Data migration process to LADM-COL model

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SUMMARY

The implementation of the multipurpose cadastre public policy has been adopted by Colombia to better explain the country's physical and legal reality…

The approval of Law 1955 of 2019 has resulted in the Medellín cadastre office taking on the role of Cadastral Manager. This implies a series of new challenges for the institution, including managing the regulatory and technical changes that come from the multipurpose cadastre policy's formulation and implementation. According to the above, decentralization is one of the main pillars defined by the cadastral authority, accompanied by the standardization of cadastral products, using the LADM-COL model as the main mechanism, which is a national profile of the ISO 19152:2012 standard.

Since 2019, the cadastre office in the municipality of Medellín has been working to adapt to the new definitions and technical requirements in conjunction with the SwissTierras Colombia project on various work fronts, including transforming municipal data to fit the LADM-COL model.

This article describes how the migration of the Medellin cadastre information to the LADM-COL model has been carried out. This process identifies the institution that holds the official information on the land objects to be migrated and the standards for verifying the alphanumeric and geographical information to ensure its relevance to the topic and technical quality. Subsequently, the information has been homologated to comply with the domains, relationships, and land objects defined in the LADM-COL model.

The migration of the Medellín cadastre database, which has more than one million parcels, has demonstrated that it is possible to migrate the information from a consolidated cadastre to the LADM-COL model and shows the path to other cadastral managers, as this has been the first time that this has been done in Colombia.

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1. MULTIPURPOSE CADASTRE IN COLOMBIA

CONPES 3958 of March 26, 2019 (CONPES for its Spanish acronym, National Council for Economic and Social Policy) proposes a strategy for implementing the multipurpose cadastre public policy, which allows for a comprehensive, complete, updated, and reliable cadastre that is consistent with the digital real estate Parcel registration system and operates in conjunction with other information systems. To achieve this objective, a seven-year action plan (2019-2025) is proposed that considers the use of cadastral information and institutional capacities at the national and regional levels. This should allow Colombia's cadastral information to be gradually and progressively updated to achieve updated cadastral information coverage of 60% in 2022 and 100% by 2025. This multipurpose approach can provide mechanisms for financial sustainability and continuous updates.

To this end, actions being implemented include integrating the cadastre registry, implementing the LADM standard, improving the country's geodetic network, and analyzing and updating cartography. However, to address the limitations of the traditional institutional scheme, which is insufficient for guaranteeing cadastral updating in Colombia, the decision to decentralize the cadastral activity being carried out by the IGAC (Agustin Codazzi Geographic Institute) was made, by creating and empowering cadastral managers (public and regional entities) to implement cadastral management as a public service. As of December 2021, there were already 32 cadastral managers covering 266 municipalities (IGAC, 2021). In this new ecosystem, IGAC continues to function as a regulatory body responsible for consolidating cadastral information from around the country (Decree 148 of 2020), and as cadastral manager for those municipalities that haven't cadastral managers. In February 2022, the IGAC established that those cadastral managers must periodically deliver the information resulting from cadastral management through the current Cadastral Information Reporting Model—an application model derived from the extended LADM-COL Cadastre Registry model—via the Interlis (.xtf) exchange format. This must be made using the transitional tool for periodic reporting developed by SwissTierras Colombia in coordination with IGAC (Resolution 315 of 2022).

2. MEDELLIN CADASTRE OFFICE AND ITS NEW CADASTRAL MANAGER ROLE

2.1 History

In the case of the city of Medellín, we can find references to a cadastral office in the year 1926 with the issuance of an Agreement dated January 14, 1926, and by which the census office was eliminated and *"...a Municipal Cadastre office is created..."* As such, 1926 could be considered the beginning, conformation, or emergence of a kind of *local cadastre for the city of Medellín*, without losing sight of the fact that the national cadastre was formed years later. Along with the creation of the city's cadastre office, a series of regulations were issued related to the city's cadastral activity:

- Municipal Agreement 159 dated June 23, 1926 *"...whereby the Cadastre and Statistics offices are reorganized..."*
- Ordinance 33 dated April 21, 1926, which *"... orders the creation of the Municipal Cadastres ...*" and which additionally states, "*... in Medellín there shall be a special employee...called "director of the Municipal Cadastre*," with the mission of drawing up the city's cadastre and the premise that it would be *"free of unfounded or arbitrary calculations."* In July of that year, the *"Municipal Cadastre and Statistics Board"* was formed, which was responsible for carrying out the appraisals of the sections into which the Municipality of Medellín had been divided.

From the beginning of cadastral management in Colombia, as well as from the first mentions regarding the creation of a cadastre office in the city of Medellin until now, many important moments have shaped the development of procedures regarding the collection, maintenance, and use of cadastral information. Today, Colombia is called upon to create a new cadastral model that focuses on the multipurpose approach to build an information system that records updated data on land—including formal and informal Parcels—as well as information on rights, responsibilities, restrictions, site plans, values, and other information of interest about the Parcels, such as occupancy, value, use, and urbanization.

2.2 Challenges and opportunities of the multipurpose cadastre approach

Cadastral information and its multipurpose approach are key tools for understanding the territory—which includes understanding its dynamics, successes, and failures—regarding planning, risk management, and the administration and conservation of natural resources, among others. It is also important to understand it at a strategic level to plan its development, since it provides first-hand knowledge on the processes that take place within a city. In terms of land management, the importance of cadastral information and its associated processes are widely known concepts for administrators, planners, technicians, and other professionals

involved in land administration. All technicians knowingly acknowledge that cadastral information is society's most important asset.

In a transition period such as the one Colombia is going through, which culminates a long period of armed conflict, rethinking the structure of land administration systems is of utmost importance to effectively consolidate a peaceful society. As such, the need to create this new vision of the cadastre one facing the new challenges that have been identified and are leading to dizzying changes in technology over the last decade, including digitization and the use of models comes to the forefront.

Without a doubt, the greatest challenge faced when applying this multipurpose approach to the cadastre is the change in the paradigm for collecting and managing cadastral information. As such, the latest norms issued to regulate and guide the cadastral activity highlight new ways of carrying out land intervention. One of these ways is committing to indirect methods of information collection by integrating various sources of information that account for the changes between the cadastral database and the reality of the real estate. Today, it is essential to make use of remote sensing imagery, the integration of administrative records, econometric models, Big Data analysis, and other sources of information to make cadastre management efficient and agile, with great benefits for municipal finances and land use planning.

3. MIGRATION OF MEDELLÍN CADASTRE DATA TO THE LADM-COL MODEL

The ISO 19152:2012 LADM standard defines a conceptual domain model for land administration, suggesting that adoption by a country requires building a national profile, in which the necessary adjustments are made to support the regulations of the country that is adopting it. The standard is clear in leaving the scope of application up to each of the entities that incorporate it, which offers a range of possibilities when it comes to implementing it.

Colombia has been working on adopting the model since 2016 as part of the Multipurpose Cadastre project. However, in 2020, this scope was expanded to incorporate the Land Administration System in Colombia. Its implementation is based on the adoption of the ISO 1952:2012 standard and the model descriptions for each land object included in the system.

Since the model's incorporation into the Multipurpose Cadastre framework and the new cadastral information management structure in Colombia where decentralization via cadastral managers as a key pillar of public policy, it has become even more necessary to incorporate standardization mechanisms .

Therefore, one of the most relevant challenges analyzed during the model's adoption is the impact on the entities because of transforming their data and responding to what is now part of this ecosystem. The model's real implementation has the flexibility to opt for various technical

mechanisms. Specifically, the Medellin cadastral manager opted for a design that would not impact its information management system at such a fundamental level, due to the time and cost involved in having a system built in such a way that the information can be monitored in LADM-COL.

3.1 Data migration processes

With the adoption of the LADM model as a standard for the administration of land information, it is necessary for Colombia's cadastral managers to migrate their information to this new model to achieve interoperability regarding the exchange and management of information. The strategy to migrate data from the municipality of Medellín's cadastral and registry information system to the application model based on the LADM-COL model is presented below.

3.1.1 Input preparation:

Before starting to migrate the information to the LADM-COL model, it is necessary to identify which entities oversee officially managing the land objects required by the model. It should be noted that some objects may be managed by the cadastre and the registry simultaneously, but the official information only appears in one of the entities.

The objects to be identified are:

Party package

- **Party:** The party that has a relationship with the Parcel via some kind of right, restriction, publication, or liability. Traditionally, both the cadastre and registry manage this object, but the registry is responsible for the veracity of the information.

Administrative package

- **Parcel:** Corresponds to the basic administrative unit of the cadastre and registry in Colombia. Both formal and informal Parcels appear in the cadastre database, while only formal Parcels are found in the registry.
- **Right:** This object is responsible for registering the rights that a party exercises over a Parcel. This object can be managed by the cadastre and the registry. The registry identifies the Parcels for which the parties have a right of ownership, i.e., the formal Parcels, and the cadastre identifies the Parcels that have a right of possession or occupancy, i.e., the informal Parcels.
- **Restriction:** This object makes it possible to define the legally constituted and registered restrictions that affect a party's rights in relation to the Parcel. The registry is the entity responsible for managing the restrictions that may be associated with a Parcel.
- **Responsibility:** This object makes it possible to define the party's obligations in relation to the Parcel.

Spatial unit package

- **Plot:** This land object is defined as the portion of land in a defined geographical area. Usually, this land object is managed by the cadastral manager and may be stored in its database as an alphanumeric or spatial record.
- **Building:** This land object makes it possible to manage Buildings on a plot of land, understanding a Building as the union of materials adhered to the land, of a permanent nature, regardless of what it is made of. This land object is managed by the cadastral manager and may be stored in its database as an alphanumeric or spatial record.
- **Building unit:** This land object makes it possible to manage the building units associated with a building, understanding the building unit as the set of materials consolidated within a building that has specific characteristics in terms of its physical elements and uses. This land object is managed by the cadastral manager and may be stored in its database as an alphanumeric or spatial record.
- **Right of way:** This land object allows for the management of a Parcel's Right of ways. This information has been managed alphanumerically by the registry, but the LADM-COL application model allows it to be spatialized.

Surveying and rendering package

- **Boundary points:** This object defines the points that form the boundaries of a terrain. Traditionally, this information has not been managed by any of the public policy actors, but it can be deduced from the land's spatial units.
- **Surveying points:** This object defines the points that make up the buildings, building units, and right of ways. Traditionally, this information has not been managed by any of the public policy actors, but it can be deduced from the spatial units related to buildings or right of way.
- **Control points:** This object defines the topographic or geodetic points used as a starting point for implementing a cadastral survey. Traditionally, this information has not been managed by any of the public policy actors at the time of the topographic surveys, which is why this land object does not need to be managed in the data migration.
- **Boundaries:** This object defines the dividing lines that separate one Parcel from another, which may or may not be physically materialized. Traditionally, this information has not been managed by any of the public policy actors, but it can be deduced from the land's spatial units.

Sources

- **Administrative sources:** This object is used to store those sources consisting of documents (mortgage documents, notarial documents, historical documents, etc.) that document the relationship between the parties and the Parcels. This land object can be managed by the cadastre and registry; the registry has the current information for formal Parcels, and the cadastre has the associated supporting documents for informal Parcels.

- **Spatial sources:** This object is used to store spatial data sources (geographic entities, satellite images, photogrammetric flights, lists of coordinates, maps, old or modern plans, location descriptions, etc.) that technically document the relationship between parties and Parcels. Traditionally, this information has not been managed by any of the public policy actors at the time of the topographic surveys, which is why this object does not need to be managed in the data migration, since there is no information available.

Identifying which public policy actor is responsible for managing each LADM-COL model object results in a map of the inputs to be collected to start evaluating the data's migration to the application model.

As several actors may be involved in managing the objects, the collection of inputs can result in a large amount of data in different formats that must be standardized and centralized to be managed.

Cadastral database management

The cadastral database's objective is to record the physical reality of the Parcels located in a territory. To achieve this, the database has traditionally been divided into two areas, an alphanumeric cadastral database, and a geographic cadastral database, which communicate through a shared code such as the Parcel number (see Illustration 1). There are several reasons for this:

- **Technological evolution of databases**: The first database management systems did not have the capacity to manage alphanumeric and geographic information, so the information needed to be physically separated.
- **Information management:** Information management is carried out by various working groups, in which the cycle for updating alphanumeric information is different from that of geographic information.

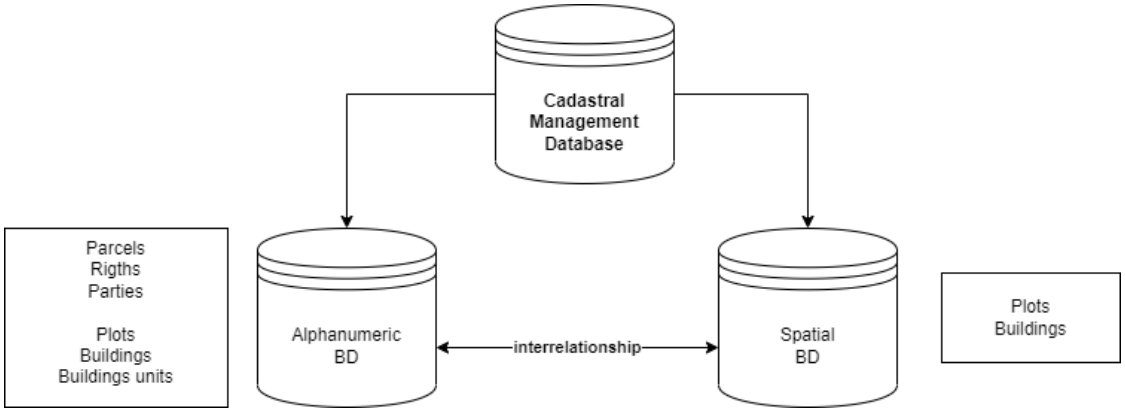

Illustration 1. Cadastral database structure

This creates several challenges in information management:

- **Information synchronization**: Since the alphanumeric and geographic databases are separated, information synchronization processes must be defined and maintained. For example, if a Parcel is no longer available in the alphanumeric database because it was merged or divided, the information in the geographic database must also be updated accordingly.
- **Information management**: The generation of statistics to consolidate the database's status or to implement massive data transformation processes.

When performing the migration, it is of utmost importance to know how the information is stored and managed in the database. In the case of the cadastral database, the alphanumeric and geographic information must be unified in a single database. For example, the alphanumeric and geographic fields should be unified so as not to have repeated records, which complicates information management.

Registry database management

The registry database's objective is to record the legal reality of the Parcels located in a territory; the Parcels registered in this database correspond to the Parcels that officially have a right of ownership. It is important to note that this database only manages alphanumeric information.

Cadastre-Registry Relationship

The registry database is interrelated with the cadastral database through the real estate registration file and the code from the Registration Office for Public Records (ORIP, as per its acronym in Spanish) (see Illustration 2). To identify all existing Parcels, it is important to remember that there is an overlapping of Parcels managed by cadastre and registry, i.e., the same Parcel may be managed by both entities. This must be kept in mind when integrating the inputs to avoid having duplicate records.

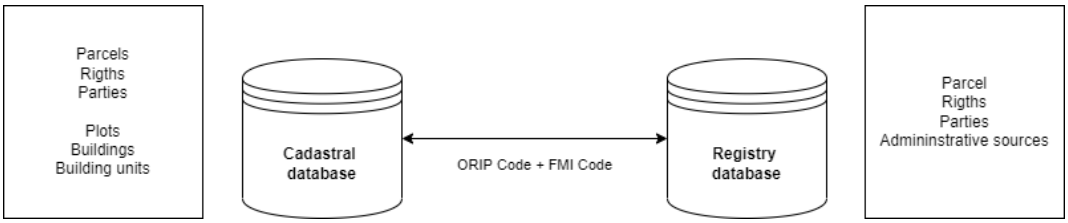

Illustration 2. Relationship between cadastral and registry databases

Once we have identified the objects of interest, we need to know how the information is managed and how it is interrelated with other required inputs. All the information should be centralized in a single database to:

- Standardize the format of the data to be used
- Centralize access to information

This facilitates the automation of data extraction, transformation, and loading processes.

3.1.2 Debugging and data cleansing

Since possible inconsistencies in the information collected may cause problems when migrating the information to the LADM model, a series of verifications must be performed on the data to ensure its correct structure and quality.

Verification of alphanumeric information

- **Duplicate data**: Inputs may have duplicate records for some of the objects; the objects must be checked to ensure that there are no duplicate records.
- **Special features**: The text type fields must not have special characters. These special characters can cause problems when trying to generate a valid XTF file.
- **Duplicate spaces or spaces at the beginning or end**: To improve data quality, verify that text fields do not have duplicate spaces or spaces at the beginning or end.
- **Code structure**: For example, the Parcel number is a code of 30 numeric characters, where the first two digits correspond to the department code and the following three digits correspond to the municipality code. Sometimes these codes are not correctly filled out, causing inconsistencies when trying to integrate the information. The codes should be verified, including the Parcel number, the previous Parcel number, the real estate registration file. Inconsistencies should be corrected when possible.
- **Value ranges**: The value ranges for certain fields must be verified. For example, the appraisal of a Parcel must not be negative.
- **Value domains**: The value domains for certain fields must be verified because they may have invalid values or may not be standardized. For example, a person's ID type may be written in various ways, making it difficult to process and standardize. Therefore, all domains should be normalized and standardized; this will allow for the integration of different inputs and their homologation to the selected LADM-COL model.
- **Missing data or outliers**: In the inputs, there may be mandatory fields that are not filled in. For example, the field for the parties' identification numbers should be filled in, but it may be empty or have an atypical value such as a string of text or spaces. When a field is mandatory and the value is not available, a standard value should be assigned that will allow it to be identified to verify it manually.

Geographic information verification

- **Topological errors**: The geographic information may have topological errors that must be corrected to generate a valid XTF file.

- Duplicate nodes must be removed
- Intercepting nodes must be corrected
- Dangling nodes must be corrected
- Spatial overlapping of the same class of objects must be corrected

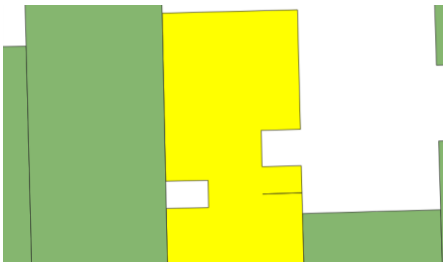

Illustration 3. Topological errors.

- **Geometry standardization:** GIS software has various ways to verify the geometry. However, the leading geometry modeling standard for GIS software is the OGC Simple Features Interface Standard (SFS). To facilitate the integration of the information, the geometry is converted to the OGC standard.

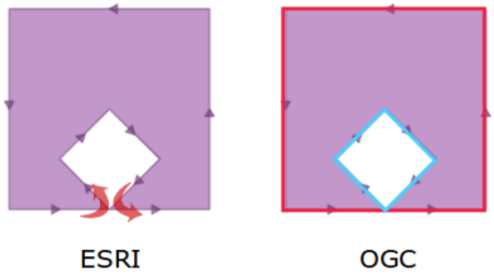

Illustration 4. Standardization of the geometry representation.

3.1.3 Information preparation

Once the inputs have been debugged and cleaned the application model (based on the LADM-COL model) that will undergo the ETL process must be defined. For practical purposes, the cadastral survey application model will be assumed as the model to which the information is to be migrated. The following adjustments shall be made to the information:

- **Required fields:** At this stage, each of the objects that make up the model must be evaluated. The mandatory fields defined in the application model must be available and not null. If a mandatory field is not available, a temporary value must be assumed for migration.
- **Domain homologation:** The LADM model defines value domains for some fields, which will not coincide with the domains defined in the inputs that have been collected. Therefore, the domains of the base information must be homologated with those of the

LADM model. The best way to carry this out is through a domain homologation resolution issued by the regional entity in such a way that the domains managed by the entity and their homologation in the LADM model are clearly and officially approved. The domains defined in the LADM model must be adopted so that regional entities can better manage their information, to guarantee the correct cadastral identification during the processes of conservation, dissemination, and updating with a multipurpose approach.

- **Coordinate system:** Resolution 471 of 2020 of the Agustín Codazzi Geographic Institute established the Unique National Origin cartographic projection as the cartographic projection to be used for all products in Colombia's official basic cartography. For this reason, geographic information must be transformed to the national single origin coordinate system EPSG:9377. Using this projection offers the advantage that all the cadastral information collected in the national territory can be integrated in one place.
- **Information generation:** Managing information in the LADM-COL model entails considering information that has not traditionally been managed by cadasters, but which is of utmost importance to ensure a realistic cadastral inventory of the territory. For this reason, once the information analysis has been carried out, it may be necessary to incorporate the parent Parcels and their associated information, such as rights, parties, buildings, and corresponding Building units. The databases that are being used as inputs may not have this information, but it could be deduced after analyzing existing Parcels.

3.1.4 ETL implementation

Once the information has been prepared and the mandatory fields are filled in, the field domains have been standardized and correspond to those defined in the LADM-COL model, and the relationships between the objects that define the model have been established, the information can be transferred to the LADM-COL model via ETL implementation. When implementing ETL, the objects that make up the model should be ordered as follows:

- **Administrative package migration**: The first step is to migrate the administrative package information, first creating the information from the basic administrative unit and its associated or related categories such as the Parcel, rights, and restrictions.
- **Party package migration:** Start with the migration of the parties, considering that only one party must be registered in the database at a time. Subsequently, groups of parties must be created, and, if applicable, their respective share or percentage of ownership must be filled out. Once the creation of the parties and groups of parties has been completed, the table of rights and restrictions must be updated to associate each right with its corresponding party or group of parties. The LADM-COL model categories to

be migrated are: party and group of parties. Then, fill in the relationship between parties and group of parties.

- **Migration sources:** Each of the RRR (Rights, Restrictions, and Responsibilities) must have an associated administrative source that serves as supporting evidence of the party's RRR over a Parcel, which is why the administrative sources must be created and associated with their respective RRR. The LADM-COL model categories to be migrated are: administrative sources. Then fill in the relationship between the RRR and administrative source.
- **Spatial units package migration:** Each Parcel's spatial units should be listed, considering the Parcel's condition. To perform this migration, each spatial source must first be migrated, paying special attention to the buildings, and Building units. The structures must be migrated first, followed by the building units associated with their respective building. The LADM-COL model categories to be migrated are: land, buildings, building units, and right of ways. Then, fill in the relationship between the Parcel and the spatial units.
- **Topography and rendering package migration:** Traditionally, cadasters and registries have not managed the information regarding the topography and rendering package. However, this information can be calculated based on the spatial units. The LADM-COL model categories to be migrated are: boundary marker, survey marker, and boundary. Then fill in the relations between boundary points and boundaries.

3.1.5 Information verification

Once the information has been migrated to the LADM-COL model, a quality control check must be performed on the database generated to verify that the information was successfully migrated, and that no information was lost in the process. To perform this verification, check the following:

- The total number of records for each LADM-COL model category corresponds to the total number of records available in the inputs used.
- A stratified random sampling is carried out and a set of Parcels is selected, taking the type of Parcel into account. For the selected Parcels, verify that the migrated information corresponds to the input used. In this process, all the objects related to the Parcel are also verified, including rights, restrictions, parties or groups of parties, plots, buildings, etc...
- Once the database has been generated, it is exported to the XTF exchange file format and the model is verified to ensure that the migrated data comply with the structure and restrictions defined for the LADM-COL database used.

If there is an error in any of the defined rules, the inconsistency must be corrected and the ETL must be rerun.

4. CONCLUSION AND NEXT STEEPS

Some entities in Colombia have effectively implemented the LADM-COL on their cadastral data collection processes, but the Catastral Manager of Medellin has been the first entity to transform the existing information on their databases to the new LADM-COL data model.

This migration of the Medellín cadastral database done together with SwissTierras project, funded by SECO-Switzerland has demonstrated that it is possible to migrate the existing information from a consolidated cadastre, not yet on the new Multipurpose Cadastre defined by recent public policy in Colombia, to the LADM-COL model.

This exercise has been also useful to IGAC, the Cadastral National Autorithy, to improve the data model, and it has also been useful to improve the existing tools developed by the national and regional entities, and also by SwissTierras Colombia.

The data migration process to the LADM-COL model allowed cadastre Medellín to identify the missing information and start the due processes for its collection and management.

It's expected, as well, to share this positive experience to other cadastral managers to show the way on how it can be done.

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BIOGRAPHICAL NOTES

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Andrés Guarín is a cadastral engineer and geodesist, with a master's in information sciences and communications from the Universidad Distrital Francisco Jose de Caldas. During his professional occupation, he has been the technical leader for implementing several GIS projects, from analysis, design, and development to the implementation stage. He was engaged in drafting the conceptual design of the new Multipurpose Cadastre of Colombia and is currently he is a consultor in the Proyecto de Modernizacion de la Administración de Tierras in Colombia, funded by SECO (Swiss Cooperation).

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