Evolution of modern cadastre during the period 1990 – 2020 – Future trends

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HELLENIC CADASTRE

During the 1990s, the Cadastre is defined as "*a Land Information System (LIS) designed to assist in land taxation, real estate conveyancing, and land redistribution. A Cadastre is normally a parcel-based system, i.e, information is geographically referenced to unique, well-defined units of land*" (The FIG Statement on the Cadastre, 1995). Data of general interest to a wider community of interest, which are usually considered part of the Cadastre, include: **land parcels** (e.g. location, boundaries, coordinates), **land tenure** (e.g. property rights, ownership, leases) and **land value** (e.g. quality, economic value, tax value, value of improvements). Supplementary geo-information for land development (e.g. buildings, agricultural data, forestry data, utilities, fisheries, environmental quality and demographic data) can also be connected to land parcels.

In other words, "*Cadastre*" takes the form of a "*Cadastral System*" which provides a 2D representation of spatial information. The descriptive information (such as land value, ownership, or use) embedded in the textual or attribute files of the Cadastral Data Base, can be accessed by the unique parcel codes shown on the cadastral map [1].

In mid 1990s, further impulsion emerges for the implementation of land management policies in order to provide the necessary framework for recording land related data and supporting effective decision making (FIG-UN FAO, 1995) [2]. This results in the re-examination of the framework, main goals and objectives of Cadastre and in its gradual conversion into "**Land Administration**" (LA). LA is defined as "*a process of information determination, recording and dissemination about the ownership, value and use of land when implementing land management policies*" (UN/ECE Land Administration Guidelines, 1996) [3].

In 1998, FIG Commission 7 publishes the first edition of the "*CADASTRE 2014*" Report (which is finalized in 2014) [6]. CADASTRE 2014 underlines the trends in the cadastral field, provides suggestions and generally, demonstrates an ambitious vision for the Cadastre over the following 20 years towards 2014. CADASTRE 2014 is meant to fulfil a multi-purpose role, while taking the emerging technological advances into consideration. In addition, the more general term **"(land) object"** is introduced as the basic real property element to which Rights, Restrictions, and Responsibilities (RRRs) apply.

The new term "**Land Governance**" which emerges approximately in 2010 is referred to *"the policies, processes and institutions by which land, property and natural resources are managed. Land Administration Systems provide a country with an infrastructure for implementing of land policies and land management strategies in support of sustainable development"* (FIG, 2014) [5]. In that context, a LAS is considered an operational subset of Land Governance.

A fundamental milestone for the upcoming evolution of 3D Cadastre is the conceptualization of the Land Administration Domain Model (LADM), which in 2012 becomes the International Standard "**ISO 19152**". LADM enables the combination of land administration information from different sources in a coherent manner and furthermore provides an abstract conceptual (modular and extensible) representation scheme related to *Parties* (people and organizations), *Basic Administrative Units*, *Rights, Responsibilities, and Restrictions* (RRR) (ownership rights), *spatial* (surveying) and *legal sources* (titles, deeds etc), as well as *2D / 3D representations* (geometry and topology) *of spatial units* (e.g. parcels, etc) [4].

After LADM has broadly been recognized as one of the best models to unambitiously represent 3-D RRRs (legal aspects), extensive research is also being conducted on various spatial data models and virtual 3D topographic / city models (e.g. CityGML, BIM, InfraGML, LandXML, IndoorGML, etc) which can be used to describe the physical reality. The integration of LADM with some of those spatial models is leading to quite promising results (Kalogianni, et.al, 2017) [7]. Furthermore, standardization in the land administration domain has been expanded to 3D and even 4D representations (integration of the temporal dimension either as separate attribute or via truly integrated 4D spatio-temporal geometry/ topology) in order to become the foundation of a sustainable and smart economic development.

ENABLING TECHNOLOGIES

In the 1990s, cadastral surveying is usually conducted using either simple ground survey methods (e.g. use of plane tables or tapes and optical squares) or more sophisticated methods, e.g. EDMs and Total Stations for acquiring higher accuracy data. Global Positioning Systems (GPS) technology is broadly introduced in field surveys in order to provide higher accuracy at a relatively low cost.

Commonly used data for cadastral surveying in the 1990s are aerial photographs, orthophotos and enlarged photo-prints which also enable more cost-effective surveys. The use of analytical photogrammetric methods and GPS ensures the derivation of high accuracy information.

Geographic Information Systems (GIS) and other computerized mapping systems become the fundamental tool for the creation, management and maintenance of geospatial data bases, which set the foundations for a multi-user and multi-purpose Cadastre (The FIG Statement on the Cadastre, 1995).

In the last decade, the frantic technological evolution in the domain of geo-informatics, data acquisition systems and ICT is inevitably leading to a vast amount of geographic data types available for collection and processing in order to fulfil the demands and the objectives of multi-purpose and fit-for-use LIS; Lidar data, aerial photographs, UAV images, satellite imagery, field data, laser scanning data, mobile mapping data, GPS / GNSS data and citizen-collected information are among those data types.

Current trends in land administration include the use of cloud technology, web and mobile services, which a) promote faster and cheaper data creation, management and maintenance and b) provide the capability of real-time storage of very large data volumes. Moreover, the introduction of VGI (Volunteered Geographic Information) Practices into Cadastre and Land Administration procedures has become a subject for further investigation and research, as recent studies have proven that *"the crowdsourced draft cadastral maps can be low-cost, fast, and free of gross errors"* (FIG, 2019) [8]. This leads to the conclusion that the use of VGI could fulfil the urgent societal and governmental needs and requirements through the establishment of a fast and low cost LAS, which in turn is aiming to improve transparency and provide support to the national economy.

PERSPECTIVES OF FUTURE CADASTRE

Many countries are looking to the future at how their Cadastres can develop to better satisfy the societal demands. A good example is Australia where the Intergovernmental Committee on Surveying and Mapping (ICSM) has just released a National Cadastral Reform and Innovation Strategy titled **"CADASTRE 2034".** The aim of the proposed 3D, federated and based on common standards, LAS, is to be a highly influential part of tomorrow's decision support systems; powering land and real property integrated and sustainable management, development and investment [9].

In the vision of "CADASTRE 2034", current and future technology is a primer enabler for implementation of the cadastral reform strategy. As actual part of CADASTRE 2034 or, as potential part of the Cadastre over the following 30 years, indicative initiatives / actions towards a more effective land governance could include:

- Taking full advantage of automated workflows and integrated systems that enable mobile business and online consumer transactions.
- Determining various rights, restrictions and responsibilities (RRR) on land and managing them inside a proper legislation and policy framework.
- Promoting real-time, direct transfer of survey accurate field data to the cadastral Data Base.
- Further exploitation of semantic web technology (Web 3.0) and especially, the semantic tagging of the content.
- Extensive use of computer graphics, innovative visualization technologies and the BIM.
- Further research on 4D spatio-temporal representations, and last but not least,
- Compliance of all national cadastral reform strategies with the basic principles for efficient, secure and transparent land governance and adoption of good land governance practices.