

SiGIT Land Information System and the Challenges Imposed by the Fit for Purpose Approach to Land Administration

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Key words: SiGIT, Land Information System, Fit For Purpose Land Administration, Interoperability, Community-based crowdsourcing

SUMMARY

With the launch of a massive land tenure registration program, called the "Terra Segura" program, aiming at registering 5 million parcels and 4 thousand communities, there are several challenges that need to be overcome to ensure the achievement of the program's objectives and expectations.

From the results of recent tests, there is a need to implement changes to available tools and methodology to ensure the program can reach a cruise speed in registration process. These include interoperating with other cadastres, making widely available a mobile application, training of communities for a community-based crowdsourcing registration and for continuous cadastre updates, and ensuring all updates can be included in the national cadastre of lands.

The main goal at this moment is to facilitate the massive land tenure registration, reducing the time and costs of collecting information and promoting a more participatory intervention of the communities. This paper focuses on the challenges imposed by these new requirements and provides recommendations based on the results of experiments being done in rural areas of Mozambique.

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1. INTRODUCTION

It is now five years since the Mozambican's Land Information Management System (LIMS/SiGIT¹), an ISO 19152 Land Administration Domain Model (LADM) based system, was developed, under a Government project named "Land Tenure Security".

With the launch of the "Terra Segura" program² aiming at registering 5 million parcels and 4 thousand communities, SiGIT was adjusted to accommodate new requirements designed to align the application with Fit For Purpose (FFP) land administration methodology. A mobile application was also developed to substitute the paper based procedure to capture field data.

More recently, and because there is a need for reaching cruise speed in registration process, other requirements were defined such as:

- i. interoperate with other cadastres, the ones that are upstream the registration, to validate tenant's identity, namely for individuals (ID³ number) and for organizations (NUIT⁴ system), avoiding data duplication and reducing time to collect tenant's data. This requirement poses a huge challenge since not all cadastres are ready to interoperate and there are still problems with data quality. Another constraint is the fact that by law there is no enforcement of data sharing between these institutions. There are duplications in data.
- ii. utilize imagery to speed-up the obtain spatial information of land parcels and communities as recommended by the FFP approach to land administration.
- iii. provide tools to ensure that communities can register their own lands and that communities are able to keep their land cadastre up-to-date, as recommended by McLaren et al, 2016, Balas et al, 2017a, and Simon , 2017.
- iv. be able to integrate the community implemented registration into a national database. Although, in Mozambique, in strict legal terms this is not necessary for security of tenure purposes, it assists in the recognition of rights by the State and may also serve other purposes, such as providing more accurate statistics, investment analysis, land use plans, trends in land rights transfer, etc.

¹ Sistema de Gestão de informação sobre Terras

² In April 22, 2015, by the President of Mozambique

³ Unique citizen number

⁴ Unique fiscal number

The analysis of the tests and current practice suggests an holistic approach based on 5 pillars (Balas et al, 2017b): (a) Standards - to speed up the process and facilitate data quality; (b) Technology (IT) - to enable, from the start, the acquisition, storage, processing, analysis and maintenance of the cadastre; (c) Awareness and Knowledge - to ensure that communities and rural dwellers end up driving rather than participate in the process; (d) Logistics - in order to enable effective realization, scaling and cost-effectiveness, while ensuring incorporation of local resources; and (e) Management and Leadership - to ensure that the critical organizational and human aspects, beyond the technical exercise, are dully taken care of.

The main goal at this moment is to facilitate the massive land tenure registration, reducing the time and costs of collecting information and to promote a more participatory intervention of the communities. This is in line with several recommendations of work being done in Africa, as presented by Groenendijk et al, (2016) and Ambani et al, (2017).

These are the challenges for the next cycle of developments of the SiGIT application. We intend to illustrate the work that is being performed and the support that this land information system can provide to accelerate that process of systematic land tenure regularization.

2. THE DEVELOPMENT OF SIGIT APPLICATION

The SiGIT application was developed in 2012 under the "Land Tenure Security" project, a Millennium Challenge Corporation funded project. The SiGIT architecture and design has been guided by the 10 (ten) Land Administration Principles as stated in Williamson et al. (2010) and the 10 (ten) vital considerations to ensure success of land systems implementations as proposed by Lewis (2009). These concepts were very important to gauge security, scalability and sustainability of the system.

The system incorporated into its workflows all land-related legislations, regulations and policies, and all land administration processes (Figure 1) from registration, to taxation, to expansion or reduction of area, to transmission of rights, to revocation or cancellation of rights (Balas, 2016a). The system was developed with specialized workflows for urban and for rural areas as well.

As recommended by Williamson et al. (2010) SiGIT must ensure flexible responses to challenges associated with change, and gives the DINAT⁵ higher chances of both short and long-term successes. In the past five years, several changes were implemented to accommodate these challenges. The main changes were: (i) harmonize Individual Land Tenure Regularizations (RDUAT) and Community Delimitations (DelCOM)), ensuring that community and individual rights are registered simultaneously; (ii) interoperate with a mobile application for field data collection reducing data rejection due to poor data quality or wrong parameters, and increasing speed for data collection and manipulation.

⁵ National Directorate of Lands

These adjustments allowed the following benefits (Balas, 2017):

- i. reduce the rejection rate of field data - from 54% to 1% rejection rate;
- ii. reduce the collection and processing time - from 56 to 18 minutes;
- iii. reduce in 60% the overall costs of in community delimitations when done in clusters; and reduce in 40% the costs of individual parcels registrations when combined with community delimitations⁶;
- iv. allow a higher control of the performance of field workers - by having specific reports requested by management;
- v. allow corrections in the field and afterwards - by having quality controls embedded in the application and a cloud-based module, and well performing manipulating data between these two working areas;
- vi. ensure security of access and data manipulation - by defining user profiles and authenticating them.

3. THE MOZAMBIKAN FIT FOR PURPOSE APPROACH

3.1 Proposed Processes

Initially there were two separate process areas: Individual Land Tenure Regularizations (RDUAT) and Community Delimitations (DelCOM). The work was performed by separate service providers, and it was not linked in any way. For the RDUAT processes, the focus areas were prioritized based on some criteria, being one of them the existence of a delimitation process in the community. However, most communities have not yet been delimited. This may reduce the focus areas available for RDUAT. Additionally, communities often complained that delimitations alone would not secure their rights and that individual rights should also be considered.

Having in mind recommendations of Enemark et al., (2014, 2016) that the land administration needs to be designed to fit the peoples' interest, and based on best practices and lessons learnt from previous exercises, a recommendation was made to harmonize these two process areas in a unique methodology. This exercise to combine RDUAT and DelCOM, intended to:

- Design harmonized working processes for community delimitations and individual land tenure regularizations;
- Include the guidelines for FFP Land Administration approaches;
- Establish standards for managing and executing all proposed activities under the methodology, with details for implementing, measuring and enhancing processes;
- Assess the necessary capacity to execute all processes;
- Disseminate the information to all levels (central, provincial, district and community);

⁶ Based on the cost estimates after the field tests were performed in Chicuangue, and utilizing the combination of activities to reduce costs. Estimates did not include acquisition of images nor the acquisition of differential GPS.

- Create mechanisms to evaluate performance at all levels.

The methodology was designed with efforts to create common processes for these two areas, to define processes in a uniform way, to create a norm for utilization, to define key performance indicators for each process and to design the required artifacts for all the involved stakeholders. By harmonizing these two process areas, Mozambique benefits from the synergies created resulting in: (i) cost reduction, (ii) time reduction, (iii) more accurate and up-to-date information; (iv) community ownership.

The harmonized FFP RDUAT/DelCOM methodology is comprised of 4 (four) processes (Figure 2). Three of these processes focus on the management, and one process details the execution of the work, which is comprised by 10 (ten) sub-processes, combining both RDUAT and DelCOM work as illustrated in Figure 3. This approach is being optimized to ensure a cost-effective massive land registration in Mozambique.

3.2 The Mobile Application

To develop the mobile solution, several frameworks and platforms were analyzed and tested. A mobile application (SiGIT Mobile) was developed, respecting both the harmonized FFP DelCOM and RDUAT methodology and the data quality controls defined for data accuracy and integrity, required by law and by the SiGIT application. So far, there were three versions of the mobile application based on the following technologies:

- ESRI ArcGIS Collector - did not allow more than two levels of quality controls in cascade and CommCare Collector - did not allow for changes in its API and could not embed detailed GIS services within the forms. Both very easy to configure the questions but with difficulties in manipulating data;
- Geo ODK⁷ Collector - also easy to implement and configure, requiring more expertise than the previous, but did not allow the re-utilization of already collected data from other questionnaires.
- a custom developed android mobile application - that combined the best of the previous tools and frameworks in a custom-made application.

Version 3 of this mobile application includes the following main components: (i) SiGIT mobile module – an android based application for field data collection (forms and spatial data); (ii) SiGIT Cloud module – a web application that runs services that synchronizes data from mobile data collectors and also communicates with SiGIT to send data. In this application, it's also possible to view, correct and return incomplete or incorrect submitted forms to the field workers, it also provides performance statistics of the field work; and (iii) SiGIT for Service Providers module – a SiGIT Back Office module enables the service

⁷ Geo ODK (Geographic Open Data Kit) provides a way to collect and store geo-referenced information, along with a suite of tools to visualize, analyze and manipulate ground data for specific needs - geoodk.com, 2014.

providers to process data of the regularizations until the process reaches the public notifications (edictals) for approval by the Provincial Administration Services.

The mobile module was developed with database, called REALM⁸ database, which gives the possibility to structure data and reuse objects that were previously collected in field (occupants, parcel holder, documents). The functionality to share those objects between devices has also been implemented in order to increase efficiency.

An Application Programming Interface (API) was developed to integrate with the SiGIT Mobile and SiGIT Cloud Repository, and the Cloud Repository and the SiGIT Back Office, as well as to allow automatic synchronizations between the three components. The Application Programming Interface aimed at: (1) allowing a two-way communication between the two ends of the registration process; (2) improving performance of data download to the SiGIT Back Office; (2) harmonizing data models between the involved applications; (4) implementing validation mechanisms, resulting in more reliable data.

Data Security was taken in account at all stages of data storage, transmission and access. Mobile Users need to authenticate receiving a session taken with limited timeout. Data in mobile devices is kept on a local encrypted database. Data transmission security is enforced by SSL⁹. Data is inserted into a cloud repository via secure Web Services and no direct access to data is enabled. The logging and traceability is preserved. User profiles have access roles to the services and to the Web component.

4. RECOMMENDATIONS

In the past two years several tests were carried out not only to tune up the methodology but also to optimize the available tools such as the mobile application and respective API. Observations were to the five pillars considered important in the holistic approach. Recommendations are therefore made in order to overcome all the challenges that still persist and that might comprise the endeavor.

4.1 Dissemination of standards

In what refers to standards, the DelCOM and RDUAT Methodology is already revised and it now includes both community delimitations and individual parcel regularizations in a harmonized way. Tools that were developed to support this methodology also allow for a more participatory and all-inclusive bottom-up cadastre and land management.

⁸ Realm is an open-source object database management system, initially for mobile (Android/iOS),.

⁹ SSL (Secure Sockets Layer) and it's successor TLS (Transport Layer Security) are methods used to secure and encrypt sensitive information like credit cards, usernames, passwords, and other private data sent over the Internet. Website pages secured with SSL and TLS are those branded with the HTTPS in their URL address.

Based on the evidence from this work, we do advocate that it is time to disseminate the revised methodology as a standard for massive land registration. It is better to start somewhere and evolve in a continuous quality cycle, the only valid approach to justify the building of the next best version.

4.2 Adopt digital collection of data

If "Terra Segura" program is to become a success, then paper based data collection should be minimized and specific arrangements must be made to ensure all service providers utilize digital forms to collect field data.

Mobile applications proved to work in other countries in Africa (Esri Collector, MAST-Mobile Application for Secured Tenure). SiGIT mobile application is now available to all service providers but other applications can be utilized as well. If another mobile application is to be utilized, specific procedures must be disseminated and enforced by the National Directorate of Lands to ensure data quality. Simultaneously, appropriate application interfaces must be developed to acquire and validate data from these applications.

In any case, ICT¹⁰ support with regards to SiGIT back office application, SiGIT cloud Components and SiGIT ICT infrastructure should be engaged to ensure availability of all services required to the systematic registration. These services must either be subsidized or be part of the registration cost as a fixed fee per registration.

4.3 Make imagery easily available

Based on the results from trial exercises we propose that the role of the community should change to a more participatory one, including involving the local community councils and members of the community for data capturing and for sensitization. Services providers could be involved in training and supervision of the work. This would reduce overall costs and would speed up the entire process. This however is only possible if mobile technology is utilized for data capturing and if imagery is made available with enough details for communities to identify parcel boundaries and spatial unit boundaries of their territories (visible boundary approach in FFP land administration).

In the past year, the SiGIT mobile application was tuned so that questionnaires were easy to fill-in and could utilize local languages. Tests were made with high school students from the community after they were trained to properly utilize the mobile devices and work together with local community councils in data capturing.

However, there was a huge effort to work on freely available images to make them detailed enough to be utilized in the mobile application. We recommend that images must be made

¹⁰ Information and Communication Technology

available in easier ways or we would have to rely on the usage of GPS linked to the mobile devices to get adequate accuracy for spatial data capture.

4.4 Interoperate with other Cadastres

Experience illustrates that it takes at least 5 minutes to capture all information with regards to a tenant, from one's biography to taking pictures of one's documents. This is a time consuming activity, especially if several co-tenants are to be registered. On other hand, when dealing with community delimitations, there is also a need to have available other type of information such as land use plans, mining concessions, forestry concessions, amongst others. Therefore, we advocate that interoperability should play an important role.

In the past, efforts were made to interoperate with other cadastres such as the one from the IDCard and Taxation (NUIT number). This proved to be unsuccessful since these organizations did not feel compelled to share data. The efforts from the Government in the past year managed to have the Government Interoperability Framework approved. The framework provided the legal means to ensure data is only capture one and re-utilized several times. Based on the framework, an Interoperability Architecture Model (Figure 4) was defined, having in mind these requirements.

4.4.1 Upstream cadastres: the need for identity authentication

In this case, the proposal is to start with two main cadastres: the ID card cadastre and the Fiscal Cadastre (NUIT). The proposal is that when registering a Singular or Collective tenant, a picture of the ID card would be taken (or the Fiscal number is captured), and when data is uploaded into the cloud, the details required for issuing a title would be shared between these two systems: the SIGIT and the IDCard./NUIT systems. There is another system that registers companies in Mozambique, the NUEL System. However, this does not have data in a normalized database format and therefore will not be considered for the time being.

4.4.2 Downstream cadastres: providing information to/from other cadastres

There are several licensing services that Government wants to make available through interoperability and some require authentication of the DUAT. Therefore, the SiGIT application must ensure that the required information can be shared with other systems such as the mining system and the property registration system. These efforts should be taken into account as these would bring economic benefits to the country and therefore should be valued when measuring the benefits of having a complete national land cadastre.

5. CONCLUDING REMARKS

The biggest challenge of any registration process is the ability to keep the land cadastre up to date. The investments to register land and create a national cadastre are huge. It makes no sense to let it become obsolete requiring repeating exercises to register the land. Therefore, we propose that this issue is brought into attention right from the beginning of the registration process and not when it ends.

From previous work and tests performed (Balas et al, 2016a, 2017a,b; Norfolk, 2017; Groenendijk et al, 2017), there seems to be a common understanding that communities can be made responsible for this task. However, in our point of view, this would only be beneficial if these changes are part of the National Cadastre and not only part of the community cadastre. For that, appropriate means must be delivered so that communities not only capture these changes but that these are sent to the Land National Cadastre for update. Our proposal is that a mobile device is left within the community with a specific module within the SiGIT Mobile application for specific updates to the community land cadastre. However, and because technology might be a problem in some cases, we also advocate that a dossier with the details of all parcels is left with the community and that specific procedures are taught to the community to update the cadastre. Government should also deliver the communication channels between the community and the district land offices.

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FIGURES

**SiGIT Processes
For a Sustainable Land Administration**

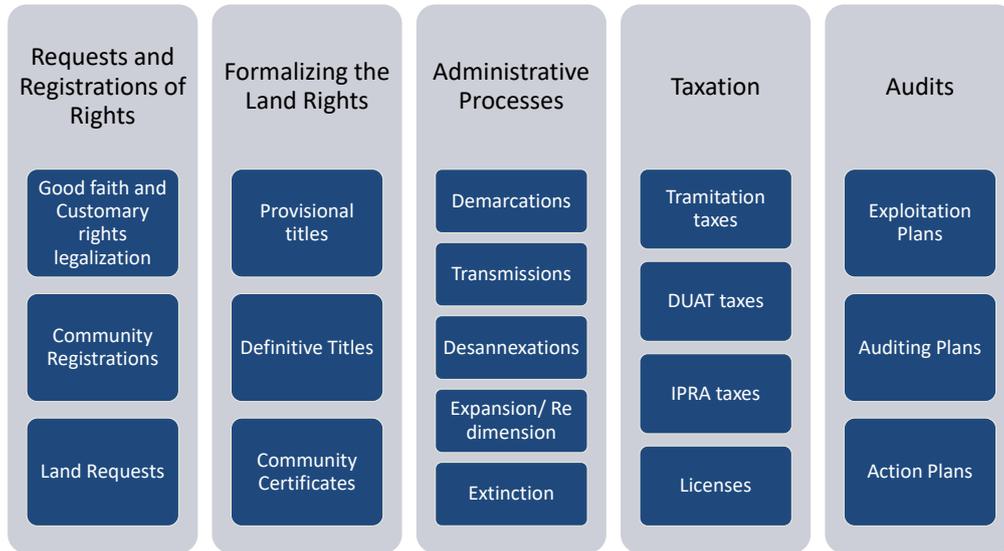


Figure 1: SiGIT current functionality (Balas, 2016b)

Management and Control SubProcesses

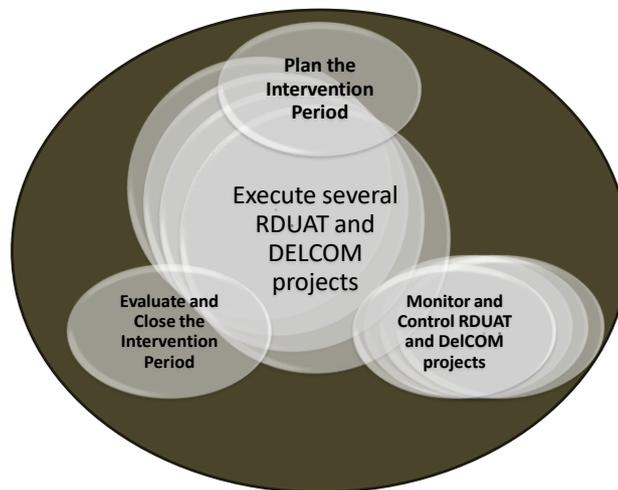


Figure 2: The Management Processes considered for the RDUAT/DelCOM Methodology (Balas, 2016a)

Execution SubProcesses

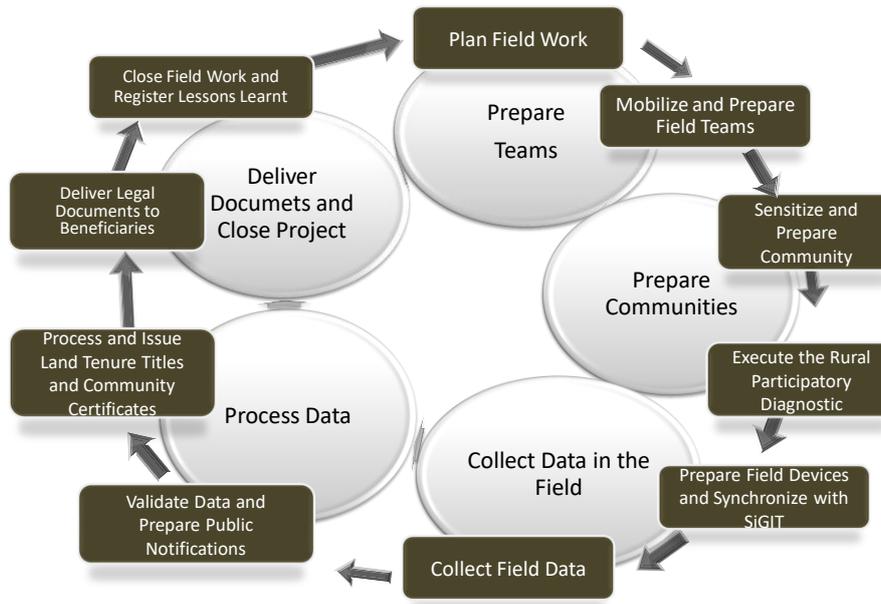


Figure 3: The Execution Processes considered for the FFP RDUAT/DelCOM Methodology (Balas, 2016a)

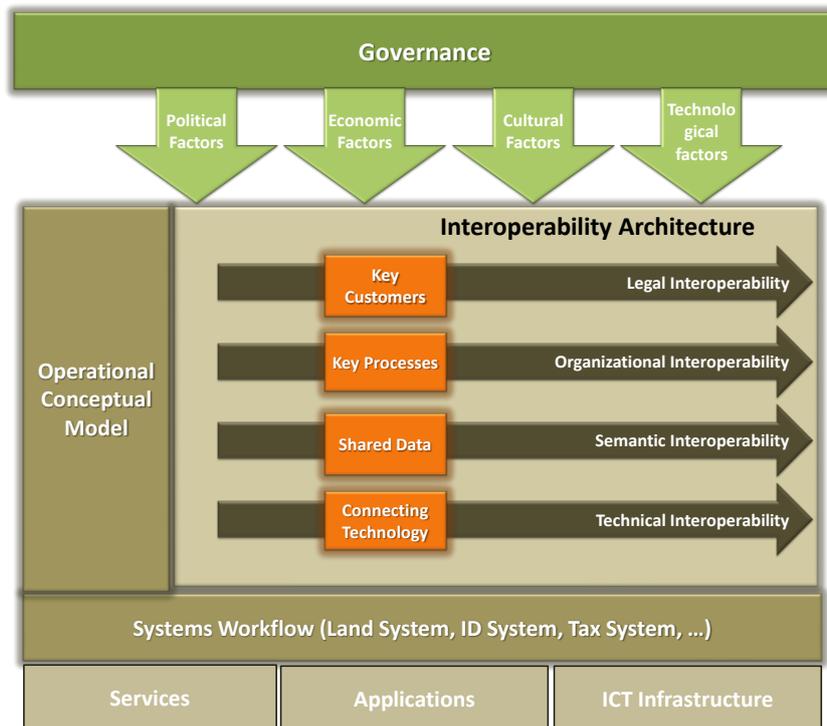


Figure 4: Interoperability Architecture Model

BIOGRAPHICAL NOTES

Marisa Balas is the Operations Director at EXI, a Mozambican company responsible for developing and implementing the Land Information Administration System (LIMS/SiGIT) in Mozambique. She has a Masters degree in Management of ICT and a degree in Business Administration. In the past 5 years she coordinates the team that supports the SiGIT land system at DINAT. She also teaches Project Management and Strategic ICT planning at the University Eduardo Mondlane. Her current interests are related to the improvement of the Fit For Purpose Community Delimitations and Individual Parcels Registration methodology, involving communities in the process of data collection and data maintenance.

Simão Joaquim has a honors degree in Geography by Eduardo Mondlane University, focusing on remote sensing, GIS and land administration. He is currently the National Director of Lands, and previously was the National Director of Lands and Forestry. He was also in charge of Special Economic Areas Service. Currently his areas of interest are related to the systematic registration of the "Terra Segura" program, with focus to enhance field and office work of all stakeholders.

José Almeirim de Carvalho is a Geographic Engineer, graduated in 1982 by Eduardo Mondlane University (Maputo – Mozambique), and with a PhD in geographic information sciences, obtained in 1995 from the University of Paris VII (France). He has performed over

the past 45 years as expert in Geographical Information and in IT at the National Centre for Remote Sensing and Cartography (CENACARTA) and at the National Directorate for Land of Mozambique (DINAT). In addition to having exercised various functions and responsibilities he was also National Director of DINAGECA, the old DINAT, for a period of 5 years, and Deputy National Director of CENACARTA, for 15 years.

João Carrilho is an Environmental Engineer, and MSc. in Remote Sensing. Currently an independent Consultant, advising the National Director of Lands in Mozambique. He coordinated Land projects from 2011 to 2016, implementing systematic individual and community land tenure regularization. He managed rural finance projects from 2006 to 2011 Carrilho served as Vice-Minister of Agriculture and Rural Development from 2000 to 2005. He was the Chairman of the Institute for Rural Development from 1996 to 1999. Carrilho is undergraduate in Civil Engineering and Agricultural Development.

José Murta is currently the CEO of EXI Lda a company that is responsible for the SiGIT (Land Management System) maintenance and associated application and IT services. He also manages the business consulting department at EXI Lda providing these services to help customers in their business transformation efforts using the IS/IT solutions provided by EXI Lda. His current interests are focused on business architecture and enterprise architecture.

Christiaan Lemmen holds a PhD from Delft University, The Netherlands and he is geodetic advisor at Kadaster International. He is visiting researcher at the Faculty of ITC, University of Twente, The Netherlands and chair of the Fit-For-Purpose Land Administration Working Group of FIG Commission 7 on Cadastre and Land Management. He is director of the FIG Bureau OICRF. He is an advisor for the National Director of Land in Mozambique.

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