Institutions for Equity&Resilience
ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 16-20, 2020

Surveying the Landscape of Land Rights Documentation Tools

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Paper prepared for presentation at the
"2020 WORLD BANK CONFERENCE ON LAND AND POVERTY"
The World Bank - Washington DC, March 16-20, 2020

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Abstract

With a significant portion of the world's land being undocumented, it is widely understood that technology can play a key role in accelerating the pace of land rights documentation and formalisation. 'Responsible land administration' shifts the paradigms of land administration design and management, challenging conventional forms; and promotes innovation that integrates the understanding of ethical and social dimensions. Besides, this concept aims to align with the specific needs and skills of individuals, governments and other society actors. Therefore, while technology advances, the elaboration of ethical and sustainable development standards within the implementation of innovative tools gain traction. The use of technological innovation in land documentation processes offers advantages such as the reduction of costs and promote greater transparency, especially in low- and middle-income developing countries. In accordance, a fit-for-purpose land administration approach to these solutions would ensure that social needs are met and their application to specific situations is easy.

By recognising this need, several companies and organisations have developed systems and applications to make it easier for governments, communities, and individuals to document and map their land. While the majority of these systems have attempted to fill the data gap left by a top-down system, they each offer unique features and functions. To better understand the landscape of applications that can be used, this paper introduces a comprehensive list of available systems so that stakeholders can more easily determine which systems fit their needs best. The paper tries to support decision-makers involved in land administration and recordation projects to make informed decisions when choosing which system to use. A comparative assessment of systems and publicly available data published on the company and organisational websites was conducted. The review covered the following systems: Aumentum OpenTitle, Cadasta, Fulcrum, Mapit GIS, Meridia°Survey, Mobile Applications to Secure Tenure (MAST), Open Data Kit (ODK), Social Tenure Domain Model (STDM), Solutions for Open Land Administration (SOLA) & Open Tenure, and Trimble Landfolio.

Key Words: Land Rights; Land Documentation; Land Administration Systems; Land Tools, Fit-For-Purpose; Scaling Up Land Rights; Data.

Introduction

As land administration is found to be more and more related to the most solid responses to global challenges, securing people's land rights becomes an urgent sustainable development matter. Tenure security enables the environment for development and requires reflection. Even though advocacy for secure land rights and policy or academic discussions by different actors take place, implementation strategies are still a subject of examination. It is necessary to think about the challenges and solutions but, most importantly, the possibilities available.

Land tenure documentation efforts from region to region are diverse. In most cases, conducted by governments and their institutional frameworks. The main question focuses on the suitability of the processes to the community needs. As in a bottom-up development perspective, there is no one-size-fits-all solution of land and property documentation to different tenure systems. On the other side, methods can be developed and adapted to specific contexts. Especially, technology plays an important role in documenting land and property rights.

Innovation in technological tools for land documentation could re-structure the way land rights are promoted, protected and, lastly, delivered to local and indigenous communities. Tackling important constraints such as bureaucracy, high costs of implementation, lack of transparency and traceability, inefficient processes and coverage can lead to finally unlocking people's rights and the strengthened use of those. Across this paper, secure land rights are addressed from the perspective of their technical application and how these are being adapted to be reachable on the ground for people in their context. After characteristics are defined innovative approaches and challenges, different technological tools and systems available are explored and contrasted through secondary qualitative research. This, with the objective of presenting a broad overview on the landscape of innovative land documentation approaches and opportunities and challenges are unpacked.

1. Technology as a game changer

Governmental and development institutions have promoted the development of tools for land administration to reflect the continuum of land rights (GLTN, 2012), especially in the global south. Processes within traditional surveying and land registration methods can be inefficient, exclusive,

expensive and slow. Therefore, the delivery of documented rights to access and control land is delayed (Enemark et al., 2014). Hence, inefficient methods represent an obstacle to securing tenure for communities. Without effective and appropriate tools, governments experience challenges to overcome the formal-informal gap in land governance systems and institutions. On the contrary, specific contexts require specific solutions and that is because fit-for-purpose for land rights documentation innovations are important. Another important need is scalability, which is a high challenge for land agencies and other stakeholders. Fit-for-purpose land administration tools now available has grown substantially over the last three decades (Bennett et al., 2019).

In principal, international development agencies and organisations have reinforced efforts to achieve better practices in administrating land, including tenure registration. To illustrate these efforts, the Voluntary Guidelines on the Responsible Tenure of Land, Fisheries and Forests (VGGT) highlight the relevance of implementing technology-based tools (FAO, 2012). The development of digital tools is encouraged across relevant institutions from different sectors. These guidelines promote suitable technology, expected to make land documentation services cheaper, easier, more accessible, transparent and efficient. Digital surveying tools needed to record and protect people's tenure, should collect data from land and their holders with the accuracy needed for the purpose – and should aim for complete coverage first and incremental improvement later. Also boundaries and overlaps need to be document to show the reality on the ground. These are features that can be provided by digital land documentation tools. As low-income and developing countries struggle with resources for tools innovation, not only governments but also the participation of development agencies and private sector is key in developing scalable methods with innovative and socially responsible digital tools. Furthermore, technology-based implementations facilitate that land documentation is taken from the governmental domain to 'a more community-driven endeavour deriving from specific needs and purposes of a locality' (Lengoiboni, 2019).

2. Current gaps for the application of technical solutions in land administration

Lemmen et al (2020) have compiled actions and features considered as required in the conformation of land administration systems and tools, through an updated overview of standardisation, technical approaches and land data acquisition methods. According to this analysis, there are important characteristics to be fulfilled or addressed by systems in order to make land administration effective (See Table 1). Actions

identified should be part of the planning and implementation process by stakeholders involved in the implementation of technological solutions.

Table 1. Actions needed in land administration implementations and tools. Adapted from Lemmen et al. 2020.

Actions Needed in Land Administration	**Stakeholder Promoter**
Recognition of land tenure, use, value and development data. Considerations on elements such as a gender, conflict and disaster.	Framework for Effective Land Administration (UNGGIM, 2019)
Establishment of cost-effective, efficient and interoperable administration land capabilities. More automated and open to new data sources and technologies.	Open Geospatial Consortium (OGC) – White Paper on Land Administration
Standardisation including valuation, fiscal representations, spatial planning and zoning inclusion with legal implications.	The Land Administration Domain Model (LADM) / ISO Standard
Fit-for-purpose data capturing. Cost-effective time-efficient, transparent, inclusive, scalable, and participatory data collection and management, including participatory surveying, volunteered and crowd-sourced land information. Dynamic processes involving adaptation to different contexts, technology availability, and existing administrative approaches.	FFPLA International Federation of Surveyors (FIG) / University of Twente (Netherlands)
Transition towards bottom-up land registration approaches Data generation and use by people, through applications and services	International Federation of Surveyors (FIG)

Simultaneously, the authors recognise substantial developments of automation in land administration, in conjunction with adaptation and response of land administration systems to natural disasters and disputes amongst other issues to be addressed in a new era of land administration Unger et al. (2019). For example, the integration of Automated Feature Extraction (AFE) is referred in the first category while Disaster Risk Management (DRM) is mentioned as an innovative framework combination.

Nonetheless, innovation developers and promoters face threatening aspects that beyond the technical scope of systems and tools. Lengoiboni et al. (2019) identify four cross-cutting challenges for the implementation of land administration innovations. First, the arrangement of 'balance' within the diversity of land tenure systems and plural land rights to address worldwide, as well as adjusting to the corresponding institutional land governance settings. The authors explain that digital and innovative approaches in documenting land and tenure rights add layers of complexity to the process that need to be considered (See Table 2). The range of challenges cover a range from efficiency-related aspects to ethical considerations in order to fully secure and protect people's land rights.

Table 2. Challenges in the implementation of land administration innovations. Adapted from Lengoiboni et al., (2019).

1) Further complexity added in recording land rights	Inclusion of more components to consider in adjustment processes, such as: - Provision of both paper-based documents and digital databases from different stakeholders; - Speed and ease of data collection; - More efficient data management; - Inclusion of poor and vulnerable groups
2) Flexibility and diversity in the land documentation process	Initiatives adjust and diversify in the implementation process. One example of challenge is the inclusion of tenure plurality implies intrinsic replication of both statutory and customary norms, intentionally or unintentionally. This may represent a challenge because carrying on social norms through innovations may perpetuate

	structural marginalisation for certain groups such as in the case of women.
3) Legitimacy across innovations	Challenging is to maintain legitimacy of documents, processes and actors involved. To tackle this issue, it is necessary to explore the purpose of land documentation.
4) Achieving landholders protection-responsive open data	To find a balanced use of data through transparency and openness at the same time than protecting the landholder.

Besides the technical level in the development of tools facilitating digital land documentation, it is crucial to consider these external challenges mentioned above. Most importantly, the identification of how these paths are being embraced and adopted by innovation tools emerging and consolidating in the land administration field is highly relevant.

3. Lessons from scaling up technology

When using technology to map, register and manage land rights, scalability often turns out the be one of the key barriers to success. Multiple solutions may perform when conducting land registration for a small sample of parcels (e.g. thousand parcels). In contrast, in order to scale up processes, further operations and ICT architecture are required. The implications from those may transform efforts into more complex and challenging procedures.

In order to provide a deeper understanding of this assessment, the following common scalability issues are addressed:

1. Customisation and configuration: As legal and technical requirements differ from country to country, how easily can the system be tailored to a specific country and modified to fit the particular local workflow and terminology?
2. Data syncing and concurrency: As the mobile solution should be able to work offline in areas without data access, how does the system handle offline-use and syncing of data between field devices and the central database?

3. Access management: As hundreds of field agents could be working each day in the field, how is access and authorisation handled and structured (e.g. role-based permission hierarchies)?
4. Validation and verification: As data usually progresses sequentially through stages of verification and validation by customary chiefs, licensed surveyors, lawyers, notaries and government officials, does the system offer ways of making it easy for those external parties to engage with the system to perform such actions?
5. Hardware compatibility: As each organisation or project often uses different kinds of GNSS receivers, how does the system integrate with such hardware in a user-friendly and failsafe way, without the need of expert knowledge?
6. Interoperability: As land rights data needs to be distributed and shared amongst several key actors and authorities, how does the system enable such integrations with other systems?

4. Methodology and data collection

Secondary data about innovation in land administration systems presented in this paper was collected through qualitative desk-based research and comparative analysis. Existent information serves as a 'starting point for additional research' (Stewart and Kamins, 2019). Data available online was used as a reference to read innovative systems or other tools applied to land administration. A technical comparison (Section 6) between the systems was divided into two main parts: mobile and back office features. For the first category, features include device requirements, surveying and mapping methods, data input and output, legal data entry, and security management. In the second category, features reviewed involve legal data management, spatial data management, data input, and output and security.

The review of the various land systems included research of various components that are critical for effective recording and management of land rights. Whilst some of the systems show strengths in different areas, only two out of all the solutions are complete, meaning that they include nearly all of the features, including mobile and desktop implementations, web-based interfaces, surveying and mapping options in the field and in the office, secure connections and data storage, import and export of various data formats, and the ability to audit edits which were made to the data.

The following are the systems and solutions assessed:

- Mobile Applications to Secure Tenure (MAST): https://www.land-links.org/tool-resource/mobile-applications-to-secure-tenure-mast/
- Aumentum OpenTitle: https://tax.thomsonreuters.com/en/aumentum/opentitle
- Solutions for Open Land Administration (SOLA) & Open Tenure: http://www.fao.org/tenure/activities/administration/recording-of-rights/software/en/
- Meridia°Survey: https://www.meridia.land/
- Cadasta: https://cadasta.org
  MapitGIS: https://mapitgis.com/
  Fulcrum: https://www.fulcrumapp.com/
- Open Data Kit (ODK): https://opendatakit.org

5. Examples of innovations in land administration and relevant features.

The technical dimensions of ten innovations and possibilities available for land registration were compared. These are just a few of the tools that could be used for this purpose. Our selection is biased by the resources available, and use-cases we were aware of. The comparison of the systems addressed in this paper, includes information about the systems reviewed in two main lines. The first line is the analysis of mobile features which include device requirements, surveying and mapping, methods, data input and output, legal data entry, and security management. The other line of analysis consists in reviewing back office features which involve legal data management, spatial data management, data input and output, and security. The following paragraphs describes each of the systems to contextualise the technical comparison in Section 5 with extended characteristics.

a) Aumentum OpenTitle

Thomson Reuter's Open Title is a crowd-sourcing software aiming to help communities to 'better govern their natural resources' through community-based recording of land claims, mapping and data collection. Particularly, the software focuses on land tenure claims and the recognition at a community level using a participatory approach. Some of the features mentioned are data view, data moderation, storage of documents and photos. The software can be used as a data recorder for official purposes and for monitoring climate change monitoring as well. Capacity-building for community members is another feature remarked,

in order to issue community-endorsed tenure rights recognition at a community level (see Thomson Reuters Foundation, 2012)

b) Cadasta

Cadasta provides technology in the form of open and flexible digital tools aiming to help users collect, manage, store and analyse data on land and resource rights. Cadasta offers users a suite of Esri-powered tools and an online platform, to bring fit-for-purpose solutions to the local context. Cadasta works with the LADM, promoting community-based data collection and management, prioritizing participatory processes (Cadasta, 2020; Thomson Reuters Foundation, 2019). Amongst the features they mention are mobile data collection, high-resolution imagery, multiple basemaps, and customised operations and reports for users.

c) Fulcrum

Fulcrum is a multi-purpose data collection tool, not specifically aiming at land registration. Through quick generation of digital forms, Fulcrum offers data collection and communication services. The company aims to tackle productivity issues within organizations, with a major focus on optimising workflows and processes including teams and roles management. For certain related sectors such as agriculture, Fulcrum aggregates online/offline field data collection which may also facilitate aspects such as easy translation of data collected into data analysis and monitoring. In the case of environmental services, the company presents specialised mobile data collection solutions addressing technical needs for accurate data from sampling, monitoring, species tracking, surveying, amongst other types of field activities. Some of the main features are customisable accurate data collection, enabling fast decision-making, geographical referencing and automation of workflows (see Fulcrum, 2020).

d) MapIt GIS

Spatial asset collection, GPS survey and data management are the solutions offered by this tool, aiming to increase productivity and efficiently in conducting fieldwork. Land surveying is one of the possible applications of this tool. However, the company remarks that Mapit GIS is mainly for professional use and does not mention the application of this tool in participatory approaches. Main features are cost-effective

mapping and surveying, multi-modal field customizable data collection, flexible survey design and accurate measurement (see MapIt, 2020).

e) Meridia°Survey

Created by a social enterprise, Meridia°Survey is a technology platform integrating mobile and back office software, training for local implementers and modular integrations. Meridia's mission is to unlock the value of land for especially smallholder farmers in low and middle-income countries through securing their land and property rights. The company has focused on simplifying the entire process for smallholder farmers in developing countries to secure land and property tenure through formally recognised documentation. These efforts lead to major transparency and lower implementation costs (Agarwal et al., 2019). Meridia°Survey has become a cost-effective proven solution that offers features such as multiple survey methods, highly accurate land survey, customisable legal, social and spatial data collection, monitoring and reporting, use with and without internet connection, full auditability and advanced security. Meridia°Survey is considered as a solution that is strong on scalability, usability-focused approach and data consistency (Lemmen et al., 2020) (See Meridia, 2020).

f) Mobile Applications to Secure Tenure (MAST)

This tool was created by USAID as an innovative pilot to tackle tenure insecurity and its negative effects on people. MAST is an Easy-to-use, cost-effective, flexible, open-source smartphone application able to capture information required in formal land rights documentation. This information includes geospatial and demographic information. Its Land Rights Infrastructure component provides functionalities such as customizable set-up, security of data, a database system configured on the LADM/STDM and visualization of spatial data, amongst others (See Land Links, 2015).

g) Open Data Kit (ODK)

Created by the ODK Development Team, ODK is a mobile tools suite used for data collection, management and use. Especially designed for resource-constrained environments and communities, this tool is free and can be applied to multiple objectives. Survey is one of the possibilities through using ODK. The type of

data collected with the tool can vary because it is flexible, scalable and works in disconnected environments (see Brunette et al., 2017).

h) Social Tenure Domain Model (STDM)

Developed by the Global Land Tool Network, STDM functions as a concept and a pro poor land information tool aiming to close gaps in conventional land administration and facilitating administration of customary and informal tenure systems. This tool provides a standard for representing the people to land relationship regardless of the legal or technical aspects. Some important features of this tool are easy and customisable data collection, spatial data visualization in multiple layers and inclusion of several formats of documents (see Lemmen, 2013).

i) Solutions for Open Land Administration (SOLA) & Open Tenure

Developed by UN's Food Agriculture Organization (FAO), with the support from the UK Department for International Development (DFID), SOLA and Open Tenure are an integrated model and an open-source software aiming to protect tenure rights. The objective of the tools is 'to make recording of land rights faster, more affordable and in reach as a mean to increase tenure security' (FAO, 2020b). On one hand, SOLA integrates easy customisation of land registration and cadastre functions. On the other hand, Open Tenure collects data on tenure relationship helpful for communities to assess, clarify and protect both individual and collective tenure rights. The tools provide improved transparency and are also based on the LADM (see FAO, 2020b).

j) Trimble Landfolio

Landfolio is a software for land management and land administration management. It is built on the ESRI platform and other industry databases. Some of its main features are complete configuration and integration of key workflows, involving from registry and cadastre to natural resources management. In the case of its application in public land registry, Landfolio offers automation solutions, incorporation of multiple types of data and integration with existing cadastre mapping and valuation systems. The tool boost transparency, accuracy and auditability of land records.

6. Comparative technical assessment of the tools

To further comprehend the landscape of applications, a comprehensive list of available systems was compiled and compared. This assessment will be useful for stakeholders to determine the needs fitting with the innovation tools of land administration. The following analysis looks first at the mobile components of the systems, then at the back office data management features. STDM and Landfolio did not include mobile components, a highly needed component in the land sector. However, both can be used with other mobile solutions, STDM in particular is compatible with ODK. In contrast, MapIT only offers a mobile component, but no back office component.

6.2 Mobile Components

In comparing the mobile components of the various systems, it was found that all of the systems support Android, Cadasta and Fulcrum also support iOS, but only Cadasta supports Windows in addition to the other operating systems. The ability to support iOS, Android, and Windows gives Cadasta an advantage in terms of the available mobile devices that can be used with the Cadasta system.

All of the systems listed are able to use the device's internal GPS for mapping, but only half of them can also collect spatial data using an external GPS for higher accuracy without third-party tools or data imports. Only Meridia°Survey supports logging raw GNSS data for post-processing with selected external GPS, which is helpful in achieving accuracy without connectivity, and required by some cadastral agencies. Only a few systems offer additional mapping methods such as trilateration and coordinate averaging. While a feature of drawing on the device is available in most systems, another unique feature of Meridia°Survey, is the option for the user to snap to existing features while surveying, avoiding the double surveying of shared boundaries. This can reduce surveying time and help to avoid overlaps by creating correct topology in the field, but must be used with care so not to oversee boundary conflicts.

All systems in the comparative assessment offer the ability to collect data on- and offline and to import and export various data file formats, but MapIT and ODK lack automated solutions to sync data collected between different devices. All tools enable users to enter text data (some in the form of drop-down lists).

However, only half[1] of the systems assessed also allow the recording of audio and video information. Meridia°Survey, Cadasta and Open Data Kit are the only systems from the group that provide the option to use digital signatures and Meridia°Survey adds the option to collect digital fingerprints. These options are particularly useful in countries where residents do not have formal identification cards or large share of illiterate participants.

Additionally, most systems have some level of security and support user authentication except for ODK and MapIT. Most of the systems also have the ability to support multiple languages but only a few[2] have the ability to display performance dashboards. Meridia°Survey provides the additional option to configure settings for the mobile app by user, project, client, and product.

6.3 Back office components

In relation to the back office category, Meridia°Survey offers a complete feature list. For legal data management, this includes features such as image text recognition, filtering, calculated fields, and record linking, some of which are also available with other solutions. In relation to functionality for spatial data management, Cadasta and Meridia°Survey show an exhaustive list of features, such as maps, spatial editing, warning for geometry issues, topological editing (snap to other features), and spatial data filtering. Automated field query generation and automated GNSS post-processing are only available in Meridia°Survey. It is important to note that MapIt lacks back office components so it is not considered in this category.

All of the reviewed systems support exporting data in different spatial and non-spatial formats and importing spatial data is supported by most systems except for ODK. As for security, all systems offer extensive features such as secure connections, user authentication and backups. ODK misses user rights management and a full audit trail the latter also misses for Cadasta.

7. Findings from a technical assessment of tools

[1] Cadasta, Meridia°Survey, MapIT, Fulcrum, ODK support collecting audio and video
[2]. Meridia°Survey, Cadasta, and SOLA have a performance Dashboard on mobile

The following paragraphs presents the outcomes of the assessment conducted (on September 24, 2019), which were divided into the same categories: Mobile features and back office features. Different methods, components and characteristics from the systems are deployed for a clear understanding of possible land administration applications.

7.1 Mobile features

a. Device requirements:

   All of the systems support Android, Cadasta and Fulcrum also support iOS. However, Windows is only supported by Cadasta.

b. Surveying/Mapping methods:

   All of the systems enable the use of the device with internal GPS for mapping, but only half of them are able to also use an external GPS for higher accuracy without add-ons or third-party components. Log raw GNSS data for post-processing with selected external GPS, providing accuracy without connectivity, is possible only with Meridia°Survey.

   - Only a few systems offer additional mapping methods such as trilateration and coordinate averaging.
   - Most of the systems provide drawing features on the device but the ability to snap to existing features for correct topological surveying in the field was only offered by Meridia°Survey.

c. Data Input / Output:

   - All of the systems allow the collection of data online and offline, and to import and export various data file formats, MapIT & ODK lack automated syncing between devices.
   - In all systems, it is possible to enter text data (and some in the form of drop-down lists) but only half of the systems also allow the recording of audio and video information.
   - Meridia°Survey, Cadasta and Open Data Kit appear to be the only systems that give the option to use digital signatures. Meridia°Survey also has the option to collect digital fingerprints. These options are particularly useful in countries where residents do not have formal ID cards which makes it hard to legally identify them.

d. Security:

- Most systems have some level of security.
- Most systems support user authentication, with the exception of ODK and MapIT.

e. Management:
   - Most of the systems have the ability to support multiple languages.
   - Despite a few systems assessed have the ability to display performance dashboards, only Meridia°Survey presents the option to configure settings for the mobile app per user/project/client/product.

As mentioned above, STDM and Landfolio do not contain a mobile component.

7.1 Back office features

a. Legal data management
   - In comparison to other systems, Meridia°Survey presents a varied list of features. The less common features include text recognition, filtering, calculated fields and record linking, only Meridia°Survey offers all of these features.

b. Spatial data management
   - Cadasta and Meridia°Survey provide the user with a highly comprehensive functionality for spatial data management including maps, spatial editing, warning for geometry issues, topological editing (snap to other features) and spatial data filtering; Meridia°Survey presents the possibility of automated field query generation and automated GNSS post-processing.

c. Management
   - Cadasta, Meridia°Survey, Fulcrum and ODK are the systems including various ways to summarise the collected data including customizable dashboards and reports and interfaces to review the data.

d. Data Input / Output
   - All systems support exporting data in different spatial and non-spatial formats. Importing spatial data is supported by most systems apart from ODK.

e. Security

- Most solutions comprehensive security features, this includes secure connections, in-country hosting (on request), (automatic) data backups, user authentification, and (automatic) backups.

ODK and STDM miss user rights management and a full audit trail/history (the latter also misses for Cadasta). Additionally, other characteristics of the systems were compared to unveil differences that may serve for fitting purposes. The following table gathers business models, licenses, pricing and data models from the solutions assessed.

Table 3. Comparative analysis of solutions and technical features.

	Aumentum OpenTitle	**Cadasta**	**Fulcrum**	**MapIt GIS**	**Meridia°Survey**	**MAST**	**Open Data Kit**	**STDM**	**SOLA & Open Tenure**	**Trimble Landfolio**
Business Model	Business (for Profit)	Donor funded NGO (not-for-profit)	Business (for profit)	Business (for profit)	Business (for profit)	Donor funded	Donor funded (by private sector)	Intergovernmental / International Development Agency	Intergovernmental / International Development Agency	Business (for profit)
License	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary	Open source	Open Source (Apache 2.0)	Open source (GNU General Public License v3.0)	Open Source, latest commit 2016	Proprietary
Pricing	Unknown	Free or low cost	SaaS (user subscription), features as Add-on	One time purchase per device	SaaS (Base price + unit costs)	No license costs; unknown configuration costs	Free	Free	Free	Unknown
Version analysed, Release date	2019	2.0, March 2019	2019	7.2.3, July 2019	5.13, September 2019	2019	1.21, May 2019	1.7, 2018	1.1, August 2018	iOS 2.19.12.31.1 Android, March 2019,
Data Model	Not tested	Custom	Custom	Custom (LADM is possible)	Custom, LADM compatible	LADM	Custom, (LADM is possible)	STDM,	STDM	Not tested

Conclusion

Land administration is transiting towards innovative approaches that move from top-down to bottom-up perspectives. This transformation of systems also implies the conversion of institutions such as customary governance units, governments or agencies, and institutional settings into different shaped entities and dynamics. A general impression from all the systems and solutions reviewed lead to uncovering openness

as a trend, which facilitates the inclusion, participation and decision-making by communities. This openness is being accelerated by the use of new technologies. Similarly, the review of the various land systems included research of various technical components that are critical for effective recording and management of land. Whilst some of the systems show strengths in particular subsections, Cadasta and Meridia°Survey fulfill the assessment criteria as defined here, in correspondence to the needs of land administration. These key features include mobile and desktop implementations, web-based interfaces, surveying and mapping options in the field and in the office, secure connections and data storage, import and export of various data formats, syncing between multiple devices and the back office and the ability to audit edits made to the data. Both tools leave ground for new developments in the technical dimension of land administration. But, also represent opportunities for local communities and for the integration of a diversity of tenure models, formal and informal systems.

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ANNEX 1. LIST OF TABLES

Table 1. Actions needed in land administration implementations and tools. Adapted from Lemmen et al. 2020. 5

Table 2. Challenges in the implementation of land administration innovations. Adapted from Lengoiboni et al., (2019). 6