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# LAND ADMINISTRATION DOMAIN MODEL IS AN ISO STANDARD NOW

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## Abstract

A group of land administration professionals initiated the development of a data model that facilitates the quick and efficient set-up of land registrations. Just like social 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 organisations. 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. As a result, the governance and quality aspects of the data sets vary. Land administrations worldwide are often incomplete, data are not up-to-date and not fit for purpose. At the same time, new Land Administration Systems (LASs) are being developed all over the world *again and again*. Sometimes countries even have more than one IT-system for land administration. The wheel keeps being re-invented. This has a huge impact on the continuity and effect of LASs.

Internationally, the wish emerged for a widely accepted data model (domain) standard, making use of the knowledge already existing worldwide. This wish was supported by UNHABITAT, the Food and Agricultural Organization (FAO) of the UN and the International Federation of Surveyors (FIG). This data model should be able to function as the core of any land administration system. The standard should be flexible, widely applicable and function as a gathering point of a state-of-the-art international knowledge base on this theme. This common standard has now been designed and is currently proposed for implementation. It is called the Land Administration Domain Model, in short: LADM.

It is available since December 1st 2012 as a formal International Standard, published as ISO 19152:2012.

This paper analyses the impact of the standard with regard to the development of (and information exchange) between Land Administration Systems.

Real impact is already visible in open source software development for land administration.

The continuum of land rights is supported. There is also a continuum of accuracy, of land recordation's, of types of spatial units, of types of parties involved, and of data acquisition approaches. All this is supported in LADM – allowing for a flexible, step by step approach in the development of a Land Administration based on the needs, priorities and requirements of users and society. This can be combined in a natural way with organisational development with a proper alignment to ICT development. This makes the concept of LADM a basis for strategic development in land administration.

## Introduction

Land Administration documentation indicates the relationship between people and land. However, about three-quarters of these people-to-land-relationships concerning about 4.5 billion cases the world over are not documented, which often results in land disputes and land grabbing, thus denying the local people of their rights. Sustainable development, human rights or spatial planning are difficult to achieve without proper land administration. But proper land administration systems need proper data standards, which facilitate quick and efficient setup of land registrations.

It's a pity to see the wheel being re-invented again and again, leading to waste of time and money, especially in countries that do not have the means or funding. New land administration systems are being developed worldwide. They experience the same struggles again and again — how to divide responsibilities, how to bring together fragmented data sets of different organisations, how to define public or private roles or which IT structure to choose. As a consequence, land administrations are often incomplete, and data is not up-to-date and lacks quality and governance. A successful Land Administration System (LAS) provides solutions for those issues. LASs require a data model that is able to structure and connect the data.

There was an emerging global demand for a widely accepted data model (domain) standard making use of the already existing knowledge.

A group of Land Administration (LA) professionals, see Annex 1, initiated the development of a conceptual data model that facilitates the quick and efficient set-up of land registrations. This common data model which is flexible enough to function as the core of any land administration system.

## Background

How governments deal with the land issue, could be defined as land policy, and part of the governmental policy on promoting objectives including environment sustainability, economic development, social justice and equity, and political stability. Having a policy is one thing, having the instruments to enforce this policy is another. Therefore governments need instruments like regulations concerning land tenure security, land market, land use planning and control, land taxation, and the management of natural resources. It is within this context that the function of LASs can be identified: a supporting tool to facilitate the implementation of a proper land policy in the broadest sense (UNECE, 1996, Van der Molen, 2006).

Until today most countries (states or provinces) have developed their own formal LAS. Some countries operate a deed registration, while other operate a title registration. Some systems are centralised, and others decentralised. Some systems are based on a general boundaries approach, others on fixed

boundaries approach. Some LASs have a fiscal background, others a legal one (Bogaerts and Zevenbergen, 2001; UNECE, 1996). However, organisational structures with distributed responsibilities and ever changing system requirements make the separate implementation and maintenance of LASs neither cheap nor efficient (UNECE, 1996). Furthermore, different implementations of LASs do not make meaningful communication very easy, e.g. in an international context such as within Europe or in a national context (for example in a less developed country) where it may happen that different partners in development co-operation design and provide different LASs without co-ordination.

Experience of the authors learns that it is very easy to make LASs very complex and that it is really complex to make it easy. Standardisation is supportive and helpful in design and (further) development of LASs. It is relevant to keep data and process models separated, this means (inter-organisational) processes can change independent from the data sets to be maintained. The data model can be designed in such a way that transparency can be supported: this implies inclusion of source documents and inclusion of the names of persons with roles and responsibilities in the maintenance processes into the data model. A further lesson learnt is that the number of attributes should be minimal; during the design of the data model there may be lack of awareness that there is something like a "multiplier": depending on the number of objects and subjects each attribute can have millions of instances. The LA organisation is responsible for the quality of all those data. There is already impact if the number of attributes can be simply reduced with one.

Standardisation is a well-known subject since the establishment of LASs. Standardisation concerns identification of parcels, documents, persons, transactions, control points and many other issues. It concerns the organisation of tables in the registration and references from those tables to other components, e.g. source documents and maps; this includes efficient access to archives. It concerns coding and use of abbreviations, e.g. for administrative areas. It concerns workflows, etc. It should be observed that all this is valid for both paper based and for digital LASs. During analogue to digital conversions (many) inconsistencies built up in a paper based system appear: there can be parcels in the registry which are not on the map and the other way around. Such errors should be ***impossible***, because a real right is in principle always related to a person and to a piece of land in reality. The same is valid for the representation of this reality in a register and on a map. This type of inconsistencies should be impossible, ***but they exist***. Measures have to be taken to avoid this in the future after computerisation.

What can go wrong if you don't have a standard for the Land Administration Domain? What goes wrong if you don't have standards? Many things went well before standards were introduced. Greenway (2005) gives some examples of standards: the format of telephone and banking cards; the internationally standardised freight container; the number of businesses implementing ISO 90003 (quality management) and ISO 14000 (environmental management); the universal system of measurement known as SI4; ISO

codes for country names, currencies and languages; paper sizes and so on. He states that this list points to the ubiquity of standards, but also begins to indicate the economic benefits that they provide. That is the confidence that things will work and will fit together. He quotes key findings from a NASA5 report (NASA, 2005): 'Standards lower transaction costs for sharing geospatial data when semantic agreement can be reached between the parties', and: 'Standards lower transaction costs for sharing geospatial information when interfaces are standardised and can facilitate machine-to-machine exchange'. So, standards are, amongst other things, widely used because of efficiency and because of support in communications based on common terminology. One more issue is the LAS development. As highlighted above many countries are working on this. The data model is *the core* in those developments.

Internationally, the wish emerged for a widely accepted standardized domain model, making use of the collective knowledge already existing worldwide. This wish was supported by the International Federation of Surveyors (FIG) and UN-HABITAT and also by the Food and Agricultural Organization (FAO) of the UN. The data model should be able to function as the core of any land administration system. The standard should be flexible, widely applicable and function as a gathering point of a state-of-the-art international knowledge base on this theme. After an extensive design and development procedure, starting in 2002 within the FIG and from 2008 within ISO TC211 and involving many stakeholders from all over the world, this standard has now been published.

## LADM Requirements

A comprehensive overview of user requirements for the Land Administration Domain is available in (Lemmen, 2012). Main political objectives such as poverty eradication, sustainable housing and agriculture, strengthening the role of vulnerable groups (e.g. indigenous people and women), are in many ways related to access to land, and to land-related opportunities. This implies as a requirement that all possible relations between people and land should be re-presentable in the model: formal and informal tenure, customary tenures etc.

The development of LADM is based on user needs. Open markets and globalisation require a shared ontology allowing enabling communication between involved persons within one country and between different countries. This is also strongly related to the acquisition of large tracts of lands by international parties – for example in Africa. Proper (transparent) management of such transactions requires an overview of the existing situation and agreements with all involved parties.

A standardised land administration domain model should be as simple as possible, in order to be useful in practice. It should be adaptable and adoptable to local situations. The technology adopted should be sufficiently flexible to meet *anticipated future needs* and to permit system growth and change. The common denominator, or the *pattern* that can be observed in land administration systems with

*legal/administrative* data, *party/person/organisation* data, *spatial unit (parcel) /immovable object* data, data on *surveying (object identification)* and *geometric/topological* data should be included. Holding shares in rights must be supported. Inclusion of new data and data updates should be based on documents – inclusion of a wide range of documents with administrative and legal contents or with field observations should be supported. Deed and title based systems (and others) should be documented. This condition implies the maintenance of history. Distributed systems or users may not only be interested at the current state of objects, but they may need a historic version of these objects. It may be that the organisation responsible for the maintenance of the objects is not interested in history; the distributed use may require this (for example taxation). The names of persons responsible for transactions are part of the data set (conveyors, surveyors, registrars, etc). All updates should be traceable. This is one more reason for management of history and for documentation of all updates.

The model should be implementable as a distributed data set with inter-organisational workflows. Data packages have to be defined with links to land administration organisations and responsibilities and liabilities. Users/Customers are taking up a much more directive role. Organisations are becoming more dependent of each other and are in fact forced to openness (of systems) and exchange (of data). Developments such as chain orientation, digitisation and new technologies are leading to the fading of physical product concepts.

It should be possible to avoid redundancy and to keep data to the source. Redundancy is a main reason for complexity, inefficiency and unclear responsibilities.

Further important considerations during the design of the model where, that it should cover the common aspects of land administration, worldwide. This means it should be possible to represent all people – land relationships independent from regulations related to local approaches in adjudication, maintenance and data provision processes and also independent from local legislation, customary or informal rules. Further there should be no mix with management of workflows and financial processes. This means neither exclusion of important dates in a transaction (check in, observed in the field, accepted, verified, validated, etc.) nor the roles and the names of the responsible persons. Those attributes are transparency related and should be published.

Information products are becoming flexible combinations of digital data components and additional facilities and services. For combined data products from different sources the quality descriptions and meta data related to the original data are relevant in relation to liability and information assurance.

Of course existing ISO and other open standards should be followed, including FIGs de facto standard Cadastre 2014 (Kaufmann, and Steudler, (1998).

The application of new technologies, such as Global Navigation Satellite Systems, should be assessed from an economic rather than a technical perspective (UNECE, 1996). Provisions must also be made to

accommodate future changes in the network that may occur as a result of technical improvements. These may affect *all co-ordinate based systems*. If co-ordinates are an essential component of the cadastral system than the survey technique must be capable of producing these. Imagery can be used depending on the user requirements, cost, and timing among other factors. It should be possible to include all documentation on data collected as evidence from the field.

A key component in LASs is the spatial unit, the parcel identifier or the unique parcel reference number. This acts as a link between the parcel itself and all record related to it. It facilitates data input and data exchange. See (UNECE, 2004). Identifications should be free of semantics, there is a need for 'identification' providers, e.g. for parcels, areas, names, rights, restrictions, taxation, mortgages, land uses, surveys and documents.

Flexibility of the model should be based on the recognition that people's land relationships appear in many different ways, depending on local tradition, culture, religion and behaviour. Inclusion of data in the LAS based on the model may not only be based on formal registration of formal land rights, but may also be based on observations in reality, resulting in recordation (not a formal registration) of informal land use rights. 'People – land' relationships can be expressed in terms of *parties having (social) tenure relationships to spatial units*. Flexible and extensible coding of types of rights and restrictions, etc. is needed. A non-natural person may be a tribe, a family, a village, a company, a municipality, the state, a farmer's community/co-operation, a slum dwellers group/organisation, a community. This list may be extended, and it can be adapted to local situations, based on community needs. *Land rights* may be formal ownership, apartment right, usufruct, freehold, leasehold, or state land. It may be social tenure relationships like occupation, tenancy, non-formal and informal rights, customary rights (which can be of many different types with specific names), indigenous rights, religious rights, possession, or: *no land rights (no access to land)*. There may be overlapping tenures, claims, disagreement and conflict situations. There may be uncontrolled privatisation. Again, this is an extensible list to be filled in with local tenancies. A *restriction* is a formal or informal entitlement to refrain from doing something, e.g. it is not allowed to have ownership in indigenous areas. Or it may be a servitude or mortgage as a restriction to the ownership right. There may be a temporal dimension, e.g. in case of nomadic behaviour when pastoralists cross the land depending on the season. This temporal dimension is sometimes of a fuzzy nature, e.g. "just after the end of the rainy season".

Representation of a broad range of spatial units, with a clear quality indication, should be possible. *Spatial units* are the areas of land (or water) where the rights and social tenure relationships apply. Spatial units should possibly be represented as a text ("from this tree to that river"), as a sketch, as a single point, as a set of unstructured lines, as a surface, or as a 3D volume.

This range of representations of spatial units and parties, combined with the UN Hahitat continuum of land rights can cover community based LASs, or rural, or urban, or other types of formal LASs, like Marine Cadastres and 3D Cadastres. *If all data are collected in the same structure than the integration with between informal recordation's and formal LAS is possible.* Surveys may concern the identification of spatial units on a photograph, an image, or a topographic map. Surveys can be conventional land surveys, based on hand-held GPS. In all cases the representation of 'legal' reality should be distincted from the 'physical' reality. There may be sketch maps drawn up locally. A sketch map may be drawn on a wall, from which a photograph is taken.

Depending on the local situation, different registrations or recordings of land rights are possible. In rural areas there can be spatial units covering customary areas. Those spatial units can be recorded as 'text based' spatial units, where boundaries are described in words. Or as 'line based' spatial units, drawn on low accurate satellite images. The tribe may be represented by its chief. Formal property based spatial units can concern formally registered ownership with a related owner and with identified boundaries by accurate field surveys. Persons living in 'structures' in slum areas may be identified by fingerprints. The (social) tenure relationship to the spatial units may be represented by points collected with (hand-held) GPS instruments – source documents may be printed from websites providing spatial data. Spatial units in urban business districts can be conventional parcels with high accurate boundaries. Spatial units in residential areas can be derived from aerial photographs. Or total stations, radar detection, recording, cyclomedia, pictometry, or other sensors can be used. Digital video or voice recording are also possible.

Data quality of spatial data may be improved in a later stage of development. Note that there may be a serious need for accurate geo-data in slum areas: the value of land in slum areas near city centres can be very high. Person identification is not a primary responsibility of cadastre and land registry, but might be of relevance in LA processes. It can be observed that biometric approaches are coming more and more available; in passports, in access to countries. Identification documents can be 'time-line' disrupted when new documents are provided. It is possible to link fingerprints to points (co-ordinates) or polygons.

In conclusion: LADM should integrate essential data as party names and rights with source documents as titles, deeds, survey field data, court decisions, decisions made in participatory mapping and other decisions. All essential data can be related to authentic sources: documents, imagery with evidence from the field, GPS tracks and so on – available ISO standards should re-used to support multi media archives and measurements and observations as well as spatial representations. A very relevant issue is that (documented) field surveys can be included in combination with re-constructabable adjustments to the spatial database. History should maintainable and all attributes may have a set of quality elements. This allows for proper combinations with workflow management. The continuum of land rights has to be supported.

## LADM Goals

The International Standard for the Land Administration Domain serves the following goals.

1. *Establishment of a shared ontology implied by the model*. The knowledge of the land administration domain is documented – focus on data.

2. *Support to the development of the application software for LA.* The data model is the core here.

3. *Facilitation of cadastral data exchange with and from a distributed LAS.* This can be between cadastres, land registries and municipalities and between countries in a federal state or between countries.

4. *Support to data quality management in LA.* 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.

A specialisation of LADM is the Social Tenure Domain Model (STDM). It is developed by UN HABITAT, the International Federation of Surveyors and the University of Twente, Faculty ITC. STDM broadens the scope of land administration. It provides a land information management framework that integrates formal, informal and customary land systems. It also integrates administrative and spatial components. Doing so, the model describes relationships between people and land in an unconventional manner: it has the power to tackle land administration needs in communities, such as people in informal settlements and customary areas. The emphasis is on social tenure relationships as embedded in the continuum of the land rights concept promoted by the Global Land Tool Network and by UN-HABITAT.

## LADM: a technical description

The model integrates essential data as party names and rights with source documents as titles, deeds, survey field data, court decisions, decisions made in participatory mapping and other decisions. All essential data can be related to authentic sources (documents, imagery with evidence from the field). Available ISO standards are re-used to support multi media archives and measurements and observations as well as spatial representations. History is maintained and all attributes may have quality elements. This allows for proper combinations with workflow management which in itself is not included in the data base – except for issues as role in the process (conveyors, surveyors) and relevant moments in applications (issuance data, acceptance date etc).

The three main packages of the LADM consist of the Party package, the Administrative package and the Spatial Unit package. The main class of the party package of LADM is class LA_Party with its specialisation LA_GroupParty.. A Party is a person or organisation that plays a role in a rights transaction. An organisation can be a company, a municipality, the state, or a church community. A 'group party' is any number of parties, forming together a distinct entity. LA_PartyMember' is documenting the association of a party member with the constituent group party with attributes such as membership share or date of membership in the group.

The administrative package concerns the abstract class LA_RRR (with its three concrete subclasses LA_Right, LA_Restriction and LA_Responsibility), and class LA_BAUnit (Basic Administrative Unit). A 'right' is an action, activity or class of actions that a system participant may perform on or using an associated resource. Examples are: ownership right, tenancy right, possession, customary right or an informal right. A right can be an (informal) use right. Rights may be overlapping or may be in disagreement. A 'restriction' is a formal or informal entitlement to refrain from doing something; e.g. it is not allowed to build within 200 meters of a fuel station; or a servitude or a mortgage as a restriction to the ownership right. A 'responsibility' is a formal or informal obligation to do something; e.g. the responsibility to clean a ditch, to keep a snow-free pavement or to remove icicles from the roof during winter or to maintain a monument. A LA_Baunit (an abbreviation for 'basic administrative unit') is an administrative entity consisting of zero or more spatial units (parcels) against which one or more unique and homogeneous rights (e.g. an ownership right or a land use right), responsibilities or restrictions are associated to the whole entity as included in the Land Administration System. An example of a 'baunit' is a basic property unit with two spatial units (e.g. an apartment or a garage). The spatial unit package concerns the classes LA_SpatialUnit, LA_SpatialUnitGroup, LA_Level, LA_LegalSpaceNetwork, LA_LegalSpace- BuildingUnit and LA_RequiredRelationshipSpatialUnit. A 'spatial unit' can be represented as a text ("from this tree to that river"), a point (or multi-point), a line (or multi-line), representing a single area (or multiple areas) of land (or water) or, more specifically, a single volume of space (or multiple volumes of space). Single areas are the general case and multiple areas the exception. Spatial units are structured in a way to support the creation and management of basic administrative units. A 'spatial unit group' is a group of spatial units; e.g.: spatial units within an administrative zone (e.g. a section, a canton, a municipality, a department, a province or a country) or within a planning area. A 'level' is a collection of spatial units with a geometric and/or topologic and/or thematic coherence. The Spatial Unit Package has one Surveying and Spatial Representation Subpackage with classes such as LA_SpatialSource, LA_Point, LA_BoundaryFaceString and LA_BoundaryFace. Points can be acquired in the field by classical surveys or with images. A survey is documented with spatial sources. A set of measurements with observations (distances, bearings, etc.) of points, is an attribute of LA_SpatialSource. The individual points are instances of class LA_Point, which is associated to LA_SpatialSource. 2D and 3D representations of spatial units use boundary face string (2D boundaries implying vertical faces forming a part of the outside of a spatial unit) and boundary faces (faces used in 3D representation of a boundary of a spatial unit). Co-ordinates themselves either come from points or are captured as linear geometry.

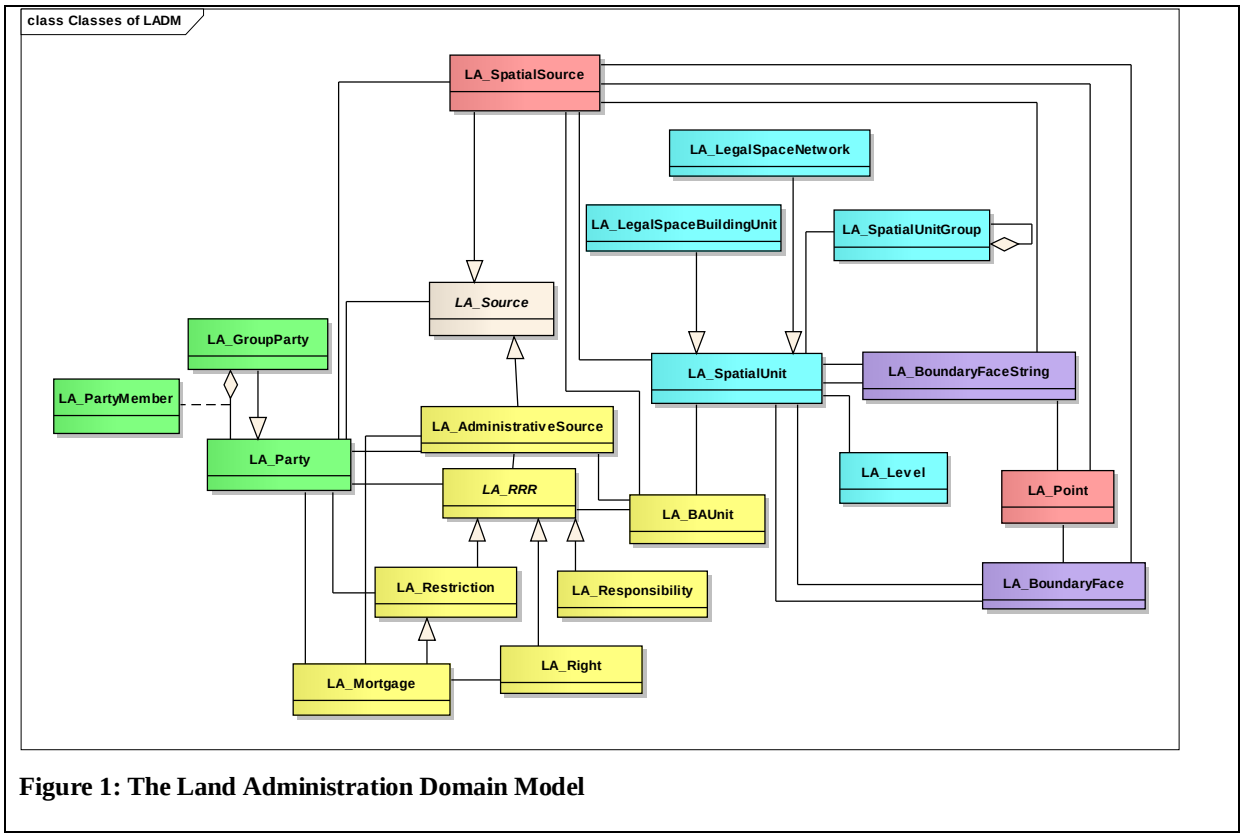
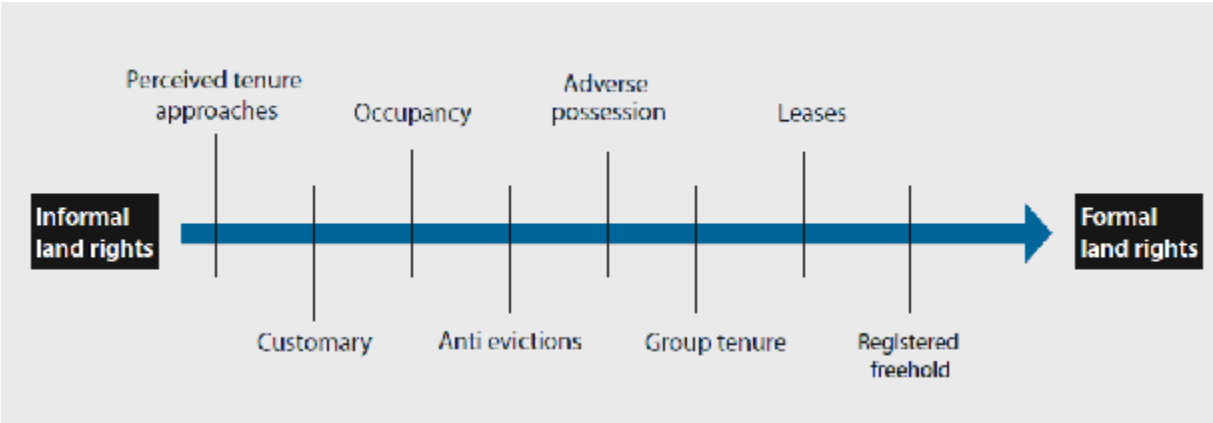



**Figure 1: The Land Administration Domain Model**

## The Continuum of land rights

The continuum of land rights disserves extra attention to understand the possible impact of LADM.

In UN-HABITAT (2003 and 2008) the various types of 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, see Figure 2.




**Figuur 2: The continuum of land rights**

Today there is more and more discussion about complete global coverage of land administration, see for example (Bennet et al, 2010). There can be support in the avoidance of land grabbing with an overview of the complete set of existing people to land relationships. Knowledge on areas which are included in land registry and areas which are not included has a special value in this context.

Enemark (2012) recognises cadastre as the core engine for spatially enabled land administration. According to him spatial enablement is not primarily about accuracy: it is about adequate identification, completeness and credibility. Systems should be built using a 'fit for purpose' approach while accuracy can be incrementally improved over time when justifying serving the needs of citizens and society. In relation to the concept of the continuum of land rights such a fit for purpose approach could then be referred to as a 'continuum of accuracy'. Where spatial units are concerned a continuum can be introduced too, see Lemmen (2012) – with a literature overview to this subject included. Spatial units can be text based, point based, line based, polygon based or volume based (e.g. for 3D cadastre, relevant in mega cities). Same is valid for data acquisition at administrative and spatial side, a wide range of options is available. In (Zevenbergen, 2013) pro-poor land-recording systems is introduced. Again a continuum of approaches is related. One more 'continuum' is at the subject side: there can be individuals, groups, groups of groups, communities, governmental organizations.

CheeHai Teo, (2012) introduced a 'continuum of approaches', ranging from 'less rigorous' to more 'rigorous', a 'continuum of technology', ranging from 'less sophisticate' to 'more sophisticate' and a 'continuum of measurement' from 'more precise' to 'less precise'.

The Social Tenure Domain Model (STDM) (Augustinus et.al, 2006, FIG, 2010), as a specialisation of the Land Administration Domain Model, brings all required functionality together. This functionality is also available in the LADM (ISO, 2012). LADM includes the so called Basic Administrative Units, allowing grouping of spatial units. This functionality is not explicitly (but implicitly) available in STDM. Augustinus (2010) explains that the approach as in Social Tenure Domain Model "will open up new markets to the land industry and it will also be an opportunity to develop new skills and improve management skills. According to her STDM could make it possible for all citizens to be covered by some form of land administration system, including the poor, thereby improving the land management capacity of the industry, as well as addressing upcoming challenges such as climate change. Also, STDM should contribute to poverty reduction, as the land rights and claims of the poor are brought into the formal system over time. It will improve their security of tenure, increase conflict resolution, limit forced evictions, and help the poor to engage with the land industry in undertaking land management such as city wide slum upgrading or rural land management. The pro poor land management approaches under

development by GLTN partners is a new way of doing business and is key to solutions for the challenges of today and tomorrow".

FAO's Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (FAO, 2012) outline principles and practices that governments can refer to when making laws and administering land, fisheries and forests rights. This very comprehensive set of guidelines includes 'delivery of services' and 'records of tenure rights'. In those areas some of the guidelines are highlighted here:

- national standards should be developed for the shared use of information, taking into account regional and international standards. States should strive to establish and maintain accessible Inventories,
- where possible, States should ensure that the publicly-held tenure rights are recorded together with tenure rights of indigenous peoples and other communities with customary tenure systems and the private sector in a single recording system, or are linked to them by a common framework. Systems should record, maintain and publicize tenure rights and duties, including who holds those rights and duties, and the parcels or holdings of land, fisheries or forests to which the rights and duties relate,
- the spatial accuracy for parcels and other spatial units should be sufficient for their identification to meet local needs, with increased spatial accuracy being provided, if required over time, and:
- to facilitate the use of records of tenure rights, implementing agencies should link information on the rights, the holders of those rights, and the spatial units related to those rights. Records should be indexed by spatial units as well as by holders to allow competing or overlapping rights to be identified. As part of broader public information sharing, records of tenure rights should be available to State agencies and local governments to improve their services. Information should be shared in accordance with national standards, and include disaggregated data on tenure rights.

Those highlights can easily be brought in alignment to the continuum approaches.

## LADM Maintenance and development

LADM is maintained by ISO/TC211. Relevant existing international standards[1] have been re-used in LADM. Those data standards are accepted in the world of the Geographical Information Systems and Data Base Management Systems – and maintained by ISO TC211.

LADM is a conceptual model and is already is use as such (country profiles, integration in INSPIRE and the Land Parcel Identification System of the European Union, basis for software development initiatives

[1] For example: ISO/IEC 13240:2001, *Information technology — Document description and processing languages — Interchange Standard for Multimedia Interactive Documents (ISMID);* ISO 19107:2003, *Geographic Information — Spatial schema;* ISO 19108:2002, *Geographic Information — Temporal schema;* ISO 19111:2007, *Geographic Information — Spatial referencing by coordinate;* ISO 19115:2003, Geographic information — Metadata; ISO 19125-2:2004, Geographic information — Simple feature access — Part 2: SQL option; ISO 19156:2011, Geographic information — Observations and measurements

at FAO and UN Habitat, etc, see Lemmen (2012), the next steps include elaborating (via a country profile) and realizing a technical model suitable for implementation: database schema (SQL DDL), exchange format (XML/GML), and user interface for edit and dissemination. A good option for this is the collaboration between FIG and OGC to standardize this technical model (with options such as CityGML or LandXML). 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). The exact naming of these activities differs from country to country, and their order of execution may differ. However, in some form or another, the following steps performed by various public and private actors, which are all somehow related to cadastral registration, are recognized: develop and register zoning plans, design new spatial units/objects; acquire appropriate land/space; request and provide (after check) permits. Etc.

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. Important are ISO 19152 (LADM) and ISO 19156 (Observations and Measurements), and very related and partially overlapping is the scope of the new OGC's Land Development – Standards Working Group (LD-SWG), 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 in our developing environment!

## Impact of LADM

ISO standardisation is a comprehensive, extensive, formal process with continuous peer reviews and iterations based on experience of earlier implementations. For LADM this (creative) approach resulted in finding common denominators in land administration. The innovation is in the availability of the LADM as a basis for structuring and organising of representations of people to land related information in databases in a generic way. This means that the LADM is one of the tools (or better: conditions) for the implementation of the continuum of land rights and for FAOs Voluntary Guidelines.

The wide range of functionality of LADM is in support to:

- the continuum of land rights (management of different tenures in one environment), the continuum of approaches, the continuum of recordation, the continuum of spatial units and subjects. The LADM opens options now to bridge gaps between cultures where *People to Land relationships* are concerned, definitively not only in support of globalisation, but also with a strong attention to bring support in the protection of land rights (tenure certainty) for all,
- land administration system design and development with coverage of all tenure types. Those systems can operate in formal and informal environment ("self made land administration"). LADM describes the data contents of land administration in general. Implementation of the LADM can be performed in a flexible way; the standard can be extended and adapted to local situations. Alignment with ICT developments is possible (the LADM is available in a well known modelling language, model driven architectures can be developed on the basis of the standard,
- the quality upgrading of existing (not proper maintained) datasets (consistency building and validation),
- the management of a wide range of documentation. This concerns evidence from the field and legal, transactional, and administrative documents,
- land administration development. Software and data base developers are happy: they like stable (but extensible) standards as a starting point for developments. Both industrial software developers and open source software communities are enthusiastic. LADM allows a flexible, step by step approach in the development of a Land Administration based on the needs, priorities and requirements of users and society. This can be combined in a natural way with organizational development with a proper alignment to ICT development,
- the linking to workflow management. Processes are not integrated in LADM, linking is possible by role types, versioning, quality labels and exchange of data between involved organisations,
- structuring and organising data in interaction with data in other databases. Databases can be implemented in a distributed environment in different organisations with different responsibilities in Land Administration and population registration. The LADM is usable within a Spatial Data Infrastructure. This concerns the data exchange between organisations involved in land administration. The LADM "packages" have been introduced for a proper representation of tasks and responsibilities (which can be in different organisations). LADM can be a basis for combining data from different LASs; e.g. LASs with datasets on formal and informal People to Land relationships. The International Standard includes informative example cases with People to Land relationships demonstrating the flexibility of the standard. For implementation in SDI the links to external classes in other registrations are important, and:

There is support from professionals, e.g. within FIG (FIG submitted the New Working Item Proposal to ISO, LADM is 'FIG Proof'), UN-HABITAT (the development and implementation of STDM), EU (attention to LADM in relation to the Land Parcel Information Systems, INSPIRE), FAO (LADM as basis for FLOSS/SOLA) and countries (Cyprus, Portugal and Honduras, Canada, Indonesia, Uganda, Senegal, Vietnam and China and South Korea) are interested. See: http://wiki.tudelft.nl/bin/view/Research/%20ISO19152/WebHome (this wiki includes LADM documentation).

The standard has been designed in such a way that it can easily be changed depending on local demands. Use of the standard is far away from 'dogmatic implementations' with fixed rules; on the contrary the approach is as flexible as possible. It is a common language for LA enabling understanding each other. ISO has a standard update cycle for revisions of standards.

A choice for LADM is a strategic choice with its support to the latest insights and global views: the continuum of land rights and the FAO Voluntary Guidelines. ISO guarantees proper maintenance of the standard – future developments in the domain can be included in this way. The standard has been developed by experts from all over the world: UN Habitat Land Tenure Section with its comprehensive knowledge on customary tenure systems, EU Joint Research Centre with a broad knowledge base on INSPIRE and LPIS, the United Nations School for Land Administration Studies with many alumni on top positions in land administration organisations in many countries and representatives from Land Administration organisations, universities and normalisation institutes joined forces in this development. During the development there has been a continuous support by experts from the International Federation of Surveyors with a broad view on land administration and from experts in legislation and Geo ICT. Existing knowledge is integrated.

The standard allows for the implementation of a rich functionality over distributed environment. Some of the offered options still have to be discovered, for example during pilots. A LADM community is developing. So far workshops have been organised in 2003, Enschede, the Netherlands, in 2004, in Bamberg, Germany, in 2009, Quebec City, Canada and last year (2012), in Rotterdam, the Netherlands. The LADM 2013 will be in September 2013 in Malaysia. More and more questions on application issues arrive to the editors.

A conformance test is included in the standard. Many county profiles and legal and spatial profiles are included.

This makes the concept of LADM a basis for strategic development in land administration.

Let's built the systems now to achieve the wider goals.

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# Annex I

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