Legal Aspects of 3D Property Rights, Restrictions and Responsibilities in Greece and Cyprus

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Key words: 3D Property, 3D Cadastre, Legal Framework, Rights, Restrictions, Responsibilities (RRRs)

SUMMARY

This paper aims to identify and evaluate the constraints imposed by the legal framework both in Greece and Cyprus that prohibit the extensive development and application of 3D Cadastres. Property laws and customary rights in both countries present several similarities; e.g. co-ownership in shares as the result of the existing inheritance system, custom derived land-tenure patterns, such as separate ownership of plantations or constructions on foreign parcels and overlapping property rights. This range of land rights, restrictions and responsibilities (RRRs) identified in the Greek and Cyprus jurisdictions, requires proper 3D registrations complying with each legal structure, as well as systematic encoding and modelling, fully exploiting technical capabilities of 3D representations.

Within the present study land law relating to RRRs in the two countries, as well as legal documents and mechanisms, producing and maintaining data about spatial extent of legal RRRs are thoroughly examined and presented. Through this analysis it was concluded that prevailing legislations both in Greece and Cyprus contain contradictory laws on property rights and several deficiencies, regarding the establishment of an operational framework for the development of 3D Cadastres. The same applies to other jurisdictions and land tenure systems, as evidenced by relevant scientific publications and research papers. Recent studies (Ploeger, 2011; Paulsson and Paasch, 2011; Erba, 2012) state that further and more focused (international) research is needed along with a common, conceptual framework allowing the exchange of legal 3D RRR information within the cadastral domain.

Taking into account these concerns and incentives, the present study gives special emphasis to the legal aspects of 3D RRRs in Greece and Cyprus, in an effort to evaluate the solutions that match legal requirements in the most optimal way. It is obvious that for both systems, reforms and adjustments are required, in order to introduce a modern property tenure system that fully complies with the objectives of a 3D Cadastre and benefits from its implementation. Special attention is given to the necessary changes and refines in customary laws that mainly applies in the Aegean islands of Greece, creating complex RRRs, mixed up in multiple layers below or above the land surface. Legal relations on RRRs are presented through characteristic cases and examples of complex 3D reality. The integration of these legally defined spaces to a 3D cadastral system, should leave no doubt about the way RRRs are connected and affect each other, as well as connect parties and property units, based on the conceptual framework of 'Cadastre 2014' (Kaufmann and Steudler, 1998) and the Land Administration Domain Model (ISO 19152, 2010).

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1. INTRODUCTION

1.1. Laws and Customary Rights referring to Legal Relations on RRRs

Property rights can be defined as an "umbrella concept" which includes several types of rights to different forms and uses (Benda-Beckmann et al., 1996). Property rights, if considered as a government-issued title linking a person with a piece of land do not capture the complexity and dynamism of diverse property rights, uses and forms of the real world. Furthermore, property rights are based on multiple legal frameworks (such as statutory, customary, case and local laws) which co-exist, influencing each other in the course of time. This multiplicity and interaction between legal orders eventually result in significant property law modifications, which in turn contribute to increase tenure confusion and uncertainty, especially for less favored groups. In other words, property rights should be legally "well-defined", in order to provide tenure security and efficiency in use (Meizen-Dick and Pradhan, 2002). This also applies to the legal meaning of 3D properties, which comprises the extension and definition of rights, restrictions and responsibilities (RRRs), as derive by the land law (also called real estate or property law) in the different national legal systems. For example, in civil law jurisdictions, legal boundaries do not necessarily coincide with real features (unless parties involved declare the coincidence of their boundaries); while in countries where the general boundary rule is applied real objects are the representation of legal objects (Molen, 2003).

1.1.1. Land Law: Basic Concepts and Property Partition

Land law originally relied on the Latin maxim "Cuius est solum, ejus est usque ad caelum et ad inferos" (who owns the land, owns up to the heavens and down to hell), a principle protecting land ownership during roman times against actions for trespass (such as invasion of others' possessions or erection of structures over another's land) and limiting recognition of underground property rights. Later on, the extent to which the maxim's rights could be enforced has been tempered by laws and jurisprudences, which largely contributed to the legal rules applying in modern societies. These include among others, air rights, mining, power lines, underground subways and various uses of our complex reality.

Building on the heritage of Roman law, a large number of property law systems protected the unity of property by restricting its horizontal partitions into multiple surface and subsurface parts. In early societies property rights were related to the functional use of the land and therefore properties were divided through horizontal functional partitions. In later times, as in the modern West world, many societies abandoned the impractical functional property in favor of spatial property (of absolute ownership and decision rights) which provided greater flexibility to accommodate structural transformations (Parisi, 2002).

According to the Roman accession rule "superficies solo cedit" (that which is attached to the land becomes part of the land), the property owner can claim ownership to any construction erected on his land. This rule prohibiting the horizontal fragmentation of property, has been gradually abandoned either by the informal division of buildings especially by poorer people, or formally, by including new provisions for the separate ownership in the different European civil codes, to cover a number of practical problems. First, the separate ownership concept was legally introduced by the Code Napoleon (1804) and was later spread to European countries and other parts of the world. Given that housing needs increased over the years, the demand for standard agreements became imperative and special statutes were adopted. Legislations clarifying rights, restrictions and responsibilities of co-owners especially concerning the maintenance and repair of the common parts of buildings were passed in different countries, in regards to their point of view.

The property division into apartment ownership (also called condominium or strata division or horizontal division) is created by means of a splitting deed regulating the different rights and obligations among the inhabitants of the building. Apartment ownership presents a great diversity in the different national land law. In several legal systems the land and the building are jointly owned and the co-owners are granted exclusive right to use a specific apartment (as in the Netherlands, or in Finland and Sweden with the difference that the owners are shareholders of the corporate law), while in others, the apartment ownership is separated from land ownership (as in Scotland) or it is combined with joint ownership "in forced indivision" of both the land and the main structures of the building. Within this context, courts and legislatures in both civil and common law jurisdictions, have adapted to the modern needs of land owners and developers recognizing new property concepts of multiple ownership and complex constructions, as well as special agreements between parties.

It is evident that the above mentioned horizontal partition of property as well as the obligations among the co-owners, require a rigid registration and representation of 3D spaces thus generated, supported by an efficient legal framework for defining and protecting 3D RRRs.

1.1.2. Other RRRs requiring 3D Registration and Representation

Apartment's ownership is the most typical example of 3D space stratification; however, other constructions above or below the ground (see Figure 1), can also be considered as legal objects and, depending on each country's legal system, may be registered as separate property within a cadastre or other registry. In many jurisdictions, these 3D cadastral objects are spatially indexed in relation to the associated surface parcel, while in others this information is separately kept in special registries. The integration of this information into a national cadastral system is considered, both technically and legally, as a very challenging task.

Moreover, our physical and built environment comprises interests in land having spatial or non-spatial dimension, not necessarily restricted to a single parcel or related to associated ones. These may include development rights such as air, riparian water and littoral rights, rights to minerals and vegetation or rights in relation to building regulations and customary law. The organization, management and representation of these parcel or non-parcel based interests in a traditional 2D cadastre is not really feasible; therefore a 3D cadastre should be

considered to spatially register property RRRs, obviously supported by an appropriate 3D legislative framework which can incorporate and reflect ongoing practices and modern market demands.

Figure 1. 'Athens Street Mall' Project (Vagianou and Papathanasopoulou, 2012)

RRRs and spatial units generated may vary by content between different countries in respect to their legal system:

- Airspace rights, a relatively new type of development rights that refer to the 3D space above a property, which can be reasonably used or occupied. Airspace ownership has to be legally limited and 3D displayed, not to interfere with air travels, as derived by the aviation law.
- The "building-within-a-building" is a new concept in the commercial office market (of New York) that recaptures and exploits spaces in office towers that were not fully used, in order to accommodate different tenancies benefiting separate entrance and minimizing costs.
- Rights to exploit mines and produce minerals lying below the surface of the property, depending on each jurisdiction.
- Littoral and riparian water rights in front of properties, according to relative national legislation.
- Special constructions above or below freeways, railroad tracks, such as bridges, tunnels etc.
- Telecommunication and electric conduits and utilities on land ownership.
- Rights that comply with zoning and planning regulations for urban growth, management and protection of environment and cultural heritage.

1.1.3. Customary Rights – Horizontal Partition in the Aegean

Customary rights still remain in some parts of the world regulating the creation, possession, use and transfer of RRRs. Customary law, controls legal relations on ownership rights such as joint properties, implantation privileges, constructions on foreign parcels, etc. For example, in the Aegean, customary rules were and still are a major regulatory factor for the function of local societies. Particularly in the Cyclades, due to the lack of space, the ground's intense relief and the socioeconomic conditions that prevailed, laws arranging the partition of land and buildings and establishing the succession to land property have been utilized. These rules were linked to tradition and their principal effect has been the protection of the family and its transfer from one generation to the next, resulting in the structure of the type of property devolved. Separate ground floor (katoi) and upper floor (anoi) residences have been traditionally under a system of horizontal property, evidently not complying with the Roman accession rule. The owner of the ground floor also owned the land parcel, while the owner of the upper floor owned the roof (and air), having no land share. Under this special system of co-ownership, each floor's rights, even without land share, are separate, transferable and registrable.

It is quite obvious that Greek legislation contains contradictory laws on property rights, which is rather confusing; therefore there is a need to perform relevant reforms and adjustments in order to tackle this situation. A primary arrangement would be to repeal old laws such as (superficies solo credit) Article 954 of the Civil Code, while reviewing and redefine those applied to comprise the description of three-dimensional objects (Tsiliakou and Dimopoulou, 2011).

1.2. Legal Documents and Mechanisms producing and maintaining data about Spatial Extend of Legal RRRs

Within each jurisdiction, various organizations dealing with land registration and rights' management processes contribute to the production and circulation of a variety of land related information. These organizations have a range of in-house databases and activities in regards to their specific functions, and often operate independently, based on their own indexing and identification system, thus making interoperability a rather difficult task.

1.2.1. 3D Land Related Information in Greece

In Greece, various Organizations and State Departments under different operational status, standards and techniques, produce land related information that may be three-dimensionally registered in a land administration data model. Among them the most important are:

- The ongoing Hellenic Cadastre (HC) that collects information on property objects and this information is in reference with the land-parcel and is analyzed on the two dimensions of the real objects. The outlines of the buildings (although this information is collected by the adjudication process) are not represented on the cadastral maps and the transition to a 3D cadastre requires further model refinement.
- In areas where the HC project is not yet operational, the registration of rights is still under the system of Mortgage (or Hypothecs) Offices, where a copy of each deed of transfer of property rights as well as of charges, easements and other restrictions is registered. Under this system, RRRs and land parcels' boundaries are extensively verbally described in each deed, while a graphical plan is also attached to transactions and horizontal ownership

establishments (floor plans), and deposited to the Notary Public, obligatory since 1977. Therefore deeds do not contain 3D information, unless recently compiled topographical plans comprising coordinates and/or heights are accompanied.

So far the two systems operate in parallel, but as planned, the system of mortgage offices will be abolished, gradually replaced by the HC which will cover the entire country.

- The Hellenic Mapping and Cartographic Organization (HEMCO), as the competent authority for the preparation of strategies and guidelines for the compilation of the cadastral project and for providing the necessary infrastructure data (topographic data and aerial imagery), for the promotion of the HC project. Currently HEMCO is also the contact point for the INSPIRE directive along with the development of the National Infrastructure for Geospatial Information, a system of organizational, institutional and technological interoperability for Greece.
- Networks and public utilities are recorded and managed by the responsible (private or state) organizations. Although these data are not structured through land parcels, they may affect them by imposing RRRs (e.g. allow or prohibit certain land use) and therefore this information needs to be integrated into a land administration system in order to unambiguously represent the space limits of interrelating and spanning RRRs.

1.2.2. 3D Land Related Information in Cyprus

In Cyprus, the Department of Lands and Surveys (DLS) is the authority responsible for the operation of land registration, which is the oldest department in the government service, dating back to 1858. The main responsibility of DLS is the registration of immovable property on the island and other rights and restrictions associating the properties with the parties. The registration is based on cadastral plans, which are linked to the national grid and cover the whole island. All parcels, including state land, appear on register and on plans. The registration is based on "The Immovable Property (Tenure, Registration and Valuation) – Cap.224" Law.

The three dimensional land related information is registered for various cases, including the following:

- Registration of jointly-owned building. This type of registration started in 1981 to meet requirements of strata division buildings. Before proceeding with the registration, a building permit and a division permit need to be obtained from the appropriate authority (Town Planning and Housing Department or Local Authority). Special plans are prepared to define the various types of rights and restrictions. The owners get title certificates for each apartment and they are co-owners of the parcel-lot on which the building is built as well as of common areas.
- Registration of passage, right-of-way to a property, through another property.
- Registration of channeling access. This is a right of a party or property, to channel water, liquid, electricity, wires, oil, or gas through a channel, drain, mains, or a pipe, placed on, under or above another property. An example of such a right is the south irrigation underground water pipe, which has a length of 110 km, and is registered for the benefit of the Cyprus Government and under the custody of the Water Development Department.
- Registration of dual ownership. Dual ownership exists in cases where the land is owned by a person other than the owner of the buildings, trees etc standing thereon. Various

provisions in the "The Immovable Property (Tenure, Registration and Valuation) – Cap.224" Law encourage the readjustment of the interests of the various owners so that both the land and all trees or buildings are owned by the same person.
- Rights concerning the exploration and the exploitation of mineral wealth of Cyprus are granted by the Mines Service.

1.3. Contradictory Laws on Property Rights

1.3.1. Greece

The Greek legal framework governing RRRs mainly lies in the Civil Code (C.C.) and in various special laws. For example, the article 954 C.C based on the Roman accession rule "superficies solo cedit" (whatever lies above or below the surface of the ground belongs to the associated land parcel) has been amended by (Tsiliakou and Dimopoulou, 2011):

- The law 3741/1929 (article 1002 C.C) "about ownership per floors", which has determined the fundamental principles of the "horizontal ownership".
- Law about "Mines' ownership", that provides the right to search and exploit mining minerals.
- Article 1010 C.C concerning building party on an outland real estate.
- Articles 1118-1141 of the C.C. land interests, such as various servitudes, provide the benefit of holding a part of foreign land (e.g. right of way, sewers).
- Customary law, as mentioned above, that controls legal relations on ownership rights, such as joint properties, implantation privileges, constructions on foreign parcels, etc. and
- Special Real Property Objects which are manipulated not as spatial information but as descriptive one.

The areas and/or spaces generated by the division of property rights (and obligations) are descriptively given, while they may be graphically portrayed on topographical diagrams or floor plans, attached to the notary deeds. For land parcels under cadastral survey or already included into the HC project, their boundaries are delineated by observation on orthoimagery and further field surveyed where necessary. Buildings divided by notary deeds into legal partitions, are registered and maintained by the HC; for each separate legal entity a cadastral unique identifier is assigned along with the registration of their surface area and land use. The plans of floors, apartments and houses compiled for issuing building permits, are stored (in analogue form) in the competent Urban Planning Agency; cooperation between the two systems has not been realized or even predicted. Entire buildings, not divided by legal acts, are declared but not maintained by the HC. Each cadastral land parcel is linked to all RRRs that exist on it through its unique cadastral identifier.

Greek legislation contains complex and often contradictory laws on property rights, with many deficiencies regarding the registration of 3D RRRs. There is no generic or specific legislation:

- Stipulating the three-dimensional description of RRRs.
- Describing the specifications for surveying plans in 3D,

so as to get a clear view of the allocation of rights in the vertical component. To move to a 3D Cadastre it is therefore needed to perform relevant reforms and adjustments such as to

to repeal old laws such as (superficies solo credit, article 954 C.C.), while reviewing and redefine those applied to comprise the description of 3D objects.

1.3.2. Cyprus

The legal framework governing RRRs mainly lies in "The Immovable Property (Tenure, Registration and Valuation) – Cap.224" Law.

The "immovable property", according to that law, includes (a) land, (b) buildings and other erections, structures or fixtures affixed to any land or to any building or other erection or structure, (c) trees, vines, and any other thing whatsoever planted or growing upon any land and any produce thereof before severance, (d) springs, wells, water and water rights whether held together with or independently of, any land, (e) privileges, liberties, easements and any other rights and advantages whatsoever appertaining or reputed to appertain to any land or any building or other erection or structure and (f) an undivided share in any property hereinbefore set out.

The extent of private ownership of land is limited to the surface and to the substance of the earth beneath the surface and to the space above the surface, reasonably necessary for the enjoyment thereof, but shall not extend to minerals.

The above law also regulates the registration of jointly-owned buildings (strata division). Where a building permit for a building was granted after 12.2.1993 and the building consists of 2 to 4 units, it may be considered as "jointly-owned" and is registered as such upon application filed by the owners of at least 50% of the building or by the owners of two units. Title certificates are issued for each unit of the building.

Article 21 in the above law also provides that "where any immovable property is held in undivided shares, all co-owners shall be entitled, in proportion to their respective shares, to: (a) any building or other erection or structure erected upon, or affixed, to the property, (b) any tree or vine planted or any well sunk therein, (c) any permanent improvement effected therein (whether erected, affixed, planted, sunk or effected by a co-owners or by any other person)".

It is obvious from the above examples that the relevant law in Cyprus contains ambiguities and contradictions in clearly defining the third dimension of its cadastre system. The extent of private ownership of land is not distinct, because is limited to the surface and to the substance of the earth beneath the surface and to the space above the surface, reasonably necessary for the enjoyment thereof. The term "reasonably necessary", however, is ambiguous. With the exception of the horizontal (strata) division of buildings, law reforms are needed for the application of a 3D Cadastre, in Cyprus.

1.4. Similarities, Constraints and Legal Deficiencies regarding the establishment of a 3D Cadastre in Greece and Cyprus

Cyprus has a registration of title system, highly trusted by the public, while Greece is moving from a register of deed to a register of title system. Although Greece and Cyprus share common historic and cultural characteristics, the legal status of each country has a direct affect on the way property and other rights are registered, transferred and protected. After a

comparative review of the two countries' land law and cadastral legislative framework, it is obvious that there are many deficiencies concerning the registration and representation of 3D objects. Both countries are based on two-dimensional (2D) registers, lacking of proper legislation regarding 3D property in land. Furthermore ambiguities and contradictions are contained in land law resulting in a rather confusing definition of the third dimension. Buildings' partition into spatial units (such as apartments, or parking places) is descriptively provided and also depicted on floor plans that do not contain the exact height or coordinates of the spaces created. Therefore in both countries, the term "reasonably necessary" enjoyment of RRRs needs to become more specific, in order to clearly define and secure the exact spatial extent of these rights.

Some differences in terms of legal aspects between the two countries are:

- In Cyprus, all parcels, including state land, appear on register and on cadastral plans, while for the Hellenic Cadastre, the outlines of all constructions are not represented on the cadastral maps of the operating system, although this information was initially collected.
- In Cyprus, upon completion of a building or construction work, the competent authority issues a certificate of completion and the owner files an application (on a specific form) for registration of the division and the issue of new certificates of registration. In Greece such a linking procedure is not legally required; when a land parcel is partitioned (horizontally or vertically) the new property rights are registered only upon declaration, the construction being completed or not.

It seems that in both legislative frameworks, legal aspects of registering RRRs need to amend incorporating 3D registration.

2. NEED FOR CORRECT REGISTRATIONS OF RIGHTS AND LOCATION

The operation of a land administration system (LAS), in every country, is based on the relationships between parties (such as people) and property units (such as parcels). These relationships are in fact rights and restrictions (RR) relating parties and property units (ISO19152, 2010). The quality of a LAS is depended on the accuracy and effectiveness of the definition and determination of the relationships. Thus the quality of a LAS relies on the correct registration/recordation of the RR-relationships associating the parties and the property units. This is a complex process and a series of requirements need to be met to achieve the quality of the system.

The complexity of the system can be reduced by applying a standardized model. The Land Administration Domain Model (ISO19152, 2010) provides a reference model which is expected to serve two goals: (i) to provide an extensible basis for the development and refinement of efficient and effective land administration systems, and (ii) to enable involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary (that is, an ontology), implied by the model. All the involved parts of the LAS need to be clearly and undoubtedly determined and recorded/registered, i.e. the parties, the property units and the rights/restrictions (RR) relationships. As it is explained below, this clarification is not so easy to be achieved and a number of procedures are involved in the whole process.

2.1. Determination of Parties

A party is a natural or non-natural person that plays a role in the LAS. An important category of parties include those having rights and/or restrictions. A clear determination of the parties is not a straightforward procedure. Although one can argue that there are problems for the clear determination of natural persons involved in the system, in fact there are cases where this is not an easy task.

In Cyprus for example, 30% of the owners do not have a unique identification number (id) recorded in the cadastral system. The cadastre in Cyprus was established in 1858, long before the establishment, in 1955, of the Civil Registry, where the physical persons had to obligatory registered and get a unique ID. The assignment of a unique id for every owner is a complex task being carried out for many years, and has not yet been completed. Similar problems are faced for the non-natural persons. Furthermore, difficulties in the clear determination of non-natural persons occur in some cases where legal bodies are created having complex administrations and in cases of bankruptcies.

The existence of different "Party Registers", which are not always connected or integrated, is another problem. In Cyprus there is a Civil Registry for natural persons being kept by the Civil Registry and Migration Department, a Companies Registry for non-natural persons being kept by the Department of the Registrar of Companies and Official Receiver. A third Registry for natural and non-natural persons is being kept by the Department of Lands and Surveys.

The inclusion of the State/Government as a party involved in the LAS and the clarification of the RRs associated with it, is also necessary for the clear determination of parties. This applies for other authorities as well, local governments or communities, religious organizations and all other parties having a legal status.

Finally, clear determination of parties requires clear determination of property units as well. There are property units that have rights or restrictions as well. Such an example is a passage through a parcel for the benefit of a nearby parcel. Another example is the use of a parking place for the benefit of a specific apartment.

2.2. Determination of Property Units

A property unit in a LAS can be a parcel, a house, an apartment, a road, a well, a tunnel, a channel, a lake, a sea/water space, a parking place, or any other object that it is defined by the law of each country/ jurisdiction. A property unit can consist of one or more spatial units.

There are various ways to define the property units. The most common and traditional way is to represent the property units on a cadastral map, as polygons. LADM supports various ways of creating property units (spatial units). It supports 2-dimensional (2D), 3-dimensional (3D), or mixed (2D and 3D) representations of spatial units, which may be described in text ("from this tree to that river"), or based on a single point, or represented as a set of unstructured lines, or as a surface, or as a 3D volume (ISO19152, 2010). Although a land administration system could operate with any of the above spatial representations, the "3d volume" representations can enhance the functionality of the whole system and provide a new spectrum of applications.

Examples of such applications are illustrated in many recent scientific papers, and some of them have been presented in the first and in the second international workshops on the 3d cadastres, held at Delft University of Technology in The Netherlands, in 2001 and 2011 respectively (http://3dcadastres2011.nl). The 3D representations, however, apart from the complex cases, could also facilitate and support the basic cadastral operation and functionality and enhance the services offered to cadastre users.

2.3. Determination of RRs

Differences between the LASs occur, from country to country, due to the range of the rights and restrictions that are managed in each distinct system. The rights/restrictions vary from country to country and can generally be categorized as follows:

i. ownership rights
ii. usage rights/restrictions (such as lease, management, custody, residence, and usufruct),
iii. passage/channeling rights/restrictions and
iv. mortgage.

Having clarified the involved parties and property units, the clear determination of the rights and restrictions associating them, places the foundation for the operation of a Land Administration System. The "ownership" right is the most significant right of the system. The quality of a LAS increases, as long as more property units with ownership rights are clarified and secured (Elia, 2010). At the same way, a clear definition and determination of the other RRs handled by the system, serve its quality.

A big number of RRs is managed in the Cyprus cadastre, making it a multipurpose system. The RRs include: ownership, lease, passage, channeling (for the benefit of property), channeling (for the benefit of a party), storey erect, use, usufruct and residence.

Figure 2 shows an example of special plans, created in the Cyprus cadastre, to represent a horizontal (strata) division of a multi-storey building. A special plan is prepared for the ground and the other floors as well as the terrace.

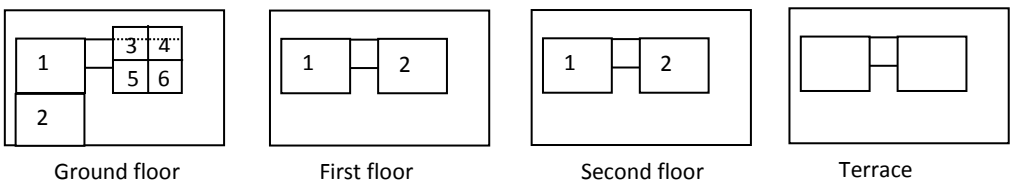


Figure 2. Existing special plans representing a strata division in Cyprus

Figure 3 shows a proposed 3D presentation of the property units of the same multi-storey building. The 3D presentation can provide better recording of legal reality and easier access and visualization.

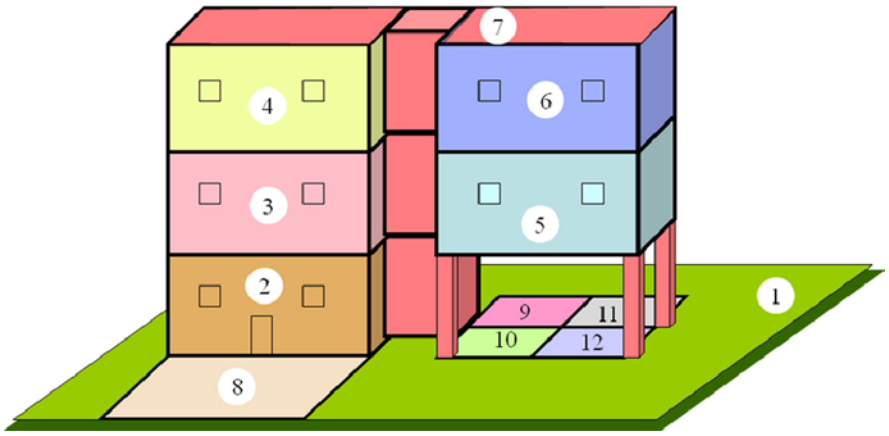


Figure 3. Proposed 3d representation of the strata division

The right-relationships connecting the parties and property units of the above example are shown in Table 1. The property units that have rights associated with them are being entered as parties (as it is proposed in LADM). The integration of the spatial component, shown in Figure 3, with the legal component, shown in Table 1, provides a clear picture of the rights associating the parties and the property units of the specific multi-storey building. (Note: The attributes in Table 1 and the presentation of Figure 3 are generalized and simplified, for the purpose of the example).

Table 1. Right-relationships connecting parties and property units of a multi-storey building

Property unit	Property type	Right	Party (Share)
1	Parcel	Ownership	John (1/5), Peter (1/5), Mary (1/10), George (1/10), Kostas (1/5), Andrea (1/5)
2	Apartment	Ownership	John (1/1)
2	Apartment	Residence	John's mother (1/1)
3	Apartment	Ownership	Peter (1/1)
4	Apartment	Ownership	Mary (1/2) George (1/2)
5	Apartment	Ownership	Kostas (1/2)
6	Apartment	Ownership	Andrea (1/1)
7	Building staircase & terrace	Ownership	John (1/5), Peter (1/5), Mary (1/10), George (1/10), Kostas (1/5), Andrea (1/5)
8	Yard with parking	Usage	Apartment 2 (1/1)
9	Parking place	Usage	Apartment 3 (1/1)
10	Parking place	Usage	Apartment 4 (1/1)
11	Parking place	Usage	Apartment 5 (1/1)
12	Parking place	Usage	Apartment 6 (1/1)

Changing the term "area" to "space" would be a first step in giving urban and environmental legislation a 3D connotation (Erba and Piumetoo, 2012). A 3D representation of spatial units supports the clarification of the spatial and legal status of every property. Despite all research

and progress during the last decade, still no country in the world has a true 3D cadastre, the functionality is always limited in some manner; e.g. only registering of volumetric parcels in the public registers, but not included in a 3D cadastral map, or limited to a specific type of object with ad hoc semi-3D solutions (e.g. for buildings or infrastructures) (http://3dcadastres2011.nl). It remains as a challenge, for every country, to spatially locate, in three dimensions, the properties and clarify at least the ownership right for each property unit. A 3D legal and spatial ownership right clarification, for all space, without any gaps, as shown in Figure 4, remains a challenge as well, and can serve broader objectives of a LAS.

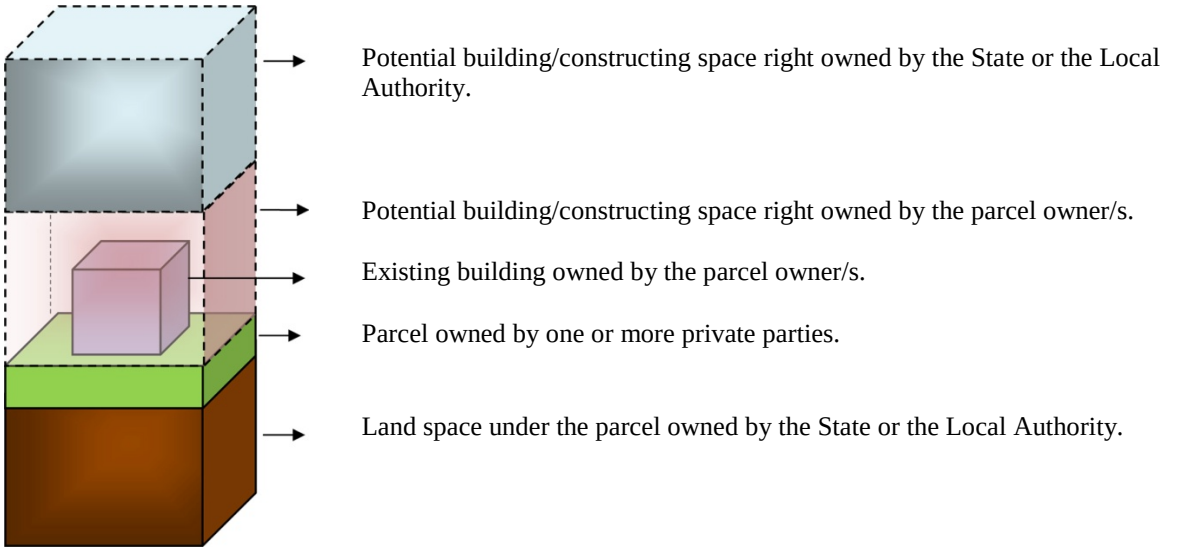


Figure 4. 3D legal and spatial ownership right clarification

3.1. Need for a common, conceptual framework allowing the exchange of legal 3D RRR information within the Cadastral Domain.

Legal aspects play an increasingly important role in establishing a functional 3D cadastral system, especially in urban areas with multilayer complex development, infrastructures and utilities, or in areas under customary rules, where even landless properties may exist. Appropriate legislation is therefore needed for the unambiguous definition and physical extent of land parcels along with interests in land affecting one or more parcels. In most jurisdictions land parcel, as cadastral unit, is referencing every right and restriction through its unique identifier. Information on land parcels where such RRs apply constitutes the core of Land Registries and Land Information Systems (LIS), based on statutory, common and customary law, reflecting each country's origin. However, national land administration systems change over time in response to modern needs and technological advantages that may broaden their initial scope in a more international context.

According to Kaufmann and Steudler (1998) the first statement in 'Cadastre 2014' concerns a complete documentation of public and private RRs for land owners and land users. It is further stated that 'Cadastre 2014' will be embedded in a broader LIS, fully coordinated and automated concerning all legal land objects in a country (or district), as defined by the laws. The legal land objects normally are described by boundaries which demarcate where a right or a restriction ends and where the next begins and the contents of that right. However, at a global level, over 70% of the land is generally outside any land registry. Therefore, depending

on the socioeconomic conditions and characteristics of these countries where informal settlements, slums and customary rights prevail, a range of interests in land, cannot be described and formally recognized into LAS. For these cases, a model has been developed, to accommodate social tenures, termed the Social Tenure Domain Model (STDM), making introducing new forms of spatial units (Lemmen, 2010). Another approach lies in a model proposed by Kalantari et al (2008), replacing the physical land parcel by a spatially referenced data model, based on the legal property object, in order to facilitate the organizing of a wider range of interests and exchange of information. According to this modelling approach, all kind of interests with their spatial dimension constitute a unique entity in the real world. In this way of modelling, RRRs are not seen as a separate entity or class and as Lemmen states (2012), RRRs are defined in legislation, there can be shares, and there can be different organizations with responsibilities in maintaining the attributes of a Legal Property Unit.

The Draft International Standard, published by ISO as ISO 19152 (also called LADM Version C) includes rights (such as real or personal rights and customary rights), restrictions and responsibilities related to components of land administration, as well as agreements on data about administrative and spatial units and source documents. The three main packages of the LADM consist of the Party package, the Administrative package and the Spatial Unit package (Lemmen, 2012). The class representing the relationship between persons is abbreviated to LA RRR, meaning LA Right, LA Restriction and LA Responsibility. The set of RRRs related to a given spatial unit or a number of spatial units are stored in the Basic Administrative Unit (LA BAUnit). This includes land, volumes and water parcels (via any geometrical defined Spatial Unit) which can be the object of RRRs held by a given Party (Hespanha, 2012).

3.2. Integration of legally defined spaces to a Cadastral System based on LADM

The LADM (LADM, 2012) supports 2D, 3D, or mixed 2D/3D representations with various levels of accuracy: text-based, point-based, unstructured (line)-based, polygon-based or topology-based. It offers a spatial representation for a variety of spatial units including normal land parcels, legal spaces around buildings, and legal spaces around networks/utilities (Figure 5). Within the LADM, classical cadastral concepts, as “parcel” and “boundary”, have been extended to be able to include spatial representations of overlapping rights/restrictions and also multidimensional objects (3D and 2D/3D, combined with temporal dimensions). Furthermore, a series of new representations are possible, apart from topologically well structured parcels.

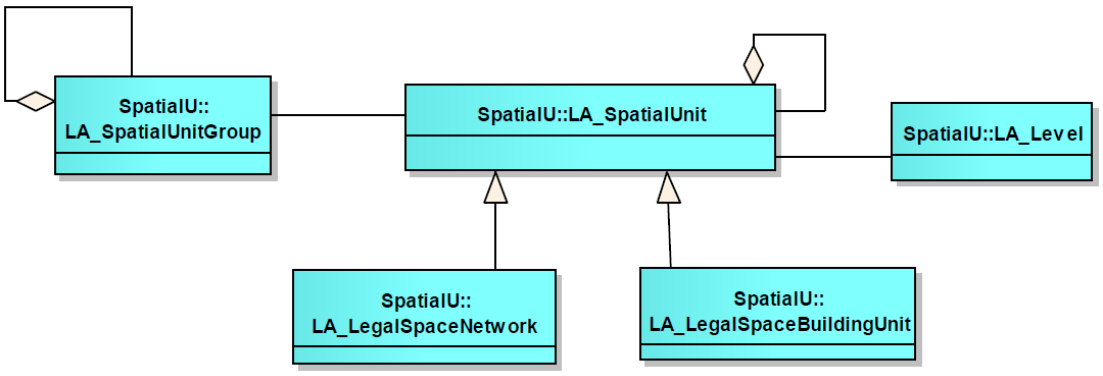


Figure 5. Classes of LADM Spatial Unit Package (LADM, 2012)

The LADM provides a conceptual description for a land administration system, including a 3D topology spatial profile (Figure 6). LADM defines a 3D parcel as the spatial unit against which (one or more) unique and homogeneous rights (e.g. ownership right or land use right), responsibilities or restrictions are associated to the whole entity based on ISO 19152 (Thompson and Van Oosterom, 2011). In case of the 3D topology representation, a 3D boundary face has plus/minus information included in the association to a 3D spatial unit. Each boundary face can be derived from the surveyor with Surveying and Representation Subpackage (Ying et al., 2011).

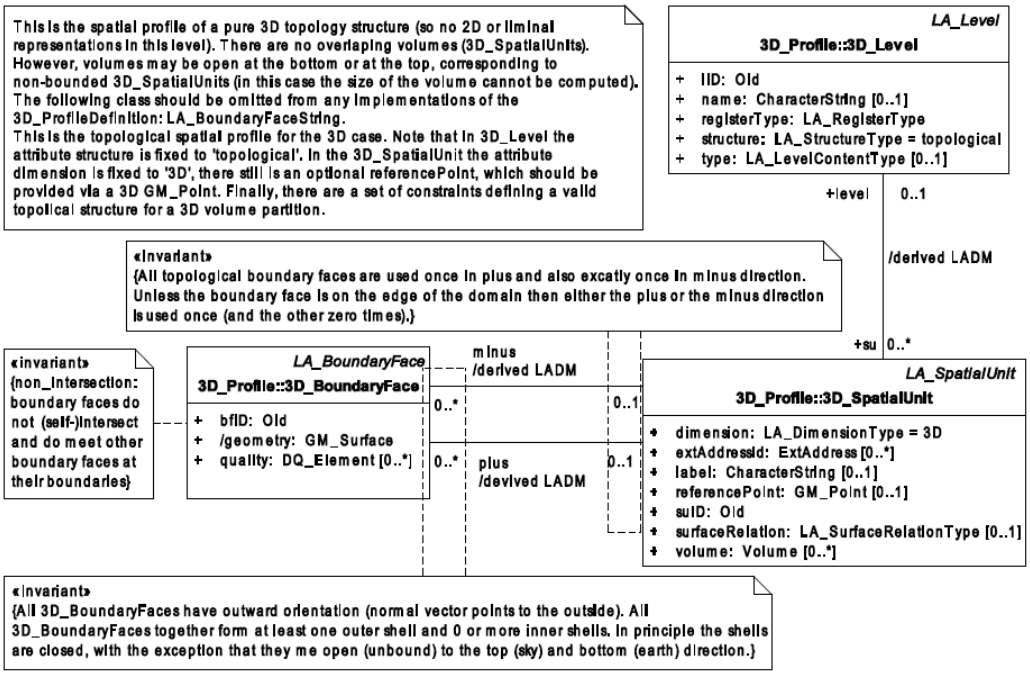


Figure 6. The notation of multiple levels in LADM – 3D topological based.

The Hellenic Cadastral model is also organized in reference with the land parcel (parcel-based), structured in cadastral sectors and cadastral sections (as a set of continuous land parcels surrounded by natural or manmade boundaries) consistent with the division used for the cadastral survey process. Concerning the buildings, their legal information is registered and maintained, while their spatial visualization is so far excluded.

Figure 7 illustrates the spatial unit class in the proposed Cyprus Land Information System data model, based on LADM. For the time being, a 2D representation of spatial units is used, which needs to be extended to 3D. The LA_SpatialUnitGroup can be used to define the level in the hierarchy of administrative subdivisions as well as for planning zoning. Cyprus is divided in districts, quarters and parcel blocks. The LA_LegalSpace-BuildingUnit can be used for the buildings registration.

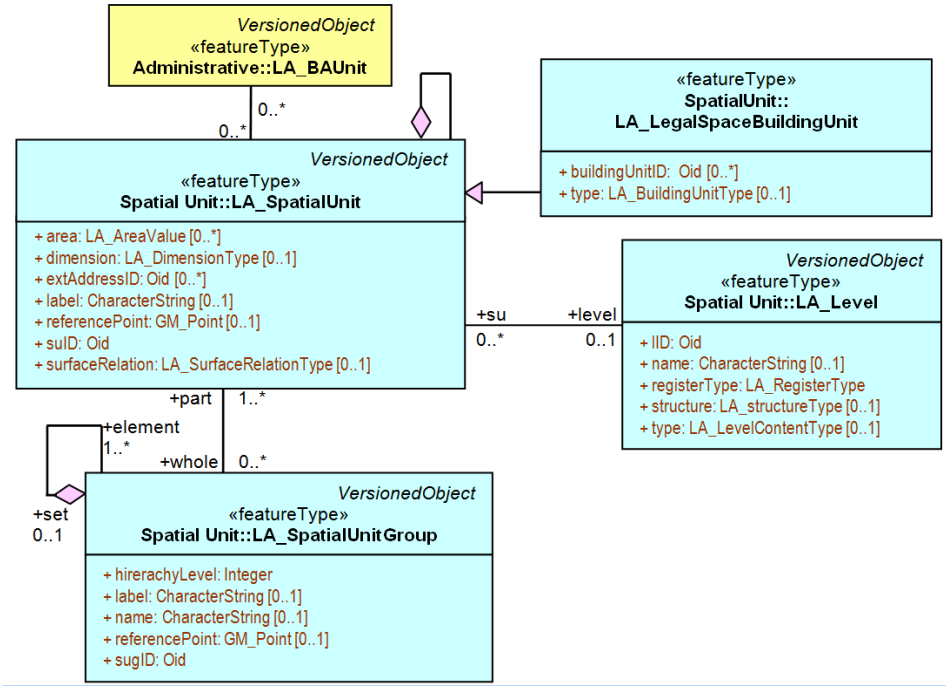
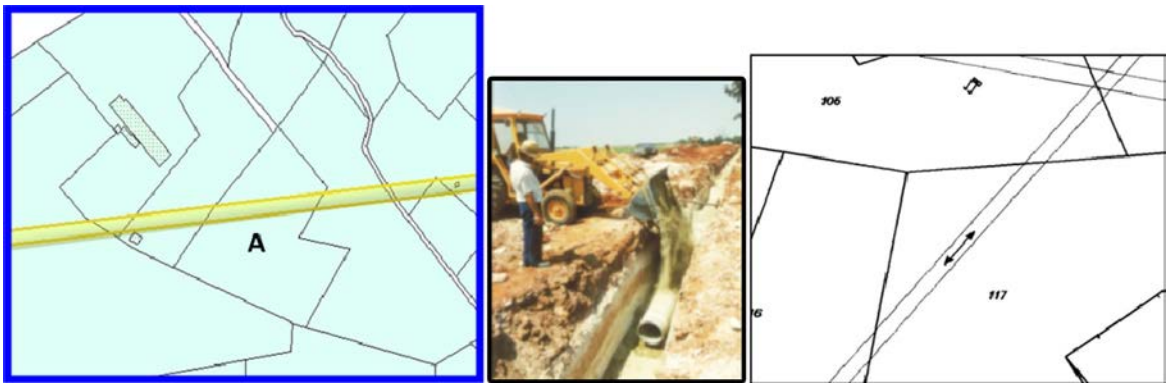


Figure 7. The spatial unit class in the proposed Cyprus LIS data model, based on LADM

A "level" in LADM is a collection of spatial units with a geometric or thematic coherence. The concept of level is related to the notion of "legal independence" from 'Cadastre 2014'. This allows for the flexible introduction of spatial data from different sources and accuracies, including utility networks, buildings and other 3D spatial units, such as mining claims, or construction works (Lemmen et al., 2010).

Figure 8 presents an instance level diagram indicating the use of a separate level for the storage of passage or channeling rights/restrictions, in the Cyprus proposed model. The specific example refers to the south irrigation underground water pipe. The channeling access right is registered for the benefit of the State. The right of the State is at the same time a restriction-for-channel over all affected parcels. In this example the right/restriction rights are given for only one parcel (parcel A). The restriction (negative side) could automatically be determined based on the geometry, and not included in the diagram. The right is appeared on the cadastral plan as a double linear feature (rights figure) and it is noted on the title certificate of the affected parcels as "right of the Cyprus Government to place and use pipes". A 3D definition of the underground pipe, however, would have leave no doubt and would have clarify the legal and the spatial position of the channeling right. Furthermore, the accurate 3D-survey of the pipe can facilitate its future tracking, needed for maintenance purposes or for any other reason. When constructing the 3D spatial unit, it has to be taken into consideration that the legal space of the spatial unit does not always coincides with the physical construction of the unit and it might be necessary to represent both situations. In this case the "volume" of the channeling right is bigger than the actual pipe volume.



Right to place and use pipes

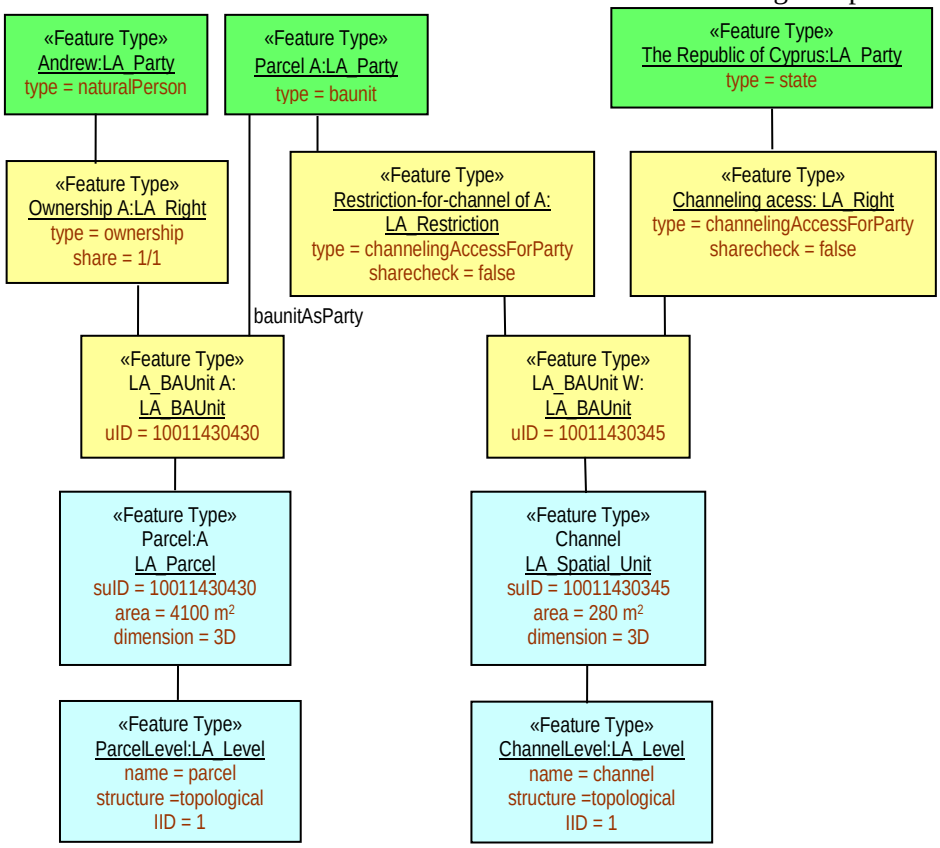


Figure 8. Channeling access right of the south irrigation underground water pipe

There are a number of papers illustrating the design of 3D cadastral models based on LADM (Ying et al., 2011; Vandysheva, 2012), and how to construct 3D spatial units and establish their topological relationships. The modelling of various cadastral entities such as complex buildings, or other types of constructions, and subsurface networks (e.g., cables and pipelines) were examined by Vandysheva et al. (2012). The 3D registration (in the Russian Federation) is based on two types of objects (a) 3D polyhedron volume (flat planes) and (b) 3D multicurve with diameter (curved surfaces around pipelines). Vandysheva et al. (2012) concluded that it is relatively easy to implement 3D cadastral entities with current technology (database, GIS/CAD). A similar approach could be implemented for the above cases in Cyprus and Greece.

4. CONCLUSIONS - DISCUSSION

The present study deals with correct registrations of RRRs and location of properties, through the experience offered by the legal framework in Greece and Cyprus. It is obvious that cadastral research as provided by the literature is mainly focused on technical aspects, although legal systems in most countries impose constraints that prohibit the development of 3D cadastres. Parties, RRRs and spatial units vary between different national land law, having an impact on 3D cadastral modelling and representation. Even terms, definition and physical extent of land parcels, as well as of interests in land, significantly differ under diverse legislations, requiring changes and amendments of regulations. The Greek and Cyprus legal framework in its current structure has limitations to effectively describe and spatially define 3D properties' boundaries (see Figure 4). Furthermore both countries are based on two-dimensional registration and cadastral systems, which do not facilitate the 3D modelling of the modern complex multilayer reality. Constraints deriving from the legal framework are not flexible to adjust. Further research in legislative frameworks incorporating 3D methodologies need to be internationally promulgated in order to clearly define, register and represent modern structures of developing property rights.

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