A technical and policy tool for urban upgrading and affordable housing planning

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Key words: Affordable housing, 3D model, Land policy, Urban planning, Valuation

SUMMARY

In this paper, a technical tool developed according to international trends to support urban reforms through readjustment of property rights is presented. The proposed framework aims to achieve the "best use" of land and allow for urban upgrading and implementation of affordable housing scenarios without public funds. The model includes the following steps: creation of 3D cadastral map/tables of the area under study; estimation of the market values of the existing property rights; identification of vacant parcels or other that can be merged and redeveloped; increase of the building factor in the area; demolition of the selected old buildings; merging of parcels; construction of the new building(s); creation of the new cadastral map and redistribution of property rights to the old owners, the constructor and to the low-income target group. The concept of affordable housing supports social stability and ensures increased participation of the private sector, the property owners, the vulnerable groups and the citizens in general in the decision-making procedure, by supporting the development of voluntary urban regeneration procedures and by allowing the development of fair win-win solutions for the state, the private sector, the property owners and the low-income earners. The proposed framework can be used by government agencies, by a great variety of professionals of the private sector and by universities to develop knowledge and experience in the current trends of research. An application case study of urban regeneration and affordable housing provision in Greece is presented using the proposed methodology.

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1. INTRODUCTION

Although most countries have passed from centrally driven economies into the free market, there is still much confusion in the housing policies implemented by the various governments. Some countries have already developed affordable housing tools, while some others are still using conflicting land policies (e.g., social housing policies that severely affect property markets). The development of modern land tools that will fit within the international framework for the good governance of land and properties and will enable affordable housing is an interesting emerging topic for research. However, as there is a global understanding that the market alone cannot satisfy the need for adequate affordable housing, the latter should be addressed separately from general land development (Zorko, 2016).

In the updated International Federation of Surveyors (FIG) land management paradigm (Potsiou, 2015) it is emphasized that special tools and regulations should be developed, within the free market economy, in order to ensure the sustainable development goals. Given that the management responsibilities for preservation, ordinary and extraordinary repairs and maintenance that the properties require in order to maintain their economic function over time are expensive and that the state cannot afford them, in the free market economies social housing (in the sense that the state builds and owns the building) is no longer recommended. Instead, affordable housing tools should be globally investigated. What is more, many countries try to improve their cadastral systems by implementing research to add the third dimension (like some European cadastral agencies, for example the Dutch (Stoter et al., 2013) and the Spanish cadastre (García et al., 2011), and some other Asian cadastral agencies) in an effort to provide a tool for good decision-making to achieve the "best use" of the urban and serviced land and its extension and the further development of the property rights and their market in the third dimension. Some cadastral agencies even do further research for providing this information in various time periods (the fourth dimension) (Siejka et al., 2014) in order to facilitate the complex market needs and emerging requirements within urban areas. Also, some countries try to initiate formalization projects in order to integrate all the informal real estate (and informal urban settlements) into the property registration systems, clear out the property rights, formalize the property market and introduce planning systems in the already informally developed urban settlements, in order to avoid further urban sprawl and facilitate further 3D urban development.

The objective of this research is, within this international policy and research framework, to develope a technical tool that serves the need for current urban land reforms, especially through readjustment of property rights within urban areas, in an effort to achieve the "best use" of land and allow for energy saving improvements, better urban planning and planning for affordable housing provision. It should serve both public and private sectors (state authorities, municipalities and professionals) and be applicable in various geographical regions (e.g., both in developed and developing economies/markets and both in formal and informal urban settlements). It should serve various self-financed, small land management purposes, various land policies and land reforms (such as property registration projects in four dimensions, property valuation, planning and land readjustment as well as affordable housing provision) with voluntary participation of citizens, property owners and the private sector, with great transparency. In this paper, the methodology adopted for the development of the technical tool is presented, in terms of 3D modelling in various scales, valuation of properties and metadata enrichment as well as readjustment of property rights and provision of affordable housing. Finally, a case study for urban regeneration of a neighborhood in Greece is presented and the conclusions of our research are discussed.

2. METHODOLOGY

In this section, the proposed framework that may lead to the implementation of urban regeneration and affordable housing provision is described.

2.1 Creation of 3D Models in Various LoDs

A fundamental part of the proposed methodology is the 3D modelling of the existing buildings in various Levels of Detail (LoDs), as well as the 3D modelling of the new buildings, after the reform. Except for providing the essential 3D information for the compilation of a 3D cadastre, the complete 3D modelling of the existing situation is also essential for the identification of "unused or underused" private or public urban plots for the implementation of the urban regeneration process together with the affordable housing scenario. The concept of LoD not only facilitates and accelerates the efficient visualization of large scenes, but also provides models of various scales according to the requirements of the various users of a multi-purpose Land Information System (LIS). The proposed procedure for the creation of 3D models of buildings of the existing situation at various LoDs is illustrated in Figure 1. The differentiation of LoDs, as proposed by CityGML (Groger et al., 2012) and implemented by Ioannidis et al. (2015) and Ioannidis et al. (2016) is used.

For the generation of high accuracy 3D models of the existing situation, a combined use of aerial and terrestrial or low-altitude UAV oblique images along with Ground Control Points (GCPs) is necessary; conventional photogrammetric techniques (i.e., bundle adjustment and stereo plotting), using stereo pairs of aerial images, in combination with Structure from Motion (SfM) and Dense Image Matching (DIM) techniques, using overlapping terrestrial or UAV imagery, as proposed by Ioannidis et al. (2016), may be applied. The outputs of the aforementioned procedures can be used for the creation of 3D building models in four LoDs. Specifically, the LoD0 model, that is, the Digital Surface Model (DSM), is created by the mass points defining the ground and the points on the top of man-made constructions and LoD1 models (i.e., prismatic models with flat roofs) are generated using the building outlines and footprints, which may be stored using the ESRI shapefile format. Whereas LoD0 and LoD1 3D models are created solely through the processing of aerial imagery, the creation of 3D models in LoD2 and LoD3 requires the use of terrestrial images or UAV images as well; the derived point clouds and orthoimages may be used for the extraction of metric, textural and color information. All this information can be used for the creation of multi-scale building models either through procedural modelling (Ioannidis et al., 2015; Ioannidis et al., 2016), or in the form of Building Information Model (BIM). It is proposed that LoD1 corresponds to the 3D model of a building, whereas LoD2 and LoD3 models represent each inner part of a building (i.e., apartment, common area, storage area).

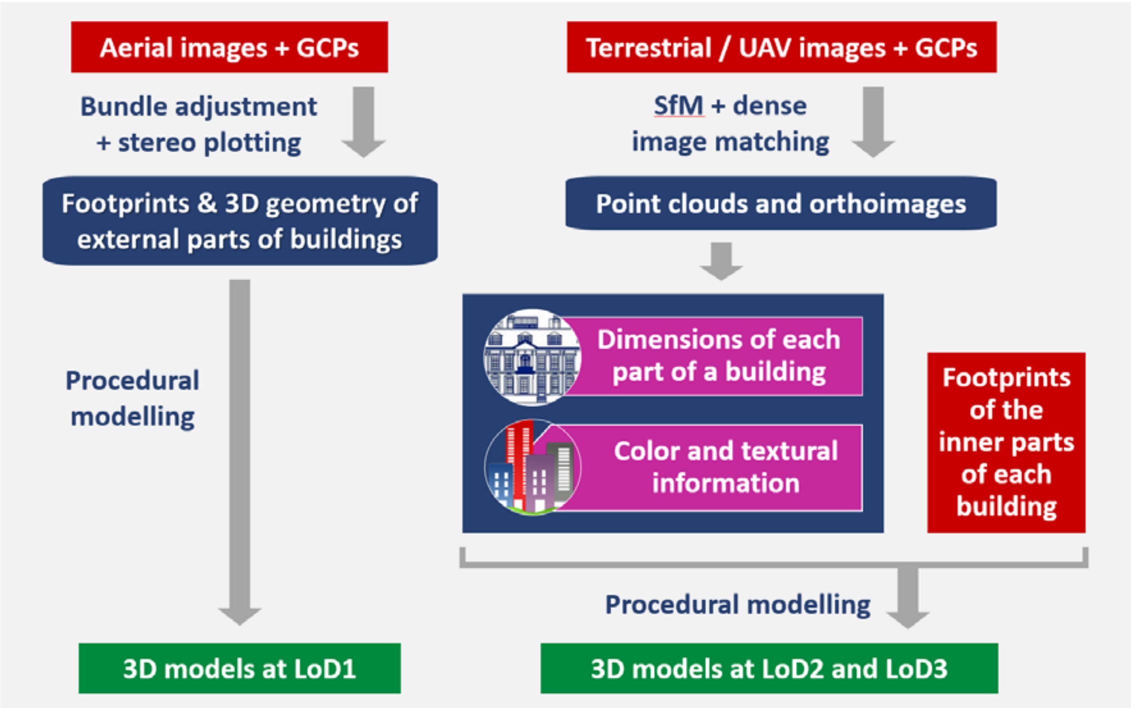

Figure 1. 3D modelling framework of the existing situation at various LoDs

2.2 Valuation of Properties

The valuation of properties, that is, the estimation of their Market Values, is a significant step of the adopted methodology; it has to be prepared in accordance to the rules and guidelines of the International Valuation Standards (IVS), Standard 1 (IVSC, 2016), taking into consideration the principle of the "highest and best use" (Appraisal Institute, 2013). The Market Value is defined in accordance to the International Valuation Standards Committee as the estimated amount for which a property should be exchanged on the date of valuation between a willing buyer and a willing seller in an arm's length transaction, after proper marketing, wherein the parties had each acted knowledgeably, prudently, and without compulsion (IVSC, 2016). The market value is considered to be the best price reasonably obtainable by the seller and the most advantageous price reasonably obtainable by the buyer and relies on the following basic assumptions:

- the two parties (seller and buyer) act knowledgeably and are willing to advance in agreement;
- the two parties are well informed, prudent and act based on their personal interest;
- the property is exposed for sale in the market for a reasonable time period;
- the price is paid "in cash" or with a financial settlement that can be considered as "in cash."

The Market Value of the subject properties should be assessed, taking into account their current and their potential condition, assuming vacant possession. In order to determine the market value of the subject properties, an appropriate method, like the Sales Comparison Method (Schram, 2014) or the Residual Method (Shapiro et al., 2012), may be adopted. In order to complete the valuation report, the surfaces of the land plots, the surfaces of the buildings and properties and the characteristics of the properties, such as floor, use and co-ownership ratio on the plot, have to be examined. In addition, an inspection has to be carried out in the field. Furthermore, a thorough market research has to be carried out, in order to determine all the critical factors that affect the value of the properties, like property market trends, demand and supply for residential units in the area, sale duration, vacancy rates, etc.

2.3 Metadata Enrichment

For a further development of the 3D models in a fourth dimension, which is the time (the 3D cadastral modelling and valuation of the existing properties and the future situation) and a fifth dimension, which is the scale (the scale reflects the various LoDs), the models need to be enriched with supplementary data and metadata, necessary for the implementation of the readjustment of property rights and the planning for the affordable housing scenario. The enrichment of the models with such data and metadata is achieved by creating an internal system Database and an external Database that is linked with the internal one through common fields.

Each 3D cadastral model that represents an apartment, a common used area or other structural or cadastral objects has to be given various attributes along with a unique identifier. The unique identifier (ID) adopted by the tool consists of twenty four alphanumerical characters and identifies each structure among all other structures in Greece. For instance, Table 1 shows the metadata that are proposed to be stored in each model, which may be a KML-COLLADA file, whereas Table 2 shows the proposed metadata schema in the internal database of the shapefiles. An external database including information concerning the buildings may also be created. This database should include the following data types (Ioannidis et al., 2016):
– spatial data (geometry and texture), including both the 2.5D footprints that refer to properties, buildings and land parcels and 3D textured models;
– time (period of validity of property rights and buildings);
– semantic (cadastral) data.

Table 1. Proposed metadata schema in each 3D model

Field Name	Field Description
Longitude	Geographic coordinate (λ) in WGS84
Latitude	Geographic coordinate (φ) in WGS84
Altitude	Geometric altitude (in meters)
File_name	Unique twenty eight digit for each 3D model: ID[24] + LoDi[4] + TIME[4], with i=1, 2, 3
Shape_Leng	Perimeter
Shape_Area	Area
PARCELID	Common key with the internal database

Table 2. Proposed metadata schema in the internal database of the shapefiles

Field Name	Field Description
Elevation	The absolute elevation of the building footprint, extracted from the DSM
Height	The height from floor to ceiling of the volume of the building
PROP_VER	The code of the cadastral vertical property where applicable, zero otherwise
PROP_HOR	The code of the cadastral horizontal property where applicable, zero otherwise
BLD_SN	The code of the cadastral building structure where applicable, one otherwise
Property_t	Description of the type of the cadastral property
Floor	Number of the floor for the structure (e.g., -1, 1, 2…)
Percentage	The percentage, in terms of ownership, regarding the parcel
USE_TYPE	Type of usage; it can be one of the following values: a = APARTMENT; b = VERTICAL RIGHT; c = RESERVED FOR FUTURE USAGE; d = COMMON AREAS; e = ROOF STRUCTURE
USE_DESC	The description of the USE_TYPE field
USE_AA	Unique number starting from 1 that identifies all the structures in a building
PARCELID	Twelve digit alphanumerical text that uniquely identifies the parcel. If cadastral information exists, PARCELID equals to the cadastral code number; otherwise, it is unique number starting from one
ID	Unique twenty four digit alphanumerical text that identifies each structure among all other structures in Greece. It is a composite key that consists of: PARCELID[12] + BLD_SN[2] + Floor[2] + PROP_VER[2] + PROP_HOR[2] + USE_TYPE[2] + USE_AA[2]
TIME	The specific time of construction or of the first detection of the construction

This database is proposed to be connected with the records of the shapefiles using one common field, the ID, which is unique for every apartment or building. In this way, every apartment or building is connected with all the available metadata. Figure 2 illustrates the external database schema adopted by the tool, including the tables that compose it, their fields, the primary keys and their relationships. According to the concept adopted, the land is divided into parcels so that each piece of land is connected with only one parcel. The parcels are described in the table "cad_parcel". Each parcel may have property units with attributes described in the table "cad_prop". For each property unit, there are registered rights (e.g., percentage of ownership) which are created based on legal documents; these documents are described in the table "cad_doc". The type of each right (e.g., easement) is described in the table "cad_right_cat_lut" and each right must refer to a beneficiary which is described in the table "cad_ben". The table "cad_doc_ben_right" is used to correlate the information between the property unit, the right, the document and the beneficiary. The table "cad_prop_parcel" relates the property units with the parcels, since one parcel may have many property units. The table "cad_bld" describes the buildings and the table "cad_prop_bld" joins the buildings to their properties. The table "cad_parcel_legal" extends the attributes of each parcel in order to describe legal elements valid for the land parcel (e.g., building to plot ratio, maximum permitted height, etc.), urban planning or architectural data (e.g., land use), real estate values (zone value, tax and commercial values), etc. Each parcel may have a number of buildings with attributes that are described in the table "cad_bldng" (e.g., construction date, number of floors, condition); this table includes metadata that refer to each building, so that 3D models in LoD1 may be enriched with them. The table "cad_bldng_parcel" serves for the linking of property rights with the buildings, for the enrichment of the 3D models in LoD2 and LoD3 with metadata.

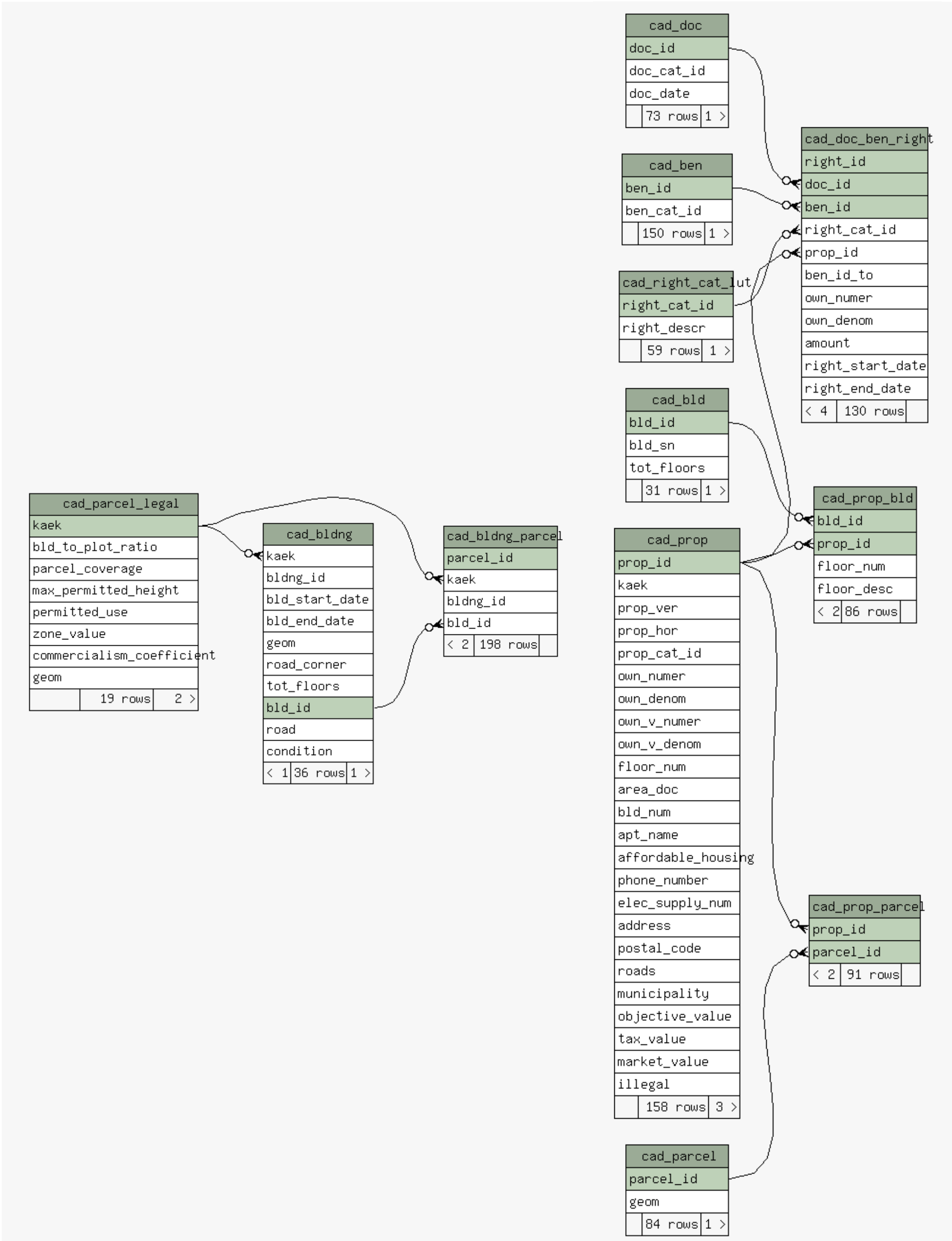

Figure 2. Entity relationship diagram showing the proposed structure of the external database

2.4 Readjustment of Property Rights and Affordable Housing Scenario

The readjustment of property rights towards an urban regeneration that implements an affordable housing scenario includes the following:

– determination of the appropriate blocks of plots for the implementation of the regeneration scenario;
– informing the property owners (individuals or the state) about the benefits and the

incentives of a regeneration project with a property rights readjustment and ensuring their voluntary participation;
- creation of a 3D cadastral database that should be updated with all the necessary information that allows for a fair property valuation;
- estimation of the market values of the existing property rights;
- merging of the allocated parcels;
- demolition of the old constructions and planning of a new building with an increased building factor by a state decision permit;
- agreement with a developer to finance and build new constructions in a controlled-profit manner by agreeing that a certain number of property units will be given at affordable prices to a certain target group;
- valuation of the new property units;
- redistribution of the property rights for the new units.

The new right holders are:
- the old right holders, who will receive new units of a higher value than the one they had prior to the reform, in order to ensure their voluntary participation and their resettlement costs for the period of reconstruction; owners should by all means receive more than what they would normally do if they would make a usual agreement with a developer;
- the developer, who will finance the new construction and work to develop the new units; the developer should receive at least as much profit as a usual standard project;
- the target group beneficiaries, who will be low and low-to-middle income households, as defined in the state list.

3. APPLICATION CASE STUDY

The application scenario for testing the proposed affordable housing framework refers to interventions of small scale in a dense urban area with some small old buildings, probably of bad condition. The study area consists of one urban block in the municipality of Kessariani, in the eastern part of Athens, Greece (Figure 3).

Figure 3. The study area, indicating the new land parcel (marked in red) for the implementation of the affordable housing scenario

3.1 Data Description

The initial data consist of the following:

- a stereo pair of analog color aerial images at a scale of 1:6000 taken in 2010, with known interior orientation; the aerial images represent the existing situation of the urban block;
- GCPs well distributed in the overlapping area of the stereo-pair;
- terrestrial images of the building façades;
- information received from the Greek Cadastre.

3.2 3D Modelling of the Existing Situation

The 3D reconstruction of the urban block of interest took place in three LoDs: LoD1, LoD2 and LoD3. The first step of the 3D modelling process of the existing situation was the calculation of the exterior orientation of the images via bundle adjustment. The final stereoscopic model of the overlapping area of the stereo pair with a correct scale, orientation and position in the Greek Geodetic Reference System 1987 (GGRS87) permitted high-precision 3D measurements in the urban block of interest through photogrammetric stereo plotting. A TIN surface and a raster DTM were then created. The acquired terrestrial images that cover the sides of the urban block of interest were used for the creation of dense 3D point clouds, meshes and orthoimages for the building façades.

The 3D model of each building (in LoD1) or each inner part of a building (in LoD2 and LoD3) was generated through procedural modelling, as it allows for the rapid and interactive updating of models. The Computer Generated Architecture (CGA) shape grammar, as introduced by Müller et al. (2006) was used. The rules defined by the CGA grammar enabled the procedural generation of complex models of buildings by firstly creating a crude volumetric model, then structuring each façade and finally adding details for doors, windows, balconies, etc., in the desired LoD (Ioannidis et al., 2015). The rules were created using metric information, color and texture for the elements of each building, obtained through the SfM and DIM procedures. They were applied to the footprints of either the buildings (in LoD1) or the inner parts of buildings (in LoD2 and LoD3). In this way, 3D models of various LoDs were created (Figure 4). The models were enriched with the appropriate metadata using the internal and external database schema.

3.3 Readjustment of Property Rights and Affordable Housing Scenario

In this section, the procedure followed for the implementation of the affordable housing scenario in the study area is described.

3.3.1 <u>General Description of the Study Area</u>

Kessariani is a suburb in Eastern Athens, close to the urban centre. It is considered to be one of the medium class residential areas of the greater metropolitan area of Athens. It is well served by public transport means (buses) and a metro station is quiet close to the suburb, which provides good access to the subject area. The building factor (i.e., the building to plot ratio) ranges from 3.6 in the central parts of the municipality to 1.8 at its outskirts, which are located on the slopes of the protected mount Hymettus. Most of the buildings are multi-storey apartment blocks constructed from 1970 until nowadays. There are also some old private residencies of bad condition which were granted to refugees back in the 1930s. The common practice for land development in the area has been the demolition of the old residential buildings, the unification of adjacent small land plots and the construction of modern residential blocks. The town planning is good enough and there is no traffic problem. The basic disadvantage of the area is the lack of free parking space. There are a few parks and public spaces in Kessariani and a basic advantage is its proximity to the mount Hymettus. The size of a typical land plot is 130-150 m^2. The newly built apartment stock has a typical apartment surface of 70-90 m^2. The values of the residential properties vary depending on their location, floor, construction quality and view. The most expensive residencies of the area are the ones located close to parks or at the slopes of the mount Hymettus. The rest of the properties are considered to be of lower value. No changes are expected in short term in the city plan of the area. The properties under valuation are located in the less advantageous part of the municipality, where the building factor has a value of 3.0.

Figure 4. 3D views of the building models at LoD1 (top-left), LoD2 (top-right) and LoD3 (bottom)

3.3.2 Inspection of the Buildings and Market Research

An inspection was carried out in the field before the estimation of the Market Values of the properties. The buildings were inspected externally; thus, the valuation of the properties is based on the assumption that their interior condition – status of maintenance is similar to their exterior condition.

Furthermore, in order to satisfy the scope of the valuation and advise upon the market value of the properties under study, a thorough market research was carried out. Consultation with real estate agents, developers and property owners took place during this investigation. The current situation in the Greek real estate market, including the municipality of Kessariani, is unfavorable. Since 2008, it has been undergoing a period of prolonged recession. Prices of both residential and commercial properties are declining to an average rate of minus 8% per year approximately. Demand is limited, the transaction volume has been decreasing while the supply is increasing. The number of transactions of the last two years is extremely limited in comparison with the previous period and the prices are in a free fall. The perspective buyers are looking only for "opportunities". As a result, the closing prices of the few properties that have been sold are very low. There is also a pronounced discrepancy between reasonable asking prices and closing prices and the negotiation margin of the sellers ranges from 15% to 20%. The stock of the newly built residencies is significant and under normal market circumstances they could be sold at 1,300-1,900 €/m^2 including extra parking and storage space. As there is not any buying interest, their market prices do not exceed 1,000 €/m^2. In addition, these unfavorable market conditions have been deteriorated since the end of 2014 as a result of the political and economic instability.

3.3.3 Determination of the Market Value of the Properties

For the assessment of the market value of the subject properties, comparable evidence of land plots and residential properties and, more specifically, newly built and 20-25 year old apartments in the immediate and broader district were considered. The resulted range of values has been found to have good correlation to reasonable asking as well as to the actual market values. Both the Sales Comparison Method and the Residual Method were used for the valuation of the properties, depending on each case.

3.3.4 Readjustment of Property Rights and Planning for Affordable Housing

For the implementation of the affordable housing scenario, a small area was selected, that comprises 5 attached land parcels. The total land area is 1,077.34 m^2, while the total built-up area is 701.19 m^2. The first fundamental step for the implementation of this scenario was the voluntary merging of the 5 land parcels for the creation of a unified parcel with re-adjustment of the property rights. The percentage of co-ownership rights of the owners in the new land parcel were estimated according to the market values of the existing property rights. The profit of the current right holders and the motivation for the voluntary participation in the project were based on the agreement that after the completion of the project the right holders will be offered apartment(s) of a significantly larger market value than those they owned plus the resettlement costs. After all, the demolition of the existing old constructions contributes to the aesthetic and environmental upgrading of the urban area.

The state offers a greater building factor for the newly created parcel (a state decision is required), so that a sufficient built-up area will be provided for the resettlement of the old right holders, the economic satisfaction of the developer and the possibility for offering some of the condos at affordable prices. The valid building factor for the case study was 3.0. It was estimated that about a 35% increase of the building factor may lead to satisfactory results. Thus, the increased building factor was 4.0 and the built-up area could be up to 4,385 m^2.

3.4 Design of the New Building

The new building was designed taking into account the increased building factor. The condos of the new building were distributed among:

- the old owners, according to their property rights and a standard profit compared to the market values of the properties they originally owned;
- the developer, who will finance and construct the new building, so that he/she will have a profit that will justify the risk of his/her investment and the agreement that part of the new construction will be sold at affordable price;
- those target groups qualified to benefit from the state's affordable housing policy.

Based on the benefits provided by the increased building factor (4.0), a new multi-apartment building was designed. It consists of a total area of 4,382 m^2 of apartments and a parcel coverage of 0.545 (Figure 5). The new building cannot be higher than 30 m, which is the maximum permitted height in the study area. Thus, a building of 9 floors was designed. Those condos that were agreed to be sold by the developer at affordable price should be sold up to the 55-65% of the market value of the rest condos. The footprint area of the new building is 587 m^2; the area of the first 7 floors is 587 m^2 each, while the area of the 8^{th} and the 9^{th} floor is 419 m^2 and 280 m^2 respectively. The building has in total 51 apartments that were distributed as follows:

- 13 apartments are proposed to be given to the old right holders/owners. Each owner was given a property of a market value 75% higher than their old property, in order to ensure that all costs for resettlement are covered and that the owners will voluntarily participate in the project.
- 20 apartments are proposed to be given to the developer, in order to cover all soft and hard costs, his profit as it would be if (s)he had invested in this plot with a building factor of 3.0, and the cost for the construction of those apartments that should be offered at affordable price.
- 16 apartments are proposed to be given to a target group eligible for affordable housing. These apartments correspond to an area of 48.30-83.25 m^2, so that they satisfy the housing needs of families comprising 2 to 4 members.

The 3D model of the building was created in LoD3 through procedural modelling. Figures 6 and 7 show 3D views of the whole urban block, reflecting the current situation and the future affordable housing scenario.

Figure 5. The horizontal plan of the new land parcel (marked in red) and the outline of the new building (marked in blue), superimposed on an orthoimage of the study area

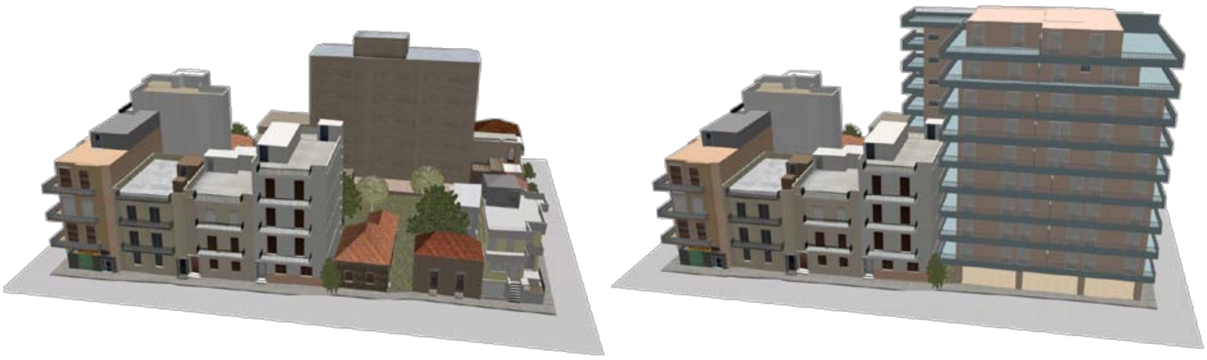

Figure 6. 3D view of the urban block of interest from the south; existing condition (top) and future affordable housing scenario (bottom)

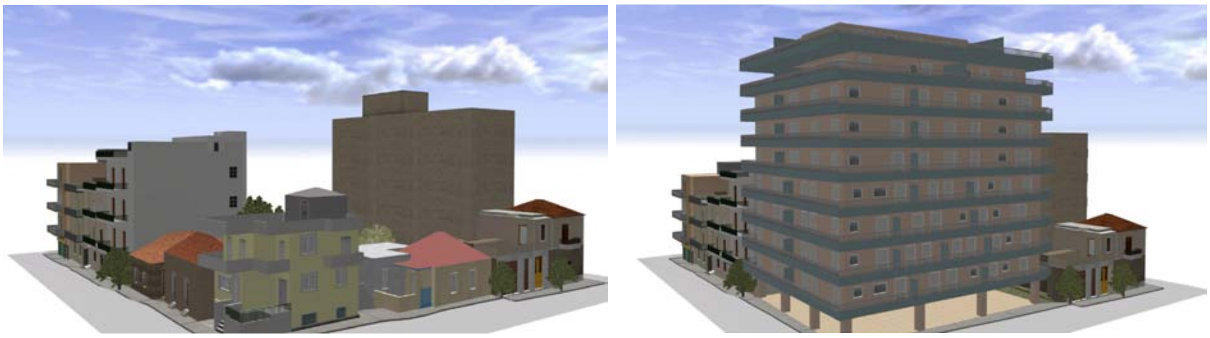

Figure 7. Southern-eastern 3D view of the urban block of interest; existing condition (left) and future affordable housing scenario (right)

3.5 Results and Discussion

By applying a readjustment of property rights and planning for affordable housing scenario in a small area of approx. 0.1 ha, the construction of 16 apartments was made possible without any funds provided by the state, to cover the housing needs of low and middle income households and be sold at the 55-65% of the market values. This was achieved by a proposed increase of 35% of the valid building factor. This scenario can be applied either by the state or by the municipality. A smaller increase of the building factor (e.g., 20-25%) will offer fewer apartments for affordable residences.

More specifically, a unified plot of 1,077 m^2 was created, in which a new building of 51 residences and a total built-up area of 4,382 m^2 was designed. The apartments were designed in a variety of sizes from 48.3 m^2 up to 140 m^2 to satisfy all needs. According to the proposal three categories of right holders should be share the new apartments, as follows:

- Old owners: 25.1% of the built-up area
  27.8% of the value
- Developer: 48.1% of the built-up area
  56.6% of the value
- Affordable residences: 26.8% of the built-up area
  15.6% of the value.

From the above, it is derived that 16 households will acquire a residence by saving 730 €/m^2 (taking into account that the sale value of the new apartments for affordable housing is 1,034 €/m^2, while their market value is 1,764 €/m^2). Simultaneously, the procedure for the old right holders is similar with the usual procedure applied in Greece, by providing their parcels to a developer for the construction of a new building and by getting back the 34% of the new construction, which is considered to be satisfactory.

The Greek Building Code allows flexibility of the building factor in favor of climate change measures and energy saving constructions. What is proposed here is that the Building Code should be changed and become flexible to allow increase of the building factor in favor of implementing either energy saving policies or affordable housing policies in new constructions or a combination of both.

4. CONCLUSIONS

In this paper, a general technical (3D + time + scale = 5D modeling) and policy framework for the implementation of an urban regeneration process is proposed and a detailed case study is given, which combines the creation of a 4D cadastre (3D geometry of the existing situation plus future scenario), property valuation, and planning for affordable housing by implementing higher urban densities. The presented affordable housing scenario was tested and proved realistic and financially sustainable and the derived results have shown that the proposed method is very successful and fits with the current international good practice. Apart from supporting affordable housing policies within the framework and the rules of the globalized economy, the proposed technical tool also supports the good governance of the cities, as it facilitates the creation of a local geospatial data infrastructure necessary for all the types of services for the management of smart cities, such as security, transportation, disaster management, etc. Also, innovative technical solutions were proposed to be used for the updating of geospatial databases, such as for data capturing (e.g., dense image matching, SfM, procedural modelling).

The affordable housing scenario supports solid stability as well as inclusive and increased participation of the private sector, the property owners, the vulnerable groups and the citizens in general in the decision-making procedure, by supporting the development of voluntary procedures and by allowing the development of fair win-win solutions for the state, the private sector, the property owners and the vulnerable groups. Also, it can support self-financed, small projects for urban regeneration and creation of green public spaces within the urban neighborhoods. What is more, the urban regeneration supports the upgrading of the cities characterized by increased urban sprawl, or the informally developed settlements and may be also applied in other countries with increased challenges due to unplanned development.

ACKNOWLEGMENTS

The valuation of the property rights at the case study area (Kessariani) was conducted by Mrs M. Filippakopoulou, licensed appraiser and post-graduate student at the National Technical University of Athens, Greece, in the framework of the research project “5 Dimensional Multi-Purpose Land Information System” **(**5DMuPLIS), which is co-funded by the EU (European Regional Development Fund/ERDF) and the General Secretariat for Research and Technology under the framework of the Operational Programme "Competitiveness and Entrepreneurship", "Greece-Israel Bilateral R&T Cooperation 2013-2015".

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