State of the Art of 2D Cadastre and Reflection on a Future 3D Cadastre Case of Morocco

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SUMMARY

Nowadays, the representation of 3D objects takes more and more importance in the treatment of geographic information. Geographic Information Systems (GIS) can integrate three-dimensional data in the fields of urban planning, simulation of future projects and integration into the landscape, etc. Consequently, the 3D data has become an interactive data of great importance.

In the Moroccan cadastre, information is represented using only 2D topographical plans. These plans do not allow a faithful presentation of reality, especially in the case of buildings with complex geometry, containing apartments belonging to several owners.
The objective of this paper is to present the state of the art of the Moroccan cadastre and make a reflection on a 3D cadastre based on previous international experiences, while maintaining the positive aspects of 2D cadastre.

In the Moroccan context, any building, whose ownership is split between several owners in batches, sharing common elements, constitute what is called co-ownership (coproperty).
A co-ownership is managed using the 2D topographic plan, but this representation does not allow a comprehensive view of the entire property. In addition, the co-ownership cannot represent 3D rights, restrictions and responsibilities related to the ownership because the vertical information exists only in vertical sections. For this reason, it is encouraged to think about a 3D cadastre which should represent both the reality and the legal value.
Based on international experiences, in the case of Morocco it is recommended to adopt a hybrid cadastre for the following areas:

- Urban areas with high density population and where there exists, multi-rise buildings
- In areas where there is an overlay between public property such as roads, bridges, monuments, high buildings and private properties.

However, the application of a 3D cadastre in Morocco is subject to several constraints. Among which we can mention:

- Technical and human resources constraints.
- Legislative constraints.
- Scientific Constraints.

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1. INTRODUCTION

Since the early 90s, the need for 3D information has become important for the users of geographic information. This three-dimensional information demand is due to the evolution of data acquisition techniques and to the evolution of software products supporting the third dimension. Hence, 3D has known a great success and rapid development; consequently this rapid progress has made the 2D representation insufficient in several domains.
In the Moroccan cadastre, information is represented using only 2D topographical plans. These plans do not allow a faithful presentation of reality, especially in the case of buildings with complex geometry containing apartments belonging to several owners.
The objective of this paper is to present the state of the art of the Moroccan cadastre and make a reflection on a 3D cadastre based on previous international experiences, while maintaining the positive aspects of 2D cadastre.

2. BASIC CONCEPTS ON THREE DIMENSION REPRESENTATION (3D)

At the beginning of this article, it is essential to review some basic concepts on 3D in literature. Depending on the context, the terms "3D dimension" and “3D shape” can get different definitions.
The 3D shape is defined by ESRI as follows: " A three-dimensional shape is : A point, line, or polygon that stores x, y, and z coordinates as part of its geometry. A point has one set of z coordinates; lines and polygons have z coordinates for each vertex" (Larrivée et al., 2002).
In 3D literature, object dimensions are related to the number of axes (or coordinates) required for positioning the objects with respect to each other’s. Thus, spatial dimensions of an object represent the space occupied by the object in the three directions of measurement that are length, width and height. We talk about linear object of one dimension (1D), a surface object of two-dimension (2D) and a volumetric object of three-dimension (3D), that is length, width and height 3D (Larrivée et al., 2002).

3. THE EVOLUTION OF 3D CONCEPTS

The development of 3D has evolved rapidly during the last years. The first step towards the third dimension was to add to each pair of coordinates (X, Y) a Z altitude recorded as a simple attribute. The main limitation of this type of approach is to allow only one Z value anywhere in the represented geographical area (Ramos, 2003). These systems have been designated by the 2.5D solution.

After that there was the 2.75D solution, which provides templates to store two different altitudes (minimum altitude and maximum altitude) for the same pair of (X, Y) coordinates. However, this solution was inadequate in the case of the representation of complex objects (Ramos, 2003).

Then, with the evolution of computer tools, researches on the concepts of 3D have increased. There were several developments of solutions including guidelines to 3D for the representation of geospatial data. An increasing need for 3D was observed in several areas, such as in urban planning, land management and cadastre.

4. USEFULNESS OF 3D CADASTRE

Considering the fast world population expansion, the use of land became of great necessity, and such necessity requires precise and reliable description of land ownership. 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, with laminated property rights in the basement and ground floors, the 2D traditional cadastre became very limited, and will no longer be able to accurately describe the spatial information rights in the third dimension (Adrien, 2010).
For instance, in the case of a road, a bridge and a building one over the other, 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.

5. CATEGORIES OF 3D CADASTRE

A 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. Land use and groundwater can be described and analyzed as well (Papaefthymiou et al., 2004). Paulsson (2007) defined the 3D property as follows: "It is a property that is legally defined both vertically and horizontally."
Adrien (2010) in his research identifies three main categories of the 3D cadastre. In the following paragraphs, we will give a brief description of each category.

The 2D Cadastre with 3D Markers: 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 owner 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.

The Hybrid Cadastre: 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:

- 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.
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The Pure 3D Cadastre: This kind of cadastre contains only volumetric parcels without holes or overlaps. Property rights are defined and attached to volumetric 3D parcels.

6. OVERVIEW OF THE MOROCCAN 2D CADASTRE

The cadastre permits to have all information concerning the quality of owners, the properties, and the elements of assessment of goods. Therefore the cadastre provides the following data: information on owners and their land properties, information about the rights and charges, and any technical data on the parcels and their geographical repartition.
In Morocco, 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. The basic elements of 2D Moroccan cadastre are cadastral maps, cadastral plans, Titles, and requisitions.
Concerning 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 people, each one has his rating share, and all people are sharing out common areas within the building.
The status of a co-ownership is governed by texts of the Moroccan law setting for each owner the rights of his part as well as the public facilities and services. In such case, a building is divided into parts: private and public. 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 collective life and the requirements for the management and maintenance of collective parts (Loi 18-00).

7. THE INSUFFICIENCIES OF THE CO-OWNERSHIP IN MOROCCAN 2D CADASTRE

The information about co-ownership is described by 2D topographical plans, which means that we cannot know what is above and what is below a floor. 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 (figures 1 & 2).
Similarly, we cannot consult several apartments at a time, as it is necessary to manually search the title in the archive because of the absence of an automatic link. Therefore, it is difficult 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 solution to enable the representation of the physical reality. A cadastre that would

allow owners to know precisely what element crosses their properties taking into account the legal values.

8. THE ADMINISTRATION RESPONSIBLE FOR THE CADASTRE IN MOROCCO

In Morocco, the main administration responsible for the management of all cadastral operations is The National Agency of Land registration, Cadastre and Cartography (ANCFCC). It was established 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.
ANCFCC is a public organism responsible for land registration and land titling. It is structured in several Directions, Departments and Services around the kingdom. 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 horizontal and vertical geodetic networks and mapping as well.
In the following we present an overall of the achievements of this agency since 1915 (ANCFCC, 2013):

- In land registration and cadastre
  - 4,004,363 established land titles.
  - 9,911,615 hectares covered by registration.
  - 9,911,615 ha bounded and surveyed.

- In the field of Cartography
  - 100% of the country covered by mapping at scales of 1/100000 and 1/250000.
  - 44% of the country covered by mapping at scale 1/50000.
  - 81% of developing areas requiring large-scale mapping, covered by maps at scale 1/25000.
  - 82 maps established for big cities.
  - 40 000 geodetic points, materialized by signals and surveyed
  - 8968 benchmarks of precise leveling established covering 13,400 Km.
  - 15 permanent GPS stations.
  -

9. REFLECTION ON A FUTURE 3D CADASTRE IN MOROCCO

In this reflection, it is suggested to establish 3D cadastre only in the situation where 2D is not able to respond to some queries such as for the following cases (Benijjane & En-nassiry, 2011) :

- For a building containing several apartments, these apartments belong to several owners that share common parts within the building.
- In the case a home is built upon a public road.
- In the case some companies need to know their rights on the use of tunnels.

In order to preserve the existing data, and exploit the benefits of 2D cadastre, we suggest moving gradually from 2D to a 3D cadastre.
For the Moroccan case, there is no need to represent all the properties in 3D, as it depends on the size, the type and the nature of the property to be described (parcel with constructions, home with one or several levels, buildings,...).

9.1 Concepts About Future 3D Cadastre Components

In order to conserve the functioning of the existing Moroccan legislation, land registration and cadastre, it is recommended that the parcel should remain the basic element of the registration, and that the 2D parcels should be kept at the medium term.
The public domain rights can be represented in 3D, like the rights of the public domain on private property such as runways, trails, drainage and irrigation canals.
Servitudes established for public benefits and regulated by the law, can be represented by 3D.
In the case of co-ownership, a 3D cadastre will facilitate understanding the components of the property and will allow users and professionals to understand and visualize common areas and private parts of any building.

In the case of urban areas: It is recommended to use the 3D representation in the urban areas where the geographical space is not spacious, constraining the government to construct complex buildings with several floors. In this type of areas there is a large number of properties. Apartments are characterized by small areas and are grouped together on condensed areas with high population density. In some cases we can also find overlays between public properties such as roads, bridges, buildings, and private properties.

In the case of rural areas: 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 because the third dimension necessitates additional financial resources.

9.2 Basic Strategies To Move To 3D Cadastre

The first step is to make a 3D support for areas with high buildings. This is the case in the big towns such as the city of Rabat (for example the districts of Agdal and Ryad), the city of Casablanca metropolis, the cities of Tangier, Marrakech, Fès and Agadir. In these towns, the existing 2D database can be used and completed by 3D data.
In order to meet the needs of professionals and public sector as well, it is very useful to provide users with the information on the extent of land ownership and the rights attached to it. So as to accomplish this task, it is suggested that if 3D cadastre is to be adopted in Morocco, it must provide proof of 3D property and the rights encumbering the ownership.

10. CONCLUSION

In this paper, we have discussed some aspects of 3D concepts. Firstly, we have introduced the state of the art of 3D concepts. Secondly, we have presented an overview of 2D cadastre in Morocco. Finally, we have described some concepts of a future 3D cadastre in Morocco.
Nowadays the need for a 3D cadastre has increased especially for urban areas with the development of multipart constructions. Unfortunately, the implementation of a 3D cadastre in Morocco is subject to several constraints such as technical, legislative, scientific, and human and material resources constraints.
Technical constraints: It is needed to pursue developments in 3D acquisition techniques (in the domain of digital photogrammetry, 3D laser scanning, GNSS ...). Regarding data processing, it will be necessary to establish an adequate 3D platform for 3D objects (complex buildings, overlaid properties) and a database which supports the third Dimension.
Legal constraints are related to problems concerning the registration of 3D property. The legal concepts should be developed in parallel with the technical aspects.
Scientifically: a great effort should be made to clarify to professionals and managers the advantages and qualities of 3D representation.
Concerning material resources constraints: the relevant departments and professionals should provide adequate scientific equipment (hardware, processors, 3D cards ...), and follow the evolution of software products supporting the third dimension. Additionally, human resources do need some training to understand 3D technology and its application to the Moroccan cadastre.

Finally, limited budgets can also obstruct the adoption of 3D representation; a great effort must be made with decision makers to convince them to adhere to the adoption of 3D technology in the Moroccan cadastre. All these constraints constitute a major obstacle to developing and moving to a 3D cadastre.

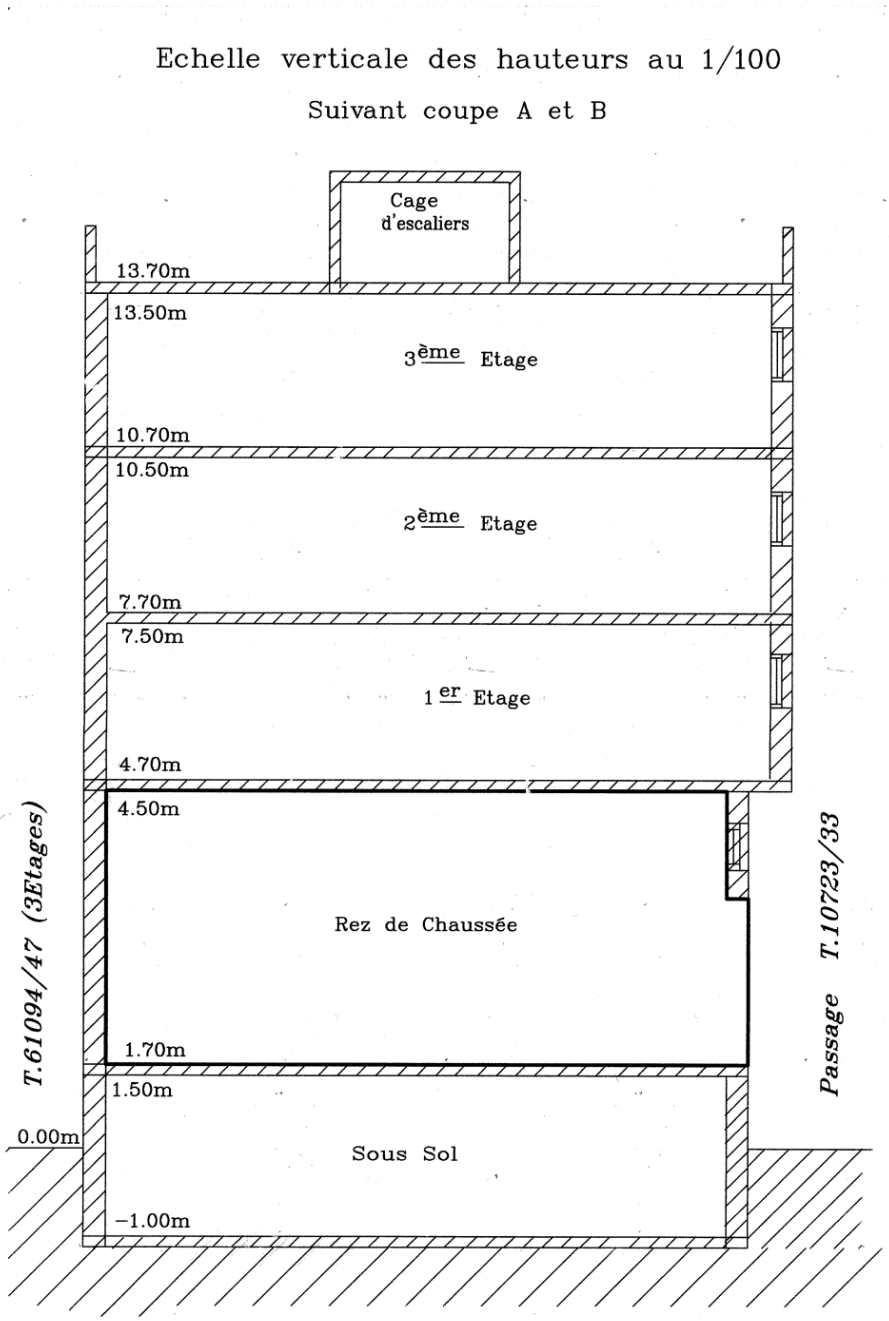

Fig. 1. Example of a co-ownership cadastral plan (vertical sections)

Fig. 2. Example of a co-ownership cadastral plan (ground floor)

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