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## **3D Cadastre for Land Administration: Some issues about the Moroccan context**

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### **ABSTRACT**

With the fast world population growing, the efficient use of land properties became of great necessity. In this context, the traditional two-dimensional (2D) cadastral management mode cannot satisfy the need of current 3D land use and 3D urban planning (Guo et al. 2014). So, developing a 3D cadastral system is a very promising solution for land administration. However, the development of such a solution can be faced to some challenged issues related to economic, legal, technical and organizational aspects. In this paper, we present some basics about the 3D cadastre in Land governance. Then, we discuss some issues about migrating to a 3D cadastre solution. Finally, we propose some ideas and reflections about the adoption of a 3D Moroccan cadastral system.

**Keywords:** 3D Cadastre, Property, Land Administration.

### **Résumé**

Avec la croissance rapide de la population mondiale, l'utilisation efficace des propriétés foncières est devenue d'une grande nécessité. Dans ce contexte, le mode bi dimensionnel de gestion cadastrale (2D) ne peut plus satisfaire le besoin de l'utilisation actuelle des terres en 3D ainsi que la planification urbaine 3D (Guo et al. 2014). Ainsi, le développement d'un cadastre 3D est une solution prometteuse pour l'administration du foncier. Cependant, le développement d'une telle solution peut s'affronter à des contraintes économiques, juridiques, techniques et organisationnelles. Dans cet article, nous présentons quelques concepts de base sur le cadastre 3D dans la gouvernance foncière. Ensuite, nous discutons certaines questions relatives à la migration vers un cadastre 3D. Enfin, nous proposons quelques idées et réflexions portant sur l'adoption d'un cadastre 3D marocain.

**Mots clés :** Cadastre 3D, Propriété, Administration du foncier.

## **1. INTRODUCTION**

The demand for modeling and handling 3D data sets has been rapidly growing during the last decades (Breunig & Zlatanova, 2011). Currently, there is an increasing need for representing and analyzing the third dimension of urban space. Nowadays, technical achievements about 3D modeling and storing are notable and make it easier to produce and access to 3D information (Hajji & Billen, 2016).

While 3D modeling is recognised as a promising solution for intelligent urban studies, rethinking the legal and economic aspects of urban space by shifting from the traditional 2D vision to a 3D approach will be necessary to develop, implement, and control urban land policies more efficiently.

A 3D cadastre is one of the tools that can facilitate that process through 3D modeling of land property. Indeed, the increasing complexity of infrastructure and densely built-up areas requires the proper registration of their private/public legal status, which can be provided only to a limited extent by the existing 2D cadastral registrations.

Paulsson (2007) define the 3D property as follows: *"It is a property that is legally defined both vertically and horizontally"*. 3D cadastre provides information beyond the typical two dimension data. It can be used to ensure the registration of property rights under and above the floor.

Urban modeling is a complex task due to the great amount of different urban entities that can be considered (Robles-Ortega et al, 2012). In the case of 3D, the complexity increases. So, defining and implementing a detailed 3D cadastral model would be challenging, money and time consuming.

Although 3D information is well established in many government agencies and private organizations that make significant 3D development, agencies with smaller budgets, especially in local government, are generally the least able to undertake significant investments on 3D data production. Their eventual 3D achievements remain mediocre (Hajji & Billen, 2016).

In the context of 3D cadastre, the challenge is more important because the complexity is more than technical. In the research field, investigations on 3D cadastre are context based. So each organization has to develop its own solution, based on the current registration system, the identified needs and its capacity in terms of available financial resources.

In this paper, we make an overview about the concept of 3D cadastre and the different approaches addressed in the literature. Then, we propose some ideas and reflections about the context of Moroccan cadastral system by raising the challenged issues about its adoption.

## **2. THE CONCEPT OF 3D CADASTRE FOR LAND ADMINISTRATION**

Land administration is concerned with three principals and interdependent commodities: ownership, value and use of land. Ownership usually relates to the possession of rights in land; value normally relates to market value; use relates to the rights related to the land (Choon & Kam Seng, 2013). In short, land administration systems are: *"the basis of conceptualizing rights, restrictions and responsibilities related to people, policies and places in support of sustainability as well as land and property"* (Choon & Kam Seng, 2013).

With the fast world population growing, the efficient use of land properties became of great necessity. This requires precise and reliable description of land ownership.

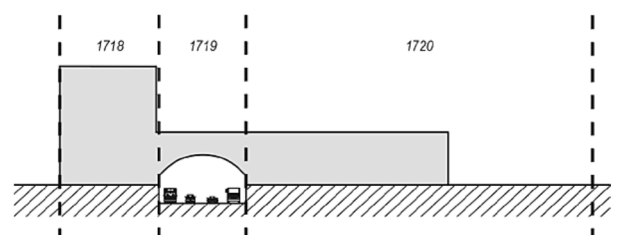
Cadastre and cadastral surveys are key aspects of land administration. The cadastral system determines for each land parcel, its location, the extent of its boundaries and surface area. Traditionally, cadastral registration systems are parcel based and are basically represented in 2D. Previously, a description of the property rights in two dimensions was sufficient to provide clear information on the legal status of real estate. Today, however, because of multiple use of space and the new form of urbanization, the 2D traditional cadastre became very limited, and will no longer be able to accurately describe the spatial information rights in the third dimension. For instance, in the case of a road, a bridge and a building one over the other (Fig.1), all with different owners, the 2D cadastre is no longer able to give a complete and sufficient description of the rights. Consequently, a 3D cadastre becomes indispensable (Semlali et al. 2015).

Some of the situations that require a veritable 3D modeling in the cadastral system are apartments with several uses such as residential, administrative, commercial; subterranean constructions such as underground parking spaces, tunnels, pipes, cables, and vertical ownership. The representation of these situations in 2D cadastre requires more than one object (parcel) in the database (Fig. 2) which causes redundancy and inconsistency of cadastral databases.



**Fig. 1. Situation of a 3D cadastre (Hassan et al. 2008)**

The physical 3D objects in a complex urban environment are hardly to be represented as cadastral objects on the current maps (Koeva & Elberink, 2016). In complex urban areas, the cadastral objects should be represented in a 3D space where spatial analysis can be conducted to extract relevant information about properties and land use which should be saved and maintained in a 3D spatial database.



**Fig. 2. Three parcels are needed to register the right of property of the building (Stoter & Salzmann (2004))**

A 3D digital cadastre would permit data associated with the real world extents of property to be digitally captured,

automatically checked against requirements and rules, combined with existing data and maintained in one system (Gulliver et al 2016).

Introduction of a 3D cadastral system would require re-defining real property in 3D space, using unambiguous 3D terminology, the establishment of legal instruments to manage 3D real property in 3D space with 3D characteristics (Kitsakis et al. 2016).

### **3. APPROACHES FOR A 3D CADASTRE**

Stoter & Salzmänn (2004) identify three main categories of the 3D cadastre. In the following paragraphs, we will give a brief description of each category.

#### **3.1 The 2D Cadastre with 3D tags**

This type of cadastre keeps the 2D parcels by adding labels on a digital map to indicate the existence of 3D information. These labels are used to mention to the user corresponding references to some documents containing 3D information such as acts or plans. The user is asked to carry out investigations to find additional information in the land register.

This type of land registry, however, does not allow a good understanding of the 3D situations, as it gives only a 2D representation of land properties, hence only one parcel can be displayed at a time. In short, this approach means preservation of the 2D cadastre with references to representations of (digital) 3D situations and the user has to consult the (digital) public registers to find the detailed information.

#### **3.2 The Hybrid Cadastre**

This approach is based on the preservation of the 2D cadastre and the registration of 3D situations by registering 3D objects within the 2D cadastral registration. This results in a hybrid solution of 2D parcels and 3D factual

objects in which the explicit relationships between the parcels and the 3D objects are maintained (Stoter & Salzmänn, 2003). Implicit relationships exist through the spatial definition of the objects and can be retrieved by spatial functions. In this case, the legal and factual registrations are combined (hybrid solution).

In a hybrid cadastre, it is possible to represent in three dimensions the infrastructures and the attached rights as well. This type of cadastre enrolls the physical 3D objects like buildings or infrastructures that may be above, on or below the surface of a parcel, for example, a tunnel that crosses several parcels. In this case, the object is registered with a spatial description with plans and sections. In this kind of cadastre, the 3D data exists in various forms (Semlali et al. 2015):

- As a text: for example, a reference number such as the complementary map's number, which itself refers to other maps or 3D models.
- As volumes showing the existence of infrastructures such as buildings or tunnels.
- As 3D drawings: 3D models representing object rights.

#### **3.3 A full 3D Cadastre**

A full 3D cadastral registration means introduction of the concept of (property) rights in 3D space. The legal basis, real estate transaction protocols and the cadastral registration should support the establishment and conveyance of 3D rights. From a practical point of view, it seems best to maintain the 2D parcel as default; only in complex 3D situations the full 3D parcel would be used. It might also be considered if a limited definition of 3D property rights would fulfill a need (e.g. one or more property layer(s) underground or above ground level and one at ground level) (Stoter & Salzmänn, 2003).

#### **4. SOME LIMITATIONS FOR MIGRATING TO A 3D CADASTRE**

For long decades, organizations have described and managed cadastral data in 2D system. In these systems, 2D properties are described by graphical documents and some digital files like cadastral plans of delimitation or other subsequent operations like partitions or fusion of land titles.

Many countries have developed 3D solutions for a 3D cadastre. However, there are some limitations to migrate to 3D cadastral solutions. A first one consists of the complexity of 3D modeling: 3D is more than adding a Z coordinates to a 2D location. 3D modeling requires knowledge about the 3D domain and technical solutions to handle 3D data. Another aspect is that 3D solutions of 3D cadastre should be developed according the specific context of each country and commercial solutions are far to respond to special contextual needs. Another factor that should be taken into account is the economic and sustainability issues of handling and storing big volumes of complex 3D data and user-friendly tools to be developed to manipulate this quantity of information.

#### **5. A 3D CADASTRE IN MOROCCO: SOME REFLECTIONS**

In this section, we will present an overview about the current cadastral system in Morocco and discuss some reflections about the migration to a 3D cadastre system.

##### **5.1 The present situation in Morocco**

In Morocco, the cadastral survey system is a core component of the property rights system which purpose is to define the location and spatial extents of land and other real properties. Topographic data about land

properties is provided by cadastral surveys which are undertaken by licensed cadastral surveyors. These surveys are referred to the Lambert conformal conic projection which is the reference projection system adopted in Morocco. Cadastral surveys must comply with rules (regulations) set by the National Agency of Land registry, Cadastre and Cartography (ANCFCC). ANCFCC is the main administration responsible for the management of the cadastral system in Morocco. It is a public administration created by law No. 58-00 (Dahir No. 1-02-125 of 13 June 2002). It carries out the establishment and preservation of all geodetic infrastructures in Morocco (geodetic network, boundary, leveling network, geoid ...), and all operations concerning land registration, cadastral operations and mapping. The Direction of cadastre conducts all technical operations related to cadastre through several exterior services. While the Direction of land registration conducts juridical operations of land registration and land inventory. On the other hand, the Direction of Cartography assumes the responsibility of establishing and maintaining horizontal and vertical geodetic networks and national mapping as well.

National services of ANCFCC ensure each cadastral survey dataset complies with the rules before approving it and then integrating it into the cadastral network system. This cadastral system is connected to the geodetic network which serves as an infrastructure for cadastral surveys.

Cadastral surveyors in Morocco already utilize digital advanced technologies when undertaking their surveys, such as GNSS (*Global Navigation Satellite Systems*), total stations and laser scanning systems, for acquiring the limits of properties with a high accuracy. However, the current system lacks a

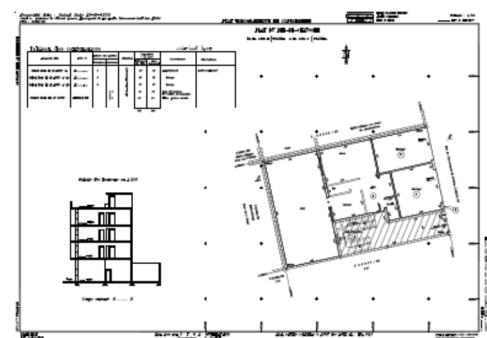
digital platform for surveyors to submit all surveyed properties in an integrated system based on a specific format or standard to allow interoperability in sharing and reusing data.

In Morocco, the cadastre is the basis for land registration. It includes geometric description of land parcels so as to provide security of tenure. The basic elements of 2D Moroccan cadastre are cadastral maps, cadastral plans, land titles, and requisitions. The actual cadastre in Morocco is basically 2D. For each property, the cadastral system provides information on owners and their land properties, information about the rights and charges, the location of the property in terms of spatial coordinates and other spatial attributes.

In the case of buildings, the dimensional information is provided by what is known as the co-ownership (co-properties). In a co-ownership, apartments of a building are owned by several owners, each one has his rating share, and all of them share some common areas within the building. In such case, a building is divided into private and public parts. Each owner holds one or more apartments, on which he has exclusive rights of ownership with certain restrictions such as the requirements to respect the framework of collective life and the requirements for the management and maintenance of common parts. The information about co-ownership is described by 2D topographical plans (Fig. 3) of each floor. Such a representation doesn't allow obtaining information about above and below each apartment. In addition, these 2D plans do not allow a global view of the entire property. Therefore, it is impossible to know the vertical extent of servitudes. Furthermore, we cannot visualize several apartments at a time, and therefore, there is not a way to

represent all the parts constituting a co-ownership using a cadastral plan.

All these difficulties make it necessary for the managers of the Moroccan cadastre to think about a 3D cadastral solution to enable the representation of the physical reality. Such a solution will permit administration to efficiently handle land registration system and will permit owners to know precisely the location of their parcels and which physical objects or property rights that cross their properties.



**Fig. 3. An example of a plan in co-ownership**

## **5.2. A 3D cadastre in Morocco: Some reflections**

As it has been stated before, three approaches can be adopted for migrating to a 3D cadastre: a full 3D cadastre, a 2D cadastre with 3D tags or a hybrid solution. The adoption of each of these solutions depends on the context of the actual cadastre, the complexity of land property and also on the requirement in terms of cost. It is important to realize that a 3D cadastre solution always depends on a specific context and is driven by user needs, land market requirements, the legal framework, and technical possibilities (Van Oosterom, 2013). We argue that a positive benefit/cost balance for using a 3D cadastre is

crucial and should be taken into consideration.

A Full digital representation of 3D property could be the adequate one to represent the 3D reality of cadastre. It permits a veritable 3D representation of parcels in a consistent way and will enable digital verification techniques (e.g., clash detection for 3D boundaries) (Gulliver et al. 2017) such as 3D visualization tools which give the opportunity to significantly improve the quality and interpretation of 3D cadastral survey datasets and the digital models they contain. Some 3D functionalities can be developed to allow 3D queries and spatial analysis which are essential for land administration and urban planning. In the “3D tag” solution, real rights to real estate are always established and registered on 2D parcels. However, the notification of the existence of a 3D situation can be added to the registration by registering a 3D tag on the parcel (Stoter, 2004). This solution consists of just tagging 3D situations in the cadastral registration where a 3D situation is represented, to permit to the user to consult the attached documents and access to the detailed information. Hence, a 2D cadastre with 3D tags is not really a veritable 3D solution because it is limited in terms of modeling and 3D data querying.

Regarding the limit of the 3D tag solution and the technical and economic exigency of the full 3D cadastre solution, we support the idea that a hybrid cadastre is an optimal solution that can be adopted by several countries and it would be optimal for the Moroccan context. Indeed, in many situations, a 2D representation can be sufficient to deal with parcels and to make queries in 2D GIS. While in other cases, where the property is more complex, a 3D representation is needed (Semlali et al. 2015):

- In the case of co ownership where several owners share the same the 2D area and share common parts within the building.

- In the case of buildings constructed vertically above a public property (Fig.1).

For the Moroccan case, we think that the choice of properties to be represented in 3D space depends on their nature and their consistence (parcel with constructions, co-ownership buildings, etc). The parcel should remain the basic element of the registration. The public domain rights can be represented in 3D such as runways, trails, irrigation canals, etc. Also, servitudes established for public benefits and regulated by the law, can be represented by 3D.

In the case of co-ownership, present in urban areas, a 3D cadastre will facilitate the understanding of the components of the property and will allow users and professionals to visualize common areas and private parts of any building. Rural areas are characterized by scattered parcels and habitats. High constructions are absent, overlays don't exist and private ownership is dominant. In this case, a 2D representation is satisfactory.

Besides these considerations, we should note that cadastral and cartographic organizations have spent too much time and money to build 2D topographic inventories with rich geometric and semantic information. Capitalization and reuse of this information, in order to inherit knowledge associated to 2D cadastral data, is a promising solution to reach basic requirements of a 3D cadastre. In other words, a 3D cadastral model can be established from existing 2D/2.5D data through a process of information integration and data reengineering.

According to the specificities of the context of 3D cadastre, a step wise methodology is

required to adopt a 3D cadastral solution. An evolutive method would be benefit to alleviate the complexity of 3D modeling and to integrate existent cadastral information to construct a first prototype of the 3D cadastre. This will ensure consistencies between actual 2D cadastre and a future 3D system and gradually evolve to a future integrated 3D solution.

## **CONCLUSION**

3D cadastre is an efficient solution for modeling and representing properties in 3D space.

It permits a good representation of complex urban areas where properties are vertical (case of ownership). So, a 3D cadastre is an optimal tool for land governance and urban planning.

In this paper, we have discussed the concept of 3D cadastre and its different solutions. We highlighted the challenge of investigation of this solution. Then, we approached the case of Morocco by presenting the actual cadastral system and some reflections to migrate to a 3D solution.

We note that more investigations are needed to deal with organizational, conceptual and technical issues.

## **7. REFERENCES**

- Breunig, M.; & Zlatanova, S. (2011). 3D geo-database research: Retrospective and future directions. *Computers & Geosciences*, 37(7), 791-803.
- Choon, TL & Seng, L.K (2013). Malaysia Towards Malaysian Multipurpose 3D Cadastre base on Land Administration Domain Model (LADM)-An Empirical Study International FIG workshop on the Land Administration Domain Model 24-25 September, Kuala Lumpur, Malaysia
- Gulliver, T. et al., (2017). A 3D Digital Cadastre for New Zealand and the International Opportunity.
- Guo, R.; Luo F.;Zhao,Z. Biao He, B; , Lin Li, Ping Luo & Ying, S. (2014); The Applications and Practices of 3D Cadastre in Shenzhen, 4th International Workshop on 3D Cadastres, Dubai, United Arab Emirates
- Hajji, R., & Billen, R. (2016). Collaborative 3D Modeling: Conceptual and Technical Issues. *International Journal of 3-D Information Modeling (IJ3DIM)*, 5(3), 47-67.
- Hassan, M. I., Ahmad-Nasruddin, M. H., Yaakop, I. A., & Abdul-Rahman, A. (2008). An integrated 3D cadastre-Malaysia as an example. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 37(B4), 121-26.
- Koeva, M. I. L. A., & Elberink, S. O. (2016). Challenges for updating 3D cadastral objects using LiDAR and image-based point clouds. In *Proceedings of the 5th International FIG 3D Cadastre Workshop*.
- Paulsson, J. (2007). 3D property rights: an analysis of key factors based on international experience (Doctoral dissertation, KTH).
- Robles-Ortega, M. D., Ortega, L., & Feito, F. R. (2012). Design of Topologically Structured Geo-database for Interactive Navigation and Exploration in 3D Web-Based Urban Information Systems. *Journal of Environmental Informatics*, 19(2).
- Semlali, E.H; Hajji, R; Benijjane, H & En-Nasiry, B. (2015). State of the Art of 2D cadastre and reflection on a future 3D Cadastre Case of Morocco WCS-CE - The World Cadastre Summit, Congress & Exhibition Istanbul, Turkey.

- Stoter, J., & Salzmann, M. (2003). Towards a 3D cadastre: where do cadastral needs and technical possibilities meet? *Computers, environment and urban systems*, 27(4), 395-410.
- Van Oosterom, P. (2013). Research and development in 3D cadastres.  
Kitsakis et al. 2016

## **8. ADDITIONAL READING**

- Stoter, J. E., & Van Oosterom, P. J. M. (2005). Technological aspects of a full 3D cadastral registration. *International Journal of Geographical Information Science*, 19(6), 669-696.
- Döner, F., Thompson, R., Stoter, J., Lemmen, C., Ploeger, H., van Oosterom, P., & Zlatanova, S. (2010). 4D cadastres: First analysis of legal, organizational, and technical impact—With a case study on utility networks. *Land Use Policy*, 27(4), 1068-1081.

## **9. KEY TERMS AND DEFINITIONS**

**Land Governance:** concerns the rules, processes and structures to be applied to land use for efficient planning and decisions.

**Cadastre:** a system of registration of properties and rights.