The second themed article collection on the land administration domain model (LADM)

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1. Introduction

Main political objectives, such as providing social justice with tenure security for all and access to housing and (basic) infrastructure, peace building and security, protecting the environment, implementing sustainable land use, strengthening the role of vulnerable groups (e.g. indigenous people and women), introducing city management with fair taxation, building smart and resilient societies, developing disaster and resource management, are in many ways related to access to land and to land-related opportunities. Achievement of those objectives is in support to the achievement of the Sustainable Development Goals (SDGs) and this requires well-functioning land administration systems.

Supporting these political objectives implies the requirement that a land administration should be able to organise and guarantee all possible relations between people and land: formal and informal tenure, customary tenures, etc. This functionality is provided by the Land Administration Domain Model (LADM) (ISO, 2012; Lemmen et al., 2015). The LADM international standard ISO 19152:2012 is based on profound knowledge of land administration (built up over centuries) as contributed through a consensus process by experts from all over the world. As a conceptual data model, the LADM can be used in support of the development of software applications for land administration purposes. In many countries land administration is organised in a distributed environment where data exchange and interoperability between involved organisations is required, this interoperability can be organised based on the LADM. The same can be done for quality management in land administration.

This article collection (earlier called 'special issue') in Land Use Policy introduces the recent developments in the Land Administration Domain Model. The collection is based on a selection of designated papers from the proceedings of LADM workshops held in recent years: Delft, the Netherlands 2017 (FIG, 2017), Zagreb, Croatia, 2018 (FIG, 2018), Kuala Lumpur, Malaysia 2019 (FIG, 2019) and Virtual 2021 (FIG, 2021). The 10th Workshop on the Land Administration Domain Model was held in March/April 2022 in Dubrovnik, Croatia (FIG, 2022). The authors of the selected papers were asked to add substantial new content to the original versions. Moreover, the papers submitted had to pass the peer review process of Land Use Policy. This article collection can be seen as the second special issue on the Land Administration Domain Model (LADM) in Land Use Policy, with the first one published in December 2015.[1] Major issues covered are related to 3D land administration, data integration between diverse organisations' registers, innovative apps for data collection, and how to link LADM with other land domain standards/models. Much of the findings presented in the articles served and is serving as input for the ongoing work on the current revision of LADM.

ISO standards, which are actually being applied, are subject to periodic revision, typically in a six to ten year cycle. A meeting of the UN-GGIM[2] Expert Group on Land Administration and Management was held on 14–15 March 2017, in Delft, the Netherlands. The Expert Group recommended to work towards accelerating the proportion of global population's with documented, recorded and recognized land rights. The Expert Group supported the upcoming ISO-TC211 and OGC review of ISO 19152 – Land Administration Domain Model.

This review is indeed needed in order to provide more complete tooling to improve tenure security and better land and property rights for all. It was also noted that land administration is a rather complex domain, and thus the revision will involve many stakeholders, namely: the United Nations Human Settlements Programme (UN-Habitat), the UN-GGIM, the Worldbank, the Global Land Tool Network (GLTN), the

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[1] See the special section on the Land Administration Domain Model in Land Use Policy, December 2015, pages 527 – 689. https://www.sciencedirect.com/journal/land-use-policy/vol/49#article-47
[2] UN-GGIM is the United Nations Committee of Experts on Global Geospatial Information Management

International Federation of Surveyors (FIG), the International Organisation for Standardisation (ISO), the International Hydrographic Organization (IHO), the Open Geospatial Consortium (OGC), the Royal Institution of Chartered Surveyors (RICS), etc.

A new edition of the Land Administration Domain Model (LADM) is under development in ISO/TC 211 on Geographic Information. The Committee is developing this new edition of the LADM as multipart (titles are working titles):

– Part 1 – Generic Conceptual Model. This part provides the scope and definitions, a general overview of the model, its core classes and its individual packages and a more detailed overview of the LA_Source and VersionedObject classes,
– Part 2 – Land Registration. This part introduces the Land Registration Standard including a refined Survey and Representation package with a range of measurement techniques. It further includes updates around the functionality published in Edition 1 of the LADM,
– Part 3 – Marine Space Georegulation. This part is based on IHO's S121 standard: Maritime Limits and Boundaries,
– Part 4 – Valuation Information. This part specifies the characteristics and semantics of data in valuation registries maintained by public authorities,
– Part 5 – Spatial Plan Information. This includes planned land use (zoning) to be converted into rights, restrictions and responsibilities (RRR), and:
– Part 6 – Implementations. This part will address a range of topics needed for implementations of LADM: developing a country profile, modelling processes/ workflows, and encodings.

These parts constitute separate standards. Each part will go through the full standardisation process. This article collection provides a foundation for the revision of the LADM (the revised version is here referred as Edition 2 of the LADM).

Edition 2 of the LADM is backward compatible, so the functionality included in Edition 1 of 2012 is included in Edition 2. The content of Edition 1 returns in Edition 2 in Part 1 (Generic Conceptual Model) and in Part 2 (Land Registration). This may seem complicated, but in this way the re-use of the contents of Edition 1 can be organised in the best possible way, not only for land registration, but also for the marine space georegulation, value information and spatial plan information.

LADM is finding increasing recognition. Kalogianni (2021) provides an overview (with sources) of fifty developed LADM country profiles. Ten of these are in the implementation phase or have been implemented. In addition, a community has developed around LADM which meets in person and online at workshops that have been organised since 2001.[3] Important global developments concerning land administration refer to the LADM as the United Nations Framework for Effective Land Administration (FELA) (UNGGIM, 2020) and the Fit-For-Purpose Land Administration Approach (FFPLA) (Enemark et al., 2014; Enemark et al., 2016). Also, the Millenium Challenge Cooperation (MCC, 2020) and other donor organisations recognise the LADM. From the bibliographies in Polat et al. (2022) and Paulsson and Paasch (2015) the academic recognition can be seen.

2. The LADM article collection

The implementation of LADM is not a goal in itself, it is serving the need to setting up good land administration systems that address and are able to adapt to current needs. The above contributions show that the LADM is applied within a professional user community. But of course, it remains a very specific topic. In each country, a relatively small group of experts is responsible to set up a land administration system. Standardised models such as the LADM support this development, which is

seen as an important advantage. That is why it is important to expand the functionality of LADM, to improve it where necessary (and where possible) and to keep it attuned to the requirements and wishes of the users.

This section gives an overview and short introduction of the included articles. The articles are introduced in alphabetical order of the family names of the first author.

Aditya et al. (2021) present the design and implementation of a LADM compliant mobile app to complete the land titling in Indonesia by 2024. About 70 million of Indonesia's 126 million land parcels are not certified. Indonesia's land administration has to deal with data reliability and quality issues, as more than 17 million of its 58 million published land titles are not spatially and legally validated. The app enables an integrated collection and validation of spatial and legal/administrative data in the field as well as a connection to the national cadastral and civil registry databases.

Alattas et al. (2021) analyse the regulations related to the use and ownership of building complexes with multiple units in Saudi Arabia. The 3D representation of subdivisions of building units is mapped through the LADM country profile. The paper bridges the gap between the project-oriented world of the Architecture, Engineering and Construction sector (Building Information Modelling (BIM)) and the legal registration as described through the LADM. The authors have the impression that their findings for Saudi Arabia can be replicated in other countries.

Atazadeh et al. (2021) observe a knowledge gap in logical relationships between legal and physical views as most of the existing approaches that integrate 3D legal and physical dimensions have been mainly proposed on a conceptual level. The main argument of their study is that the multi-dimensional nature of BIM provides the ability to extend this environment with concepts defined in the LADM. Therefore, this study investigated how an open BIM-based data model, known as Industry Foundation Classes (IFC), can be extended with LADM data elements to support integration of legal and physical views.

Flego et al. (2021) provide an analysis of registration in the maritime domain in Croatia. The analysis includes two connected key land registers: the Cadastre and the Land Book. Other authoritative data are from the Territorial units/Address register; the Utility Cadastre; the Register of Concessions in the maritime domain; Spatial Plans, and a series of registers dedicated to natural resources exploitation as well as to nature and cultural heritage protection. Redundant data and cross-registration is observed to be common for all core LADM classes contained in the registers.

Govedarica et al. (2021) share their experience in the design and implementation of a LADM-based cadastral information system in Serbia, Montenegro and the Republic of Srpska. The authors are emphasising that there is a need for modernization with more efficient and interoperable cadastral information systems. In the paper attention is given to conceptual modelling and development of LADM based country profiles in these regions, to the definition of real estate cadastre business processes, to database implementation and data migration and to the country profile implementation. Findings can be used as a basis for the development of a more general methodology for LADM-country profile design.

Hagemans et al. (2022) use the LADM in support to Cadastral Map Renovation in the Netherlands. The LADM was used as inspiration to incorporate field observations from historical field sketches in an automated way to build a so called 'Reconstruction Map', that is the renovated Cadastral Map with known geometric accuracy. Almost all observations from about 5 million digitally archived (historical) field sketches must be processed. This requires far reaching automation. An important step in this process is to redesign the current data model from parcel level to the more specific boundary level to achieve an unambiguous connection between cadastral objects and its related survey data. It has been decided to implement the presented approach in the Netherlands.

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[3] https://wiki.tudelft.nl/bin/view/Research/ISO19152/

Indrajit et al. (2021) propose an extension of the LADM. To promote exchange of information between the domains of land administration and spatial planning a new LADM package is proposed: the Spatial Plan Information Package. This work also develops a proof-of-concept of the package in the two biggest Indonesian cities (Jakarta and Bandung) with adaptation to the current national data management policies. The research shows positive results in developing the LADM country profile reflecting the real conditions and improving LAS's adaptability to be integrated with the Spatial Information Infrastructure.

Kalogianni et al. (2021) observe that, so far, various approaches for creating LADM-based country profiles have been followed. This resulted in the creation of an interesting mosaic of country profiles' developing methods, with parts to be exploited and an outline of the basic steps of the development provided. Based on this knowledge, the aim of this paper is to design a methodology for the development of LADM country profiles. A set of six generic characteristics/criteria has been developed. The designed methodology to develop LADM-based country profiles is presented and structured in three phases: scope definition, profile creation and profile testing.

Kara et al. (2021) describe the development of a prototype for the implementation of the LADM Valuation Information Model and assesses its operability through a case study in Turkey. The capabilities of the model are tested and the article presents the experiences gained during the implementation. Moreover, strategies for implementing and managing property valuation information more efficiently (e.g. bi-temporal aspects of valuation information management) are also studied and applied to the implementation. The main contribution of this paper is to provide a holistic approach on how to develop an LADM conformant prototype for managing property valuation information.

Morales et al. (2021) notice that, in order to achieve documented land rights for all, new approaches are needed to produce land data more rapidly. Those new data acquisition procedures must be simple, comply with societal needs, support data collection by citizens and allow proper scaling up. The authors designed a mobile app connected to a GPS receiver. This constellation can be used by communities to collect land data – supervised by professionals. The LADM country profile is used in several areas in Colombia with different land rights structures.

Oukes et al. (2021) describe how the Netherlands' Cadastre, Land Registry and Mapping Agency successfully undertook the renewal of the information system supporting its deeds registration. The previous system dated back to the 1980 s. In-house data modelling specialists led the program, the most extensive undertaking in decades. It is shown that beyond Model Driven Architectures, other model-driven methodologies, such as Domain-Driven Design, are useful in the land administration domain. The application of Event-Based Modelling and Event Sourcing is still relatively novel to the LA domain. The new information system is considered futureproof, delivering improvements for deed registration times, monitoring, traceability/auditing, history management and interoperability.

Polat et al. (2022) present the second bibliometric analysis of LADM based research. It is noted that this study is based on the same principles as similar research published by Paulsson and Paasch (2015). In this study, which covers 2012–2020, 175 LADM related scientific publications were found in the Scopus database. Also, the proceedings from the International Federation of Surveyors (FIG) events and workshops on LADM were investigated. This analysis considers author identification, type of paper, organisational issues, and bibliometric analysis components. The analysis considered articles, books, and proceedings directly related to the LADM.

Rajabifard et al. (2021) aim to design and develop a LADM-driven 3D Land Administration System (LAS) for Malaysia. The proposed approach includes modifications in the existing workflows for capturing 3D survey data, new architecture to support 3D land parcels, and a new database for creating an LADM-based 3D LAS in line with the data requirements in Malaysia. The major part of the upgrade from 2D to a 3D environment consists of capturing, processing and management of the height of survey points that define the parcel boundaries. This study demonstrates and confirms that the LADM standard plays a significant role in realising a 3D-enabled system for land administration in Malaysia.

Stubkjær and Çağdaş (2021) call for a mediating platform for the LADM and the OGC Land and Infrastructure Conceptual Model Standard (LandInfra). The Cadastre and Land Administration Thesaurus (CaLAThe) was issued in 2011 and based on the then draft version of the LADM standard. CaLAThe was further developed to also include terms of the OGC LandInfra standard. The recent version integrates code list names and values, reflecting both the relevant parts of LandInfra and some of the code lists from the LADM. CaLAThe thus constitutes a shared universe of discourses, a frame for joint management of the code lists of both standards.

Thompson and Van Oosterom (2021) observe that real world changes and related improvements of database representations require better tuning in many cases. The authors argue for a database with bi-temporal history – where current best knowledge of the history of the cadastre is recorded, and that history is corrected and maintained, while our past knowledge of the data is also recorded. This is realized via two types of time: database (or system) time and real world (or valid) time. Real world in this case is the reality where transactions between parties take place. Those transactions are managed in a LA database later. Their paper is intended to assist with an extension of the temporal model as input for the revision of LADM to accommodate bi-temporality.

Tomić et al. (2021) aim to assess the possibility of using existing authoritative land and other public registries data as a basis of mass property valuation for public purposes. Their results indicate that some of the required data already exist but are divided across the different key registers. As a step towards implementation, identified attributes and parties were modelled using UML use case and class diagrams to explore possible data integration. By applying the proposed real property classification and valuation indicators, the Croatian property valuation system prototype for public purposes can be developed.

Unger et al. (2021) explore whether and how the LADM, in terms of data model additions and adaptations, could support SDG-relevant domains. The authors show the potential and added value of an integrated data modelling approach, with regards to LA and its intrinsic features to other fields of study including poverty reduction, food security, and gender equality. Developments using standardised modelling approaches and domain terminologies can be used to support gathering, organising and disseminating information relevant to reporting on and monitoring of the SDGs. From the perspective of data sharing, domain models are seen as supporting this capability.

Vranić et al. (2021) note that Work Flow Management Systems (WFMS) with integrated transactional properties provides a technological platform which supports enforcing consistency within heterogeneous IT environments. The authors developed an extension to LADM for integrating processes in order to keep the data up to date. They propose to extend the LADM with a new class LA_Process, as a sub-class of the existing LADM class LA_Source. This extension is proposed to be included in the second edition of the LADM which is under development. In addition to this proposed extension of the LADM they give an example of hierarchical modelling of LA processes.

Yan et al. (2021) develop an underground utility 3D data model to manage and integrate various data from underground utility survey to underground utility data used in land administration. The LADM provides a formal language to manage the rights, responsibilities and restrictions information of land (or water), and the geospatial components. The Underground Utility Data Model (UUDM) inherits some definitions from LADM in order to manage the information related to underground utility survey and land administration. This can help to develop the data model as a standard for underground utility data management and quality control in the next step.

Ying et al. (2021) focus on the easement of the right to access, which is the right to cross the property to go to and from another property, in the context of 3D cadastres. The model of easement spatialization which

is based on BIM/IFC standards is constructed and analysed. The servient owner and the dominant owner of the easement can be linked because they are both attached to the same physical space. This paper takes a multi-storey building having individually owned condominium units as an example to demonstrate how to access the semantic information associated with the geometric information of 3D property objects in BIM.

Zulkifli et al. (2021) discuss 3D strata objects registration and implementation within the LADM framework in Malaysia. Their research presents the practical pathway towards realizing a LADM-based 3D strata objects registration in alignment with the jurisdictional settings in Malaysia. An accurate 3D cadastre for a property including strata has become important for the land administration system. A prototype is developed. The authors anticipate that this work could serve as the model for other national authorities.

The development of Edition 2 is ongoing. The papers in this collection are an important input for that edition.

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