Case study on the 3D Cadastre in Algeria:
First application of the FIG Recommendations

Mohamed Akram SEDDIKI, ALGERIA

Key words: Urban Cadastre Mapping, 3D Cadastre in Algeria, 3D Representation of Properties.

SUMMARY

The Three-dimensional representation has become in recent years a real decision-making tool in urban and planning. However, analysis of the results proved not so simple, and many questions about the feasibility and usefulness of spatial 3D representation of the physical or legal objects as well as the various solutions already are being used demonstration. The implementation of a GIS for the analysis and management of 3D cadastre data is a complex task that requires careful examination of the data, define pretreatments to be performed for each type of data before integration, the required quality, modeling logic and results. This work defined an approach to the study of a case applied to Oran city (west of Algeria) which includes four main phases:

- Design of a cadastral database;
- Acquisition, restructuring and integration of complementary external data;
- Analysis and management of 3D cadastre database;
- Example of the use of the 3D cadastre in property valuation.

RESUME

La représentation tridimensionnelle est devenue en quelques années un réel outil décisionnaire en matière d'urbanisme et d'aménagement du territoire. Cependant, l'analyse des résultats s'est révélée moins simple que prévu et de nombreuses questions quant à la faisabilité et l'utilité d'une représentation spatiale en 3D des objets physiques ou légaux ainsi que sur les diverses solutions déjà utilisées restent en cours de démonstration. La mise en place d'un SIG pour l'analyse et la gestion des données du cadastre 3D est un travail complexe qui nécessite un examen minutieux des données, de définir les prétraitements à effectuer pour chaque type de données avant son intégration, la qualité exigée, la logique de modélisation et les résultats à atteindre. Ce travail défini une démarche pour l'étude d'un cas appliquée sur un quartier dans la wilaya d'Oran (ouest d'Algérie) qui comprend quatre principales phases:

- Conception d'une base de données cadastrale;
- Acquisition, restructuration et intégration des données exogènes complémentaires;
- Analyse et gestion de la base de données cadastre 3D;
- Exploitation de l'information du cadastre 3D en évaluation immobilière.

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1.   INTRODUCTION

The problems encountered practically in urban areas, reported by cadastre engineers at several departments in Algeria are multiple. Generally, they are related to:

- *Production of graphic cadastral documentation*
  The urban environment is complex, it is characterized by the presence of small objects (house, tree, isolated, roads, narrow street, garden ...) the heterogeneity of the information in this dense environment required to produce consistent treatment to work on images of high spatial level.
- *Land investigations*
  The concentration of population and density in urban areas increases the number of land transfers.
- *Overlay properties*
  Examine the relevance of detailed representations to scale condominium lots, and even volume, and in a context of land management: property valuation, issuance of building permits, the planning and development (relocation of population).

The specific objectives of our work are to:

- Refer to the uses and knowledge of methods, models and tools for the development of a 3D cadastre, integrating internal data from the real estate survey and demarcation, and external data returned from partner organizations cadastre.
- Implement GIS and finding appropriate solutions to the establishment of cadastral maps with a consistent spatial representation (block boundaries), identifying their owners and determining the legal nature. In other words, it is the implementation of a 3D -GIS cadastre that takes into account the building volume and the changes associated with each floor plan.

2.   METHODOLOGICAL APPROACH

The approach developed as part of this work includes four phases (1. cadastral database, 2. integration of complementary external data, 3. Analysis and management of 3D cadastre database, 4. Use of the 3D cadastre in property valuation). The approach is described in the chart below (Figure 1).
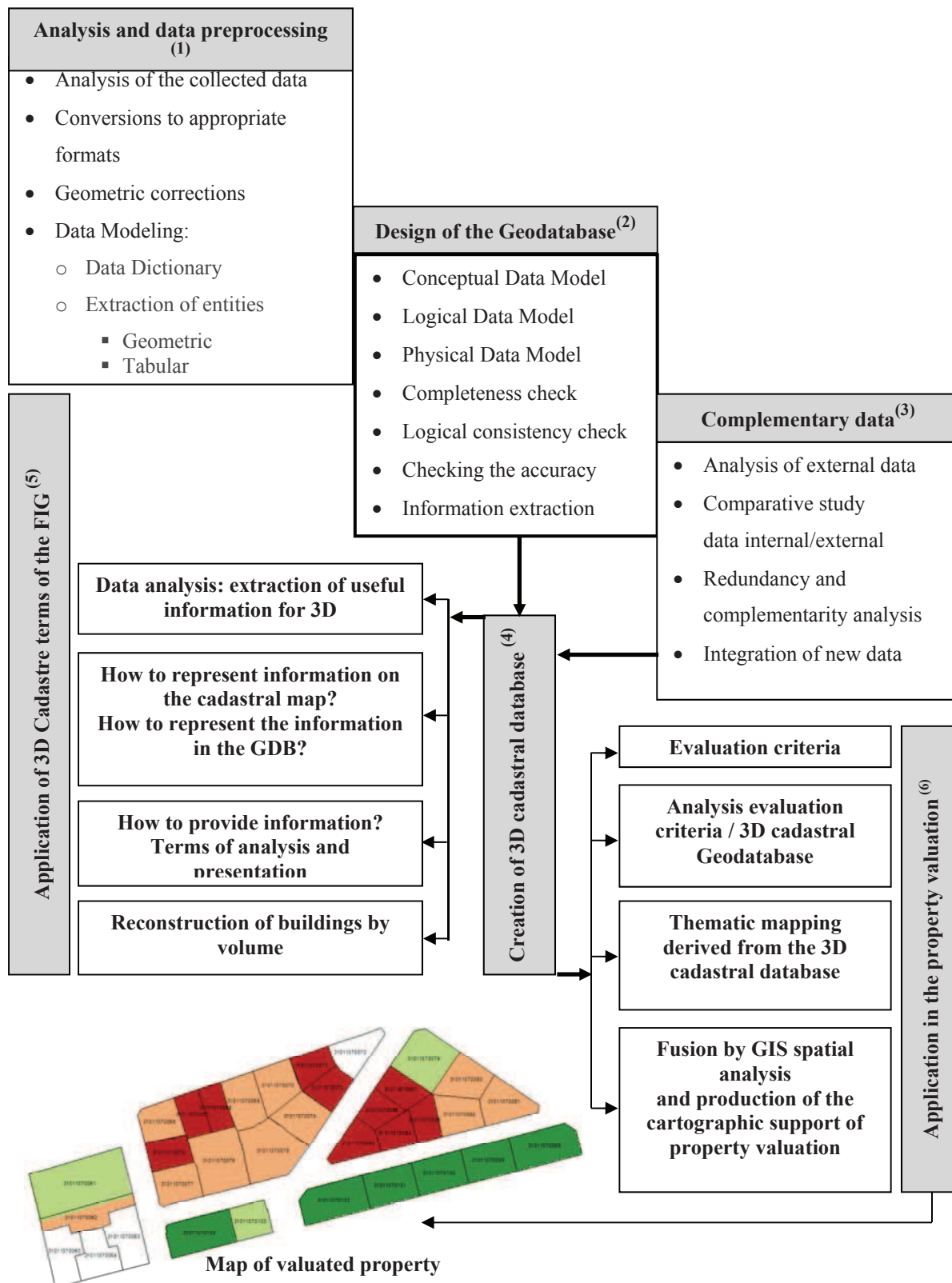
Figure 1. Methodological approach developed for the implementation of 3D cadastre GIS

3.   STUDY ZONE

Oran great Mediterranean metropolis, the capital of western Algeria, has several advantages for its coastal location, airport and relationships as it generates to Europe than to the Maghreb. It is a half hour flight from Alicante Spanish port facing it and an hour from Barcelona and Marseille. It is a strategic position; it is an attraction pole of Tunisia, Morocco, Europe and Africa.

In the case of our study, we chose a case in the city center of Oran where the integration of the third dimension to be able to represent the superposition of the properties that is not supported in the cadastral maps.

This property lies along the rue Larbi Ben M'hidi which is a section of a major axis of the city center, punctuated by several public places, including the 'place Hoche' and 'Place des Victoires'. From this primary axis branch off secondary roads, which carry tertiary axes. In the city center, primary roads distribute traffic and lead public transport within urban structure.
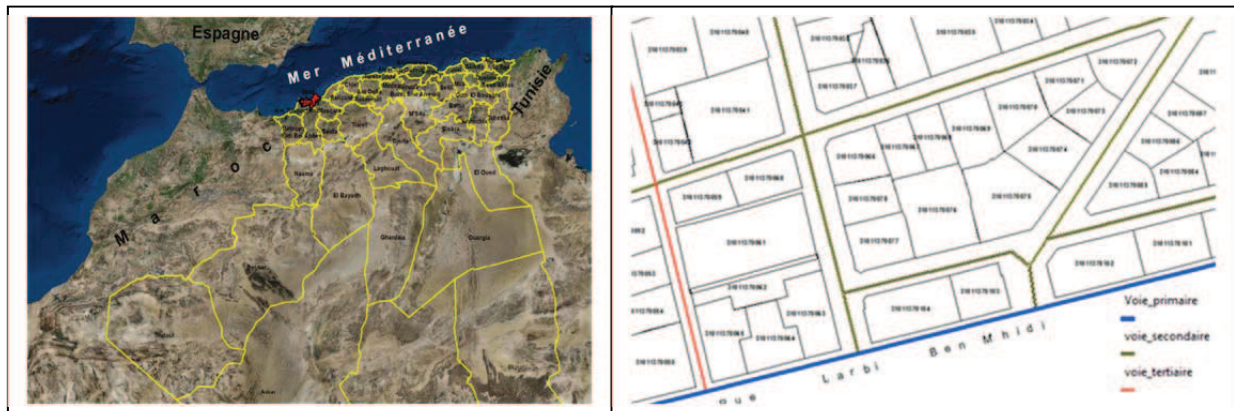

Figure 2. Location of the study area (Satellite Image: Google -earth source)

The buildings are aligned street, occupy most of the plots. They amount to three to five levels, their architecture is neo -classical, European-inspired, using columns, pilasters and cornices

The cadastre is exclusively legal in Algeria since the onset of the 1975 instruction. This means that the cadastre must ensure delineation, consistency and allocation of land ownership or other real right of property.

Despite the wealth of information that has the cadastral plan (scale 1/1000 to 1/500), recognizing block boundaries shown on a map with real limits on land, reveals non - compliances related to heterogeneity structural built property.

The consultation cadastral records confirmed the presence of heterogeneity, by calculation of the area.

Example representation property parcels on cadastral plans sections 138 and 139

Problem of archway on the ground floor

Changes to the construction Structure

Remarkable structural heterogeneity

Changes caused by demolition

Figure 3. Example of differences between graphical representation of cadastral properties and their real forms

4. DATA USED

The data is retrieved from the Cadastre Service Directorate of the Wilaya of Oran in digital and paper format:
- Graphic documentation: are sections of plans that cover the neighborhood El Emir and neighboring districts.
- Documentation literal: the main land records of the urban environment, met during conduct of cadastral mapping operations.

We got two descriptive statements division of real property, prepared by the services of the National Estate and other established by land surveyors.

Table 1 below, classifies the data according to their usefulness for each phase of implement-tation of 3D GIS cadastre project.

Table 1. Phases applications and associated data

Acquired data	Project Phases			
	Design of the cadastral database	Integration of external data	Analyses of 3D cadastral Geodatabase	Application of property evaluation
Cadastral maps sections	✓	✗	✓	✓
Land records	✓	✗	✓	✓
Description State Division	✗	✓	✓	✓
Cadastral Geodatabase GIC	✗	✗	✗	✓

5. IMPLEMENTATION OF GIS FOR 3D CADASTRE

This phase requires first, analyze the data models related to the cadastral database created with the objective:
- Extraction of useful information for 3D cadastre representation;
- To check the possibility of identifying cases of figure 3D;
- Extraction of information to be added by integration of external data;
- To build the 3D cadastral database;
- Application of the terms of the recommendations of the FIG- 3D Cadastre.

5.1 Extracting useful information for the 3D cadastre
This step is to query the database for, firstly, extract useful information that can be used to understand the type of case 3D, and secondly, to determine the number of existing cases, cadastral section.

Two types of motion can tell us about the information sought:
- The first distinguishes the islands condominium of other islands where the condition refers to the legal nature;
- The second allows to distinguish the islands condominium on cases of 3D cadastre, and other islands, where the condition is linked to automatic calculations of area (the sum of the area lots, common and private parts per floor must be equal to the total area of the island).
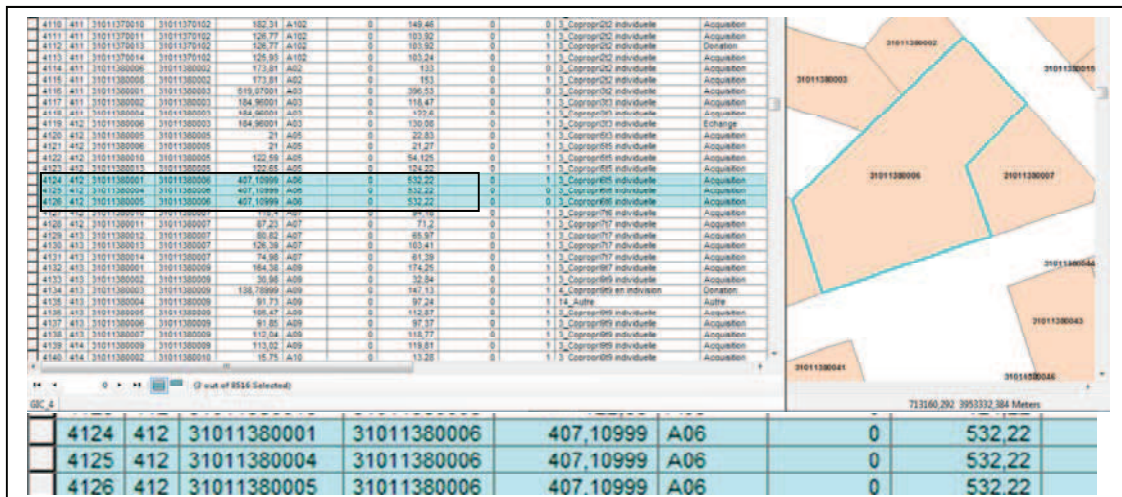

Figure 4. Example of automatic extraction of information about property is not the subject of 3D cadastre case of property number 6 of section 138
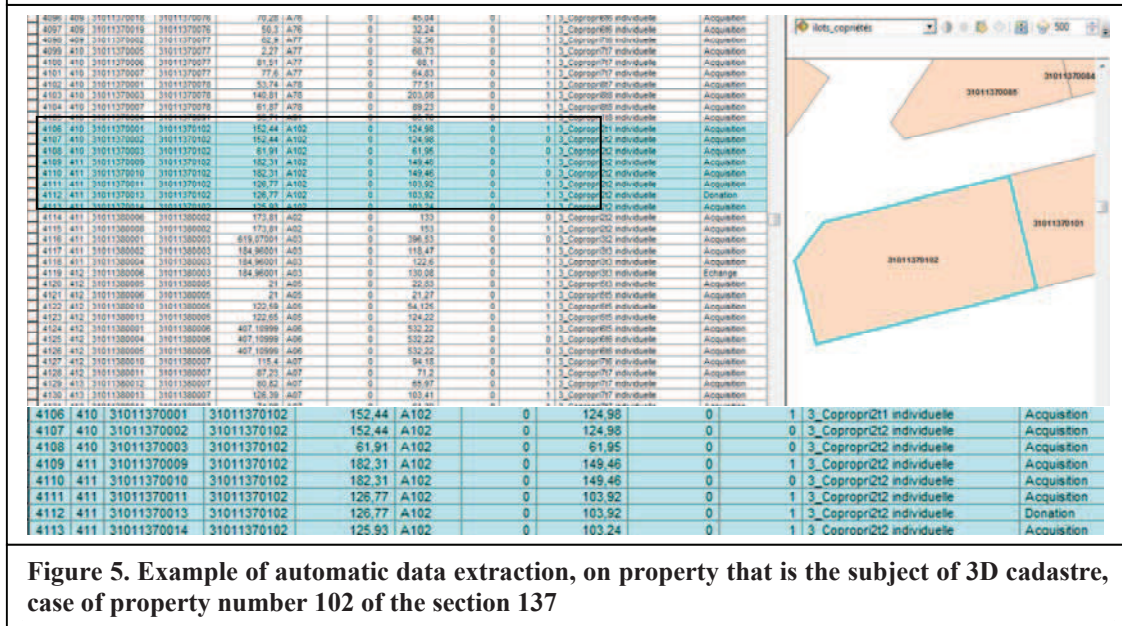

Figure 5. Example of automatic data extraction, on property that is the subject of 3D cadastre, case of property number 102 of the section 137

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Figure 6. Confirmation of information obtained by queries with real pictures, property 102 of the section 137
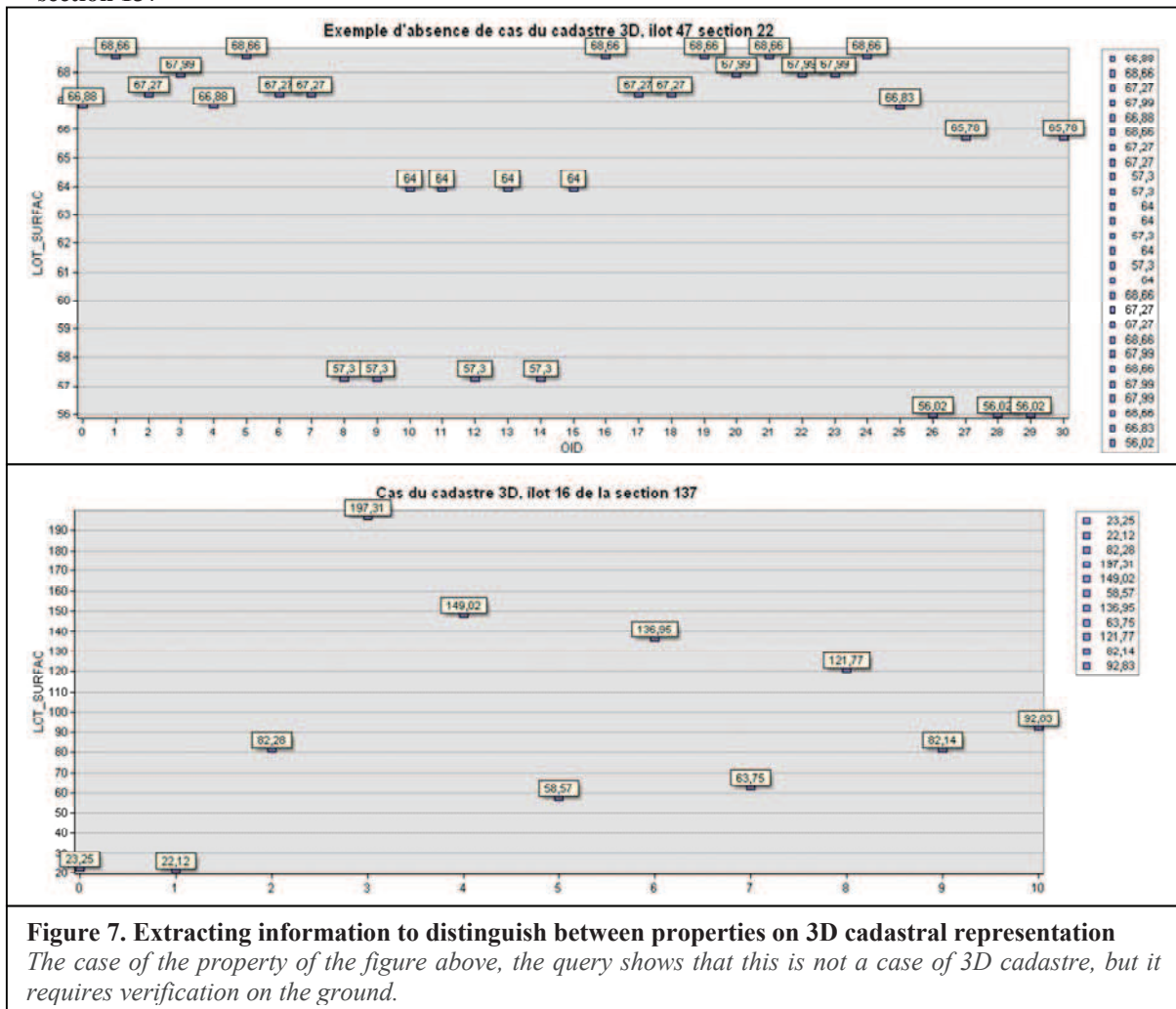

Figure 7. Extracting information to distinguish between properties on 3D cadastral representation
The case of the property of the figure above, the query shows that this is not a case of 3D cadastre, but it requires verification on the ground.

Querying the database allowed us to highlight the following:
- Always verify the information before judging the case study is that it concerns a 3D situation or not, the control must be carried out on land.
  For areas that are being cadastral Maps operations, we must mention the case by one of the solutions that will be presented in the next section.

- To reduce the work on land, we must solve the problem of insufficient graphic information of cadastral maps through integration of external data, the case in Algeria, descriptive statements division.

5.2 Integration of additional external data

To enrich the cadastral database designed, we analyzed the graphic content and literal of Descriptive Statements Division DSD established by land surveyors and by the department of state property.

The main differences are in the details on the scale, lot condominium real estate, including the designation of the lot and its composition by parts, the Official Gazette No. 14 of March 16, 2014 relates to the DSD regulations specify that information in descriptive tables of division.

The most important details to feed the database are the plans by stages where lots elements of description appear in parts.

Table 2. Summary table comparing the content of the cadastral documentation and descriptive statements division DSD established by the GEF Surveyors

Type of information	Cadastral documentation	Descriptive Statements Division
Designation boundaries origin of ownership of the land	✓	✓
Rules of management and administration of buildings or buildings group	✓	✓
Definitions and composition of private and common parts	✓	✓
Definition and composition of private parts	✗	✓
Technical characteristics of the property	✓	✓
Definition and composition of common areas	✗	✓
Setting share parts dimensions	✓	✓
The descriptive tables of devisions	✗	✓
Illustrative maps	✗	✓

Merging the two types of cadastral data and exogenous (DSD) gives birth to the cadastral Geodatabase 3D.

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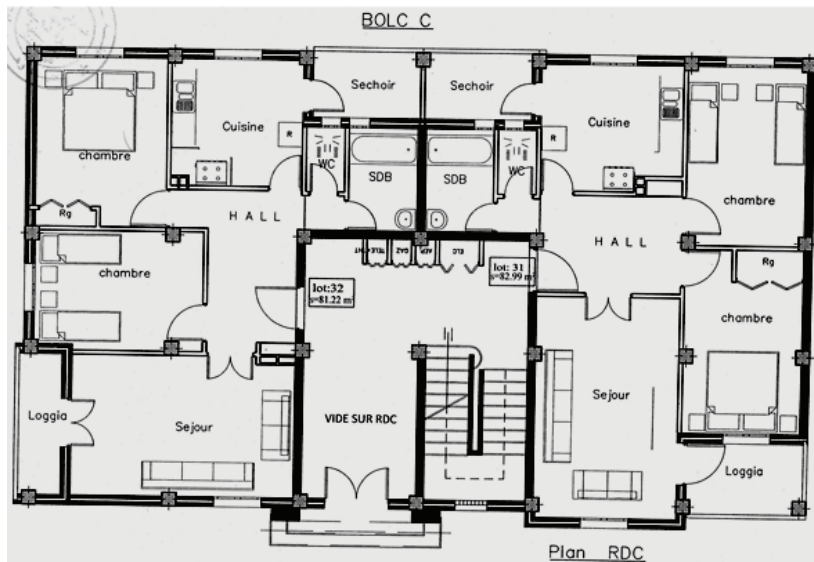18-20 October 2016, Athens, Greece

Figure 8. Example of an illustrative map floor with common areas

6.   USE OF 3D CADASTRAL GEODATABASE: FIG RECOMMENDATIONS

Our reasoning in the development of the database of 3D cadastre, takes into account the source of information on the presence of the cases, the graphic management style or attribute, and extraction techniques and updating information level property lot.
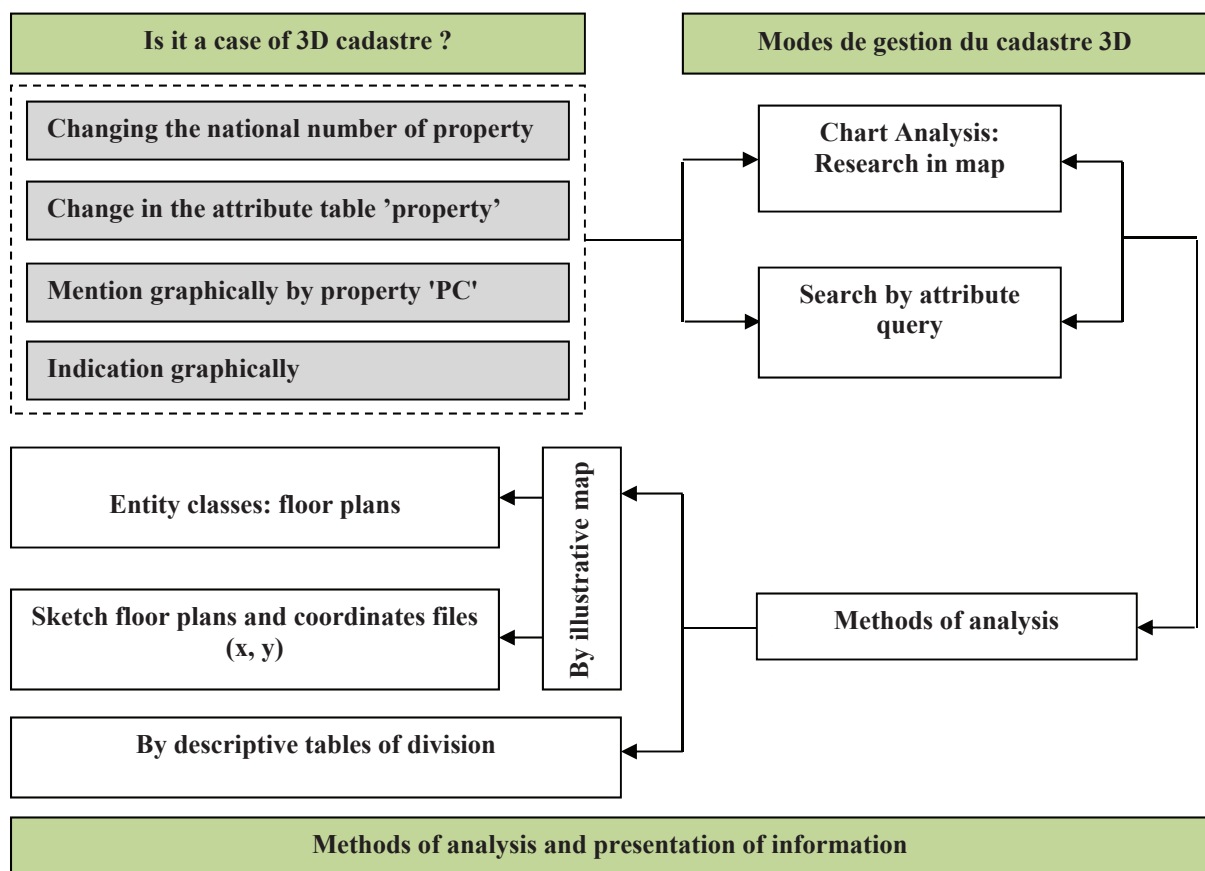

Figure 9. The 3D cadastre approach used

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6.1 Information on the presence of a 3D case

We studied three options for integrating information on the presence of condominium property subject of 3D cadastre:

- *Possibility of changing the national property number*: consists of 11 numbers for a specific designation.
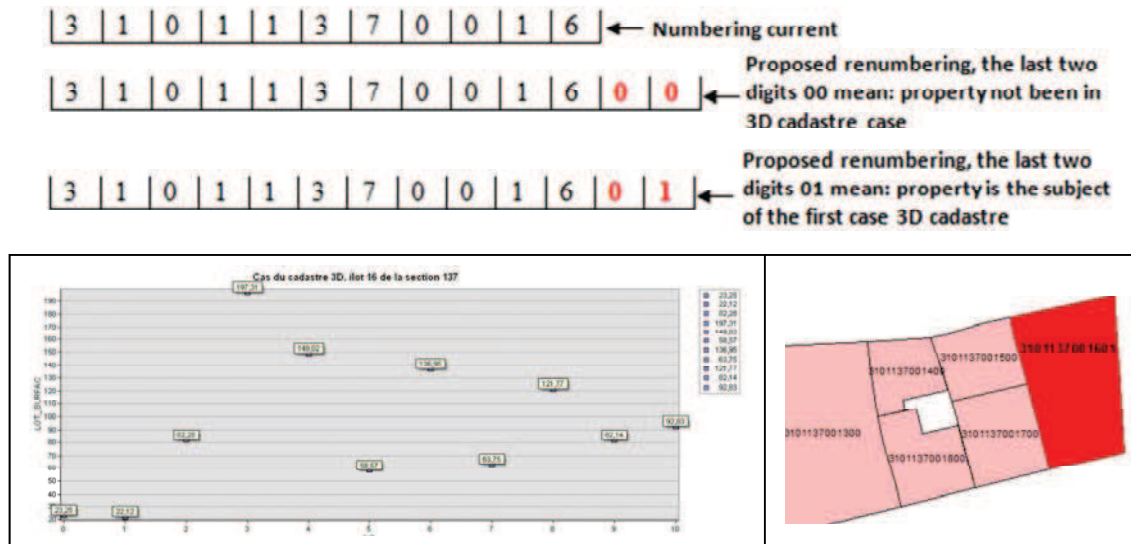

Figure 10. Renumbering allocation principle to identify the 3D cadastre case

- *Possibility to add the information in the attribute table of the entity 'property'*: the advantage here is speed for extracting information on the 3D cadastre, which is done through attribute query, provided that the table associated with the property entity, must have the column for the mention of the presence or absence of the 3D case.
- *Indication on the digital cadastral map*: we propose to mention the case by double labeling on the digital cadastral map, the first corresponds to the display of the property number according to existing numbering, and the second is the mention 'PC' inspired 3D cadastre Quebecers where PC stands for the Supplemental Plan.

  The introduction of this statement requires as the previous case, book a column in the attribute table. To avoid this situation, we propose a change in the thickness of the limits of the property. A visual enlargement that has no effect on the shape or surface of the block in question.

  The enlargement of the thickness does not produce a problem of changing the attribute data, you just create a new layer with the limits of the property concerned.

After tests and applications of all indication of 3D solutions presented above, we propose a joint solution that combines the second option of changing the attribute table and the digital cadastral map.

6.2 Modality of data 3D cadastre analysis

Three methods have been tested to meet these requirements:

- Keep the graphic content of the digital cadastral map without changes, with the introduction of information on floor in attribute tables.
- Create illustrative sketches by floor with attached file coordinates of the vertices;
- Create illustrative cadastral maps by floor.

Figure 11. Introduction detailed information per floor [first method]
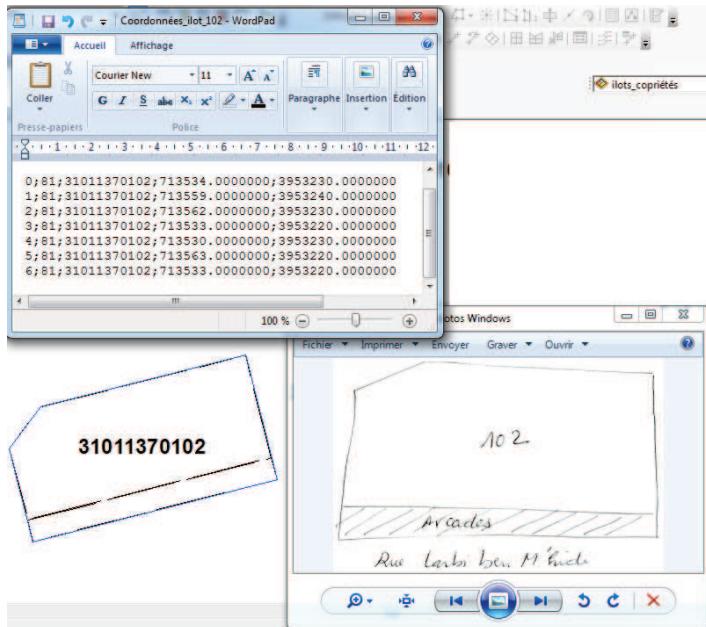

Figure 12. Ground floor map of the property 102 reproduced by use of ancillary information [second method]

Figure 13. Pictures of property selected for the application of the third method

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Figure 14. 3D reconstruction of property [third method]

7. USING GIS-3D CADASTRE ESTABLISHED IN PROPERTY VALUATION

Evaluate a property whatsoever, building land, agricultural land, property of individual housing, collective or business property is carefully calculate the market value from complete, at one time and given the real estate market.

According to the evaluation methods, internationally recognized, there are three major classes of criteria for the categorization of goods according to their degree of resemblance:

- *Location*: various parameters can increase or decrease the value of the property (distances from the center of the town, with basic equipment, various networks ...);
- *The area*: the property value is estimated by m^2, the evaluator should consider the areas of property, the volume surface concept is the factor key assessment to evaluate buildings.

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- *Configuration*: the geometry of buildings and their configuration makes the difference in sales prices of the property with same areas and same place. Two indices are to be calculated for this information:
  - Morphological complexity Index: This index is calculated by dividing the number of vertices of a polygon by its perimeter;
  - Compactness or elongation index: which is obtained by dividing the surface of a parcel by the square of its perimeter.

Classification properties according to their locations relative to the road network

2 **Class 3 represents the highest price**
3 **Class 2 represents the lowest price**

Classification of property according to morphological complexity index

1
2 **Class 4 represents the highest price**
3 **Class 1 represents the lowest price**
4

Classification of property according to index of elongation

1
2
3 **Class 4 represents the highest price**
4 **Class 1 represents the lowest price**

Classification properties according to their areas

4
5 **Class 6 represents the highest price**
6 **Class 4 represents the lowest price**

After creation of the four maps using the cadastral 3D Geodatabase, we applied a combination treatment by weighted spatial analysis, from which the process works by matrix calculation pixel by pixel.

Classification map of properties by combination of evaluation criteria Using the cadastral 3D Geodatabase

Class 8 represents the highest price
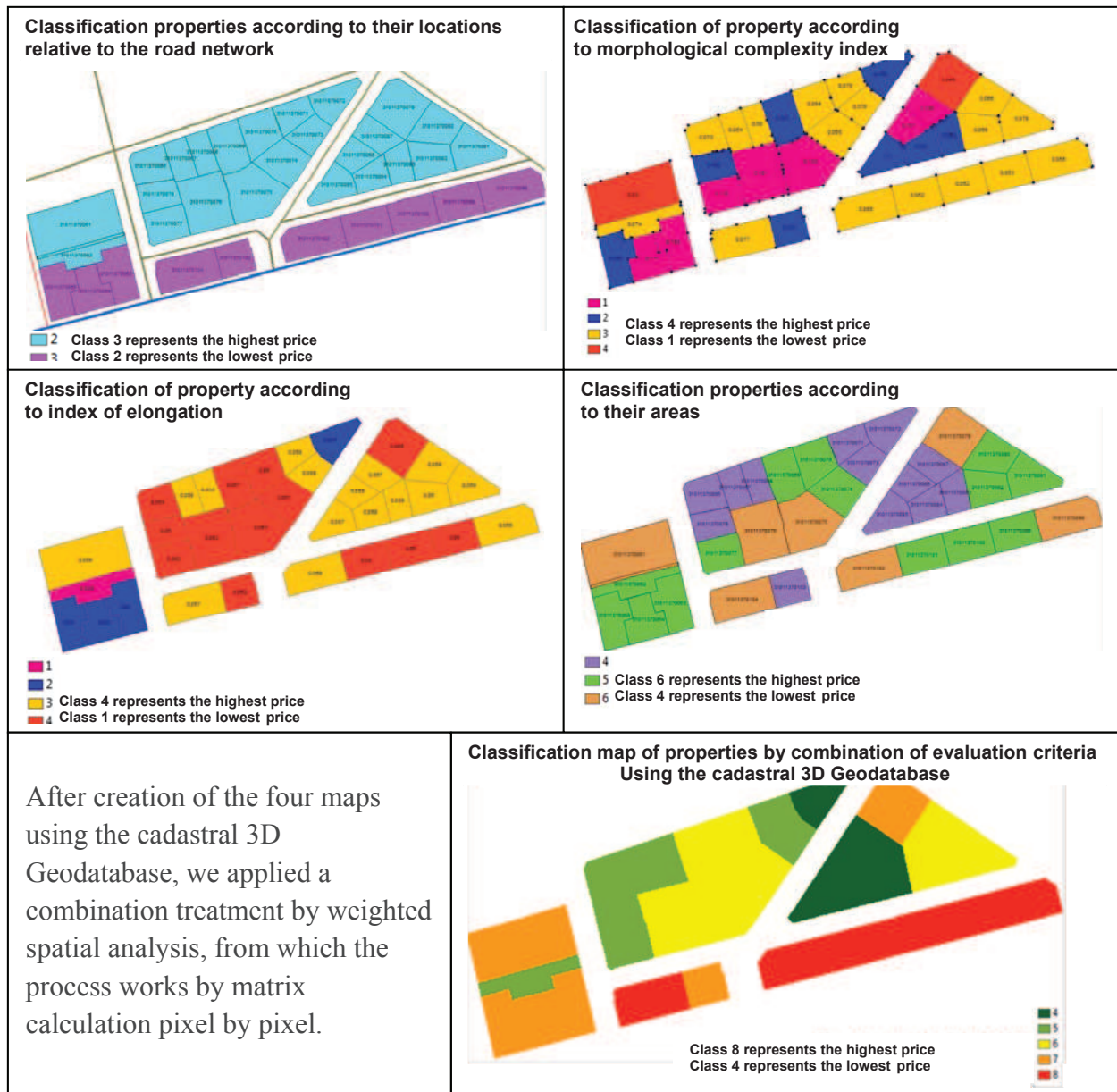**Class 4 represents the lowest price**

4
5
6
7
8

Figure 14. 3D reconstruction of property [third method]

8. CONCLUSION

In Algeria, the transition from a 2D to a 3D cadastre cadastre will, from an organizational point of view, bring a lot of changes in the instruction of the establishment of the general cadastre in urban areas.

From a technical standpoint, the graphic elements of the cadastral plan should exist as Vector and respond to a specific structure, it requires the implementation of a practical approach involving qualified personnel and equipment specially designed for have the best information as quickly as possible.

The contributions of the work done in this project, are multiple, it can be reference of 3D cadastre for handling cases of property with heterogeneous structures, provided they respect the technical and practical approach.

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BIOGRAPHICAL NOTES

Mohamed Akram Seddiki is a researcher in Department of spatial information system SIRS, in the Center of Space Technology CTS in Algeria. He obatained his surveyor diploma cadastral from the CTS in 2004 and a Master degree in space science and technology, optional Remote Sensing and GIS from the African Regional Centre for Space Science and Technology in French language CRASTE -LF in Rabat Morocco in 2010. He obtained also a Master degree in surveying science and technology from the University of Laghouat Algeria in 2015. He is also a teacher of aerial photogrammetry and digital cadastre in CTS since 2007. His research focuses on the integration of spatial imagery and the use of GIS for the establishment of a multipurpose cadastre.

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