Low Cost, Post Conflict Cadastre with Modern Technology

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Abstract

As Colombia continues the long road to peace, they recognize a key component to sustained peace and economic growth will be their cadastre. Choosing not to implement a system with traditional approaches, Colombia is embracing new technology, innovative approaches and recognized standards. This presentation will detail the technology used including Android, survey accurate GPS, the Land Administration Domain Model, and ArcGIS Online combined with innovative ways to collect ownership information.

This presentation will detail technology used and the status of progress in Colombia.

Key Words:

Land Administration, Colombia, ArcGIS, GPS, Land Administration Domain Model
1. Introduction

This paper is about Low Cost, Post Conflict Cadastre with Modern GIS Technology – with a focus to Colombia. GIS is the abbreviation for Geographic Information System.

GIS has evolved with the trend toward better organization, access, and updating of global cadastres. Mobile GIS has the potential to reverse the present crisis of growing unrecorded land and property and incomplete land administration in developing economies. As a system of record and data collection methodology for land administration, ArcGIS and mobile apps can help migrate a huge number of property-owning citizens into national legal systems in a very short period of time, both securing citizen tenure rights and increasing property tax revenue to properly fund government.

The challenges in post conflict Colombia are extremely complex. The armed conflict, rooted in disputes over land, has an enormous human, social and economic impact. It resulted in more than 5.7 million people being internally displaced according to the UHNCR, which makes Colombia the country with the highest number of internally displaced persons in the world. Another challenge is the informality of property in the rural areas of Colombia. About 4 million rural parcels in Colombia are not formally registered. There is an urgent need for acceleration of the data acquisition and management in the formalisation process in rural areas.

This paper presents an App for land administration. The App is designed to be used in an environment where categorisation of land rights, collection, recordation and publication of data on land rights and sharing of land data is organised in a complete transparent environment. In this digital environment all stakeholders can see what’s ongoing in the process of land administration. The Colombian Ministry of Agriculture and Rural Development (MADR) and the Geographical Institute Agustín Codazzi (IGAC) co-operate in a project together with the University of Twente (Faculty ITC), the Delft University of Technology (Research Centre OTB), Kadaster International
in the Netherlands and Trimble and Esri in United States – where this App has been designed and developed. The project is under leadership of Kadaster International and is supported by the Netherlands Embassy in Bogotá, Colombia. A proof of concept has been deliverd.

2. The Land Administration Domain Model

The data structure of the database with collected attributes is based on the Land Administration Domain Model. The Land Administration Domain Model - LADM is based on the common denominator or the pattern that can be observed in land administration systems: a package of party/person/organisation data and RRR/legal/administrative data and spatial unit (parcel)/immovable object data (Lemmen, 2012, ISO 2012). The LADM is flexible and widely applicable. Different types of rights, restrictions and responsibilities, parties, spatial units, roles in processes, etc. can be integrated in this conceptual data model via code lists.

The data structure as implemented contains the following classes:

- RRR class – this class includes the attributes ‘type’ (with selection from pre defined code table), ‘description’ (to be inserted manually), ‘recording date’ (generated), ‘recording person’ (generated automatically based on authentication), ‘share’ (% in a right can be inserted manually), ‘starting date’ (as in the deed, can be manually inserted) and there can be attachments (optional, there may be many attachments associated to RRR, this can be photo’s),

- Party class – this class includes the attributes ‘name of rightholder’ (to be typed manually), ‘recording date’ (generated), ‘recording person’ (generated automatically based on authentication), and there can be attachments (optional, there may be many attachments associated to Party, this can be photo’s),
- Party type – this class includes the attributes role type (with selection from pre defined code table), ‘recording date’ (generated) and ‘recording person’ (generated automatically based on authentication),

- Spatial Unit Class: this class includes the attributes ‘label’ (this is the spatial unit identifier), area (dynamically calculated when walking polygons),

- Address: area name, building name, building nr, street name, city, state, country, postal code, recording date, recording person

- Party role – this includes role type (to be selected), recoding date and recording person

It is important to minimise the number of attributes. It should be remembered that each extra attribute has to be multiplied with the number of spatial units or parties. One extra attribute in the data model has to be collected millions of times. And the quality has to be maintained. It is better to have a land administration with a small set of quality attributes per spatial unit or party then having a land administration with many non-reliable attributes.

**Country Profile – LADMCOL**

A comprehensive effort has been made by a group of experts in Colombia to provide a country profile for LADM in Colombia – named LADMCOL. This approach should result in a model driven architecture for land administration in Colombia. The developments are done in collaboration with the Swiss development Cooperation.

A version with a minimal number of attributes is under discussion in this moment.

### 3. Functionality and Technology

The idea of the App is that farmers and grassroots surveyors collect land data themselves – see section 4 on Methodology. Functionality is required for the following approach.
Right-holders can walk the perimeters of their lands using mobile phones. They may be assisted by grassroots surveyors – e.g. people from the villages, trusted by the communities. The App comes with an orthofoto of an area. The data is collected only once, the spatial and administrative data of one property are integrated right from the start of the formalisation process. The data can be collected offline, and may be uploaded later to a land administration service in the cloud. In a village meeting, the community members gather to see all the collected data on a map, and discuss and reconcile the results.

During the adjudication process in the field it may happen that overlaps between polygons are created as a consequence of disputes. Those overlapping claims are always mapped. The related conflicts have to be solved. Bigger ‘gaps’ represent areas which are still to be surveyed. This may concern government owned lands which have to be identified and included in the system.

The design environment for the App presented in this paper is Esri’s Collector App. It should be noted that alternative development environments are available. The App as presented here can be used in combination with the Trimble R1 via a Bluetooth connection. The interface between the

Figure 1: the Trimble R1 has a Bluetooth connection with a mobile where also Esri’s Collector App is installed (left). Small handheld devices are easy to use in the field (right).
R1 and the Collector App could be managed from a mobile, see Figure 1. This small handheld device collects co-ordinates with a sub meter accuracy with a global coverage.

Imagery is loaded in advance. Most boundaries are clearly visible on aerial photos or on satellite imagery. This imagery should be ‘ready to use’ and needs to be cached for this purpose so it can be used as a base-map or a ‘layer’ where zooming is possible. Then physical features off the imagery can be picked - such as fences, hedgerows, large stones, walls, ditches, etc. The polygons or tracks are recorded and can be visualised in the display of the mobile in superimposition over the imagery, see Figure 2.

Figure 2: Tracks can be visualised by superimposition over the aerial photo.

The boundaries have an intrinsic identification accuracy around one meter. This is about the same as the accuracy of hand held devices for spatial data acquisition. Administrative data are collected at the same time, see Figure 3 for the interface.
The collected (closed) polygons with associated attributes are considered to be ‘evidence from the field’. Data collected from the field can be processed and handled into a (cloud-based) geographic information system, see Figure 4.

Figure 3: interface for collection of administrative data.
4. Methodology for field data collection and data handling

After the proof of concept a further detailed methodology has been developed. This methodology will be piloted and field tested at scale. This pilot will be performed for learning purposes and building experiences in implementation. Purpose of implementation is collection of data for production of land titles. Getting overview of the required attributes required for title production is one of the expected achievements of the pilot.

This section presents this methodology (for field data collection). Field data collection succeeds procedural steps such as project block selection, preparations, awareness raising, announcement, as well as training.

The collected data from the field require data handling afterwards and should be available for public inspection. Complaints may lead to agreed changes. Areas without disputes can be certified with land titles. The results may be included in the cadastre and land registry – and regular maintenance can start.
Fast, reliable, affordable and participatory

Field data collection should be fast, reliable and affordable. This is the only alternative in support to the establishment of a nationwide land administration in Colombia within the defined timeframe of the peace treaty. The presented methodology is fast and designed to meet this requirement – a nationwide land administration within 7 years. That is 2 years of preparation and piloting and 5 years for data collection. It is reliable because the focus is on a quality link in the data between land and people. It is affordable because high precision and time consuming conventional field surveys are avoided as well highly complex bureaucratic procedures. Participatory, because people themselves will be actively involved in the data collection.

Fit-For-Purpose Land Administration

Currently, it costs at least around USD 400 to measure and register an average two-hectare parcel in Colombia. There is an estimated number of about 4 million of parcels still to be formalised, which means this will cost at least 1.6 billion USD and a substantial amount of time exceeding the 7 years set out by the government.

The DNP is looking for the most efficient processes in land administration, using innovative techniques. Therefore, Fit-for-purpose methods and techniques should be explored, tested, evaluated and implemented as soon as possible. The Fit-For-Purpose (FFP) approach to land administration has emerged to meet these simple, but challenging requirements and enables implementation of sustainable land administration systems in less developed countries at scale, see (FIG/WB, 2014; UN Habitat/GLTN/Kadaster 2015)

The FFP approach has three fundamental characteristics. Firstly, there is a focus on the purpose and then how to design the means for achieving it as well as possible; secondly, it requires flexibility in designing the means to meet the current constraints; and, thirdly, it emphasizes the perspective of incremental improvement to provide continuity. Enemark et al. further describe the three core components of the FFP concept: the spatial, the legal, and the institutional frameworks. Each of these components includes the relevant flexibility to meet the actual needs of today and
can be incrementally improved over time in response to societal needs and available financial resources.

The Fit-For-Purpose approach recommends the use of “visual boundaries” to identify the delineation of land rights (FIG/WB, 2014).

Most of the boundaries in rural areas in Colombia are visual boundaries (general boundaries): easy to identify in the field and on the imagery. In a Fit-For-Purpose approach, those visual boundaries are identified in the field and ‘digitally drawn’ on top of orthophotos using locally trained technicians. The approach is highly participatory. It was implemented earlier in countries such as Rwanda, Kyrgyzstan, Ethiopia, Lesotho and in some Eastern and Southern European Countries.

**Overview of the existing situation**

An overview of all existing people-land relationships based on Fit-For-Purpose Land Administration is needed. This is in support to all requirements related to processes for formalisation, restitution, regular maintenance and quality improvement. All people-land relationships are included: formal ownership and real rights, possession, occupancy and informal land use. Creating overview of the existing situation includes also overlapping claims, disputes and conflicts. It is crucial to get an overview of parcels or boundaries under dispute and at the same time an overview of all the areas not under dispute.

**Land owners and users provide a first indication of their lands**

Land owners and users are being invited in during a (series of) afternoon(s) in the weekend(s) in a community house or place. Here the land owners and users have the possibility to point (in front of the community) the boundaries of theirs lands in ownership or in use (occupation, possession or other types of informal use rights).

This information will be used for comparison with results of field work and for planning and logistic – activities for field work during the next days. This is relevant – because it is difficult to get an overview of what can be expected in the field in advance.
GIS software can bring support in logistics, planning and also in comparing first indicated spatial units with results of field works.

**Land owners and users walk the perimeter of their parcels**

The ‘Fit-for-purpose App’ enables farmers (with locally trained / grassroot surveyors) to walk the perimeters of their parcels themselves. Those grassroot surveyors are young adults from the villages, trusted by the communities and educated and guided by professionals.

The App comes with an orthophoto of the specific area, and the spatial and administrative information can easily be collected in the field. After the boundaries have been drawn, a preliminary identifier of the spatial unit (parcel) is drawn on the photo and linked with recorded administrative attributes. Each owner or claimant walks his/her own perimeter polygon. In each corner point the coordinates are recorded with a handheld GPS device. Data collection is done in an integrated way: the perimeter is stored as a closed polygon together with the type of right or people-land relationship (ownership, possession, occupation, informal, dispute, etc) combined with a photo of the owner or claimant and a photo of the id of the owner or claimant. This means that names and other relevant attributes and polygons (representing measured parcels) can be linked. Digital photos can be attached; existing documents like passports and IDs, selfies, photos of groups of owners, photos of existing legal documents like deeds or titles and photos of the boundaries can all be linked to the polygon.

Often there is more than one claimant for a specific parcel – for example in case of a married couple. For this reason a share in a right can be recorded to each individual claimant (LADM COL complaint).

The administrative data is collected only once, and integrated with the spatial data. All data can be collected offline and is later transparently uploaded to the cloud.

Accuracy will focus to properly linked spatial and administrative data. The fact that IDs are requested means that the government must be represented in the field. This is in general important for the success of this methodology – the people should not have the feeling that the
government is ‘far away’ in Bogotá making decisions on title later on. On site involvement is crucial.

**Participation**

Community involvement is required; the very nature of cadastral survey requires the participation of neighbours, family members, etc. Therefore, the mayor (a representative of the local authority) is informed in advance to ensure awareness and involvement of all parties. Everyone can follow the process on-site in the field. Collected data can be sent with Esri’s Collector App directly to a cloud-based GIS environment, enabling everyone to follow the process remotely – this ‘remote participation’ is important for the involvement of stakeholders who cannot be on site – and it is possible to set up transparent access to this cloud environment.

**Disputes**

It is crucial to get an overview of parcels or boundaries under dispute and at the same time an overview of all the areas which are not under dispute. A dispute map – ‘dispute holders’ should agree on the location of the disputed area- forms the basis for conflict resolution and decision making.

During the adjudication process in the field, disputes may lead to the creation of overlaps between polygons. In that case, those overlaps are mapped and the corresponding authorities know exactly where to solve which type of land related conflict. Bigger ‘gaps’ represent areas to be surveyed. This may concern government-owned lands, baldios, roads, rivers etc. which have to be identified and included in the system.

**Data handling**

After field data collection the data need to be checked on completeness. Polygons can be linked to boundaries if coordinates are within tolerances. For each boundary an “acta de colindancia” will be prepared with the location of the boundary – visualised on top of the image – the names, photographs and id photographs of the neighbors and space for a signature.
Results of field works can be compared with the first indicated boundary data.

Public inspection

Usual procedures, such as public inspections, are conducted at village meetings in the town hall accompanied by trusted third parties. At a village meeting in the town hall, the community members gather to view all the collected data on a map and discuss and reconcile the results. It is important that all owners and claimants are included – for example in case of a married couple both man and wife are recorded into the system.

Owners and claimants will be requested to show their id. This id must be equal to the one photographed in the field. The “acta de colindancia” can be signed now – this will be done independent in time for both neighbors. As soon as the acta is signed by both neighbors, the boundary will get a green color in the system. As soon as the all boundaries are green the certificate can be handed over and registration and cadastral map updating can be performed.

Configuration

The design environment in this case is based on Esri’s Collector App, which allows for very efficient data collection. The app is used in combination with the Trimble R1, for sub-metre accuracy, via a Bluetooth connection. The interface between the R1 and the Collector App could be managed from a smartphone. This configuration is fit for purpose, given the often relatively low value of rural land, the intrinsic accuracy of boundaries and even the existing norms for area calculation. The data structure of the cloud-based database with collected attributes is based on the Land Administration Domain Model, a flexible ISO standard that is widely applicable in land administration. More specifically, it will include the minimal requirements of the LADM-COL.

Lightweight devices in the field are very efficient to use in mountainous Colombia, and the tools and technologies to develop the application are available. The R1 requires a correction signal for correction of atmospheric distortions of the GPS signals. There are different options (and related costs) in the provision of this correction signal. In some remote areas there may be a need to use the R2.
The paper based approach in field data collection is in all cases an alternative to the computerised version of field data collection.

**Efficiency**

The proposed method is expected efficient because:

- Fast integrated (spatial and administrative) data collection with RI (alternatively R2 & paper)
- Data only collected once
- No need for monumentation. Monumentation and highly accurate surveys can be done later - if needed because of the land value – during the maintenance phase.
- A model with a minimal set of attributes will be used
- The “actas de colindancia” will not be signed in the field, but after the data collection, ion the municipality.

**Experiences**

A Proof of Concept conducted in the municipality of Tenjo in 2015 demonstrated that the field data collection and data handling can be carried out fast, affordable, and reliable. This Proof was carried out by IGAC, MADR, SNR, Dutch Kadaster & universities, in close collaboration with software and hardware providers. The results can be seen on: gip.itc.nl/projects/rvo_colombia, as well as in several publications.

In the Netherlands a system of definitive and provisional boundaries was successfully implemented nationwide.

**Institutional commitment**

The DNP is looking for the most efficient processes in land administration, using innovative techniques. Therefore it is important to explore, test and evaluate fit-for-purpose methods and techniques as soon as possible. In all stages of the FFP pilot (including the actual field work), the collaboration with ANT– IGAC -SNR – DNP is crucial to improve the methodology and, most
important, to ensure acceptance of the results. Most crucial is the participation of the farmers themselves in all the stages to ensure trust in the obtained results.

**Conclusions**

**References**


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