Its4land - Challenges and Opportunities in Developing Innovative Geospatial Tools for Fit-For-Purpose Land Rights Mapping

Mila KOEVA, Netherlands; Sophie CROMMELINCK, Netherlands; Claudia STÖCKER, Netherlands; Joep CROMPVOETS, Belgium; Serene HO, Belgium; Ine BUNTINX, Belgium; Angela SCHWERING, Germany; Malumbo CHIPOFYA, Germany; Sahib JAN, Germany; Tarek ZEIN, Germany; Christian TIMM, Germany; Kaspar KUNDERT, Rwanda; Placide NKERABIGWI, Rwanda; Berhanu ALEMIE, Ethiopia; Robert WAYUMBA, Kenya

Key words: Horizon2020, Land Tool, Cadastre, Eastern Africa, European Union

SUMMARY

Mapping millions of unrecorded land rights in large parts of Sub-Saharan Africa remains a challenge. The results of many existing ICT-based approaches for recording these rights have often proven to be inappropriate; therefore, a new generation of tools needs to be developed to map land rights faster, cheaper, easier, and more responsible. This is the main goal of its4land, a European Commission Horizon 2020 project that aims to develop innovative tools that respond to the continuum of land rights, fit-for-purpose approach, and provide cadastral intelligence. To deliver innovative, scalable, and transferrable ICT solutions, the its4land project builds on strategic collaborations between the EU and East Africa. The innovation process incorporates a broad range of stakeholders and emergent geospatial technologies including smart sketch maps, Unmanned Aerial Vehicles (UAVs), automated feature extraction, as well as sharing and publishing through geocloud services. The aim is to combine these innovative approaches with the specific needs, market opportunities and readiness of end-users in the domain of land tenure information recording in East Africa. Moreover, the tools target both top-down and bottom-up approaches and thus support formal land registration processes, as well as informal community based land resource documentation. The project consists of a four-year work plan, €3.9M funding, and eight consortium partners collaborating with stakeholders from different case study locations in Ethiopia, Kenya, and Rwanda that cover different land uses such as urban, peri-urban, rural smallholder, and (former) pastoralists. Major technical tasks include tool development, prototyping, and demonstration for local, national, regional, and international interest groups. However, equal emphasis is placed on needs assessment, as well as governance, capacity and business modelling.

This paper reports recent achievements, findings and challenges faced during the first half of the its4land project. The project's multi-disciplinary approach to capturing and sharing land tenure related information is presented. Stakeholders' needs, readiness, and market opportunities regarding the application of the four its4land geospatial innovative technologies, are described based on data collected from almost 60 different organizations and community groups. The paper outlines the opportunities and challenges faced in developing: 1) software tool for recording land tenure information based on hand-drawn sketch maps, 2) UAV-driven workflows for land tenure data acquisition and 3) a tool for automated delineation of visible cadastral boundaries from UAV data. The paper further highlights the potential opportunity of integrating all technologies and developed workflows into a unique its4land toolbox. Future plans and ideas for the development of a sustainable business model for commercialization of the integrated suite of land tenure recording tools within the end-user markets are shared in the paper.

Its4land - Challenges and Opportunities in Developing Innovative Geospatial Tools for Fit-For-Purpose Land Rights Mapping

Mila KOEVA, Netherlands; Sophie CROMMELINCK, Netherlands; Claudia STÖCKER, Netherlands; Joep CROMPVOETS, Belgium; Serene HO, Belgium; Ine BUNTINX, Belgium; Angela SCHWERING, Germany; Malumbo CHIPOFYA, Germany; Sahib JAN, Germany; Tarek ZEIN, Germany; Christian TIMM, Germany; Kaspar KUNDERT, Rwanda; Placide NKERABIGWI, Rwanda; Berhanu ALEMIE, Ethiopia; Robert WAYUMBA, Kenya

1. INTRODUCTION

In Sub-Saharan Africa, and also in many developing regions, there are numerous activities for land tenure recording; however, the results are deviating from the experts' expectations (Zevenbergen et al., 2013). With the challenges of incomplete recordation and escalated land disputes, an innovation for fast, accurate and cost effective land rights mapping is clearly needed.

A new generation of innovative land tenure tools which are scalable, transparent and applicable in conventional institutions are emerging (de Vries et al., 2015). Therefore, the main aim of the of "its4land", a European Commission Horizon 2020 project, is to develop innovative tools that respond to the continuum of land rights, fit-for-purpose approach, and provide cadastral intelligence.

The innovation process is based on four emergent geospatial technologies: smart sketch maps, Unmanned Aerial Vehicles (UAVs), automated feature extraction, as well as sharing and publishing through geocloud services. The aim is to combine these innovative technologies with the specific needs, market opportunities and readiness of end-users in the domain of land tenure information recording in East Africa. Moreover, the tools target both top-down and bottom-up approaches and thus potentially support formal land registration processes, as well as informal community based land resource documentation. The project consists of a four year work plan, €3.9M funding, and eight consortium partners collaborating with stakeholders from Ethiopia, Kenya, and Rwanda that cover different land uses such as urban, peri-urban, rural smallholder, and (former) pastoralists. Major technical tasks include tool development, prototyping, and demonstration for local, national, regional, and international interest groups. However, equal emphasis is placed on needs assessment, as well as governance, capacity and business modelling.

This paper reports recent achievements, findings and challenges faced during the first half of the its4land project, as well as the potential opportunity for integrating all aspects of the project into a unique its4land toolbox. The paper concludes with future plans and ideas for the development of a sustainable business model for commercialization of the integrated suite of land tenure recording tools within the end-user markets.

2. BACKGROUND

"The its4land project is a 'Research and Innovation Action' and is formally governed through the European Commission's Horizon 2020 Industrial Leadership program focused on international partnership building in low and middle income countries through the development of new technologies. More specifically the 'Leadership in enabling and industrial technologies – Information and Communication Technologies ICT (H2020- EU.2.1.1.)', under the call H2020-ICT-2015. The specific topic is 'International partnership building in low and middle income countries' ICT-39- 2015. As part of the global aim of the project can is also the idea of reinforcing strategic collaboration between the EU and Eastern Africa. It also aims to demonstrate how multi-sectorial, multi-national, and multidisciplinary design work can take place.

The consortium is multi-sectorial, multi-national, and multidisciplinary. It includes SMEs and researchers from 3 EU countries and 3 East African countries which are from Belgium (KUL – KU Leuven), Ethiopia (BDU-Bahir Dar University), Germany (WWU-University of Muenster; Hansa Luftbild), Kenya (Technical University of Kenya) the Netherlands (University of Twente), and Rwanda (INES Ruhengeri; ESRI Rwanda). In addition to technology development, the transdisciplinary work also develops supportive models for governance, capacity development, and business capitalization. Moreover, gender sensitive analysis is also incorporated.

Independent to European Commission project oversight, the project includes a dedicated Advisory Board (AB), Valorization Panels (VP), and communications and dissemination channels. The project also maintains its own ICT infrastructure to support project management, internal communications, and data management. The setup seeks to cover the depth and breadth of the land tool sector. The project operates in multiple locations across East Africa, with all case locations having different foci and including a mix of livelihoods and landscapes such as urban, peri-urban, rural smallholder, and (former) pastoralist areas.

2.1 Rwanda

In Rwanda there were huge changes with regards to land which aimed to regularize all existing lands under private, leasehold, and state tenures (Biraro, 2015a). To achieve this, a fit-for-purpose approach was used to rapidly record the whole country with an accuracy of 1-5m. More than 10 million land parcels were registered between 2009 and 2013. The challenge still remaining is how to keep the system up-to-date (Biraro, 2015b). As discussed also by Ho et al (2017) in Musanze, up-to-date land information is needed to balance the demand for urbanization and expand tourism. However, there are some economic and administrative factors that affect its realization due to current mechanisms and processes which do not actively facilitate data integration with the cadastral map to support decision-making processes. During field visits, the its4land team observed that basic topographic information such as buildings, plots and visible infrastructure, etc. is still missing – data which is important for planning at all levels. Therefore, selecting a suitable geospatial technology which can be used for maintaining and updating land information in a fast and affordable way can potentially contribute to this challenge. In this context a lot of research has been conducted worldwide, and also in Rwanda, on using Unmanned Aerial Vehicles (UAVs) (Koeva et al., 2016).

2.2 Kenya

In Kenya, pastoralism constitutes 84% of the country's total land use (Lengoiboni et. al, 2011). Therefore, one of the main challenges for the its4land project is to find the most suitable solution for recognizing pastoralist land rights, most of which has been held under customary tenure arrangements, which up till 2016, were not constitutionally recognized as a legal tenure type. However, such land use is temporally and spatially dynamic. This is exacerbated by colonial and post-colonial land reforms that sought to privatize land rights but weak land governance systems have resulted in poor quality land information. This has led to a lack of transparency over land dealings, resulting in chronic land related conflict in the country. An aim for its4land in Kenya is to leverage the geospatial technologies to not only contribute to mapping pastoral land rights, but more generally to contribute to improving the quality of land information in the country.

2.3 Ethiopia

Its4land project in Ethiopia is focused on two different cases: peri-urban and rural landscapes. Bahir Dar is one of the fastest growing cities with dominant peri-urban territories where the growth is in all directions. In Ethiopia the urban and rural land administration is separated in different institutions. Moreover, with this complexities in the landscape to distinguish a clear boundaries is quite challenging. For establishing cadaster and land administration system in the urban areas different donors, stakeholders and authorities are joining their forces. After the analysis of the possible available tools, the usage of high-resolution UAV images, geocloud services, usage of sketchmaps and automatic techniques for boundary delineation are seen as potential solutions to improve existing designs.

In the rural areas high level land degradation and land fragmentation can be observed. For reducing poverty and enhancing land productivity, responsible land consolidation is seen as a solution (Bennett and Alemie, 2016). Therefore, in the rural areas in Ethiopia there is a clear opportunity for providing local stakeholders with information such as: up-to-date images and tools for recording land data to help in the consolidation process.

3. CONTEXTUALIZATION-GET NEEDS

From the very beginning of the project the partners from KU Leuven started with their major task to capture the specific needs, market opportunities, and readiness of end-users in the domain of land tenure information recording. In 2017, they engaged with 57 organizations and community groups across the three case countries (more than 100 individuals) – Ethiopia, Kenya and Rwanda – seeking to identify relevant land issues, document land tenure information needs, readiness requirements for using its4land technologies and potential market opportunities.

The data collected indicate that cadastral data is still recognized as a critical land information need. This encapsulates common conventional requirements (e.g. accurate spatial data, tenure systems and inherent rights, restrictions and responsibilities (RRRs), and a range of socio-economic attributes of the right holder. The history of land-based conflict in these countries directed the need to acquire other ownership evidence (e.g. history of acquisition, neighbors, etc.) to support unambiguous determination of land tenure RRRs. Poor expropriation and compensation practices also stimulated the desire among communities for other property data (e.g. type of crops, fixtures on land, irrigation systems, etc.). Rwanda offered a point of difference: a centralized government focused on balancing urban-regional growth linked land information needs to development objectives. Therefore needs were focused on improving the quality of non-cadastral data and integrating this with the cadastral fabric for more insightful decision-making. In addition, since Rwanda's national land tenure regularization program has provided the government with a good source of data for decision-making, stakeholders agreed on the need to maintain the quality of cadastral data and improve data management especially data accessibility.

To meet these needs, UAV technology was considered to be of greatest potential to exploit. The other its4land tools – smart sketchmaps, automated feature extraction and geocloud services – had less clear innovation pathways, attributed to the difficulties that stakeholders often had in understanding the concepts behind the technologies, and often based their perceptions on the more familiar aspects of the technologies. Common readiness requirements identified included strategic requirements (align need with policies, political will and change leadership); structural and/or governance requirements (develop appropriate frameworks to direct action at a national level coordinate and manage new relationships between stakeholders for using the technologies and their data); organizational requirements (local changes that build organizational capacity including technical elements).

There was limited insight into potential market opportunities, with stakeholders generally believing that the likely 'market' for the its4land technologies lay in producing land information as a public good. In the short term, the main market will be the public sector; however, sound land information can lead to the development of secondary markets such as location-based goods and services in the private sector. The its4land technologies also likely face competition for resources in each of the countries, e.g. donor-funded certification and a rural land information system in Ethiopia, other fit-for-purpose technology testing in Kenya, and a reliance on proprietary GIS systems in Rwanda. In all countries, innovation will also likely disrupt existing workflows and processes.

4. RESULTS - INNOVATIVE TOOLS FOR LAND RECORDING

4.1 Software tool for recording land tenure information based on hand-drawn sketch maps

The work of the project partners from the University of Munster is related to the implementation of a sketch based geospatial data recording tool, called Smart SkeMa, especially tailored to capturing land tenure data from a local perspective. The main components of the work are (i) developing a domain model of concepts used in the description of land resources and tenures within localized contexts (e.g. at community level or within cultural groups); (ii) developing spatial models for representing sketch maps as records of land tenure information; (iii) developing methods for recognition of land tenure sketch maps and for embedding the sketch maps within existing spatial data sets (sketch map alignment).

The development of Smart SkeMa has been informed, in part, by data collected during field visits to Kenya and Ethiopia. These data were used primarily for the development of the domain model and the modules for recognition and interpretation of sketch maps.

4.1.1 Data collection - Field visits to Kajiado, Kenya and Bahir-Dar Ethiopia

Data collection was performed in workshops organized with communities. In Kenya the target community were pastoralists in Kajiado county and Ethiopia the community were an agricultural settlement on the outskirts of Bahir-Dar city in Amhara state. Each workshop consisted of an introductory lecture about mapping and how communities can develop their own land records using simple hand drawn maps. Then we carried out open discussions prompting the participants to discuss specific issues that they considered important and which could be more easily illustrated using maps. Some of the issues discussed included mapping of vegetation or water areas and some participants wondered whether these kinds of maps could be used for tracking changes in vegetation patterns. Focusing on such land issues, spatial information was collected via freehand sketches and through discussions with participants. During the group discussions participants also contributed additional information or missing information in the prepared maps. From the two field visits to Kenya and Ethiopia, 73 sketch maps at two different scales were collected. Out of the 73 sketch maps, 44 are large area sketch maps while the remaining sketch maps contain detailed local information. This data was used in the design processes for both the domain model and the sketch recognition tool.

4.1.2 Object recognition system

For the sketch recognition part, three well-known matching approaches in the area of computer vision: template based matching, supervised learning using Haar cascades (Viola P, et al., 2001) and Histogram of Oriented Gradients (HOG) together with Support Vector Machines (SVM) were explored (Dalal N, et al., 2005). The quality of the images of sketch maps taken with a mobile phone could be further improved by applying the stroke detection technique of Epshtein et al. (2010).

4.1.3 Domain Modelling

Domain model, termed the Maasai of Southern Kenyan Ontology (MSKO), was developed, by documenting concepts related to land usage in the Maasai culture in general from the literature and some concepts specific to the communities that were visited. The initial outcome, which was a glossary of terms, has been extended into a formal OWL ontology using Protégé as the modelling tool. Important concepts are annotated with images to clearly illustrate the associated concept for each term. The images and field data informed the design of the visual symbols to be used during sketching exercises.

4.1.4 Qualitative Representation of Land Tenure Maps

In the second quarter, the focus was more on current tasks especially on implementing the qualitative representations of input maps. These are necessary as an interface between the sketch map and the base map data. As with the sketch recognition work, all the components in python were implemented using Jupyter notebooks to provide better accessibility of the work. This work entirely technically involving the study of different ways to abstract away the details of numeric spatial representations (vector or raster) to obtain more cognitively plausible representations – such representations that preserve topology but do not guarantee preservation of distances.

4.1.5 Looking Ahead

During the discussions with different stakeholders, it became apparent that while almost all stakeholders found the idea of smart sketch maps interesting, many of them did not fully grasp how it would work in detail. As such, a main goal for the project is to complete an initial demo that supports an end-to-end community mapping workflow. This will enable the engagement of potential users and open opportunities to test the tool in a real world application context.
In order to make the tool useful for local authorities as well we are also generalizing the MSKO domain model and linking it with the Land Administration Domain Model (LADM). A final step in this journey will be to provide simple user interfaces for interacting with each of the Smart SkeMa's components.

4.2 UAV- driven workflows for land tenure data acquisition

The team from University of Twente (ITC) designs, tests and validates a UAV driven land administration workflow. In order to do so, a logical approach studying first policy and legal developments regarding UAV regulations in general and focus on regulatory frameworks for UAV flights in East Africa in particular has been followed. Based on the outcomes of this legal prerequisite, a phase of test flights and prototyping provides guidelines to design efficient operational workflows which meet the needs of respective users. Data acquisition workflows encompass the whole operational UAV procedure including flight planning and preparation, field work, data processing and quality assessment. Key aspects concern regulatory frameworks, the minimization of ground measurements and the implementation of the UAV workflow into each country context.

After a detailed analysis of the existing UAVs, a fixed wing UAV DT18 PPK by DelairTech was selected. One of the main reasons refers to its capabilities for mapping large areas. With a flight time of up to 90min the UAV can capture more than 1 km² during one flight with a ground sampling distance of less than 3cm. This UAV allows for direct georeferencing which tremendously minimizes the time and costs for ground surveying / truthing activities. A data quality assessment of the tests flights performed in Toulouse revealed 5-8cm absolute geometric accuracy. Each of the above-mentioned African countries received the same UAV and pilot training.

4.2.1 UAV legislation

With Rwanda, Kenya and Ethiopia, all African case locations of its4land present a different setup when it comes to UAV regulations. Rwanda enacted its regulations in April 2016 whereas Kenya just gazetted its UAV regulations in November 2017. Although at a slow pace, Ethiopia is heading into the right direction to enforce a legislation that deals with UAV flights. A comprehensive research investigation of the current status of UAV regulations in a global context is outlined in Stöcker et al. (2017). The outcomes can help to approach relevant stakeholders and to provide guidance for upcoming flights even if legal frameworks are not yet enacted. At the time being, Rwanda showcases the best status: the its4land drone was quickly released from customs and is already registered at Rwanda Civil Aviation Authority (RCAA). Two dedicated pilots are in the process to receive their official Rwandan UAV pilot license which requires a CAA-approved practical and theoretical flight assessment. The third and final step to reach full implementation refers to the operator certification which requires a special license for the institution that operates the UAV. Here, INES Ruhengeri will strive to obtain this certification in the next three months. In the meantime, a local Rwandan UAV- company named Charis UAS Ltd. is certified to operate the DT18 for the its4land project. In Kenya, before the UAV regulations became legally binding (Nov 2017), the only way to commence UAV flights was the possession of a special flight permission. This exemption was granted for the its4land partner at the Technical University of Kenya and includes as special flight permission for three weeks at a given location. The release of the UAV equipment from customs as well as the legal flight permission in Ethiopia involves the biggest challenge as the use and import of UAVs is strictly forbidden. Sensitization and communication with respective authorities are ongoing.

4.2.2 UAV data collection

Several test flights with the DT18 PPK in Germany provide sufficient data to evaluate influencing parameter on the data quality as well as initial conclusions of technological opportunities and limitations of the UAV equipment. Different ground truthing strategies as well as various processing scenarios reveal valuable insights to guide initial test flights in Rwanda and Kenya. Time consuming field work to measure high quantities of GCPs becomes obsolete and makes large-scale UAV mapping a more feasible solution for practitioners that require high geometric accuracies (Stöcker et al. 2017). After a successful maiden flight in Rwanda, potential use cases are discussed with the authorities. Additionally, several data collection flights were completed in collaboration with Charis UAS and both the peri-urban as well as the urban study area in Rwanda are already captured with UAV images. Besides Rwanda, the special flight permissions for Kenya allows to conduct UAV data collection missions in the rural Maasai land and in peri-urban Kisumu.

4.2.3 Looking Ahead

Data collection activities will increase in the next months. This rich database with various contexts, use cases and UAV flight settings will provide a profound basis to gain insight into UAV driven data acquisition workflows. Besides the research for the prototype of the UAV-based mapping workflow, knowledge transfer and capacity building in the African partner countries will play a key role. Presentations, workshops and customized tutorials will help to establish the UAV technology in the countries.

4.3 Tool for automated delineation of visible cadastral boundaries from UAV data

This innovation led by University of Twente (ITC) aims to design and implement a tool for automated boundary delineation for cadastral mapping. This is done by supporting the delineation of visible cadastral boundaries through automatically extracted features from UAV data. The tool is designed to delineate physical objects demarcating visible boundaries, which are assumed to make up a large portion of all cadastral boundaries. Those visible boundaries bear the potential to be extractable with computer vision methods (Bennett et al., 2010; Crommelinck et al., 2016; Zevenbergen and Bennett, 2015). Such an approach cannot deliver complete matching – as some cadastral boundaries are only social and not visible to optical sensors – however, even 50% matching would radically alter tenure mapping in terms of cost and effort.

The current functioning of the tool consists of (i) a methodology that automatically extracts and processes candidate cadastral boundary features from UAV data, and (ii) a procedure for a subsequent interactive delineation (Figure 1). Part (i) consists of two state-of-the-art computer

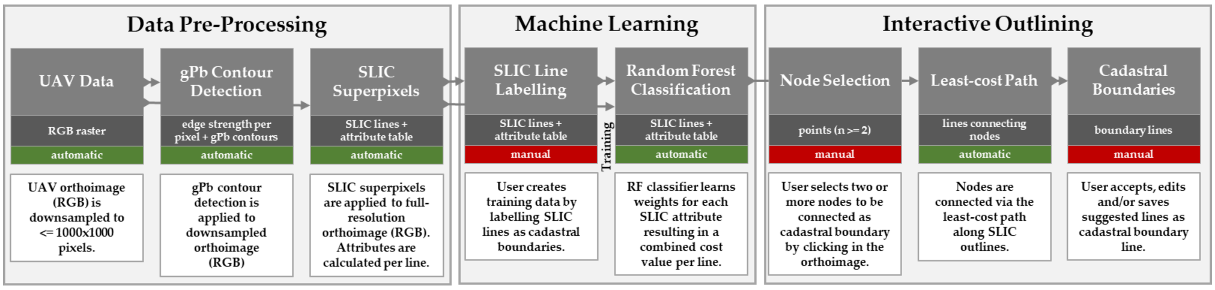

Figure 1. Delineation workflow for automated delineation of visible cadastral boundaries.

vision methods, namely gPb contour detection and SLIC superpixels, as well as a machine learning part assigning costs to each outline according to local boundary knowledge. Part (ii) allows a user-guided delineation by calculating least-cost paths along previously extracted and weighted lines. The approach has been tested on visible road outlines in two UAV datasets from Germany. Results show that all roads can be delineated comprehensively. Compared to manual delineation, the number of clicks per 100 m is reduced by up to 86%, while obtaining a similar localization quality. The approach shows promising results to reduce the effort of manual delineation that is currently employed for indirect (cadastral) surveying.

The theoretical foundation for the tool development has been described and published (Crommelinck, S. et. al. 2016). The same applies for investigations on the state-of-the-art computer vision approaches, namely gPb contour detection and SLIC superpixels, that have been evaluated separately and determined as efficient for UAV-based cadastral mapping (Crommelinck, S. et. al. 2017a; Crommelinck, S. et. al. 2017b).

Future work will focus on the tool's transferability to different scenarios and its in-field applicability.

5 TOOL INTEGRATION

5.1 Publish and share

One of the primary tasks of the partners from Hansa Luftbuild is the development of a technical platform for hosting and integrating the results, methods and tools developed by the other project partners. The technical platform is considered as the publish and share platform.

It can be considered on the on hand as a runtime environment for the tools developed in its4land and on the other as provider of integrating data and information in existing LAS or other tools. The implementation follows a toolbox approach. Publish and share provides a framework of common APIs and services used by all its4land tools. Following the toolbox approach user can select those its4land tools fitting best to his tasks. The publish and share framework can further be used to implement additional tools and methods.

The other main aspect of publish and share is the dissemination and share of data created by its4land tools to external user or systems. This will be done by service interfaces based on standards from OGC and W3C. The modeling of the interfaces follows the concepts introduces by LADM. External systems like LAS or planning systems can use this to integrate data into their own process, based on the specific national rules.

The current focus is characterized by matching requirements from the investigation made by KU Leuven related with the needs and preparing a consolidated understanding of the proposed demonstrator platform. Major efforts has been made in the joined work with colleagues developing the tool for hand-made sketch maps in adapting LADM for qualitative data and creating qualitative extended spatial reference data from this input source. An algorithm to process semantic recognized sketched object and transform corresponding qualitative representations into (approximate) metric coordinates was developed. A proof of concept implementation of the algorithm was done.

The adapted version of the land administration domain model (LADM) forms the basis for organizing and integrating qualitative described data. The already developed algorithm to create (approximate) shapes for sketched objects will be developed to prototype level and integrated into the publish and share platform. This will allow using standard interfaces like OGC WFS/WMS, REST or GeoJSON by separating the internal model of qualitative described land tenure information and their representation.

The work will then focus on integration of the tools developed by the other partners into the publish and share platform. To follow the paradigm of geocloud, the tools will be encapsulated as services with an appropriate API. The usage scenarios and workflows to combine the its4land tools with land administration systems will be defined and implemented.

5.2 Govern and grow

To support scaling and sustainable use of the its4land technologies, KU Leuven is undertaking ongoing activities that deals specifically with the development of a governance model (including a model for capacity development) to support the use of innovative tools. Aligning with the fit-for-purpose approach, this will be done especially with the aim to meet stakeholders' needs and the creation and partial implementation of a capacity development model in order to strengthen the necessary skills and competencies so that the innovation process can have sustainable effects.

During the last months, the researchers of KU Leuven were focused on defining governance and capacity development, which aims to formulate an operational definition for governance and capacity development for the use of the its4land technologies. Therefore, a literature study was conducted to provide a short yet concise overview on widespread governance and capacity development definitions. This overview shed a light on a wide array of definitions, while specifically focusing on the theories and ideological standpoints useful for the its4land tools.

In order to extend and validate the gathered literature information and to avoid that western approaches and terms will be inappropriately imposed to the African context a panel of experts from valorization partners, exploitation managers and work package leaders were approached to give their views on the first version of the working definitions through an online survey. Their suggestions and recommendations were analyzed to refine and finalize the working definitions of governance and capacity development for the use of the its4land tools. From these activities, governance of the its4land tools is defined as *"the process of interactively steering the land tenure society to sustain the use of the its4land tools"* Capacity development for the its4land tools is defined as *"The development of knowledge, skills and attitudes in individuals and networks of people that are relevant for the uptake and sustained use of the its4land tools".*

The next phase 'Review of governance and capacity development models' aims to get a better interdisciplinary understanding of existing models of governance and capacity development. This involves an extensive literature review of contemporary publications on governance and capacity development models. Simultaneously, field work for empirical data collection will take place around this period. By the end of 2018, this theoretical review can be used for the development of the conceptual governance and capacity development models. These models will seek to draw on influences from other models for application to the its4land context, while being sensitive to the need to integrate different indicators from micro, meso and macro levels.

5.3 Capitalize

The last phase of the project involves the development of a sustainable business model for commercialization of the integrated suite of land tenure recording tools, within the end-user markets. Using the results from the technical work done in the project and in parallel with the work covering the development of sustainable governance and capacity building models, actor preferences (local communities, government, investors, and small and medium-sized enterprises) will be combined with products and services. This will be done in order to define a range of business model scenarios for the different sectors and case contexts. The results of the project will be commercialized and marketed as appropriate, as products or services, and offered to the public. In order to reach the above mentioned aim a valorization panel has been established with members from the three East African countries. During the field works of the colleagues from KU Leuven meetings were held with these members who were informed and updated about the project objectives and its progress.

Six exploitable results were identified by the project partners in a workshop on 16 October 2017. These results will form the basis in the exploitation and business modelling process which is now taking shape. The project partners are making use of the European Commission offered Common Exploitation Booster (CEB) support services in order to develop a business plan. These services aim to bridge the gap between research results and exploitation by helping the project partners in raising awareness on exploitation possibilities and exploitation planning. They also clarify issues, explore solutions and actions, and anticipate possible conflicts for a successful exploitation. In addition, they set up roadmaps for the long-term sustainability of the project results; and create value out of the novel knowledge.

6 CONCLUSIONS

All eight consortium partners of its4land project are collaborating to create new innovative tools that further support faster, cheaper, easier, and more responsible land rights mapping. This collaboration is particularly needed during fieldwork in Africa. Regular management, technical meetings and workshops are also organized. As an example, a CEB workshop is planned for March 2018, which will be run by a senior expert from the META Group (under contract by the European Commission). After the workshop, the its4land business plan will be developed.

The major tasks that were completed for the project during the past two years were related with assessing the specific needs, market opportunities, and readiness of end-users in the domain of land tenure information recording to support activities of the whole project. The work was focused in the case study locations in the three East African countries. The major achievements include the following: all the activities on contextualization were completed; the first version of the smart sketch maps ontology was done, UAVs for Land Rights A Guide to Regulatory Practice was written; a prototype for the automated boundary delineation was developed, UAV flight permission in Rwanda and Kenya were received; findings from its4land work were published in scientific journals, conference papers, posters and media.

Significant impact was also achieved in terms of establishing strong partnership with technology SMEs, linking more coherently with other Eastern African technology projects, utilizing our network to better interact with top-down and bottom-up users; and setting up media partnerships with reputable global geospatial industry publications, ICT advances, end-user understandings, enhancing innovation capacity etc. Overall, the results of the project are supporting not only Eastern African countries, governments, NGOs, and academia – but, also European Union (EU) technology, SME, and government sectors. This is done mainly by advancing EU geo ICT strengths, creating new and exploitable land tenure tools and strengthening EU-Eastern African partnerships. In the next period, the focus will be on knowledge sharing, global market access and potential social and environmental impact, mobile image processing and qualitative data processing platform, implementation of qualitative representation of sketchmap, documentation of extended LADM, writing of a technical report and manual on key flight scenarios and development of a business model.

ACKNOWLEDGEMENTS
The research described in this paper was funded by the research project "its4land", which is part of the Horizon 2020 program of the European Union, project number 687828.

REFERENCES

Bennett, R., Kitchingman, A., & Leach, J. 2010. "On the nature and utility of natural boundaries for land and marine administration". Land use policy, 27(3), pp.772-779.

Bennett, R. M., & Alemie, B. K. 2016. "Fit-for-purpose land administration: lessons from urban and rural Ethiopia". Survey Review, 48(346), pp.11-20.

Biraro, M., Bennett, R. M., & Lemmen, C. 2015a. "Accelerated Land Administration Updates". In: Advances in Responsible Land Administration, pp. 145-162.

Biraro, M., Khan, S., Konguka, G., Ngabo, V., Kanyiginya, V., Tumusherure, W., Potel, J. 2015b. "Final Report of Study on the access to the land tenure administration system in Rwanda and the outcomes of the system on ordinary citizens". LAND Project, USAID, Kigali, Rwanda.

Crommelinck, S., Bennett, R., Gerke, M., Nex, F., Yang, M., Vosselman, G. 2016. "Review of Automatic Feature Extraction from High-Resolution Optical Sensor Data for UAV-Based Cadastral Mapping". Remote Sensing, 8(8), pp.1-28.

Crommelinck, S., Bennett, R., Gerke, M., Koeva M.,Yang, M. Y., & Vosselman, G. 2017a. "SLIC Superpixels for Object Delineation from UAV Data". UAV-g conference, Bonn, Germany, pp.1-8.

Crommelinck, S., Bennett, R., Gerke, M., Yang, M. Y., & Vosselman, G., 2017b. "Contour Detection for UAV-Based Cadastral Mapping". Remote Sensing, 9(2), pp.1-13.

Dalal N, and Triggs B. 2005. "Histograms of Oriented Gradients for Human Detection." In CVPR 2005, IEEE Computer Society Conference On Computer Vision and Pattern Recognition, 1:886–893. IEEE.

de Vries, W. T., Bennett, R. M., & Zevenbergen, J. 2015. "Toward Responsible Land Administration". In Advances in Responsible Land Administration, pp. 3-14.

Ho, S., Biraro, M., Muvunyi, G., Wayumba, R. 2017. "Field Data Results, Version 1.", its4land, KU-Leuven, Belgium

ICAO, 2011. Unmanned Aircraft Systems (UAS). Cir 328 AN/190.

Koeva, M., Muneza, M., Gevaert, C., Gerke, M., & Nex, F. 2016. "Using UAVs for map creation and updating. A case study in Rwanda", Survey Review, 1-14.

Lengoiboni, M., Arnold K. Bregt, and Paul van der Molen. 2010. "Pastoralism within land administration in Kenya—The missing link." Land Use Policy, 27.2 pp.579-588.

Stöcker, E.C., Bennett, R.M., Nex, F.C., Gerke, M. and Zevenbergen, J.A. 2017. "Review of the Current State of UAV Regulations". In: Remote Sensing: open access, 9 (2017) 5article no. 459, p.26

Stöcker, C., Nex, F. C., Koeva, M. N., & Gerke, M. (2017). Quality assessment of combined IMU/GNSS data for direct georeferencing in the context of UAV-based mapping. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 42 (2017): 355.

UN-HABITAT. 2012. "Handling Land–Innovative Tools for Land Governance and Secure Tenure". GLTN. Nairobi.

Viola P, and Jones M. 2001. "Rapid Object Detection Using a Boosted Cascade of Simple Features." In CVPR 2001, Proceedings of the 2001 IEEE Computer Society Conference On Computer Vision and Pattern Recognition, 1: I–I. IEEE.

Zevenbergen, J., Augustinus, C., Antonio, D., & Bennett, R.. 2013. "Pro-poor land administration: Principles for recording the land rights of the underrepresented". Land use policy, 31, pp.595-604.

Zevenbergen, J., and Bennett, R. 2015. "The visible boundary: More than just a line between coordinates". In GeoTechRwanda, Kigali, Rwanda, pp 1-4.

BIOGRAPHICAL NOTES

Mila Koeva is an Assistant Professor working in 3D Land Information. She holds a PhD in 3D modelling in architectural photogrammetry from the University of University of Architecture, Civil engineering and Geodesy in Sofia. Her main areas of expertise include 3D modelling and visualization, 3D Cadastre, 3D Land Information, UAV, digital photogrammetry, image processing, producing large scale topographic and cadastral maps, GIS, application of satellite imagery for updating cadastral information among others. She is Chair of 3D GeoInfo 2018 and co-chair of ISPRS WG IV/10. From April 2017 she is Project Coordinator of its4land, a multidisciplinary European Commision Horizon 2020 project.

CONTACTS

Dr. Mila Koeva
Assistant Professor

University of Twente, ITC Faculty - Department of Urban and Regional Planning and Geo-information Management (PGM) Department
PO Box 217, 7500 AE Enschede, THE NETHERLANDS
Tel. +31 (0)5 3487 44 10
Email: m.n.koeva@utwente.nl
Web site: www.its4land.com, https://people.utwente.nl/m.n.koeva