Legal Independence, Modularity and Implementation of LADM using INTERLIS – Case Study of the Colombian ISO 19152 Profile

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Key words: Multipurpose Cadaster in Colombia, LADM based on INTERLIS, Legal Independence, Model-Driven Architecture, Automated Data Validation Tool and Service, FOSS Solutions

SUMMARY

The new Multipurpose Cadaster of Colombia defines, as a standard to achieve data interoperability, the ISO 19152 (LADM).

The Project "Modernization of Land Administration in Colombia", funded by the Swiss Economic Cooperation (SECO), has supported the governing bodies in developing a Colombian profile of the norm (LADM-COL). This profile follows a modular approach which means that it consists of several thematic data models that extend a core LADM data model, meeting the requirement of the principle of Legal Independence established for the new National Multipurpose Cadaster.

For the technological implementation of the LADM, the Project suggested to apply the conceptual description language INTERLIS, for which a complete tool chain is available. The Project's development team contributed to the evolution and completion of these tools, and integrated them in a web-based system, which allows massive validation, storage, visualization and downloading of data according to the defined LADM-COL models.

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1. INTRODUCTION AND BACKGROUND

Colombia is a social state of law, organized in the form of a unitary, decentralized Republic, in which there is territorial and administrative decentralization. Within the framework of administrative decentralization, there is an institution responsible for the registration of real property and another entity responsible for the cadaster or physical identification of the immovable properties.

The Colombian legislation through innumerable laws and decrees has established the obligatory nature of the interrelation that must exist between the land registry and the cadaster. However, in rural land there is a coincidence of only 46% and in urban land of 68%, between the properties identified in the cadaster and those legally identified by property registry (CNMH, 2015).

With the National Development Plan (Congreso de la República de Colombia, 2015) and the Public Policy Document (CONPES) for a new Multipurpose Cadaster (Departamento Nacional de Planeación, 2016), the Colombian Government delimited the framework for the future Land Administration System emphasizing the need for new standards to ensure data integrity and interoperability, including the adoption of ISO 19152:2012 (LADM), among others. Within the new framework, the tasks of the different institutions are closely related, which makes it difficult to delimit which datasets are managed by whom. The legal independence is therefore a crucial principle established in the new legal framework. The new framework also foresees the delegation of competences to territorial entities (e.g. municipalities) and even the private sector, another reason why clear technical product specifications and particularly data models are required.

In addition to the support given to national public institutions to define a Colombian profile of the ISO 19152:2012, the Modernization of Land Administration Project, funded by the Swiss Economic Cooperation (SECO), suggested the application of the MDA approach for the implementation of the LADM. Model Driven Architecture (MDA) as a software design approach for system development, was established and introduced by the Object Management Group (OMG) in 2002. The conceptual schema language INTERLIS offers being an efficient means of MDA since it allows the formal description of conceptual models and, therefore, the implementation of a physical model through specialized software (Germann et al, 2015). In addition, it includes a data-exchange format derived directly from the model, giving the advantage of being able to validate data against it, including data types, values, relationships and constraints.

It is in this context that the article aims to present, besides conceptual considerations, some important legal aspects as well as the modularization of the Colombian LADM profile as well as the important progress in providing a generic solution for the implementation of any national LADM profile described in INTERLIS.

2. ISO 19152:2012 – LAND ADMINISTRATION DOMAIN MODEL

The ISO 19152:2012 norm, known as the Land Administration Domain Model (LADM), is a conceptual model of reality which considers patterns of land administration systems of many different countries, for the management of, e.g. legal land information, information of interested parties, information of spatial units, or even the surveying data required for defining the geometric part of a spatial land unit (Lemmen C., 2012).

It is important to understand the LADM as a conceptual model and not as a data product specification (Lemmen, Van Oosterom& Bennett, 2015). UML diagrams are commonly used to describe the LADM, which allows users to see – and to discuss – the relationships between the administrative land objects (the BAUnits) and its structural components such as the parties, the rights, restrictions or responsibilities that a party might have over an administrative object, and finally the spatial representation that an object can have. Thus, the LADM provides a standard based on a certain terminology of land administration (Gozdz & Van Oosterom, 2015).

3. MODULARITY OF LADM-COL AND LEGAL INDEPENDENCE

Colombian regulations on Land Administration establish limitations that deal with the different specialized legal spatial objects, and for whose generation, maintenance, exchange and publication of data where different state institutions are responsible.

The fact that the administration of each legal spatial object is unique and supported by its own legal framework requires that each theme can be managed in isolation to the legal needs of the others. Therefore, the set of legal spatial objects, managed by each institution of Land Administration according to the application of a given law and/or adjudication procedure, should be considered as objects of the same thematic layer, and hence one layer for each of these adjudication processes should exist (Kaufmann & Steudler, 1998).

This necessary legal and/or institutional independence requires that each institution assumes the responsibility for its own data and an adequate way to guarantee interoperability. However, ISO 19152:2012 does not describe how to manage these sets of legal spatial objects, so that the achievement of this objective cannot simply be delegated to LADM (Bajo, Guarín, Zarama, Baron & Ruiz, 2017).

Thus, each part of Land Administration that manages its legal spatial objects according to its own legislation, is proposed do so based on a unified core model of LADM, specializing it according to its own needs.

Therefore, while adopting ISO 19152, legal independence can be achieved by modularizing the LADM, which allows each institution to work with its own legal spatial objects that fall within its competence according to the current legal framework. In this way, all the resulting modules per topic (Figure 1) are created around the same ontological principles and the same semantics defined by LADM (Bajo et al, 2017).

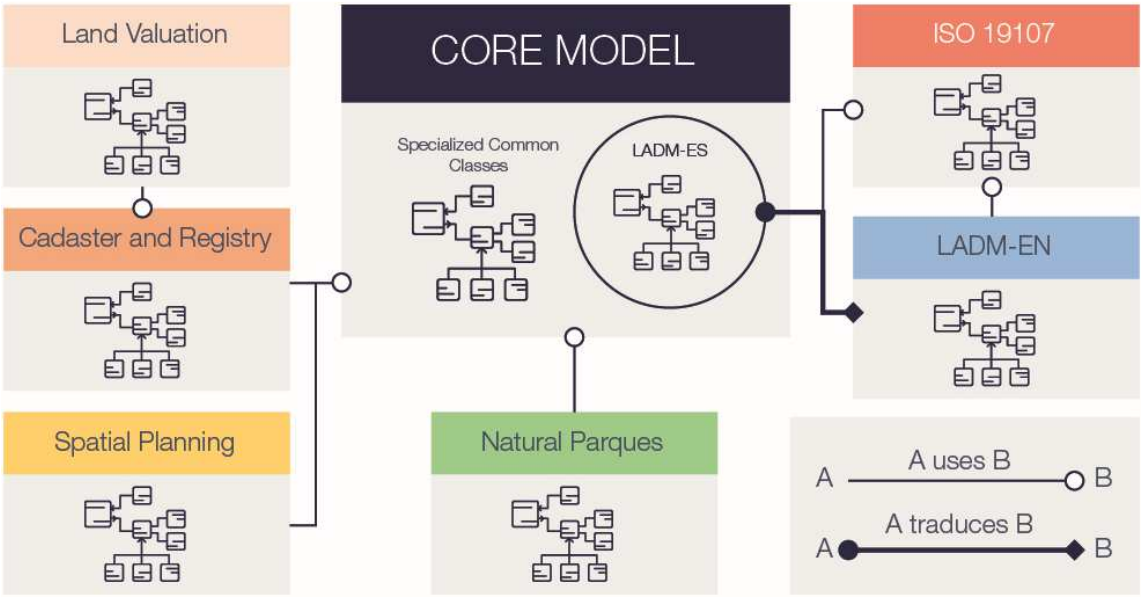


Figure 1. Modules of Colombian LADM profile

The following comparison of UML class diagrams of the Cadastre-Registry model on the one side (Figure 2) and the Spatial Planning model on the other (Figure 3) depicts how the LADM is used as the base ontological and semantic model specialising its basic classes for each thematic model. In the case of the cadaster-registry model the specialized BAUnit class is the *predio* (parcel), in the case of the Spatial Planning model it is the spatial planning zone (*zonaPOT*) which concurrently represents at the same time the restriction on a *predio* object.

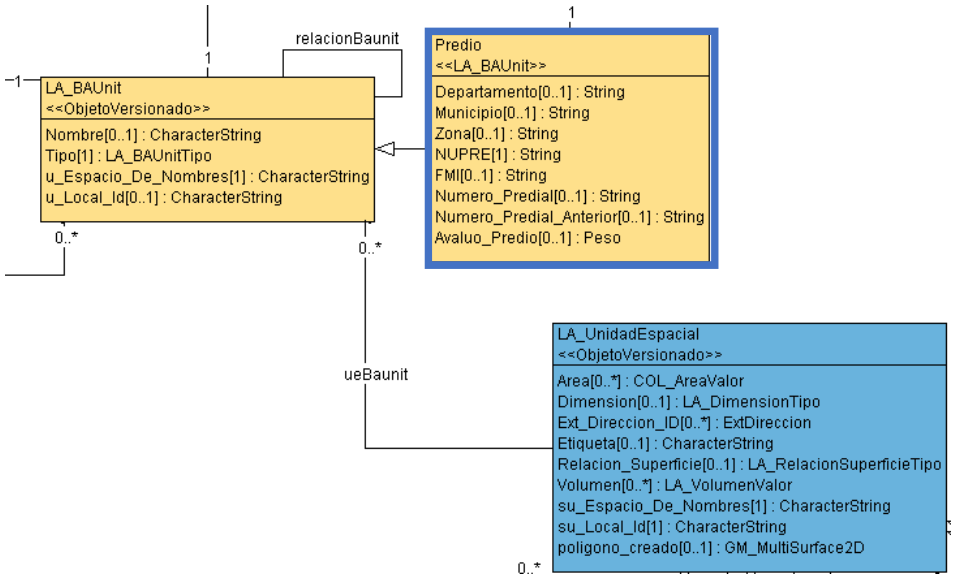


Figure 2. Cadastre-Registry Model with specialized BAUnit class ”predio”

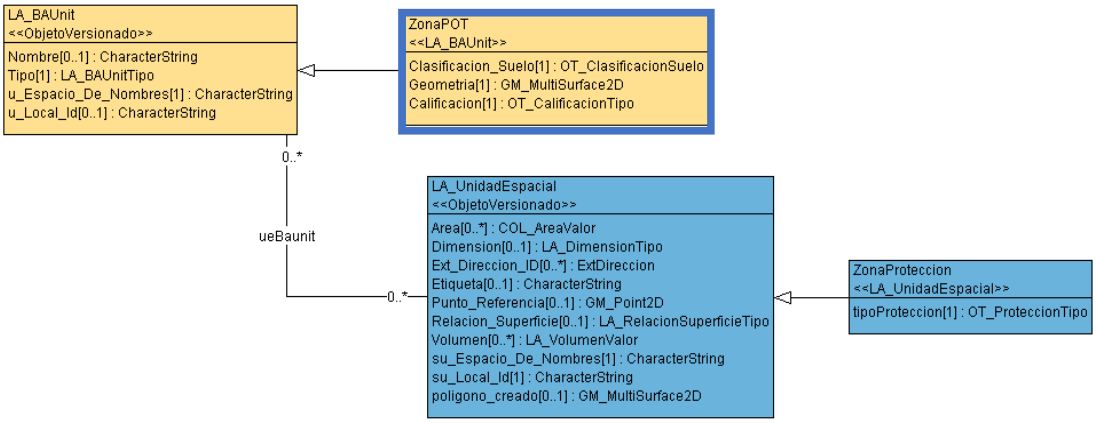


Figure 3. Spatial Planning Model with specialized BAUnit class ”zoning”

4. PARTICULARITIES OF THE CADASTRE-REGISTRY MODULE

Within the particularities of the Cadastre-Registry module of the LADM-COL, emphasis is placed on the administrative package, in which the Basic Administrative Unit class (BAUnit) is represented by the parcel (*predio*), which is defined as "the parcel not separated by another public or private parcel, with or without buildings and other constructions, belonging to natural or legal persons. The property maintains its unity even though it is crossed by public water currents "(IGAC, 2016).

Within the Cadaster - Registry module of the LADM-COL, for the class of Rights, Restrictions and Responsibilities the information for which the public land registry is responsible has been considered, based on the information of the existing legislation.

In the case of rights, the following types of rights were identified: collective property, right of ownership, leasehold, property, possession, occupation, mere tenure and mining right. Each of the types of rights has different associated domains that correspond to relative contracts, such as leasing, a contract associated with the right of mere tenure. ISO 19152: 2012 when referring to LA_RightType points out among others lease, fishing, grazing and mentions ownership, occupation and tenancy, that is to say that the same list confuses types of rights with types of contracts. However, each national profile must be able to distinguish its types of rights according to the corresponding legislation, and each type of right must have the corresponding contracts. It is suggested that a new version of the LADM standard clarifies this aspect.

In the domain of restrictions are listed in a general classification the types of legal acts that involve a limitation or burden with respect to the right of ownership over real property, for example: Easements, embargoes and environmental restrictions. Now, in relation to responsibilities, LADM establishes that a responsibility is a formalized obligation to do something, therefore, responsibilities of constitutional, legal, administrative, judicial or contractual origin have been identified in the Colombian profile. However only the last three are subject to registration.

ISO 19152:2012 establishes that a right or responsibility is directly associated with exactly one (1) party and exactly one (1) basic administrative unit (BAUnit). However, in the face of restrictions, these will be associated with zero or one (0..1) party, and exactly one BAUnit. In this regard we consider that the treatment of the restrictions should be the same as that of the responsibilities, considering that if the rule establishes that LA_PartyType can be a BAUnit, in the case of an existing restriction the association should also be exactly one (1) party and exactly one (1) basic administrative unit. However, in practical life it is found that a BAUnit does not always have an associated responsibility or a restriction, therefore the responsibilities as well as the restrictions should be associated with zero or one (0..1) party and exactly one BAUnit.

One of the singularities of the Cadaster-Registry data-model of the LADM-COL relies in the definition of a new “Publicity” class that refers to annotations external to the RRR, mainly related to post-conflict processes (restitution alerts, victims or displacement processes). These alerts are recorded as informative and do not in themselves establish neither a restriction nor right nor responsibility. Figure 4 illustrates the UML diagram with the class “Publicity” (-*Publicidad*- highlighted in blue) of the Cadaster-Registry data-model of LADM-COL.

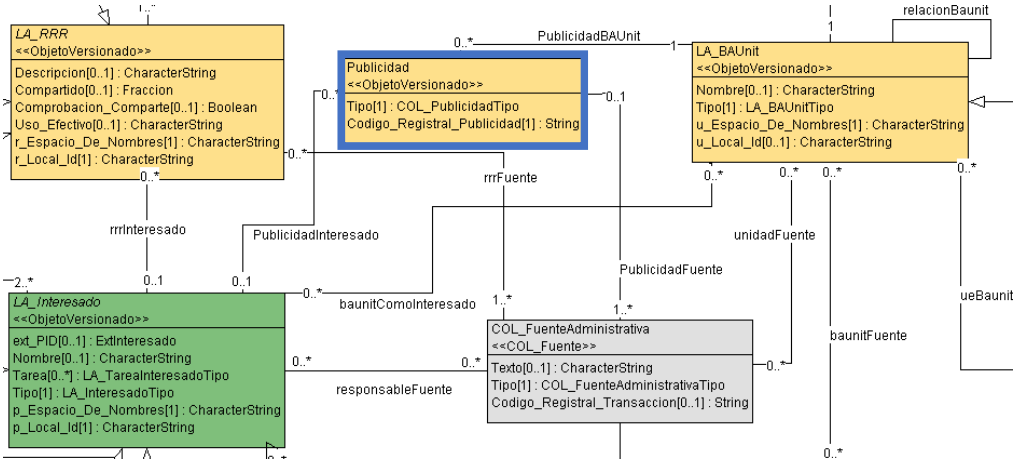


Figure 4. Publicity class of the Cadastre-Registry model of LADM-COL

Finally, we consider it of the utmost importance to bear in mind that Colombia has high rates of informality in land tenure. In this regard, we note that LADM is very clear in stating that a spatial unit can only be associated with one level of ownership. However, if it is the same spatial unit in which property and possession rights concur, it is not possible to maintain this relationship. To include the association of the respective informality, we must consider two different spatial units (which must be the same) to identify ownership on one side and possession on the other. Therefore, it is recommended to consider, for a new version of the LADM standard, that the relationship of the spatial unit to the rights is zero to many (0..*).

5. DATA EXCHANGE USING INTERLIS

INTERLIS is a conceptual schema language (CSL, synonym of Data Description Language), used for the formal and system independent description of relational or object-oriented data models (KOGIS, 2006). INTERLIS is a language with a structured syntax, which allows its use in computer systems. Because of its clarity and cleanliness, it also facilitates reading by persons, without the need for a high level of specialization in computer languages. This improves communication between IT specialists and professionals of the information treated (German et al, 2015). INTERLIS follows the Model-Driven Architecture's (MDA) approach principles, as it "enables the utilization of data modelling in close connection with a system neutral (XML-based) interface format" (Kalogianni, Dimopoulou, Quak, & Oosterom, 2016). Thus, by applying INTERLIS to the proposed model, "directly implementable data models are provided, which support the technical implementation of LADM" (Germann et al, 2015).

Another important advantage of the standard, not only in the context of the new Multipurpose Cadastre in Colombia, is the possibility to "quality check INTERLIS data (XML) against INTERLIS data models, thereby enabling fully automated quality control or validation of data" (Germann et al, 2015). Using Object Constraint Language, it is possible to define model based complex constraints, even of topological type. Figure 5 shows some topological rules of the

Cadaster-Registry model of LADM-COL. The "no_overlaps" function is implemented as a JAVA plugin to be executed from the iliValidator tool.

```
FUNCTION no_overlaps (
    Objects: OBJECTS OF ANYCLASS;
    SurfaceAttr : ATTRIBUTE OF @ Objects RESTRICTION ( SURFACE )
  ): BOOLEAN;

...

CLASS Terreno EXTENDS LA_UnidadEspacial =
  ...
  geometry (EXTENDED) : MANDATORY GM_Surface2D;
  SET CONSTRAINT no_overlaps( ALL, >> geometry );
END Terreno;
```

Figure 5. Section of the LADM-COL cadaster model in INTERLIS (incl. defined topological rules)

6. INTERLIS TOOL CHAIN AND WEB SYSTEM FOR LADM-COL

INTERLIS enters to support the implementation of ISO 19152: since it is an object-oriented language it adapts perfectly to the modularization needs of the LADM-COL as described above. It is therefore necessary to have an ecosystem of tools designed for an institutional environment with heterogenous technological systems and platforms.

All tools were developed and extended completely in free and open source software (FOSS). They integrate widely adopted existing components and in conjunction allow massive validation, storage, visualization and data exchange according to any INTERLIS based data model (Figure 6).

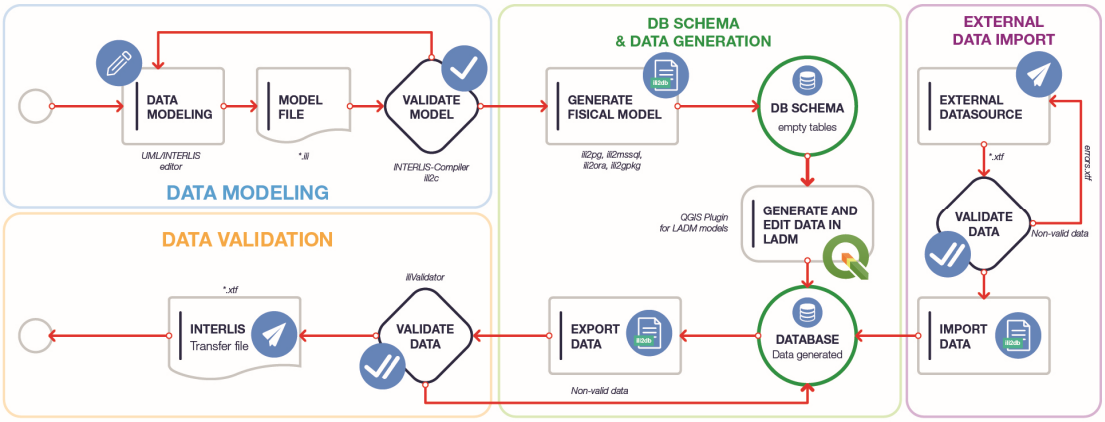


Figure 6. Ecosystem of Tools used in a typical workflow for implementing INTERLIS models

Table 1 describes the tasks of each tool involved in typical INTERLIS based data model implementation.

Table 1. Available INTERLIS tools for model implementation

Tool	*Functionality*	*Language*
UML/Interlis-Editor[1][2]	Modeling in UML and conversion to an INTERLIS model *.ili	Java
INTERLIS-Compiler ili2c[3]	Validates the syntax of the .ili files, produces other output formats.	Java
ili2db[4] (ili2pg, ili2gpkg, ili2sqlServer[5], ili2ora, ili2fgdb)	Used for O/R mapping of object-oriented models to a relational DB schema; import and export DB data to XTF exchange format	Java
QGIS Plugin "Project Generator"[6]	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 and quality checks.	
iliValidator[7]	Validates the integrity of data to be exchanged with respect to the rules and constraints established in the model (including topological constraints, etc.).	Java

The described tools were integrated in a web-based system, consisting of several modules and independent services that provide massive and automated validation, DB import, query, visualization and data download functions. To comply with the MDA approach, the core of the system are the thematic models of the LADM-COL, stored in a repository of official models; the interfaces and forms of the modules are adjusted semi-automatically to each model. This considerably reduces the development phase and emphasizes the design (Figure. 7 below).

[1] http://www.umleditor.org/
[2] https://github.com/AgenciaImplementacion/umleditor, including improved editing, reporting and export functionalities, contributing to the compatibility with other UML Editor, such as Enterprise Architect.
[3] ibid.
[4] https://github.com/claeis/ili2db
[5] https://github.com/AgenciaImplementacion/iliSuite
[6] https://github.com/opengisch/projectgenerator and https://demo.qgis.org/plugins/projectgenerator/
[7] https://github.com/claeis/ilivalidator

It is worth describing in greater detail the Data Validation Service module, used to validate data against official models. The service allows to define and apply complex validation rules, in accordance with the defined data quality evaluation specifications of the multipurpose cadaster.

Figure 8 shows the Validation Service user-interface and Figure 9 below depicts the validated dataset. As seen there are overlapping parcels, the result of the validation is shown on the error report generated by the service.

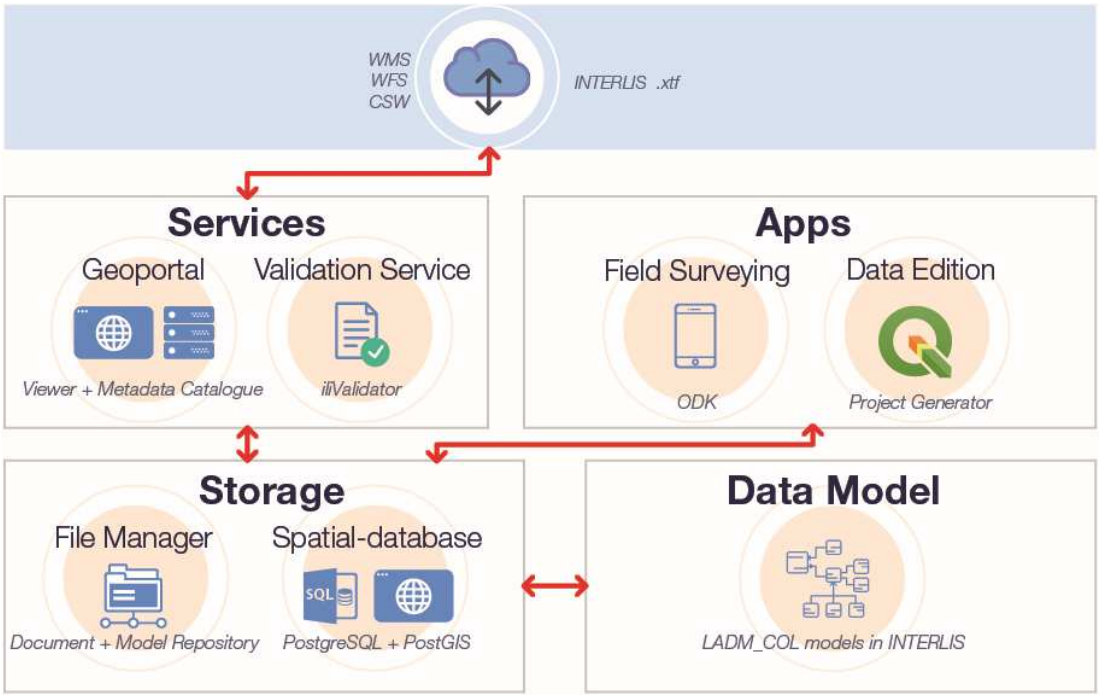


Figure 7. Main components of the LADM web-based data reception system

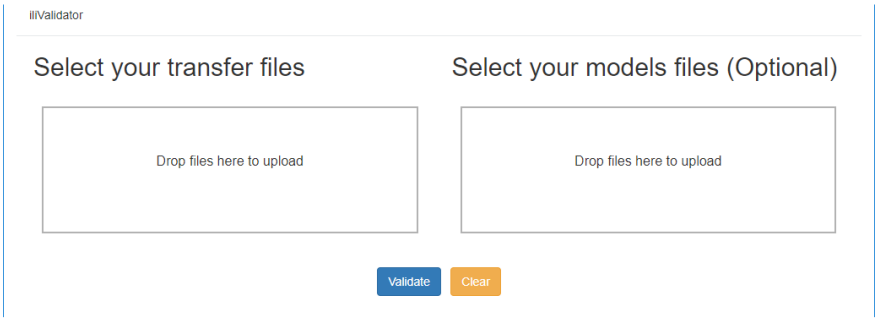


Figure 8. Web Validator service

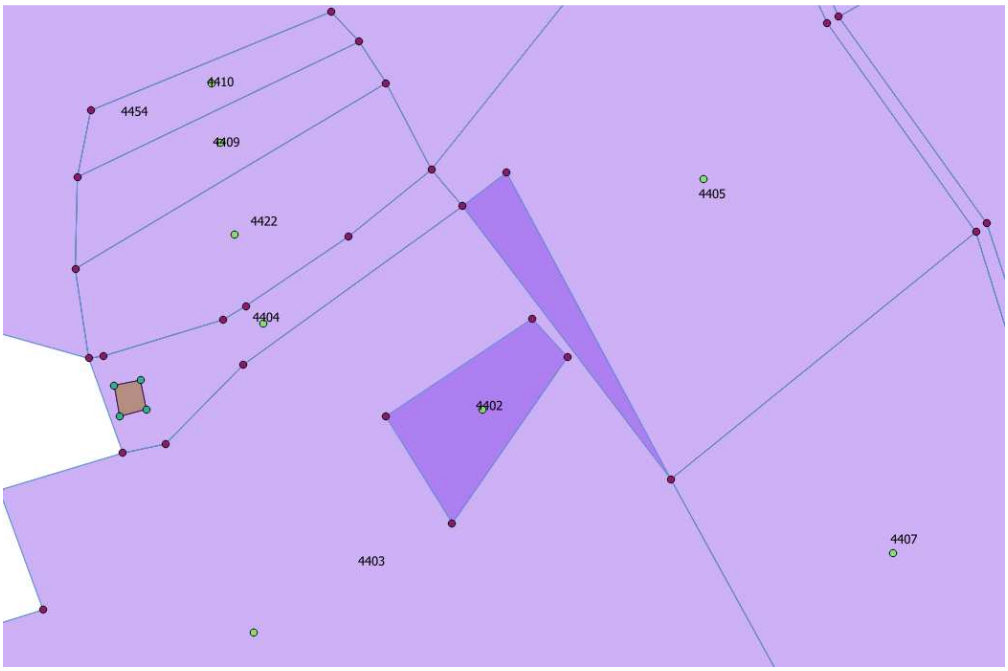


Figure 9. LADM-COL test data-set in La Palma, Colombia

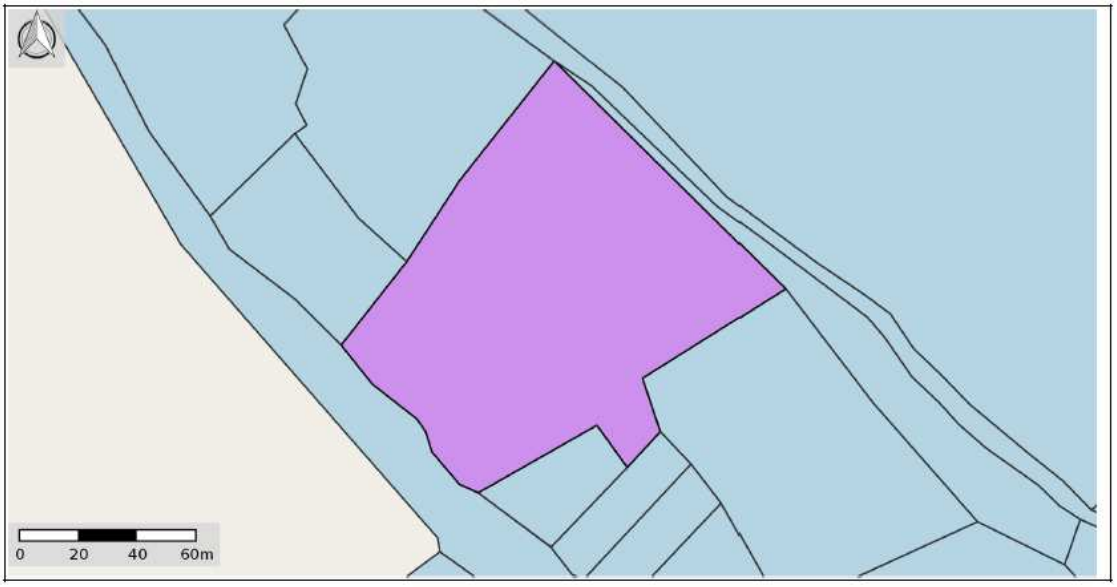
Figure 10. Validation error report

The developed LADM-COL GIS viewer allows, once data is validated and loaded to a PostgreSQL/PostGIS Database, to query data of a BAUnit and its associated rights and the party which holds the corresponding right.

A report on restrictions or responsibilities on a parcel of the Cadaster-Registry model, derived from data of the Spatial Planning model, can also be generated (Figure 11 and Figure 12 below).

IDE-AT

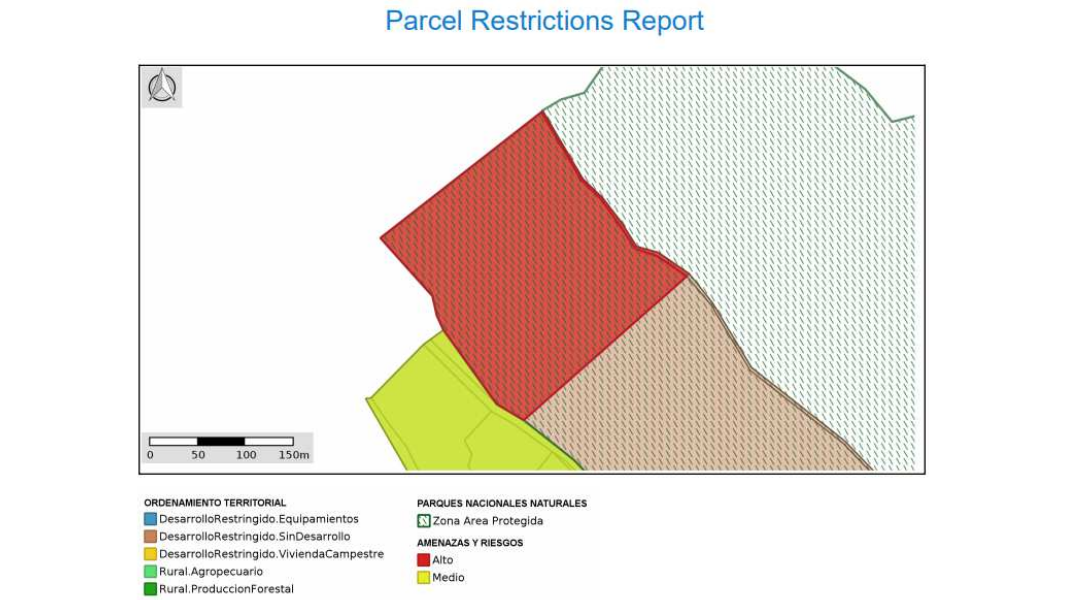
Rights report



NUPRE	0007	Parcel number	XXXXX0000000000230XXX000000000	Parcel Name	SIN INFO

RIGHTS					
ID	5485				
Right Type	Holder	Registry Code		Description	
Interesado					
ID Type	National ID	Given Name	Adriana		
Gender	Femenino	Family Name	Rojas		
ID	5486				
Right Type	Holder	Registry Code		Description	
Interesado					
ID Type	National ID	Given Name	Dora		
Gender	Femenino	Family Name	Mahecha		

Figure 11. Querying information on rights and the right holders (parties) of a parcel



Restrictions

Restriction Type	Details	Restricted Area	Parcel Percentage
Natural hazards	Level: High | Not Mitigable | Type: Mass Movement	49380.59	100.00
National Natural Parks	PNN: Las Palmas	49380.59	100.00
Land Planning	Land Use: Restricted Development. Without Development	49380.59	100.00

Figure 12. Restrictions and responsibilities report

7. CONCLUSIONS

From the point of view of legal independence principle, each institution responsible for land administration data must identify the territorial objects defined by law and guarantee that the information is truthy and updated. The model LADM_COL is designed by different modules in which it is possible to identify the entity responsible for the data.

The introduced “Modularity” of the LADM-COL helped to meet the required legal independence, an institutional reality in Colombia. The use of the object-oriented INTERLIS language facilitates the implementation of the legal independence principle.

The LADM-COL Cadaster-Registry model finds a particularity in the class "Publicity" that goes beyond the RRR, defining a new type of relationship between parties and basic administrative units.

The ecosystem of reliable INTERLIS tools now available, allows to develop an information infrastructure based entirely on a MDA approach. This facilitates implementation of any LADM country profile.

The developed data validation service increases productivity by automatically and massively check data against a given model as well as the defined validation rules.

The developed Data Reception System is easily deployable by administrations with limited resources (e.g. Municipalities) and can be considered as a generic information infrastructure of Land Administration, with LADM as the underlying model.

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BIOGRAPHICAL NOTES

Lina Baron studied law at the Santo Tomas University in Bogota and has postgraduate diploma in administrative law from the National University of Colombia and another in Tax Law at the Pontificia Universidad Javeriana. She has worked in several public and private entities related to agrarian, environmental, and real estate law. Currently, she works for the Superintendence of Notaries and Registry (the National Registry) in the implementation of the new multipurpose cadastre and in the development of the new registry information system.

Fabián Mejía, 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".

Lorenz Jenni studied surveying and geomatics at the University of Applied Sciences in Basel and has a master's degree in GIS of the Universitat Politécnic de Catalunya. The last 15 years he has been working as a consultant in cooperation projects related to land administration and land information management, with Swiss Government, KfW, European Union, IDB and the World Bank, in Latin America, Caribbean and South-East Europe. Currently he is the technical team leader of the project "Modernization of Land Administration in Colombia".

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