

# **Extended models from the Colombian LADM Profile as support of Land Use Planning**

**Fabián MEJIA, Alejandro TELLEZ and José Antonio PINZON, Colombia, Daniel CASALPRIM and Moisés POYATOS, Spain**

**Key words:** Multipurpose Cadaster Colombia, LADM based on INTERLIS, LADM and SDI integration, Land Use Planning Data Model

## **SUMMARY**

In Colombia, each institution with interests and competencies on land uses their own model to store and manage the data needed to meet their own scope and needs, but this is done without a shared standard between them that permits the data interoperability. For this reason, the building of the Spatial Data Infrastructure for Land Administration (IDE-AT) is one of the priorities in Colombia. This infrastructure must have tools and functionalities that enable an environment of interoperability of data and services between the entities involved in territorial planning

The new Multipurpose Cadaster of Colombia defines, as a standard to achieve data interoperability, the ISO 19152 (LADM). This standard should not only be seen useful for issues related to cadaster and registry. Beyond the land tenure, there are other important topics, such as environment areas, ethnic and ancestral territories, forestry, hydrology, national heritage and others. These themes will become part of the national profile of LADM (LADM-COL), composed of a basic core of common semantics and a set of extended models for the different areas of land administration.

Over the next few years, with the support of the SECO (swiss cooperation) funded project “Modernization of Land Administration in Colombia” and under the SDI for land administration framework (IDE-AT) as the coordinator of the decentralized management of land administration data in Colombia, the concept of modularity among the entities involved in the land administration should be consolidated. This will permit the definition and building of new extended models.

Among the extended models, Colombia has an accepted conceptual land use planning model (LADM-COL-OT) that has been defined with the participation of the project under the leadership of Planning National Department (DNP). This extended model is currently under validation by the governmental entities involved in this domain . The LADM-COL-OT, shall be officialized to incorporate existing data and new data coming from the land use plans that are currently being developed. Finally, the existing tools that have been designed need to be tested and improved with real data.

# **Extended models from the Colombian LADM Profile as support of Land Use Planning**

**Fabián MEJIA, Alejandro TELLEZ and Jose Antonio PINZON, Colombia, Daniel CASALPRIM and Moisés POYATOS, Spain**

## **1. INTRODUCTION AND BACKGROUND**

Colombia faces transcendental changes to the definition of public policies related to land governance since the peace process between the FARC and the Colombian government that resulted in the “General Agreement to End the Armed Conflict and Build a Stable and Lasting Peace” (Acuerdo Final. 2016). Among other initiatives, the Colombian government decided to create the Modern Multipurpose Cadaster that integrates the planning and territorial information systems through the public policy document called "Policy for the Adoption and Implementation of a Rural-Urban Multipurpose Cadaster" (DNP. 2016) from the National Council of Economic and Social Policy (CONPES 3859 of 2016). The public policy proposes the adoption of international standards adapted to the Colombian case (ISO 19152 - LADM-COL) with the scope to integrate the information provided by the public entities related to land information to make it available for everyone, according with the open data policy.

Colombia has been working on the construction of the Multipurpose Cadastral Data Model (IGAC/SNR. 2016), and the evaluation of the first data set provided by the pilot projects is currently being developed. This will help define the expansion phase to scale up the methodology to the entire country, where interinstitutional participation will be crucial. Some of the main activities for the implementation of the modern multipurpose cadaster are development, building and implementation of the National Multipurpose Cadastral System, strengthening of the current cadastral systems for the administration and management of the cadastral information, execution of processes for data acquisition, update and maintenance of the cadastral information with a multipurpose approach and the inclusion of the social tenure plan for rural property with the participation of entities such as the Geographic Institute Agustín Codazzi (IGAC), Superintendence for Registry and Notaries (SNR), the National Land Agency (ANT) and the National Planning Department (DNP).

Currently, each institution uses their own model to store and manage the data needed to meet their own scope and needs, but do not have a shared standard between them that permits data interoperability. For this reason, the building of the Spatial Data Infrastructure for Land Administration (IDE-AT) is one of the priorities. This infrastructure must have tools and functionalities that enable an environment of interoperability of data and services between the entities involved in the land sector (Gozdz. 2015) previously mentioned.

The standardization is based on the application of the Land Administration Domain Model (LADM) (ISO. 2012) and its adoption as a Colombian profile, called LADM-COL, considering the principle of legal independence and based on the Model-Driven Approach (MDA) (Mejia,

et al. 2017). This proposal is based on the definition of several extended models on key issues related to land administration that should be articulated around LADM-COL.

The “Modernization of Land Administration in Colombia” project, funded by the Swiss Economic Cooperation (SECO), has supported the governmental entities in developing a Colombian profile of the norm (LADM-COL) based on the ISO 19152:2012 and the building of the extended models for land administration (Baron. et Al. 2017).

In the specific case of the extended model for land-use planning (LADM-COL-OT), its building implies a high complexity since it has a strong relationship with other issues related to affectations in the territory. In this context, another important concept is proposed: “The model’s interrelation”, which is described as the need to reuse information coming from different models (all based on LADM). Some BA-Units described in environmental models can be considered as restrictions or responsibilities for other BA-Units belonging to the cadastral model and data from Cadaster-registry must be used to define land use planning areas as input layers. It is here where a complex panorama of relations between land administration issues come to light, and the principles of legal independence, modularity an interrelation are advantageous.

## **2. THE LAND ADMINISTRATION DOMAIN MODEL – ISO 19152:2012**

### **2.1 Basics**

The LADM is a conceptual model that captures the semantics related to land administration based on agreements about “geometry, temporal aspects, metadata and also observations and measurements from the field” (ISO. 2012).

It is important to understand the LADM as a conceptual model and not as a data product specification (Lemmen, et al. 2017). UML diagrams are commonly used to describe the LADM, which allows users to see and discuss the relationships between the administrative land objects (the BA-Units) and their structural components such as the parties, the rights, restrictions or responsibilities that a party might hold an administrative object and the spatial representation of the object. Thus, the LADM provides a standard based on a certain terminology of land administration, as described in ISO 19152:2012.

LADM is divided into a set of classes (Figure 1), grouped into three main packages (parties, administrative and spatial unit) and a sub-package (surveying and representation -spatial unit sub-package-).

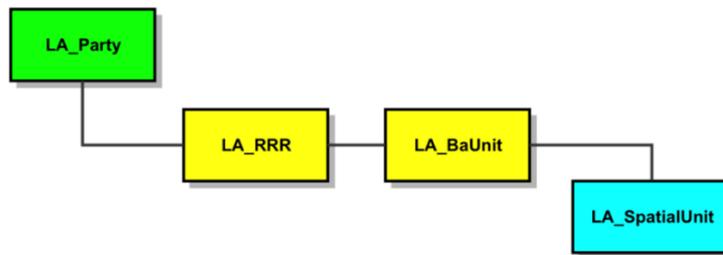


Figure 1 Main classes and packages of LADM

## 2.2 LADM - Colombian Profile

ISO 19152:2012 defines the Land Administration Domain Models as a reference for land administration. It must be considered as a conceptual model instead of a data product specification (ISO. 2012) and emphasize its function as a generic domain model. It can then be extended with new attributes, operators, associations and even additional classes, depending on the needs of a country or a specific region, and provide an abstract conceptual model. This is why, for the Colombian context, a national profile of LADM must be developed before its adoption.

Since September 2015, under the leadership of the swiss cooperation (SECO) and with the involvement of institutions, such as Instituto Geográfico Agustín Codazzi (IGAC), Decentralized Cadasters, Property Registry (SNR), National Land Agency (ANT), Land Restitution Unit (URT), and others, several workshops have been organized to develop the conceptual modelling process and the methodology for defining a Colombian LADM. These workshops have been conducted with the technical assistance of experts in the norm who moderated the modelling sessions with the local specialists.

One of the main challenges in defining the Colombian profile has been the establishment of the core model (Baron. et Al. 2017) conceived as the fundamental part that holds all common classes related to land administration issues. This leaves in the core model the very basic definition of ISO 19152, a set of abstract classes that establishes the main concept of the elements that participate in any extended model of LADM.

In this approach, the “Modernization of Land Administration in Colombia” project, together with the Colombian government, promote the concept of modularity of LADM (Bajo. et Al. 2017). Each topic of land administration consists of separate models all based on the same core model (LAMD-COL) and include geometry data type defined on ISO 19017. This concept allows each institution to work with its own legal spatial objects within its competence according to the current legal framework. In this way, all the resulting modules per topic (Figure 2) are created around the same ontological principles and the same semantics defined by LADM.

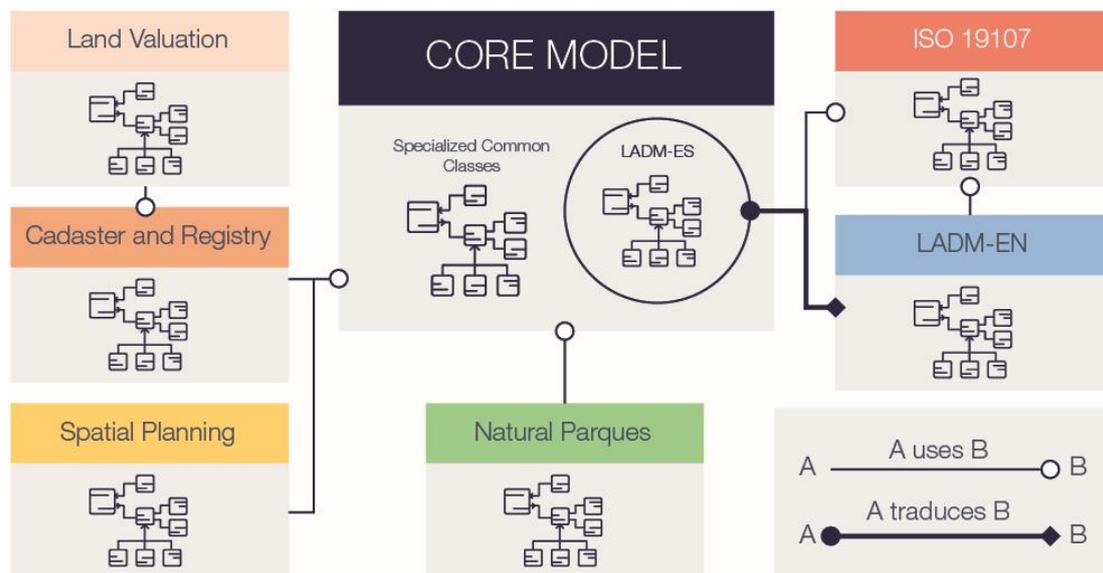


Figure 2 Modules in the LADM-COL

As a result of the building of extended models related to land administration in Colombia, the following stages have been identified and the tools developed that allow the definition and operation of these LADM-COL extended models based on INTERLIS.

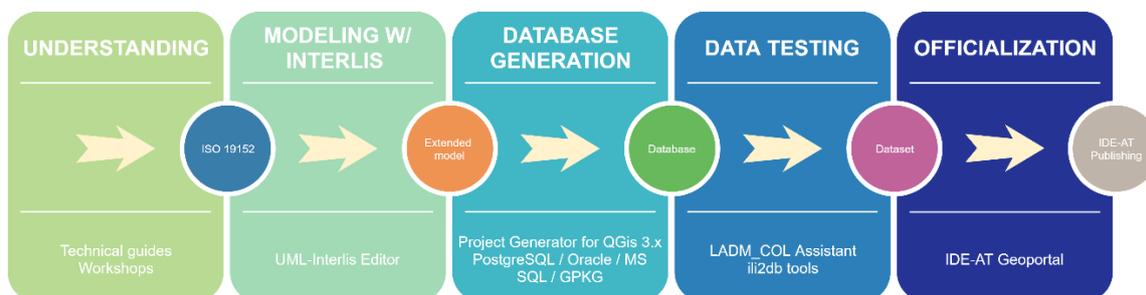


Figure 3 Principal stages for defining extended models of LADM

### 3. FOSS TOOLS FOR IMPLEMENTING LADM EXTENDED MODELS DESCRIBED ON INTERLIS

In support of the implementation of the LADM - COL standard, a set of free and open source software (FOSS) tools have been developed. They have been designed to supply the needs of the governmental entities involved in the process of data acquisition, data management and data exchange related to land administration (Jenni, et al. 2017). These tools are, on one hand, those that facilitate the work with models (creation of conceptual models, their compilation and their loading as a physical model in a database) and, on the other hand, those that allow data processing (massive load, massive validation, import and export).

The following figure illustrates a conceptual generic workflow of model's implementation using INTERLIS, starting from the definition of the model itself in a conceptual language and its transformation to a physical database model. This is followed by the structuring/loading of data, and it ends in the data transfer and validation according to the given model.

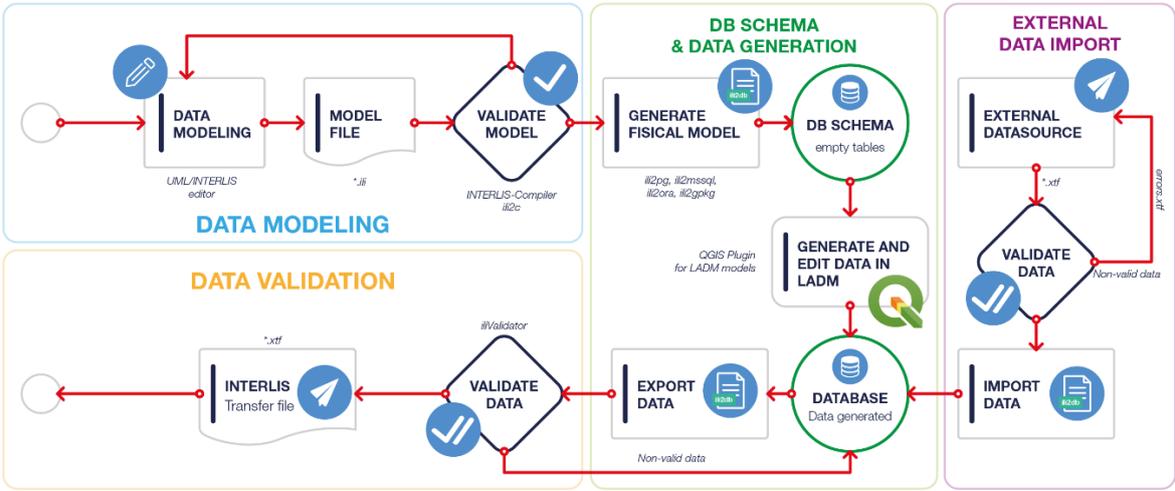


Figure 4 Interlis Workflow

Figure 4 describes each tool and its role into the typical conceptual INTERLIS workflow implementation. These tools are free and open source, and its source code is published on the Project's GitHub Page (<https://github.com/AgenciaImplementacion/>).

<i>Tool</i>	<i>Functionality</i>	<i>Language</i>
UML/Interlis-Editor	Modeling in UML and conversion to an INTERLIS model file *.ili	Java
INTERLIS-Compiler ili2c	Validates the syntax of the .ili files, produces other output formats.	Java
ili2db (ili2pg, ili2gpkg, ili2sqlServer, ili2ora, ili2fgdb )	Used for O/R mapping of object-oriented models to a relational DB schema; import and export DB data to (XTF) Interlis exchange format	Java
QGIS Plugin "Project Generator"	Generates interfaces and forms to edit data according to the model including domains, relations, constraints and data types	Python, C++
QGIS Plugin "Asistente LADM-COL"	Assits in the workflow of generating model-conform data, data querying, quality checks and printing/reporting.	
iliValidator	Validates the integrity of data to be exchanged with the rules and constraints established in the model (including topological constraints, etc.).	Java

Table 1 Tools and functionalities for implement INTERLIS-based models

The following diagram shows the value chain of the data in a decentralized operating environment applied to any topic of land administration.

In this case, the existence of two main actors is assumed. Firstly, a public or private operator that performs the activities of data collection, structuration and delivery, and on the other hand, a land administration public entity, in charge of receiving, validating and publishing the data according to its competence.

Principal steps for both actors and tools proposed by the Project are shown in Figure 5.

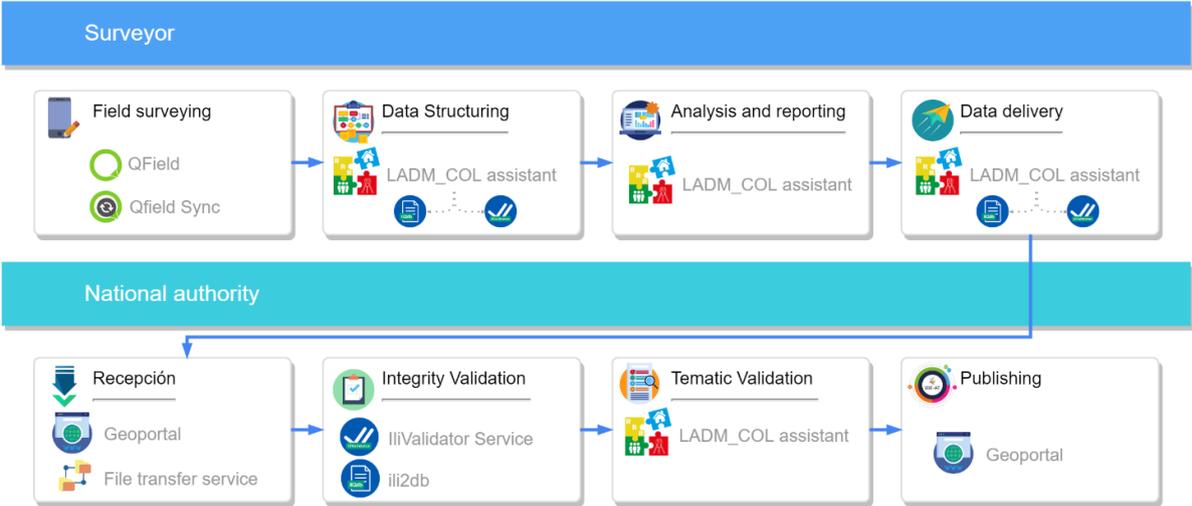


Figure 5 Workflow in a decentralized operating environment

**4. TERRITORIAL PLANNING MODEL**

Colombia is divided into 1102 municipalities, which are responsible for defining their own land use plans every 12 years. Those plans are the basic tools defined by the 388 Law of 1997 and are conceived to order human occupation in each part of the territory. In practical terms, land use plans defined so far lack standardized criteria, having even different conceptual bases, and this is the reason why the use of LADM is required: to unify semantics and ontology around land use planning in Colombia. Furthermore, it is possible to reuse the tools developed by the “Modernization of Land Administration in Colombia” project in coordination with IGAC, ANT, SNR and DNP, on the framework of the new Multipurpose Cadaster pilot’s projects funded by the World Bank. Those tools allow the definition of a conceptual model described in INTERLIS and to capture, edit and exchange data using standardized formats following the semantics established by LADM.

The proposed Land Use Planning Model (LADM-COL-OT) is conceived to formulate the Land Use Plan (not the diagnostic) and includes the main information of Land Use Plans according to the Colombian regulations (Law 388-1997, Law 1454-2011, Decree 1077-2015) (Zabala, 2018). This model is based on the LADM standard elements: Basic Administrative Units (BA-

Units), spatial units, rights, restrictions and responsibilities (RRR), stakeholders (Party) and Sources.

### 3.1 Basic administrative units

Several basic administrative units are defined, because different area types are defined within a plan and have different effects on the land use through rights, restrictions and responsibilities.

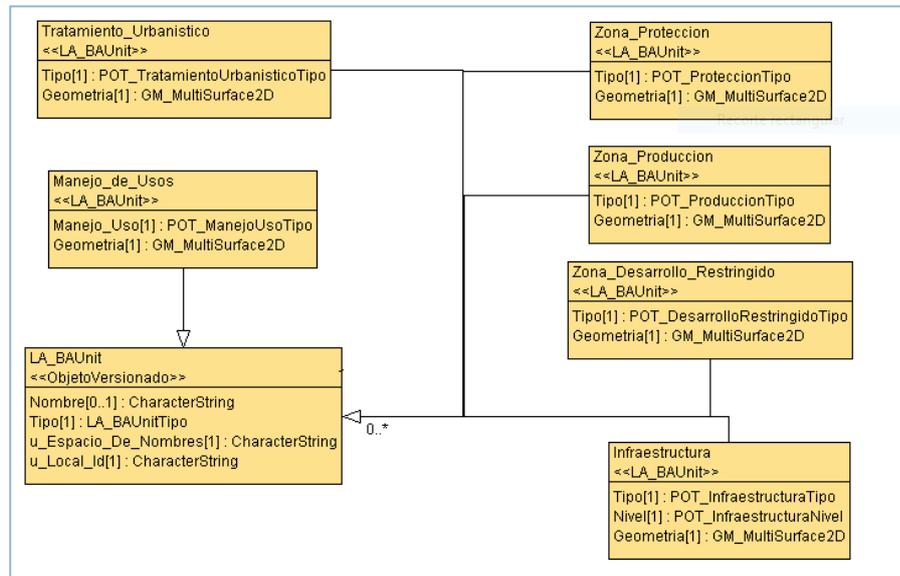


Figure 6 BA-Units in LADM-COL-OT

### 3.2 Spatial units

Spatial units are defined as areas that do not have a direct impact on the territory through rights, restrictions or responsibilities.

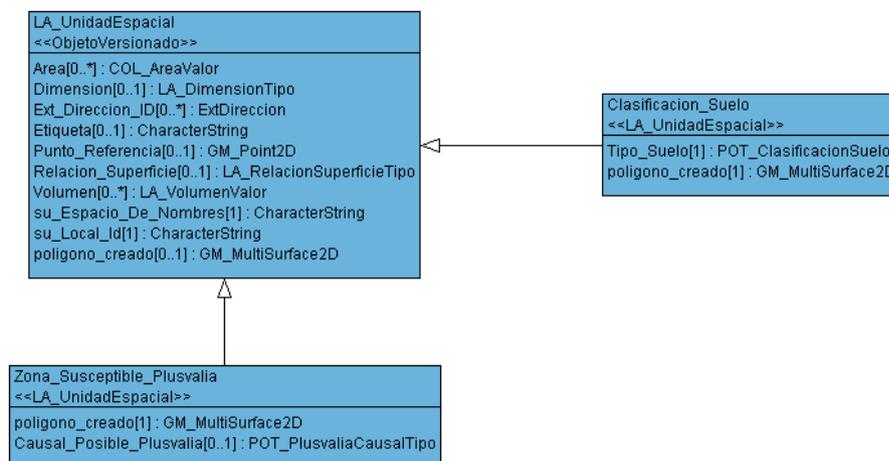


Figure 7 Spatial units in LADM-COL-OT

### 3.3 Parties

In the Land Use Planning Model, the municipality (Municipio) was defined as the main interested party, because it is the municipality which authorizes or forbids actions by public or private entities on their territories.

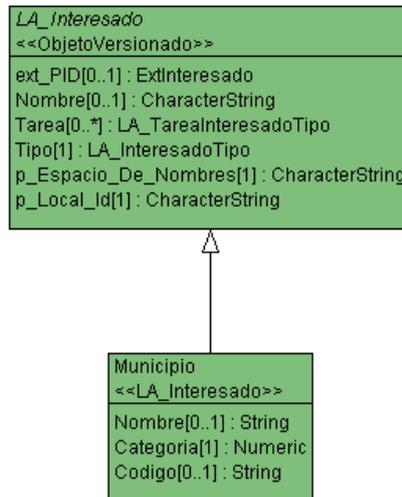


Figure 8 Parties in LADM-COL-OT

### 3.4 Rights, Restrictions and Responsibilities

At the level of rights, restrictions and responsibilities, the Land Use Planning Model must consider the different basic administrative units defined, and the defined domains contemplate all the possible RRRs that may exist on each of the basic administrative units, taking into account the hierarchy of restrictions. For instance, restrictions established by protection areas are more significant (more restrictive) than restrictions supposed by other BA-Units.

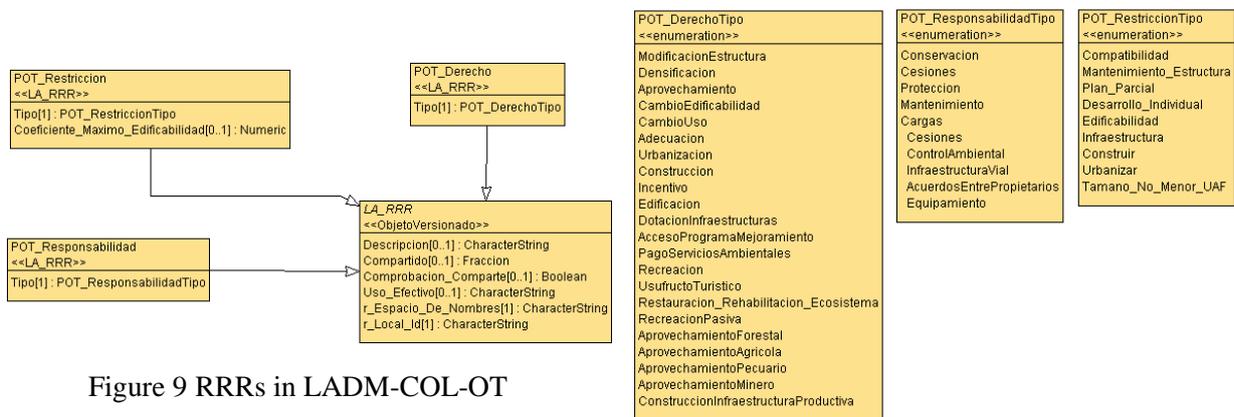


Figure 9 RRRs in LADM-COL-OT

Figure 10. Domains in LADM-COL-OT model

### 3.5 Sources

It refers to documents concerning the formulation of the land use plan, such as norms, decrees, and mainly the final document of the plan for the period formulated (According to Colombian Law, it must be renewed every 12 years but can be updated yearly).

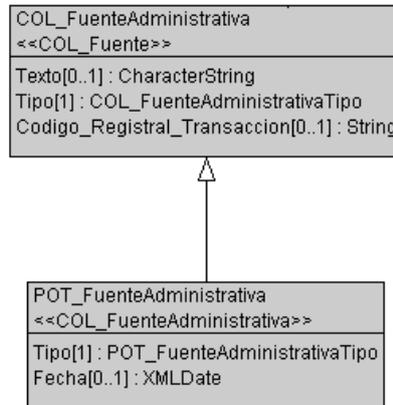


Figure 11 Sources in LADM-COL-OT model

## 5. MODELS INTERRELATION AND THE SDI FOR LAND ADMINISTRATION

Currently, Colombian entities use data modeled by themselves without attending to a single standard and without the possibility of efficiently interoperating with other institutions. For this reason, the construction of a Spatial Data Infrastructure for Land Administration (SDI-LA) is one of the main priorities. This SDI must have tools and functionalities that enable interoperability of data and services between the entities, and it must be focused on the citizen.

SDI-LA is a thematic node of the Colombian Spatial Data Infrastructure (ICDE) and should be an entry point where different users interact with a universe of resources, services and applications, based on the need to facilitate access and use of territorial information.

Thus, the different models of land administration converge in the SDI-LA environment, where the objects administered by a single theme can serve as an input to create new objects for another theme of the land administration (e.g. river flows are the main input to define hydraulic rounds and their environmental protection areas. Each of these levels of information is defined in an independent data model and is managed by different entities). Also, existing objects in a data model can suppose limitations/conditions for the establishment of activities that are mapped in another model (e.g. indigenous lands and ancestral territories are areas where the development of commercial activities, such as mining or extensive agriculture, is not allowed. In consequence, areas defined on indigenous reserves model will be a restriction on land use, defined in the use planning model).

Figure 12 shows how the information contained in the cadaster-registry model (left) is linked to the Land Use Planning Model (right). Using one spatial query, it is possible to obtain a report of restrictions and responsibilities falling into a given parcel

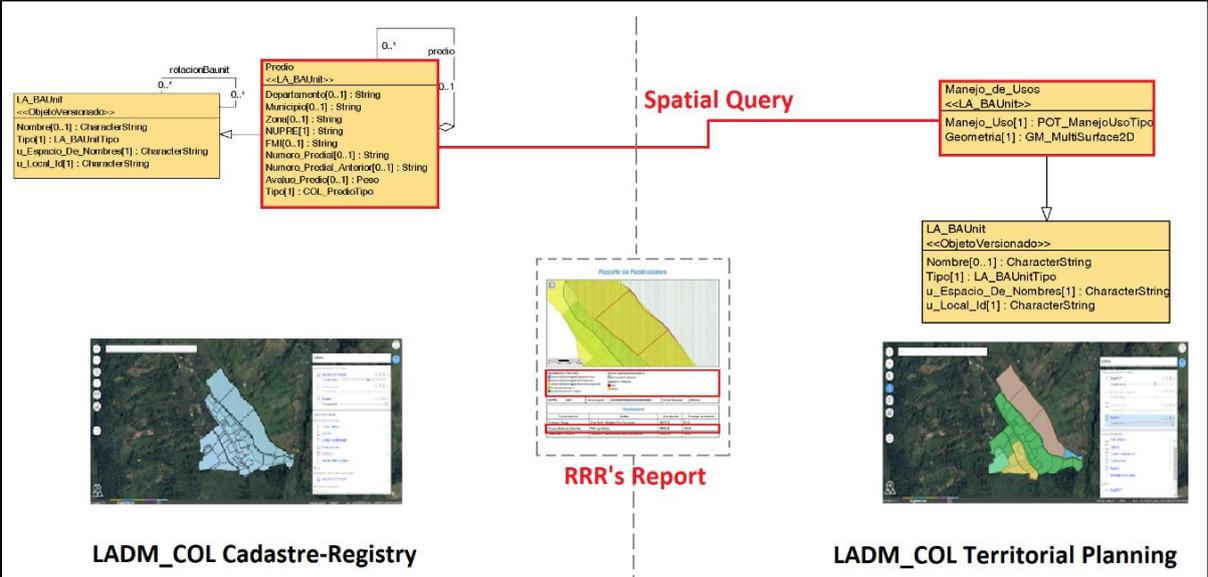


Figure 12 interrelation between LADM-based models

The information contained in both models is stored by independent entities, using independent data models and even different technologies, but thanks to the implementation of an SDI, it is possible to access the information using standardized exchange formats. In addition, a new concept called interrelation between models is applied. Previously, it was common to talk about crossing geographic layers, but now that it is a complex issue (such as territorial ordering) it is not enough to cross two layers because there is information beneath the layers that must be taken into account at the moment of the analysis. It is not sufficient to know which area of ordering covers a plot and how much area is affected. It is necessary to know the rights and restrictions imposed by the given ordering zone and this can only be achieved through the interrelation between models. Thanks to the use of standardized LADM semantics, it is possible to navigate between the different relationships among the BA-Units and the RRRs defined for each model.

### 6. CONCLUSIONS AND RECOMMENDATIONS

The adoption of the ISO 19152 LADM as standard and the implementation of the concept of modularity based on the legal independence principle, composed of a basic core of common semantics and a set of extended models for the different areas of land administration is facilitating the achievement of data interoperability among entities involved in the land administration.

The Swiss cooperation, together with the Planning National Department (DNP), has defined a land use planning model (LADM-COL-OT) that is currently under validation by the governmental institutions involved in this domain. This extended model shall be officialized in order to incorporate existing data and new data coming from the land use plans that are currently being developed. This will permit to consolidate the adoption of the LADM-COL in the country and its expansion to other topics related to land, but some benefits have already been identified.

Among these benefits, the construction of the Land Use Planning LADM-COL model (LADM-COL-OT) has allowed the identification of gaps and normative contradictions in relation to the formulation of this instrument. It has also evidenced the need to issue regulations to enforce its implementation by territorial entities. In case of overcoming these challenges, the model will not only facilitate the formulation of the plans but will also improve their quality.

Besides this, the construction of the model has allowed progress in the integration and articulation between the different sectors (environment, housing, agriculture, culture) and its impact on the territory. This being an achievement of great importance because it is a work space that allows us to address this issue in a comprehensive manner.

Our main recommendation is to continue working on the validation and implementation of the LADM-COL-OT to improve its definition and we encourage the Colombian entities to work in defining more extended models related to Land use planning issues that will facilitate the data interoperability under Spatial Data Infrastructure for Land Administration (SDI-LA).

## REFERENCES

- Acuerdo Final. (2016). Acuerdo final para la Terminación del Conflicto y la Construcción de una Paz estable y duradera. From Mesa de Conversaciones: <http://www.altocomisionadoparalapaz.gov.co/procesos-y-conversaciones/Paginas/Texto-completo-del-Acuerdo-Final-para-la-Terminacion-del-conflicto.aspx>
- Bajo, V., Guarín, A., Zarama, O., Barón, L., & Ruiz., J. (2017). La independencia legal en la administración de tierras y la modularidad del perfil colombiano de la ISO 19152 (LADM). Annual Conference Commission 7, FIG. Cartagena, Colombia.
- Baron, L., Mejia, F., Jenni, L. (2018) Legal independence, modularity and implementation of LADM using INTERLIS – case study of the Colombian ISO 19152 profile, LADM2018Workshop. Zagreb, Croatia
- Departamento Nacional de Planeación. (2016). Política para la Adopción e Implementación de un Catastro Multipropósito Rural-Urbano (CONPES 3859). Bogotá, Colombia: DNP
- Gozdz, K. J. and Van Oosterom, P. J. M. (2015). Developing the information infrastructure based on LADM – the case of Poland. Survey Review.
- IGAC/SNR. (2016). Conceptualización y especificaciones para la operación del Catastro Multipropósito (Versión 2.1.1). Bogotá, Colombia
- ISO (2012). 19152:2012 Preview Geographic information -- Land Administration Domain Model (LADM)
- Jenni, L., Guarín, A., Ziegler, S., & Bajo, V. (2017). Development and Deployment of a LADM Implementing Toolkit in Colombia. Washington, Annual Land and Poverty Conference. Banco Mundial
- KOGIS. (2006). INTERLIS 2.3 Reference Manual. Bern, Switzerland. From [http://www.interlis.ch/interlis2/docs23/ili2-refman\\_2006-04-13\\_e.pdf](http://www.interlis.ch/interlis2/docs23/ili2-refman_2006-04-13_e.pdf)
- Kalogianni, Eftychia & Dimopoulou, Efi & Quak, Wilko & Oosterom, Peter. (2017). LADM AND INTERLIS AS A PERFECT MATCH FOR 3D CADASTRE. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.
- Lemmen, C., Oosterom, P., & Bennett, R. (2015). The Land Administration Domain Model. Land Use Policy, 49, 535–545.
- Mejía, F., Carrillo, G., Ramirez, S., Jenni, L. (2017). The model Driven Architecture Approach for ISO 19152 (LADM) Implementation – Use Case of the LADM-COL Profile. Annual Conference Commission 7, FIG. Cartagena, Colombia
- UNE-EN ISO 19152. (2013). Información Geográfica. Modelo para el ámbito de la administración del territorio (LADM). ISO 19152:2012. Madrid, Spain: AENOR.
- Zabala, S. (2018). Aplicabilidad y Variaciones del Modelo Especializado de Ordenamiento Territorial en el Marco de la Infraestructura Colombiana de Datos Espaciales.

## **BIOGRAPHICAL NOTES**

Fabián MEJIA

Cadastral and Geodetic Engineer, Geographic Information Systems specialist of the *Universidad Distrital Francisco José de Caldas*, experience in implementation and modernization of Data Management Systems for land administration in Colombia. Holds the position of development leader of the project “Modernization of Land Administration in Colombia”.

Alejandro TELLEZ

Systems Engineer and Software Engineering Specialist of *Universidad Distrital Francisco José de Caldas*, Bogotá. The last 7 years has been working in technology innovation projects for several public and private entities. Currently works as part of technical team of the project “Modernization of Land Administration in Colombia”

José Antonio PINZON

Ph.D. in Territorial Planning and Regional Development. M.Sc. in Economics of the Environment and Natural Resources. Cadastral and Geodesic Engineer. Training courses in Korea and Japan, related to issues of Sustainable Urban Development and Territorial Planning, José Antonio is the Deputy Director of Housing and Urban Development of the National Planning Department - DNP. He has worked as a Consultant for the Housing Sub-Directorate; Manager of the Cadastre and Mining Registry in the National Mining Agency; Sub-Secretary of Information and Strategic Studies in the District Planning Department of Bogotá; and Consultant in the Administrative Departments of Planning and Cadastre of Bogotá, as well as in the Agustín Codazzi Geographic Institute. Among others, the most important areas of interest and research are: city systems, land use planning, urban development, urban financing, cadastre, housing, economic and environmental assessment; and GIS.

Daniel CASALPRIM

Specialist in Project Management of Map Production, Land Tenure and Property Rights projects, he has leaded Technical Teams and the implementation of innovative production structures in these areas during more than 15 years in Latin America, Africa and Europe, with different funding agencies. He has managed map production projects for governmental agencies in South America, leaded a fiscal cadaster project in Cameroon and a land delimitation project in Ecuador (Programa Sigtierras). He has also been involved in the LIFT project in Ethiopia (DAI) through the evaluation of the Rural Land Administration System, funded by DFID. Currently he is leading the technical team involved in the Proyecto de Modernización de la Administración de Tierras in Colombia, funded by SECO (Swiss Cooperation).

## **CONTACTS**

Fabián MEJIA

Agencia de Implementación Proyecto Modernización de Administración de Tierras en Colombia - BSF Swissphoto AG

Av el Dorado No. 69 - 63, Edificio Torre 26, Oficina 406, Bogotá DC  
COLOMBIA  
Tel. +57 7040687  
Email: fabian.mejia@bsf-swissphoto.com  
Website: <https://www.proadmintierra.info>

Alejandro TELLEZ  
Agencia de Implementación Proyecto Modernización de Administración de Tierras en  
Colombia - UT Swissphoto - INCIGE  
Av el Dorado No. 69 - 63, Edificio Torre 26, Oficina 406, Bogotá DC  
COLOMBIA  
Tel. +57 7040687  
Email: omartellezf@gmail.com  
Website: <https://www.proadmintierra.info>

José Antonio PINZON  
Departamento Nacional de Planeación  
Calle 26 # 13-19 - Edificio Fonade, piso 8, Bogotá DC  
COLOMBIA  
Tel. +57-3815000  
Email: jpinzon@dnp.gov.co  
Web site: <https://www.dnp.gov.co>

Daniel CASALPRIM  
Agencia de Implementación Proyecto Modernización de Administración de Tierras en  
Colombia - BSF Swissphoto AG  
Av el Dorado No. 69 - 63, Edificio Torre 26, Oficina 406, Bogotá DC  
COLOMBIA  
Tel. +57 7040687  
Email: daniel.casalprim@bsf-swissphoto.com  
Website: <https://www.proadmintierra.info>

Moisés POYATOS  
Agencia de Implementación Proyecto Modernización de Administración de Tierras en  
Colombia - BSF Swissphoto AG  
Av el Dorado No. 69 - 63, Edificio Torre 26, Oficina 406, Bogotá DC  
COLOMBIA  
Tel. +57 7040687  
Email: moises.poyatos@bsf-swissphoto.com  
Website: <https://www.proadmintierra.info>