USAID
FROM THE AMERICAN PEOPLE

EVALUATION, RESEARCH AND COMMUNICATION (ERC)

Mobile Application to Secure Tenure (MAST)

FINAL PROJECT REPORT

NOVEMBER 2016

This document was produced for review by the United States Agency for International Development. It was prepared by Cloudburst Consulting Group, Inc. for the Evaluation, Research, and Communication (ERC) Task Order under the Strengthening Tenure and Resource Rights (STARR) IQC.

Prepared for the United States Agency for International Development, USAID Contract Number AID-OAA-TO-13-00019, Evaluation, Research and Communication (ERC) Task Order under Strengthening Tenure and Resource Rights (STARR) IQC No. AID-OAA-I-12-00030.

Implemented by:

Cloudburst Consulting Group, Inc.
8400 Corporate Drive, Suite 550
Landover, MD 20785-2238

EVALUATION, RESEARCH AND COMMUNICATION (ERC)

Mobile Application to Secure Tenure (MAST)

FINAL PROJECT REPORT

NOVEMBER 2016

CONTENTS

ACRONYMS AND ABBREVIATIONS

BRN	Big Results Now
CCRO	Certificates of Customary Rights of Occupancy
DfID	Department for International Development
DLO	District Land Office
ERC	Evaluation, Research, and Communication
GOT	Government of Tanzania
GPS	Global Positioning System
LAC	Land Adjudication Committee
MAST	Mobile Application to Secure Tenure
MOL	Ministry of Lands, Housing and Human Settlements Development
NGO	Non-Government Organization
NLUPC	National Land Use Planning Commission
NORC	NORC at the University of Chicago
OGC	Open Geospatial Consortium (OGC)
PELUM	Participatory Ecological Land Use Management Tanzania
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
STARR	Strengthening Tenure and Resource Rights
STDM	Social Tenure Domain Model
TAGRODE	Tanzania Grass Roots Oriented Development
TI	Trusted Intermediary
USAID	United States Agency for International Development
USG	United States Government
VC	Village Chairman
VEO	Village Executive Officer
VLA	Village Land Act

1.0 INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

The Mobile Application to Secure Tenure (MAST) pilot project (2014-2016) was originally designed to test a concept: ***can a participatory or crowdsourced approach to capturing land rights information using mobile technology be deployed and used effectively to create an inventory of land rights?*** Over the course of the pilot, the focus of efforts expanded from testing a concept to actually delivering formalized documentation of land rights in collaboration with the Government of Tanzania (GOT).

As the goals of the pilot shifted over the past 15 months, the project worked closely with the District Land Office in Iringa Rural District (DLO), the Iringa Rural District Government, the National Land Use Planning Commission (NLUPC) and the Ministry of Lands, Housing and Human Settlements Development (MOL) to:

- Develop an easy-to-use mobile application that meets the requirements for delivery of Certificates of Customary Rights of Occupancy (CCROs) to villagers; and

- Develop a participatory methodology for securing land rights, that meets the requirements of Tanzania's land laws, provides focused training on women's land rights and engages with villagers – called Trusted Intermediaries - in the land mapping and documentation process.

The pilot grew out of an idea proposed in a paper entitled *"Crowdsourcing Support of Land Administration - a new, collaborative partnership between citizens and land professionals."*[1] This seminal paper presented an innovative approach to addressing the land tenure gap and focused on the possibility of "crowdsourcing" property information by working with local people. It challenged land professionals to re-conceive how land administration services might be managed and delivered. The paper outlined a new citizen-centered collaborative model for land administration that would be more responsive to the needs of the disadvantaged and vulnerable, increase access to land markets, reduce costs associated with formalizing land rights and, as a result, increase security.

The MAST pilot activity was designed to test the hypotheses presented in this paper and to support USAID development objectives, particularly the use of science and technology to resolve development problems. The pilot has provided field-based insights into the following:

1. Citizens' and communities' reaction to and engagement with the approach and its impact on perception of tenure security;

2. The ability of the surveying profession / land professionals to support efforts to crowdsource land rights information in a collaborative manner with citizens;

[1] See RICS:http://www.rics.org/site/scripts/download_info.aspx?downloadID=8083&fileID=10840

3. The characteristics of a good 'Trusted Intermediary' (TI) to support the capture and maintenance of land rights information;

4. Identify what land rights information must be captured to meet the legal requirements of the Government of Tanzania;

5. Test a range of technology tools available and identifying the most affordable and appropriate to support the approach;

6. Establish approaches for sustaining the maintenance and security of land right information after the pilot and expanding its use; and

7. Explore how the results from the pilot can be shared and the lessons and practical applications expanded, replicated and scaled for USAID and others.

The MAST pilot provided an opportunity for USAID, in partnership with the GOT, to design, develop and deliver a new approach to securing land rights in a context where demands for land are rising, conflict over land is wide-spread, and social norms limit the ability of women to exercise their legal rights to land.

1.2 PROJECT CONTEXT

The MAST Pilot originally anticipated conducting three pilots in different countries and environments, with a variety of cultural, legal, land tenure, administrative and professional landscapes, in order to gather as much experience as possible to shape and guide the way of inventorying land rights. Tanzania was selected as the site of the first pilot, and subsequently for the second and third pilots. Through comprehensive stakeholder engagement and review of the country's land administration framework, ERC determined that the objectives of the pilot aligned with the needs of the Government of Tanzania to demarcate and secure rural land rights, to identify methods to help improve the delivery of land administration services to citizens, and to stimulate economic development, particularly by promoting large-scale investment in agriculture.

During the past decade, Tanzania has experienced high rates of economic growth, due in large part to sound economic reforms. As part of its development agenda, Tanzania has encouraged large scale investments in agriculture, both domestic and foreign, recognizing the role that investment in key sectors of the economy can play in fostering domestic growth.

In 2009, a strategy called '*Kilimo Kwanza'*, meaning 'Agriculture First' or "Priority to Agriculture" was designed to attract investment in agriculture and underscored the critical importance of the private sector participating actively in agricultural production (Tenga, W. and Kironde, L. 2012). The Southern Agricultural Growth Corridor of Tanzania (SAGCOT) was launched in 2010 to operationalize Kilimo Kwanza. Subsequently, in 2013, the GOT's Big Results Now (BRN) initiative, which aims to support the improvement of commercial agriculture in partnership with the private sector and smallholder farmers, was also launched. BRN aligns with the Government's Vision 2025 goals of increasing food security and reducing poverty across the country.

However, investments in the agriculture sector have been hampered by weaknesses in the land administration system. Given that the vast majority of claims to property are undocumented, the GOT and investors do not always have a clear understanding of which lands are available for commercial development. Smallholders who lack documented land rights may be more vulnerable to lose land or lose of access to critical resources. For women, social norms often prevent them from fully exercising rights to land they hold under the law. These constraints may limit investments needed to improve agricultural productivity.

Previous land registration projects introduced various methodologies and provided practical field experience for the formalization of property rights under the existing legal framework. These previous interventions often required large upfront investments (i.e. GPS equipment, GIS software and computer investments) and required sustained technical assistance and/or material resources, which were not always available. The results and impact, therefore, have been limited.

MAST was designed to capture land rights information in a manner that is consistent with the requirements of the Village Land Act of 1999, but that can be implemented in a more efficient and cost-effective manner than previous projects. MAST supported decentralized land administration service delivery and thus presented an opportunity to help the GOT provide an efficient and participatory registration processes at the village level.

With GOT involvement and support of the pilot, and with a level of acceptance among stakeholders, USAID decided to focus the pilot's efforts in Tanzania and expanded from work in one village to work in three villages. This changed the focus of the pilot from an exploratory exercise to a more formal test of the technology and the participatory approach that was used in the context of one country with a specific land administration framework. This scale up presented opportunities to build on the work already conducted in Tanzania, but also presented challenges, which are discussed below.

1.3 PILOT LOCATIONS

The MAST pilot operated in two phases: an initial "test" phase, which worked in one village in Iringa Region, and a second "scale" phase, which worked in two additional villages, also in Iringa Region. Iringa falls in the important SAGCOT region, a zone of interest for both the Government of Tanzania and USAID. The three pilot villages were chosen in consultation with the MOL, the NLUPC and the DLO.

The first phase of the MAST pilot took place in a relatively small village, Ilalasimba, which is located in Iringa Rural District of the Iringa Region. Ilalasimba village was chosen for the first "test" phase of the pilot because it is fairly representative of the average Tanzanian village. Most of the economic activities within the village are focused on agriculture. Maize is the predominant crop, and several secondary cash crops are grown by inhabitants (tomatoes, sunflower and tobacco). It has an estimated area of 64.9 sq. km and a small population of 325 households. On average, each household occupies 2 or 3 parcels. Parcel sizes range from 5 to 10 acres and larger holdings are farmed in peripheral areas of the village. In addition, there was not much land-based conflict evident in Ilalasimba: a benefit during a phase when the pilot was focused on testing technology and methodology.

The second phase of the pilot represented a modest scaling effort, in two additional villages in Iringa Region: Itagutwa and Kitayawa.

Itagutwa village is 30 km northeast of Iringa city. It has an area of 75.18 sq. km. and has a population of approximately 1,672 persons, and roughly 441 households. Itagutwa was the largest of the three

villages. On average, each household occupies or farms approximately 3 parcels, resulting in approximately 1,300 parcels in the village. Almost all of the villagers depend on agriculture for their subsistence, with maize, sunflower, beans, and tobacco being the principal crops. The village has a number of pastoralists, but most have settled and pursue farming or are engaged in pastoral farming or herding. There was a very modest amount of land-based conflict in the village.

The final village in which the MAST project worked is Kitayawa. Kitayawa village is 22 km south of Iringa city and is located in the Kilolo District of Iringa, Tanzania. It has an area of 46 square km and a population of approximately 2,118 persons, or roughly 546 households. On average, each household occupies or farms 3 parcels, yielding approximately 1,600 parcels in the village. Like in the other villages, almost all of the villagers depend on agriculture for their subsistence, with maize, sunflower, beans, and tomato being the principal crops however, some crops are produced for national markets. In order to begin the pilot activities, each village needed to have an up-to-date and approved Village Land Use Plan (VLUP), which was acquired and put in place with the help of the NLUPC. Village governance institutions including the Village Council also need to be in place. In all villages, a Land Adjudication Committee (LAC) needed to be formed, and a local registry office needed to be built or renovated in order to provide safe storage for land documents.

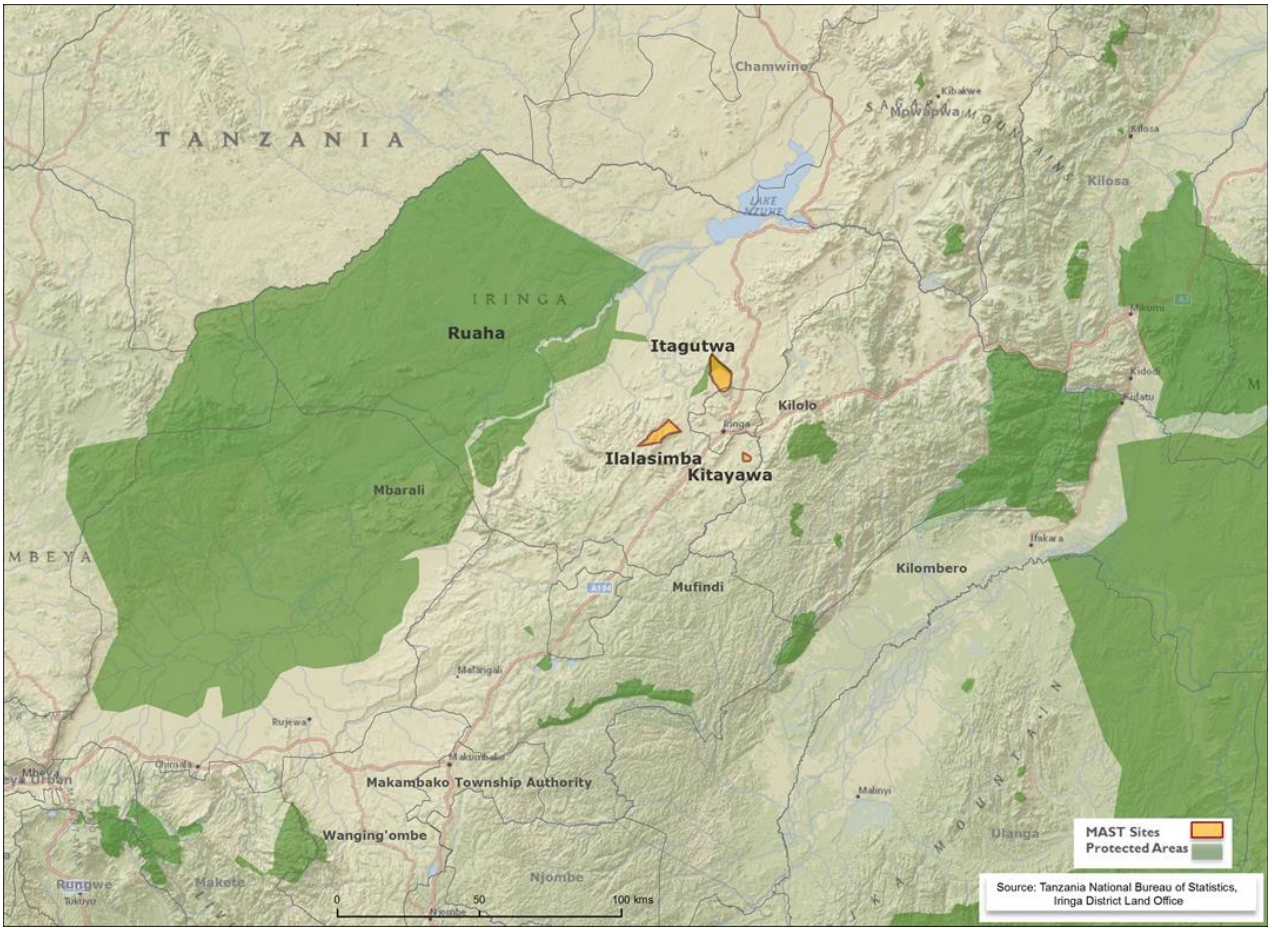

Figure 1.1: Map of Iringa Rural District with Ilalasimba, Itagutwa and Kitayawa highlighted

2.0 METHODOLOGY

The MAST pilot project was implemented in two stages. The first (mobilization) stage was focused on developing and testing a simple-to-use land information system. The land information system consisted of a mobile application that can be used to record and capture property rights information, and a back-end data management infrastructure that imports and stores the information that was recorded in the field. This land information infrastructure was implemented on a cloud-based server and privileges were provided to the GOT in order to give land administration officials the ability to review and process land information and to issue Adjudication Forms and CCROs, which provide legal recognition of property rights. The second (implementation) stage of the project was replicated in each pilot village and was led by ERC and its national implementation partners, CARE International Tanzania (CARE) and its partner Tanzania Grass Roots Oriented Development (TAGRODE). All work was conducted in close collaboration with the Iringa DLO. Implementation involved mobilizing and organizing each village in preparation for adjudication, building awareness of land laws and land rights, and providing technical training on the mobile application in order to build capacity. Once training was complete, the land adjudication process started. The process involved mapping lands and collecting of property and personal information from villagers and then processing and validating this information in order to issue legal documentation of land rights.

2.1 MOBILIZATION STAGE

2.1.1 MOBILE APPLICATION TO SECURE TENURE

The MAST application is an integrated suite of applications that was designed to support the collection and management of land rights information. It consists of a mobile application to capture land rights information in the field, and a back-end land rights data management web infrastructure application that includes tools to manage an inventory of land information. The data management web infrastructure application is housed on a cloud-based server. **Figure 2.1** below provides a conceptual overview of the MAST architecture.

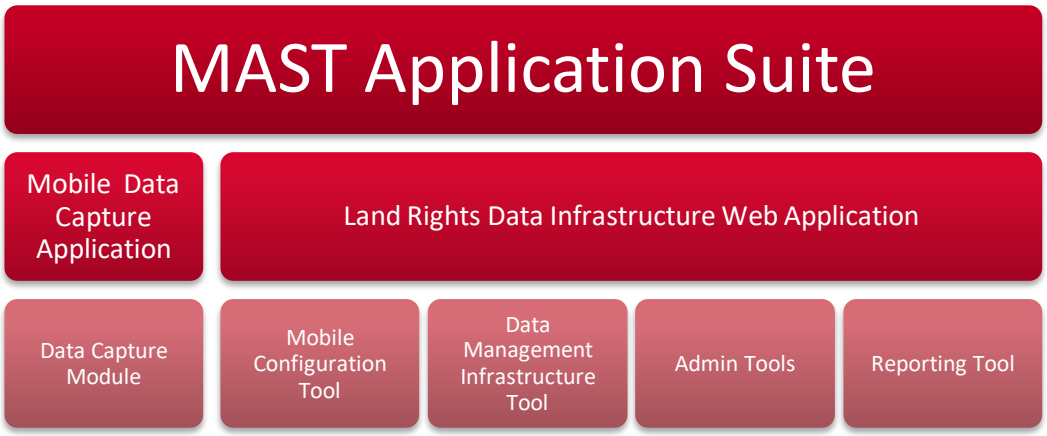

Figure 2.1: MAST Conceptual Architecture

The key component of MAST Framework is an Android-based **Mobile Data Capture Application** that can be used to capture of land rights information (spatial, alphanumeric and multimedia). Data can be collected off-line; users do not need to be connected to the cloud-based server on which data is stored. Rather, data is collected and stored on the users' handheld device, and once the user has internet access, data can be synced and sent back to the server.

The **Land Rights Data Management Web Application** provides the MAST Mobile Data Capture Application with a back-end web application facility to configure the mobile application, manage data collection, and manage land rights information data that has been collected in the field. It has three principle components:

- The ***MAST Administration Tool*** provides functionality to manage users and roles; configure survey projects; configure master attributes for use in projects, and manage base mapping data (i.e. import and configure data layers or layer groups).

- The ***MAST Configuration Tool*** provides functionality to configure the attribute fields that are required for a specific project on a data form template. The configured data template is then downloaded to the MAST mobile application through a web service, which allows for a pre-defined form to be used for data collection.

- The ***Data Management Tool*** enables the import and validation of data that is transferred from a mobile device to the data management web application. It processes and validates data according to predefined rules, facilitates the visualization and editing of data, and allows for the configuration and generation of formal land rights documentation (i.e. Adjudication Form and CCROs).

While the MAST software infrastructure was developed in such a way that it became very Tanzania specific, the underlying framework is quite robust and was designed to be adapted to different cultural, legal, land tenure, administrative and professional landscapes. However, MAST consists on a complex array of open-source software tools and frameworks which makes replication of the software environment difficult for everyday users. Please refer to Annex 1, which outlines key steps, prerequisites and considerations that should be taken into consideration when implementing MAST in different locales.

2.1.2 DATA MODEL AND ATTRIBUTES

MAST provides a flexible data model that was adapted to meet the needs of rural land adjudication in Tanzania and so it was configured to align with the requirements of the Village Land Act of 1999 (VLA). In Tanzania, MAST initially used the Social Tenure Domain Model (STDM)[2] as the basis to configure attributes required for rural land adjudication. However, this model was modified, with the help of the MOL and the District Land Office, to mirror the contents of legal documents that are normally needed to apply for CCROs (i.e. specific tenure type). The primary documents utilized to identify and define the MAST attributes were the Adjudication Form and the CCRO. For each spatial unit (parcel in the case of Tanzania), the following attributes were captured:

General
Person Type
Number of signatory(s)
Witness 1
Witness 2

Property
Existing Use
Proposed Use
Right of Way/Other Use
Land Type
Neighbor North
Neighbor South
Neighbor East
Neighbor West

Person
First Name
Last Name
Middle Name
Gender
Mobile No.
Occupation
Education Level
Age
Marital Status
Owner
Administrator
Citizenship
Resident
Institution name
Address
Phone Number

Type of Tenure
Type of Tenure (single occupancy, multiple occupancy (joint), multiple occupancy (in common), tenancy in probate, and tenancy with (guardian or administrator)
Occupancy Type/Right (Certificate of Customary Rights of Occupancy, Derivative Right)
Resident

[2] The STDM extends the Land Administration Domain Model (LADM) and provides a flexible approach to land information infrastructures. STDM also supports the UN-Habitat "continuum of land rights" approach, which advocates documenting a range of informal rights rather than the formal rights alone (UN-HABITAT, 2008). The STDM has at its core a central relationship between parties (persons), social tenure relationship (right) and spatial unit.

2.2 IMPLEMENTATION STAGE

This stage focused on implementing the MAST software application suite and at the same time, developing and deploying a participatory framework to effectively engage citizens in project processes. The project created local level capacity building programs that built awareness of the provisions of Tanzania's land laws, land rights generally, and women's land rights specifically. Village leaders were trained in land laws and rights, while local youth were trained to capture land rights information using mobile phones. The implementation stage involved the following nine steps:

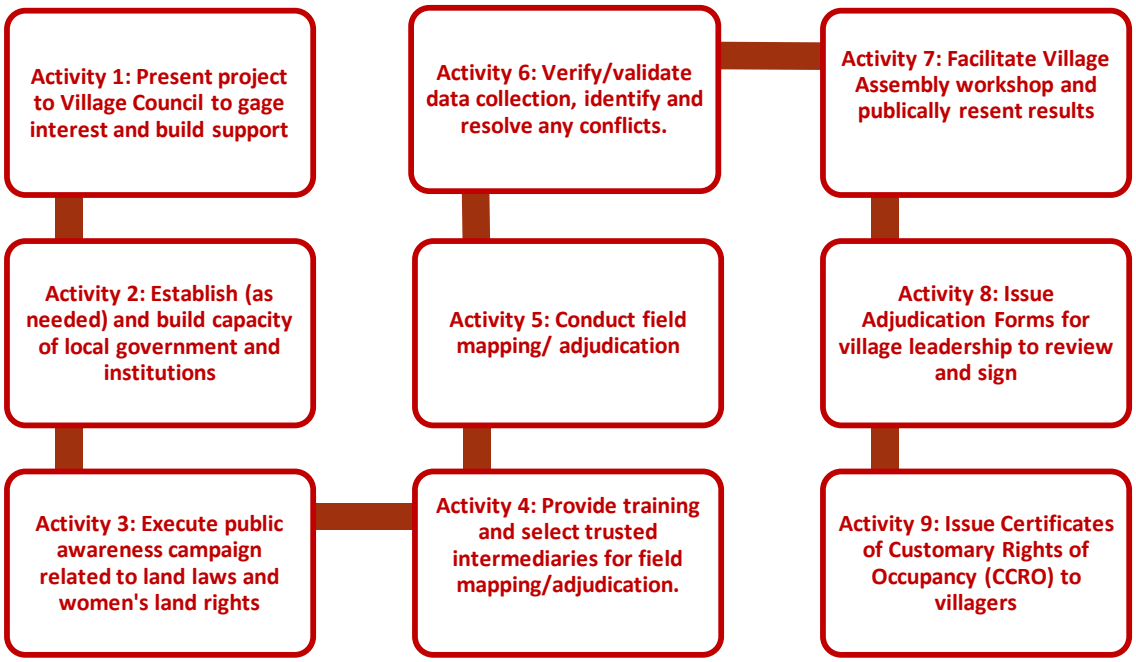

Figure 2.3: Implementation Steps

Implementation activities were broken into four main phases: Outreach and Training; Field Adjudication and Data Processing; Data Verification and Validation; and Printing and Presentation of Land Rights Documents. These implementation steps outlined below were followed in all three pilot villages.

2.2.1 OUTREACH AND TRAINING

The project was initiated and coordinated at the District Level, through discussions with the District Land Office and the District Executive Director. Through a series of discussions with district leaders the pilot identified required steps for implementation, potential sites for implementation, and how to engage with DLO staff.

Once target villages were identified (in coordination with USAID and the DLO), the next step was outreach to the Village Council (VC) to gauge local interest in and support for the project. If the Village Council provided permission to launch the project, discussions then focused on the importance of community participation. The project explained that the desired end result of the pilot would be the systematic adjudication of all parcels within the village, which would result in all villagers being granted CCROs. The pilot team explained that the costs for adjudication would be paid by the project. This coordination with village leaders paved the way for further outreach and training.

The pilot provided training to members of the Village Council. The focus of this training was on land laws, land rights, and the land adjudication process. Training sessions were conducted by CARE and TAGRODE, in collaboration with DLO officials. Training materials were collected from the MOL, Haki Ardhi, and the Participatory Ecological Land Use Management Tanzania (PELUM) project. All training materials were provided in Swahili.[3] The logic behind providing training to the Village Council was to have leaders serve as key stakeholders in the project and enable them to speak authoritatively about the land laws, and associated rights and processes.

Following the training of the VC, a village-level workshop was held to provide information and improve awareness of land laws and the adjudication process to the wider community. This workshop provided a forum to explain and promote a participatory adjudication process within the village. During the workshop, the village leaders identified members for the Land Adjudication Committees. A separate Village Assembly workshop was held to confirm the members of the LAC and to identify persons who would serve as Trusted Intermediaries: youth who could be trained to use the MAST mobile application to support land adjudication.

Once village-level workshops were completed, the project conducted hamlet-level outreach sessions in each village. Hamlet-level outreach sessions were initiated by TAGRODE and facilitated by the DLO. DLO staff facilitated training of land laws at the hamlet level, while TAGRODE prepared villagers for the process by presenting maps to hamlet leaders, obtaining descriptions of lands occupied by villagers and discussing logistics/requirements for mapping. The execution of hamlet level training was an important component in the project, as it was found to be most appropriate method of disseminating information in the village, and allowed for greater participation from female members.

2.2.2 FIELD ADJUDICATION AND DATA PROCESSING

The adjudication process started with training on the use of the MAST technology. In 2015, the MAST project team started by training DLO staff and District government staff on MAST. Training was provided in a workshop format, which included lectures, presentations and step-by-step demonstration of the MAST tools. Hands-on training of the MAST Mobile Data Capture Application was also provided at a park in Iringa Town. Data that was captured on the mobile application was then uploaded to the MAST Data Management Infrastructure, and an overview of how data is synchronized and managed was provided to participants.

At the end of this initial training course, the DLO designated two persons to work with the MAST implementation team at the village level. Technology training at the village level focused on local youth, called trusted intermediaries (TIs). In addition to training on the MAST technologies, specifically the MAST Mobile Data Capture Application, the TIs received training on the land laws and how to conduct the adjudication process. A Field Training Manual was used to guide participants in the key steps required for collecting the data for adjudication. The training culminated in the selection of smaller set of young women and men who would worked as Tis. The selection of TIs was based on their execution of field tests and an assessment of their performance by the MAST implementation team. TIs were allocated a small daily per diem for their work.

3 Training guide book for Village Land Act of 1999; Land Act of 1999 (Swahili version); Village Land Act No. 5 of 1999 (Swahili Version); Village Land Policy of 2002; and Land Regulation, Land rights for women, conflict resolution, and marriage law.

The formal adjudication process consists of mapping parcel boundaries and collecting needed information from villagers. To ensure good participation in the process, TAGRODE engaged with hamlet leaders and villagers, reviewing hard copy maps that displayed hamlet boundaries placed on top of satellite images. These maps were used to gather information about the general types of land holdings in each hamlet. This engagement helped bring the adjudication process to life for villagers, and at the same time, provided an important reference for field mapping. TAGRODE worked with hamlet leaders to identify dates for mapping by TIs. The MAST implementation team and village leaders worked to ensure that as many villagers as possible would be available on those dates to facilitate the adjudication process.

Figure 2.4: TAGRODE overseeing the capture of land rights information by Trusted Intermediaries in Ilalasimba.

After TIs were trained, they were deployed to capture the parcel boundaries in their village using MAST. TIs captured data by interviewing villagers and walking the boundaries of their parcels. Adjudication was conducted alongside members of the Land Adjudication Committee. The MAST Mobile Data Capture Application facilitated the capture of information by Tis by integrating advanced geospatial and visualization tools along with data entry forms.

For each parcel, information about the person-to-land relationship was captured. TIs captured general property information, personal information and occupants' current tenure relationship, as well as information required for printing Adjudication Forms and CCROs (including photos of parcel owners). Data that was captured by TIs was verified (see more details in section below) by Land Adjudication Committee members, who are present throughout the field adjudication process. Data was also verified in the field by TAGRODE and/or DLO staff, before being marked as complete. Figure 2.5 below outlines the general steps of the adjudication process. Once spatial data was captured, and before personal information was captured, parcel owners were asked if the maps captured on the device reflected on the ground reality as they understood it.

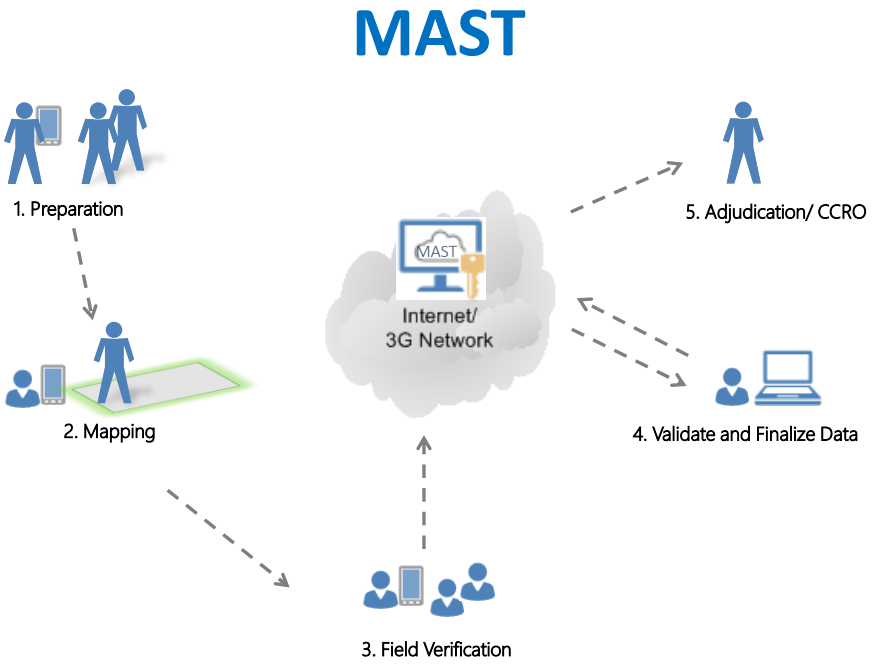

Figure 2.5: Village-Level Adjudication Process using MAST

2.2.3 DATA VERIFICATION AND VALIDATION

Data verification and validation protocols were implemented for each village. Data verification occurred in the field, and focused on reviewing spatial data collected by TIs to determine whether units coincided with the physical landscape features, and that attributes concerning persons and tenure were complete. If data records were confirmed to be complete, data records were marked as "complete" in the mobile device, and then uploaded to the MAST Data Management Infrastructure at the end of the day, when the project team returned to Iringa Town and was able to connect to the internet.

Once data was synced to the Data Management Infrastructure, DLO staff would validate it. The most critical step in the process was editing and correcting data, which usually required manipulations such as the movement of vertexes. Approved data would be used to finalize land records; rejected data would need to be revised and re-reviewed. Once data was validated, the MAST Data Management Infrastructure was used to generate and print Adjudication Forms and CCROs.

Key Lesson: Data validation and editing was the most labor intensive and time consuming part of the MAST adjudication exercise. Human resource requirements and data validation workflow processes should be carefully evaluated when implementing future projects that use the MAST technology.

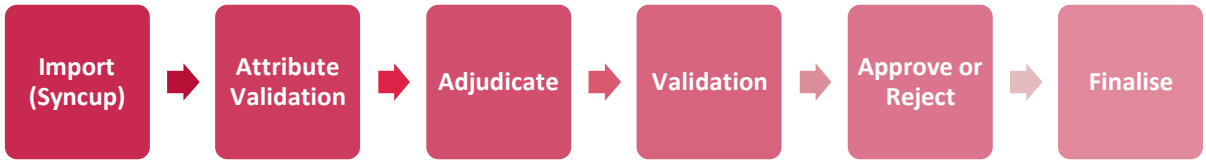

Figure 2.6: Stages of land record validation

2.2.4 PRINTING AND PRESENTATION OF LAND RIGHTS DOCUMENTS

Once mapping was completed and data was verified by the DLO, results were presented to village leaders and to villagers at a workshop. This allowed villagers and the MAST project team to discuss the process and any concerns related to the adjudication process.

Figure 2.7: TAGRODE field coordinator providing brief on MAST project in general

These workshops also served another function: they helped the project team understand how villagers perceived the project – the benefits and the costs – and it ensured greater transparency around the important public service of delivering CCROs. Based on a limited number of informal interviews conducted during these events, citizens reported the following benefits from the project: a better understanding of the legal framework related to land (rights and obligations); improved sense of security of tenure, particularly for women and children; a reduction in land conflicts; a sense that land was less likely to be provided to non-residents; and, the introduction of a more formalized structure for the selling of lands by villagers. In each village the project prepared a poster was prepared. The poster contains a map that identifies the lands that were mapped.

DLO staff then used MAST to generate and print Adjudication Forms. The Adjudication Forms were delivered to members of each Village Council for review and signature. DLO staff were present during this process to note any corrections to data on each of the Adjudication Forms. This review of the Adjudication Forms serves as the final verification of land rights data at the village, and where errors were encountered, DLO staff made manual corrections to the forms and then made corrections in the MAST Data Management Infrastructure application. The corrected final forms were taken back to each of the villages for final signature. Once Adjudication Forms were verified, they were signed by the Village Chairman/woman and parcel owners (and/or property administrators). Once the Adjudication Forms

were signed and finalized at the village, the formal status of the spatial unit in the MAST Data Infrastructure was changed to "adjudicated."

The execution of the Adjudication Forms allowed the District Land Officials to proceed to the next stage: printing CCROs. Draft CCROs were printed and reviewed against information in the MAST Data Management Infrastructure. This preliminary verification step was introduced to reduce the potential for error during printing and to reduce costs. The GOT requires that CCROs to be printed on official, government-issued "crested" paper, which is quite costly. Once validated, CCROs were then printed in triplicate on crested paper and dispatched and delivered to the village for signature.

After draft CCROs were delivered to villages, the information was once again verified by village leaders before being signed by villagers. Again, the signature of CCROs required close coordination with village leaders and oversight by the MAST Project Team. After the appropriate signatures were collected at the village, the CCROs were returned to the DLO where they were signed by the Land Officer. The signing of CCROs by District Land Officer was quite labor intensive. The final signature required a manual review of data in which the Land Officer carefully verified all information on the CCRO against the information on the executed Adjudication Form.

Once CCROs were signed by the Land Officer, they were once again returned to the village and distributed to parcel owners (and/or property administrators). One laminated copy was given to the parcel owner, one copy was filed in the Village Land Registry and the final copy remains at the DLO and was filed in the District Registry.

3.0 TRANSITION TO LAND TENURE ASSISTANCE PROGRAM

As part of the closure of the MAST pilot, ERC was asked to transition its pilot activities to the USAID Feed the Future Land Tenure Assistance (LTA) Activity. Efficiently transitioning the MAST project from the pilot environment to the LTA project was very important as LTA will use and adjust the MAST software application suite in its programmed activities.

To facilitate an efficient transition, ERC implemented a two-month transition period from July 1 to August 31, 2016. Ongoing project activities during this period were focused on the final data validation, printing, signing and delivering of CCROs for Kitayawa village (Pilot 3). Lead management during this period was implemented by the Feed the Future Land Tenure Assistance (LTA) Activity, with support provided by CARE and its local implementing partner, TAGRODE.

A tentative timeline for the implementation of project activities was established during ERC's field visit in late May/early June 2016. This timeline is provided below identifying responsibilities:

Table 3.1: Finalization of MAST Pilot Project, Kitayawa

KITAYAWA	**REVISED MILESTONE DATE**	**Column 1: ERC**	**Column 2: LTA**	**Column 3: CARE/ TAGRODE**
Results and Rights Document				
Adjudication Forms	June 3, 2016	√	--	√
Printing of CCROs	July 1, 2016	√	--	√
Registration of CCROs	July 15, 2016	--	√	√
Dispatching to Village	July 15, 2016	--	√	√
Signature at Village	July 29, 2016	--	√	√
Finalization at DLO	August 19, 2016	--	√	√
Village Assembly Workshop	August 26, 2016	--	√	√

USAID requested that ERC and LTA clearly define roles and responsibilities for key stakeholders to ensure a smooth continuation of activities associated with USAID-sponsored land adjudication in Tanzania. The agreed upon roles and responsibilities are outlined below:

- LTA assumed management and oversight of all of the remaining MAST pilot activities, including ensuring that adequate staff were assigned by the DLO to finalize technical and administrative tasks outlined in Column 2 in Table 3.1 above;

- LTA coordinated day-to-day oversight responsibilities with TAGRODE. TAGRODE continued to provide necessary financial and logistical support to DLO for all activities outlined in Table 3.1 (Column 3);

- TAGRODE was responsible for maintenance of ERC equipment that was being used to finalize the delivery of CCROs. This included: two mobile phones, one router and one power pack. TAGRODE provided these to CARE for shipment to Cloudburst;

- ERC finalized a property disposition plan and submitted it to the USAID Contracting Officer; and

- CARE coordinated all reporting and close out activities with TAGRODE, including the oversight of activities, logistical and transport support and the financial disbursement of required per diems to the DLO.

In addition to project management responsibilities, the transition process sought to transition specific technical resources to LTA and USAID that were needed to facilitate a complete transition of the MAST pilot project to LTA project. These included hardware, software and other special resources. These items and executed actions are summarized below:

- **Source Code to MAST Software:** Final MAST Source Code was uploaded to GitHub. MAST I (used for Ilalasimba) was uploaded on August 5, 2015. MAST II (used for Itagutwa and Kitayawa) was uploaded on March 30, 2016 (https://github.com/MASTUSAID/).

- **Access to MAST DMI:** The super user access to the MAST (web) Data Management Infrastructure was provided to LTA.

- **APKs for MAST V2 – MAST Pilots:** ERC provided all of the APK files used during the MAST pilot to USAID and LTA. ERC noted that the APK files provided were for project-specific use, and have purposely not been uploaded to GitHub or shared with a larger audience, as the use of the APKs by unauthorized users, could compromise the MAST software and pilot data.

- **MAST Technical Documentation:** ERC has uploaded reformatted technical documentation for MAST Version 2.1 to GitHub (as PDF):
    - MAST2_Technical Document_Phase2
    - MAST2_deployment_environment_setup_guide_Phase2
    - MAST2_development_environment_installation_setup_guide_Phase2
    - MAST2 Mobile Application_User Manual_Phase 2
    - MAST2 Web Application_User Manual_Phase 2

  Additionally, ERC has provided LTA with Swahili field training manuals. These manuals have also been provided to the DLO and were used for training of Trusted Intermediaries

- MAST Village Level Training Manuals Part 1 and 2 (Swahili)

All documents have also been uploaded at: (https://github.com/MASTUSAID/DOCS2/)

- **Amazon Cloud Server/ Hosting**: In March, 2016, based on a request from the USAID COR, user accounts with administrator privileges for the MAST Amazon Cloud Server account were created and provided to USAID. The transfer to LTA of the technical and financial control of the Amazon AWS Server used to host the MAST DMI took place on June 17, 2016.

- **Hardware:** The hardware equipment that was acquired and utilized under the MAST project included a server, a printer, 12 mobile phones, 2 tablets, 2 routers, 6 battery packs and other ancillary equipment that includes cords, USB charger adapters, etc. While most of the hardware was returned to the ERC for use in other activities, the server and battery packs were provided to the DLO to support additional land administration activities. ERC cataloged and transferred equipment to the DLO on July 30, 2016.

- **Technical Software Requirements:** LTA made several early technical requests to ERC for information concerning the development of MAST software. ERC provided template reports that were included in MAST to LTA for their use in their program. Copies of these template reports were provided on June 30, 2016.

- **Provision of Final Data Sets to DLO:** Based on discussions with the DLO, in conjunction with USAID/Tanzania, and based primarily on the fact that the GOT does not have written guidelines for the protection of land rights and personal information, ERC determined that the data from the MAST pilots should be provided to the DLO in a useable format and kept on a secure server. ERC exported the final data set from MAST in a Personal Geodatabase (PGDB). The PGDB was provided on August 15, 2016 and consisted of parcel shapefile and ancillary tables for Ilalasimba and Itagutwa and Kitayawa.

- **Extending Data Access to MAST:** In addition to provision of the final datasets, USAID requested that direct access to MAST database be provided to users. USAID requested that ERC explore providing direct connection through a GIS client (i.e. QGIS) and also provide a Virtual Machine for MAST. On June 30, 2016, ERC provided USAID a series of documents describing the procedure for connecting to the MAST database via QGIS. In August, 2016, ERC established a virtual machine package by using the OSGEO software. ERC provided the package file to the USAID, along with instructions needed to access the package or MAST server and components.

4.0 RESULTS

The MAST pilot project was designed, in part, to determine whether a process could be developed that would use a crowd sourced approach to capturing land rights information using mobile technology. The pilot then evolved to also test if this information, once gathered, could be used by the GOT to issue formal documentation of land rights, particularly CCROs.

One of the main results from the pilot is the mapping of parcels and collection of geospatial and personal/tenure information on a mass scale and in a systematic manner. A second critical result from the pilot is the issuance and delivery of legal land rights documentation (CCROs), again in a systematic manner. We discuss each set of results (to date) below.

4.1 MAPPING RESULTS

The mapping effort and spatial data generated from the MAST project in Ilalasimba and in Itagutwa are presented by in the tables below.

4.1.1 SPATIAL AND PERSONAL DATA CAPTURE

In the first pilot village, Ilalasimba, data capture and field adjudication took place over a three-week period and resulted in the capture of nine hundred and ten (910) parcels. This represents an average of 6 parcels per day by each TI, or 55 parcels per day in total.

Table 4.1 Ilalasimba: Number of Parcels, by Hamlet

Hamlet	# of parcels	% of total	Average size of Parcel (ha)	Total Area Mapped (ha)
SONGAMBELE	162	18%	1.7	275.7
IPANGANI	112	12%	1.6	178.1
ILALASIMBA	245	27%	0.7	173.8
KALANGALI	146	16%	1.1	164.2
IGUNGANDEMBWE	245	27%	1.7	413.6
Total	**910**	**100%**	**1.3**	**1205.3**

In the second pilot village, Itagutwa, data capture and field adjudication took place over a five-week period and resulted in the capture of 1139 parcels as of May 2016. This represents an average of 3.9 parcels per day by each of the 11 TIs, or an average of 39 parcels per day in total.

Table 4.2 Itagutwa: Number of Parcel, by Hamlet

Hamlet Name	# of parcels	% of total	Average size of Parcel (ha)	Total Area Mapped (ha)
MAPULULU	328	28.80%	1.7	565.64
ITAGUTWA	428	37.58%	1.3	550.73
MLENGE	120	10.54%	3.5	423.51
KIPENGELE	263	23.09%	0.9	246.53
Total	**1139**	**100.00%**	**1.6**	**1786.4**

In the third pilot village, Kitayawa the average mapping resulted in the capture of 1878 parcels in a four-week period. This represents an average of 6 parcels per day by each of 12 TIs, or an average of 72 parcels per day in total.

Table 4.3 Kitayawa: Number of Parcel, by Hamlet

Hamlet Name	# of parcels	% of total	Average size of Parcel (ha)	Total Area Mapped (ha)
IDOTWE	186	9.86	1.35	251.61
IGULA_A	65	3.45	0.41	26.33
IGULA_B	157	8.32	1.22	190.91
LUSAULA	216	11.45	2.79	601.81
MADUKANI	302	16.01	0.68	204.30
MBOTE	313	16.60	1.55	486.08
MSEKE_A	185	9.81	0.99	182.63
MSEKE_B	73	3.87	2.13	155.27
SEKUSE	226	11.98	1.53	346.50
UNYANYE	163	8.64	2.62	427.50
Total	**1886**	**100.00**	**1.5**	**2872.94**

TIs from Ilalasimba helped to train TIs in Itagutwa and TIs from Itagutwa helped to train TIs in Kitayawa. This type of training model helped save costs while also building inter-community trust and reinforcing to new TIs that they did not have to be surveying professionals to learn how to map.

4.1.2 LAND RIGHTS DOCUMENTS

In the first pilot village, Ilalasimba, 910 parcels were mapped and 910 Certificates of Customary Rights of Occupancy (CCRO) were issued to villagers. In Itagutwa, over 1139 parcels were mapped. Of these, 1,126 land holders were issued CCROs.[4] Data on CCRO issuance for Kitayawa was not available at the time of this report, however, a general land holding classification is provided in Table 4.6 for the 1,886

[4] It is important to note that the difference between the number of parcels mapped for Itagutwa and the number of CCROs issued was due to cancelation of 13 parcels by Village Council during the data verification and validation process in the village. Those parcels that were cancelled were either duplicates or were cancelled as a result of an automatic reassignment process that cancels one parcel and creates a new record.

parcels that have been mapped in that village[5]. Initial evidence suggested that MAST had a significant impact on women's land rights in the villages in which it worked. In all three pilot villages, men were originally opposed to the idea of women owning land and receiving CCROs. However, as the numbers below show, through education, training, and outreach, the project achieved parity between land registrations for women and men. This is a critical outcome.

Table 4.4: Number of Land Rights Documents Issued, by Tenure, Ilalasimba

Type of Tenure	# of Land Holdings by Tenure Type	% of land Holdings by Tenure Type
Single occupancy/ male	447	49%
Single Occupancy/ female	278	31%
Joint Tenancy/ Male & Female	28	3%
Tenancy in Common	136	15%
Institution	10	1%
Tenancy in Common (probate)	11	1%
Total	**910**	**100%**

Table 4.5: Number of Land Rights Documents Issued, by Tenure, Itagutwa

Tenure Type	Holding by Tenure by Tenure Type	% of land Holdings by Tenure Type
Single occupancy/ male	231	20.52%
Single Occupancy/ female	373	33.13%
Joint Tenancy/ Male & Female	359	31.88%
Joint Tenancy/ Male & Male	3	0.27%
Joint Tenancy/ Female & Female	7	0.62%
Tenancy in Common	48	4.26%
Institution	16	1.42%
Tenancy in Common (probate)	91	8.08%
Guardian(Minor)	10	0.89%
Total	**1126**	**100%**

[5]Of the 1886 parcels that were mapped for Kitayawa during the MAST pilot, CCROs were not processed for 34 parcels/properties. Decisions not to process these land records, which amount to less than 2 percent of the total, were taken jointly by the DLO and Village Leaders (Chairman, VEO and Adjudication Committee), primarily due to existing disputes with neighbors or family members that could not be resolved during the MAST adjudication process.

Table 4.6: Number of Land Holdings, by Tenure, Kitayawa

Tenure Type	Holding by Tenure, by Tenure Type	% of land Holdings by Tenure Type
Single occupancy/ male	501	26.56
Single Occupancy/ female	423	22.43
Joint Tenancy/ Male & Female	382	20.25
Joint Tenancy/ Male & Male	10	0.53
Joint Tenancy/ Female & Female	7	0.37
Tenancy in Common	79	4.19
Institution	15	0.80
Tenancy in Common (probate)	466	24.71
Guardian(Minor)	3	0.16
Total	**1886**	**100.00**

4.2 Project Timeline

Program Stage/Tasks	2014												2015												2016											
Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
MOBILIZATION																																				
Initiate project	■	■	■	■	■																															
Develop technical solutions				■	■	■	■	■	■	■																										
IMPLEMENTATION																																				
Pilot #1: Ilalasimba																																				
Outreach and Training													■	■																						
Field Adjudication & Data Processing															■																					
Data Verification and Validation																■	■	■																		
Print/Process of Land Rights Documents																	■	■	■	■	■	■	■													
Pilot #2: Itagutwa																																				
Outreach and Training																						■	■													
Field Adjudication & Data Processing																							■	■												
Data Verification and Validation																								■	■	■	■	■								
Print/Process of Land Rights Documents																										■	■	■	■	■						
Pilot #2: Kitayawa																																				
Outreach and Training																										■										
Field Adjudication & Data Processing																											■	■								
Data Verification and Validation																													■							
Print/Process of Land Rights Documents																														■	■	■				
Transition to LTA																																				
Close Out Activities/ Transfer of Technical Resources																																	■	■		

5.0 DISCUSSION

The MAST pilot project faced a number of challenges from inception to final implementation. In this final section, general observations and key lessons learned are presented. These observations are grouped into the following six thematic categories:

1. National Level
2. District Level
3. Village Level
4. Mapping/Technology
5. Land Use
6. General Issues and Sustainability Concerns

These observations can inform the development of future implementations of MAST in rural Tanzania and in other locations. The following observations were shared during a lessons learned workshop that was held in Dar-es-Salaam on June 3, 2016.

NATIONAL LEVEL

Early stakeholder outreach helped to inform the design of the MAST pilot program. The project used an extensive stakeholder outreach strategy to collect information from a variety of NGOs, donors and government agencies regarding the land administration framework in Tanzania. Stakeholder engagement helped to inform project design by highlighting pitfalls associated with previous land administration programs. This early engagement facilitated a detailed understanding of the rural development context as well as local land laws and associated rights.

Government engagement was important for integrating MAST into rural adjudication processes. The primary focus of early meetings with the GOT was to determine whether the generalized boundary mapping approach proposed by utilization and testing of mobile technologies was consistent with the requirements of the land laws. The formalization of land rights in Tanzania requires government to exercise its authority for issuing rural land rights documentation. The MOL provided an authoritative interpretation of land laws, helped with key legal definitions and was particularly important for integrating legal requirements into the MAST software.

Partnering with government at the operational level facilitated implementation at the district and local levels. While senior MOL officials were generally supportive of the MAST pilot, a particularly helpful working relationship with the Ministry was forged at the operational level. MOL Land Officers worked collaboratively with MAST project staff in the field to provide introductions to district officials, assisted in the selection of pilot villages based on defined criteria, and helped bridge an important gap with beneficiaries, both at the district and village levels.

Lack of funding inhibits a stronger partnership with Ministry. The lack of funding or financial support for rural adjudication programs, however, inhibits the development of a more robust partnership with the Ministry. Despite a well-defined legal framework that seeks to facilitate more transparent and efficient land administration, a lack of funding means that the mandate of the Land Office at the MOL remains weak. In the absence of adequate funding, the Ministry's capacity to deliver land administration services at large scale may be challenged.

DISTRICT LEVEL

District staff brought a sufficient level of expertise in surveying and mapping. Systematic land regularization or adjudication programs, like the one implemented under the MAST pilot, requires a high level of technical expertise in demarcating lands, digitizing and creating maps, and managing land data. The MAST pilot benefited from the DLO's experience and expertise in this regard. The DLO staff had no difficulties in understanding MAST, utilizing the MAST technologies and/or adapting them to rural adjudication processes.

Implementation activities benefited from active supervision by our implementing partners. CARE International, and its implementing partner, TAGRODE, provided technical support and forged a working relationship with the DLO for the implementation of MAST. Active engagement by CARE and TAGRODE was necessary to ensure that project activities were being implemented according to established schedules. However, the need for active oversight and support to the DLO during this pilot placed additional pressures on project resources. It also raises some concerns related to scaling-up systematic adjudication programs and ensuring the sustainability of this effort.

Cumbersome procedures defined in the VLA place pressure on limited resources at the DLO. Despite having experience in implementing rural adjudication processes, the DLO processes for implementation are quite rigid. This means that the DLO follows very prescriptive procedures, such as being present to witness the signing, registration and dispatching of CCROs to villages. As a result, these seemingly simple procedures required the full attention of the District's Senior Land Officer, creating additional stresses on the DLO, on the project timeline and on project resources. These procedures are very time consuming, especially when performed by a single person. As a result, while parcels were mapped quite quickly, actual data verification, adjudication and processing of final land rights documents took substantially more time than anticipated. It would be helpful to identify opportunities to streamline these procedures.

Expectations and roles need to be clarified and aligned. Although the project team developed a strong and collaborative relationship with the DLO it was necessary to take time to clarify project roles and responsibilities and the responsibilities of the DLO. For example, the project was not aware, that after the delivery ceremony of CCROs in Ilalasimba, the DLO had not established an expedited timeline to sign and deliver CCROs back to the village. As a result, the delivery of documents was delayed by several months. The DLO expected that costs associated with this work would be assumed by the project, while the project assumed that these tasks would be undertaken by the DLO as a part of their normal business operations. To overcome this problem, the project entered into a Memorandum of Understanding with the DLO to clearly define roles and responsibilities, to expedite the timeline for processing Adjudication Forms and CCROs for Itagutwa and Kitayawa, and to clarify payment of extra duty per diems for some project work.

Lack of funding and technical resources limits the DLO's land administration capacity. Especially in pilot villages 2 and 3, the MAST project found that DLO had limited capacity to address project demands while also addressing other regular office demands. The capacity of the DLO is directly tied to the limited financial resources that are allocated by PMO-RALG to the district for implementation or support of adjudication programs. Seemingly routine land administration work executed under MAST, such as printing and processing of CCROs, required additional financial (extra-duty per diems) and logistical (transportation) support.

VILLAGE LEVEL

Regular and active engagement with community leaders helped to improve project planning and create realistic timelines. The MAST project engaged village leaders to establish buy-in to the project, and collect information regarding the village, local population and economic activities. This was done through culturally appropriate engagement methods (for example, having local staff sit with and listen to village leaders) prior to initiating project activities. The information that was gathered helped MAST improve project planning and address, at an early stage, logistical challenges that could impede implementation – i.e. land disputes, understanding the number of persons not currently residing in village, villagers' availability in relation to planting or rainy season.

Prioritizing hyper-local advocacy and training was key to securing and protecting land rights. While initial outreach and training efforts in Ilalasimba were provided at the village level, hamlet-level training proved particularly effective. Early on, the MAST team noticed that few women attended and were vocal during village-level meetings. Therefore, the project decided to emphasize hamlet-level outreach efforts in order to extend land rights trainings to more villagers, particularly women, and to build household-level buy-in for the mapping process. This hyper-local approach resulted in increased knowledge and a deeper understanding of land laws and land rights in each of the pilot villages. Hamlet-level outreach and training took place before the start of land mapping. Much of the success of the MAST program may be due to villager-level buy-in that resulted from this implementation activity.

The Trusted Intermediary model proved effective. The process of engaging villagers in land rights documentation has proven effective, and TIs proved themselves to be capable, efficient, and reliable para-surveyors. The rural land adjudication process requires knowledge of the local environment and land holdings, and benefited from the TI's institutional and physical knowledge of their village. As a result, entire villages were mapped in a matter of 3-4 weeks; a stark improvement over prior tilting efforts. Having fellow villagers conduct the mapping also helped to build trust and willingness among other villagers to participate in the project. TIs essentially became the internal champions of the project, and facilitated the execution of an effective and efficient field adjudication program in pilot villages.

Putting youth engagement at the center of technology training yielded benefits. Technology training programs focused on youth and incorporated observation and active learning (i.e. hands-on training that was easily adopted by youths at the village level). Active learning led to better learning outcomes and good use of MAST technologies at the village level. TIs were so interested in this experience that some expressed a desire to do more – to learn how to verify data collected, or to volunteer to train youth in follow-on villages. TIs also expressed an interest in learning and using other mobile technology, such as LandPKS. This suggests that the MAST project was able to build practical skills and capacity among youth: capacity that other donors and other projects might leverage to extend benefits and improve livelihoods.

Trusted Intermediaries from one village were effective trainers of other TIs. Trusted Intermediaries in Ilalasimba expressed a strong interest in helping to train TIs in the next pilot village. The MAST project experimented by inviting four of these TIs to work alongside project staff to train TIs in the second village, Itagutwa. This proved to be a successful innovation as youth in Itagutwa pointed out that having the TIs from Ilalasimba involved in training built their confidence. One youth from Itagutwa noted that he felt that if the youth from Ilalasimba could do this work then he (and his peers) were more confident that they could also do the work effectively. He said that they might not have felt

this way if only DLO or project staff provided training. TIs shared their experiences and knowledge with their peers and this proved beneficial during field implementation.

Targeting of women and other vulnerable groups was key to increasing security and promoting gender equality. ERC focused on raising women's awareness of land rights by incorporating gender specific materials in program activities and emphasizing the importance of having women attend village-level trainings, workshops and community activities. MAST also worked with village leaders to ensure a gender balance on governance institutions and focused on recruiting young women to work with the project as trusted intermediaries. This strategy helped build a foundation for women's participation in the project, helped build a community-wide understanding of the rights of women to land in the pilot villages, and helped ensure that CCROs would be issued to women directly. As a result, women in the pilot villages have gone from having no formal land rights and strong customary norms that discouraged claiming these rights to holding CCROS in their own names and jointly with men.

Relying on citizens in the implementation process facilitated the resolution of some land disputes. While the MAST pilot did not formally incorporate a dispute resolution mechanism in its implementation strategy, it provided training on the adjudication process to clarify how disputes would be handled during mapping and following data collection (the issuance of Adjudication Forms and CCROs). The mapping process was implemented by having TIs and LAC members walk with land holders and neighbors to identify boundaries. This participatory process helped to identify existing conflicts in pilot villages, and provided an immediate and local method to resolve them.

Careful messaging was needed to emphasize the benefits of secure tenure rights. The MAST pilot project provided careful messaging around the likely benefits of securing land tenure by procuring CCROs. This messaging was incorporated into community outreach activities in order to help align expectation of villagers. More specifically, the project emphasized that by having a CCROs a woman or man would have stronger rights to use and benefit from land, that inheritance rights would be more secure, and that future conflicts should be reduced because it would be clearer who had legal rights to which parcels. The project purposefully did not highlight the possible connection between CCROs and access to credit.

MAPPING/TECHNOLOGY

Affordability of internet services is a major barrier for the implementation of land information system projects. The pilot has illustrated that internet costs can be a barrier for implementing, utilizing and adopting ICT projects. During the course of the MAST pilot, the project explored options to reduce internet costs. However, because the DLO does not have an allocated budget for ICT, and because of the high costs of associated with obtaining and maintaining an office internet connection, the project covered these costs. The lack of dedicated funding for ICT raises challenges related to the ability of the DLO and other DLOs to support a MAST-like approach to land rights adjudication.

Geospatial resources and tools require careful planning and potential data acquisition, but are easily adopted by beneficiaries and essential for data validation. Significant investment and time is required to obtain and process geospatial resources such as imagery, and create base mapping data (i.e. village roads, boundaries) in MAST, but the incorporation of these resources and the use of GIS/GPS tools in the MAST Mobile Data Capture Application proved useful for orienting villagers for

field work, demarcating boundaries and resolving conflicts. This represents a tradeoff: if MAST is to be effectively scaled, the acquisition and use of imagery will represent a substantial expense unless an alternate strategy to acquire imagery can be identified.

Mapping accuracy and data quality has been improved by tasking and orientating beneficiaries during field adjudication. Although satellite imagery proved important for mapping and understanding the landscape, simple errors in parcel boundary demarcation were encountered. This is not unexpected given that TIs are not professionals and received limited technology training. The observations from the first two pilots and results from the final pilot village indicate that, by improving the way TIs were tasked each day (i.e., systematically mapping portions of a hamlet each day) and by providing additional landscape orientation using basemaps and imagery, TIs can improve their efficiency, which can help avoid duplication of efforts (i.e. duplicate parcels, gaps, other errors). Providing TIs with printed maps showing tasking areas, shared resources and background imagery could further improve the quality of data collected by TIs in the field.

Lack of mapping data reduces efficiencies and increases ambiguities during formal adjudication and data validation. The absence of adequate and coordinated land information, especially land use planning data, which delineates existing and future land uses in the village to guide TIs during field adjudication, has created uncertainties during the demarcation of land boundaries. This has reduced efficiencies in processing and finalizing data. It has also led to time consuming on-site audits by land officers. New workflow processes, involve rotating staff to and from the field to improve understanding of local situations, are currently being implemented in Kitayawa, and are helping to address these problems and reduce the time needed to process and validate data.

Lack of reliable existing data (including VLUPs) increases potential for land disputes. While the DLO has proven to be technically astute in absorbing technologies and processes, the use of inadequate base mapping data during the land use planning process has created an environment where designated uses conflict with existing uses. Using an outdated or non-representative land use plan can lead to conflicts, and also introduces potential errors in the rural adjudication process.

LAND USE

Poor land use planning framework has potential for excluding pastoralists and farmers in marginalized zones, and is increasing disputes. While the village land use planning (VLUP) process, as outlined in the laws and procedure manuals, is supposed to be participatory, the pilot found that village-level participation in the VLUP process is often not representative. For example, in Ilalasimba, pastoralists felt that their concerns were not addressed by the VLUP process. The pilot also found that VLUPs often did not reflect the village's customary understanding of different land uses, land allocation, and boundaries. During village scoping, the pilot found that village leadership often either did not have a copy of the VLUP, or did not know where it was housed. This suggests that the VLUP is not seen as a useful tool for village planning, likely because it is seen as inaccurate or not representative.

Villagers and village leaders may benefit from coupling MAST technology with other land use management technology. In informal interviews, MAST beneficiaries expressed the following sentiment: "my land is mapped, documented, and secured: now what?". Villagers noted that now that their land rights were more secure, they would benefit from having access to land use management information so that they could better capitalize on their CCROs. Such information might be provided by coupling the deployment of MAST technology with other USAID-supported mobile technology,

specifically the LandPKS applications. This would enable land rights holders to identify soil conditions, land cover and share information with others who face similar concerns and constraints.

GENERAL ISSUES AND SUSTAINABILITY CONCERNS

Financial Sustainability. The systematic registration of land rights is a large undertaking that requires both a political commitment and a financial commitment. The MAST pilot tested an approach that reduces the time and may reduce the costs associated with this process. Such an approach may prove helpful to the GOT in achieving its goals regarding the registration of land rights for a large number of citizens. However, to implement this approach at scale, district land offices will need dedicated and sufficient funding from PMO-RALG, including funding for ICT needs and for staff to travel to and from villages. In addition, the GOT will need to identify an appropriate revenue-generating strategy to sustain these efforts. The MAST pilot assumed the costs of issuing CCROs – villagers received documents for free. Assuming the GOT will continue to charge a fee to deliver CCROs, the price to do so needs to reflect demand for these services and needs to be transparent. Currently, it is not clear what villagers in different locations are willing to pay for these services (given the fact that many villagers do not understand or do not see many benefits associated with having a CCRO). This is an issue that will, presumably, be addressed by the GOT and/or through USAID's Land Tenure Assistance (LTA) Activity and DfID's Land Tenure Support Program (LTSP) activities.

Subsequent registration. The MAST pilot project was designed to test a citizen-centric approach to capturing land rights; it was extended to support the issuance of formal land rights documents. It was not designed as a land information system nor to provide functionality for the subsequent registration or transfer of land rights stemming from inheritance, sale, subdivision, etc. However, it is clearly the case that in order for a technology-based approach to land registration to succeed and meet the needs of the GOT and land users in the country, a solution to the problem of efficiently and effectively transferring rights to parcels will need to be developed. While this is possible, it is an issue that, like financial sustainability, will presumably be addressed by the GOT and/or through the LTA and LTSP activities.

Staffing issues. The DLO is currently not staffed at a sufficient level to support the systematic adjudication of land rights while also conducting normal office business. The project experienced delays processing and validating data as a result of limited number of DLO staff with GIS expertise. In addition, because DLO staff participate in training exercises, mapping exercises, the delivery of Adjudication Forms, signing Adjudication Forms, and the delivery of CCROs – all of which take place in villages – staff needed to juggle responsibilities and, at times, this negatively impacted the project's delivery timeline. If the GOT wishes to implement a broader systematic adjudication process it will need to build capacity among a cadres of professionals and devote resources to staffing District Land Offices. This capacity building might be done in conjunction with universities and training colleges.

The requirement to use official "crested papers" and ancillary forms and/or supplies creates a high "sunk cost" for the adjudication of land. The costs associated with adjudicating lands in Tanzania are quite high due in part to the requirement to use official papers and ancillary forms. These costs are significant: on average they are approximately $6.50 USD per parcel. The MAST pilot project absorbed these and other costs of delivering CCROs, rather than passing these costs on to villagers. In order to encourage more villagers to participate in adjudication efforts, the GOT should consider relaxing some of these requirements. Reducing costs associated with procuring official papers could help efforts associated with scaling adjudication process in Tanzania.

Using and transitioning to a cloud-based land information system presents opportunities and challenges. The MAST pilot has proven that cloud-based systems and mobile technologies can be deployed and used in rural areas with limited internet access. This approach may present opportunities for building a reliable inventory of lands quickly. The MAST software application suite uses cloud-based technologies and does not require the same level of investment as traditional ICT systems. However, the cloud storage chosen for MAST is not without a cost. The hosting service chosen for MAST costs approximately $500 a month. While it is not an insignificant sum, it is lower than large-scale investments in software and hardware that are typically involved in creating formal land information systems. Nevertheless, the GOT wishes to use a cloud-based data storage system to provide land titles, it will need to allocate an adequate budget for the costs of storage. At the same time, the transition to cloud storage has also had an impact on existing business processes at the DLO and highlighted that the systematic adjudication of lands places strains on resources. It has also raised concerns related to the hosting, management, storage and privacy of resultant land rights information.

Clarifying benefits of technology. Government ownership and political will are essential to successfully implement any important policy. The Government, particularly the MOL, may face challenges in meeting commitments to implement national-level adjudication programs, given the limited staff and budgets available for these activities. The GOT has approached the option to use mobile technology cautiously and so it will be important to understand the potential this (or other) technology has to deliver land administration services in a more timely, and perhaps more cost-effective, manner. MAST seems to fit well with government development priorities for inventorying lands and attracting agricultural investment, but it remains to be seen whether it will be widely adopted by the GOT.

Per-diems and Participation: As highlighted in the sections above, community engagement was effective to implement a MAST-driven adjudication process. However, this participation came at a cost. Almost all activities, including the participation of the DLO and of villagers in the project, was tied to the provision of per-diems. In Tanzania, per-diems are used as the main incentive for ensuring engagement in development programs. While the pilot incorporated per diems in order to guarantee the participation of GOT officials (including the DLO), budget allocations for per diems for villagers were low. The apparent need to use per diems to ensure participation in project implementation activities has implications for efforts to scale MAST and land adjudication.

5.0 CONCLUSION

At the conclusion of the MAST Pilot Project we are able to provide field-based insights into the following issues that motivated the activity. These conclusions were shared during a lessons learned workshop that was held in Dar-es-Salaam on June 3, 2016:

1. **Citizens' and communities' reaction to and engagement with the approach and its impact on perception of tenure security**:

Citizens and communities were supportive of this approach to mapping and capturing land rights information. The project did not, in its limited experience, encounter any resistance from community members or village leaders to the methodology or to the activities. Rather, in each community villagers expressed an interest in participating in the project. The project, like many land certification or tilting projects, did raise some conflicts – often intra-familial conflicts that needed to be resolved by the Village Council. Only in rare cases were conflicts taken beyond the Council to the ward level or higher. Villagers also self-reported that they expect the delivery of CCROs to reduce future conflicts – particularly for women and their children. The project also helped to expand understanding around women's land rights, which had, anecdotally, a strong impact on women's perception that their tenure security had increased as a result of the project.

2. **The ability of the surveying profession / land professionals to support efforts to crowdsource land rights information in a collaborative manner with citizens:**

Surveying and land professionals working in the DLO, the NLUPC and the MOL were very capable of supporting the MAST pilot activities related to crowdsourcing land rights and working collaboratively with citizens. In particular, GOT staff led trainings on the land laws, provided careful oversight of data validation, and engaged with citizens on the review of Adjudication Forms. Staff from the NLUPC assisted in updating land use plans and in identifying conflicts among land users during land use planning process. MOL staff were very helpful in identifying ways to improve the MAST technology so that it tracked legal requirements more closely. Taken together, these professionals made important contributions that improved MAST application functionality. Their strong involvement in the pilot may also have provided villagers with a greater confidence and trust in the MAST methodologies.

3. **The characteristics of a good 'Trusted Intermediary' (TI) to support the capture and maintenance of land rights information:**

The pilot worked with over two dozen young women and men who served as Trusted Intermediaries. We identified several characteristics of a "good" TI. These included the following: a strong interest in learning new skills, adaptability, a willingness to engage with others, and facility with technology. Both women and men made good TIs and in both Ilalasimba and Itagutwa women held the record for mapping the most parcels in a day. Having both women and men as TIs may have helped to encourage conversations around women's land rights and may have helped women feel more comfortable seeking rights in their own names, though this is speculative.

4. **Identify what land rights information must be captured to meet the legal requirements of the Government of Tanzania**:

   By working closely with the DLO and the MOL, the project was able to identify what land rights information is required in order to issue formal documentation of rights. As noted above, there is not a consistent interpretation at the district level of what land rights data is required, and so being able to rely on the MOL to provide expert guidance on these points was very helpful.

5. **Test a range of technology tools available and identifying the most affordable and appropriate to support the approach**:

   In the initial stages of the pilot, ERC worked with USAID to explore and test a variety of data platforms, technologies and mobile applications that could be applied to the MAST pilot. The initial focus of discussions was on identifying existing web mapping platforms, web mapping servers, and development frameworks, tool kits, libraries and databases that could be used for hosting data or as tools to develop a data management back-end. The project also explored an assortment of mobile applications or tools kits that could either be used for a mobile application. Most prominent among these was ESRI's ArcGIS mobile application. Options were also explored to build the platform using Open Data Kit (ODK). The project decided, however, to issue a Request for Proposals for the development of an integrated solution: a mobile data capture tool and data management facility, given that these were identified as key elements to test the technology in Tanzania and given opportunities for securing tenure by issuing land rights documents.

6. **Establish approaches for sustaining the maintenance and security of land right information after the pilot and expanding its use**:

   Throughout this project, the MAST team has sought to engage national and district level stakeholders to build support for the pilot's new and innovative approaches to collecting and storing land rights information. These approaches, particularly, general boundary mapping, the use of relatively simple tools (mobile phones), the use of local people to support the adjudication process, and the use of cloud-based tools and storage facilities, were presented to GOT and other stakeholders as tools that could be used to address many of the shortcomings of conventional land administration systems. The MAST team has worked closely with the DLO to build capacity to carry on land adjudication efforts using MAST by providing a variety of trainings and by procuring a server and printer for the office. The MAST team has also shared information with, and made presentations to, other donor agencies operating in the land sector in Tanzania. Most recently, USAID has integrated MAST into its Land Tenure Assistance (LTA) program and will utilize the technology at larger scale to support efforts to deliver secure land rights in 41 villages in Tanzania. However, for the GOT to deploy MAST at a large scale, the government would need to dedicate financial resources to the acquisition of geospatial imagery, the training of staff, hiring personnel, providing for logistical support and the appropriate ICT infrastructure.

7. **Explore how the results from the pilot can be shared and the lessons and practical applications expanded, replicated and scaled for USAID and others:**

   USAID has been able to share the results and lessons learned from the MAST Pilot Project in several ways. First, the Agency supported the developed of a Performance Evaluation of the pilot, which is publically available. Second, the Agency has discussed MAST at several forums, sharing

lessons and discussing opportunities to replication. For example, this past March USAID supported a panel discussion of the MAST project at the 2015 LANDac Conference in Utrecht, at a FIG Conference in Malta in 2015, and at the 2016 Annual World Bank Conference on Land and Poverty. The Agency has developed other materials, including stories and commentaries that discuss the impact of the MAST project. And finally, this lessons learned document attempts to share lessons learned related to the project. USAID plans to scale MAST in Tanzania through the Land Tenure Assistance (LTA) Activity, a Feed the Future program being managed by USAID/Tanzania.

By sharing these lessons learned, the MAST project hopes to inform discussions related to the use of technology to close the worldwide tenure gap, the important issue of securing women's rights to land and the role that local citizens – or para-professionals – can play in mapping and recording land rights. The MAST pilot provides some evidence that coupling awareness raising around land laws and land rights with training on the use of technology, local citizens can have a more central voice in the process of securing land rights. The pilot also provides some evidence that this participatory approach may be especially important for women, whose land rights remain insecure due to persistent customary practices.

6.0 REFERENCES

Fimbo, G. M. (2004): Land Law Reforms in Tanzania. Dar es Salaam, Tanzania, Dar es Salaam University Press Ltd.

Lemmen (2010): The Social Tenure Domain Model, A Pro-Poor Land Tool, International Federation of Surveyors, Global Land Tool Network and United Nations Human Settlements Programme (UN-HABITAT), March 2010

Lemmen, C.H.J., Augustinus, C., van Oosterom, P.J.M. and van der Molen, P. (2007): The social tenure domain model: design of a first draft model, International Federation of Surveyors (FIG) May, 2007

Lugoe, F. N., (2007): *Focal Issues in the Land Policy Reform Agenda in Tanzania: Inputs Based on Tanzania's Experience,* Dar Es Salaam Institute for Land Administration and Policy Studies, DILAPS, presented at the CBU/CASLE/ AfRES Conference on Sustainable Human Settlements held in Livingstone, Zambia.

Lugoe, F. N., (2008): Challenges and Issues in the Surveying and Mapping of Tanzania Land, Topo-Carto

Hassan, A. and Semkwiji, D. (2011): The Role of Mobile Phones on Sustainable Livelihood, The Economic and Social Research Foundation (ESRF), ESRF Discussion Paper No. 33,

Institute of Electrical and Electronics Engineers (1987): IEEE Guide to Software Configuration Management (IEEE Std 1042-1987). New York, NY: Institute of Electrical and Electronics Engineers.

International Organization for Standardization & International Electrotechnical Commission (1995). Quality Management—Guidelines for Configuration Management [ISO 10007:1995 (E)]. Geneva, Switzerland: International Organization for Standardization/ International Electrotechnical Commission.

Institute of Electrical and Electronics Engineers (2005): IEEE Standard for Software Configuration Management Plans (IEEE Std 828-2005). New York, NY: Institute of Electrical and Electronics Engineers.

McLaren, 2011 Crowdsourcing Support of Land Administration a new, collaborative partnership between citizens and land professional, RICS: http://www.rics.org/site/scripts/download_info.aspx?downloadID=8083&fileID=10840

Molen, van der, Paul (2003): Future Cadastres, Proceedings FIG Working Week Paris, 2003

Molen, van der and Lemmen, Christiaan (2004): Unconventional approaches to land administration – a point of view of land registrars and land surveyors, in: proceedings of the Expert Group Meeting on Secure Land Tenure, 11-12 November 2004, UN Gigiri, Nairobi, Kenya, published by the International Federation of Surveyors, Denmark, 2005

Odgaard, R. (2006) Land Rights and Land Conflicts in Africa: The Tanzania case, Danish Institute for International Studies, Copenhagen

Pedersen, R.H (2010): Tanzania's Land Law Reform; the Implementation Challenge, , DIIS Working Paper 2010:37 Danish Institute for International Studies, Copenhagen

Pedersen, R.H and Huale. S (2013): Women, Donors and Land Administration The Tanzania Case, , DIIS Working Paper 2013:19, Danish Institute for International Studies, Copenhagen

Tsikata, D. (2003): Securing Women's Interests within Land Tenure Reforms: Recent Debates in Tanzania, Journal of Agrarian Change 3 (1 and 2):149-183.

Tenga, W. and Kironde, L. (2012): Study of Policy, Legal and Institutional Issues related to Land in the SAGCOT Project Area, report commissioned by the World Bank

UN-HABITAT(2008): Secure Land Rights for All United Nations Settlement Programme, Nairobi, Kenya.

USAID (2011): USAID Land Tenure Tanzania Profile, http://usaidlandtenure.net/tanzania

Williamson, Ian P., (2000): Best Practices for Land Administration Systems in Developing Countries, International Conference On Land Policy Reform Jakarta, 25-27 July 2000.

Wily, L. A. (2003): Community-based land tenure management: Questions and answers about Tanzania's new Village Land Act,1999, IIED, Issue Paper 120.

Legal Instruments

The Courts (Land Disputes Settlements) Act, 2002

The Village Land Act, No 5 of 1999

The Land Act, No. 4 of 1999

The Land Use Planning Action No. 6, 2007

The Land Survey Ordinance (CAP 390)

ANNEX I

Key Considerations for the Recreation or Redeployment of the MAST Software Application Suite

The successful implementation of the MAST technology in Tanzania has created visibility, and subsequently demand for the technology, and as a result, has created a need to disseminate and share the software application suite. While the MAST software code and related scripts/databases are available on GitHub, the establishment of the software application suite remains complex and requires careful consideration by stakeholders in recreating or redeploying the technology.

This annex was developed to provide stakeholders an overview of the MAST technology, and particularly to help them meet the challenges of understanding what is involved in the recreation and redeployment of the MAST software application suite. The term stakeholder is used loosely in this section and is defined as an individual, group, or organization, that may be interesting in documenting and protecting land rights of people. Core stakeholders could include donors, national level government agencies or land departments or even regional or district-level land departments. Other key stakeholders could be rural collective and/or economic organizations, NGOs or CSOs and/or private service providers that are implementing projects and are concerned with protecting and documenting land rights.

Before starting the process of reconfiguring or redeploying MAST, several key decisions are required to determine whether your organization has the appropriate resources to perform, manage and/or implement such a project or whether it may be best to outsource key elements of development and/or even implementation. Careful attention by the stakeholder is required here; the decision to develop and implement such a complex software project internally versus outsourcing development is not simply a matter of having the financial resources or having a capable GIS professional or programmer on staff. It is a critical decision that is based on the scope of the undertaking, time, costs and financial and technical resources.

This Annex should be used as a tool that guides stakeholders through a series of steps, considerations, and best management practices for recreating or redeploying the MAST software application suite. Key steps are as follows:

1. Project Management Team (organization level)
2. Establish Technical and Software Resources
3. Review of Software Resources Documentation
4. Develop Project Plan
5. Define Requirements
6. Establish Development Environment
7. Download and Build Source Code
8. Make Modifications based on Requirements
9. Testing
10. Deployment to AWS

1. Project Management Team

The initial step involved in MAST deployment or re-deployment is to ensure that you have in place an appropriate **Project Management Team** with enough understanding of data management, software development and its lifecycle. An understanding of land administration is also a benefit and useful when the team is defining requirements or implementing a project using MAST in a particular locale. A mixture of these two skill sets will ensure that you have the capacity needed to conduct the project from concept to field implementation. Having one technologically capable/competent person on staff is unlikely to be sufficient to get your project done. The person assigned to manage the software project should possess a technical background in software development, GIS, cadastral mapping and/or land registration. The team should also understand Open Geospatial Consortium (OGC) compliant tools (e.g. OpenLayers and Geoserver), and databases (PostgreSQL, PostGIS) and their implementation. Key project manager attributes include the following:

- Interpersonal skills and leadership – which will involve liaising with subject matter experts and ensuring that tasks are being implemented according to schedule and costs;
- Informational responsibilities – monitoring performance and keeping executive management informed of performance; and
- Decision making – should be empowered to a point where they can make decisions regarding the allocation of resources.

As noted, the implementation of MAST requires a complex mix of human resource attributes as the successful design, development, and implementation of an information technology (IT) project such as MAST is a very complex process.

It is highly recommended that the Project Management Team conduct a needs assessment **before** launching work to adapt the MAST technology suite for use in a particular locale/context. A needs assessment provides an opportunity to analyze the legal, political, social and technological issues that could impact the success of a MAST deployment. To this end, a needs assessment should carefully review:

- The appropriate legal and regulatory framework associated with land administration and use of technology to map, record and register land rights of women and men;
- The specific legal process associated with formally registering land rights of women and men;
- The specific configuration needs associated with adapting MAST to a new locale/context;
- The specific technical requirements associated with computer equipment, printers, internet connectivity, data storage, etc.;
- The specific constraints associated with formally registering land rights of women and men and the broader political framework that may constrain the delivery of land administration services or costs of these services;
- The technical capabilities of likely partners within and outside government;
- The availability and/or costs of high resolution maps and other geospatial data;
- Political buy-in and support of key stakeholders within and outside government;
- The level of land-related conflict in the locale/context;
- The likely socio-economic costs and benefits of the deployment of MAST technology and implementation approach in the locale/context; and
- Potential obstacles to the implementation of the MAST technology and implementation approach within and outside government.

2. Establish Technical and Software Resources

Stakeholders must address several key decisions when undertaking a project such as recreating or redeploying MAST. The adaptation of MAST database and tools requires an understanding of many different components and is not a simple feat, and like any application development, requires the interplay of many different components all at the same time.

Whether an internal or an external development option is chosen, what is critical at this juncture is to **Establish Technical and Software Resources.** Ideally, a technical and software resource team should include a technical manager (as opposed to the project manager). The technical manager should be in charge of development or programming and should have a background in database design and management, Java-based application programming and Android mobile application development, or be familiar with database administration. Below please find a summary of attributes of key development resources:

Java web application Developer

- Knowledge of J2EE platform
- Knowledge of Spring framework
- Knowledge of Hibernate ORM
- Knowledge of server-sided programming in Java
- Knowledge of client-sided GIS programming in HTML/CSS, Javascript, OpenLayers or Leaflet and Jquery.
- Knowledge of JTS/JSTS
- Versed with OGC specifications
- Knowledge of Geoserver and its API's

Android Application developer

- Knowledge of Android development SDK
- Knowledge of Google Maps API for Android v2
- Knowledge if Java Topological Suite (JTS)

RDBMS Specialist

- Intermediate knowledge of PostgreSQL RDBMS
- Intermediate knowledge of PostgreSQL database administrator
- Knowledge of PostGIS extension of PostgreSQL database
- SQL proficiency
- Knowledge of PostGIS spatial functionality

3. Review of Technical Software Documentation

The third step involves the **Review of Technical Software Documentation**. The project manager or his/her assignees will need to have a thorough understanding of the MAST software framework, and specifically, understand how it can be modified to meet future project requirements. A full review of the high-level technical documentation, as well as specific deployment documents, may be required at this point. These documents may include:

- MAST2 Technical Document_phase2.pdf – reflects changes in the data model and ER diagram, definition of tables and fields;
- MAST2_deployment_environment_setup_guide_Phase2.pdf; and
- MAST2_development_environment_installation_setup_guide_Phase2.pdf.

A review of these documents will provide stakeholders with a high-level understanding of the MAST software architecture and the quality of software tools and frameworks utilized in the construction of MAST. A review of the above cited documents will help stakeholders predict general requirements for their project, which may entail either integrating scripts and code, or building out tools sets within the existing application frameworks. This step is especially important given that MAST is built on a series of open source software and additional development on such frameworks often requires substantial time and effort.

4. Develop Project Plan

Based on a review of technical resources and documentation, the team assigned to develop your MAST project should create a technology development plan. The technology plan will help to identify needs and establish priorities based on the available resources and time. The development of a technology plan is critical and it establishes an initial roadmap that the project team members can use to guide them through the project activities.

The points below will help form a basic structure of the project plan:

- Assumptions and Constraints: develop a list of assumptions about your development project that is based on any constraints for all project phases of the project. For example, review constraints related to budget, staff, equipment, technology, schedule, acquisition, government support or buy-in, etc. that apply to the project
- Project Strategy: the project strategy describes in detail the lifecycle of the project. This will include a that defines resource allocation, roles and responsibilities for software development, and define whether or not there are any needs for acquiring new software and hardware tools, to facilitate development.
- Data / Configuration Management: develop a data and configuration management plan that defines how data and artifacts will be managed throughout the lifecycle of the project and work with stakeholders to consider how data will be managed after the project ends to promote sustainability and to protect the valuable information stemming from implementation.
- Risk Management Strategy: define a strategy to identify risks, frequency of risks in development and implementation, and identify a team member that will need to be responsible for tracking risks etc. This task is normally assigned to a project manager.
- Verification/Validation Strategy: the project plan also needs to identify and outline how and when resources will be allocated to review internal work products. This should include creating a plan or strategy for determining of how artifacts will be validated, tested and released.
- Sustainability Strategy: the sustainability plan should clearly identify how the project will build support and generate sufficient revenue to ensure that mapping, recording and registration activities are able to continue beyond the project's term.

While adopting MAST to use in your locale is primarily a technology activity, the project manager should be an integral part of this activity and should have the input in the development project plan. While the project plan may be defined with only a general understanding of technology requirements, it provides

an important preliminary baseline for management to estimate what resources may be needed to implement the project, estimate time required, and develop a framework for a budget. As defined above, this project plan also outlines logistical matters such as communication, evaluation, testing and deployment requirements.

5. Define Requirements for Jurisdiction

The third step in adapting MAST for use in your project is to understand, analyze and **Define Software Requirements** so that the MAST software application suite can be adapted to support the capture of land information in your jurisdiction. The definition of requirements should be performed by a land tenure or land administration specialist who possesses ample background and understanding of pertinent land administration systems to define requirements for adopting MAST to either a country's customary or formal land administration system. While there are common processes present in all land administration systems, the implementation of MAST in any jurisdiction will require careful consideration of the both customary and statutory land administration frameworks. Each country has its own land administration system that is based on its customs, traditions, laws and policies. Stakeholders who are adapting MAST, and for that matter any information system that seeks to automate the process of capturing land rights information, must be able to engage with stakeholders and review and analyze national (and sometimes regional or local) customs, traditions and practices in addition to national laws and policies. Such an understanding is paramount to define the opportunities and constraints of implementing a unique cadastral and registration system such as MAST.

The initial configuration of MAST was made specifically to address tenure gaps. To fully understand the local situation and to identify ways that the technology can help improve current processes and governance, stakeholders may also consult an array of tools and publications that outline key considerations or best management practices for implementing a land administration system. Williamson (2000) outlines key considerations of a land administration system as:

1. Land policy principles
2. Land tenure principles
3. Land administration and cadastral principles
4. Institutional principles
5. Spatial data infrastructure principles
6. Technical principles
7. Human resource development principles

This important step will result in a document, which defines how MAST software application suite can be adapted to support customary or statutory land administration systems.

6. Establish Development Environment (prerequisites)

Once technical and legal requirements are defined, and depending on whether your organization chooses to adapt the MAST software application suite internally or outsource its development, you should establish a **Development Environment** for testing. A testing environment should be established to allow for loading of base software builds and for the isolation of new code or experimentations to existing code. The establishment of a testing environment involves the download of software prerequisites such as application frameworks and the loading of a compiled web application archive (.war) file.

For full details, please refer to the following document:

- MAST2_development_environment_installation_setup_guide_Phase2.pdf

The following resources should be downloaded and established for each development or test machine:

MAST Web Infrastructure

The core tools and software used to develop MAST web infrastructure are:

- Java JDK7
- PostgreSQL 9.3 /PostGIS 2.1
- Apache Tomcat 7
- Eclipse Luna IDE

Please note that stakeholders will also need to download source code for MAST web infrastructure from GitHub (https://github.com/MASTUSAID/MAST-DMI) and minimal PostgreSQL scripts (https://github.com/MASTUSAID/DB-SCRIPTS) that are to be run on the database to schema and load mandatory master tables.

Step	Comment
Step 1: Install Java JDK 7	• Download the Java 7 JDK update 56 or later from http://www.oracle.com/technetwork/java/javase/downloads/index.html • Run the exe file and follow the instructions.
Step 2: Setting Java and JRE Home	• From Control Panel open System Properties and create a new system variable JAVA_HOME specifying the JDK installation folder as variable value.
Step 3: Installing PostgreSQL	• The graphical installer for PostgreSQL includes the PostgreSQL server, pgAdmin III, a graphical tool for managing and developing databases, and StackBuilder, a package manager that is used to download and install PostGIS. Download PostgreSQL graphic installer from http://www.enterprisedb.com/products-services-training/pgdownload#windows.
Step 4: Verifying the Installation	• There are several ways to verify the installation. You can try to connect to the PostgreSQL database server from any client application e.g., psql, pgAdmin, etc.
Step 5: Installing PostGIS	• After Postgres Installation is complete, the installer will launch the Stack Builder application for installing Postgres extensions. Select the postgres database that has been installed, from the dropdown. Expand the spatial extension node and select the PostGIS option to install PostGIS.
Step 6: Creating and populating database from script	• Run the script mast_configurations_schema.sql to create database schema. • Once database schema is created run the script mast_configurations_data.sql to populate master tables. • Validate whether all the tables have been created and master data populated in this new database.
Step 7: Apache Tomcat	• Download or use the latest version of Apache Tomcat Server installer executable

Step	Comment
Installation	file. • Choose Type of Install as FULL to install all features. In configuration option keep everything as default. Provide the user name and password and note it somewhere for future reference. • Select the path of JRE as installed in the local system/server.
Step 8: Apache Tomcat Configuration	• Refer to installation guide for steps regarding configuration of Apache tomcat application server that is to be used with development environment to deploy the application in debug/run mode.
Step 9: Install Eclipse Luna	• Eclipse Luna Integrated Development Environment is used as development platform for coding and compiling of MAST web infrastructure source code downloaded from GitHub. • Download and install Eclipse Luna in local machine. • Install Maven plugin dependency. Maven plugin can be installed from Eclipse market place.

MAST Mobile Data Capture Application (Android)

The core tools and software used to develop MAST mobile application are:

- Java JDK7
- Eclipse Luna IDE
- Android Development Tools (ADT Plugin)
- Android Software Development Kit (SDK)

Step	Comment
Step 1: Installing Java JDK 7	• Installation method is same as above.

Step 2: Installing the Stand-alone SDK Tools	• Download the SDK from the following url: https://developer.android.com/sdk/index.html#Other
	• The downloaded package is an executable file that starts an installer. The installer checks your machine for required tools and installs it if necessary. As a minimum when setting up the Android SDK, you should download the latest tools and Android platform:
	• Open the Tools directory and select:
	  ○ Android SDK Tools
	  ○ Android SDK Platform-tools
	  ○ Android SDK Build-tools (highest version)
	• Open the first Android X.X folder (the latest version) and select:
	  ○ SDK Platform
	  ○ A system image for the emulator, such as ARM EABI v7a System Image.
	• For using Google Maps API download Google Play services package. Open the Extras directory and select:
	  ○ Google Repository
	  ○ Google Play services
	• Once you've selected all the desired packages, continue to install and accept license agreement.

Step 3: Installing the Eclipse Plugin	To add the ADT plugin to Eclipse: • Start Eclipse, then select **Help** > **Install New Software**. • Click **Add**, in the top-right corner. In the Add Repository dialog that appears, enter "ADT Plugin" for the *Name* and the following URL for the *Location*: https://dl-ssl.google.com/android/eclipse/ **Note:** The Android Developer Tools update site requires a secure connection. Make sure the update site URL you enter starts with HTTPS.

7. Download of Code (and building source code)

Creating a separate development machine, or isolating development, follows general best management practices and allows development to occur outside of the production environment (i.e. on a separate machine from the one on which the software will be deployed). The establishment of a testing environment protects "live servers," databases and data, and provides a safe environment where source code can be loaded and updates can be made.

The establishment of development prerequisites on development machines allows for software code and databases to be downloaded, established and tested. For full details, please refer to the following document:

- MAST2_development_environment_installation_setup_guide_Phase2.pdf

The process for establishing MAST development environment for the mobile application includes:

Download & Deploy Source Code (Mobile Data Capture Application)

Step	Comment

Step 1: Download Source code	• Visit https://github.com/MASTUSAID/MAST-MOBILE to download MAST Mobile Application source code. Download the zip file on to local system by clicking Download ZIP button.
Step 2: Configure and Build Source code	***Prerequisite: For configuring the source code in Eclipse, it is mandatory to have working knowledge of Eclipse IDE and Android SDK. Without knowledge of these it would be difficult for the user to setup the source code and configure to work in debug environment.*** • Extract the downloaded zip file to local computer and open Eclipse and create a new workspace in the folder where you extracted the source code, then import Android code into workspace option.

The process for establishing MAST development environment for the MAST DMI includes:

Download & Deploy Source Code (Web Infrastructure)

Step	Comment
Step 1: Download Source code	• Visit https://github.com/MASTUSAID/MAST-DMI to download MAST Data Management Infrastructure Source code. Download the zip file on to local system by clicking Download ZIP button.
Step 2: Configure and Build Source code	***Prerequisite: For configuring the source code in Eclipse, it is mandatory to have working knowledge of Eclipse IDE and Maven. Without knowledge of these it would be difficult for user to setup the source code and configure jdk environment to work in debug environment.*** • ***Follow similar steps as for android code, except when importing expand*** Maven and select" Existing Maven Projects". Press next. Select the root folder of extracted MAST archive where pom.xml is located. Click finish. Above activity would set up the maven project on to the new eclipse workspace that you created. • Then the user will need to set the Tomcat/webapp path for locally installed tomcat. This path can be set in pom.xml under artifact **maven-war-plugin.**
Install Geoserver	• Copy the geoserver.war to Tomcat/Webapps folder. • From Run Command type "Services.msc" to open services window. From the list of services select the **Apache Tomcat 7.0** service stop and restart the service. • When the service starts tomcat would automatically extract the war file in webapp folder.

8. Make Modifications to MAST based on Requirements

While your modifications to the software code and database will be based on defined requirements for any particular project, the assigned software development team should be conscious of the need to establish and maintain the integrity of the products you create. Essentially, there needs to be an established and methodical review of code and software artifacts, and coordination for implementing changes in the artifacts that are used to construct and maintain MAST. The modifications to MAST, therefore, involves identifying specific configuration items for the software project, controlling these configuration items and making changes to them, and then recording and reporting the status and change activity for these configuration items so that future users can keep track of such changes. While

MAST was not designed or intended to be used as a maintainable software application (nor is it licensed as such), its popularity and application in other locations has prompted the need for careful management. Stakeholders can refer to relevant industrial standards from IEEE and ISO (see IEEE 1987a IEEE 2005a, ISO1995b).

9. Testing

Testing is important process which helps to verify and validate that the modifications that have been made to the software meet the full and intended purpose as outlined in the software requirements documentation. Testing represents a critical phase of quality control in the software lifecycle. In fact, verification and validation in and of itself is considered to be a systems engineering discipline. Verification and validation helps to determine if work products comply with their specifications and are fit for their intended use. Verification is usually an internal process in which software developers verify if the software functions according to specifications. This involves validations of scripts, code, artifacts, etc. Validation is a more formal process in which managers or intended users establish the fitness of a software product for its operational mission. That is users "validate" whether the software prototype meets requirements. This usually entails "user acceptance testing" in which the actual software users are able to test the software to make sure it can handle required tasks in real-world scenarios, according to specifications. This process usually makes users to think more deeply about their needs and discover that some of the requirements were stated incorrectly and require modification. It is, therefore, important to make this process as iterative as possible so that corrections can be made to software so that it functions to meet its intended purpose.

10. Deployment to Amazon Web Services (AWS)[6]

Once the reconfigured MAST software application suite has been tested and is determined to be stable, it will need to be established on a server. The stakeholder will be concerned with replicating the development environment of the MAST web infrastructure in a Linux based Ubuntu 14.04 LTS operating system. The following steps detail actions you must take to deploy MAST. For full details, please refer to the following document:

- MAST2_deployment_environment_setup_guide_Phase2.pdf

Step	Comment

Step 1: Upgrade Ubuntu Packages	• To upgrade ubuntu packages type following on terminal prompt and press enter:
	  ○ $Sudo apt-get update
	  ○ $Sudo apt-get upgrade

Step 2: Install Java JDK	• To install java using package add oracle java repository using below mentioned command on the terminal:
	  ○ $sudo add-apt-repository ppa:webupd8team/java
	  ○ $sudo apt-get update
	• To install java run command as mentioned below:
	  ○ $sudo apt-get install oracle-java7-installer
	• This command will configure the java_home path along with installations.

[6] Please note that the following steps outlined assume that MAST is to be deployed on a Linux based Ubuntu operating system.

Step	Comment
Step 3: Install PostgreSQL	• PostgreSQL is available in Ubuntu repository by default
Step 4: Install PostGIS	• PostGIS is available in Ubuntu repository by default.
Step 5: Restore database	• Download PostgreSQL database backup tar file from GitHub (https://github.com/MASTUSAID/DB-SCRIPTS) and copy into the database server and restore.
Step 6: Install ApacheTomcat 7	• Download the Apache Tomcat7 64 binary file for Linux environment from • https://tomcat.apache.org/download-70.cgi • Copy and extract the tar file in the Ubuntu server. Tar file contains all the dependencies required, no there is no need to run any installations.
Step 7: Configure ApacheTomcat 7	• Please refer to steps and scripts in the MAST2_deployment_environment_setup_guide_Phase2.pdf
Step 8: Configuring Context .xml and Server.xml	• Configure datasource JDBC • Configure database server details and credentials.
Step 9: Deploy Geoserver and MAST WAR files	• Copy the geoserver.war and mast.war files to Tomcat/Webapps folder
Testing Deployment	• To check whether Geoserver and MAST web infrastructure have been deployed correctly user the below mentioned URL: ○ http://IP(ubuntu server):80/geoserver/web/ ○ http://IP(ubuntu server):80/mast/

Once you have deployed MAST on a cloud-based server, establish a URL for accessing the MAST software. Once the MAST application is up and running, using the administration tool will facilitate the establishment of a survey project, manage data layers, layer groups and also to manage users who will be accessing the web and mobile applications. Data and attributes can be configured through the use of the configuration tool, while the data management tool allows for the management of incoming data and administration of land records. For more details, please refer to the MAST User Manuals, which are made available on GitHub: (https://github.com/MASTUSAID/DOCS2/).

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov