Towards an Automated Information System for Cadastral Survey in Egypt

Adel HAGGAG, Ibrahim SHAKER and Mohamed El-MAGHRABY, Egypt and Ali ZOBAREI, Syria

Key words: cadastre, land parcel, spatial data.

SUMMARY

Cadastre systems which are a subset of spatial information systems, aim at identifying and maintaining legal boundaries of properties, also provide information related to nature, size, and ownership of land use and elements. The fundamental structure for collecting, storing, and retrieving information in cadastre systems is the cadastral parcel. It will not be possible to design a global cadastral system suitable for any case and all circumstances. This is true specially when considering the socio-economic basic conditions, which are different from country to country. The different forms of land tenure and the legal situation in this field give the framework for cadastral systems, and how to carry out its technical features.

The present form of cadastral system in Egypt, usually suffers some deficiencies such as the limiting capabilities for providing data, database updating; the very slow rate, with a lot of routine in carrying out the cadastral functions, tasks, and their costs. So, considerable time is needed in order to access, locate, retrieve and update the information that stored in traditional forms of cadastre system database, as well as, the data-updating process is so difficult. In addition, like most developing countries, the growth of population, and the rapid developments within society are increasing the demand on urban and rural land, and highlighting the urgent need for current, relevant, and easily accessible information.

The main objective of this paper is to Improve and develop the present form of cadastral survey system in Egypt towards an automated cadastre information system, by using some recent techniques and technologies of computer and surveying science, to be able to satisfy the requirement and needs due to technological and social development. Consequently, data collection and import (different sources and types), designing and establishing a cadastral system relational database, building cadastral digital map layers, and developing computer software package "Cadastre ver.2.3" using Visual Basic for Application VBA language in Microsoft Access Environment are the main stages of establishing developed system.

The main functions and tasks of the developed cadastral system can be summarized as: exploring, searching, retrieving, and displaying the stored spatial and non spatial data, with an efficient manner, responding to many of queries about the stored spatial and non spatial data, creating deeds related to parcels, land use, utilities, buildings, and flats, achieving all types of transactions on parcels and buildings and flats automatically and safety process, updating the graphical data in the database map layers, and updating the attribute data in the database tables.

ملخص البحث:

إن نظام التسجيل العقاري هو نظام معلومات مكاني يختص بتعريف وضمان الحدود القانونية للملكية وبتقديم المعلومات عن ملكية وحجم وطبيعة استخدام الأرض وعناصرها المكانية، فالوحدة الأساسية له هي قطعة الأرض لذلك يتم تجميع البيانات وتخزينها وتنظيمها في قاعدة بياناته واستخراجها وعرضها بشكل أساسي في مستوى قطعة الأرض. من غير الممكن تصميم نظام تسجيل عقاري عام أو عالمي مناسب لكل الحالات والظروف ولاسيما أن الخصائص الاقتصادية والاجتماعية تختلف من بلد لآخر لذلك إن الأشكال المختلفة لملكية الأرض والحالة القانونية والظروف السياسية والبنية التحتية للبلد هي التي ستحدد هيكلية نظام التسجيل العقاري، ولكيفية إنجاز عناصره الفنية.

إن استخدام الطرق والتقنيات التقليدية في نظام التسجيل العقاري الحالي في مصر, جعله يواجه قصورا وضعفا من حيث قدرته على التزويد بالمعلومات المتعلقة بالأراضي واستعمالاتها. فهو يعاني الكثير من الروتين والبطء في إنجاز الوظائف والمهام العقارية, وتحديث البيانات والخرائط في السجل العقاري. وهذا بدوره يؤدي إلى عدم قدرته على مواكبة التغيرات المستمرة في حدود الملكيات وأصحاب الأملاك مما يجعله لا يعبر عن الواقع تماما, وكذلك لإهدار الأموال العامة والخاصة. إضافة لذلك إن الزيادة السريعة في عدد السكان في مصر, والتطور الاجتماعي السريع وبالتالي زيادة الضغط على الأراضي في الأرياف والمدن قد أظهرت بوضوح الضرورة إلى الحصول على المعلومات المتعلقة بالأراضي واستعمالاتها بشكل منظم وسهل وسريع, وإلى ضرورة تحديث البيانات الموجودة آنيا.

يهدف هذا البحث إلى تحسين وتطوير نظام التسجيل العقاري في مصر نحو نظام معلومات عقاري مؤتمت, وذلك باستخدام التقنيات والبرامج العلمية والتكنولوجيا الحديثة في مجالات المساحة والحاسبات ونظم المعلومات, ليكون قادرا على مواكب التطورات التكنولوجية والاجتماعية والاقتصادية السريعة و الكبيرة. لذلك تم وضع وتنفيذ خطة عمل لتطوير هذا النظام العقاري, وأهم مراحلها هي: تجميع واستيراد البيانات (مختلف الأنواع والمصادر), ثم بناء قاعدة بيانات علائقية بحيث تسمح باستيعاب وتخزين كل البيانات المتعلقة بالأراضي, وكذلك الربط بين هذه البيانات بشكل فعال ومنظم. وكذلك بناء طبقات الخرائط العقارية الرقمية, وتم تطوير حزمة برامج "Cadastre ver.2.3 " بالحاسب الآلي الشخصي باستخدام تطبيقات لغة البرمجة فجوال بيسك في بيئة نظام مايكروسوفت أكسس, تسمح بالاستفادة من البيانات المكانية وغير المكانية المخزنة في قاعدة البيانات ولها القدرة على استكشافها والربط بينها وعرضها ومعالجتها بشكل يحقق الغرض من البحث.

ويتميز هذا النظام العقاري المطور بالعديد من الميزات مقارنة بالأنظمة التقليدية الحالية, من خلال الوظائف والمهام التي يمكن تنفيذها بواسطته وأهمها: تأمين الوصول للبيانات المخزنة في قواعد البيانات، واستكشافها ومعالجتها والربط بينها وعرضها بطريقة فعالة وسهلة وسريعة وبأقل كلفة وجهد وزمن، وكذلك تأمين البحث السهل والسريع عن أنواع محددة من البيانات بخصائص معينة في قاعدة البيانات. إضافة لاستخراج سند ملكية لقطعة الأرض أو الوحدات العقارية الأخرى واستخداماتها وأهم الخدمات الأساسية المتوفرة تحت وعلى وفوق سطح الأرض وكذلك الأبنية والشقق والملاك والمستخدمين وغير ذلك من البيانات الضرورية. وأيضا إنجاز كافة أنواع التعاملات على قطع الأراضي والأبنية والشقق بشكل آلي وسهل وسريع وآمن ودقيق. إضافة لإمكانية تحديث كافة البيانات المتعلقة بالجداول وطبقات الخرائط بشكل مستمر وفقا للتغيرات على أرض الواقع.

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1. INTRODUCTION

Cadastre systems, which are a subset system of spatial information systems, aim at identifying and maintaining legal boundaries of properties, also provide information related to nature, size, and ownership of land use and elements. A cadastre is normally a parcel based and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection. Cadastral improvement is concerned with the Reform of cadastral systems.
It will not be possible to design a global cadastral system suitable for any case and all circumstances. This is true specially when considering the socio-economic basic conditions, which are different from country to country. The different forms of land tenure and the legal situation in this field give the framework for a cadastral system, and how to carry out its technical features. On the other hand, the political circumstances are dictating the financial and personnel investment in the cadastral system. Finally, but last the country's infrastructure (nature, traffic, technical infrastructure, education etc.) influence the technical options in establishing a cadastral system.
The present form of cadastral system in Egypt, usually suffers some deficiencies such as the limiting capabilities for providing information, database updating; the very slow rate, with a lot of routine in carrying out the cadastral functions, tasks, and their costs. In addition, like most developing countries, the growth of population, and the rapid developments within society, are increasing the demand on urban and rural land, and highlighting the urgent need for current, relevant, and easily accessible information. Of course, introducing digital cadastral systems, by means of modern techniques in surveying and computer sciences, will provide fast access, retrieval, handling, and updating of large amounts of data included in the current land register systems.

2. THE JUSTIFICATION OF CADASTRAL DEVELOPMENT:

There has been a dramatic increase in interest and activity in the establishment and improvement of cadastral and land information systems over the past decade or so as an important mechanism in supporting the provision of secure property rights in land, which has become very evident over the last ten years. As a result of this improved understanding of the role of cadastral systems, the debate is moving from "whether cadastral systems are necessary" (there is now almost universal agreement that some form of regularisation of land

rights is essential for all countries) to "what is the most appropriate cadastral system for a particular country". A summary of the reasons for this increased interest is set out below.

- a resurgence of interest in land tenure, land titling, cadastral, land administration and land management issues about ten years ago in the international organisations, such as the World Bank and the United Nations, as well as in individual country aid agencies.
- cadastral and land information systems, are increasingly being accepted as basic infrastructure required for sustainable economic development and environmental management, especially in developed countries.
- the growth in information technologies which have specific application to the automation of cadastral records, and the associated growth of interest in related land and geographic information systems, has given cadastral and related projects a higher profile and priority due to the benefits to be derived from the new information environment.
- the last decade has seen a dramatic growth in enabling technologies which have the ability of improving the efficiency and speed, and reducing the cost of establishing and maintaining cadastral and land information systems. Some examples include satellite position fixing (GPS), digital theodolites, computing and advances in photogrammetric mapping.
- there has been a growing interest and understanding from researchers about cadastral and land information systems with the result that there is now a substantial body of knowledge on the subject. In addition there are now many conferences, workshops, professional activities, research papers, reports, books, newsletters and journals providing information in support of cadastral reform and related activities.
- the importance of cadastral systems, and more recently land and geographic information systems, to economic growth, environmental management and social and political stability has been equally recognised and promoted by both rural and urban sectors, thereby supporting and making possible national cadastral reform programs (Williamson, 1995).

3. METHODOLOGY OF INVESTIGATION

In order to improve and develop the form of cadastral survey system in Egypt towards an automated cadastre information system, to be able to satisfy the requirement and needs due to technological and social development, some recent techniques and technologies of computer and surveying science were used, and the work plan of establishing and implementing the sought cadastre system for Egypt, which consist of four main stages, have suggested and curried out. The work plan main stages are, namely: data collection and import (different sources and types); designing and establishing a cadastral system relational database; building cadastral digital map layers; developing computer software package “Cadastre ver.2.3” using Visual Basic for Application VBA language in Microsoft Access Environment. Of course, the execution of each one of the above four stages, could involves several steps, where surely will require of existence of appropriately designed computer software packages, will be utilized. Other wise particularly for executing the final stage, new software packages should be designed and implemented.

All included steps that form the entire work plan, for our purpose here, and covering these major stages of development, are depicted schematically in figure (1) as a block diagram, and will be displayed in the following.
In the first stage, which is data acquisition “data collection and import" from different sources and types, the data have captured, in both spatial and non-spatial (attributes) format. The spatial data “maps”: may be in digital form, or as a hard copy form, which should be in turn digitized and converted into vector map layers and attributes data. The non-spatial data “Attributes” :also may be hard copy sheet, or as electronic files stored on disks.
The second stage, which is building the cadastre system relational database, was achieved by two steps, namely: designing the database, and creating the database. The database design was 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 was used to create the database itself .
The third stage, which is building cadastral digital map layers, was achieved by four steps, namely: defining layers and attributes (defining map geographic features and their attributes, and organizing the map data layers), converting Spatial data into vector digital format, making spatial data usable (topology construction, and identifying and fixing digitizing errors), and external non-spatial data feeding.

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, and which is basically execution of the four and last stage of our work plan depicted in **figure 1.** In this context, personal computer software package was designed and established by the author, using Visual Basic for Application VBA language in Microsoft Access Environment on Microsoft windows XP platforms, and based on relational database management system, and Arc_GIS system.

4. MAIN COMPONENTS OF DEVELOPED SYSTEM

- Spatial and non_spatial data.
- Developed and Existing Software: Developed software: (“Cadastre ver.2.3”), and Existing Software: (Arc GIS, Microsoft Access).
- Available hardware.
- Users (persons and organizations).

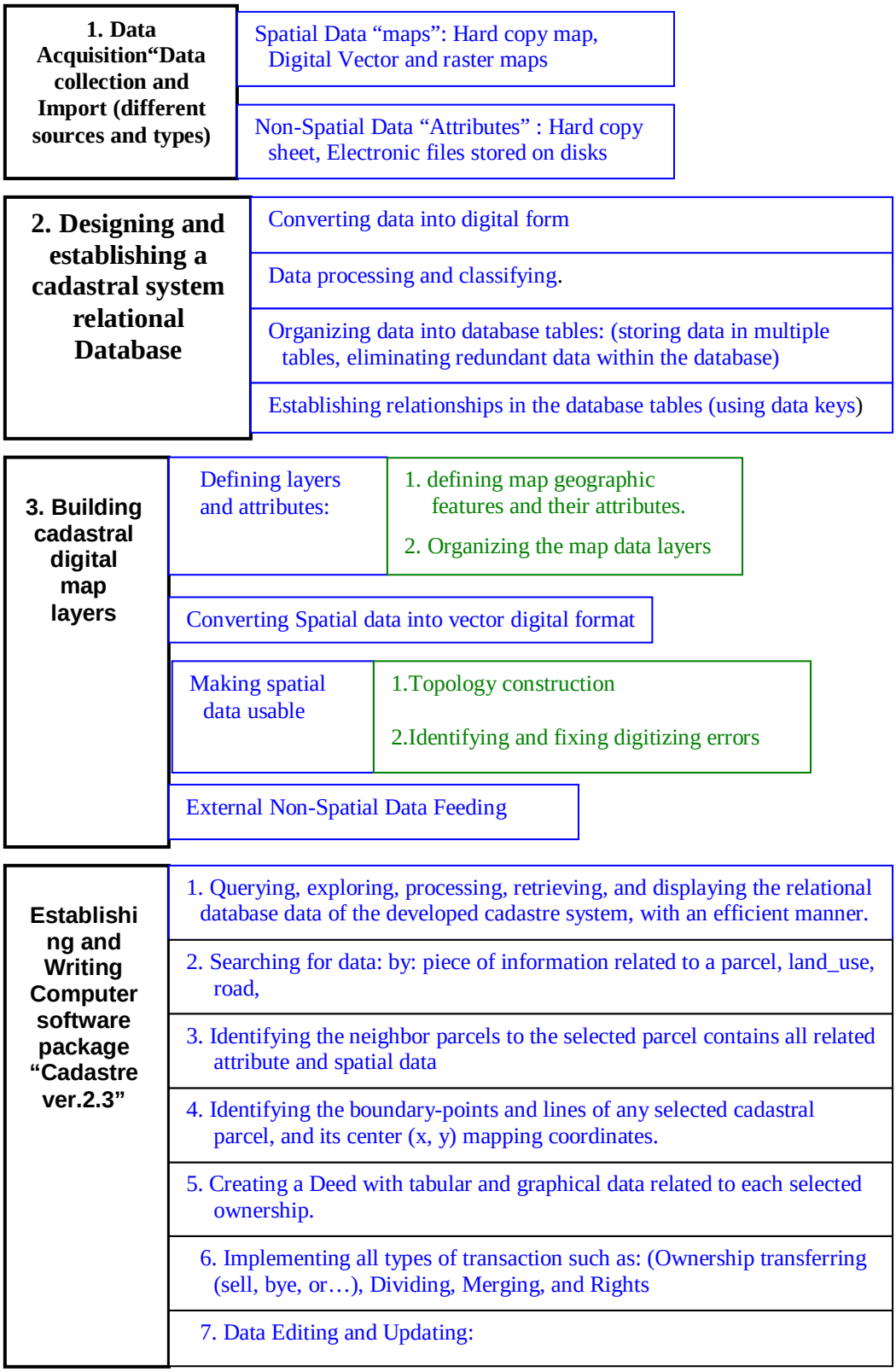


Figure (1) Developed cadastral system – work plan

5. DATA ACQUISITION (DATA COLLECTION AND IMPORT) FROM DIFFERENT SOURCES AND TYPES.

The cadastre is an information system consisting of two parts: (i) a series of maps or plans showing the size and location of all land parcels, and (ii) the text records that describe the attributes of the land (Turker and Kocaman, 2003). The basic spatial unit of cadastre is a land parcel on which land tenure and land use records are compiled **(figure 2).**

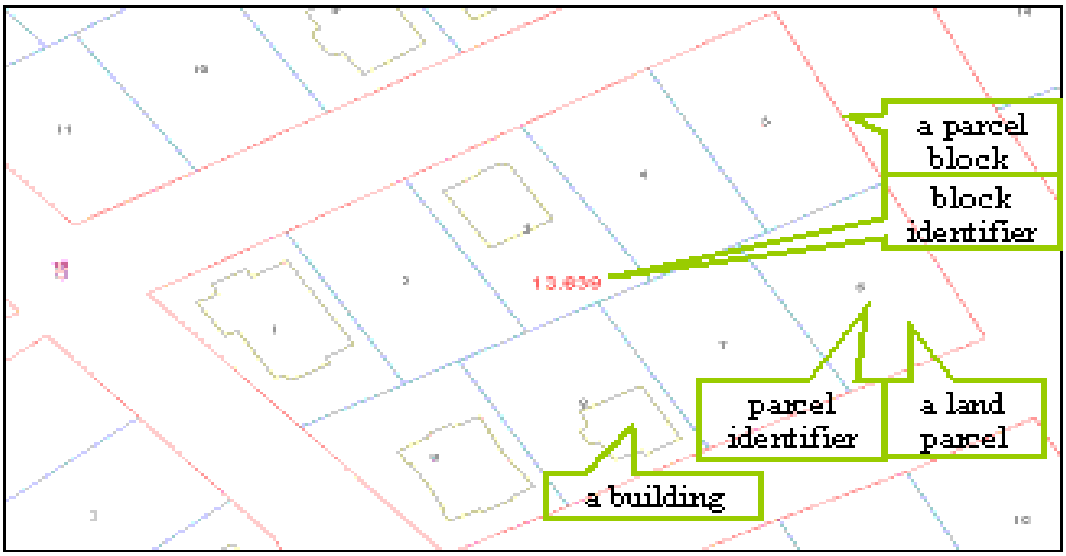


Figure 2: A part of a cadastral map.

All cadastral data are include accurate geodetic control points, 1:25000-scale maps, forest maps, the geodetic reference network, cadastral maps, land use information, and land tenure records.
To efficiently design a cadastral database, the user needs were determined. The intended users of the database were identified and analyzed.
The main cadastral objects defined are as follows: (i) land parcel, (ii) parcel block, (iii) country, (iv) province, (v) district, (vi) quarter, (vii) village, (viii) person (real and juridical), (ix) buildings, (x) cadastral map, (xi) ground control points (GCPs), and (xii) other land related data linked to cadastral data (such as transportation and vegetation data).

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

Also, additional descriptive data, "will be display later" 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).

6. DESIGNING AND ESTABLISHING A CADASTRAL SYSTEM RELATIONAL DATABASE

- Converting data into digital form
- Data processing and classifying.
- Organizing data into database tables: (storing data in multiple tables, eliminating redundant data within the database)
- Establishing relationships in the database tables (using data keys)

7. BUILDING CADASTRAL DIGITAL MAP LAYERS

- Defining layers and attributes:
    1. Defining map geographic features and their attributes.
    2. Organizing the map data layers
- Converting Spatial data into vector digital format
- Making spatial data usable
    1. Topology construction
    2. Identifying and fixing digitizing errors
- External Non-Spatial Data Feeding

8. ESTABLISHING AND WRITING COMPUTER SOFTWARE PACKAGE "CADASTRE VER.2.3"

Developing Computer software package in Microsoft access environment using visual basic for application language.

1. Querying, exploring, processing, retrieving, and displaying the relational database data of the developed cadastre system, with an efficient manner.
2. Searching for data: by: piece of information related to a parcel, land_use, road,
3. Identifying the neighbor parcels to the selected parcel contains all related attribute and spatial data
4. Identifying the boundary-points and lines of any selected cadastral parcel, and its center (x, y) mapping coordinates.
5. Creating a Deed with tabular and graphical data related to each selected ownership.
6. Implementing all types of transaction such as: (Ownership transferring (sell, bye, or…), Dividing, Merging, and Rights changing.
7. Data Editing and Updating: Edit (Add new, and delete) and update spatial and non-spatial data of the developed cadastre system database layers and tables related to parcels, land use, Building, floors, and flats, Roads, Utilities, and owners).

9. KINDS OF CHANGES

Different kinds of changes in terms of geometric as well as non-geometric changes (attribute) are categorized into following groups:

1. Changes occurred in shape and number of land parcels:
   The main reason for such a change may be seeked in two factors. The first is the Islamic heritage law in our country that results to splitting of land parcels into small sizes after a few generations. The other reason is the poverty in rural area that makes the people to sell part of their lands to compensate their living expenses.
2. Ownership changes: The major reason for these changes is made by the owners, such as ownership transferring
3. Land use changes: Land use changes are one of those cases that may be occurred through human activities as well as natural phenomena. Some of the annual changes are related to alternate cropping patterns, changing farmland to other uses such as orchard or settlement and industrial sites in rural areas, changes in relation to urban development. Such changes occur in rural area every year due to lack of a valid policy in concern with land use changes.

10. DEVELOPED CADASTRAL SYSTEM DATA TYPES

10.1 Digital Map Layers

1. Administration cities layer
2. Administration markaz "s" (governorates) layer
3. Administration villages (municipalities) layer
4. Administration hod "s" (districts) layer
5. Administration parcels base layer
6. Land use layer
7. Buildings layer
8. Roads layer
9. Main water utility layer
10. Main electric utility layer
11. Main gas utility layer
12. Main telecommunications utility layer
13. Main Sewer utility layer

10.2 Digital Database Tables Data

The database tables have classified into the following eight groups related to data types.

10.2.1 Administration divisions

1. Administration divisions are: (City (governorate), Markaz (province), Village (muncipality), Hod (district), and Parcel).
2. Data types: (ID, Name, and Number).

10.2.2 Parcels main data

1. Shape: (Parcel_id, Parcel_number, Parcel_Area, Parcel_Perimeter, Parcel_(X,Y) Coordinates for shape center).
2. Boundaries: (Arc_id , Length, Right poly, left poly, From_node, to_node, Node_id, X_node, and Y_node).

Figure (3) contains sample of the descriptive data, related to administration divisions and parcels main data stored in the sought cadastre system relational database.

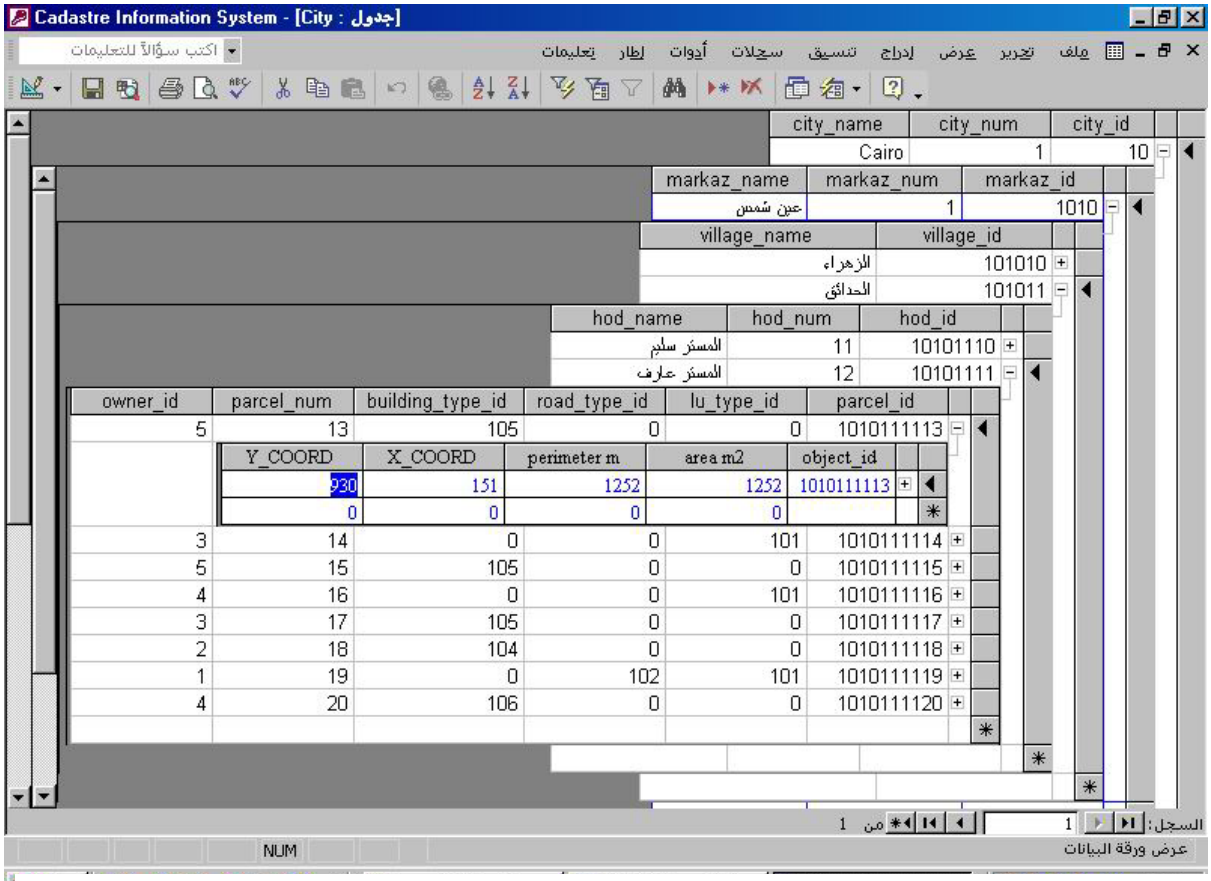


Figure 3. sample of the descriptive data, related to administration divisions and parcels main data

10.2.3 Buildings data tables

1. Building_types: (Living, Educational, Industrial, Commercial, Public, Governmental, Archeological, Sporting, Military , and Religion).
2. Living Buildings:
    a. Living Building Features: (Build_id, Build_number, Build_name, Hight_m, Area_m2, Perimeter_m, Number of_floors, Owner_id_(Organization), Number_of_flats_per_floor, Street_name, Telephon_number, and Notes).
    b. Living Flat_Features: (Build_id, Flat_id, Flat_num, Floor_num, Number_of_rooms, Area, Direction, use_type, Water_meter, Eectric_meter, Telephone_number, and Notes).

3. Educational Building Features: ((Build_id,Build_number, Build_name, Hight_m, Area_m2, Perimeter_m, Number of floors, Number_of_flats_per_floor, Street_name, Telephon_number, Owner_id_(Organization, Education_class, Education_type, E_mail, and Notes.)
4. Other Building Types Features: (Build_id, Build_number, Build_name, Hight_m, Area_m2, Perimeter_m, Number of floors, Street_name, Telephon_number, Owner_id_(Organization, E_mail, and Notes.).

Figure (4) displays samples of the descriptive data related to building_types, other building types features, living building features and living flat_features data stored in the cadastre system relational database.

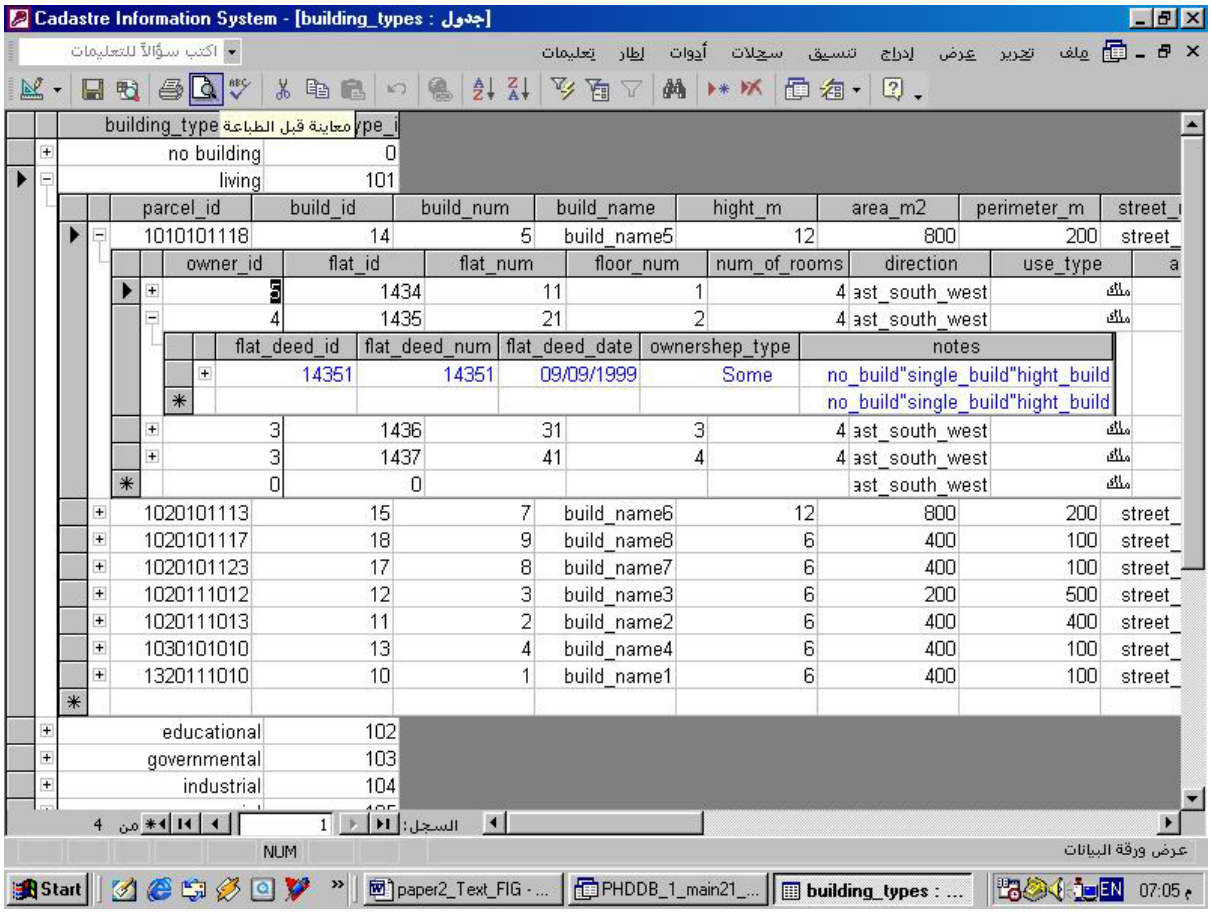


Figure 4. sample of the descriptive data related to building_types, other building types features, living building features and living flat_features data.

10.2.4 Roads data tables

1. Road_types: (Highway, First_order Road, road_under_construction, Agriculture Road, Street, bridge, foot_path, track,and tunne).
2. Roads Properties: (road_type_id , road_id, road_num, road_name, Length (km), Width, Organization, date_of_construction, max_speed, and Asphalte).

10.2.5 Utilities data

1. Utilities_types: (Water, Electric, telecommunication, Gas, and Drainage).
2. Utilities_features: (utility_type_id, utility_feature_id, utility_feature_name_arab., utility_feature_name_engl).
3. Feature_Data: (feature_code, Length, hight , area , diameter , Size, Depth, average slope, material_type , record , kind , class , and Notes).

10.2.6 Land use data types:

Agriculture, Brush land, Forest, Water, Barren area, pasture, Public, and fruitful trees.

10.2.7 Owners Data:

Owner_id, tenant_id, nation_num, f_name, m_name, l_name, Address, birth_date, telephone_num, mobile_num, fax_num, e_mail_adress, and professions.

10.2.8 Ownership Data:

1. Ownerships: (,Parcels_landuse ownership, Living Buildings ownership, Living, Buildings Flats ownership, and Utilities ownership).
2. ownership data: (Ownership_ID, Ownership_number, Ownership_date, Ownership_type (Some, or all), Ownership_Share, and Ownership_notes).

11. MAIN FUNCTIONS AND TASKS

The developed cadastral system can achieve many functions and tasks related to each on of land parcels, land use, buildings and flats, roads, all utilities, owners, and ownership. **Figures (5 to 8)** display these features and the main tasks that can be achieved on each type of features. The following is brief review of the main functions and tasks that the developed cadastral system can archive.

1. Exploring, Searching, retrieving, and displaying the stored spatial and non spatial data, with an efficient manner. **Figure (9)** displays, for example, this task on parcel land use.
2. Responding to many of queries about the stored spatial and non spatial data.
3. Creating deeds related to parcel_landuse, buildings, and flats.
4. Achieving all types of transactions on parcels and buildings and flats automatically and safety process. **Figure (10)** displays for example the task of parcel ownership transfer

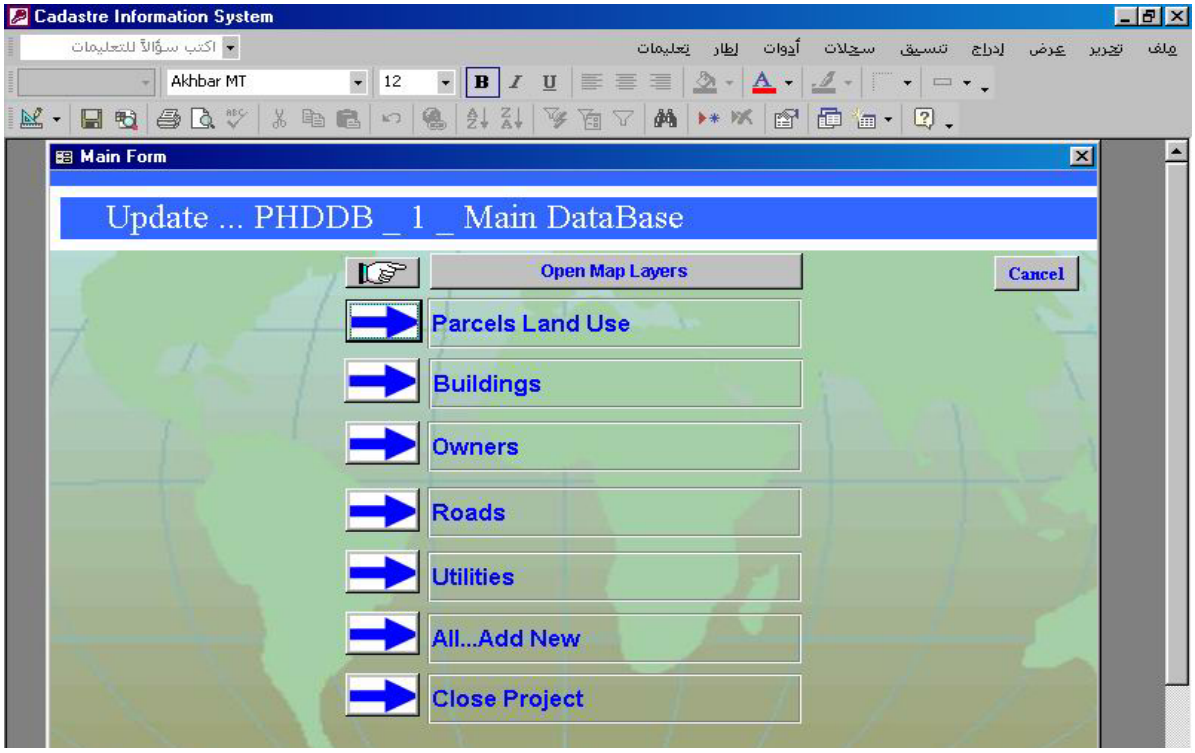


Figure 5**.** The developed cadastre system main Screen displaying the main features used in this system database

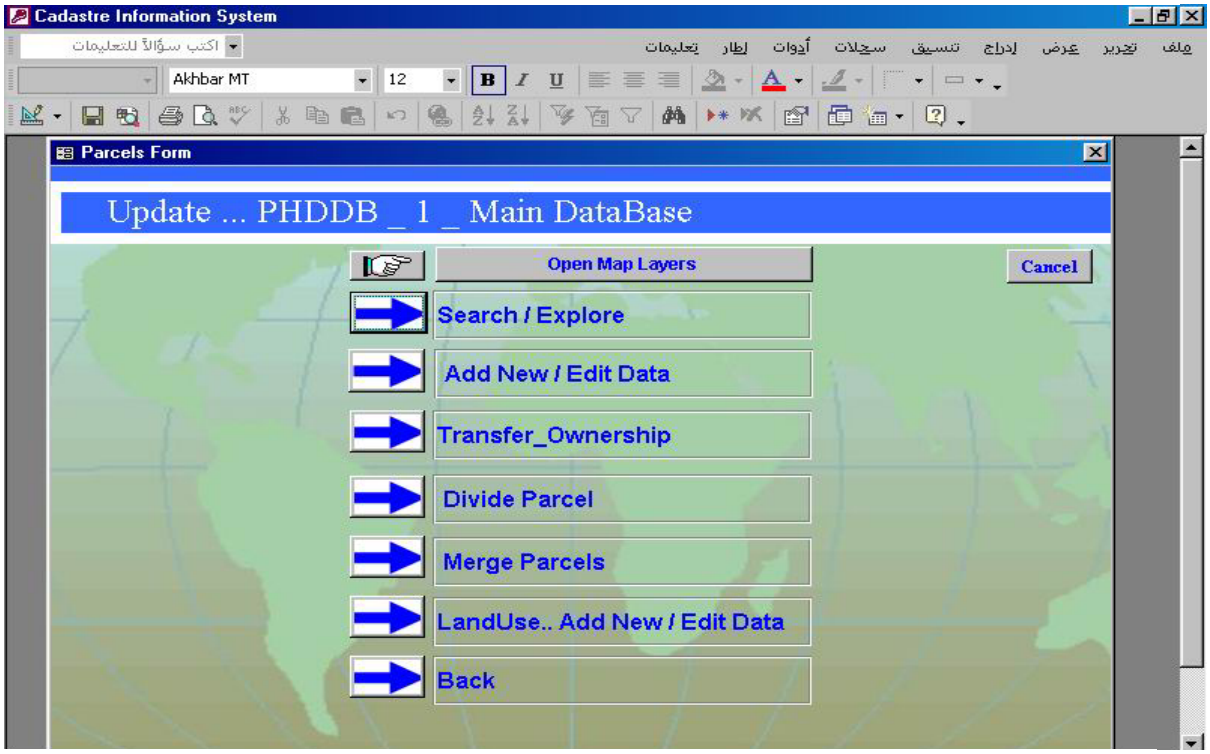


Figure 6. The main screen related to parcels and land use

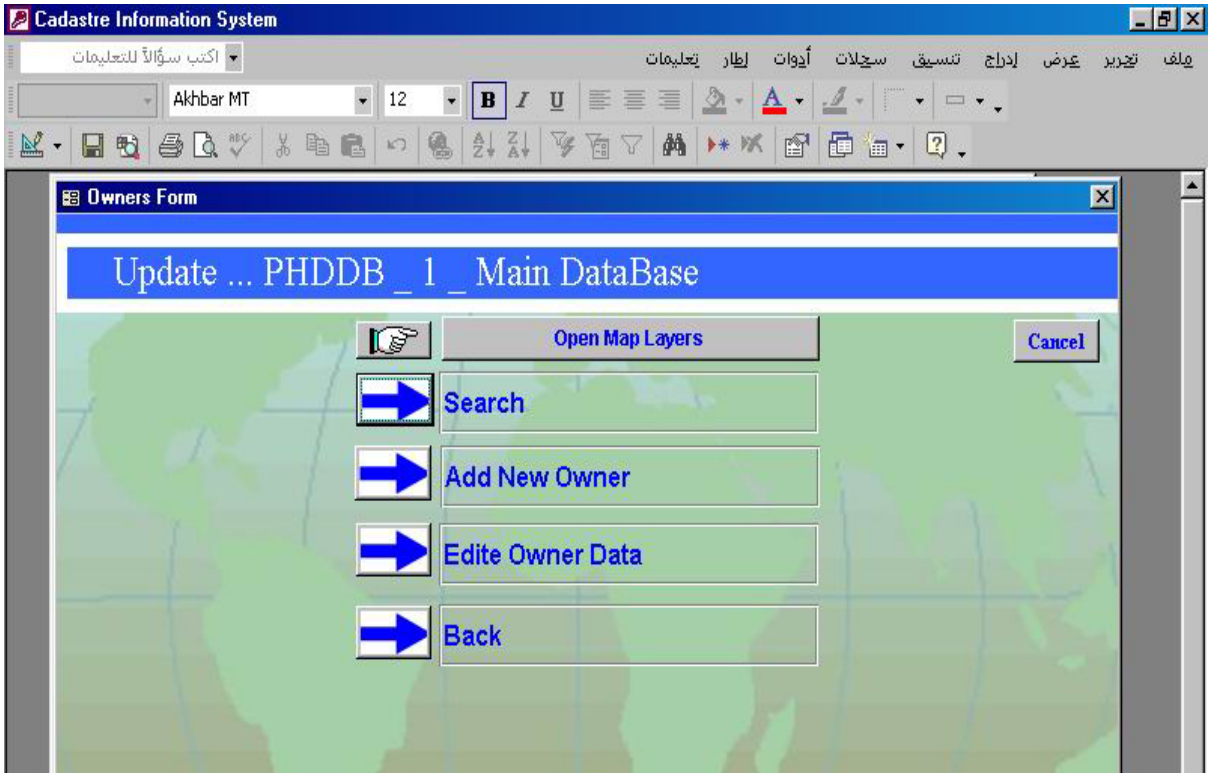


Figure 7. The main screen related to owners

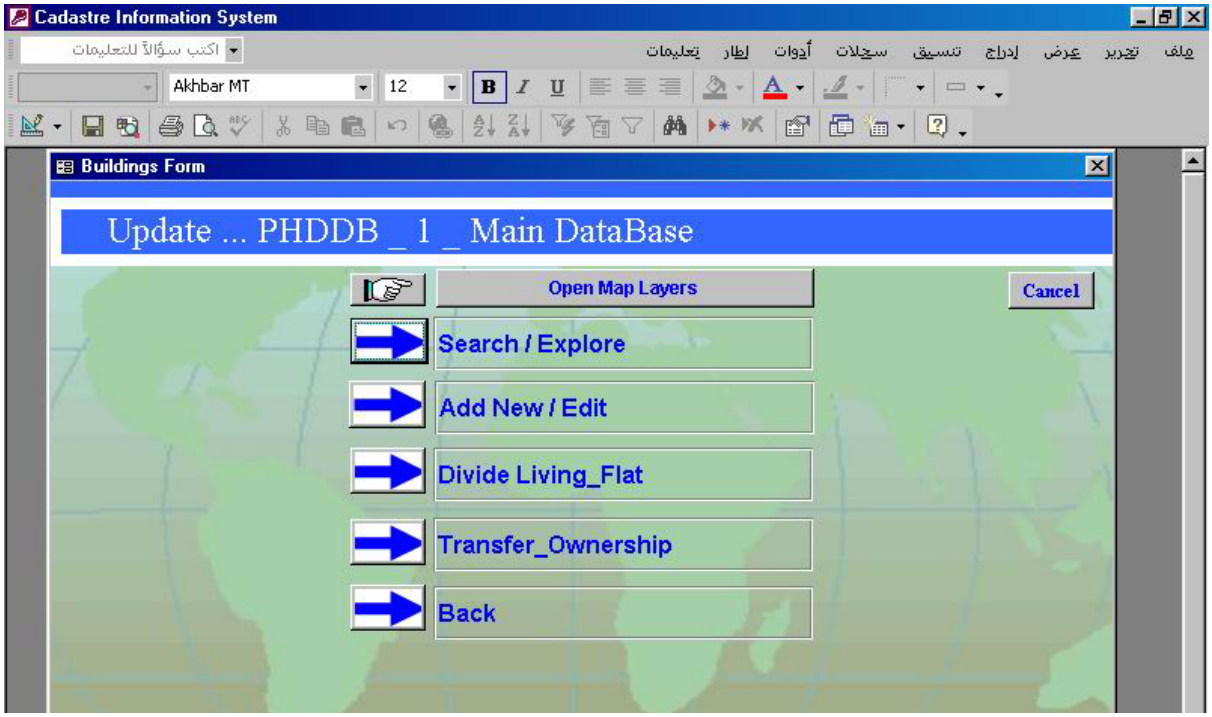


Figure 8. The main screen related to buildings

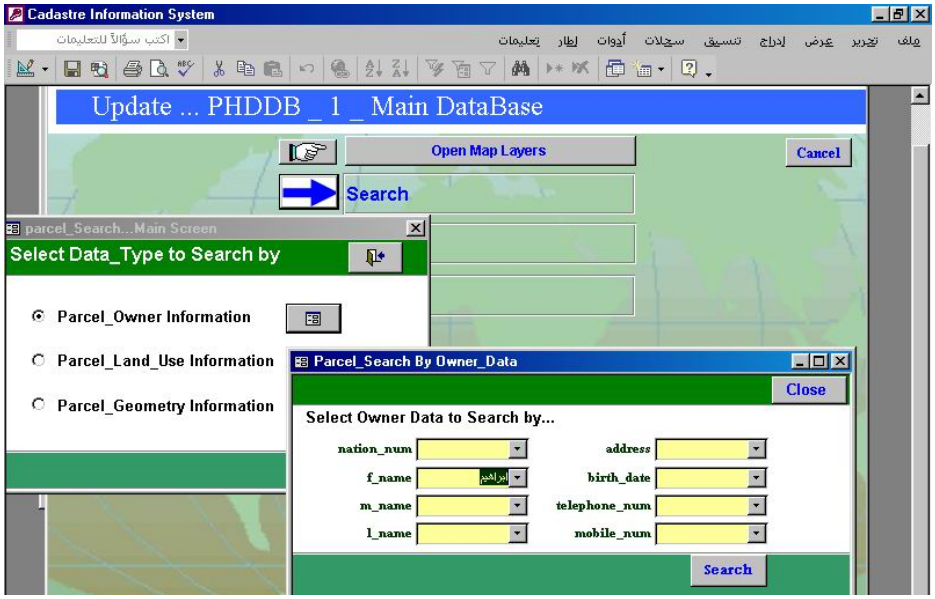
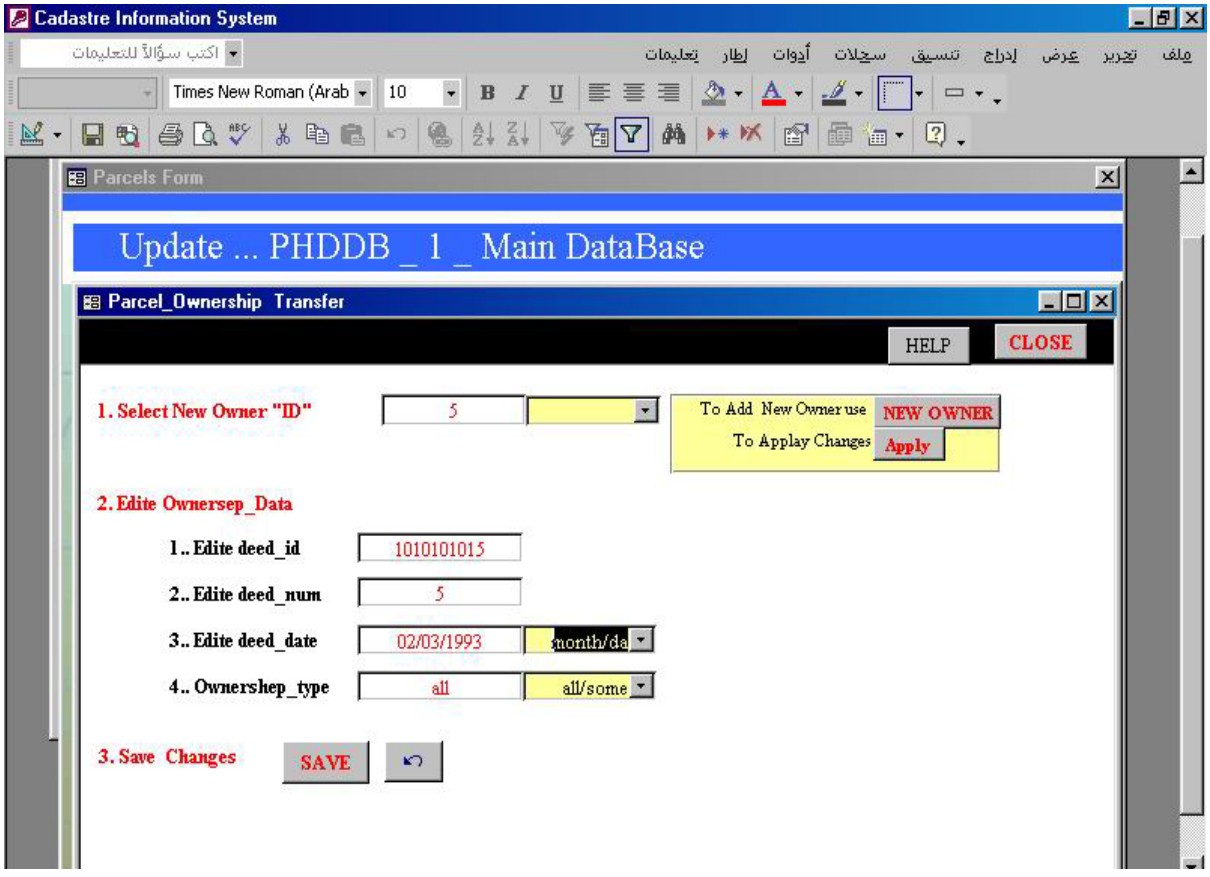


Figure 9. Some steps of search task related to parcel land use data type



also **figures (11 and 12)** display the main screen and the first step of the parcel division task.

5. Updating the graphical data in the database map_layers.
6. Updating the attribute data in the database tables.

12. CAPABILITIES AND BENEFITS

1. The built cadastral system database, allows to import, store, integrate and inter-relate between lands related information from different sources, so it provides the following advantages:
2. The process of large amount and different types of storing data is accomplished in the most regular, and efficient manner, leading to:
    c. Eliminate redundant data in the database, and
    d. Keeping the database from growing too large.
    e. Optimum benefits of spatial and not spatial data can be achieved.
3. The developed database is flexible enough to allow inclusion of new functions required of the written software package.
    2. The built database allows to import, store, integrate and inter-relate between lands related information from different sources, so the built cadastral system, provides the following advantages:
4. Provides cadastral database for all related sources Supporters.
5. Growing the private and public activities and works.
6. Save the public and private money, time, and effort.
7. Also, it makes updating of large amounts of data included in the database as easy and fast as possible.
    3. Implementing all types of transaction such as: (ownership transferring (selling, buying, or…), dividing, merging, rights changing, and data editing (add new, delete, and update). for spatial and non-spatial data of the developed cadastre system database layers and tables on ownerships related to Parcels, Land use, Building, floors, and flats, Roads, Utilities, and Owners. for spatial and non-spatial data of the developed cadastre system database layers and tables.
    4. The processes of acquiring data , and responding to queries, will be implemented as easy and fast as possible.
    5. Providing data types for all private users and state organizations related to sources supporters.
    6. Developing procedures of coordination between private and state organizations and corporations related to sources.
    7. Prevent the duplications of field data capture, or data import from different sources, so the database will be the main source of data that attain the following:
        - Prevent of duplications of storing the same data in different sources databases
        - Acceleration and facility of Decision making for different utility projects.

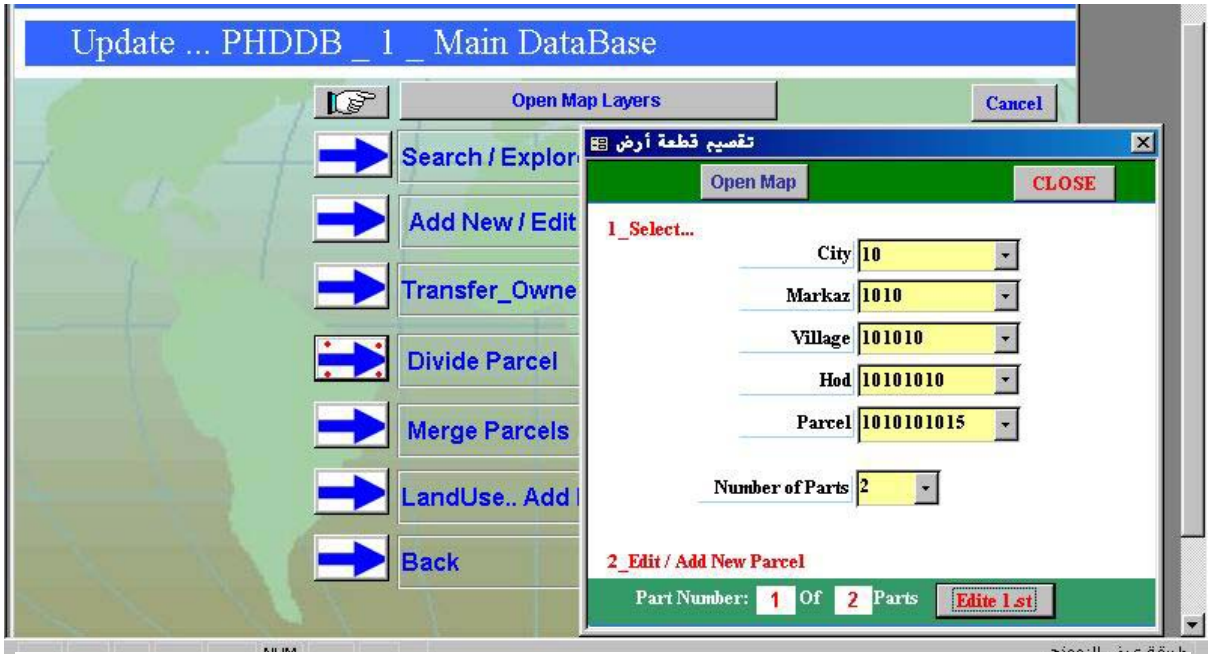


Figure 11. Main screen of the parcel division function

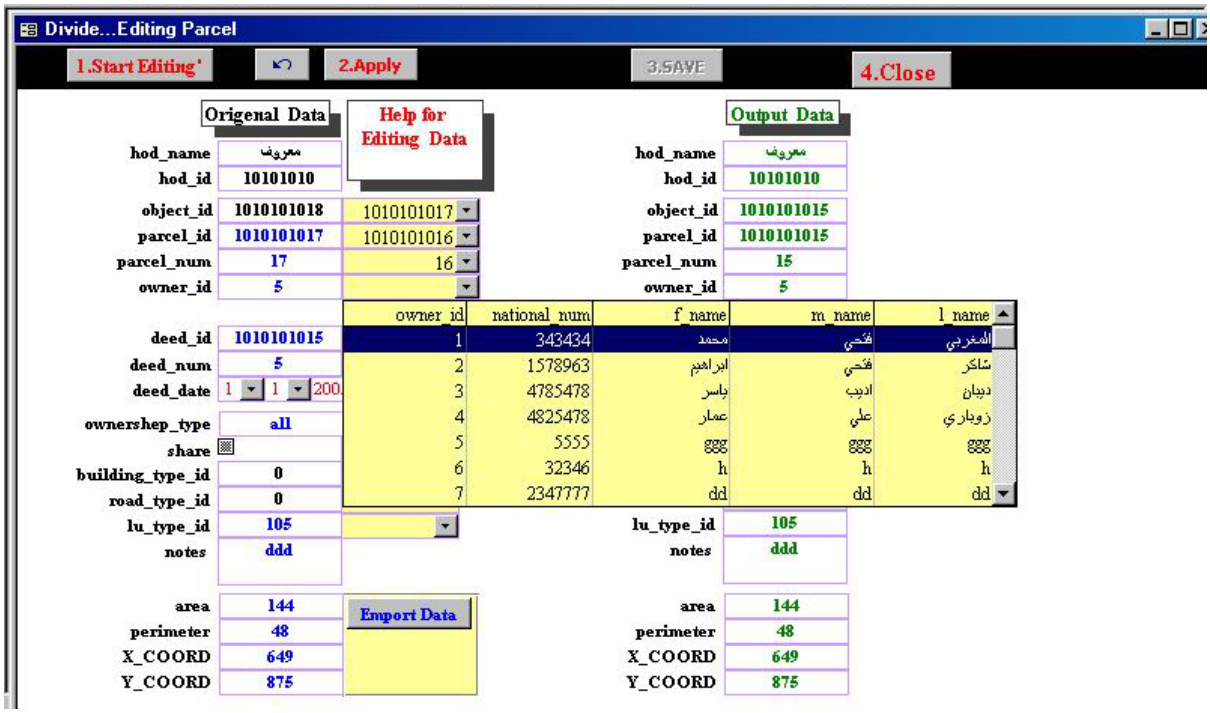


Figure 12. Example the first step of the parcel division function

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