

The Land Administration Domain Model (LADM): Motivation, standardisation, application and further development



Peter van Oosterom^{a,*}, Christiaan Lemmen^{b,c}

^a Delft University of Technology, Faculty of Architecture and the Built Environment, Department OTB, GIS Technology Section, P.O. Box 5030, 2600 GA Delft, The Netherlands

^b Dutch Cadastre, Land Registry and Mapping Agency, Apeldoorn, P.O. Box 9046, 7300 GH, Apeldoorn, The Netherlands

^c University of Twente, Faculty ITC, P.O. Box 217, 7500 AE, Enschede, The Netherlands

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ABSTRACT

This article is the introduction to a themed issue on the Land Administration Domain Model, the ISO 19152:2012 international standard. The Land Administration Domain Model (LADM) facilitates the efficient set-up of land administrations. It can function as the core of any land administration system. LADM is flexible, widely applicable and functions as a gathering point of a state-of-the-art international knowledge base on this theme, reflected in aspects such as full versioning/history, integration with legal and spatial source documents, a range of 2 Dimensional and 3 Dimensional (2D/3D) geometry and topology options, unique identifiers, and explicit quality indicators (metadata). It can be aligned to the global agenda where land administration is concerned. This paper describes the context and the actual standards development of the LADM. Further, some future trends in the domain and the maintenance of the standard is discussed. This completes the scene and provides the background for the papers in the themed issue

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1. Introduction

This article is the introduction to a themed issue on the Land Administration Domain Model, the ISO 19152:2012 international standard. The importance of land administration as basis for a country's suitable development by providing a basis for security of tenure, valuation and taxation, spatial planning, and land/resources management is first recaptured and put in a global perspective with actors such as UN-Habitat, the Food and Agricultural Organisation of the United Nations (FAO), the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM) and the International Federation of Surveyors (FIG). The needs for, and benefits of, a domain standard are next elaborated on. The ever increasing role of Information and Communication Technology in general and specific developments (such as 3 Dimensional and 4 Dimensional representations, semantic web-technology, mobile applications and more direct updating by actors, including the community) are among the functionality to be supported by future systems. This article also explains the LADM development process and history within FIG and the International Organisation for Stan-

standardisation (ISO), and then looks forward to the maintenance and further development of the standard. This completes the scene and provides the background for the papers in this themed issue. In the second half of this article, the papers are introduced one by one and put into the above described context of standardization and future developments within land administration.

2. Land administration

Land administration supports the provision of security of tenure; it is a basis for valuation and taxation of property, for access to credit (as a basis for investment), for sustainable land use, minimisation of land conflicts, and better management of natural resources. Just like these issues benefit from proper land administration, land administration systems themselves benefit from proper data standards. In many countries the responsibilities and tasks in land administration are distributed among different branches of government and government agencies. Sometimes those organisations deal with different administrative territories, all of which may have subdivisions again: central, regional and local responsibilities, with either public or private roles. Many systems are related to administration of specific tenure types based on specific legislation and regulations. As a result, the governance and quality aspects of the datasets vary. Land administrations world-

* Corresponding author.

E-mail address: P.J.M.vanOosterom@tudelft.nl (P. van Oosterom).

wide are often incomplete; data are not up-to-date and not fit for purpose. At the same time, new land administration systems are being developed repeatedly all over the world. Sometimes countries even have more than one computerised system for land administration. The wheel keeps being re-invented. This has a huge impact on the continuity and effect of land administration systems.

3. Domain standards

LADM is one of the first spatial domain standards within ISO TC 211. TC 211 is the Technical Committee on Geographic Information within the ISO. There is a need for domain specific standardisation to capture the semantics of the land administration domain on top of the agreed foundation of basic standards for geometry, temporal aspects, metadata, and also observations and measurements from the field. This is required for communication between professionals, for system design, system development and system implementation purposes and for purposes of data exchange and data quality management. Such a standard will enable Geographical Information Systems (GIS) and database providers and/or open source communities to develop products and applications. And in turn this will enable land registry and cadastral organisations to use these components to develop, implement and maintain systems in an even more efficient way. LADM provides a shared ontology, defining a terminology for land administration. It provides a flexible conceptual schema with three basic packages: parties, rights (and restrictions/responsibilities) and spatial units. LADM supports the development of application software for land administration, and facilitates data exchange with and from distributed land administration systems. An important aspect in the development of coherent (Spatial) Information Infrastructures (SII) is that the various standardised domain models are reusing the same model patterns as solutions for the same situations. The standard supports data quality management in land administration. Use of standards contributes to the avoidance of inconsistencies between data maintained in different organisations, because data duplication can be avoided as much as possible. It should be noted here that implementing a standardised data model can be supportive in the detection of existing inconsistencies.

4. Global agenda

Land is a cross-cutting theme in the global development discourse. The UN Post-2015 Development Agenda (UN, 2012, 2014a,b) includes consideration of land related issues across a wide range of objectives. Good land governance should also be seen as a means of supporting the global agenda such as the Post 2015 Agenda on 'Realizing the Future We Want for All' (UN, 2012). The vision includes issues relevant for development, implementation and use of land administration systems. For example: 'universal access to clean water and sanitation' 'resilience to natural hazards', 'eradicating income poverty and hunger'; 'ensuring access to land and natural resources, and 'conflict-free access to natural resources'.

The UN Committee of Experts on Global Geospatial Information Management guides the development of technology infrastructure to support land applications (UN-GGIM, 2013). The Food and Agricultural Organisation of the United Nations (FAO) has initiated and developed the 'Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security' (FAO, 2012). This comprehensive guide recommends that, where possible, states should ensure that the publicly held tenure rights are recorded together with tenure rights of indigenous peoples and the rights of the private sector in a single, or at least linked, land record system. In addition, the UN-Habitat's

continuum of land rights is now a widely accepted philosophy (UN-Habitat, 2008). In the 'continuum of land rights approach' land rights are viewed as existing along a continuum, with some settlements being more consistent with law than others. This view makes it possible to include the people with the weakest tenures in the idea of sufficient legal access. Apart from formal tenure types also informal and customary types of tenure are recognised and included. This breakthrough in the perspective of land rights is implemented in current land tools,¹ as well as in those under development by the Global Land Tool Network. Implementation of the 'Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security' and of the 'continuum of land rights' is the driving force behind a new era of land administration. The International Federation of Surveyors (Enemark et al., 2014) argues for the need to move beyond mere advocacy of the accepted continuum of land rights approach and focus on embedding it into real land administration solutions. The World Bank has combined with the International Federation of Surveyors to promote the Fit-For-Purpose Land Administration approach that provides the opportunity to build appropriate land administration systems within a relatively short time, for low costs with the option to upgrade when required (Enemark et al., 2014).

5. Development of new land administration systems

The 'Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security', the 'continuum of land rights' and 'Fit-For-Purpose' Land Administration require a flexible land administration system supported by a flexible legal framework recognising the different types of tenure. Recognising a variety of appropriate and legitimate land tenure forms should be based on an overview of the existing de facto and de jure land rights. Codification can be done by state authorities with involvement of local communities. Co-ordination needs to be organised; it should be clear which authority is responsible for this task for which area. Overlaps in tenure records may occur; the boundaries of areas related to authorities may be fuzzy—for this reason a national tenure overview needs to be established. Recording a variety of appropriate and legitimate land tenure forms implies developing an overview of all the existing land rights. A plurality of units of measurement is being used. Some rights may be extra-legal and/or illegitimate—but need to be recorded as a first step in the process of recognition of the right. The functionality of LADM, and also its specialisation the Social Tenure Domain Model (STDM) (Lemmen et al., 2007; Lemmen, 2010) can support an approach where all land tenures and land rights are recognised, collected, maintained (with options for upgrading) and published. The Social Tenure Domain Model is a pro-poor land information management system that can be used to support the land administration of the poor in urban and rural areas, which can also be linked to the cadastral system in order that all information can be integrated. This can be combined with a range of spatial units. Implementation at country level could be based on an approach to 'categorise, collect, convert' (Lemmen et al., 2015). Categorisation involves classification and developing a typology of land rights, tenure types and/or social tenure relations, on the basis of a tenure security assessment at country level.

¹ A land tool is a practical way to solve a problem in land administration and management. It is a way to put principles, policies and legislation into effect. The term covers a wide range of methods: from a simple checklist to use when conducting a survey, a set of software and accompanying protocols, or a broad set of guidelines and approaches. The emphasis is on practicality: users should be able to take a land tool and apply it (or adapt it) to their own situation. See: <http://www.glt.net/index.php/land-tools/introduction-to-land-tools>.

Collect means collecting data related to land rights based on Fit-For-Purpose approaches in Land Administration. Convert means options for formalisation and maintenance at organisational level and information-infrastructure at technical level.

6. Further development of existing land administration systems

The use of Information and Communication Technology in society will further develop. The authors expect that by the year 2025 meaningful information exchange between different domains or disciplines will be possible at a global, national and local level. This information exchange will be based on several well-established domain standards as the LADM (Uitermark et al., 2010). The information infrastructure will provide the environment for integrated and 'seamless' access to several data sources in different domains. Furthermore, the information infrastructure will provide the environment in which these sources can be maintained in a consistent manner. Domains will have links with other domains, which require that updates take care of consistency with related registrations. For land administration systems, as the cornerstone of the information infrastructure, these links with other registrations are numerous, for example, persons, buildings, rights, or topography. Satellites can monitor changes, providing information to be linked to 'RRR-SpatialUnit' and other data layers. RRR is the abbreviation for 'Rights, Restrictions and Responsibilities'. Inclusion of land administration in global spatial data infrastructures is under debate. A characteristic of all these registration issues is that people, spatial objects or spatial phenomena and the relationships between these are important. Emerging examples of this are: registration of ground water quota (note that this clearly has a 3D and temporal character), carbon credit quota registration (as a tool to assist in taking measures against global climate change), or rights to all kinds of natural resources. But also the physical plans (spatial zoning plans) and the associated rights, restrictions and responsibilities they contribute, will belong to this category of 'new' issues.

The increasing complexity and flexibility of modern land use requires that land administration systems will need an improved capacity to manage spatial units in three dimensions and not only in two dimensions as a representation of parcels on a conventional cadastral map. A temporal (fourth) dimension can be integrated with the spatial dimensions, or as separate attribute(s). In the long-term for future versions of LADM, an integrated 4D registration of all objects, will be the most effective solution. The *4D integrated space/time paradigm*, as a partition of space and time without gaps and overlaps (in space and time), is a very generic and solid basis.

7. Semantic web-based content

The differences in (legal) concepts, terminology and languages which are used in the different Land Administration Systems still limits the access to and understanding of Land Administration data in an international context. However, legal concepts of the different countries will be formalised using semantic web technology, similar to all other kinds of knowledge. These formalized semantics are used in mapping between the concepts and terminology from different countries, allowing the users to have access to all information in an unambiguous and understandable manner. So by the year 2025, via these semantic translators, foreigners can as well understand and trust the content of a Land Administration System as natives do: so, the meaning is unambiguous and clear to outsiders such as foreigners, but also to machines.

8. LADM development process

The design of LADM took place in an incremental approach with continuous expert reviewing from 2002 to 2006 within the International Federation of Surveyors. Then a design and development process for international standards was followed. The first step in this process was to confirm that a particular international standard is needed. For this purpose a New Work Item Proposal was submitted by the International Federation of Surveyors to the Technical Committee 211 of ISO and to the Technical Committee 287 of CEN on Geographic information which runs in parallel to TC211. The proposal was accepted after voting in May 2008. Then a working group of experts was established to prepare a working draft. This draft was forwarded to the Technical Committee for a consensus-building phase. The result was called a Committee Draft. As soon as the first Committee Draft was available it was distributed for comments to the members of the Technical Committee. In October 2009 consensus was attained and the text finalised for submission as a Draft International Standard. The Draft International Standard was accepted after voting in June 2011. The Final Draft International Standard was accepted in October 2012 and Edition I of the standard was published in December 2012.

The development of LADM was supported by UN-Habitat, the Food and Agricultural Organization of the United Nations, the Joint Research Centre of the European Union and the International Federation of Surveyors. More than fifty experts from around twenty countries contributed to the development of the standard (Uitermark, 2012; Lemmen et al., 2013).

With LADM and STDM, information-related components of Land Administration can be registered worldwide in a standardised way. The standard focuses on flexibility based on a continuum of continuums. This concept has several dimensions:

- It recognizes that a continuum of tenure exists in terms of social tenure relationships, such as occupancy, usufruct, informal rights, customary rights, indigenous rights and nomadic rights.
- In the same way, parties holding the rights may not only be natural or legal persons, but could be a family, tribe, community, village, or a farmers' cooperative.
- Also the spatial unit may not only be a land parcel, but can also vary according to where the rights and social relationships apply, e.g. a point cadastre rather than a parcel boundary, or 3D volumetric parcel, or it could be text based or photo based.
- Similarly, one may talk about a continuum of data acquisition methods or technologies that will include what could be called "continuum of accuracy".
- Another dimension could be a continuum of land recording and credit accessibility, ranging from informal land offices in an informal settlement to a governmental land registry.

It is the vision of the authors that in moving towards the year 2025, access to land-related information will be enabled for everybody (via the internet), creating a 'spatially enabled society'. Many Information and Communication Technology related developments will strengthen the relationship between land administration and other registrations, such as building, address, company and population registrations. Options, such as data integration will be aligned to institutional strengthening and development.

9. Maintenance and development of standards

The LADM standard is now being used, but it is inevitable that further issues will arise. These may range from detecting and correcting simple text errors, via omissions to further extension of the

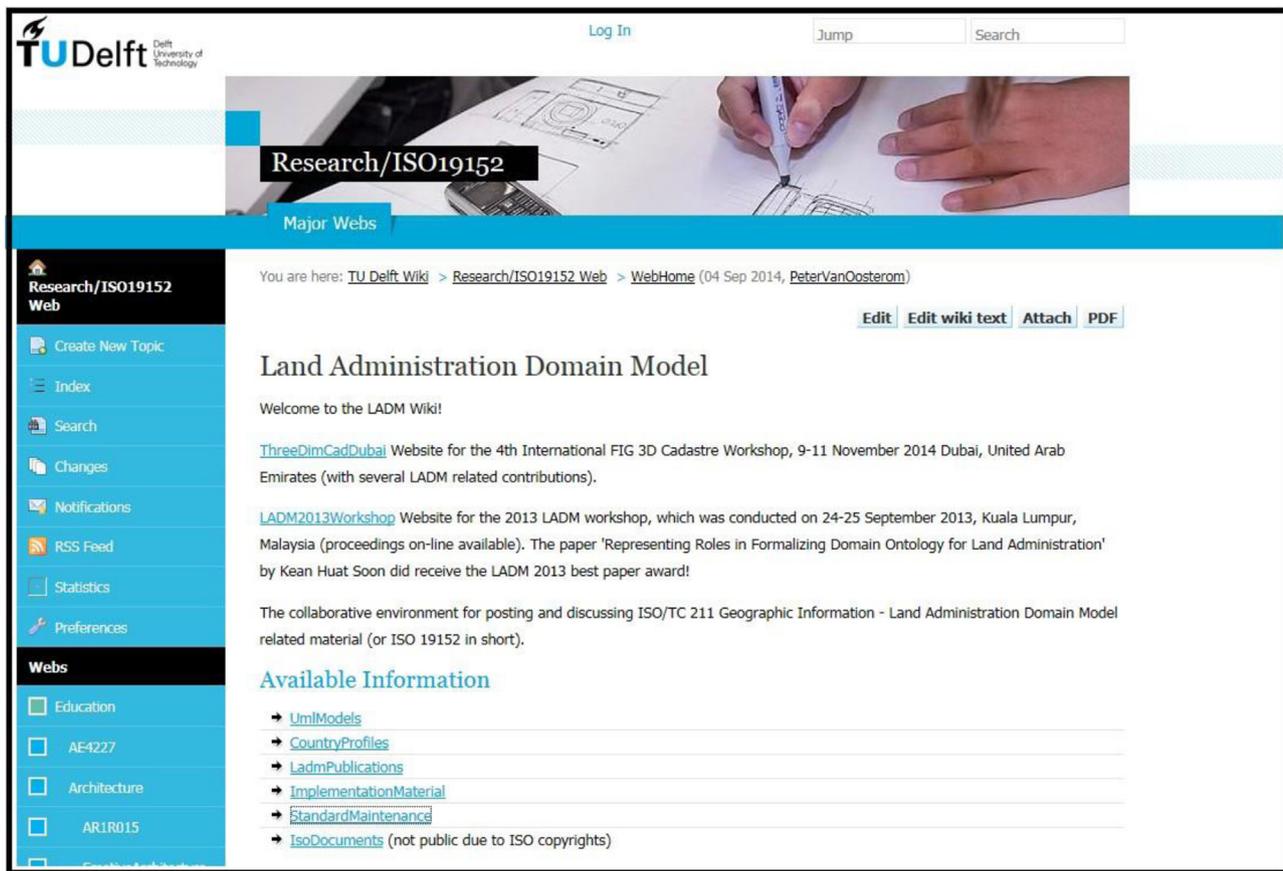


Fig. 1. The LADM Wiki (at isoladm.org).

standard, e.g. extension of the legal model as suggested by Paasch (2012), or valuation/taxation extensions or moving informative code list values to normative parts of standards, possibly including semantic technologies for more precisely defining code list values; e.g. a semantic hierarchy. Within the standardization processes there are different methods for handling these issues/requests: the corrigendum for fixing small mistakes, or revisions of the standard for significant changes and extensions by the TC211 of the ISO. In the meantime the LADM Wiki isoladm.org (see Fig. 1) functions as a collective memory. The Wiki intends to support the following activities:

1. Maintenance of LADM in accordance with ISO requirements.
2. Registration and publication of various code lists (and web services for use).
3. Collection and dissemination of best practices.
4. Planning of LADM related events (stand-alone or combined).
5. Checking if models are LADM conformant (conformance testing).
6. Provision of training and education.

LADM is a conceptual model and is already in use in the form of various country profiles, integration in the Infrastructure for Spatial Information in the European Community (European Community, 2007) and the Land Parcel Identification System of the European Union (Sagris and Devos, 2008), and as the basis for software development initiatives at FAO and UN Habitat (see Lemmen, 2012). Implementation includes elaborating (via a country profile) and realising a suitable technical model: database schema, exchange format, and user interface for edit and dissemination.

The expected developments relevant for land administration for the next decade can be grouped into a series of trends (Lemmen and Van Oosterom, 2011; Uitermark et al., 2010):

1. Mature information infrastructure.
2. Dynamic process models.
3. 3D (and 4D, that is, space and time integrated) administration.
4. Parcel design applications.
5. More than traditional rights, restrictions and responsibilities.
6. Faster and more direct updating by actors.
7. International seamless registration.
8. Semantic web-based.
9. Mobile applications content.
10. Monitoring applications.
11. Community-driven cadastral mapping (crowdsourcing of cadastral data).

10. Growing importance of 3D in the complete spatial development life-cycle

When considering the complete development life-cycle of rural and, in particular, urban areas, many related activities should often also support 3D representations (and not just the cadastral registration of the 3D spatial units associated with the correct RRRs and parties). Several of the activities and their information flows need to be structurally upgraded from 2D to 3D representations. Because this chain of activities requires good information flows between the various actors, it is crucial that the meaning of this information is well defined—an important role for standardization. Very relevant are ISO 19152 (ISO, 2012) and ISO 19156 Observations and Mea-

surements (ISO, 2011), and very related and partially overlapping is the scope of the new OGC's Land Development—Standards Working Group, with more of a focus on civil engineering information, e.g. the planned revision of LandXML (to be aligned with LADM). This phenomenon is especially true for 3D cadastre registration because it is being tested and practiced in an increasing number of countries. For example, for buildings (above/below/on the surface or constructions such as tunnels and bridges), and (utility) networks, this overlap is clear. LADM is focusing on the spatial/legal side, which could be complemented by civil engineering physical (model) extensions. It is important to reuse existing standards as a foundation and to continue from that point to ensure interoperability in the domain.

11. Community-driven cadastral mapping: updating by actors

The currently established update procedures are expected to be simplified in the future (Uitermark et al., 2010). For example, to split and sell a part of a parcel requires professionals, such as notaries, surveyors and registrars, each performing certain sub-tasks. Based on authenticated identification of persons and trusted reference material (e.g. high resolution and up-to-date geo-referenced imagery), via web-services, seller and buyer draw the new boundaries of the split part of the parcel and complete the transaction, including payment via a web-service of the bank, e.g. in The Netherlands the 'iDeal' system for digital payment is in use (<https://www.ideal.nl/en/>). The required web-services and protocols are currently being developed and implemented, e.g. web feature transaction services (OGC, 2010). The accuracy of digital reference material will become so high that there is no need to perform external survey. The reference material can also include the 3D aspect, e.g. in The Netherlands the completed elevation dataset was available in 2012 with an accuracy of 2–3 cm, about 10 points per m², with nationwide coverage (AHN, 2010). Integration of outdoor geo-information with indoor spatial-information and building information modeling is underway. The role of local authorities will be to provide the required infrastructure, links to other parts of the geo-information infrastructure, and perform quality control and validate transactions. Community-based cadastral mapping can be integrated into LADM implementations by its functionalities for source documents for spatial and non-spatial data.

12. Overview of papers

This themed issue of *Land Use Policy* presents the use and further development of LADM from different perspectives. The guest editors have been working on the development of LADM since its inception. As part of this process several dedicated workshops were organised. In 2013 the first LADM workshop after the acceptance of LADM as an international standard was organised in Kuala Lumpur, Malaysia with over 30 paper contributions. Based on reviews of these full papers, selected authors were invited to submit an updated and significantly new version of their paper to the themed issue. After submission, the normal double blind peer review process was applied in order to make sure the required high quality criteria of the journal were met.

The first paper, by Christiaan Lemmen, Peter van Oosterom and Rohan Bennett, can be considered as an introduction of the LADM standard itself and as background for this special issue. It provides an overview of the LADM and the basic information-related components of land administration—including those over land, in water, below the surface, and above the ground. The standard is an abstract, conceptual model with packages related to: parties (people and organisations); basic administrative units, rights,

responsibilities, and restrictions (ownership rights), and spatial units (parcels and the legal space of buildings and utility networks). The spatial units package has a sub-package for surveying and representation (geometry and topology). This paper examines the motivation, requirements and goals for developing this domain model. Further, the standard itself is described and the content of potential future maintenance.

Jenny Paulsson and Jesper Paasch present a survey of literature on LADM. The LADM has been the subject of numerous research activities since 2001, covering technical implementation issues, real property registration issues, and legal and organisational aspects. The aim of this study, in which 184 LADM publications are analysed, is to provide an overview of the research as evidenced by research publications to discuss the distribution of interest areas within LADM research. In the study three phases are identified: initial phase (until 2007), development phase (2008–2012), and operational phase (2013 onwards). The publications in the initial and development phase formed an important part of the standard development: first of all content wise, but also for standard consensus building. The result shows that technical and real property registration issues have been in focus throughout the surveyed period, whereas research on organisational matters, such as efficiency and how to organise and manage interests in land and the benefits and costs for implementing the standard, has been rather limited.

The next paper, by Mohsen Kalantari, Kenneth Dinsmore, Jill Urban-Karr and Abbas Rajabifard, provides a roadmap to bridge the gap between cadastres and the LADM. The adoption of LADM can have significant impacts on the process of managing cadastral information. This includes the impact on existing institutions. The authors explain that the adoption of the LADM requires a holistic approach that considers the LADM not only as a data model for cadastral information, but also as a cornerstone in systems of land administration. An implementation roadmap is introduced. Then a comprehensive analysis is given on the potential impact of LADM adoption in jurisdictions with an established cadastral information system and in jurisdictions in the process of establishing such a system.

Rod Thompson presents an approach to the creation and progressive improvement of a Digital Cadastral Data Base (DCDB). The LADM provides a model of a schema in which the progressive creation and improvement of a DCDB is possible—with attention to costs and benefits. Based on experience gained in the development of cadastral databases, a logical schema is presented and discussed. The proposed development of a LADM-based cadastral schema can support all levels of encoding, variable accuracy and topological purity, while maintaining a full history. This would allow data quality to vary by geographic and temporal location and would be configurable to allow for country profiles as permitted under the standard; thus permitting local terminology and language to be retained. Findings indicate that such a schema is a practical proposition for the development of a DCDB.

Charisse Griffith-Charles, Asad Mohammed, Sunil Laloo, and Jamal Browne present a paper describing the key challenges and outcomes of piloting the STD in the Caribbean. The Organisation of Eastern Caribbean States (OECS) is developing a regional land policy guideline that will address the most critical land issues being faced. Pro-poor land tools have been evaluated on capabilities of provision of a comprehensive land administration with facilitation of the equitable use and allocation of the limited land resource in the sub-region. A proposed STD profile is presented that addresses land issues common to most of the OECS. The preliminary results of pilot testing of the implementation of the STD are presented. It was found that middle and lower middle income groups are resistant to the idea of recognising informality because

they perceive difficulties in differentiating between legitimate land tenure rights and illegal occupation and use.

Modelling the land rights of indigenous tribes with LADM, with a case from Brazil, is the subject of an introduction by Silvano Paixão, Joao Hespanha, Tarun Ghawana, Andrea Carneiro and Jaap Zevenbergen. The issue of indigenous land rights is a particularly pressing political and socio-economic issue in contemporary Brazil. Violent land disputes between non-indigenous land owners and indigenous people with overlapping claims to land rights are a complex problem. This is related to the bureaucratic and slow process of land adjudication. Another issue associated with indigenous land rights is the deforestation process. The paper aims to define indigenous land rights in Brazil, as described under various laws, in the framework of the LADM. This review of the existing legislation framework supports the establishing of legal sources and definitions for a number of LADM classes and packages. The descriptive text is complemented with diagrams in Unified Modelling Language (UML). This is a fundamental step in defining a LADM model for indigenous land rights in Brazil.

The application of the LADM in building a country profile for the Polish cadastre is the subject of the paper by Jarosław Bydłosz. In Poland the scope of the cadastre concerns mostly spatial information, whereas a land registry generally concerns legal information. The traditional Polish cadastral model consists of sixteen diagrams available in UML notation. As a result of its complexity, it is only understood by a small number of professionals. The construction of the Polish cadastral profile based on the application of the LADM is described in the paper. This profile presents the main relationships within the Polish cadastral system and is simpler to understand than the traditional model. It can be actively used by the wider public and is therefore potentially of great benefit to land administration in Poland. It may facilitate cadastral data transfer and exchange and it may also help to reduce data redundancy within Polish land administration systems.

Mario Mađer, Hrvoje Matijević and Miodrag Roić provide a comprehensive analysis of possibilities for linking land registers and other official registers in the Republic of Croatia based on the LADM. Weak or non-existing linkages between registers and data redundancy are the causes of various unwanted consequences for public authorities, citizens and companies as the end-users of that data. Based on an analysis of redundancies in the land registers suggestions are given for improvements by introducing links based on the LADM. A compliance analysis between registers and LADM was conducted by using schema matching, a set of techniques used for comparing schemas which is a well-known approach within the database research domain. The outputs of this research can be used to create a strategy for improving the effectiveness of the overall system of registers.

Christina Gogolou and Efi Dimopoulou focus on standardisation of land administration for the integration of cultural heritage in land use policies. Nowadays, there is a great interest in the digital documentation and visualization of cultural objects, together with the quest of new technologies for efficient management. As a result, the utilization of international standards and models for land administration is in the forefront. The utilization of standardized modelling and more specifically the LADM is examined, as a basic tool for the development of spatial infrastructure for archaeological areas and cultural heritage of Greece. The LADM can include various rights, restrictions and responsibilities that appear in properties with cultural interest with a detailed description of the spatial information of these properties. Interoperability of the data models of the land administration systems is a relevant subject in relation to this.

The research from Halil Ibrahim Inan and associates land use/cover information with land parcels represented in LADM. There are obstacles against defining generic specifications in this field. The paper presents the different types of land use/cover classification systems for different purposes and different data qualities,

scales and contents. The management of land use/cover data in association with cadastral land parcels has been studied in a pilot area in Turkey. Information on sub-divisions of land parcels (sub-parcels) was studied. A special overlay operation with and without predefined tolerances was performed. It is found that the level of detail of external land use/cover datasets increases association errors; that using tolerances to reduce these errors causes data inconsistencies and that direct harmonisation of two datasets may be a robust solution.

Yuefei Zhuo, Zhimin Ma, Christiaan Lemmen and Rohan Bennett apply LADM for the purpose of the integration of land and housing information in China. This paper identifies and reviews the legal requirements for the integration of land and housing information in China. Specifically, the existing land legal system, consisting of seven levels of legislation, is interrogated. A collection of legal requirements emerges: these are categorized into themes including registration, maintenance, mortgage, transfer of real estate rights, relevant materials and archives, and preliminary notice. In order to be more applicable for the next design of the LADM country profile for China, these legal requirements are further converted into packages, classes and attributes by referring to LADM. The existing databases of the Chongqing Municipality are used to support the modelling process. The paper concludes that the legal requirements can be used as a foundation for an integrated system in China.

Nur Amalina Zulkifli, Alias Abdul Rahman, Peter van Oosterom, Tan Liat Choon, Hasan Jamil, Teng Chee Hua, Looi Kam Seng, and Chan Keat Lim highlight the importance of the Malaysian LADM country profile in land policy. In Malaysia some land policies were implemented based on the National Land Code in order to ensure uniformity of land policy and land law. Rapid development and various needs for securing proprietors' interests have made many demands on land administration. A 3D cadastral system is proposed. The two organisations responsible for managing and maintaining the land administration have their own information systems. There is a need to improve the land administration system towards e-Government services. This paper outlines Malaysian land policy in relation to the framework of the National Land Policy and LADM as a reference model for land administration.

The introduction of 3D land administration is also one of the main issues in the improved South Korean LADM country profile, as presented in the paper by Bo-Mi Lee, Taik-Jin Kim, Byung-Yong Kwak, Young-Ho Lee, and Jinmu Choi. The document ISO 19152:2012 includes the first version of the South Korean LADM country profile. However, as a result of the special law of cadastral resurvey 3D has been introduced (Lee et al., 2014) to support 3D partitioned use rights for buildings and underground facilities. The new 3D cadastre model can represent physical and legal information on these objects. The proposed 3D South Korean LADM country profile is the basis for the next generation of land administration models in Korea.

Volkan Cagdas and Erik Stubkjær present a Simple Knowledge Organization System (SKOS) based vocabulary for Linked Land Administration information in their 'Cadastre and Land Administration Thesaurus'. SKOS is a formal language designed by the World Wide Web Consortium (W3C) for standardised representation of structured vocabularies to enable publishing structured data in a machine-readable and interlinked way. The main purpose is to contribute towards the development of 'Linked Land Administration' that adopts Linked Data technologies. The thesaurus is mainly derived from terms defined in ISO 19152:2012 LADM, has been extended with temporal/activity concepts, and now consists of 143 terms, the relations of which are recorded according to the mentioned SKOS standard.

Finally, further modelling of LADM's rights, restrictions and responsibilities (RRR) is provided by Jesper Paasch, Peter van Oos-



Fig. 2. The LADM Working Group of Experts during its meeting in Molde, Norway, May 2009 (Photo Bjørnhild Sæterøy).

terom, Christiaan Lemmen and Jenny Paulsson. A more detailed classification of the legal part of the LADM is proposed (i.e. based on RRR). Besides the more obvious formal rights descriptions, this paper also deals with informal rights descriptions as introduced in the STDM as a foundation for further LADM development. The authors base their research on the Legal Cadastral Domain Model, which is used as a conceptual basis for creating an additional level to the LADM. The incorporation of a specialized classification of RRRs in the LADM is of value for more inclusion of data on social tenure in international land administration. The LADM allows national profiles to be added to the standard, though such profiles are also relevant within a country. These profiles are needed in cases where detailed data of interests in land have to be exchanged internationally. International data exchange requires maintenance of code tables representing the different RRRs in use within countries.

13. Conclusion

After more than a decade of development, the LADM became an international standard in 2012. This themed issue of *Land Use Policy* reflects on this process and its result, and presents the initial use and further developments of LADM. These are exciting times, as the phase of obtaining experiences with the LADM have now arrived, and first lessons learned can be obtained. The papers in this themed issue describes the state of the art of LADM use, and also indicates several areas for further improvement, and often provide indication or solutions to be included in the future version of LADM. Within ISO TC211 this well documented knowledge is valuable input for the future revision of ISO 19152!

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