Uses of Recent Techniques for Establishing a Good and Up-to-date Base for a Modern Cadastre System

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Key words: cadastre, land parcel, spatial data.

SUMMARY

The current form of cadastral system in Egypt is faced with many troubles and powerless capabilities in providing information related to land and its uses, such as: landowner, boundaries, ownership and the roots of this ownership, relation between owners and user of the parcel, purchase and mortgage matters, etc. So, considerable time is needed in order to access, locate, and retrieve this information, which in turn lead to a significant wastage of public and private money, and effort. In this paper, the main objective is to design and establish a good, and up-to-date base for a modern cadastre system for Egypt, by using the recent techniques and technologies in surveying and computer science. Hence, automating the cadastral map data features, into a usable digital format into the computer, building the relational-database from the automated internal and external attribute data of the cadastral area under study, and designing a computer software package, which is capable of extracting, as many queries as possible, about the essential attribute data related to cadastral parcels and its circumstances, from the established relational database system are the three major stages that have been set up as a work plan of our investigation. This developed system considers the following two basic points: The system provides current, relevant and easily accessible attribute-data related to cadastral maps; optimal use of modern technology for data collection, data processing, data storage and retrieval, and data updating.

ملخص البحث:

إن أنظمة التسجيل العقاري اليدوي في مصر تواجه قصورا و ضعفا من حيث قدرتها على التزويد بالمعلومات المتعلقة بالأراضي و استعمالاتها, لذلك نحتاج لفترة زمنية طويلة من أجل الوصول إلى البيانات المتعلقة بالأراضي واستخلاصها وتحديثها. مما يؤدي إلى إهدار كميات كبيرة من الأموال العامة و الخاصة. يهدف هذا البحث إلى استخدام التقنيات والطرق والبرامج الحديثة في مجالات المساحة والحاسبات, بغرض تصميم وبناء أساس قيم وقابل للتطوير لنظام تسجيل عقاري حديث "Modern Cadastre System" لمصر, كبديل لأنظمة التسجيل العقاري التقليدية الحالية, بحيث يكون قادرا على استيعاب كميات كبيرة وأنواع مختلفة من البيانات المتعلقة بالأراضي والتعامل معها بشكل منظم وسهل آخذا في الاعتبار سرعة الوصول إلى البيانات واستخلاصها, بالإضافة إلى تحديث هذه البيانات آنيا مما يؤدي إلى توفير بالكلفة و الجهدً والزمن مقارنة مع الطرق التقليدية. لذلك تم تحويل الخرائط العقارية (Cadastral Maps) (خرائط فك الزمام) من صورتها الورقية إلي الشكل الرقمي (Digital Maps) على الحواسب الآلية, وكذلك جمع المعلومات المتعلقة بهذه الأراضي من المصادر المختلفة, ثم توجيه هذه المعلومات نحو بناء قاعدة بيانات "Database", بحيث تسمح باستيعاب و تخزين كل البيانات المتعلقة بالأراضي, وكذلك الربط بين هذه البيانات بشكل فعال ومنظم. وتم تخطيط و تصميم حزمة برامج "Software Package" تعمل على الحواسب الآلية الشخصية بحيث تسمح بالاستفادة من البيانات المخزنة في قاعدة البيانات ولها القدرة على استكشافها وعرضها ومعالجتها بشكل يحقق الغرض من البحث. ولقد حقق هذا النظام العقاري المطور العديد من الميزات مقارنة بالأنظمة التقليدية الحالية, وأهم هذه الميزات: توفير الوقت والجهد والتكاليف اللازمة للبحث عن البيانات وتجميعها, كما يضمن عدم تكرار هذه البيانات في جداول قاعدة البيانات وبالتالي يسمح بتعامل أسهل وأسرع وأكثر فعالية في استدعاء البيانات والتعامل معها, بالإضافة إلى قابلية قاعدة البيانات التي تم تصميمها لعمليات التحديث والتطوير تبعا لمتطلبات العمل.

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1. INTRODUCTION

Parcel-based land information systems, or cadastres, form a subset of spatial information systems, in which the fundamental structure for collecting, storing, and retrieving information, is the cadastral parcel. Their primary objective is to provide a complete, up-to-date record of ownership of land, value, and land use in graphical and textual format.

In Egypt, the present forms of cadastre systems are faced with many troubles and powerless capabilities in providing information related to land and its uses, such as: landowner, boundaries, ownership and the roots of this ownership, relation between owners and user of the parcel, purchase and mortgage matters, etc. Also, The work in the Cadastral department and the related provincial and district offices are conducted at very slow rate, with a lot of routine work. The rate of producing cadastral maps is very slow, because of using old techniques in surveying and map production. A large percentage of rural areas (agriculture and new land areas), in Egypt, are not yet covered by new cadastral maps. Most of existing cadastral maps are now out of date, because the updating procedure is not working efficiently, which makes the cadastral system to be inconsistent, due to the old and new information. The duplication of information means wasting of effort, time, and money. This also makes the updating process more difficult. Also the Daftar-El-Misaha and Daftar-El-Mizaniya are not subjected to changes according to any alterations in the property boundaries and ownership. A lot of transactions are not registered, due to the expensive charges of the registration. Moreover, the cadastral process includes provincial and district offices, where the connections between them are by transportation or mail (not by computer system), and consequently, this also causes waste of time and effort.

In addition, in Egypt, like most developing countries, the rapid growth of population with its increasing demands on urban and rural land, has highlighted the urgent need for current, relevant, and easily accessible information, for use by planners and administrators concerned with land capabilities, land control and use, property assessment and taxes, etc. Such urgent need for an optimized and automated cadastral system for Egypt, has been an important motivation behind undertaking the current research contained herein.

However, in most countries, the cadastral system may be generally divided into two main categories, namely: the urban cadastre, which is concerned with buildings, ownership, number of stories, number of apartments in each story, quality evaluation, …etc.; and agricultural cadastre, which is concerned with the land agriculture and vegetation, ownership, areas for taxation purpose, perimeters, and neighbors for complete parcel definition, particularly for the land division view points, selling, and purchasing,…etc. In both cases, there is an important legal part concerning each property, known as legal rights, which depends mainly on the law adopted, which may defer from country to another. However in our case here, the present investigation will be concentrated on the agricultural cadastre only, from two principal characteristics, which are the geometrical part of each parcel as well as its land use. The geometrical part may include parcel area, perimeter, mapping coordinates of its nodes, its relationships with neighboring parcels, …etc. The land use may include building, vegetation, infrastructure utilities, …etc. Moreover the legal part of the cadastral system will not included here, but the design will take it by real application.

2. METHODOLOGY OF INVESTIGATION

In order to design and establish a good, and up-to-date base for a complete modern cadastral system for Egypt, by using the recent techniques and technologies of computer science, there are three major stages of the work plan, which must be curried out one after the other. These three stages are, namely: automating the cadastral map spatial-data; building the cadastral-system database; establishing and implementing the sought cadastre system for Egypt.

All require steps, which constitute the entire work plan, for our purpose here, and covering these three major stages of development, are depicted schematically in **figure(1)** as a block diagram. The explanation of the major steps involved into each one of the above three main stages of our work plan, as given in figure1, will be displayed later.

In the first stage, that is automating the cadastral map spatial data, the main target will be the data capture, in both its spatial and attribute format. The spatial data may be in digital form, or as a hard copy form, which should be in turn digitized. In our case here, the practical implementation of the developed cadastre system, will be applied on a hard copy map, in a region of north Cairo. The attributes or descriptive data will include, for example parcel number, parcel owner, area, hod name, land use type, … etc. Now, the first step is to make the map data under consideration ready for digitization process by identifying its data layers and attributes.

The second stage, which is building the cadastre system database, is achieved by two steps, namely: designing the database, and creating the database. The database design, will be executed by organizing the data into tables in a way making the information easy to retrieve, and makes maintenance of database easy, and then establishing the relationships between tables. Then, to complete the database building, Microsoft access method, which allows database to be used with visual basic applications, and having a good database design interface for setting up tables, indexes, queries, and tables relationships will be used to create the database itself .

At this point, the necessary cadastral maps were automated, and the cadastre system relational database has been completely built. Because this type of relational database can contribute a great deal of regularity, accuracy, reliability, and improve the data acquisition, processing, storage, and retrieval at minimum time and cost, it gave us the chance to design and develop efficient computer package software to be capable of using and implementing those capabilities of the designed database of the sought cadastre system in Egypt, which is basically execution of the third and last stage of our work plan depicted in figure1. In this context, personal computer software package is designed and established by the author, using visual basic programming language on Microsoft windows 95/98 platforms, and based on relational database management system.

3. USED DATA: SOURCES AND ACQUISITION

The available data for the current practical application, with 1:2500 cadastral hard copy map, covering some villages, located in the north east part of Cairo city, as sown in **figure (2).** This map includes several layers such as parcels layer, roads layer, buildings layer, vegetation

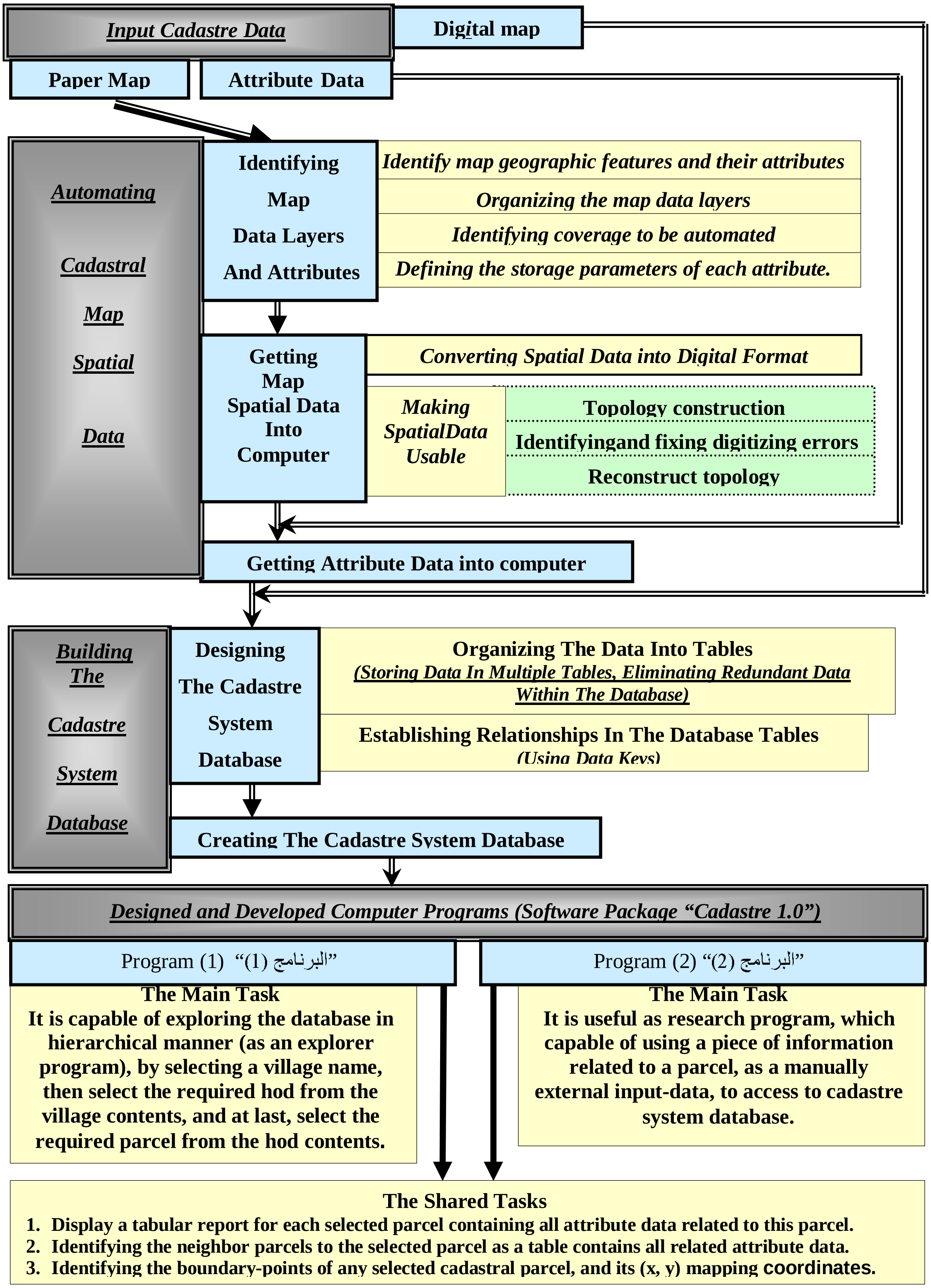


Figure (1) Developed cadastral system – work plan layer...etc. Therefore, the hard copy cadastral map forms the first main source of digital map spatial data (map features), and non-spatial data (feature attribute tables PAT & AAT) for the developed cadastre system. Data on a hard copy map, which is required to be in digital form, can be captured into computer, by manual digitizing each feature, one by one, or by using an

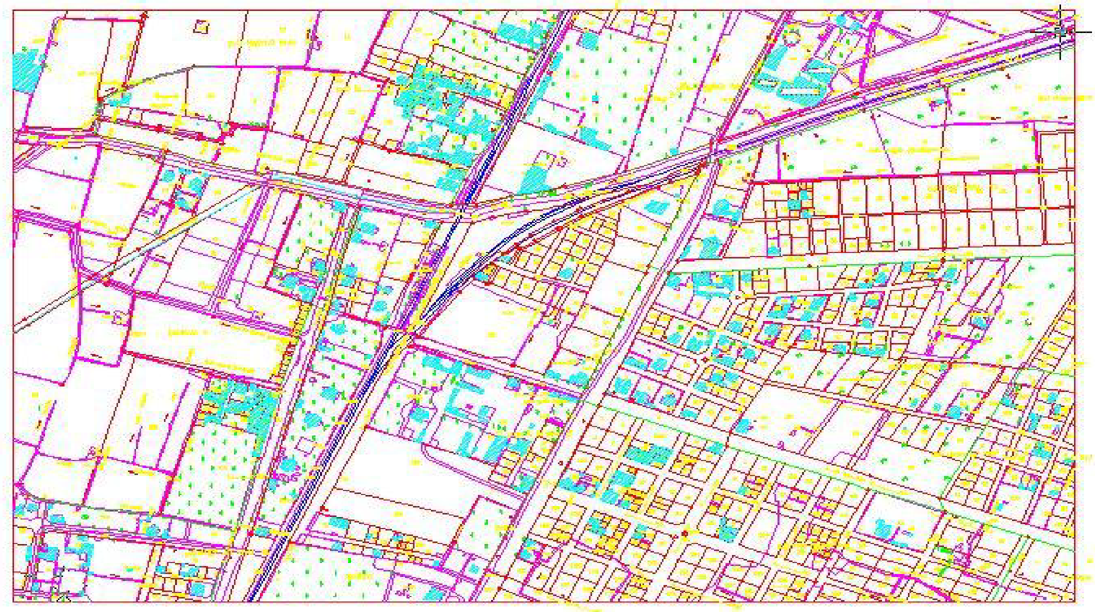


Figure (2). cadastral hard copy map

electronic scanner (automatic digitizing), whoever the former approach is used here, as will be indicated later.

Also, additional descriptive data, such as: village name, hod name, hod number, hods included in each village, parcels included in each hod, parcel number, parcel owner, the type of land use for each cadastral parcel, … etc., represent the external needed data, to be captured from its several resources, to complete the building of the database of the sought cadastre system. The non-spatial attributes associated with map features, can be entered in a new file or later after reconstructing the topological attribute files (PAT & AAT), which has been used in our example here. Tables (1 to 5) contain samples of the external descriptive data, that are needed to complete building the sought cadastre system database. Although these five tables are self explanatory, a brief description of their contents will be given bellow, for the sake of completeness:

Table 1: this table is a sample of prepared feature attribute tables in the map database, which comprises three main tables: the first table is the Polygon Attribute Table (PAT), which includes for each parcel the following items: parcel area, parcel perimeter, parcel ID, and (x, y) map-coordinates of the parcel label. The second table is the Arc Attribute Table (AAT), containing the arc definitions such as: From Node, To Node,

Table 1 Feature Attribute Tables (PAT & AAT)

a. Polygon Attribute Table (PAT) for the parcel coverage, which created by topology construction by DAK. *(Number of records "rows" is equal to the number of the parcels in the coverage, which is 716 parcel in our example here.)*					
AREA (M2)	**PERIMETER (M)**	**PARCEL_**	**PARCEL_ID**	**X_COORD (M)**	**Y_COORD (M)**
24605.410	665.3954	2	1	63.3131	898.0787
…	...	…	…	…	…
Up to 716 record					

b. Arc Attribute Table (AAT) for the parcel coverage, which created by topology construction.

(Number of records "rows" is equal to the number of the arcs in the coverage, which is 2593 arc in our example here.)

FNODE_	**TNODE_**	**LPOLY_**	**RPOLY_**	**LENGTH**	**ARC_**	**ARC_ID**
24	3	3	4	7.287601	24	24
…	…	…	…	…	…	…
Up to 2593 record						

c. Point Attribute Table (PAT) for the parcel coverage, which created by topology construction. *of records "rows" is equal to the number of nodes in the coverage, which is 1894 node in our example here.)*		
Y_NODE	**X_NODE**	**NODE_ID**
825000	645000	1
…	…	…
Up to 1894 record		

Table 2 Villages, Hods, as included in the study area

اسم القرية **Village Name**	اسم الحوض **Hod Name**	رقم الحوض **Hod Number**
عرب أبو طويلة	الهراوي	3
عرب أبو طويلة	معروف	6
المطرية	الوقف	6
المطرية	عين شمس	7
الزهراء	أغوب بك	15
الزهراء	عرفي الغربي	16
الزهراء	عبد الرحيم	17

Table 3 The parcel owners in the study area		
Parcel Number	**Parcel Owner**	
8	علي عزالدين زوباري	
32	أمجد سالم محمد	
…	…	…
Up to 716 record		

Table 4 Sample of land use type, and the cost per feddan of each parcel in the study area.		
parcel_num	**Land use type**	**Cost Per feddan**
3	بناء	40000
14	زراعة	20000
147	مكان عام	30000
11	غابة	35000
…	…	…
Up to 716 record		

Table 5 Sample of included parcels in each hod of the study area.			
HOD_NAME	**PARCEL_NUM**	**HOD_NAME**	**PARCEL_NUM**
الوقف	**17**	**معروف**	41
Up to 17 record		**Up to 79 record**	
عين شمس	**63**	**المستر بلنط**	15
Up to 59 record		Up to 17 record	
جنينة بلنط	**8**	**بحر موسى**	7
4 records		Up to 75 record	

Table 6. Lest of some features and related attributes

Geographic feature	Feature class	Feature attribute
Parcels	Polygons	Area Owner Perimeter
Land use	Polygons	Land use type Land-use code Cost per hectare
Roads	Lines	Road code
Soils	Polygons	Suitability
Streams	Lines	Stream class

Left Polygon, Right Polygon, and Arc identifier. The third table is the Point Attribute Table (PAT), which includes the Nodes definitions, namely: Node identifier, the Nodes (x, y) map coordinates of the boundary corners of the parcels.

Table 2: it illustrates the villages' names, and names and numbers of hods in each village, as included in the study area.

Table 3: this table represents a sample of existing parcels with their owners, as included in the study area.

Table 4: it is a sample showing the land use type of each parcel, as well as the cost per feddan, as existing in the study area.

Table 5: this table is a sample of included parcels in each hod of the study area.

4. AUTOMATION OF CADASTRAL MAP SPATIAL DATA

The process of automating the map spatial data involves several steps, that is [ESRI, 1990; Hassen, 1992]: Identifying map data-layers and attributes, getting map spatial data into computer, and Getting the external attribute data into computer.

4.1 Identifying map data-layers and attributes

In the first step which is identifying map data-layers and attributes, the following four operations are involved:

1. Map geographic-features and their attributes have been identified on the map sheet in our hands. For example, parcel, which is a polygon feature, is needed as one geographic feature, with area, owner, land-use code, and perimeter, as attributes table (6).
2. Then, since the amount of information on the base map may make data capture more difficult, the base map has been organized into several layers, such as parcels, land use, roads, buildings, streams, soils, wells, and administrative boundaries. Additionally, there are number of factors influence layer organization in a geographic database, and they differ with each application. Two of the most common considerations for organizing layers include feature types (point, line, or polygon) and thematic grouping of features. Typically, layers are organized so that points, lines, and polygons were stored in separate layers. Each layer is called coverage, which consists of topologically linked geographic features and their associated attributes stored as an automated map[e.g. Nassar, et. al., 1995]. For example, well sites that represented by points (nodes), stored in one layer, while roads that represented by lines (arcs), were organized in another layer, and parcels that represented by areas (polygons), were stored in third layer, as depicted in **figure (3)**. In additional to the main coverage features (nodes, arcs, and polygons), there are another two features, namely: label points and tics [ESRI, 1990]. Features also organized thematically by what they represent. For example, parcels organized in one layer, and buildings in another. Although parcels and buildings are both polygon features, it makes sense to store them separately. For example, the attributes associated with a parcel might include its land-use, while attributes for buildings might include number of flats. Because their associated attributes differ significantly, the parcels and buildings should be stored in separate layers **figure (4)**.

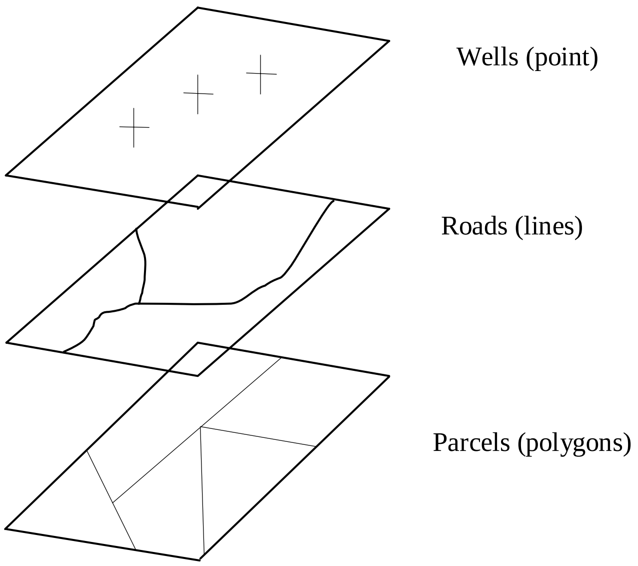


Figure 3 Organizing data layers After [ESRI, 1990]

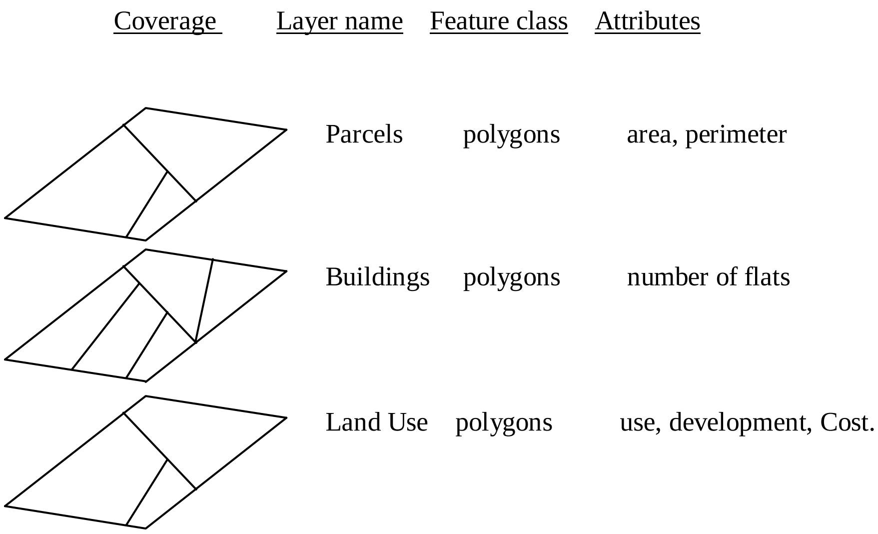


Figure 4 Organizing features thematically in layers After [Nassar and Baraka, 1995]

3. After that, the needed coverages for our database, the parcel coverage in our example, has been identified to be automated, and the attributes needed for these layers, in the map database, have been determined. The process of identifying the geographic features and their attributes, and organizing this information into layers, determines the coverages, that must be contained in the digital geographic database [e.g. Akef, 1991]. A coverage consists of topologically linked geographic features and their associated attributes "descriptive data" stored as an automated map [ESRI, 1990]. In some cases, the data layers were available on separate maps, or already in digital format on the computer. In other cases, we have to automate layers from a single base map. In these instances, it is often easier to create separate map manuscripts for each layer, since the amount of information on the base map may make data capture more difficult. So, each coverage was identified to include certain group of share some common characteristics and require, almost the same type of analysis. These features in each coverage are one of three types, points, lines, and polygons. Once each map manuscript has been digitized, we have the needed geographic features stored as x and y coordinates, in the digital database, along with the attributes in the coverage feature attribute table **figure (5)**.
4. The specific parameters (numbers or characters) for each attribute and the types of values to be stored were decided. For example, "علي عز الدين زوباري". Similarly, for attributes representing numeric values, such as parcel number, the actual value has been stored (for example: 4). When the attribute describes a class, it might be easier and more efficient to store a code for the class rather than a description [ESRI, 1990, Abd-Elrahman, 1994], for example, the character string "Land Use" has been stored as either a character code (LU), or a numeric code (100). In addition, because it makes the process of selecting and drawing features of a particular class easier, attributes have been coded.

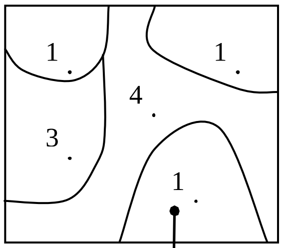
4.2. Getting map spatial data into computer

In this stage, the main target is the data capture, in both its spatial and attribute format. The map data may be in digital form, or as a hard copy form, which should be in turn digitized. In our study here, the practical implementation of the developed cadastre system, was applied on a hard copy map. This stage means to convert features on a cadastral hard copy map to a digital format on the computer, and then making it usable. In this section a brief description of data capture and digitizing process, and stages of making the spatial data usable, will be given.

4.2.1 Converting map spatial data into digital format (digitization process)

The process of capturing spatial data manually is called digitizing. Before achieving the digitizing process, to be more efficiently captured the map data, the used base map has to be prepared first. The overall purpose of preparing the map, is to minimize the number of questions that will be encountered against the operator during the digitization stage.In this stage, the hard copy map has been captured into computer, by manual digitizing using a manual digitizer (Tektronix 4958). Data on a map, can be captured by digitizing each feature, one by one, or by using an electronic scanner to capture an entire sheet of features [e.g. Ragab, 1996; Nassar et. Al., 1997a]. Data in the form of known coordinate values can also be

captured, by typing-in the exact x and y coordinates. Each of these options requires some preparation before the data can be properly interpreted by the computer.
Digitization is the process of converting the spatial features on a map into a digital format. Digitizing involves manually tracing all features on a map. This can be demonstrated, by taking any map manuscript, and breaking it into its component parts. That is a number of points and lines.



parcel_cod	parcel_num	perimeter	area
1	1	664.2748	24592.96
2	3	251.7359	1645.97
3	4	650.1929	2002.93
4	15	533.2702	
5	17	394.0521	9676.60
15109.98			

parcel_cod	cost	owner	lu_cod
1	40000	Fayez jrad	100
2	20000	Ramez Mohamed	200
3	40000	Ali zoubarei	100
4	30000	Abdelkader krdokli	300
5	40000	Nezar mahros	100

Figure 5. Graphic data / Tabular data integration After [ESRI, 1990]

4.2.2. Making digitized spatial-data usable

While, in our study here, the practical implementation of the developed cadastre system, has been applied on a hard copy map, the process of converting base map data into digital form in the computer, involved many problems, which can be classified into three major items, according to the three vector data-structure types, which are: polygon data, linear data, and point data [Abd-Elrahman, 1994]. Such problems must be solved and recovered before beginning the steps of making spatial data usable. Accordingly, these problems have been explicitly defined, and the practical solution for them has been achieved using the AutoCAD commercial software.
Then, the steps of Making spatial data usable were started, Even if one very careful while digitizing, the connection between lines will not be made perfectly. So making this spatial data usable really means making coordinate data free of errors and topologically correct. This is accomplished by establishing the existing spatial relationships (constructing topology), identifying digitizing errors, correcting them, and then reconstructing the topology [ESRI, 1990]. These steps are found to be possibly executed by using an available commercial software package, namely: Data Automation Kits (DAK).
Since topology makes explicit relationships between geographic features within any given coverage, the errors that may exist in the data, have been identified, and fixed (missing data has been added, and wrong data has been removed and replaced by the correct data). DAK software has been used in our study, to identify some of digitizing errors automatically, after the topology has been constructed. The operator has identified other errors, after the digitized data have been examined and compared with the original manuscript. At last, because the process of editing the coverage spatial features has changed the pre-established spatial relationships, in the previous step, these relationships have been updated by reconstructing topology between spatial features.

4.3. Getting external attributes into computer

As mentioned in the previous section, and displayed in tables (2) to (5), after making spatial data usable, additional external attribute data, that still needed to be specified in our database, such as: the village name, hod name, hod number, parcel number, parcel owner, land-use type of each parcel…etc. have been added into the parcel coverage, by key-board, or transferred from another computer systems, by electronic files stored on fixed or removable discs.

5. BUILDING THE CADASTRE SYSTEM DATABASE

Building the cadastre system database, effective with visual basic applications, consists of two steps, namely: designing the database, and creating the database. This stage is found to be possibly achieved by using an available commercial software package, namely: Microsoft Access (Access 2000).

5.1 Designing the cadastral system database

To have a good database design, and to achieve an efficient data management, within the developed cadastre system database, the data have been organized in away that meet the following database design objectives [McFadden, 1991]:

1. Eliminate of redundant data.
2. Stores data in an efficient manner possible to keep the database from growing too large.
3. Provides minimum search times when locating specific records (data easy to retrieve).
4. Makes data updates as easy as possible to be implement.
5. To be flexible enough to allow inclusion of new functions required of the program.
6. Keep the database easy to maintain.

The design of a good database involves the following three stages [Hawryszkiewyez, 1991], namely: organizing the data into tables, establishing the relationships between tables, and creating and storing any necessary queries for the application. Each one of the above listed stages will be discussed bellow in the following subsections.

5.1.1 Organizing attribute data into tables

One of the key aspects of a good database design is determining how the data will be organized in the database. To have a good design, we organized the data in away that makes the information easy to retrieve, and makes maintenance of the database easy. Within our cadastral database, data has been stored in multiple tables, which are: VILLAGE table, HOD table, USE table, PARCELS table, and PAR_INFO table (tables (7) to (11). Although these five tables are self-descriptive, a brief description of their contents will be given bellow, for the sake of completeness:

Table (7): this table displays villages-names, and their specific codes as is stored in the database.

Table (8): this table contains the hods attributes, such as: hod name, hod_ number, and hod code, in addition to the villages codes as a foreign key links this table to the "village" table.

Table (9): it is a sample showing the initial attributes of each parcel, such as: parcel number, parcel owner, hod cod (as a foreign key linking this table up to hod table), parcel code (as a primary key linking this table to the (par_info) table), and land use code (as a foreign key linking this table to the (use) table).

Table (10): it is a sample representing all other attributes related to parcels, and not included in the "parcels" table such as: parcel area, parcel perimeter, (x, y) map coordinates, and parcel code (as a primeray key linking this table to the "parcels" table).

Table (11): this table contains the land use types, and cost per feddan of each type of land use, and the land use code (as a primary key to link this table to "parcels" table).

5.1.2 Establishing relationships between the database tables

When data is normalized and information is moved from one table to another, a method must exist to relate the two tables. The method for making the relationships between the database tables is to use data keys or (key fields) [Jennings, 1997; Perry, 1998]. A key field is one that uniquely identifies a record. A key field may be one that has meaningful data in it, or it may be a created field that serves the only purpose of providing a unique identifier for the record. The main criterion for the key field is, that it must be unique. **Figure (6)** for example, shows a parcels table with a key field (parcel_cod) added to provide a unique identifier for each record. Often for dealing with parcel information, an account number (parcel code) is created for each parcel, and is used as the unique identifier. The key field is presented in both database tables of the relationship. For the hod table **figure (7)**, one can assign a unique identifier to each hod record. Then the same identifier will be included in each of the parcels

Table 7. VILLAGE table (as output of access and stored in database)

VIL_COD	VIL_NAME
A	**عرب أبو طويلة**
B	**المطرية**
C	**الزهراء**

Table8. HOD table (as output of access and stored in database)

VIL_COD	HOD_NAME	HOD_NUM	HOD_COD
A	الهراوي	**3**	**1**
A	**معروف**	**6**	**2**
A	**المستر بلنط**	7	**3**
B	**بحر موسى**	**4**	**4**
B	**عليش**	5	**5**

Table 9. Sample PARCELS table (as output of access and stored in database)

PARCEL_COD	PARCEL_NUM	OWNER	HOD_COD	LU_COD
2	1	**فايز علي جراد**	**1**	**100**
4	**4**	**علي عز الدين زوباري**	**1**	**100**
…	**…**	**…**	**…**	**…**
Up to 716 record				

Table 10 Sample (Parcels information) PAR_INFO table(as output of access and stored in database)

PARCEL_COD	**AREA m2**	**PERIMETER m**	**X_COORD m**	**Y_COORD m**
2	24592.96	664.2748	645063.24482	824897.9686
5	15109.98	533.2702	645249.7386	824946.1719
…	…	…	…	…
Up to 716 record				

Table 11. USE table (as output of access and stored in database)

LU_COD	LU_TYPE	COST
100	بناء	40000
200	زراعة	20000
500	مياه	25000

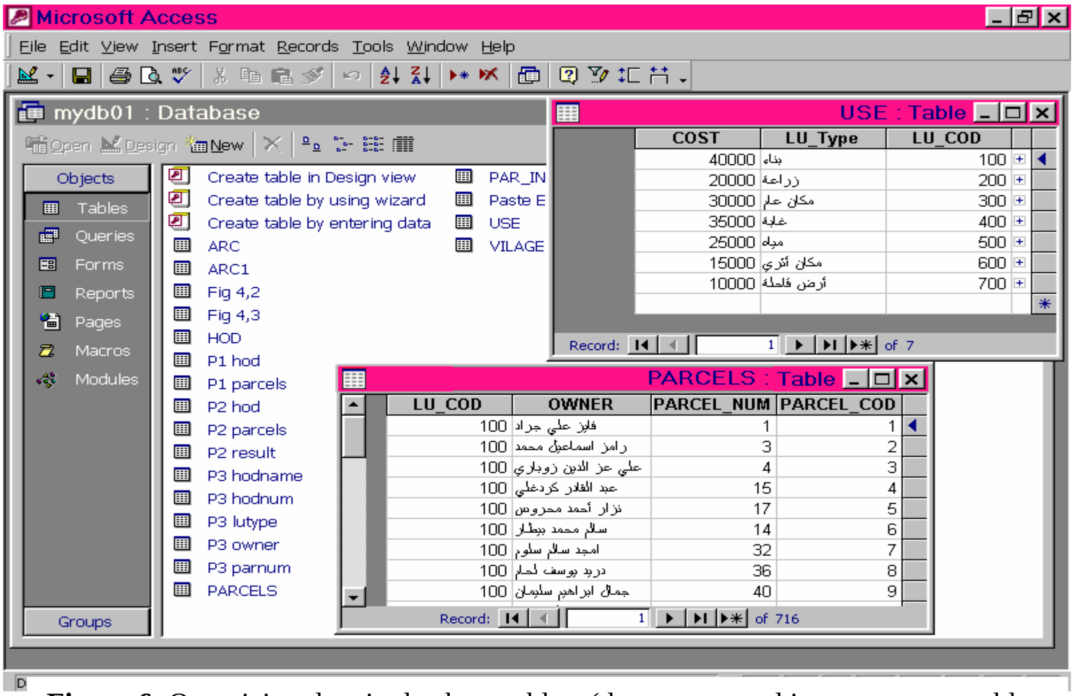


Figure 6. Organizing data in database tables (data was stored in one or more tables, redundant data were eliminated, also, a key field "parcel_cod" was added to provide a unique identifier for each record in a parcels table)

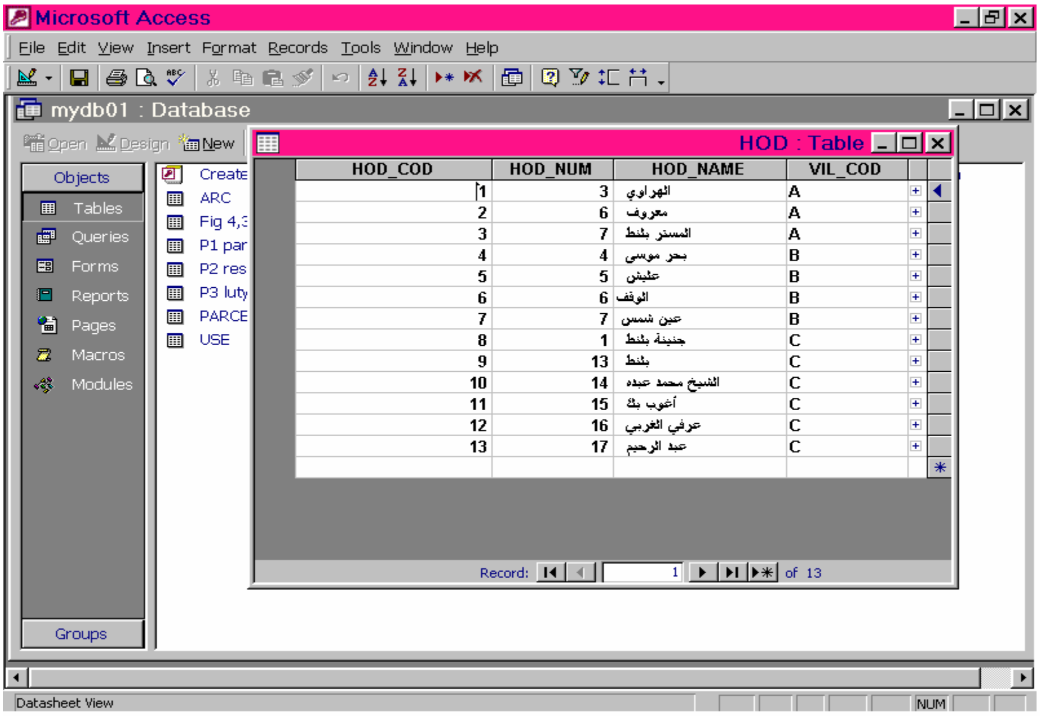


Figure7. Use of key field (a unique identifier "hod_cod" has been assigned to each record in a hod table)

records to indicate the hod to which the parcel belongs. If the key-field value is not unique, there is confusion about the hod information for a parcel.
According to using data keys or (key fields), there are three types of relationships can be recognized between database tables, namely [e.g. Hawryszkiewyez, 1991; McKelvy, 1997]: one-to-one relationship, one-to-many relationship, and many-to-many relationship.

5.2 Creating the cadastre system database

The first step in implementing the database design is to create the database itself. There are three main methods of creating an Access database for use with Visual Basic, that is, the Data Manager application provided with Visual Basic, Microsoft Access, and the data-access objects with a program. [e.g. Jennings, 1997; Johnson, 1997]. In the current investigation, the Microsoft access, as available commercial software, has been used to setup the relationships between the Database tables. Access has a good visual design interface for setting up the main database elements, such as: tables (records and files), indexes, queries, and table relationships, and it is capable of setting up the tables relationships in two graphic forms. **Figure (8)** shows two cases of the graphical display, the use of key fields, and the relationships between the designed database tables in our study here.

6. DEVELOPED CADASTRAL SOFTWARE PACKAGE

At this point, according to the stipulated methodology and working plan for the sought modern cadastre system in Egypt, the fist two main stages, namely: Automating the map spatial data, and building the cadastre system database, have been completed, utilizing some of the available commercial software modules. This means that, the final stage of the established cadastre system database, into a practical usable cadastre system, for the convenience of any user in Egypt, still remains to be carried out. This latter stage, necessitates the development of a special software package, named here as “CADASTRE 1.0” to be designed by the authors.

6.1 Objectives and capabilities

The main goal of the developed software package “CADASTRE 1.0” is to access into the cadastre system database and explore, locate, retrieve, and process its data, with an efficient manner, concerning with the input data. In this context, there are two main programs, namely: EXPLORE, and SEARCH. The operator can select any one of those two programs from the main screen, since the two programs differ, essentially, by the way of accessing to database data. The program EXPLORE is capable of exploring the database in hierarchical manner (step – by - step), by selecting a village name, then select the required hod from the village contents, and at last, select the required parcel from the hod contents. On the other hand, unlike program EXPLORE, the program SEARCH is useful as research program, which capable of using a piece of information related to a parcel, as a manually external input-data, to access to cadastre system database. Then the two programs (software package) are capable of executing the following three shared tasks:

1. Display a tabular report for each selected parcel containing all attribute data related to this parcel.
2. Identifying the neighbor parcels to the selected parcel as a table contains all related attribute data.

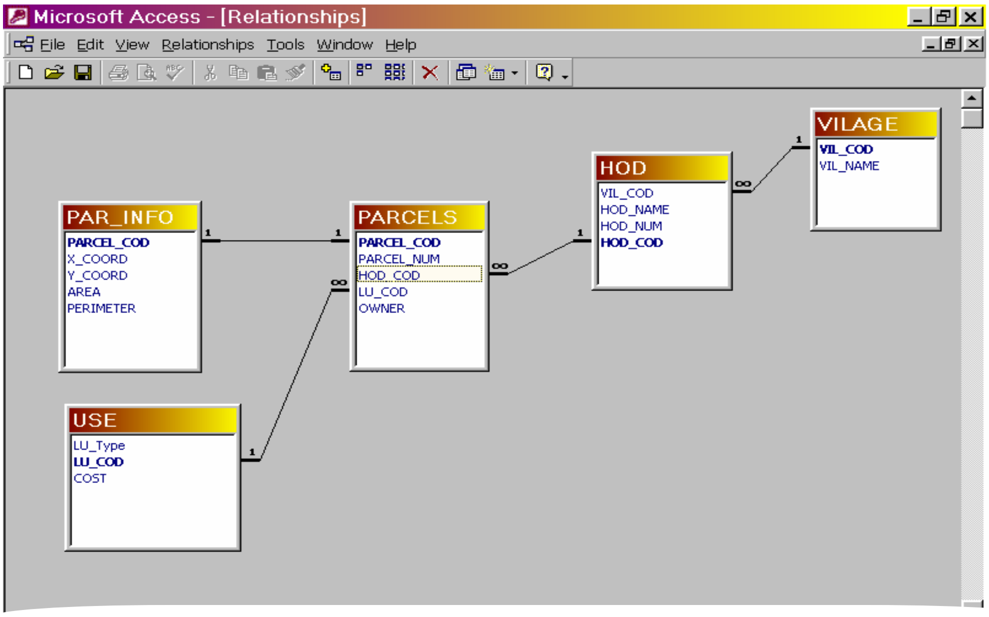


Figure 8a Graphical display of the relationships between database tables

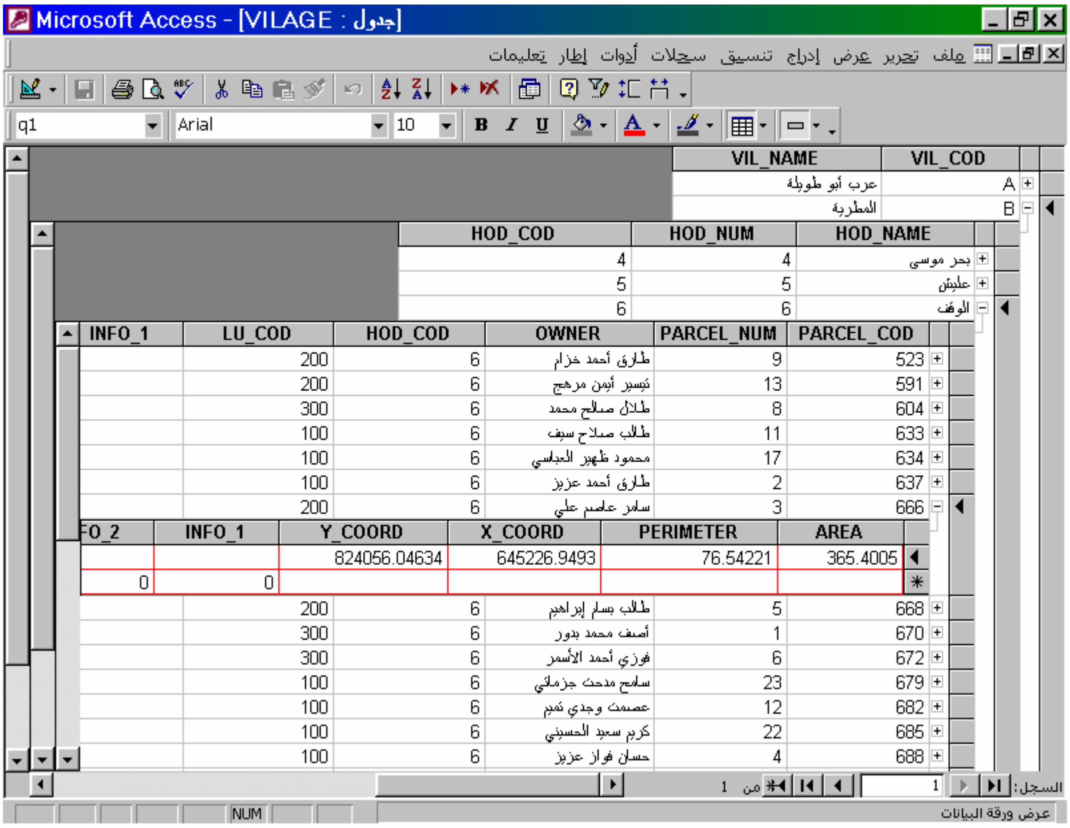


Figure 8b Graphical display of the relationships between database tables

3. Identifying the boundary-points of any selected cadastral parcel, and its (x, y) mapping coordinates.

6.2 Form of input data

Because the program EXPLORE is designed to work as an explorer program, the operator does not need to inter an external data into it. Consequently, the first step is to select the required village name, as an input data, from the available combo-box list at the main screen of program EXPLORE, which contains all villages' names included in the designed cadastre system database. Subsequently, one can select the required hod, as an input data, from the output table that contains all hods included in the above selected village. At last, the required cadastral parcel can be selected, as an input data, from the previous output table, that contains all parcels included in the above selected hod.

Conversely, unlike program EXPLORE, the program SEARCH is designed to work as a research program as mentioned before, so the operator needs to input, by keyboard, an external data into it. The main screen of program SEARCH contains six check boxes, they are "parcel owner", "parcel number", "land-use type (Lu_type)", "hod name", "hod number", and "x, y point coordinates (node_ coor.)". When any one of these check boxes is selected, a related text box will appear, then the operator can write a new available external input data in it, and then click on the “Find” bottom to display the results in a new table on the computer screen.

6.3 Form of output results

Output is the procedure by which data is presented in a form suitable to the user. Data are output in one of three formats, namely: Hard copy, soft copy, and electronic format. Each one of the two programs of the developed cadastre system here is designed to output the results, on the computer screen (Soft copy output), as explicit tables, that can display the attribute data of the cadastral parcels in optimum way. In addition, for printing purposes, all output results (resulted tables) of the two programs, that displayed on the computer screen, are automatically saved in the cadastre system database, so the operator can print it immediately (hard copy output). On the other hand, the package output can be saved in electronic format, as a computer compatible files stored on fixed or removable discs. The outputs of the software package (two programs) are tabular attribute data, which contains the attribute data for each parcel such as area, perimeter, owner, (x, y) coordinates for each parcel corner point.
The main output results of the program EXPLORE are the followings:

1) The villages’ names, which included in the cadastre system database **figure (9)**.
2) The "hods" table, which contains attribute data related to all hods included in the selected village **figure (10)**.
3) The "parcels" table, which contain attribute data related to all parcels included in the selected hod.
4) Parcel report table, which display all attribute data related to a selected parcel.
5) Neighboring parcels table, which contains attribute data relate to all parcels Neighboring to the selected parcel.
6) Parcel boundary-points table, which displays the boundary-points (x, y) coordinates related to the selected parcel.

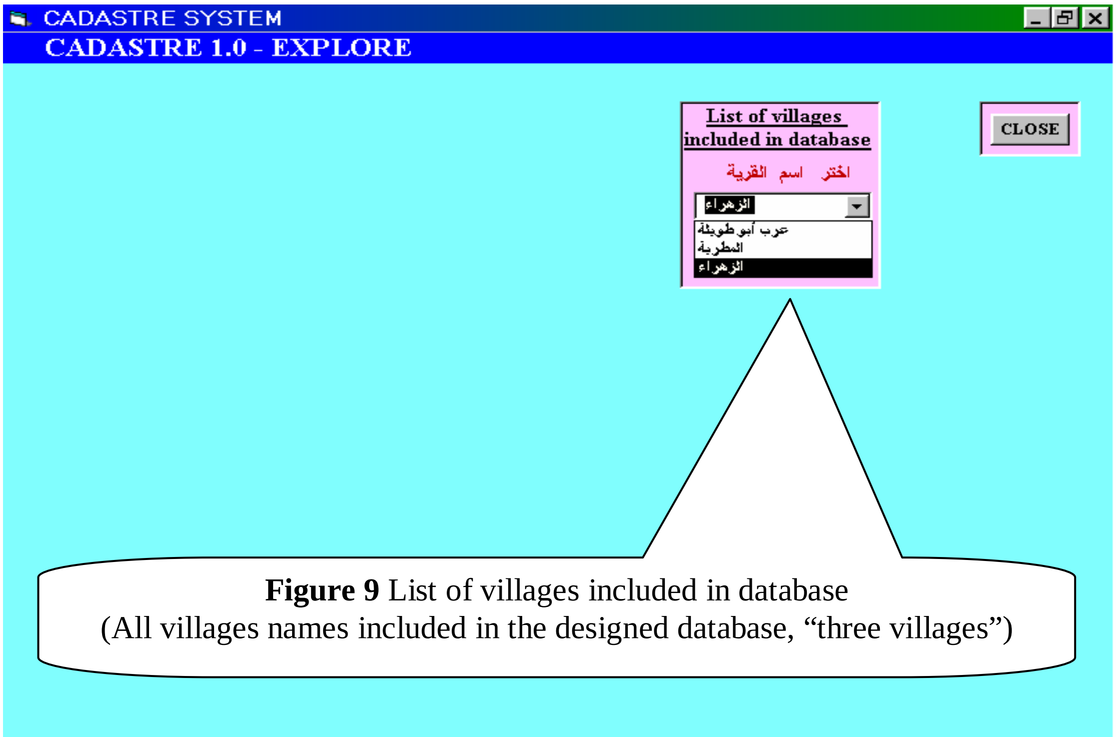


Figure 9 List of villages included in database
(All villages names included in the designed database, "three villages")

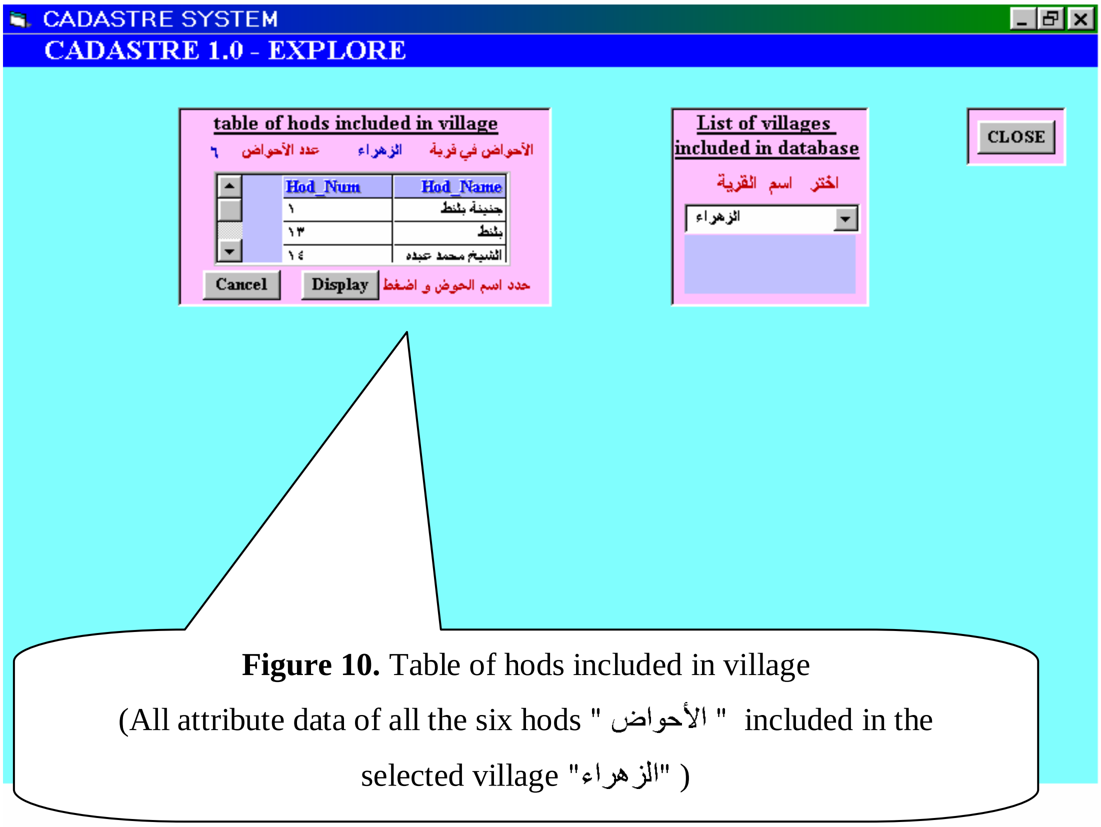


Figure 10. Table of hods included in village
(All attribute data of all the six hods " الأحواض " included in the selected village "الزهراء")

As an overall summary of EXPLORE output results, in the three above steps, one more additional screen is also provided, which gives the whole possible resulting functions, that the program EXPLORE can execute and give, which is depicted in **figure (11)**. For printing purpose (hard copy outputs), all previous output resulted tables, given in steps (1 to 3), as a soft copy outputs of the program EXPLORE, are automatically saved in the system database. For example, **figure (12)** displays the printed attribute data related to “parcels” contained in the selected "hod”.

On the other hand, the output of the program SEARCH differs relative to the type of the external input data as shown in table (12), and **figures (13 to 16)**. The operator can select the required parcel by either its number, owner, or any other included attributes from the above output tables, depending again on the external input data, and then, as program EXPLORE, Program SEARCH is capable of output the following results (figure 11).

1. Parcel report table (4).
2. Table of neighboring parcels to a select one.
3. Parcel boundary points, and their (x, y) mapping coordinates.

Table 12 The output results of the program SEARCH according to the external input-data only.

Input data	Resultant data related to parcels
Parcel number	Table contains all parcels having the same input number, and their related Attribute data
Parcel owner	Table contains all parcels that owned by this input owner, and their related Attribute data
Land-use type	Table contains all parcels having the same input land-use type, and their related Attribute data
The hod-name	Table contains all parcels included in the hod, that has the input name, and their related attribute data
The hod-number	Table contains all parcels included in the hod, that has the input number, and their related attributes
Point (x,y) coordinates	Table contains the parcel containing the point that has the input coordinates, and its attribute data

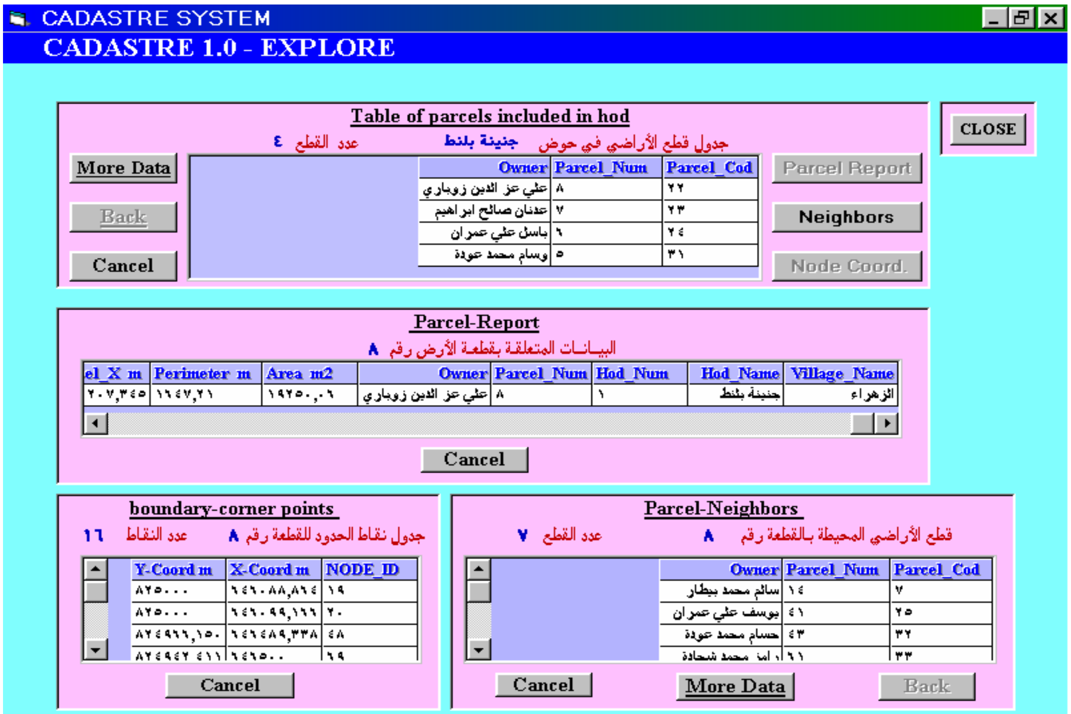


Figure 11. The whole output results of the program EXPLORE (In case, the selected parcel number is "8", as a one of the four parcels existing in the established database, and included in the selected hod " جنينة بلنط ")

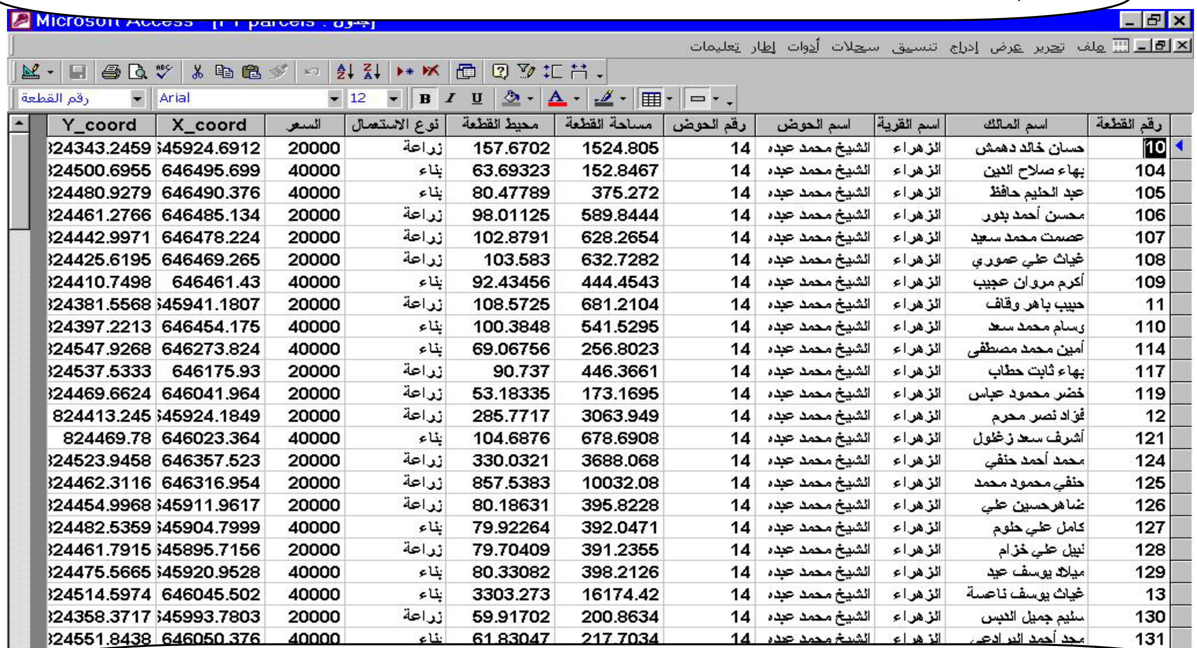
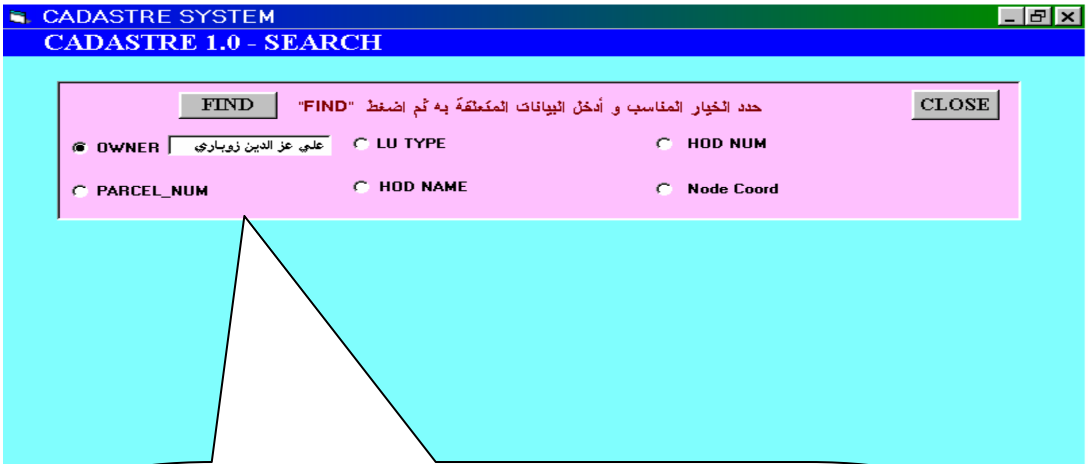


Figure 12. program EXPLORE: the output hard copy (all attribute data related to parcels included in the specific selected hod, which automatically saved in the designed database for printing purposes, when desired)



Figures 13ز Sample selecting a check box (The desired "owner" check box as a selected one, and the associated text box having an assumed changeable input owner-name " علي عزالدين زوباري", which appears on the right side of it)

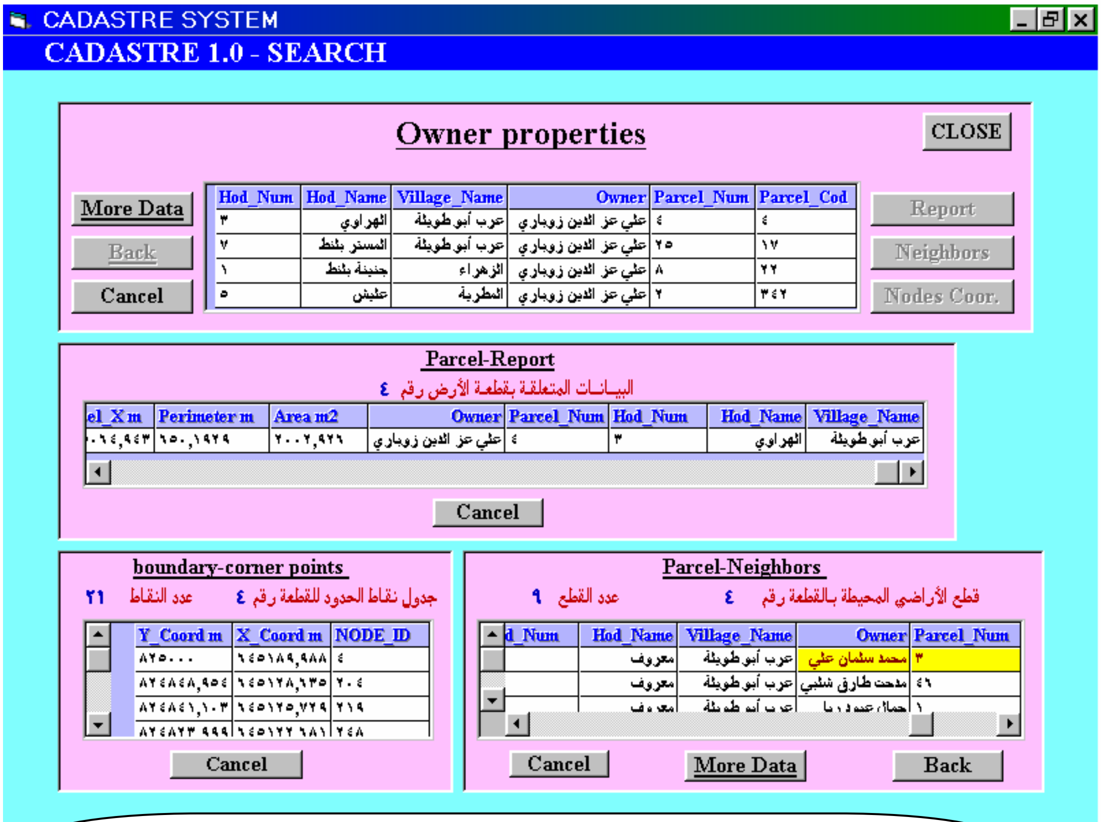
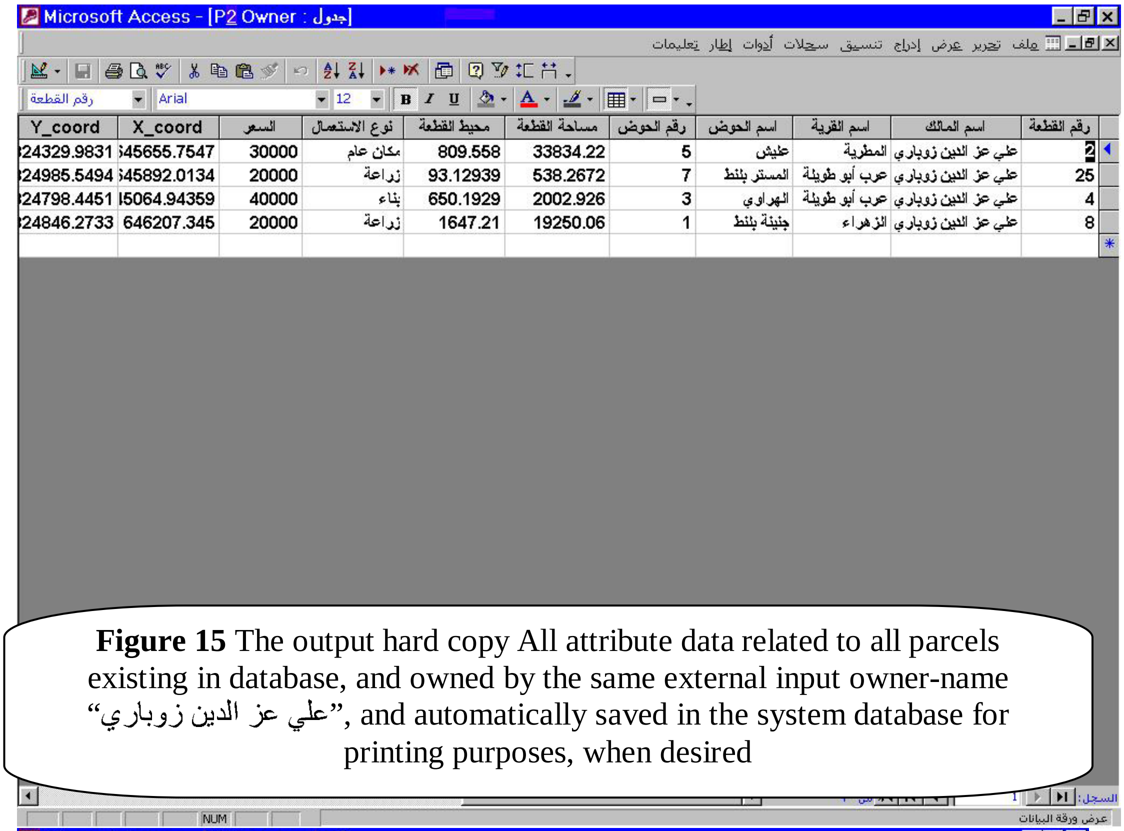


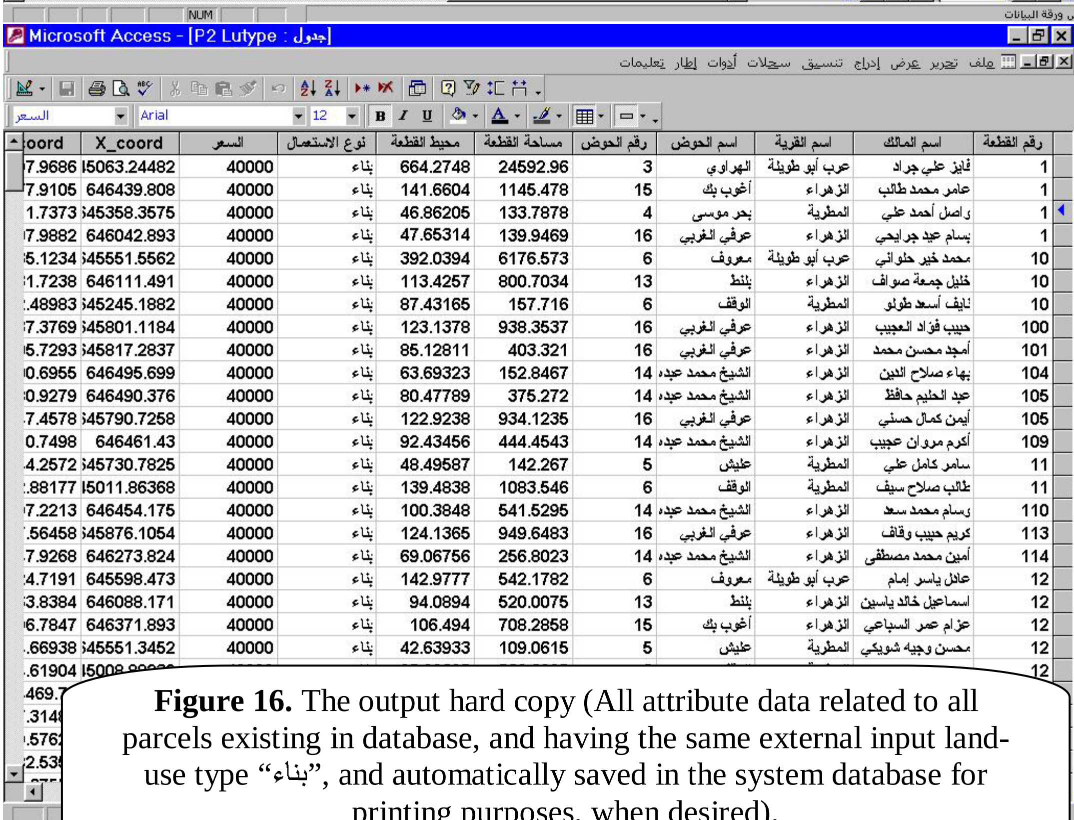
Figure 14 The whole output results of the SEARCH program, as displayed especially for the parcel owner "علي عز الدين زوباري" as an external input data



Microsoft Access - [P2 Owner : جدول]

Y_coord	X_coord	السعر	نوع الاستعمال	محيط القطعة	مساحة القطعة	رقم الحوض	اسم الحوض	اسم القرية	اسم المالك	رقم القطعة
24329.9831	545655.7547	30000	مكان عام	809.558	33834.22	5	عليش	المطرية	علي عز الدين زوباري	2
24985.5494	545892.0134	20000	زراعة	93.12939	538.2672	7	المستر بلنط	عرب أبو طويلة	علي عز الدين زوباري	25
24798.4451	15064.94359	40000	بناء	650.1929	2002.926	3	الهراوي	عرب أبو طويلة	علي عز الدين زوباري	4
24846.2733	646207.345	20000	زراعة	1647.21	19250.06	1	جنينة بلنط	الزهراء	علي عز الدين زوباري	8

Figure 15 The output hard copy All attribute data related to all parcels existing in database, and owned by the same external input owner-name "علي عز الدين زوباري", and automatically saved in the system database for printing purposes, when desired



Microsoft Access - [P2 Lutype : جدول]

coord	X_coord	السعر	نوع الاستعمال	محيط القطعة	مساحة القطعة	رقم الحوض	اسم الحوض	اسم القرية	اسم المالك	رقم القطعة
7.9686	15063.24482	40000	بناء	664.2748	24592.96	3	الهراوي	عرب أبو طويلة	فايز علي جراد	1
7.9105	646439.808	40000	بناء	141.6604	1145.478	15	أغوب بك	الزهراء	عامر محمد طالب	1
1.7373	545358.3575	40000	بناء	46.86205	133.7878	4	بحر موسى	المطرية	واصل أحمد علي	1
7.9882	646042.893	40000	بناء	47.65314	139.9469	16	عرفي الغربي	الزهراء	بسام عيد جرايحي	1
5.1234	545551.5562	40000	بناء	392.0394	6176.573	6	معروف	عرب أبو طويلة	محمد خير حلواني	10
1.7238	646111.491	40000	بناء	113.4257	800.7034	13	بلنط	الزهراء	خليل جمعة صواف	10
.48983	545245.1882	40000	بناء	87.43165	157.716	6	الوقف	المطرية	نايف أسعد طولو	10
7.3769	545801.1184	40000	بناء	123.1378	938.3537	16	عرفي الغربي	الزهراء	حبيب فؤاد العجيب	100
5.7293	545817.2837	40000	بناء	85.12811	403.321	16	عرفي الغربي	الزهراء	أمجد محسن محمد	101
0.6955	646495.699	40000	بناء	63.69323	152.8467	14	الشيخ محمد عبده	الزهراء	بهاء صلاح الدين	104
0.9279	646490.376	40000	بناء	80.47789	375.272	14	الشيخ محمد عبده	الزهراء	عبد الحليم حافظ	105
.7.4578	545790.7258	40000	بناء	122.9238	934.1235	16	عرفي الغربي	الزهراء	أيمن كمال حسني	105
0.7498	646461.43	40000	بناء	92.43456	444.4543	14	الشيخ محمد عبده	الزهراء	أكرم مروان عجيب	109
.4.2572	545730.7825	40000	بناء	48.49587	142.267	5	عليش	المطرية	سامر كامل علي	11
.88177	15011.86368	40000	بناء	139.4838	1083.546	6	الوقف	المطرية	طالب صلاح سيف	11
7.2213	646454.175	40000	بناء	100.3848	541.5295	14	الشيخ محمد عبده	الزهراء	وسام محمد سعد	110
.56458	545876.1054	40000	بناء	124.1365	949.6483	16	عرفي الغربي	الزهراء	كريم حبيب وقاف	113
.7.9268	646273.824	40000	بناء	69.06756	256.8023	14	الشيخ محمد عبده	الزهراء	أمين محمد مصطفى	114
4.7191	645598.473	40000	بناء	142.9777	542.1782	6	معروف	عرب أبو طويلة	عادل ياسر إمام	12
3.8384	646088.171	40000	بناء	94.0894	520.0075	13	بلنط	الزهراء	اسماعيل خالد ياسين	12
6.7847	646371.893	40000	بناء	106.494	708.2858	15	أغوب بك	الزهراء	عزام عمر السباعي	12
.66938	545551.3452	40000	بناء	42.63933	109.0615	5	عليش	المطرية	محسن وجيه شويكي	12
.61904	[illegible]									12

Figure 16. The output hard copy (All attribute data related to all parcels existing in database, and having the same external input land-use type "بناء", and automatically saved in the system database for printing purposes, when desired).

7. CONCLUSION

Based on the practical application of the developed Relational database, the designed database, unlike the present, and traditional forms of cadastre system database in Egypt, provides many advantages, such as:

1. The process of storing data in the developed relational database is accomplished in the most regular, and efficient manner, leading to eliminate redundant data in the database, and keeping the database from growing too large.
2. The database of the developed cadastre system allows to import, store, integrate and inter-relate between lands related information from different sources.
3. Also, the modern software packages, that are used in a modern cadastre systems, can utilizing the capabilities of this designed relational database, and accessing into it, and exploring, locating, retrieving, and processing its data, with an efficient manner, which leads to save the public and private money, time, and effort.

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