SmartLandMaps - From Customary Tenure to Land Information Systems

Auriol DEGBELO, Germany and Claudia STÖCKER, Germany and Kaspar KUNDERT, Rwanda and Malumbo CHIPOFYA, The Netherlands

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SUMMARY

Millions of customary land rights are still undocumented worldwide. Recording and digitizing the plurality of these land rights has been identified as a key challenge in previous work. Documentation is an essential step to make effective progress towards a more sustainable future of our planet and for achieving the SDGs, with Goal 1 “No Poverty” (Indicator 1.4.2: proportion of the total adult population with secure tenure rights to land) in particular.

To advance the documentation of customary land rights, SmartLandMaps follows an approach based on three pillars: acceptance, efficiency and flexibility. With our approach, we contribute to the advancement and sustainability of efforts to record customary land rights worldwide and bridge the gap between low-tech participatory mapping and modern Land Administration Systems. In particular, we put a strong emphasis on fostering the reuse of collected datasets through the use of semantic technologies. The aim of this article is to introduce the SmartLandMaps initiative and the opportunities offered by our approach.

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1. INTRODUCTION

Land has a central role to livelihood, identity and power. The documentation of land rights is an essential step to make progress towards a more peaceful and sustainable future of our planet and for achieving the SDGs, with Goal 1 “No Poverty” (Indicator 1.4.2: proportion of total adult population with secure tenure rights to land) in particular. In most cases, the land of indigenous people is governed by customary law and informal arrangements ruling community allocation, access, use and transfer of land and natural resources. In contrast to statutory tenure, customary tenure is usually not fully protected by the state. Millions of those customary land rights are still undocumented. Evidence presented in Figure 1 shows that in some countries, more than half of the lands held or used by indigenous communities are still not acknowledged by the government.

Figure 1. More than half of the lands held or used are still not acknowledged by the government in many countries worldwide. Data from (Dubertret and Alden Wily, 2017). Map from http://www.landmarkmap.org/.

Customary tenure systems reflect community-based property systems often rooted in ancient practices. The organic nature and intricacy of such land rights systems, however, present major challenges to effectively model and document land claims within standard, generic land administration systems (Chipofya *et al.*, 2020). Digitizing this plurality of customary land rights has been identified as a key challenge in need of further innovations in previous work (Lengoiboni, Richter and Zevenbergen, 2019). The aim of this article is to briefly introduce the

SmartLandMaps initiative and its vision for addressing this challenge. SmartLandMaps aims to provide bottom-up approaches to record customary land rights worldwide and efficiently digitize them to bridge the gap between low-tech participatory mapping and modern, digital Land Administration Systems. SmartLandMaps follows an approach based on three pillars: *acceptance*, *efficiency* and *flexibility*. The three pillars are arguably aspirational, and we elaborate on our ideas to realize these aspirations below.

2. A BIT OF HISTORY

SmartLandMaps started as an initiative building on the success of the "its4land" project[1]. Inspired by the continuum of land rights, fit-for-purpose land administration and cadastral intelligence, the its4land project developed a suite of land tenure recording tools and consulting services to responsibly record land rights. The project consortium used a strategic collaboration between the EU and East African Universities to propose innovative, scalable, and transferrable ICT solutions, including sketch mapping, unmanned aerial vehicles, automated feature extraction and geo-cloud services to store and disseminate land data (Koeva *et al.*, 2020). In particular, a tool called SmartSkeMa was developed that supports data collection with sketched information, transforming hand-drawn spatial representations into high-quality maps for GIS usage (Chipofya *et al.*, 2020). SmartSkeMa was prototyped by the University of Münster and tested in Southern Kenya and Ethiopia. A local domain model has been developed which formalizes the human-land relations in the Maasai nomadic pastoralist society in Kenya (Karamesouti *et al.*, 2018). SmartLandMaps intends to leverage SmartSkeMa and deploy it in additional countries and scenarios. The three pillars of SmartLandMaps (Figure 2) are introduced next.

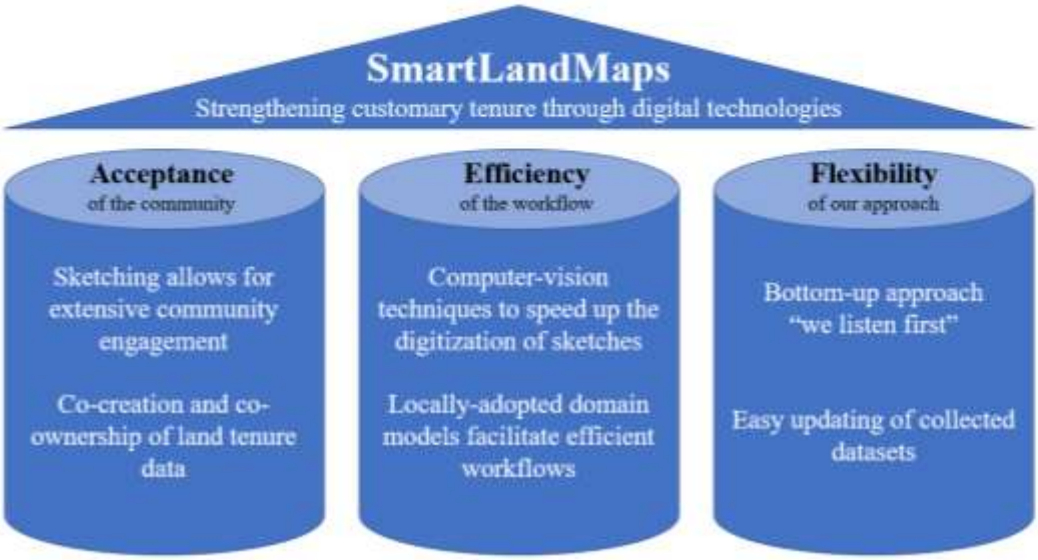

Figure 2. Approach of SmartLandMaps and ideas to realize these aims.

[1] Its4land was a Research and Innovation Action project funded under the Horizon 2020 program of the European Commission (www.its4land.com).

3. **ACCEPTANCE**

Community-based mapping is a widely accepted format in development interventions (International Land Coalition, 2008). Particularly for land use planning and land rights documentation, the participatory approach became a genuine tool to empower communities by improving control over their land and facilitating knowledge sharing among various stakeholders supporting advocacy on land-related issues. Eilola *et al.* (2019) reported that participatory mapping using georeferenced images is useful to capture local spatial knowledge from stakeholders and increase the confidence in the mapped information for decision-making purposes.

The SmartLandMaps approach will use community mapping to gain information on rights, restrictions and responsibilities over land. The early involvement of local communities allows for co-creation and increased understanding and fosters co-ownership of land data. Embedded in an inclusive environment, this approach ultimately increases the acceptance of existing people-to-land relationships mitigating conflicts over land.

Various mapping techniques were developed and promoted during the past years reaching from low-tech procedures such as drawing sketches in the sand to advanced technology-dependent approaches utilizing tablets or survey-grade GPS. The choice of a mapping approach largely depends on various factors, including accessibility, affordability, a target level of self-sufficiency, and scalability among others. At the same time, context-sensitive requirements or geographical constraints might further determine the choice of appropriate mapping tools. This could include legal requirements (e.g. Community Land Act in Kenya, §8), technical reasons (e.g. a closed canopy preventing the reception of GNSS signals), the possibility to access the plots (both physical and security-wise), or very practical considerations (e.g. the time needed to walk around boundaries of large land plots to collect data).

In many contexts, sketches are favoured as an appropriate means to collect spatial data on existing customary tenure systems for several reasons: Firstly, a sketch-based approach is inclusive because it brings communities together and fosters joint discussions about the boundaries of the rights restrictions and responsibilities. Although the participatory mapping process will require some education and sensitization in understanding mapping, possibly reading aerial photographs, it will not exclude computer-illiterate community members who often belong to more marginalized groups such as women, ethnic minorities, and internally displaced persons. The transparency of the collected information is a valuable part of the process. The risk of overlapping claims and conflicts after the digital recording of the information is largely mitigated. Secondly, conducting a discussion with a community at a fixed place is more practical and time-efficient than walking around plot perimeters and gathering GPS locations. For these reasons, SmartLandMaps will use sketches (e.g. freehand, sketches on existing satellite images, aerial images or topographic maps) as media to gather spatial information with the option for additional ground-truthing using GPS measurements of landmarks. If a printer is not available, the map can be projected towards the wall, and information could be drawn on a white cloth or paper sheet.

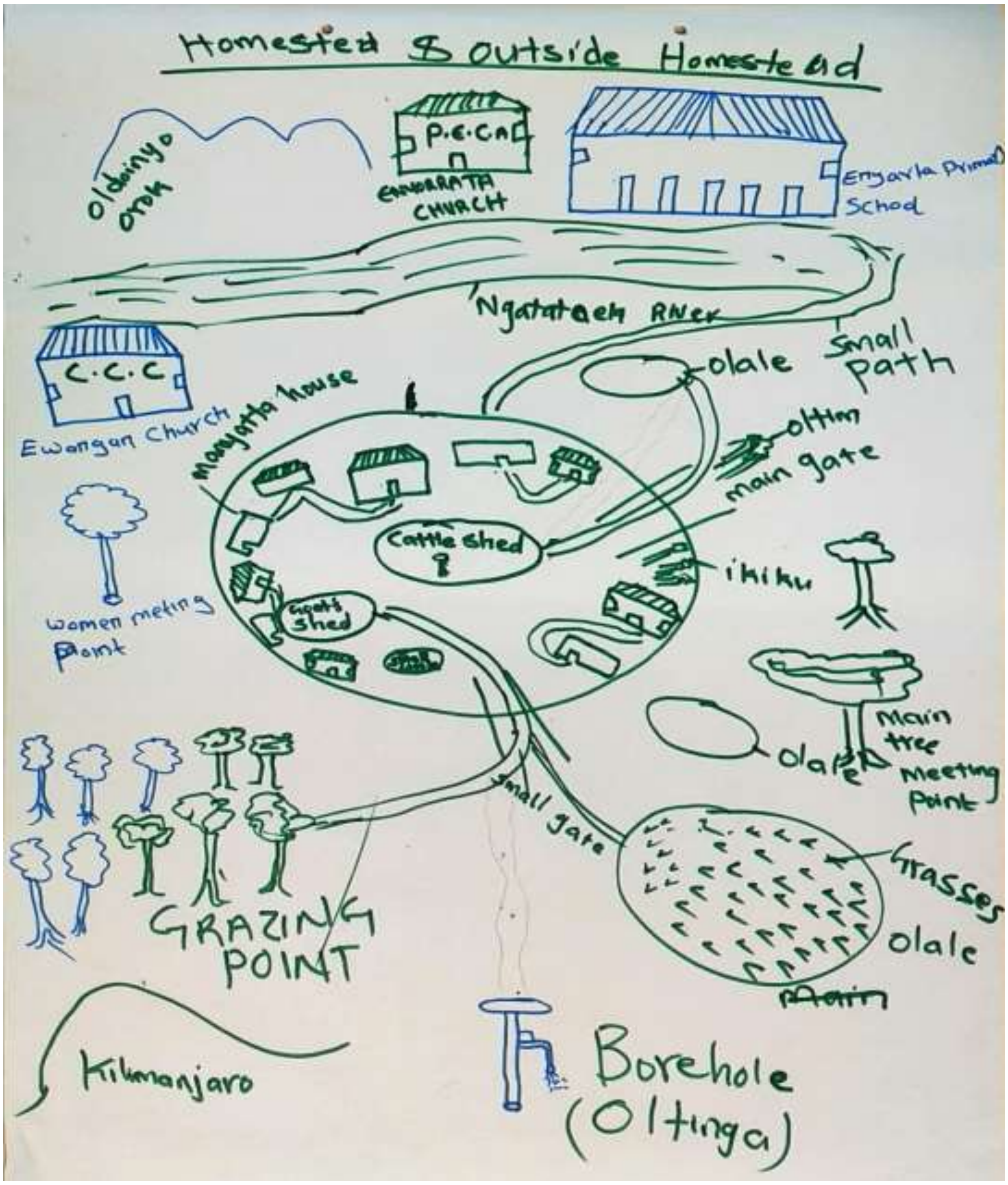

Figure 3. An example of a sketch collected during a field mapping activity in Kenya. Source: its4land project.

Figure 3 shows an example of a sketch map collected during a participatory mapping activity in Kenya. This sketch map provides an overview of the spatial arrangement of relevant geographic features and spaces for the community, e.g. the two meeting trees of which one is reserved solely for women. Sketched by a group of women from the homestead shown at the centre of the sketch, the map depicts the location of the resting place for pregnant and young livestock (labelled ‘olale’) as well as a location labelled grazing point, which is near a borehole and at the foot of Mount Kilimanjaro.

It is important to note here that distances and indeed any length measures in this map are not representative or even indicative of real ground distances between the depicted features. For example, the ‘olale’ is actually just outside the compound as is almost always the case, while the borehole is at least two kilometres away. The grazing point is near the borehole but from there Mount Kilimanjaro is only visible on the horizon. The significance of this sketch is the social and cultural information it carries. It documents the forms of tenure enjoyed by the homestead as a whole, and by individuals or subgroups within the homestead.

4. EFFICIENCY

Land right information has two main components: the spatial component (i.e. boundaries of parcels and plots) and the thematic component (i.e. attributes of the land being recorded such as owner, id, land use, rights, restrictions, etc.). As to the spatial component, we use state-of-the-art computer-vision techniques to speed up the digitization of spatial boundaries collected as sketches during participatory mapping approaches. As to the thematic component, land claims will be recorded on the spot based on locally-adopted domain models. This section will focus on the spatial component. Considerations related to the thematic component are discussed in detail in the next section. On the software side, the SmartLandMaps approach is based on the SmartSkeMa tool developed during the its4land project.

SmartSkeMa provides three main functionalities to improve the efficiency of participatory land tenure documentation (Chipofya *et al.,* 2017). First, for the spatial component, SmartSkeMa supports the automated digitization of hand-drawn maps as well as the detection of feature types of the sketched objects based on a visual language of symbols. State-of-the-art computer-vision techniques speed up the digitization of spatial boundaries and feature type detection: colour-based segmentation using KNN clustering, graph generation combining corner detection and curve-following, a deep neural network built on keras/tensorflow.

Second, SmartSkeMa implements two methods for spatially aligning the sketch content to a coordinated reference system. Where a base map was used, we expect projected data in a Cartesian coordinate reference system. If the sketch is drawn on a blank paper, relative positions are used to align it with existing base map data. In this case, it is expected that some features present in the base data are included in the sketch map to act as anchors at which the two maps attach to each other. The actual alignment is computed by comparing the qualitative spatial relations between anchor features (the anchors) in the sketch and base map. The best match is one that maximizes correct corresponding relations.

Finally, SmartSkeMa supports the documentation of the actual land tenure relations associated with each mapped feature using concepts from the local culture. Here, efficiencies are achieved through the seamless automated translation of local land tenure concepts into LADM terms which align better with statutory land rights in most jurisdictions. This aspect relates more intimately to the flexibility pillar and is, therefore, discussed in more detail in the section below.

5. FLEXIBILITY

Next to the spatial component, a proper recording of attribute information is critical for the documentation of customary land rights. Looking closely at our exemplar sketch from Figure 3, there are two issues that need to be tackled to bridge the gap between the world of customary land and that of local legal land administration systems.

First, local communities refer to concepts using terms in the local language. There is thus the need to support multilingualism and manage naming conflicts (i.e. cases where different terms are used in the local language and in the official language to refer to the same notion). For instance, a local term used to denote the "*women meeting point*" (Figure 3, left) is *oiti* (Schultz *et al.*, 2017); the *ikiku* (Figure 3, right) refers to small trees-branches kept inside an *enkang*, used to close the main door at night (Schultz *et al.*, 2017). Recording these mappings between local terms and terms used in land administration systems is necessary to bridge the community's and the official notion of land.

Second, even within the local community, some terms are used to denote multiple concepts. Here confounding conflicts (a.k.a. homonymy) arise. An *enkang*, for instance, can refer to social units or to a household; an *oltinga* could refer to a borehole (i.e. water source drilled by machines) or to a well (water source excavated by hand). Third, some objects play multiple roles. For instance, an *oltim* (Figure 3, right) is a particular type of plant (i.e. a dead tree set), and thus has an inherent botanical function. It also has a social function since it plays the role of a gate that blocks the entry into a *boma* (Schultz *et al.*, 2017).

Ambiguities arising from naming conflicts, confounding conflicts and the multiplicity of roles fall under the umbrella of semantic heterogeneity, a topic of active research in the Semantic Web and Geographic Information Science communities. *Ontologies* are one of the prime techniques to address semantic heterogeneity issues[2]. In essence, they are helpful for knowledge organization and advanced question answering. As mentioned in (Hogan *et al.*, 2020), an ontology - in the context of computing - is a concrete, formal representation of what terms mean within the scope in which they are used[3]. A relatively well-known example of ontology in the context of land right recording is the Land Administration Domain Model (Lemmen, van Oosterom and Bennett, 2015). The Land Administration Domain Model (LADM for short) has been used in the works of others (e.g. (Griffith-Charles, 2011; Antonio, 2013; Siriba and Dalyot, 2017)), and in our own work (e.g. (Karamesouti *et al.*, 2018; Chipofya *et al.*, 2020)) for land rights documentation. The LADM is valuable because it covers the important topic of social activities related to land tenure relatively well. Nonetheless, the issues of multilingualism and

[2] For recent reviews on ontology engineering, see (Haller and Polleres, 2020; Tudorache, 2020).

[3] Note that we do *not* adhere to the realist perspective implicit in some definitions of ontology in the literature. The realist perspective, as discussed in (Reid and Sieber, 2020), has serious shortcomings when it comes to doing justice to the richness and uniqueness of local and indigenous knowledge.

of a multiplicity of roles mentioned above do not fall within its scope, and more work is needed at the modelling level to tackle them.

Building a local ontology and using it to record information about a given domain results in a *knowledge graph*. A knowledge graph is defined hereafter (Hogan *et al.*, 2020) as a graph of data intended to accumulate and convey knowledge of the real world, whose nodes represent entities of interest and whose edges represent relations between these entities. The benefits of knowledge graphs are manifold. First, they can be open or closed, supporting both enterprise and scientific use cases. Second, they provide a very flexible data model. Contrary to traditional approaches that require the definition of a rigid database schema and suffer from maintenance issues when changes arise, knowledge graphs model data as nodes and relationships between entities. As a result, they can be easily extended when updates occur (e.g. changes of existing land rights or evolution of user requirements). The third benefit of knowledge graphs is that they support the recording of semantically-rich information, easing thereby the integration with other data sources (e.g. existing local land use plans). In a nutshell, knowledge graphs support the flexible addition of *relationships* between data items and data sources, providing thereby a good technological basis for updating customary tenure data. They are also a good basis for bottom-up approaches because they are helpful to record concepts of land in congruence with their usage in the local community.

6. DISCUSSION

Connection to the fit-for-purpose philosophy. Four key principles mentioned in (Enemark *et al.,* 2014) underpin the fit-for-purpose philosophy: 1) general instead of fixed boundaries; 2) areal imageries instead of field surveys; 3) purpose-dependent instead of one-size-fits-all accuracy; and 4) recurrent updating. Since the SmartLandMaps approach is much in line with the fit-for-purpose philosophy, its novelty is not conceptual. Instead, the SmartLandMaps approach illustrates *one* technological path towards realizing the desiderata of the fit-for-purpose methodology. In particular, the discussion on a data model to flexibly record and extend attribute-related information in Section 5 should be viewed as a complement to Morales *et al.* (2019)'s in-depth discussion on technological considerations of spatial data recording.

Maintainability. Most tenure maps are one-off maps, meaning that they provide legally-acceptable evidence for a present status. We lay the foundation for maintainability by allowing for the safe storage of the data collected in a secured and most sustainable environment available (e.g. cloud, national land administration information systems, spatial data infrastructures).

Scalability. The SmartLandMaps approach combines both low-tech (sketches) and high-tech (automated digitization & semantic technologies) techniques to advance land rights information recording and management. The low-tech end lowers the entry barrier to data collection, i.e. communities can contribute their data without being tech-savvy. There are also monetary advantages since sketches enable the collection of general boundaries without expensive field equipment (e.g. survey-grade GPS). On the high-tech end, the use of (semi)-automated sketch digitization and semantic technologies can result in efficiency/quality gains during data digitization and updating, as discussed above. Thus, the SmartLandMaps approach potentially addresses three bottlenecks of the adoption of an innovation: the mastery of technical skills, monetary resources, and time resources. Ultimately, the scalability of our approach needs to be demonstrated through pilot studies and will need to incorporate other critical elements of innovation diffusion (see Rogers, 2003), such as communication channels and the peculiarities of the social systems where it is deployed.

7. CONCLUSION

Millions of customary land rights are still undocumented worldwide. Recording and digitizing the plurality of these land rights have been identified as a key challenge in previous work. The SmartLandMaps approach aims to combine low-tech (sketches) and high-tech (automated digitization & semantic technologies) techniques to bridge that gap. This article has presented the key pillars of our approach and vision.

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BIOGRAPHICAL NOTES

Auriol Degbelo is a fellow of the EXIST Business Startup program and a Privatdozent at the University of Münster, Germany. His research interests include semantic integration of geospatial information, re-use of open government data, and interaction with geographic information.

Claudia Stöcker is a fellow of the EXIST Business Startup program at the University of Münster and a PhD Candidate at ITC, University of Twente in the Netherlands. Her research expertise includes land administration, photogrammetry and remote sensing, as well as community mapping.

Kaspar Kundert is a fellow of the EXIST Business Startup program at the University of Münster. He lives and works since 2010 in Kigali, Rwanda where he advises on GIS and Geodata4Africa, with a special focus on advancing innovative mapping in support of sustainable development.

Malumbo Chipofya is Assistant Professor of Land Informatics at the University of Twente. His research interests broadly cover modelling customary land tenure systems, applications of distributed and decentralized systems in Land Administration, and sketch based geodata creation and use in Land Information Systems.

CONTACTS

Auriol Degbelo
University of Münster
Institute for Geoinformatics / SmartLandMaps
Heisenbergstrasse 2, 48149
Münster
GERMANY
Email: auriol.degbelo@uni-muenster.de
Web site: https://sites.google.com/site/aurioldegbelo

Claudia Stöcker
University of Münster
Institute for Geoinformatics / SmartLandMaps
Heisenbergstrasse 2, 48149
Münster
GERMANY
Email: claudia.stoecker@uni-muenster.de
Web site: https://www.researchgate.net/profile/Claudia_Stoecker

Kaspar Kundert
University of Münster
Institute for Geoinformatics / SmartLandMaps
Heisenbergstrasse 2, 48149
Münster
GERMANY
Email: kundert@uni-muenster.de
Web site: https://www.linkedin.com/in/kaspar-kundert-30286110/

Malumbo Chipofya
University of Twente
Department of Urban and Regional Planning and Geo-Information Management
Hengelosestraat 99, 7514 AE Enschede
The NETHERLANDS
Email: m.c.chipofya@utwente.nl
Web site: https://people.utwente.nl/m.c.chipofya