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LADM COL

Land Administration Model

Vol. 2:

LADM Approach in Colombia

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AGUSTÍN CODAZZI



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Preliminary Considerations

The Instituto Geográfico Agustín Codazzi (Agustin Codazzi Geographic Institute —IGAC by its acronym in Spanish—), in its exercise as the maximum cadastral authority, gives the following linear and progressive documents, with the present one being the second. These documents are the result of a research process emphasized in bibliographical review and the generation of documents that could be used as input for the comprehension, development, and promotion of the Land Administration Domain Model (LADM) and the adoption of this one to the Colombian profile, denominated as LADM-COL.

Throughout the document review, it will be possible to encounter diverse technical and methodological analyses of the process, history, changes, and behavior that the LADM-COL Extended Model Cadastral-Registration, and the various application models that surged in the framework of Multipurpose Cadastre, thus seeking to make the cadastral approach the center of these writings so that the various actors of the cadastre and the community in general have within reach a purified and synthetic version of the processes, lessons and current state of the adoption of the models, based on official documentation from the IGAC as the governing body.

Regarding the documentation of these models, it has been observed that if the official information, issued by different national organizations, is contrasted over time, since the conception of the standard’s inclusion in Colombia, it may present some ambiguities or appear to be inconsistent in terms of the terminology associated with designated them and the competencies related to them. This corresponds to the institutional development, evolution, and understanding of the implementation of the Land Administration Model in Colombia, oriented towards cadastral management with a multipurpose emphasis.

In the ensuing part is a conceptual map displaying the name of each document, a brief description, and the position that it occupies within the sequence, to delimit its scope and provide the reader with a general overview that allows them to navigate its contents more easily (Figure 1).

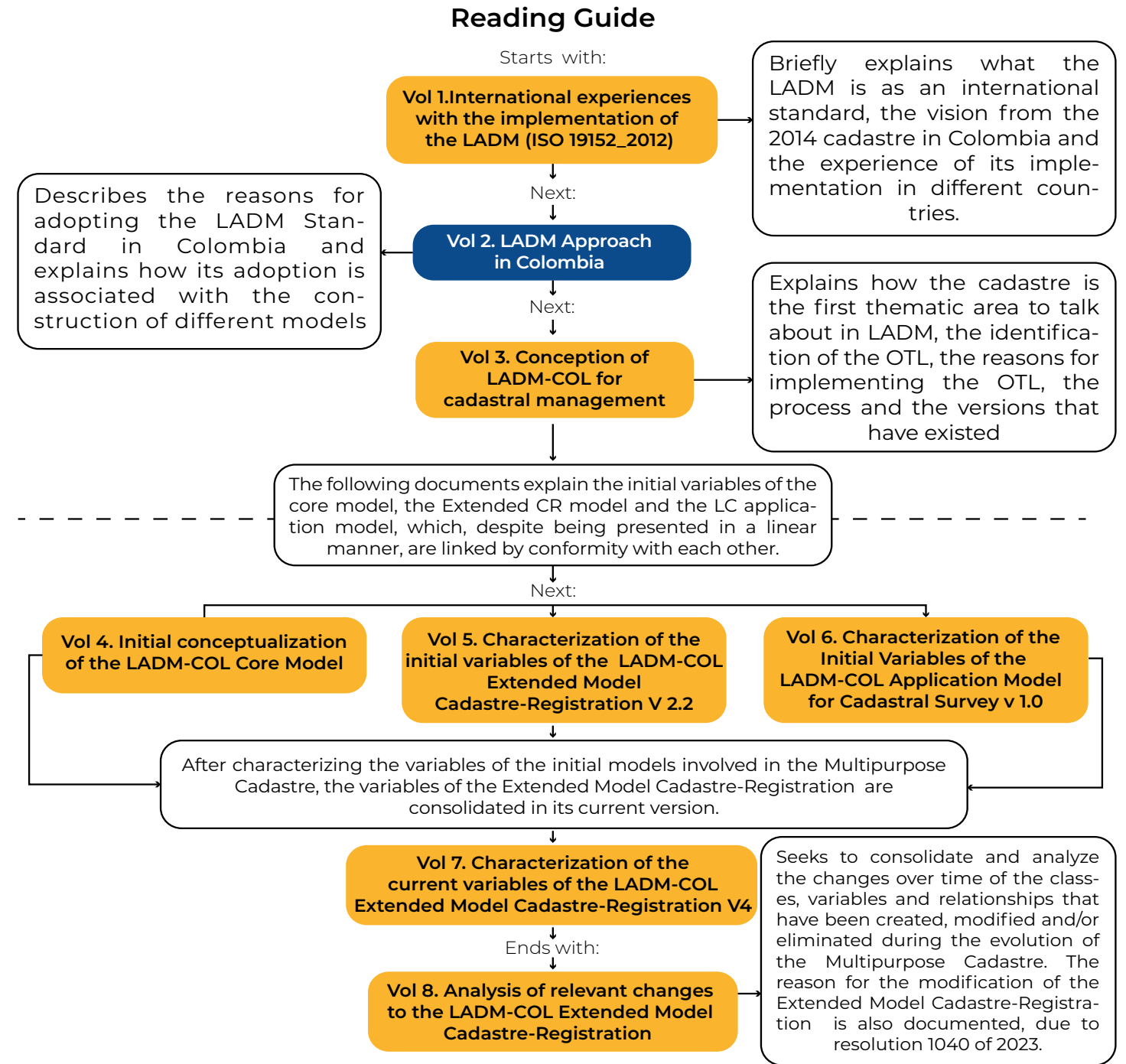


Figure 1. Reading Guide for Documents Related to LADM Conceptualization in Colombia.

Introduction

The document addresses the question of how the concept of the LADM (Land Administration Domain Model) started in Colombia, derived from the international standard. This topic is discussed through the following questions: Why was the LADM adopted in Colombia? Why look for a standardized international model? And why was the LADM chosen as a response to the land modernization?

The LADM was born from the definition of an international standard for the modeling of land administration systems, which has extensive international implementations, applied research projects, and technological solutions available all around the world. Taking this into account, it is valid to ask: why LADM is involved with cadastral modernization in Colombia? The answer to this question is important because it is related to the reasons that give rise to a proposal for land administration which is based on the cadastre. The question of why start with the cadastre will be analyzed through four main sections:

» The first section presents brief accounts that explain the history of the first mention of the LADM in Colombia. This section also documented the concept of a Colombian profile and the principles by which the land modernization process began.

» The second section is divided into two: The first one looks to register the principal elements of the document, decisions, and some characteristics that must be emphasized of the ISO 19152: 2012 LADM standard. On the other hand, the second one answers the questions that arose over time, particularly those related to the decision to adopt the LADM for Colombia and use it as a standard for the national cadastral data administration, due to the fact that were conversations about a possible decentralization of cadastral management.

» The third section concludes the document by showing the current state of the LADM-COL, its role in public administration, and how in the present year there have been some advances in the development of multiple systems in different national organizations, to start the land modernization process and get close to a trustworthy and complete land administration system.

ISO 19152:2012 LADM Standard Characteristics

What is LADM?

LADM is a reality conceptual model that defines a common terminology for land administration considering general patterns in geographical information management (International Organization for Standardization [ISO], 2012). It is a standard based on the *Multipurpose Cadastre* concept, also known as *multifunctional cadastre*, that is based on the legal information, party information, spatial unit information, or even the topographic survey data that are necessary to define the geometrical part of a land spatial unity recognizes the diversity of legal, social and environmental conditions that affect land property. The model is a useful tool that facilitates the interoperability, quality, and updating of land information, as well as improving citizen services.

Furthermore, this conceptual model captures the semantics related to land administration, based on the agreements of geometry, temporal aspects, metadata, and the observations and/or field-captured measurements. Within these agreements, it is possible to see how LADM allows portraying the rights, restrictions, and responsibilities (RRR) that exist over the basic administrative units, alongside delineating the relationships among people, organizations others, and spatial units.

Where Does LADM Come from and Why Is It Important to Evaluate it?

LADM international standard emerged or was inspired by the vision of cadastre 2014, as a response to the need to have a common conceptual model for land administration, considering that, even if this cadastre vision indicates it, the cadastral mapping, cadastral maps, and systematization models that related must be left in the past. The analog systems must transform into digital systems for them to be not only dynamic but also able to extract cartographic information at any scale and without any inconvenience. Similarly, it aims to improve the precision and consistency of land information, enabling the reuse of integrated and interoperable information between the different information systems of a country, organization, or others.

In this cadastre vision, five principles were established, with the *legal independence principle* being one of them. The reason this is mentioned is because it is the foundation of the LADM concept as an international standard, promoting that each knowledge area related to land administration could describe its principal geographical elements so they could be incorporated into the land administration system. All must be done following the conformance of the general standard but without prejudice to possible modifications.

Another principle that maintains the cadastre 2014 concept and its integration with LADM is the efficiency and efficacy principle, as it establishes that land administration based on cadastral information should be efficient and effective in the gathering, updating, and diffusion of information about land resources, assuring that the information is precise, updated, and accessible. This has the aim of making the cadastre more profitable and useful for society.

Finally, it is worth emphasizing the principle of community participation. As the LADM model aims to ensure interoperability and integration of cadastre with multiple information systems while also being a standard for land

administration, it is crucial for society and the community to understand it and, most significantly, to actively engage in the processes unfolding in the land. Therefore, this principle advocates for people to participate in the development and operation of a multipurpose cadastre where their opinions are not only considered to meet socialization requirements but also to inform data characterization and determine implementation methodologies in land management, among other aspects.

Conception of the LADM ISO 19152:2012 Standard in the Colombian Context

The ISO 19152: 2012 Standard defines land administration as “the process of determining, recording, and disseminating of information about ownership, value, and use of land when implementing land management policies” (ISO, 2012, p. 8). Thus, when interpreting the concept of *Land Administration System* (LAS), for which the LADM standard was created, it can be defined as a *Land Information System* (LIS), with cadastre as its main axis. In other words, it is a spatial information system, updated and based on properties and/or parcels, which also contains information about land parties, rights, restrictions, and responsibilities. Not only that, but it also involves the real estate market, territorial planning, and even environmental management of the land (IGAC, 2016) (Figure 2).

The LIS based on the LADM is the main source of determining, recording, and disseminating information about land-related activities and annotations, along with their geometrical components (ISO, 2012, p.8). One of the objectives of the LADM standard is to unify the vocabulary or semantic framework underpinning various LIS or Geographic Information Systems (GIS), proposing a clear conceptual structure that allows for a simple, efficient, and effective conceptualization of the-

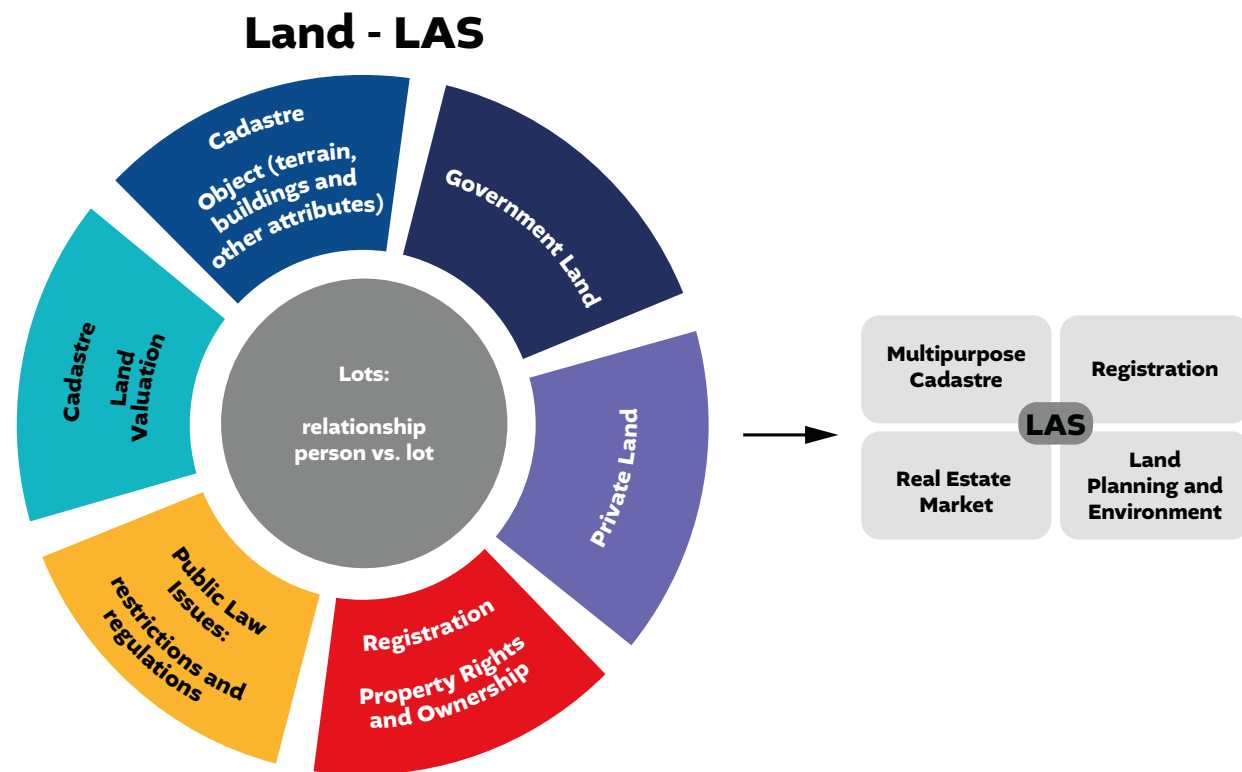


Figura 2. LADM Outline. **Source:** IGAC & SNR (2016).

se systems, without conditioning it to specific methodologies, while safeguarding the legal independence principle that was previously mentioned (IGAC, 2018).

LADM provides a unified framework of land data administration that is based on common ontology and semantics that facilitate data exchange and interoperability through appropriate methods. To contribute to this objective, LADM has a Model-Driven Architecture (MDA) emphasis that allows conceptual data models to remain technology-neutral in their implementation, being useful to the land administration field (Ramírez et al., 2020).

This conceptual model is commonly depicted through UML diagrams that

allow users to visualize and discuss the relationships among the legal land objects or basic administrative units (BAUnits) and their structural components such as parties, rights, restrictions, or responsibilities that a party could have over an administrative object, and ultimately, the spatial representation that an object may possess. In this regard, the LADM provides a standard based on specific land administration terminology.

The LADM consists of 3 units or packages: first is the Party Package, the second is the Spatial Unit Package, and the third one is the Administrative Package, which has two essential components, the basic administration unit (or legal land object) and the RRR (Rights, Restrictions, and Responsibilities) (Figure 3).

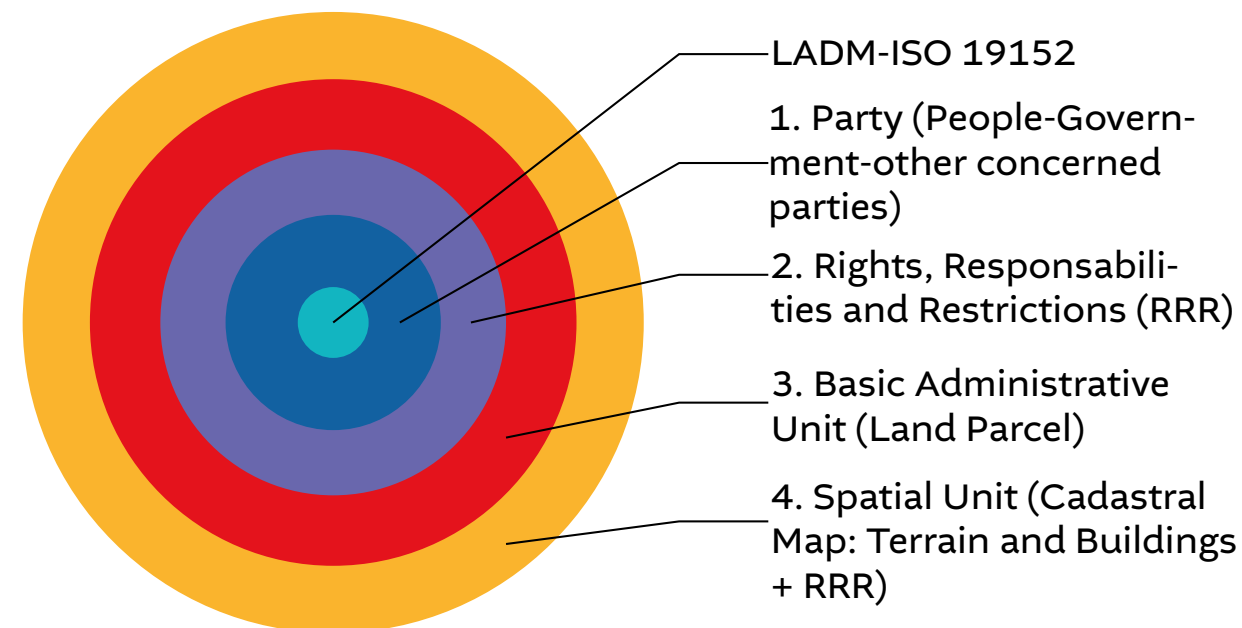


Figura 2. LADM Outline. **Source:** IGAC & SNR (2016).

There is also the Surveying and Representation Subpackage, part of the spatial unit package (IGAC, 2016), which will be discussed in a subsequent document.

Interaction of the LADM with the Colombian profile

What is a Profile and Why is a Colombian Profile Talked About?

The word *profile* refers to the adaptation of a norm, standard, or guideline, among others, to the reality of a specific territory. In this case, when a LADM Colombian profile is mentioned, it refers to the adaptation of the ISO 19152:2012 standard to Colombian reality, incorporating new aspects and considering that not everything described in the standard will apply to Colombia.

By the year 2015, the Colombian government was already discussing the integration of the LADM standard into the land administration processes. Nevertheless, before this, some considerations should be given on how to implement the standard and adapt it to the reality of the Colombian context (IGAC & SNR, 2020), as well as its administrative structure.

What is the LADM Colombian Profile?

The LADM Colombian profile was created based on two main aspects, which served as the basis for its implementation in Colombia. The first aspect is the post-conflict scenery, settled on the Havan Peace Agreement of 2015, and documented in the Integral Rural Reform. In this context, cadastre becomes an opportunity to address issues related to land resource management, deeply affected by the armed conflict over generations. Thus, the Multipurpose Cadastre emerges, alongside the need to optimize detailed geographic information about the land. This optimization becomes necessary for the consolidation of peace and the effective fulfillment of the pillars agreed upon in the Agreement (Departamento Nacional de Planeación —National Planning Department [DNP, by its acronym in Spanish]—, 2016).

The second aspect that was considered in the discussion of LADM in Colombia is the gap between the access and disposition of land information

that's always been present, since 2014, the national organizations didn't have a system, service, repository or tool that could manage the information of the national territory. The limitations of the availability of the information generate the problem of finding different types of cadastral data, as the cadastral and registration information are not integrated. Likewise, regarding the territory regulations relevant to the decision-making process most of them come from different sources without any apparent administrative unit.

The former is caused by the lack of unified concepts and/or exchange formats for geographic information, as well as the reluctance of organizations to share their information. Simultaneously, various languages, formats, reference systems, and cartographic inputs, among others, are used for generating, manipulating, and even sharing geographic information, which contributes to the problem, because when someone attempts to review and compare such information they find discrepancies, as the different types of information do not match each other (DNP, 2016).

Because of the issues mentioned above, it was necessary to begin the land administration modernization process, in the framework of the international cooperation project funded by the Swiss Agency for Development and Cooperation (S). In this endeavor, the Colombian government, as the promoter of the Peace Agreement and aided by various governments, looks to strengthen national institutions by transforming them in terms of geographic information management. The aim was to build a data model that provides the standardization of concepts, information exchange, interoperability, and the building of software applications for managing the country's geographic data.

During the discussions on the modernization Project, the SDC presented the idea of involving an international standard, known as LADM, which is described and justified in the ISO 19152:2012 standard. This standard consists of a modular approach composed of various thematic data models that are an extension of the core LADM data model.

When this proposal was presented to the committees where the different national organizations such as IGAC, the Superintendencia de Notariado y Registro (Superintendence of Notary and Registration —SNR by its acronym in Spanish—), and the Infraestructura de Datos Espaciales (Colombian Spatial Data Infrastructure —ICDE by its acronym in Spanish—) met, the proposal was well-received by several reasons, including:

- » The LADM is a conceptual model, which provides a structure to organize information, but it does not define how that information is stored or represented.
- » The LADM is a modular model, which means that it could be divided into different components that could be adapted to the specific needs of the country or region.
- » LADM is based on the ISO 19152:2012 standard, adaptable to fulfill the specific needs of every country or region.

Afterward, the organizations and their representatives evaluate the viability of adapting the standard and how it could benefit the country, particularly its implementation in land administration, the outcome of this validation process was deemed favorable due to its ease of management and its advantages in integration and interoperability between information systems. As a result, Colombian organizations began a discussion about LADM.

Within these discussions, it was decided that, at least for the development stage of the Colombian profile, ICDE and IGAC would be responsible for leading the process of conceptualization, appropriation, and generation of the LADM adjusted to Colombia. Consequently, it was clear that official adoption would require defining and identifying a *Legal Land Object* (LLO), which acts as the principal element of the Colombian profile proposal since they are the basis for land information management.

This legal land object is defined as a land portion that has legal documentation. This implies that it is legally established and can be classified as several types like parcels, slots, estates, properties, districts, towns, and states, among others.

According to the LADM standard, the characteristics of LLO are based on the following elements:

- » Spatial Units: Land sections that constitute LLO.
- » Group Party: People or organizations that have a type of link with LLO.
- » Rights, Restrictions, and Responsibilities (RRR): Rights, restrictions, and responsibilities that can be held over the LLO or that the LLO must receive or apply to itself or some adjacent element.

For the determination of an LLO, there must be an identification of its physical, legal, and administrative attributes. Physical attributes include location, shape, size, and limits, among others. Legal attributes include ownership, rights, obligations, etc. Lastly, the administrative attributes of an LLO include its administration and management. The process to determine it includes the following stages:

- » Data acquisition: During this stage, information about the physical, legal, and administrative attributes of the LLO is collected. This information may come from various sources, such as public documents, cadastral records, registration entries, etc.
- » Information Analysis: During this stage, the collected information is analyzed to identify the physical, legal, and administrative attributes of the LLO.
- » LLO Determination: During this stage, the LLO is determined based on the attributes identified in the information analysis stage.

It is important to highlight that every national organization could define its LLO following the previous considerations, and the guidelines provided by the ICDE for that process. However, each organization may request assistance from the ICDE for the determination.

Once the process of identification and determination of a LLO as the central element of the LADM was defined, it was possible to conceive a *Colombian profile* named LADM-COL —Resolution 642 of 2018— (IGAC, 2018). This is a unique model that, through defining standard data semantics, facilitates governance, exchange, and interoperability between institutions' information systems that produce or manage land information in the country. Also, it contributes to improving the quality of the data managed by the Colombian government organizations (ICDE, 2022). Furthermore, it serves as a reference for the conceptualization of Colombia's Land Administration System (LAS), which aims to integrate processes and stakeholders involved in territory management.

To create thematic models (extended models) derived from the LADM-COL, each organization must propose them (Resolution 642 of 2018) as well as they should propose the extended model for the LLO in their jurisdiction.

Knowing the structure of the LADM-COL model, which was legally endorsed for the first time in the Resolution IGAC 642 SNR 5731 issued on May 30, 2018, the international cooperation project appointed with the technological implementation of LADM in Colombia proposed the use of INTERLIS conceptual descriptive language as a standard for exchanging data models. This language has been successfully implemented in the Swiss cadastral system for several decades (Swissterras, 2017). Additionally, in Switzerland, the development and enhancement of open-source software tools were undertaken, enabling the use of standard and automatic data validation (Álvarez, 2019).

Once the language and operation of the LADM-COL model in Colombia were understood, Swiss Cooperation, in conjunction with IGAC and SNR, would be responsible for managing and implementing all changes to this model. However, in 2020, the ICDE was established as the committee responsible for the production, exchange, access, and use of geographical information in Colombia, as well as for administrating the core LADM-COL model CONPES

4007 (DNP, 2020). This means that ICDE took on the task of defining not only the guidelines but also the best practices that all organizations managing data on national territory should follow to implement the standard in their information systems. This process would be led by IGAC in its role as the technical operational coordinator of ICDE (2022).

As a complement to this adoption, and being considered a new language in Colombia, the international cooperation project team designed and provided a set of tools on a web platform for quick data access, data manipulation, and generation of geographic and cadastral information following the LADM-COL standard. Additionally, the project development team contributed to the enhancement and completion of these tools by integrating a web-based system, a massive validation process, data storage verification, visualization, and data download, based on the models defined by LADM-COL.

Other Important Aspects of the LADM-COL Standard

Although it's been established that the LADM, as an international standard for land administration, was conceived with the vision of the Multipurpose Cadastre in mind, according to the FIG, the model is also useful for managing data related to environmental administration, characterization of ethnic and ancestral territories, mapping of biological branches like forestry, and characterization of national heritage, among others. These themes are integral components of the LADM-COL national profile.

As an example of the application of the LADM-COL standard in a different context than cadastre, the creation and formulation of the territorial planning Model (LADM-COL-OT by its acronym in Spanish)¹ which was defined and led

¹ This model, when made official, seeks to incorporate existing data and new data from the land use plans being developed into the standard that aims to achieve interoperability within the framework of the land administration system. interoperability within the framework of the territorial administration system. It is important to highlight that the IGAC participated in the generation of this model by taking part in the discussion tables for the consolidation of the different for the consolidation of the different classes and attributes of the first version issued by the Ministry.

by the DNP. This model was officially approved and adopted on July 12, 2022, by the Ministry of Housing, City, and Territory, which issued Resolution 0495 “By which the LADM_COL - POT Extended Data Model is adopted for the formulation of territorial planning”.

At this point, it is important to look at the scenery of the legal independence principle, which is the basis for the creation of all the extended models that could finally conceive the LAS in Colombia. This principle states that each LLO is linked to the law, meaning that a specific law defines these objects, so each one should correspond to an individual data layer. The following presents how several types of information are binding for a LAS, whether administered by a single organization or by several (Figure 4).

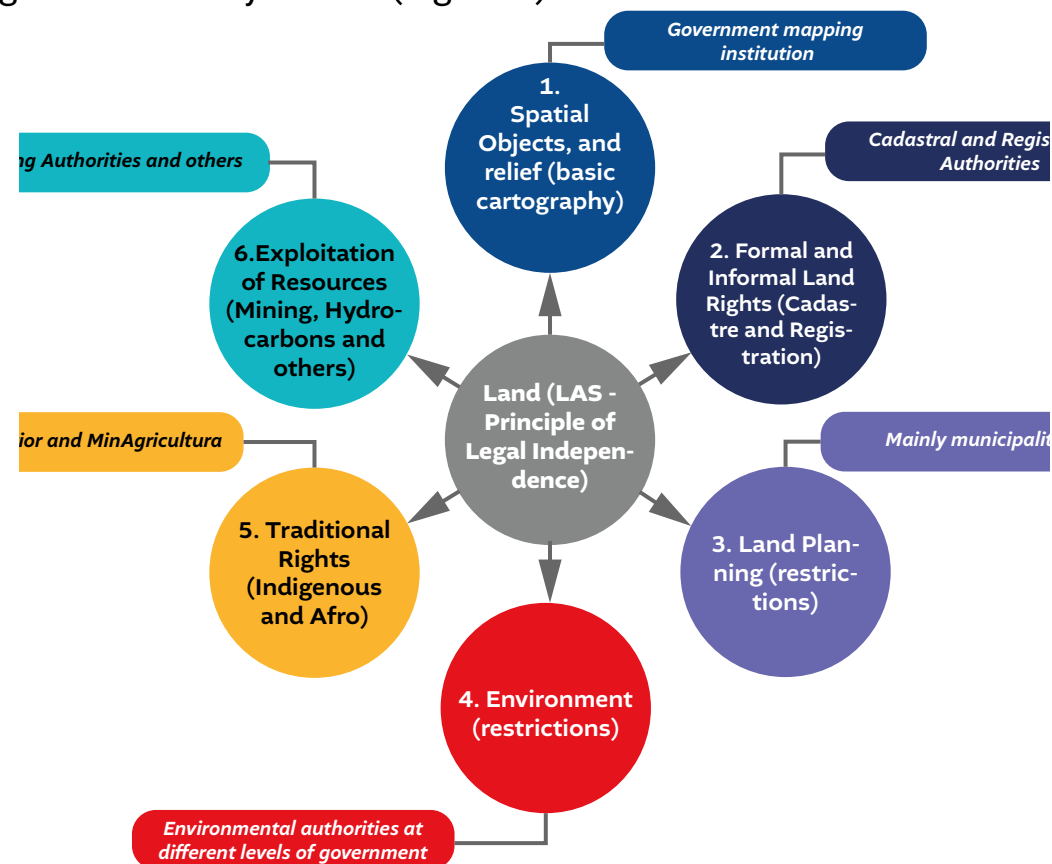


Figure 4. The LAS, Land, and the Legal Independence Principle. **Source:** IGAC & SNR (2016).

The SDC proposed different ideas regarding conceptual data models that could work for implementing the LAS in Colombia. One of the first versions was published in November 2017, where the core LADM-COL appeared as shown in Figure 5².

After several years of adjustments, testing, and working sessions among various organizations —IGAC, SNR, ICDE, Ministry of Environment and Sustainable Development (MinAmbiente), Ministry of Housing, City and Territory (MinVivienda)—, the current version (Figure 6) has been completed. This version serves as the basis for structuring and defining extended models of land objects, under the responsibility of the organizations involved in implementing the ISO 19152 LADM standard.

Conformance of the LADM-COL Model

To gain a better understanding of the implementation and adoption process, it is essential to analyze and interpret the LADM-COL standard, considering how these models are composed.

The core model holds a central position, while extended models derive from it. Although they should be like the core model, extended models include specific details in their structure related to the LLO to characterize them.

These diagrams of elements allow the identification, characterization, and representation of a unique Legal Land Object (LLO) with a minimum set of necessary variables (or attributes).

Finally, application models are a specialization of an extended model. In other words, they are a *specialization of the specialization* and answer specific issues associated with the extended model and its LLO (Figure 7).

As extended models derive from the core model, and application models branch off extended models, they will have a conformance level that should be low, medium, or high once they are built.

² It is important to emphasize that the explanation of the composition, structure, relationships, cardinalities, variables, among others, of the core model LADM-COL version 2.2.0 are particularities of Figure 5, which will be addressed in a later which will be addressed in a later paper.

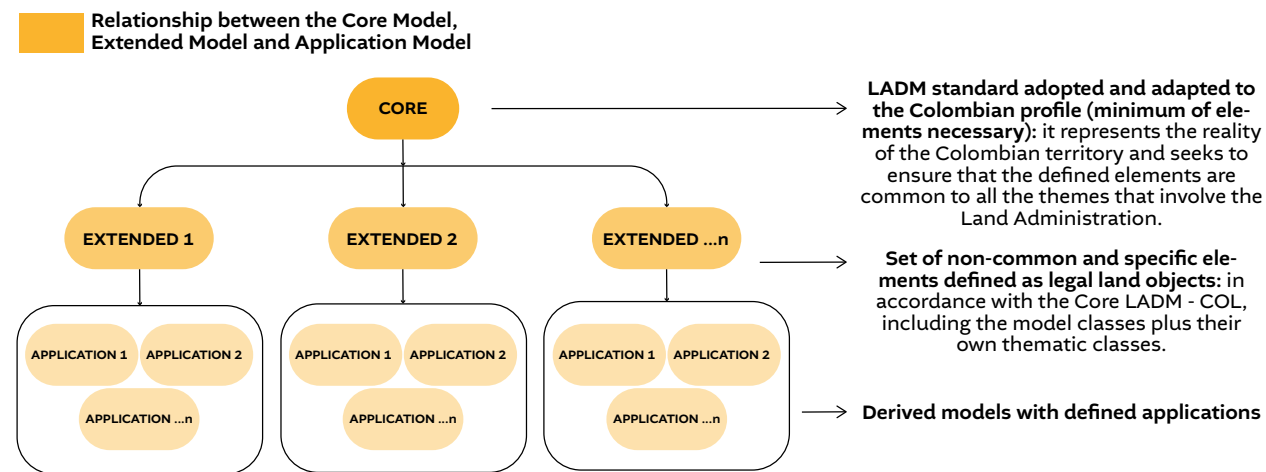


Figure 7. LADM-COL Conformance Levels.

The conformance level indicates how well the model aligns with its parent model. This means that for an extended model, its conformance level is high if it matches every element (classes, attributes, and relationships) of the core model, medium if it excludes some elements, and low if there's minimal correspondence with the core model. Likewise, an application model's conformance level—whether high, medium, or low—depends on its alignment with the structure of the extended model it comes from.

Considering that one of the main reasons for adopting the model is to guarantee interoperability among information from various organizations for building the LAS, defining these conformance levels helps maintain awareness that interoperability arises from the “compatibility” of information. Consequently, the conformance levels serve as a qualitative measure of assessment. This observation should be kept in mind during the construction and analysis of the different models.

In conclusion, modifying a specific model will require a reassessment and adjustment of the models derived from it. For example, if there is a change in an extended model, the application models that originate from it must be adapted, otherwise, they may become less compliant.

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