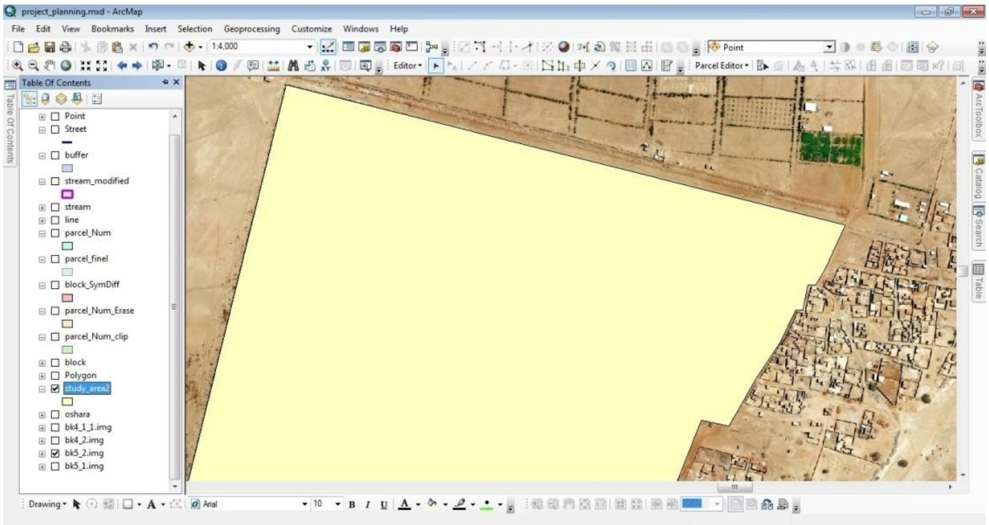


Figure 4.8: Study area layer

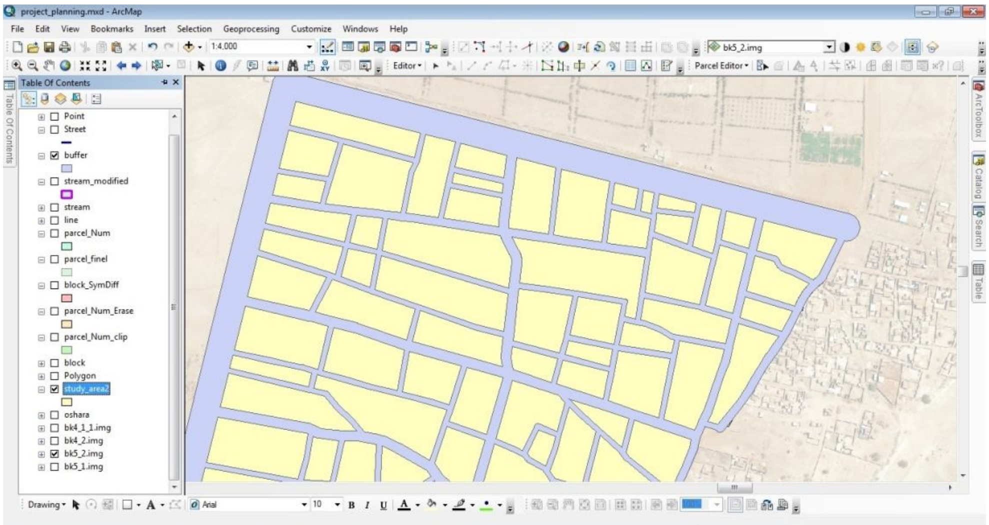


Figure 4.9: Using Buffer Street layer to figure out the blocks

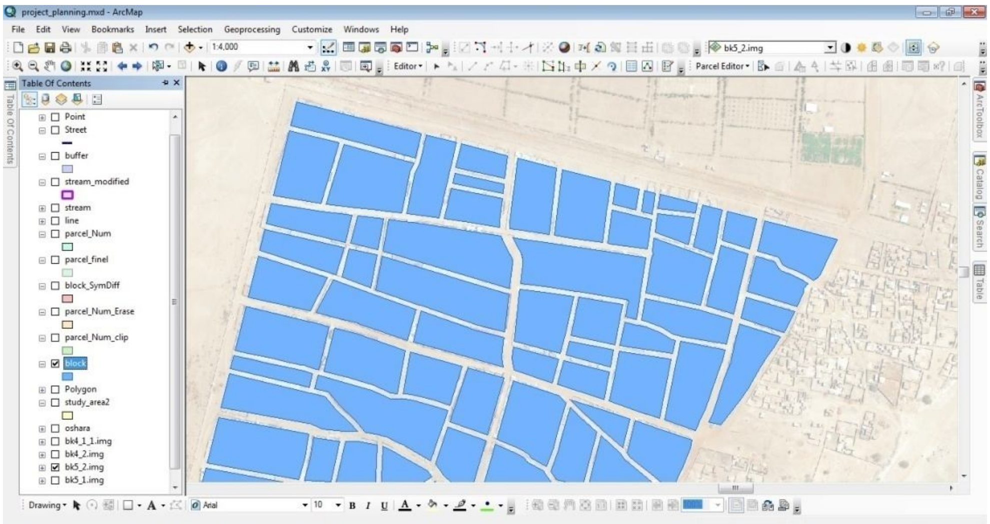


Figure 4.10: The new Shape of Blocks in Block layer

Secondly, to gain the vacant areas which can make use of it, even the small areas which touching the street buffer, there are two methods, the first one: Erasing the (Block) layer by using (Parcel Erase), the second one: using the (Symmetrical difference) Tool with (Parcel) layer and (Block) layer.

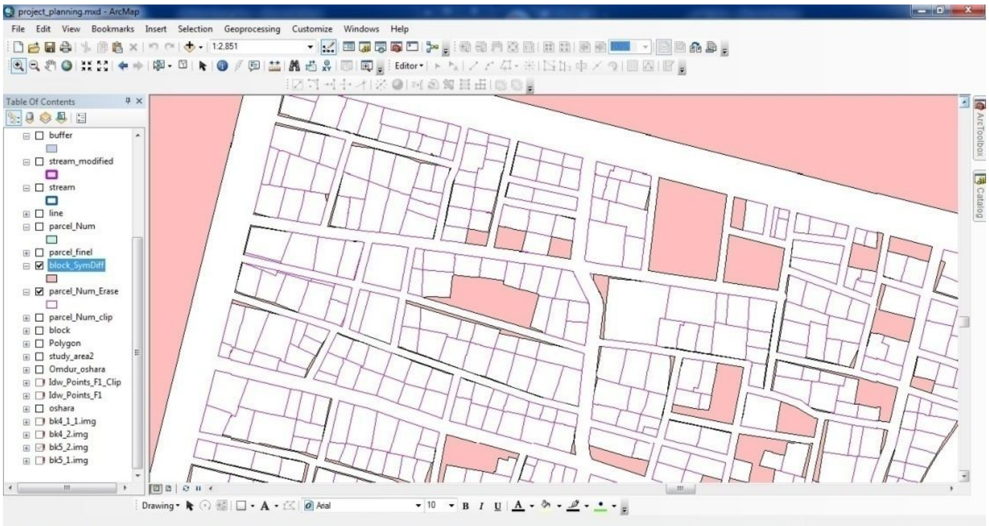


Figure 4.11: (Block Sym Diff) layer representing vacant areas

The General plan of the Blocks has been modified by adding the vacant areas to suitable parcels, and few corrections to keep the alignment of the general shape of blocks.

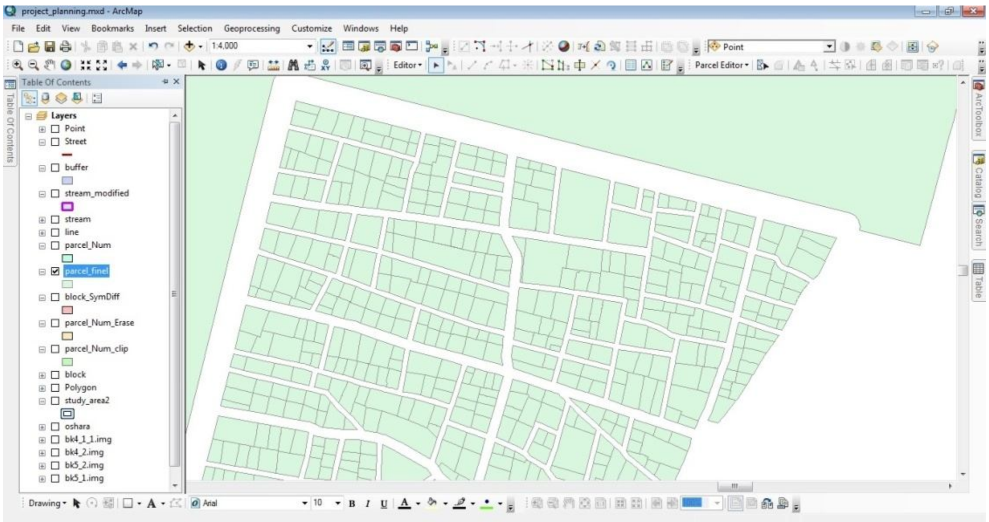


Figure 4.12: The final plan (Parcel Final) layer

4.3.3 Data Analysis

In conjunction to the new proposed system (model), re-planning the study area had been started by surveying of existing parcels (4.3.1), parcel layer had been created (Figure 4.3), after the creation of parcels' map with, parcel had been numbered to be used in the filling of form 1, parcel number must be a unique number (identifier) to link the parcels' map with the attribute table.

The empty parcels or vacant areas had been Detected automatically using attribute table and inquiry tools (select by attributes), by writing this code (Parcel_No= "Null") on the (select by attributes window) and it had been documented in a report (Figure 4.13).

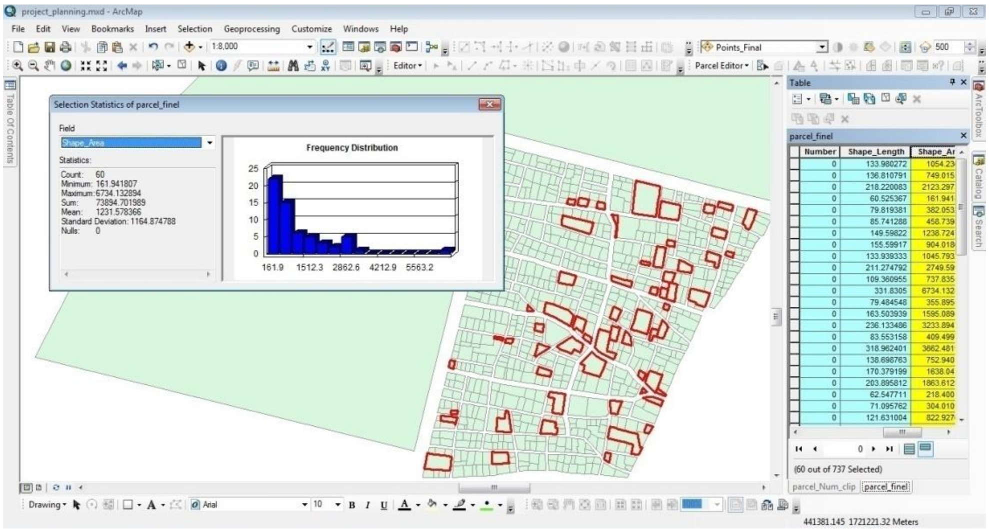


Figure 4.13: Detection of new parcels and making a report

The detail of empty parcels of the study area had been documented as follow: 60 parcels of area between 162 to 6734 SM.

The parts of any parcels which had been omitted in 4.3.2.6 to satisfy the required road's width, (figure 4.7) and the field of area had been used to calculate the compensations cost for each owner by multiplying the area by value of the squared meter. Field Calculator in the attribute table had been used as a tool and immediately making report for the results (figure 4.14).

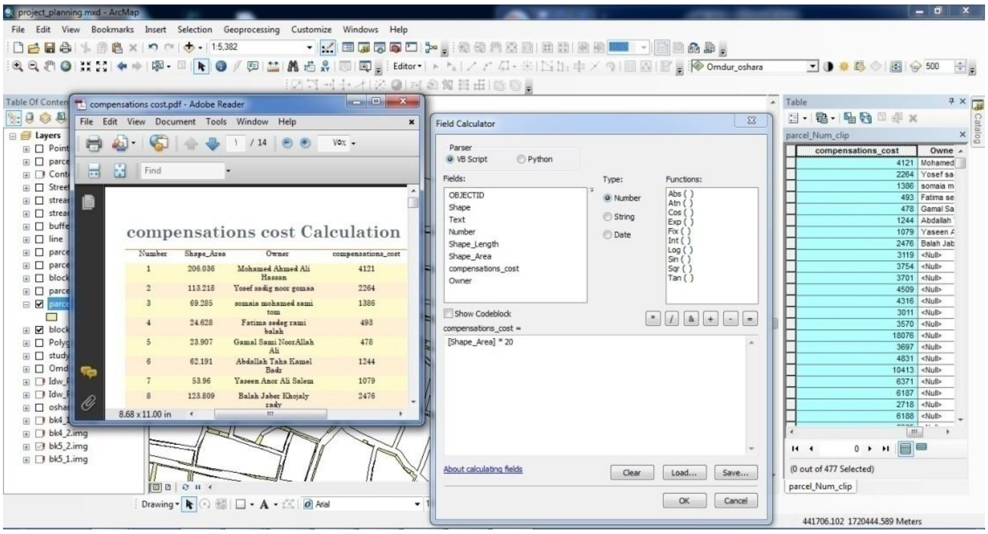


Figure 4.14: compensations cost and making a report

The parcels which of area less than 200sm, restricted from registration according to the conditions of land registration terms had been determined by using Analyses tools, Selecting by Attribute and making report,

No. of Parcel	***Land Use***	***Area***
Null	Government Reserve	161.9418
Null	Government Reserve	173.7465
Null	Government Reserve	191.8993
9	Residential Parcel	185.7647
17	Residential Parcel	156.8226
20	Residential Parcel	190.1474
21	Residential Parcel	188.1989
126	Residential Parcel	150.3676
172	Residential Parcel	194.4539
203	Residential Parcel	197.3348
204	Residential Parcel	186.972
211	Residential Parcel	118.2634
234	Residential Parcel	166.3036
277	Residential Parcel	104.5584
361	Residential Parcel	180.1521
362	Residential Parcel	163.2458
374	Residential Parcel	171.7432
452	Residential Parcel	152.3479
465	Residential Parcel	188.5259
489	Residential Parcel	124.9974
498	Residential Parcel	190.8029
574	Residential Parcel	143.7525
579	Residential Parcel	184.7046
581	Residential Parcel	93.85047
635	Residential Parcel	170.1184

Table 4.1: parcels less than 200m^2

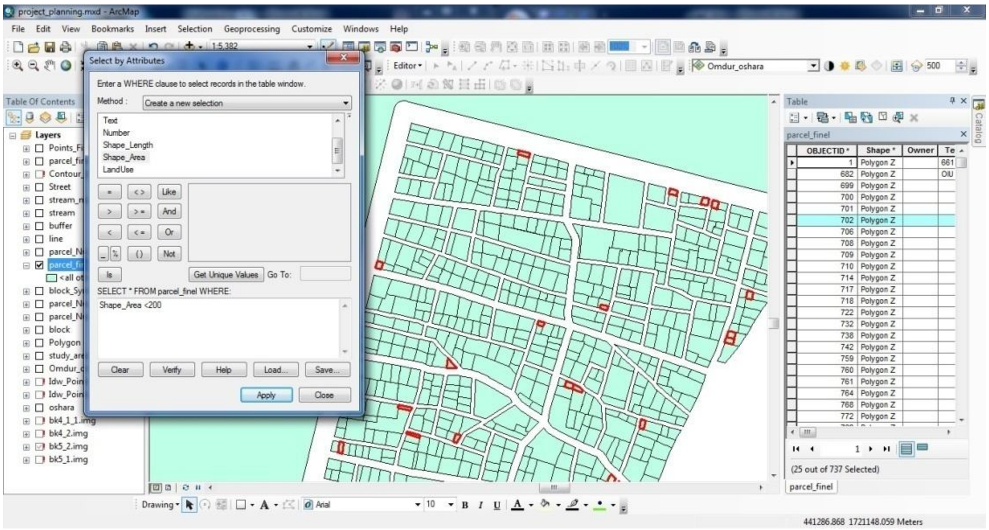


Figure 4.15: Selecting the parcels which it area less than 200m^2

Parcels of sides facing the roads of layer the lest than 10m (restricted due to the conditions of slums and village re-planning issued by Physical Planning Department) had been determined by converting parcel final layer from polygon feature into polyline feature on layer Parcel Final Line then this layer had been classified into two types (Wall fence) facing street and (Inner), after that Selection by attribute had been used to select the lines which less than 10m and Wall fence, then using the suitable manipulation to solve the case, and making report using attribute table.

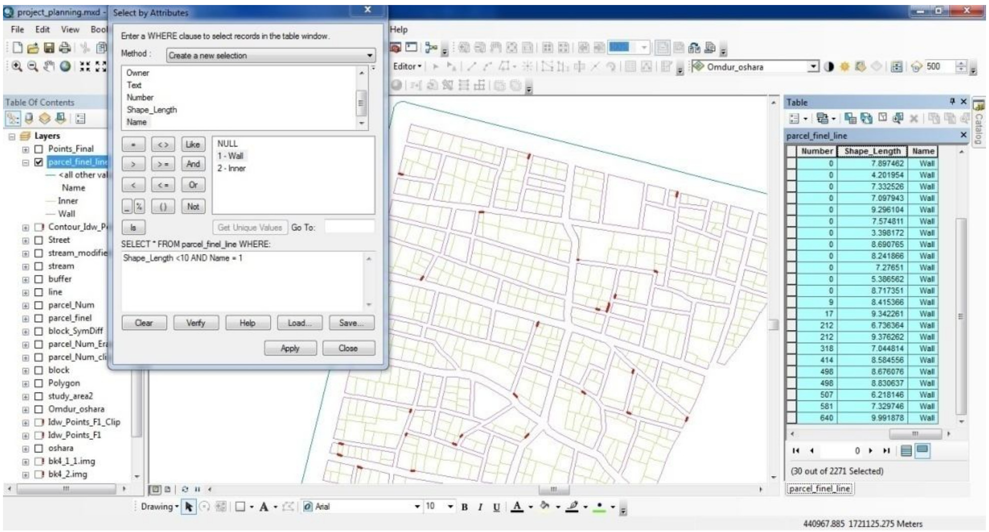


Figure 4.16: Selecting the edges which it length less than 10m

4.4 Model design

The power of GIS Software lies in its capability to assemble a set of tools and processes in one model to perform a particular task, this compilation is called modelBuilder, GIS can create the model by Using Model Builder.

Model had been built to assemble all the previous procedures in one tool called Planning (figure 4.17) and (figure 4.18) added to the toolbox to be used as a flowchart to repeat the process each time.

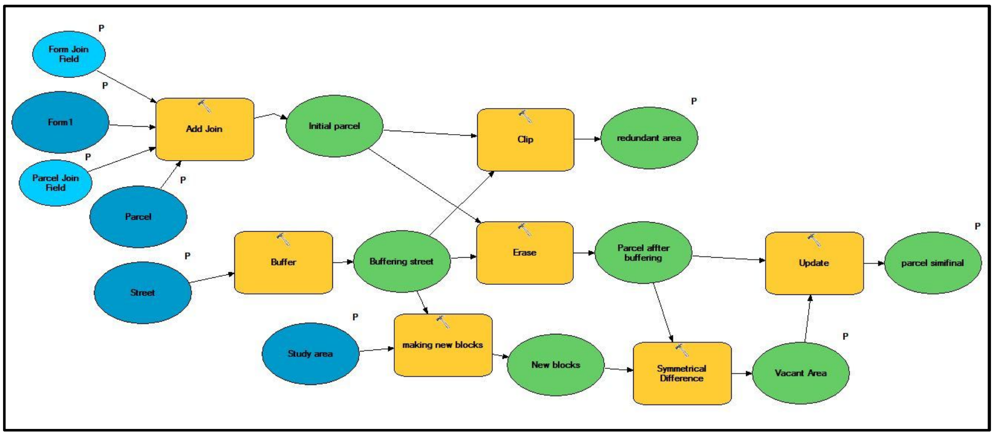


Figure 4.17: Planning Model

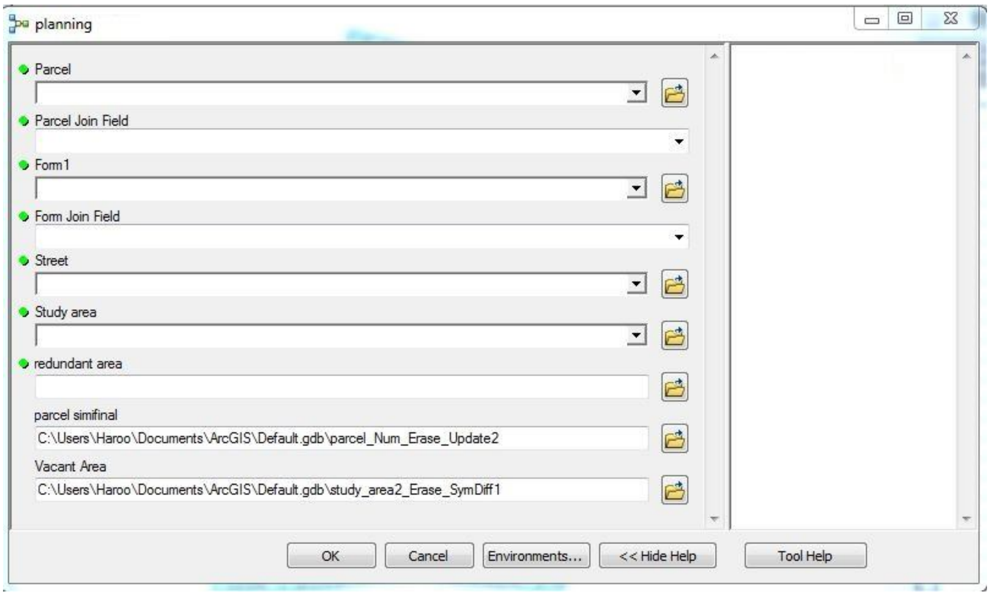


Figure 4.18: Planning Model window

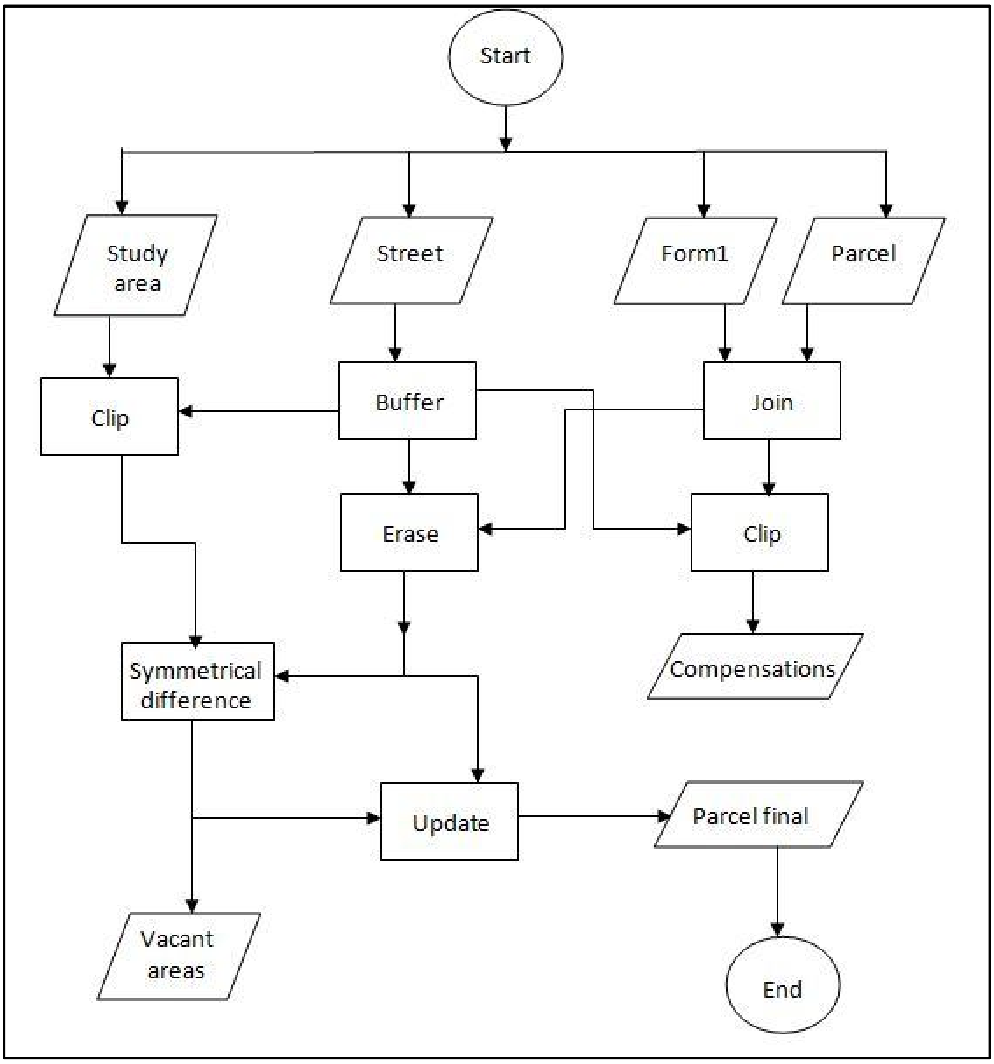


Figure 4.19: the flowchart of the model

CHAPTER FIVE

RESULTS AND ANALYSIS

Apply the analysis steps as show in the model builder (figure 4.17) the following results had been obtained:

- All empty parcels had been determined and reported to be registered as a government reserve (figure 4.13) 60 parcels. These parcels can be used for utilities, green areas and the compensations of the omitted parcels.
- The omitted parts of parcels, which had been resulted from the widening the width of the roads, had been determined (figure 4.7) to be used in the calculation of the compensations cost (figure 4.14).
- Parcels of area less than 200sm which are restricted from registration had been determined (figure 4.15), 25 parcels to be solved by combination of the neighboring ones and merging small ones to the parcel satisfying the regulations of land registration.
- Parcels of sides facing the roads of width less than 10m had been determined (figure 4.16) 30 parcels.
- Finally all parcels satisfying the conditions of Physical Planning Department and Land Registration had been determined including the omitted areas of parcels for the purpose of compensations.
- The Parcels had been classified and symbolized according to their land use to be ready for layout and print. (figure 5.1)

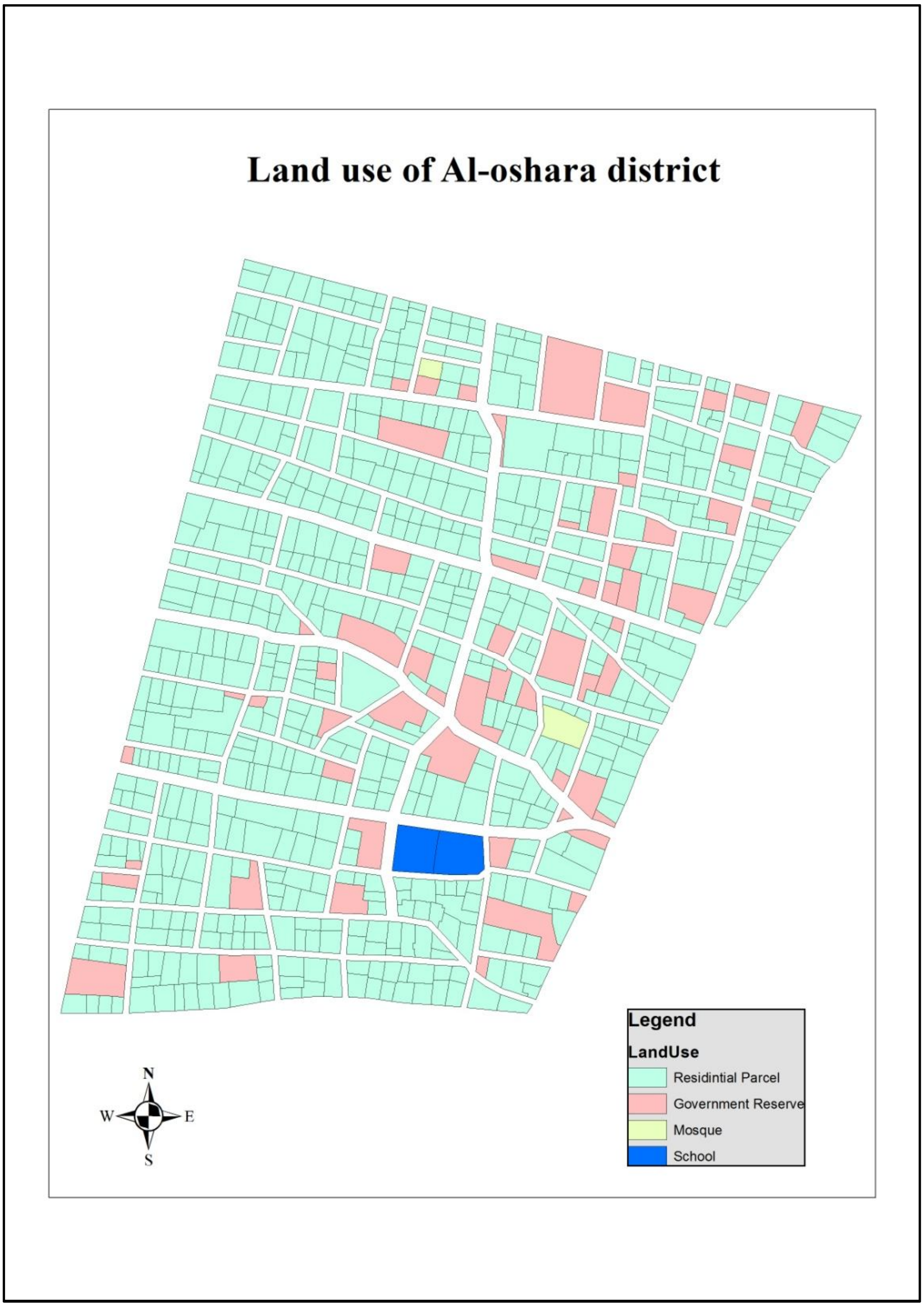


Figure 5.1: Classification of the parcels according to their land use

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The most important result in this thesis is a creation and determination of a specific path which leads to integration the attributes and spatial data to flow efficiently and systematically during the re-planning process. Therefore the conclusion of the thesis can be written as follow:

- Creation of model builder (flowchart) to execute re-planning procedures automatically to reduce: cost, effort, error, time and human fatigue.
- Integration of steps re-planning, registration and administration.
- Available digital database for extension of services utilities, electronic government, and etc.
- The storage of spatial and attributes data in a digital form is more reliable, that preserves rights and properties.

6.2 Recommendation

In closing to this thesis we recommended by the following:

- To Review and deeply studying for the re-planning process at all millstones to assemble all its procedures in proper way to make a full automated model with a global standard.
- To make use of the previous studies in the scope of land suitability and land availability, in order to manage the land use, and distribute the services and vacant areas in proper way.
- We recommend by extending this thesis, and make use of the GIS in terms of using parcel fabric technique.
- We recommend by extracting the contour from the Aerial photograph in order to use it in the scope of draining systems

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