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

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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 to improve and develop these settlements to be at the perfect planning level, with minimum damages as much as possible. Execution of this process manually leads to slow down the solution with disconnected procedures and sometimes to increase the complexity of the problem by adding new extension of informal settlements, 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 govern 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 process 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 photographs 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. Finally a digital re-planning model for the informal settlements had been designed to be as a guidance to execute the same steps for other areas by changing the data only.

Keywords **-** *Model builder, Parcel, Aerial Photograph, Automation*

المستخلص – عملية أعادة تخطيط المستعمرات السكنية من العمليات المعقدة المحكومة بأسس ضوابط فنية ولوائح قانونية وإجراءات وخطوات عملية لتحسين وتنمية هذه المستعمرات بتخطيطها بالصورة المثلى وتقليل الأضرار بقدر الإمكان. إجراء هذه العملية بالطرق اليدوية يؤدى إلى تأخير حلها وعدم ترابط الإجراءات المطلوبة وأحيانًا يساهم فى زيادة تعقيد المشكلة بإضافة إمتدادات عشوائية جديدة وضياع الزمن والجهد والتكلفة المالية ويقلل من الدقة. فى هذا البحث تم إقتراح طريقة جديدة تعتمد على الانظمة 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. أخيراً تم تصميم نموذج رقمى لإعادة تخطيط المناطق العشوائية لتنفيذ نفس الخطوات كدليل للمناطق الأخرى بتغيير البيانات فقط.

INTRODUCTION

The problem of the informal settlement in the Sudan started in 1980's. This problem had affected the big cities particularly the capitals of the states. The most cities which had been affected widely were Khartoum

north, Omdurman and Khartoum, the capital of the Sudan. The main reasons of this huge settlement were:

- Drought and desertification.
- Wars.
- Lack of services in rural areas.
- Weakness of rural economy.
- Improvement of life quality.

Growth and expansion of informal settlements on the edges of the cities, which lacking urban planning and service utility, by rural areas citizens, with their village's habits and traditions, as a result of this situation these cities had been changed to big villages. This situation increases the burdens on the existing services such as health, water, electricity, security, drainage, sewerage, education, transportation.. etc. It is difficult to extend and establish basic services to these districts, due to irregularities of narrow roads, construction of buildings by plans and materials not satisfying the planning specifications together with the absence of empty lands enough for the construction of services. Many social, economic and political complicated problems were the direct results of informal settlements. The currently applied approach for re-planning these districts is to collect the spatial and attribute databases by direct field work manual techniques. The processing of the collected raw data is carried out manually. This method is complicated, very tedious, costly and time consuming. Documentation of the obtained databases has many drawbacks such as lack of: reliability, accessibility, integrity, efficient storage and retrieval, link between spatial data and attributes, proper standards and digital spatial analysis facilities. According to the nature of the problem any delay of the solution process will increase the complexity of it widely and decrease the chances of the success of the solutions. The proposed digital process had concentrated on geo-referenced aerial photographs or satellite imageries for spatial data acquisition and designed forms compatible with the attributes tables to collect basic information of the owners and the status of their ownerships. Geographic Information Systems softwares had been applied for input, processing, analysis and presentation of data. These sofwares have the capabilities of:

- Spatial data input capabilities in digital forms
- Efficient Processing of spatial data
- Link between spatial and non-spatial (attributes) data
- Storage of complex structures common in spatial data
- Analytical techniques unique to spatial data
- Design model builder as a flowchart to execute the designed steps automatically.
- Dissemination of data between different participants with high security.
- Support decision making.

Advantages of automation of re-planning

- Support decision making by available, accessible, up-to-date and reliable spatial data and attributes.
- Provide efficient documentation and storage.
- Guarantee the repetition of the process with the same standards.
- Ease of management, exchange, dissemination and sharing of data.
- Introduce a digital application for the electronic government.
- Avoid forgery.
- Eliminate human fatigue.

METHODOLOGY

This chapter explains the proposed automation of re-planning process as an alternative to the current applied system used in the re-planning. The advantages of automation of this process are to reduce time, cost and effort, preserve rights, and provide efficient documentation, storage, and retrieval. The steps of design of the proposed model had been stated below.

Study area

The study area is AL-Oshara village, which is located south east of Omdurman city, 1km west of White Nile, confined between Easting coordinates (440330 & 441486)E and Northing coordinates (1720112 &

1721125)N, WGS84 datum, UTM projection Zone 36N.

Sources of data

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

Produced by: Khartoum State Survey Department.

Year of Photography: 2008.

Resolution: 10cm

Datum: WGS84.

Projection: UTM, Zone 36N.

- Sudanese Law of Land Registration (1925) modified in year 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 1.

ArcGIS 10.2 software had been used to automate the re-planning process and design a model with full database for spatial data linked to attribute data, which has the capability of use for storage, analyses and editing by changing the data only.

Steps of the design of the proposed model

Main steps for the creation of the proposed model:

Data collection

Aerial photograph of the study area had been input to ArcGIS software, ArcMap interface, see Figure 2.

A form had been filled with the attribute data about parcels from the study area including: basic information of the owner and the parcel, (Figure 1).

Data processing

Many steps had been followed to process the data.

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,

Digitizing and making a parcel layer

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

Fill of Form1 and link to the 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 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 (fig 1) had been linked to spatial data (parcel layer), Parcel-No field had been used as Id number (key field).

Classification of 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 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 to satisfy public transportation, and general services.

Buffering the roads

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

Clipping and erasing the parcels using road' 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 and the output is (Parcel Erase) layer, a layer of the omitted parts had been created using Clip tool, and the output is (Parcel Clip) layer, using (parcel) layer as a source layer and (buffer street) as clip or erase layer.

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 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.

Secondly, to make use of the determined vacant areas, 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.

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.

Data Analysis

In conjunction to the new proposed system (model), re-planning the study area had been started by surveying of existing parcels, parcel layer had been created (Figure 3), parcels had been numbered to be used in the filling of form in Figure1, and 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 13).

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 to satisfy the required road's width, (Figure 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 14).

Parcels of sides facing the roads of length less 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.

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 model Builder, GIS can create the model by Using Model Builder.

All the previous procedures had been built in one model called Planning (Figure 15) which had been added to the toolbox to be used as a flowchart to repeat the process each time.

RESULTS AND DISCUSSION

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 documented to be registered as a government reserve (Figure 13) 60 parcels. These parcels of various areas can be used to distribute utilities, green areas and also make use of them for the compensations of the parcels which had been omitted.

-The omitted parts of parcels, which had been resulted from the widening the width of the roads, had been determined (figur.7) to be used in the calculation of the compensations cost (Figure 14).

-Parcels of area less than 200sm which are restricted from registration had been determined (Figure 15), of total number 25 parcels. These parcels can be re-planned by combination of the neighboring ones and merging small ones to the neighboring parcels that satisfying the regulations of land registration.

-Parcels of sides facing the roads of width less than 10m had been determined (Figure 16) 30 parcels.

-Finally all parcels that satisfying the regulations of Physical Planning Department and Land Registration law had been determined and documented including the areas of the omitted parts of the affected parcels

-The Parcels had been classified according to their land use and symbolized, also it had been ready for layout and print out.

CONCLUSIONS

•Informal settlement process can be conducted automatically by running the designed model by changing the data only.

•Automation of the process reduces cost and time which enables the elimination of problem complexity.

•The digital spatial database can be used for different purposes such as management of services, census, economic and social planning...etc.

•The dimensions of the sides of the omitted part of each parcel can be measured directly and precisely from the digital map to be demarcated in the field (Figure 7).

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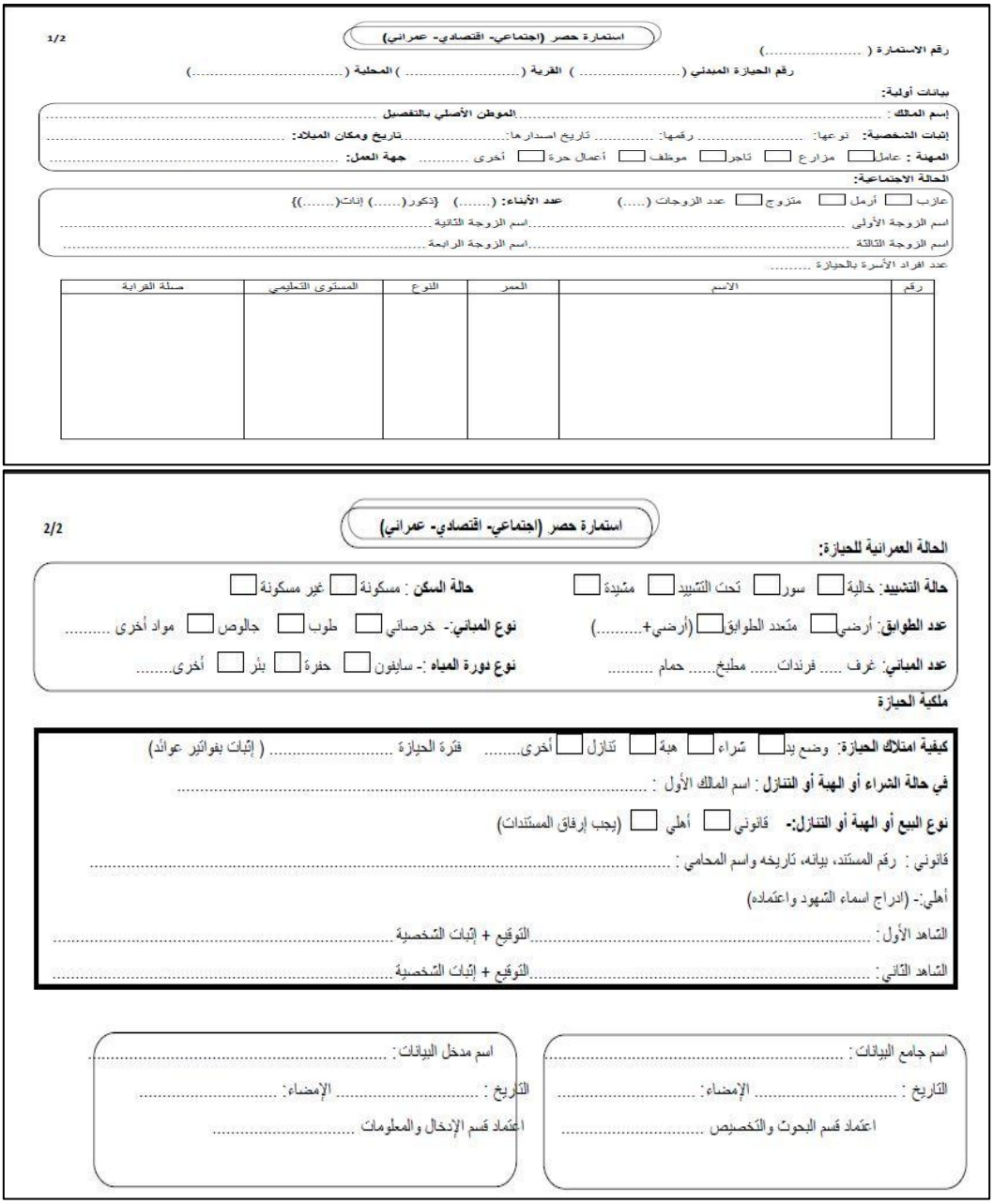

استمارة حصر (اجتماعي- اقتصادي- عمراني)

1/2

رقم الاستمارة (.....)

رقم الحيازة المبدئي (.....) 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 ..... فرندات..... 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 1: Form of attribute data

Figure 2: Preparing Image using ArcMap

Figure 3: Parcel feature class

Figure 4: Street feature class

Figure 5: Buffering of street layer

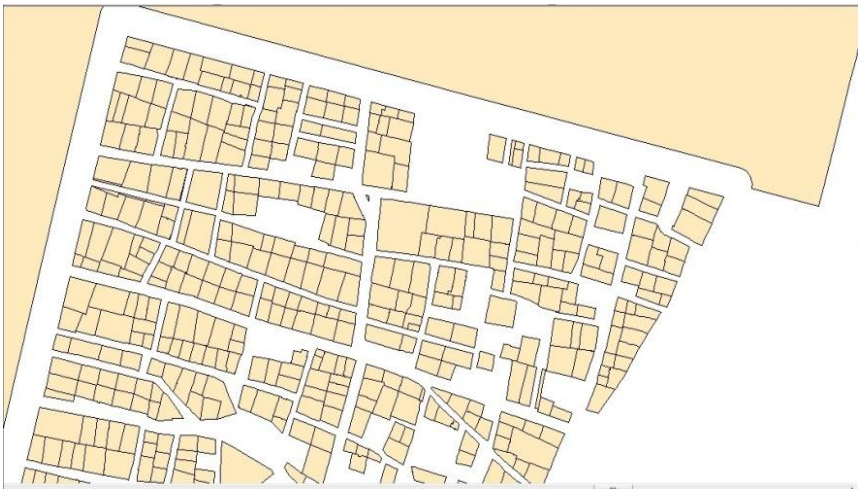

Figure 6: Layer after using Erase tool

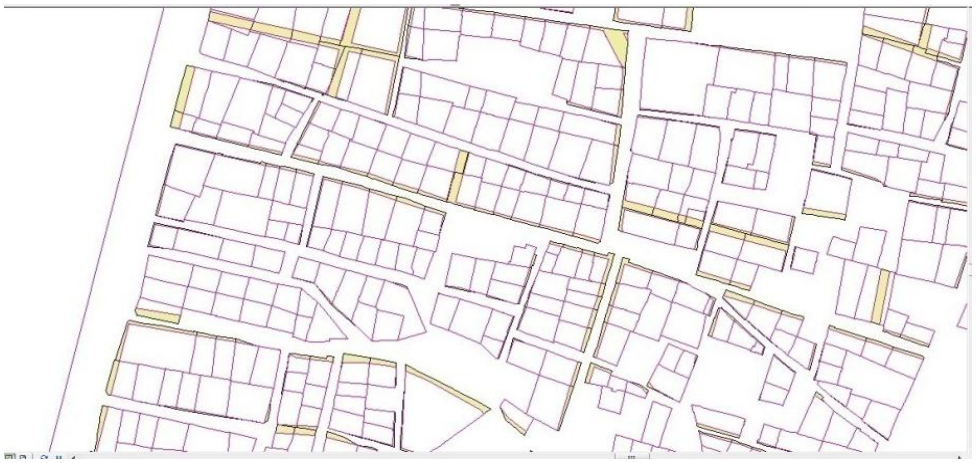

Figure 7: Layer after Using Clip tool

Figure 8: Study area layer

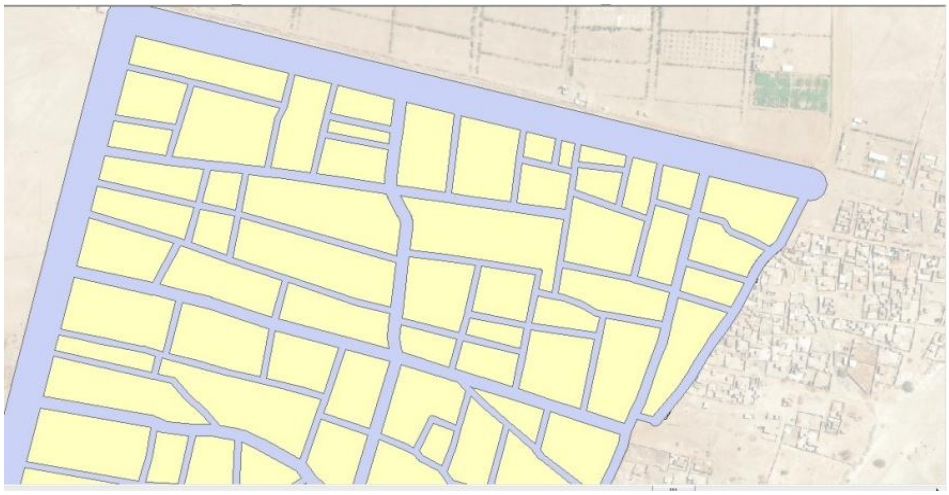

Figure 9: Using Buffer Street layer to Figure out the blocks

Figure 10: The new Shape of Blocks in Block layer

Figure 11: layer representing vacant areas

Figure 12: The final plan (Parcel Final) layer

Figure 13: Detection of new parcels and making a report

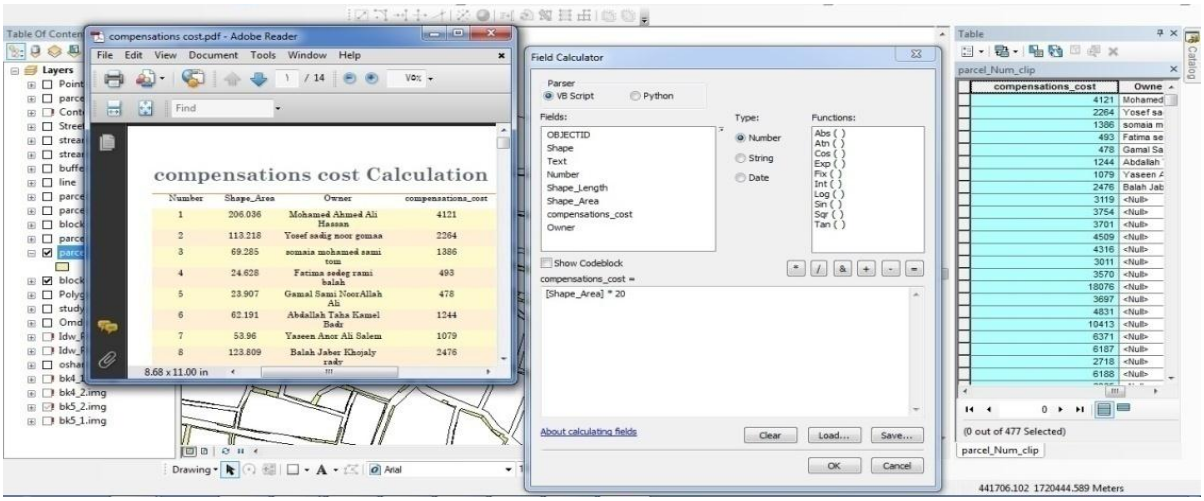

Figure 14: Compensations cost and making a report

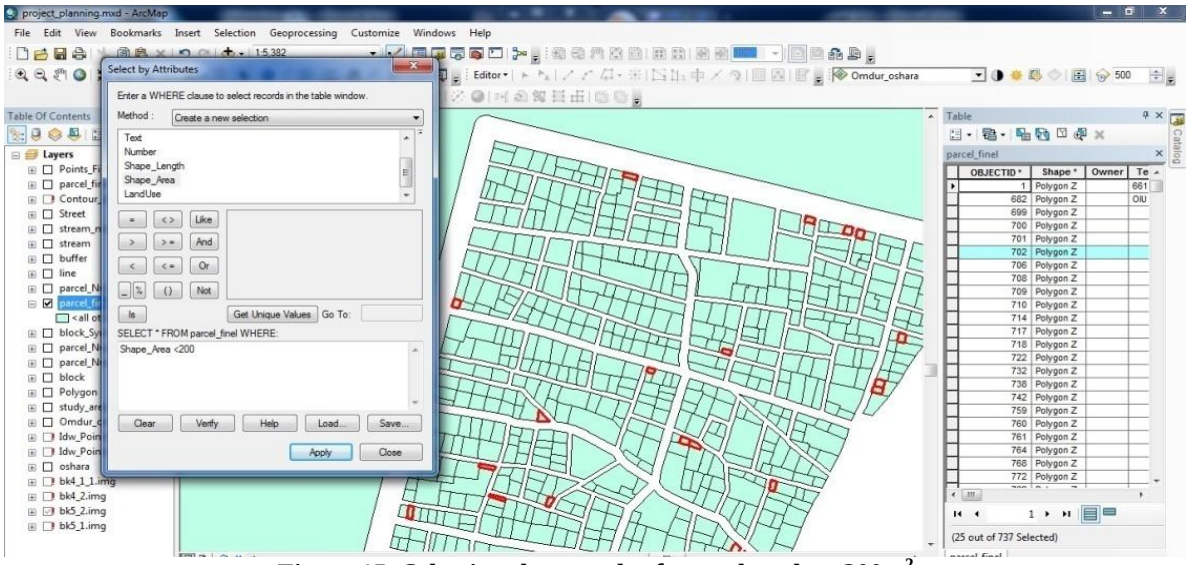

Figure 15: Selecting the parcels of areas less than 200m^2

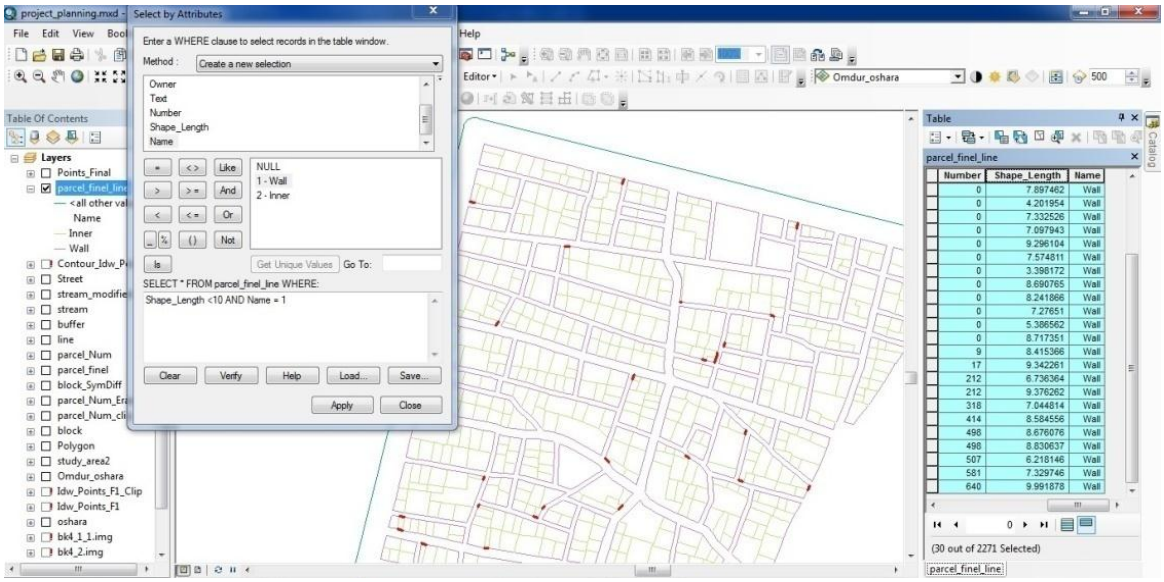

Figure 16: Selecting the edges which it length less than 10m

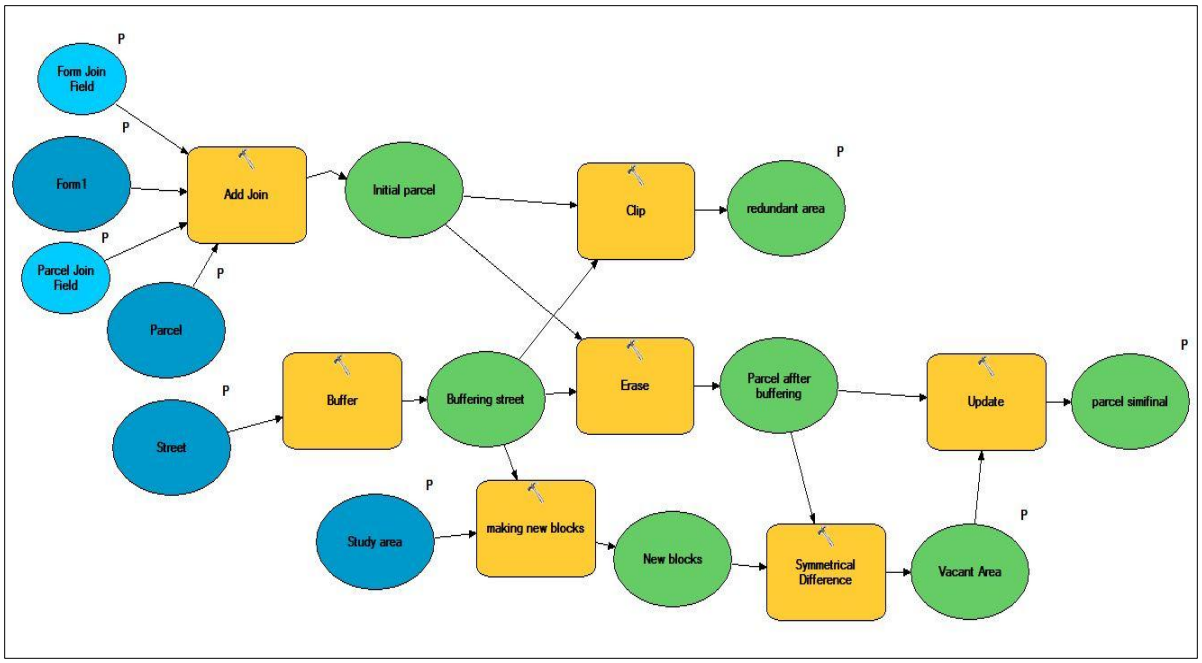

Figure 17: Planning Model Builder

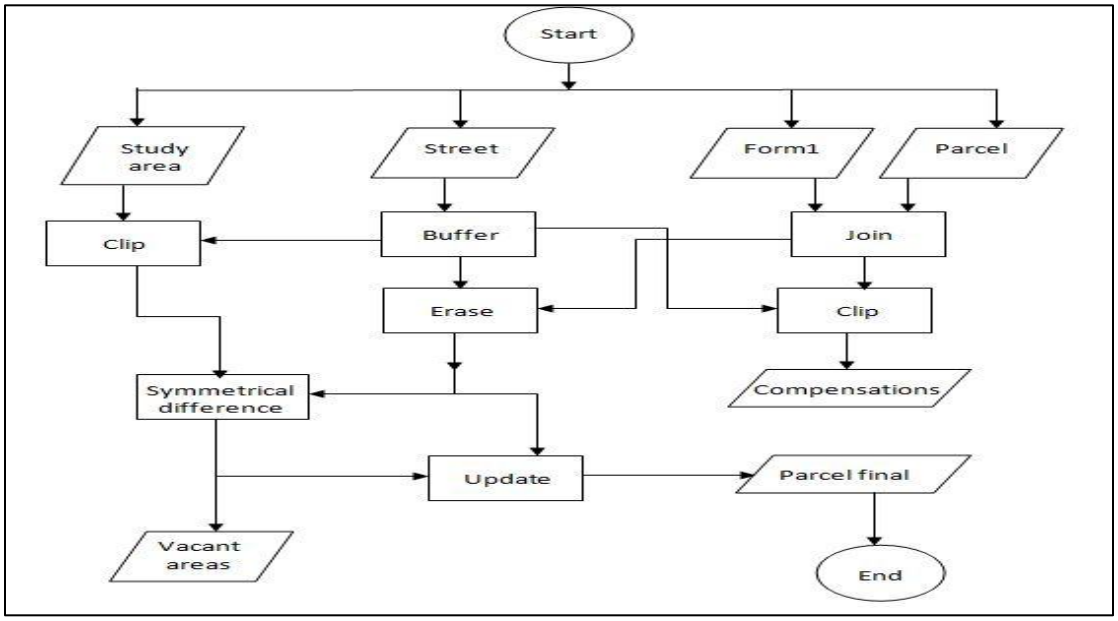

Figure 18: The model flowchart