DIGITAL CADASTRAL MAP: A MULTIPURPOSE TOOL FOR SUSTAINABLE DEVELOPMENT

Moha ELAYACHI and Prof. El Hassane SEMLALI, Morocco

Key words: cadastral information, digital cadastral map, design, implementation, sustainable development.

ABSTRACT

The cadastral system is the basis used for the protection of the property by means of title registration and cadastral plans. Each parcel and its owners are registered and all the spatial structures consisting of location, boundaries and contents are described in a cadastral map. Therefore, the cadastral system is seen as a land information system affording information on real estate of a property. It improves the land management whether in urban or rural areas. In urban area, it is becoming a fundamental framework for planing, assessment and collection of rates and taxes. In rural areas, the claim to ownership increases the investment in agricultural lands and the property business. Then an appropriate cadastral system should be designed and established by and for a particular country.

One of the important components of any cadastral system is the cadastral map. But the existing systems consisting of paper maps and conventional land registers are becoming inefficient. For that reason, a Cadastral Information System (CIS), based on digital cadastral map in which attributes and map data on cadastral unit are stored in the same database, should be introduced. The CIS should be designed to support not only the cadastral mapping or the land surveying and titling but also a variety of purposes such as identifying specific areas, determining limits of different status of land, sustainable development, social stability, land management and agricultural studies.

The aim of this paper is to undertake a research about advantages of digital cadastral map and its uses in implementing a multipurpose cadastral information system for sustainable development. For this reason, we will present some aspects of the existing cadastral systems and their shortcomings. On the other hand, we outline the possibilities of integrating other systems with digital cadastral map so as to enhance the land planning and management. The comparison between the traditional and the new approaches of designing and implementing cadastral information systems is discussed.

INTRODUCTION

The cadastral system can be established for fiscal purposes, for protection of property rights or for being a multi purpose system. In the first case, the cadastre is defined as general public inventory of land objects in order to assess the values of land properties and to order land taxation. This system is seemed to be an important source of wealth for

societies. The aim of this kind of cadastre is to obtain information about owners (names, addresses, etc.) and their properties (surface, boundaries, tenure, etc.). In the second case, the cadastre is the basis for land titling and land registration. It includes geometric description of land parcels and land register so as to provide security of tenure. It is closely linked to title registration rather than taxation. The last case consists of cadastral system that is the basis to support not only both fiscal and titling systems but also the land management and markets, the agricultural productivity and sustainable development. This kind, called a multi purpose system, must be appropriately designed to serve the needs of development. Each kind of these systems can be applied to modernize the management of land. Then the fundamental component of a multipurpose cadastral information system based on digital cadastral map will be well constructed.

The role of this system is to enhance the managing and controlling the land resources with a focus on sustainable development. The advent of computer technology is the principal tool that modernized the existing cadastral systems. The effects of their sophistication are observed along many sectors of the societies. However, the until now existing cadastres become inefficient, so the government are forced to improve them.

THE SHORTCOMINGS OF EXISTING CADASTRAL SYSTEMS

The aim of this part is to present the technical aspects of the cadastral system. It means that the authors will not discuss the other aspects of cadastre such as: legal or institutional aspects. From this kind of view, the cadastre incorporates land registration and cadastral survey.

The land registration deals with establishing lists of owners and all their properties. Details that must be stored for each property are:

- the name, the date of birth and the address of land owner,
- the description of the location of the property,
- the number its parcels, the size and area of each parcel,
- the district where is the property,
- Additional information about the property like title number, name of cadastral agency, the nature of ground use and all the rights and restrictions.

The cadastral survey, on the other hand, serves as a way furnishing the geometric description of each parcel. It consists of determining the parcel boundaries, the surface and the parcel co-ordinates. This spatial structure is usually stored in an analog cadastral map.

According to Williamson (1997) who investigates on "the justification of cadastral systems in developing countries", the principal causes of the environmental degradation in the rural areas are: inappropriate government policies, migration and population growth, clearing of forests, modern farming technology and the development of the international markets. These factors have an unfortunate consequence on the urban environment such as the high pollution levels and the deteriorated infrastructures.

Then the cadastral and land information systems are considered as the convenient keys to some of these problems. In most developing countries, are cadastral systems out of date and inaccurate.

All the factors listed above affect the technical aspects of land management. Therefore the significant problems of these aspects in the existing cadastres are:
- Storing cadastral unit attributes and map data in different systems,
- Low precision of geometric data,
- the hardness of the analog form of cadastral surveying with paper,
- the slowness of updating, retrieval and storage process in the conventional system,
- the disability for performing analysis and report in an easy way,

Currently, some governments of developing countries have become increasingly aware of deficiencies in their cadastral systems and they proposed a program to overcome some problems of conventional strategies. They try to take advantage of the new technology based on computerized information system in order to enhance the manner of working and to upgrade the skills of personnel. But we must mention that the new technology can't obviously be a tool to avoid bureaucratic or administrative problems (Hendrix and al., 1996).

Therefore they must conduct suitable projects to extend the conventional systems to cover new issues:
- Automation of administrative tasks,
- Development of applications for managing the cadastral registers,
- Development of analytical tools for setting up digital cadastral maps and plans,
- Automation of land management for consolidation issue,
- Implementation of land information system (LIS).

Moreover, the old systems will be extended and enhanced by the use of GIS technology and modern procedures for data management. The expansion of classical model of cadastre should lead to their integration within the multitask system that may serves the objective of collecting, processing, analyzing and editing the spatial information. It will improve the management of natural resources and promote an efficient production in sustainable manner. The major effect of this new system is the protection of land use rights and the establishment of security of tenure for users. The fundamental elements for the expansion will be cadastral mapping and cadastral registration. Thus the first aim is to implement both computer titling and digital mapping and to provide a linkage mechanism for system survey, land registry and land management. Secondly, is to establish a system that will serve a legal and/or a fiscal purpose (Kaufmann and al., 1998). So the function of the cadastral map must be redefined to integrate the modern method of creating data models.

DIGITAL CADASTRAL MAP FOR A MULTIPURPOSE CADASTRE

The principal element of any modern cadastre is the digital cadastral map, for it's a large view of a geographic area and it can be displayed and printed at different scales. Its major advantage is to display the spatial relationships between land objects. It is obviously

organized into layers or themes giving information about properties, buildings, land use and population. On the other hand it must be a tool to describe the location, the shape and the contents of each object.

The spatial and non-spatial data should be linked on the map. This linkage is very important as it enables us to process, to analyze land situation and to make decision. For that reason, it's necessary to develop a system that allows the storing and processing operations in the same geographic database. For example a layer containing social information will require to be linked to the object indicating the concerned area with the social information. Hence we can divide the digital cadastral map into two levels: digital data modeling and object-based representation.

The digital data modeling is usually used as an elevation model that combines many elevation data (DTM) into a data structure. DTM will be a principal source of collecting data such as studying soil erosion and environmental impact. The DTM helps scientists to extract slop values (gradient, aspect, profile convexity and plan convexity) and terrain features related to surface hydrology such as drainage channels, topology of channel network and descriptive information.

The object-based representation (OBR) involves the association of attribute data with objects and the suitable relationship among objects having spatial and non-spatial information. The spatial objects can be property parcels, administrative districts, and plant zoning and civil networks.

The classification of the other systems that will be incorporated into the digital cadastral map is shown in figure 1.1.

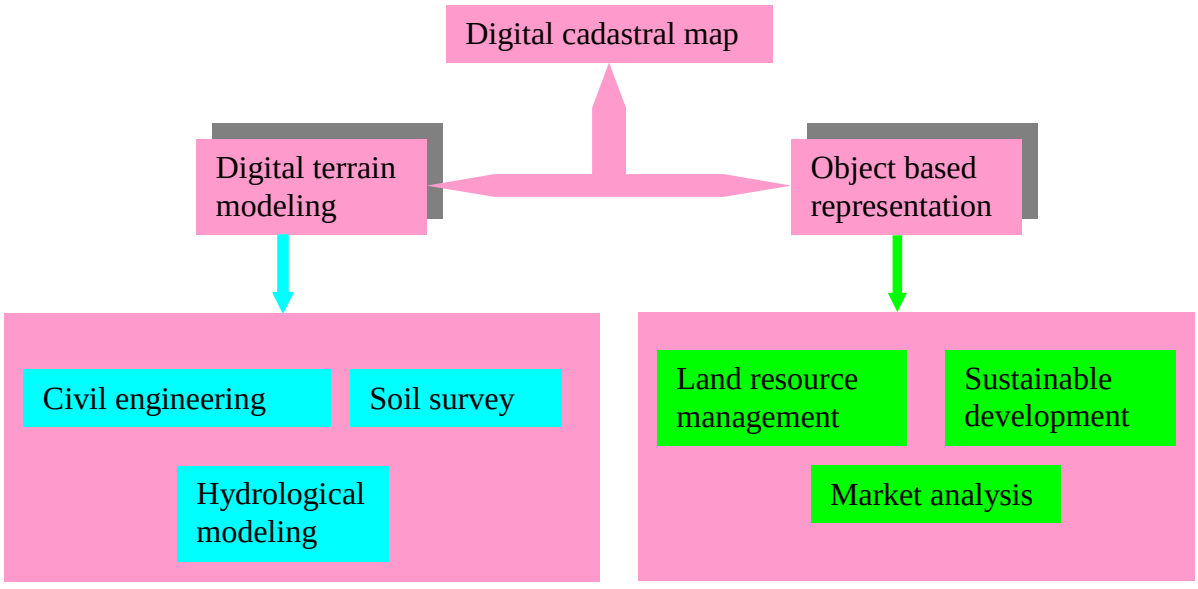

Figure 1.1: other systems that can be incorporated in digital cadastral map

Civil engineering

Civil engineering activities that include road design, site planning of dams and open cast mining require DTM in order to accomplish the visibility analysis, the relief shadow analysis, the profile computation and the volumetric computation. All these activities include a set of data that can perform operations on digital cadastral map. Examples of such operations include combining layers to form new sites, classifying zones and choosing the appropriate site for civil projects. These projects refer to municipal planning and management activities such as school, political district, traffic analysis and managing of public facilities. This means that the governments must use the digital cadastral map in order to find all aspects of legal situation of piece of land, though they will loose money and time spent for inadequate planning.

Soil survey

The digital cadastral map also serves the purpose of gathering soil data for performing studies on experimental agricultural farms. The soil data surveyed includes qualitative description such as texture class, color, geological formation, and legal information about every piece of land and land owner. They, in addition, include quantitative description such as porosity, thickness, soil profiles, and the surface of the area under studied.

Hydrological modeling

The hydrological modeling is used to study water resource management and pollution control. It starts with studying the discharge of rainwater, ground water discharge, storage, filtration and evaporation. The data obtained from DTM and soil survey overlaid with cadastral layer and legal information in a digital cadastral map enable us to determine new aspects of land uses.

Land resource management

With this category of studies we can implement a national guidelines for land management by integrating natural resources into a digital cadastral map. The result consists of attribute data such as land ownership and graphical data such as roads, building or public institutions that are linked through unique identifiers assigned to spatial units such as land parcels. Then the cadastral map facilitates in a systematic manner the collection and storage of data related to land resources. It defines where dangers can be caused by natural phenomena and where certain managements are permitted or forbidden. The aim is to regulate land use and environment protection and construction laws.

Market analysis

Marketing leads with determining potential customers, reaching customers and maximizing sales through distribution channels (Beaumont, 1991). The important need of a digital cadastral map in market analysis is derived from the dynamic nature of the demand and supply of products and services. In digital cadastral maps, are located buildings, specific

areas and owners, thus we can forecast various locations for competing stores, pricing and product performances of customers. On the other hand, the customary rights can be documented on a digital cadastral map because it documents all aspects of land.

Sustainable development

The principal objects of a digital cadastral map are property parcels, resource polygons, road and utility networks, topographic data, and census and electoral polygons. Then the creation, retrieval, and maintenance of these spatial objects are the fundamental to modern cadastral information system. The types of spatial objects that require maintenance are location, spatial extent, and attribute data such as ownership and land parcels. Therefore integrity of data should be maintained at every time an update is performed. If the size of a land parcel is changed, it would be necessary to change all attribute data that are affected by this change. The digital cadastral map enables users to issue data retrieval as well as requests visually because it permits a systematic way to store and to retrieve multiple values for the attribute data for a specific land parcel.

CADASTRAL INFORMATION SYSTEM: DESIGN AND IMPLEMENTATION

The cadastral information system (CIS) is a kind of geographic information system (GIS) that are powerful tools. To use a CIS, we must become aware of a variety of modeling techniques and model structures. Then, it's very interesting to look into an approach that enables the integration of cadastral operations with GIS packages and develop a tool that should be of use in a multipurpose system. The investigation wherefore can be conducted through three levels.

In the first step, the existing cadastral applications must be understood and all projects conducted for modernizing cadastral system should be analyzed. All other existing maps and information on cadastral data must be investigated to give a comprehensive view about cadastral data and operations to offer recommendations. The purpose of this level is also to describe different approaches used to design a CIS.

In the second step, it's necessary to outline different methods for linking cadastral data models to GIS software. Then, we must discuss the existing methods their strengths and weakness.

On the other hand, the third step is concerned with the manner to implement the conceived system. It shows how the new approaches can de implemented through new systems such as ArcView or ArcInfo and how this new technology supports a variety of data and layers of data.

The traditional approach and its limitation

The traditional development approach includes the life cycle that assumes that the development of any application flows through various levels. The most common levels are requirement analysis, designing, and development, testing and maintaining. The

philosophy of this approach involves that we must complete any stages after handing the previous one. According to Taylor (1992), there are some limitations of this methodology:

- It rarely delivers the solutions that managers want,
- It requires specialized personnel for analysis, design, programming, testing and maintaining,
- It's very difficult to execute as described,
- It's taking too long.

However, the object technology can enhance the traditional life cycle in two important manners. Firstly, it can reduce the barriers between stages by providing a common set of constructs for use at each level. Secondly, it provides specific tools to assist each level of life cycle methodology and the tools of the implementation stage are well established.

The object oriented approach

The object-oriented approach introduces the concepts of the object oriented programming (OOP) that are objects, messages and classes (Adam and al., 2000). The objects are software packages that contain related data and methods (encapsulation). They correspond to real-world objects such as parcels, roads, and building, owners and rights. The messages are the means by which objects communicate. For example, objects request services from one other, working together to carry out specific operations. The classes are templates for defining kinds of objects. Classes are usually defined as special cases of each other and organizing information about objects in a natural and intuitive manner.

CONCLUSION

We have proposed in this paper an outline of the limitations of the existing cadastral system, the advantage of a digital cadastral map to found a multipurpose cadastral system and role of the object oriented technology in developing cadastral information systems. Compared with existing cadastral systems, the cadastral information system based on digital cadastral maps gives an overview about its uses and solutions. The CIS can be expanded to serve the purpose of sustainable development. Under the assumptions that many governments conduct various projects related to land planning and management, the CIS is the safe manner to integrate all projects in a same system. This has the advantage of being easily designed and implemented and incorporating the existing data, because the model data will be formulated in a digital format.

For further research, we will investigate how the object-oriented technology can be used to design and to implement a cadastral information. This can be achieved by a case study that will be conducted in Morocco. To further outline the whole importance of the multipurpose CIS, comparative studies should be performed.

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CONTACT

Moha Elayachi
Senior lecturer
Department of Geodesy and Topography
BP.6202
IAV Hassan II, Rabat-Instituts
Rabat
MOROCCO
Tel. + 212 6238 4596
Fax + 212 3777 8135
Email: m.elayachi@iav.ac.ma.

Professor El Hassane Semlali
Department of Geodesy and Topography
BP.6202
IAV Hassan II, Rabat-Instituts
Rabat
MOROCCO
Tel. + 212 6238 4596
Fax + 212 3777 8135
Email: e.semlali@iav.ac.ma .