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THE LAND ADMINISTRATION DOMAIN MODEL: ADVANCEMENT AND IMPLEMENTATION

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Abstract

This paper uses developments across a global range of case countries to justify the updates and explain likely implementations. The aim is to provide readers a state-of-play LADM snapshot, and also provide information on likely future additions, modifications, and functionalities.

Key Words:

Land Administration Domain Model, LADM implementation

1. Introduction

Worldwide, effective and efficient land administration is an ongoing concern, inhibiting economic growth and property tenure. In many nations, land administration systems are either non-existent or manual paper-based or semi-automated systems subject to limited public access. All of these approaches are at significant risk of data loss and failure due to lack of interoperability.

The Open Geospatial Consortium published a White Paper on Land Administration (OGC, 2018). This white paper provides an overview of the land administration domain and proposes actions needed for design and development of implementation standards for this domain – this includes as main reference, the Land Administration Domain Model (LADM), see ISO (2012). Close cooperation between the Open Geospatial Consortium (OGC) and ISO is expected to accelerate these developments. The charter members of the OGC Landinfra Domain Working Group seek to identify enabling standards and best practices to guide countries in a programmatic way, to establish more cost effective, efficient and interoperable land administration capability, to upgrade current manual to semi-automated processes, and to suggest solutions that are more automated and flexible to new data sources technologies.

Countries are developing and implementing LADM profiles and several software vendors are implementing LADM compliant data structures.

ISO TC 211 on Geographic Information is developing a new edition of the LADM. This paper discusses the developments and its implementations. It was discussed and agreed in ISO TC 211 to publish LADM Edition II as multipart. A proposal related to this will be presented. This proposal will find its way with ISO Technical Commission 211 on Geographic Information where LADM will be further developed.

2. LADM Country Implementations

A significant number of undocumented people-to-land relationships exist in many countries; they constitute an important barrier to economic development, especially that of rural areas. Although countries often have established procedures to register these relationships, typically, procedures involve outdated, costly and time-consuming workflows, and in many cases, require workflow resources that are simply unavailable. The vital, underlying technology and standards to collect and manage the required data are complex and sometimes inaccessible, or if available, tools do not comply with adopted (inter)national standards. If we continue down this path, the registration of undocumented people-to-land relationships will take significantly more time and money than governments are willing to afford and be held responsible for. While each issue mentioned above presents a substantial challenge, it is only by addressing them holistically that a significant impact

can be obtained. Using the post-conflict Colombia as a pilot area and fit-for-purpose land administration as philosophy (FIG/World Bank, 2014; UN Habitat/GLTN/Kadaster, 2016), we have developed and tested a simplified, communitybased, standards-compliant methodology and supporting technology, to register people-toland relationships in a fast and economically viable way. A country cannot afford to be non-compliant with the ISO's 19152 standard, which defines a reference land administration model (LADM). Its adoption, however, adds a whole level of complexity to existing procedures.

In this section developments across a global range of case countries are presented to justify the updates and explain likely implementations. Real country implementations (Mozambique, Indonesia, Colombia, Benin, Malaysia and Scotland) will be presented and discussed. It should be noted here that in many other countries LADM profiles are (in different stages of) development. See the ISOLADM site: https://wiki.tudelft.nl/bin/view/Research/ISO19152/ Kalogianni et al, (2019) give an overview of LADM Country profiles, see Table1.

Table 1. LADM-based country profiles

#	Country/ Jurisdiction	Prefix	Cadastral System Status	Mapping with LADM classes	Concep-tual Model/ UML	Confor-mance Level test (Annex A, ISO19152)	Technical Impleme-ntation	Develo-ped by
1	Colombia	COL_	Establi-shed and modernised	Yes	Yes	No	Yes (INTERLIS)	Academia & Gover-nment
2	Croatia	HR_	Establi-shed	Yes	Yes	Yes	No	Academia & Govern-ment
3	Cyprus	CY_	Establi-shed	Yes	Yes	No	No	Academia
4	Czech Republic	CZ_	Establi-shed	Yes	Yes	Yes	No	Academia & Govern-ment
5	Greece	GR_	Not fully establi-shed	Yes	Yes	No	Yes (INTERLIS)	Academia
6	Hungary	HUN_	-	-	Yes	No	No	Academia
7	Indone-sia	ID_	Establi-shed	Yes	Yes	No	Yes (3D visualisation)	Academia
8	Israel	IL_	Establi-shed	Yes	Yes	No	No	Academia
9	Japan	JP_	-	No	Yes	No	No	Academia
10	Korea	KR_	Establi-shed	Yes	Yes	No	No	Academia & Govern-ment

#	Country/ Jurisdiction	Prefix	Cadastral System Status	Mapping with LADM classes	Concep-tual Model/ UML	Confor-mance Level test (Annex A, ISO19152)	Technical Impleme-ntation	Develo-ped by
11	Malaysia	MY_	Establi-shed	No	Yes	No	Yes (Oracle Spatial – Bentley Microstation)	Academia & Govern-ment
12	Monte-negro	MNE_	Not fully establi-shed	Yes	No	Yes	No	Academia
13	Poland	PL_	Yes (cadastre & land registry)	Yes	Yes	No	No	Academia
14	Portugal	PT_	-	-	Yes	No	No	Academia
15	Queen-sland, Australia	QLD_	Establi-shed	No	Yes	No	No	Academia
16	Republic Srpska	BHRS_	Not fully establi-shed	Yes	Partially	No	No	Academia
17	Russian Federa-tion	RF_	Establi-shed	No	Yes	No	Yes (Interactive 3D visualisa-tion)	Academia
18	Serbia	RS_	Establi-shed	Yes	Yes	Yes	No	Academia
19	South Africa	-	Establi-shed	Yes	Yes	Yes	No	Academia
20	The Netherlands	NL_	Establi-shed	No	Yes	No	No	Academia
21	Trinidad and Tobago	-	Establi-shed	No	No	No	Partially	Academia
22	Turkey	TR_	Establi-shed	Yes	No	No	No	Academia
23	Victoria, Australia	VIC_	Establi-shed	Yes	Partially completed	No	No	Academia

The aim of the presented profiles from Mozambique, Indonesia, Colombia, Benin, Malaysia and Scotland here below is to provide a state-of-play LADM snapshot. Based on this requirements can were derived on likely future additions, modifications, and functionalities of the LADM.

In spite of all of the developments in standardization at the conceptual level and at the data exchange level, it remains a challenge to implement land registration systems that really help countries in having an affective an efficient land administration.

2.1 Mozambique

It is now eight years since the Mozambican's Land Information Management System (LIMS) (in portuguese SiGIT – Sistema de Gestão de informação sobre Terras), was developed, under a Government of Mozambique (GoM) project named "Land Tenure Security".

The system was developed by a local firm, EXI, in cooperation with National Directorate for Land (DINAT) in Mozambique. The decision to develop with a local firm was to ensure scalability and continuity as well as sustainability. The decision to build a customised application based on current legislation and business practices would ensure GoM (a) a smooth and phased organizational transformation; (b) the implementation of workflow and processes according to reality and for the reality; (c) a more manageable and more cost-effective application life cycle; and (d) economies of scale reducing overall costs by including both rural and urban land processes into a single application (inclusion of districts and municipalities).

SiGIT was designed with the LADM being the pillar for its architecture. In fact, SiGIT is the first LADM based country implementation. The SiGIT system supports both rural and urban land administration processes:

- Requests and registration of rights: good faith and customary rights registration, community registrations and land requests' applications;
- Formalising land rights: provisional and final titles as well as community certificates,
- Administrative processes: demarcation, transmissions, expansions/reductions, disagregation, and extinctions/revokes of land parcels; and:
- Taxation: process taxes, DUAT taxes, IPRA taxes, construction taxes, special licenses, etc
- Audits: exploitation plans, auditing plans and action plans.

With the launch of the "Terra Segura" program, another massive land tenure regularization program from the GoM, SiGIT was adjusted to accommodate new requirements designed to align the application with Fit For Purpose (FFP) land administration methodology (Balas, 2018). A mobile application was also developed to substitute the paper-based procedure to capture field data, including alphanumeric, geographic, and pictures of documents and parcels/people. This application enhances not only quality control of data, but also the speed-up of the registration process. Results from the upgrade implementation include: (i) reduction of time; (ii) reduction of errors; (iii) reduction of costs; (iv) increase of team's productivity; (v) increased process control and data security. (Balas, 2017).

During the research for the implantation of the LADM some issues were taken in account:

- A parcel must have a complete shape of its boundaries, and all vertices must be recorded. A minimum of 3 vertices is required;
- Mozambican law indicates that parcels must be contiguous, i.e., cannot be divided by rivers, or roads. In this case, two parcels or more are created;
- A parcel cannot go over a provincial boundary. If so, two or more parcels are created;
- There are no ownership rights over the land, just LAND USE RIGHTS;
- The Protection of women, orphans and other vulnerable groups is also important and therefore must be part of the decision-making process. Example an orphan is entitled to have a land title but requires a legal guardian; and:
- A parcel must have its entire life cycle embedded into the application.

There are 3 groups of classes: Party, Administrative and Spatial. The SiGIT architecture considered however additional extensions, for specific data and land administration processes, including statistics.

For the class LA_Party: new attributes were added because of requirements from the land law. This considers the Fiscal Number and Nationality - important for land title term and taxes.

Communities are an important issue for Mozambique Land Cadastre. Individual Person was also further detailed for Moz data purposes.

La_BAUnit is extended to “Processo” to capture administrative data utilized to issue land titles and parcel life cycle. The “processo” is linked to the Land office that originated the land parcel file, since the law establishes that land parcels can only be allocated to one administrative authority, either a municipality or a province.

LA_Rights class was extended to “Forma de Aquisição” to include “Good faith right” and “Customary right”, “Authorised right” (very important for Good faith and Customary Practices occupations, as well for title term and taxes).

LA_Restriction class was extended to “Finalidade” as a way to register the restrictions in terms of “Land Uses” applied to that land parcel (very important for title taxes). There is also an extension “Forma de Uso” that clarifies whether the parcels is being exploited as “Familiar purpose”, “Community purpose” or other utilization (very important for title term and taxes). Restrictions of blocking passage, selling land, changing land use purposes are embedded in the law and indicated for all parcels.

In LA_SpatialUnit added information with regards to maritime areas, partial protection areas, total protection areas (very importan to decide on issuing land titles and special permits). LA_SpatialUnitGroup included information regarding areas of priority development (very important to calculate land taxes).

LA_LegalSpaceBuildingUnit was extended to Class BuildingUnit to capture data for IPRA (property tax). This extension allowed for capturing data with regards to the property, constructed area, construction average cost, and a series of other attributes required to calculate property tax, including those related to type of municipality.

In general, there were additional attributes required by land law or regulations and/or statistical information

At present, new interfaces are being developed to accommodate different mobile applications for field data acquisition.

This developments in Mozambiaque underline the need for functonality in valuationa and taxation and also interoperability implementations based on technical models and encodings – as proposed in LADM II.

2.2 Indonesia

Two relevant developments from Indonesia are presented here. One is related to data acquisition (Aditya et al., 2019) and one is related to spatial planning and a permit system (Indrajit et al. 2019).

Land registration activities emerge as a national priority in Indonesia aiming at completing land registration progress for all unregistered land parcels in Indonesia by the year 2024. A national project on systematic land registration has been implemented to map all land parcels and to certify unregistered land parcels nationwide from village to village.

Current progress on the land registration program in Indonesia uncovers an essential need for the adoption of mobile technologies. This is in support to the acceleration of the mapping of all land parcels - with assured land data quality.

Local land offices and project executors see a mobile application as an alternative that facilitates public participation and supports surveyor's tasks to collect land boundaries and their associated formal data for land registration purposes (Aditya, 2019). As a result, various tools of data collectors have been implemented by surveyors and project contractors enabling field data collection.

Unfortunately, these tools provided challenges on data standardisation and data usability hindering an efficient land registration to take place. Based on user studies and evaluation of existing tools a mobile data collector has been developed enabling surveyors and para surveyors, residents to help and support the government surveyor in the land registration program.

In this approach the data collection and verification on land boundaries (and their corresponding status) by para surveyors can be submitted to the national databases, pending for approval by local land offices.

The data structure of the App is comepletly in alignment with the LADM basic classes: parties, RRRs, spatial units, surveying and mapping classes. Information on taxation, valuation and land use can be captured and linked with LADM external classes.

This tool is targeted to help government surveyors and para surveyors to collect physical documents from landowners by applying a photo-scanning and indexing. Application forms and related formal letters submitted by landowners are converted as digital data and sent to national land databases. The application server receives the submitted data and subsequently forwards these essential source documents to the national LADM-based land databases.

The mobile App is designed to facilitate the para surveyors collecting spatial data and legal documents needed for every parcel. Legal documents will be obtained using the questionnaire method; therefore, it will ease the para surveyors.

Geotagged video and photo in regards to identity and means of boundary determination of the field for each land parcel can be stored and uploaded into the databases.

Using the app, surveyors produced a comprehensive data set of coordinates, metadata and ownership documents related to individual parcels. The app can connect to an external geodetic GPS antenna to gain more accurate GPS coordinates of land boundaries. The app can also facilitate manual input of distance measurements when the field survey takes place in an awkward location such as in narrow urban alleys.

At the end of the survey day, registrars and government surveyors in local land offices can validate survey data. In addition to the function to facilitate first land registration, the app facilitates cadastral map validation.

Para surveyors in villages can submit correction and verification on the neighbourhood boundaries, street names and other toponym data. Para surveyors can also draw points, lines and polygons and their corresponding attributes to add new features related to state and public properties in their neighbourhood and upload the data into the land databases.

One of the critical requirements was that para surveyors require minimum complexities for them to complete their participation.

The app is written using native Java and implemented various open source platforms, including a search engine server to enable the integration of documents and spatial data. Considering different qualities of internet infrastructure in Indonesia, para surveyors can use functions in the app either

in an online or offline condition. In case the network is not available, para surveyors can still collect data, but the data submission will be made automatically by the app when the internet is available. Traditionally, land registration is delivered solely by government officers and licensed surveyors as a rigid formal procedure. Massive adoption of mobile technology and huge government targets on land certification have pushed the government to adopt the new design of land registration business processes. The government must see digitalisation and public participation as opportunities to speed up the cadastral mapping progress. The solution is expected to bridge community participation and government initiatives to accelerate completeness in cadastral mapping and to increase land information quality.

The other development in Indonesia is on the apllication of LADM data modeling of spatial planning information to ensure the interoperability of information of Rights, Restrictions, and Responsibilities (RRRs) with zoning regulations from spatial plannning fromlocal governments (Indrajit et al. 2019). We also examine the existing national data sharing policies which can be utilized to make land information useful for improving EODB - World Bank's Ease of Doing Business. A country (or city) can improve the EODB index if its rules and regulation efficient, transparent, and easy for economic actors. Spatial planning, together with land tenure, land valuation, and land development, produce spatial units containing RRRs for each lot, including for business activities. The spatial plans (spatial units with RRRs) are the result of the spatial planning process, which balances social, economic, and environmental aspects to achieve sustainable development. Indonesia's progress in establishing the foundation of national permits systems and the role of standardization of land information in improving the effectiveness of land registration and making construction permits system effective is presented in (Indrajit, 2020). It is concluded that the addition of large-scale mapping in One Map Policy and implementation of LADM for spatial planning is a priority for improving the chance for having EODB success.

The experiences in Indonesia underline the need for functionality in Valuation and Taxation in LADM, Spatial Planning and technical models and encodings.

2.3 Colombia

In this moment Colombia is going through an important moment in the alignment of initiatives focussing on Land Administration modernization. Among the most important milestones in this modernization process, is the LADM Colombian profile definition as a semantics standard which had been included in the public policy standard definition. It can also be found a high-level alignment in the government entities and the selection of methodologies for the provision / formalization of data applying the land administration standard. Implementing modernization processes does not work by copying and pasting from other experiences, particularly in Colombia which has institutional, legislative, social and historical complexities that prevents the adoption of immediate transformations (Casalprim, D. and Alvarez, G., 2019).

Current efforts for automation include the consideration of the entire value chain of industrial processes. To achieve this, Integrated Management Systems focus on the inclusion of the main processes: information management and operation management. In the Land Administration case, the standardization has prioritized largely on the LADM adoption to facilitate massive data acquisition processes, modeling, Cadastre - Registry integration, and its interoperability through exposition mechanisms. The LADM plays an important role for the standardization of the domain model, including the data core elements: BA_Unit, Spatial_Unit, Source, RRR relations, and Party; however, the focus on the current LADM version is information modelling.

An important challenge is the adoption of the LADM in the workflows where the end user (the citizen) intervenes, through the standardization of the operation. Beyond modeling the ultimate state of the information, and for simplification purposes, it is necessary to model the transitional steps between final states; i.e. the transaction. For this, it is necessary to consider the integration of the stakeholders that participate in the transactional chain, including intermediaries, that can be different depending on the legal framework of each country. The Land Administration modernization process in Colombia is currently being implemented through a joint vision of many government entities and stakeholders, focusing on the data integrity and processes simplification through the development of a management model where external all the stakeholders involved in the land will be integrated in a single flow, in a single file and a unique identification of the territorial objects modeled over the LADM standard, before recording changes in the Cadastral Registry The utility of modeling the “out-of-registry” transactional process has potentialities beyond the operation which takes place through legal channels, as is the case with formally registered properties. If this standardization is applied to non-formal processes, it is possible to make the complete reality of the territory coexist in a single model without entering conflicts of competence between the "facts" registered by Cadastre and the "rights" recognized by the Registry

The adoption of the LADM standard in public policy instruments facilitates decision-making at the intermediate levels of the institutions. Thanks to this, the transitory processes have allowed the continuity and breadth of the LADM design according to the reality of the country in Colombia, instead of abandoning government efforts to apply changes. There is an evident need to make visible the central role of the citizen in the modernization processes of Land Administration.

The success of this transformation will depend on the consideration of time, steps and requirements on the transformation of the transaction processes. This implies considering the transaction as an element to standardize. It is feasible to use the LADM as an element of traceability of Land Administration transactions.

Beyond the historical control of the versioning contained in the Source, the states of Check-in and Check-out are very useful for the real-time control of what happens to the properties. Another

development in Colombia – App based data acquisition – supports this view (Casalprim, D. and Alvarez, G., 2019).

For the data collection a technology was developed that satisfies two intrinsic objectives (Morales et al., 2019). The first is to create the ability to collect data that meets the requirements of the data collection data model, and the second is to install the ability in landowners/rightholders and community members to collect the data themselves. Contrary to conventional point-based land surveys, the data model uses polygons as the basis of surveying. In addition, geometric and legal data are collected simultaneously, and this includes evidence documentation.

All types of people-to-land relationships are captured: formal, informal, customary, etc. Since the community is responsible for the data collection, several activities are organized to ensure data collection is carried out according to methodological requirements. Since every landowner surveys her/his own land, boundaries between neighbouring parcels are collected twice. In practice, during a survey either neighbour aims to approximate the boundary by staying on her/his own property and maximising land extent, which may lead to little intersection between the surveyed boundaries.

Also, points where multiple people-to-land relationships converge are surveyed multiple times. To generate the dataset that complies with the post-processing data model, a customized library was developed with functions that are used to transform surveyed data into topologically correct representations of real-world land parcels in a semi-automated way. Traditionally, the quality of the surveyed data is determined only by the accuracy of the observations made. Such a classical approach is not followed.

For this reason the inclusion an additional validation step is required that is executed in a public forum to which the community is invited by the local authorities to corroborate the results of the post-processing. During this forum event, neighbour landowners or right-holders check and approve their shared boundary with a digital signature. This procedure uses a big screen so that results are openly presented for the whole community to witness and comment on, making the procedure fully transparent. Authorities also use this forum to check and validate identities, neighbouring relationships and supporting evidence.

The last step in the process leads to the recording of different types of people-to-land relationship in the official government systems. This step includes the legal analysis of the evidence of rights provided by the citizens and the evidence existing in government information systems to determine the official type of right for each recorded relationship. Some of the people-to-land relationships can be immediately formalized and lead to land titles. Others fall into different categories of rights that require some kind of follow-up procedure, but they can potentially lead to a title also (Morales et al., 2019).

The experiences from Colombia underline the need for inclusion of transaction processes (incl blockchain) and technical models and encodings – as proposed in LADM II.

2.4 Benin

The legal foundation under the land administration in the Republic of Benin is the 2013 Land Administration Act (Code Foncier Domanial, 2013) that replaced different previous land laws. The execution of the land administration in Benin is assigned to the l'Agence Nationale du Domaine et du Foncier (ANDF), founded in 2016. With the introduction of the Code Foncier Domanial and the establishment of ANDF, Benin has decided upon a centralised land administration, with the objective of recording the entire national territory in one central land administration system. With that, ANDF faces a major challenge, given that currently, of the estimated seven million cadastral plots of land, only 50,000 plots have a land title (Titre Foncier) and are registered in the ANDF central database in accordance with the requirements of new land administration law. In addition, approximately 30% of Benin's territory has been registered in a decentralised manner by municipalities. On the one hand, through operations to draw up urban land registers for taxation and urban planning carried out by private surveyors, and, on the other hand, through projects involved in food security in rural areas. These decentralised registrations of land rights, however, are often still in analogue format and are not up-to-date, with a few exceptions (Mekking et al., 2020).

The LADM Country Profile for Benin is currently under development. It is a conceptual model that will be used as a foundation for the development and implementation of a new Système Informatique Founciers (SIF) in Benin. The LADM is not a ready to use solution for all (not one size fits all), but a proposition which can be adjusted to the specific needs and laws of a country.

The LADM Country Profile for Benin supports in functionality both the existing title system in the country and the new developed "lighter" process for non-titled 'presumed ownership' in a Fit-For-Purpose approach for land administration. Both land administration processes will be implemented under the umbrella of one nationwide cadastral map. The model takes the administrative division of Benin into account – the locations of administrative boundaries are in many places still under a process of development and finding agreements. During the initial field data collection the functionality of the profile has to support the management of fieldwork organized in projects and subprojects.

The LADM Country Profile for Benin is also suitable for the further development of the registration of personal use rights and pastoralists land rights by other organisations such as the municipalities.

Reasons to apply LADM as the base model for the Country Profile for Benin are:

- LADM is a collective experience of experts from many countries
- LADM is based on consensus and is an international standard by the International Standards Organisation (ISO)
- LADM covers the complete land administration spectrum: survey, cadastral maps, rights, restrictions, responsibilities, mortgages, persons, et cetera
- LADM supports both formal, informal and customary rights
- LADM links essential land information data to source documents, both spatial (survey) and legal (title, deed)
- All inputs and modifications are based on authentic source documents – initial data acquisition, land right transactions, establishments of rights and court decisions

Last but not least the LADM Country Profile for Benin is important as a natural language between the business and the IT organisation during the development of the new SIF.

The development of the country profile in Benin (and other countries underlines the need for some more guidance in development of such profile. This could be included in Edition II of LADM.

A further issue of attention could be more attention to models for deeds and/or title registration. See also (Lemmen et al., 2020).

2.5 Malaysia

Malaysia developed a LADM country profile in 2014 (Zulkifli et al. 2014, Zulkifli 2014). Now a database design and development of a prototype 3D cadastral registration is available. The key aspects of this prototype are based on LADM.

The LADM provides a conceptual description for land administration system, including a 3D cadastral registration. LADM defines 3D parcel as a 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. Spatial units have two specializations: legal spaces buildings and legal spaces networks. The extensions of the Malaysian country profile focus on 3D space of spatial unit based on strata objects representation. Other spatial units are out of the scope.

In case of strata objects representation, it has parcel, accessory unit, common property, limited common property and land parcel. A prototype development began with the data modelling based on LADM (i.e. selecting relevant model classes and extending the model with attributes and classes where needed). The LADM supports various options for representing spatial units; e.g. a 2D parcel or a 3D volume. 2D parcel is recognized, however, how to create and maintain 3D valid parcels is still a challenge in practice. There have been several research and development activities in the past on the LADM. However, these investigations mainly remain at the conceptual level and yet to be implemented in the real context.

A LADM based prototype has been created with confirmed feasibility in implementation. This development focuses on data migration from existing database (i.e. .xml format) to open source database (i.e. Postgres) based on the LADM standard. The visualization and application for the implementation are using open source platform (i.e. QGIS). The findings (Zulkifli, 2019) are not only important for Malaysia, but also useful for many other countries, that also have the strata title system. Further investigation is on the full potential of LADM for the Malaysia Information Infrastructure (i.e. SDI) development.

This development underlines the need for LADM technical models and encodings – as to be included in LADM Edition II.

2.6 Scotland

Registers of Scotland (RoS) is responsible for keeping public registers of land, property, and other legal documents in Scotland. Their registers include the oldest national public land register in the world: the General Register of Sasines dating back to 1617 (Reid, 2019). Scotland has a long history of land ownership and public registration – all built around what can considered to be the relatively modern concepts of transparency and openness.

RoS manage and maintain 20 public registers. The General Register of Sasines and the Land Register are the principal registers relating to land. There are 6 additional registers which have a land focus and twelve judicial registers.

RoS is going through a period of significant and sustained change. RoS had already accepted the challenge, set by Scottish Ministers, to complete the Land Register by 2024. In addition, RoS have conducted extensive customer research to better understand roles, processes, interactions, perceptions and requirements of the conveyancing process. Those insights have helped to inform a Corporate Plan. This plan has committed Registers of Scotland to delivering major digital improvements for its customers which will enhance access, as well as innovate around land and property data.

The first step toward greater transparency and openness is improving public access to the register. This has been achieved through ScotLIS (Scotland's Land Information Service). ScotLIS gives a public view of the register that hadn't been easily available since its inception. Instead of having to come into a RoS customer service building to access the register you can see it on your laptop or mobile device. ScotLIS is the start of a transformative journey.

The changes to data, software and services are standards based and often utilise open source software. By adopting a data-first strategy, RoS has built its new systems on the foundations of openness and transparency. The LADM provides an internationally recognised model and vocabulary standard which provide a solid foundation for the development process.

There are many benefits for RoS and its customers. As data custodians RoS are in greater control of their systems and can flexibly tailor output, reports and metrics to meet changing needs. RoS will reduce software lock-in from COTS (Commercial Off-The-Shelf) products and expect to increase value by becoming more relevant and cost-effective (Reid, 2019). Scotland is the first country in Western Europe that implements new systems based on LADM.

3. LADM Based Software

This section provides two examples of LADM based software applications from the geo spatial industry.

3.1 Esri

Utilizing common language within industries has long been a successful pattern within geographic information systems (GIS) to assist in identification of suitable industry specific workflows. As technology itself advances, the need for highly accessible common industry language is even more pronounced.

The Land Administration Domain Model (LADM) provides this common industry language to the land administration community through the form of academic writings and diagrams. Hands on utilization of the LADM has dictated the need for interpretation as a schema. With the advancement of GIS technologies to include not only desktop oriented spatial analysis capabilities, but also mobile field collection, web based dynamic data monitoring, time enabled tracking and the promise of an upcoming threedimensional cadastre, it is of the most importance that the land administration domain model must lend itself to ready interpretation as an easily understandable schema as well as a common language.

Before exploring the importance of the LADM schema to upholding land administration dialogue in an interconnected environment within GIS, it is important to look at the reasoning for the initial interpretation of LADM into schema within spatial software and what the ramifications are for bringing LADM into a spatial oriented architecture. One of the first implementations of LADM as working fit for purpose spatial schema format was published online by Ken Gorton of Esri in 2015 to support a pilot project including field data collection in Colombia following the peace talks which began in 2012. According to Gorton via the metadata provided on GitHub, “The LADM schema for the Colombia Pilot project was implemented […] with the purpose of representing the relevant and essential characteristics of the original schema designed by Dutch Kadaster, adding the spatial capabilities of the geodatabase and supporting the overall workflow of the data collection to be executed during the pilot.” In short, while the LADM as documented serves as an excellent road map for creating a schema, in practice some modifications are necessary to make it

accessible to a technologically advancing audience. Geographic information systems are predicated on interconnectivity, and in turn are reliant upon development of a common language or ontology, as discussed above. As hardware technology has advanced and made it possible to carry increasingly powerful portable processors anywhere, accessing data seamlessly any time has become an expectation for many around the globe. Even in places where connectivity is not reliably available, field data collection workflows revolve around sending data wirelessly back to a single source. For swift transferal of data from a mobile source to the original, a common schema is necessary.

The ability to successfully transfer data resulted in the advent of dynamic dashboarding and other visualization tools that change on the fly as new data is added, enabling decision makers to see progress, cause and effect without running computations or having to conceptualize from raw data or written reports. Understanding the advancements that are already beginning to change the terrain of geographic information systems is critical to maintaining the LADM as the common language used within land administration – from fit for purpose to government cadastral agencies. The addition of a third (volume) and fourth (time) dimension to spatial understanding will shape the future of human interaction with land administration policy. The Land Administration Domain Model should evolve to support that advancement by becoming ever more intuitive to understand and translate to schema as the industry continues to gain insight into necessary components of the model itself through practical use.

3.2 GEOFIT IGN FI

IGN FI has successfully implemented pilot projects to establish national land information systems in Uganda (2010- 2013) and Tanzania (2016-2019, ILMIS project) and is now implementing the roll-out of the National Land Information System (DESINLISI project) in Uganda (2015-2020). IGN FI in cooperation with Innola Solutions As DESINLISI, ILMIS contributed to the creation of a reliable land administration service for clients and improved public confidence in land administration services. Implementation of the ILMIS Project comprised of the following six major objectives:

1. Development of the system software and establishment of the National Land Information Centre (NLIC);
2. Rehabilitation and conversion of existing data and land records including cadastral maps and drawings into digital format that were uploaded to the ILMIS database;
3. Integration of all land records into a single data set linking land registration data comprising certificates of occupancy, land administration records and data on cadastral parcels with the appropriate domains within the ILMIS;
4. Implementation of ILMIS involving the architecture of offices, the purchase and installation of the necessary hardware, equipment and consumables according to the system

design and improve the security and reliability of the registration and cadastral service delivery;

5. Informing the public and key stakeholders of the ILMIS initiative, increase public awareness on the benefits of formalizing property rights and promote new registration and cadastral services to encourage clients to formalize property rights; and:
6. Training of MLHHSD personnel to operate and maintain the system.

Proposed in 2017 by Milledrogues at all (see Milledrogues et al. 2019) IT-Leap concept recognized the Information Technology (IT) as not only a critical component of the Land Administration systems but has been proven as a mature business driver adopting customized standard data model, automating reengineered end-to-end rule-driven business processes, integrating the enterprise, discovering and enabling public and corporate electronic services. The technology solution has been branded as Innola® framework adhering to industry standards such as ISO 19152:2012 - Land Administration Domain Model (LADM), OGC, W3C and utilizing BPMN 2.0 workflow engine and business rules management component, and based on a proven enterprise level open source technologies stack. Adopting Innola as the technology platform in the referred national scale projects has helped to structure and standardize major implementation activities that might serve as the best practice model for future projects. The key aspect of the implemented solutions was the endto-end coverage of the enterprise with integrated business processes. The availability of the framework helps with very early involvement of the customer's stakeholders in the agile development cycles. Focusing on a specific set of functions and business processes to be implemented and operated over each iteration it systematically helped to minimize and even eliminate certain technological and operational risks at the latest acceptance stages. This approach turned the scheduled implementation into a continuous knowledge exchange between the vendor and stakeholders, bringing the agile principles to collaborative development. Customer's domain experts learned understanding of the processes mapping in BPMN and provided their inputs and feedback followed with the hands on testing of the early delivered functionality. Innola framework core, built on a LADM-compliant data model, at the very early stage of the development was extended and customized according to the country-specific information content. Such adoption of the data model established a national land administration data model profile adhering to LADM standard. Base on the customized national profile data model were started incremental configuration of the working processes, transactions and related rules, forms, reports and specific operational dashboards. Successful implementation of a national land administration system depends on the most critical factor of populating the modernized system with existing relevant data, either in digital or paper form through data digitization, migration, and integration. Data capture/conversion/cleansing processes along with the data migration and maintenance has been viewed as an integral part of the overall enterprise-wide business processes supporting ongoing formalized tenure operations. A flexible land administration system implemented on top of the database, compliant with the national LADM profile, served as the integrated software conversion

tools to enable required data digitization production through easily configured workflows and rules and to allow data to be "on-the-fly" validated and consolidated. Such a system allows subsequent transactions to be linked to the back-file integrated data within the same enterprise integrated environment. As an example of the efficiency of the process in Uganda National Land Information System (NLIS) project there were implemented 29 different workflows operating specifically ruledriven 103 transactions covering all currently identified land tenure operations. The performance and efficiency of the implementation is further catalyzed by the domain expertise. The customer formed a dedicated Standards Committee focused on reviewing the efficiency of the processes including timely feedback and corrective inputs that drive system iterative evolution. The operational NLIS with migrated data also integrates with other national systems and services such as:

- Uganda Revenue Authority (URA) system to validate payment receipts provided by applicants for registration and cadastral services;
- Uganda Registration Service Bureau (URSB) system to verify legal entities (Certificates of Incorporation);
- National Identification and Registration Authority (NIRA) system to verify physical persons (National IF Cards);
- SMS Service to enable owners and applicants notification upon property related transactions filing in and completion.

Another most recent completed project in Tanzania operationalized Integrated Land Management Information System (ILMIS) based on Innola platform with 37 different workflows implementing 103 various transactions. Operational in two districts ILMIS with converted back file data integrates with other external systems and services:

- Government Electronic Payment Gateway (GEPG) to validate payment receipts provided by applicants for registration and cadastral services;
- National Identity Authority (NIDA) system to verify physical persons (National ID Cards)
- SMS Gateway to enable owners and applicants notification upon property related transactions filing

4. Land Administration Domain Model Edition II

The Edition I of LADM was published by the International Organisation for Standardisation in December 2012 as ISO 19152. Its functionality is summarized at the ISO website.

ISO 19152:2012:

- defines a reference Land Administration Domain Model (LADM) covering basic information-related components of land administration (including those over water and land, and elements above and below the surface of the earth);
- provides an abstract, conceptual model with four packages related to parties (people and organizations); basic administrative units, rights, responsibilities, and restrictions (ownership rights); spatial units (parcels, and the legal space of buildings and utility networks); spatial sources (surveying), and spatial representations (geometry and topology);
- provides terminology for land administration, based on various national and international systems, that is as simple as possible in order to be useful in practice. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions;
- provides a basis for national and regional profiles; and
- enables the combining of land administration information from different sources in a coherent manner

4.1 New Scope

ISO TC 211 on Geographic Information is developing a new edition of the LADM. Its proposed extensions in functionality are presented in a “Stage 0”document. Those extensions concern (see Lemmen et al., 2019):

- refinement of some of the existing parts of LADM Edition I. The goal is that these refinements will add more semantics to LADM, but are also backwards compatible. A good example of such improvements are the Refined Survey Model (as part of the Surveying and Representation Subpackage) and more rigid representations of the various CodeList and the values they hold (adding more structure and using sematic technologies to define meaning of values);
- the scope of LADM. The scope is extended with a valuation and fiscal perspective. This concerns a conceptual data model in a LADM Valuation Package that can be used to construct information systems for immovable property valuation and taxation and offer a data exchange option. The extended scope is presented here below. A further extension of the scope with Spatial planning/zoning with legal implications. This new LADM package implies integration of spatial planning and land administration environments and thus, re-use of zones from spatial planning as restrictions to land rights is possible;
- reformulation of the definition of land administration: land administration is the process of determining, recording and disseminating information about relationships between people and land - informal, customary and formal use and property rights - and about value and use of land;

- functionality allowing monitoring of processes and implementations based on land indicators;
- functionality allowing the linking of "legal space" to "physical objects" – by identifiers or re-use of descriptions of space. The users of indoor spaces create a relationship with the space depending on the type of the building and the function of the space. Applying LADM allows assigning rights, restrictions, and responsibilities to indoor spaces, which indicates the accessible spaces for each type of user – see (Alattas et al., 2017 and Alattas et al. 2018).
- inclusion of a normative reference to IHO S121 (Marine Limits and Boundaries) based on the LADM principles is included in the revised version of ISO 19152;
- support can be characterized as steps towards implementations. In addition to the conceptual model, the intention is that LADM Edition II will also include the corresponding technical models (CityGML, InfraGML, RDF, INTERLIS, BIM/IFC, GeoJSON). Further, there will not only be attention for the information, but also for the Land Administration processes. Finally, Edition II will also include a methodology of how the develop a country profile.

4.2 LADM II as Multipart

It was discussed and agreed in ISO TC 211 to publish LADM Edition II as multipart, as follows:

Part 1 - Land Administration Fundamentals

Part 2 - Land Registration

Part 3 - Marine Space

Part 4 - Land Valuation

Part 5 - Spatial Planning Information

Part 6 - Implementations

It is now time to provide proposals for new LADM parts. Based on current experiences and future expectations, the need and content of possible extensions will be addressed in this paper.

Edition II of the Land Administration Domain Model is backwards compatible with Edition I.

Each part will be, in principle, a standard in itself. It should read as a complete standard. This means that, for example, definitions of classes may appear in more the one part. This is unavoidable. References at the upper right of the title page will be 19152-1; 19152-2; etc.

The nature of contents of Part 1, Land Administration Fundamentals, means that it will be in one way or another supportive in reading the other parts.

Six new working item proposals for each part will developed to be submitted to ISO TC 211. The idea is that the FIG Standards Network and the FIG Commissions will be involved in this process in close cooperation with the World Bank and UN GGIM (part 1) and with the organisations for Registrars (Ipra/Cinder) for Part 2, the IHO (International Hydrographic Organisation for part 3, the Royal Institute of Chartered Surveyors (RICS) for part 4 (and other), the Open Geospatial Consorium (OGC) for part 6. The geo spatial industry will be invited to join in the submission of part 6 (and others).

The packages of LADM Edition II look as in Figure 1 below:

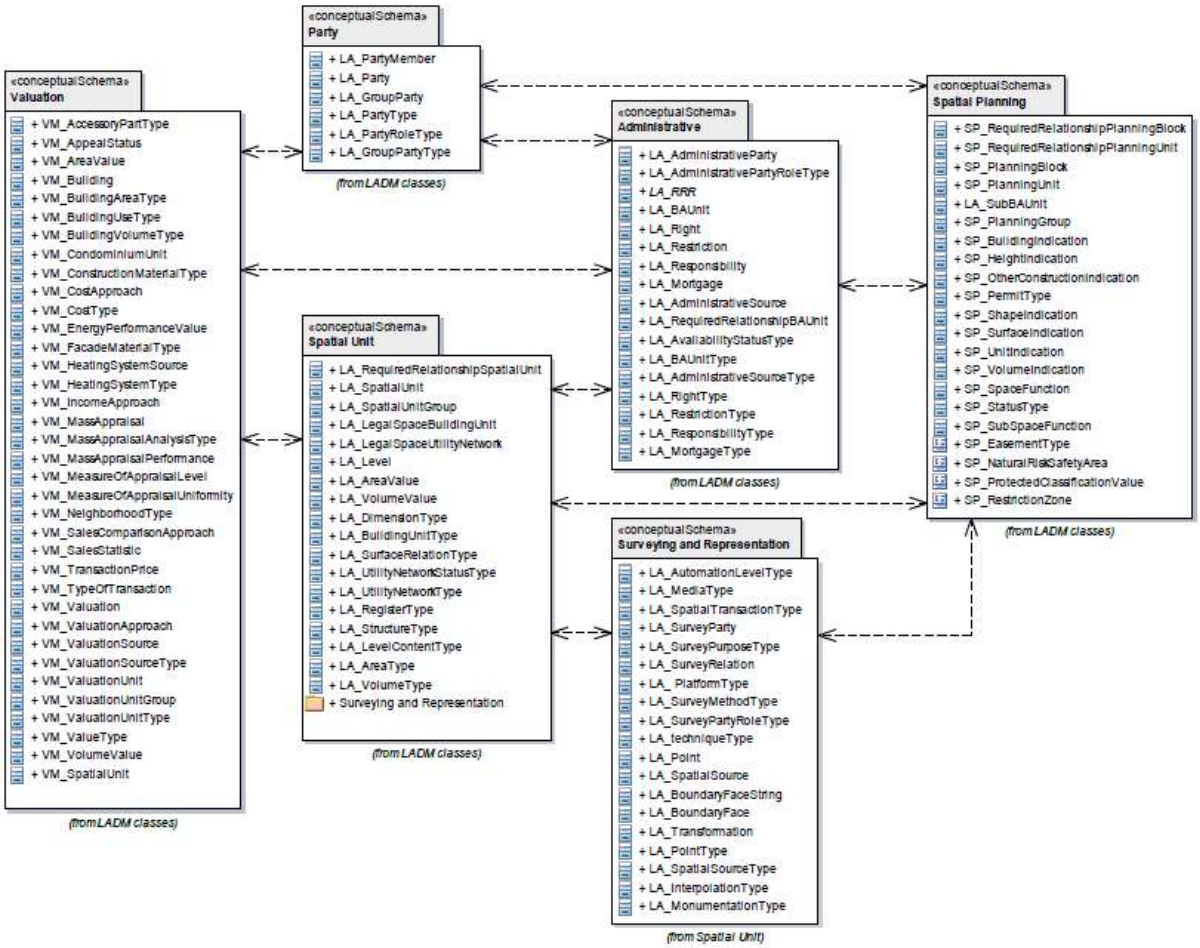

Figure 1: Packages in LADM Edition II

Those packages will be presented in part 1 – and, as far as needed, in the other parts.

In order to get a detailed overview of the contents of Edition II of the Land Administration see Lemmen, (2019).

Part 1 - Land Administration Fundamentals

This part includes the introduction to the Land Administration Domain Model in its Editions I and II. It will include an overview of packages and all definitions relevant for this part.

The most important packages in this part is the Spatial Unit Package and the Surveying and Representation Subpackage (Shnaidman, et al., 2019).

The Fundamentals in this part will highlight aspects as:

- Use of identifiers. LADM includes a Oid class that is applied in almost all classes. The normative and informative applications of Oid will be explained in this section. This includes meaning less and meaningful ids; also in indexes. Oids can be managed differently in case of shares and in relation to versions of objects and creating of new objects or deletion of existing objects. This will be described in further detail in all other parts;
- Archiving for land administration. Archives know their standards – those will be referred to. But the reality is that in land administration there can be many "versions" or "copies" of the same document that are seen as new originals. E.g. a paper original may be scanned and being declared as original after scanning. Or: deed documents from conveyors/notaries or fieldwork form private surveyors are in original in the archives of those stakeholder – but the "copy" in the land registry or cadaster is a new "original" owned by that organization;
- Blockchain as transaction mechanism; maintenance processes;
- 2D and 3D land administration. This is based on the definition of land administration: land related or space related. A fourth dimension may be time;
- Spatial Units. This is the link to spatial data infrastructure via LA_Level. This requires better reference. Different spatial units of the object may exist after quality improvements.
- Source documents. This concerns administrative/legal, spatial and integrated documents.

Classes LA_VersionedObject and LA_Source will be included in part 1 as well as datatype Oid. Further the classes: LA_SpatialUnit, LA_SpatialUnitGroup, LA_LegalSpaceBuildingUnit, LA_LegalSpaceUtilityNetwork, LA_RequiredRelationSpatialUnit and datatypes areaSize and volumeSize and all relevant Code Lists. Annexes include Spatial Units and Profiles, LADM and LPIS, 2D and 3D representations of spatial units, external classes and LADM and other TC211 standards. And a methodology for developing country profiles – see the contribution as from Mozambique here above.

Part 2 - Land Registration

This part will have its own introduction, conformance section and its own scope. It will refer to other standards relevant for this part. It will include all definitions and packages relevant for this part.

The most important packages in this part is the Party package and the RRR package.

Attention will be given to:

- Positive and negative systems;
- Legal and legitimate land rights – and:
- Models for deeds and title systems.

Classes LA_Party, LA_GroupParty, LA_PartyMember, LA_BAUnit, LA_RRR, LA_Right, LA_Restriction, LA_Responsibility, LA_Mortgage, LA_AdminsitrativeSource, LA_AdministrativeParty, LA_RequiredRelationshipBAUnits and all related CodeLists are in the part as well as datatype fraction. In the Annexes there will be attention legal profiules, the Social Tenure Domain Model, Interface Classes and land transaction rights related processes. The latter is based on the requirements as from (Casalprim, D. and Alvarez, G., 2019).

It should be noted that 'Land rights for all' demands for cooperation between different professional networks, connecting the world of registrars to the domain of land administration and vice versa. Organizing the interoperability is a key element in the strengthening these networks.

The growing power of location and internet technologies, enabled by open standards, is fast becoming a major and positive disruptor in communities of practice around the world, including the practice of land administration. The Open Geospatial Consortium in concert with the World Bank, Ipra/CINDER, the Royal Institute of Chartered Surveyors, the International Federation of Surveyors (FIG) and the ISO Technical Committee 211 on Geomatics, and others are committed to cooperation in evolving the LADM standard now under revision. For this reason a session will be organized during the 2020 Land and Poverty event (..this event was cancelled.. alternativces need to be organized later.

Part 3 - Marine Space

This part will have its own introduction, conformance section and its own scope. It will refer to other standards relevant for this part. It will include all definitions and packages relevant for this part.

The LADM standard is as-published applicable to Marine Cadastres - with special attention for the transition zone from land to sea and Marine Spatial Planning (MSP). A normative reference to

IHO S121 (Marine Limits and Boundaries) based on the LADM principles is included in the revised version of ISO 19152.

Classes may be re-used and/or are to be developed. This is also valid for Code Lists and external classes.

Part 4 - Land Valuation Information

This part will have its own introduction, conformance section and its own scope. It will refer to other standards relevant for this part. It will include all definitions and packages relevant for this part.

Property valuation systems require information related to property units together with immovable property rights, therefore, it is important to ensure that the units and the rights should have been unambiguously identified. This is supported by the land administration systems including cadastre and land registry. See Çağdaş et al. (2016 and 2017), Kara, (2018) and Lemmen et al. (2019).

Classes in this part concern: VM_ValuationUnit, VM_ValuationUnitGroup, VM_SpatialUnit, VM_Building, CondominiumUnit, VM_Valuation, VM_MassAppraisal, VM_TransactionPrice, VM_SalesStatistic, and VM_ValuationSource. All this with CodeLists and external classes.

Part 5 - Spatial Planning

This part will have its own introduction, conformance section and its own scope. It will refer to other standards relevant for this part. It will include all definitions and packages relevant for this part.

Classes in this part are: SP_PlanningBlock, SP_PlanningUnit, SP_PlanningGroup, SP_RequiredRelationshipPlanningBlock, and SP_ RequiredRelationshipPlanningUnit. All this with CodeLists and external classes.

Part 6 Implementations

This part will have its own introduction, conformance section and its own scope. It will refer to other standards relevant for this part. It will include all definitions and packages relevant for this part.

Field data acquisition and maintenance of land administration require interoperability. See the examples from Mozambique, Indonesia and Colombia above.

Encodings/technical models towards LADM implementation include furter integration with BIM/IFC, GML, CityGML, LandXML, LandInfra, IndoorGML, RDF/linked data, GeoJSON, and:

4. Process models for survey proceed. The scope of LandInfra is land development and civil engineering infrastructure facilities.

LandInfra V1.0, with an emphasis on infrastructure and on surveying, additionally supports the legal-administrative aspects of land development. This is achieved by modelling what is needed from a subset of the LADM to account for the surveying related activities, including defining the legal entities, the boundary of which are measured, as well as identification of the signing parties. A LandInfra based LADM implementation is under discussion.

5. Conclusions

Developments across a global range of case countries - Mozambique, Indonesia, Colombia, Benin, Malaysia and Scotland – have been presented to justify the updates and extension in LADM Edition II. The contents of LADM II have been briefly presented.

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