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

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The Land Tool Evolution

Only 30% of the world’s population has access to formal land administration systems to register and protect their land rights.

Mapping cadastral boundaries using traditional, field based methods often proves to be time, cost and labour intensive.
The Land Tool Evolution

Recently there are many evidences that show that the existing ICT-based approaches for land tenure recording – do not deliver what is expected.

• **1\textsuperscript{st} Generation – Conventional**
  • precise, expensive, complex procedures,
  • requiring specialists, imported, government driven (mostly)

• **2\textsuperscript{nd} Generation – Pro-Poor / Fit-for-Purpose**
  • cheaper, less accurate, simpler, barefoot, para-surveyors,
  • bottom-up, manual, participation, grass roots, diversity, scalable...?

• **3\textsuperscript{rd} Generation – Socio-Technical Fusion**
  • high tech, human touch, partnerships, innovation/market focused,
  • end-user driven, automation, artificial intelligence, robotics
Program: H2020-ICT-2015
Type of Action: Research and Innovation (RIA)
Topic: International partnership building in low and middle income countries
Acronym: its4land
Number: 687828
Duration: 48 months
Start Date: 2016-02-01
Consortium: 8 partners
Budget: 3.9 M EUR
Its4land - Aim

To develop innovative tools to make land rights mapping faster, cheaper, easier, and more responsible.
Its4land - Innovation

The innovation process incorporates a broad range of stakeholders and emergent geospatial technologies including:

- Smart sketch maps
- Unmanned Aerial Vehicles (UAVs)
- Automated feature extraction
- 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.
Case locations

**RWANDA** - developing approaches that can support updating, at scale, land rights documents and maps

**KENYA** - adapting tools to enable mapping of pastoralist land rights and layered disputes

**ETHIOPIA** - developing approaches that improve plot recordation of urban smallholder and dwellers (peri-urban and rural landscapes)
**Contextualization - Get Needs**

KUL – 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.
Draw and Make

WWU Munster - Implementation of a sketch based geospatial data recording to capture land tenure data from local perspective.

Field visits to Kajiado, Kenya and Bahir-Dar Ethiopia (data collection, data verification/validation)
Draw and Make – main activities

Development of

1. A domain model for representing sketch maps
2. A system for automatic recognition of land tenure sketch maps;
3. Spatial models for representing sketch maps as land tenure records;
4. Embedding land tenure sketch maps within existing spatial data sets (sketch map alignment).
5. LADM extensions to integrate local domain models
Draw and Make – task overview (Object recognition)

1. Symbol extraction
   - House: geom = rectangle <1, 2, 3, 4,...>
   - Graveyard: geom = polygon <1, 2, 3, 4,...>
   - Forest: geom = polygon <1, 2, 3, 4,...>

2. Symbol deletion

3. Image Segmentation

4. Classification

5. Vectorization

Pattern detection and contour detection
Draw and Make – data collection/verification

Data covering large geographic areas should be collected at multiple scales

1. Large scale maps around areas of interest (highly informative regions)
2. Small scale to cover larger regions
3. Maps can then be joined by providing cross references

Supplementary materials used: Cadastral, topographic maps, aerial and satellite images
UAV workflow for land tenure data acquisition

UT (ITC) – To design, test and validate UAV workflow

Synthesis on the current state of UAV regulations

UAV workflow for land tenure data acquisition

• Selection of a suitable UAV
• Purchase, shipping and import UAVs
• Pilot training for 8 trainees (UT, HL, BDU, TUK, INES, ESRI)

• Fixed wing UAV, 60 min of endurance
• Payload:
  – Industrial grade RGB camera
  – IMU/GNSS Applanix APX-15
UAV workflow for land tenure data acquisition

- Selection of a suitable UAV, purchase, shipping and import UAVs
- Pilot training for 8 trainees (UT, HL, BDU, TUK, INES, ESRI)

Fixed wing UAV,
Payload:
- Industrial grade RGB camera
- IMU/GNSS Applanix APX-15

Reasons for selection:
- With a flight time of up to 90min the UAV can capture more than 1 km² during one flight with a GSD of less than 3cm.
- Allows for direct georeferencing (reducing the ground surveying work)
UAV - data collection

• Test flights in Germany (testing different ground trothing strategies and processing scenarios)

• Successful flights in:
  – Rwanda (Charis UAS)- urban and peri urban area – Musanze
  – Kenya (rural Maasai land and in peri-urban Kisumu)
  – Zanzibar (World Bank collaboration)
Automate UT (ITC) – To design a tool for automatic delineation of visible cadastral boundaries based on UAV images

Review background information
Automate

Globalized Probability of Boundary (gPb) Contour Detection

**Article**

Contour Detection for UAV-Based Cadastral Mapping

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**Abstract:** Unmanned aerial vehicles (UAVs) provide a flexible and low-cost solution for the acquisition of high-resolution data. The potential of high-resolution UAV imagery to create and update cadastral maps is being increasingly investigated. Existing procedures generally involve substantial fieldwork and many manual processes. Arguably, multiple parts of UAV-based cadastral...
Automate

Simple Linear Iterative Clustering (SLIC)
Automate

Combination of:
- The two state-of-the-art computer vision methods: gPb and SLIC
- Machine learning part (assigning costs to each outline according to local boundary knowledge)

Interactive user guided delineation (by calculating the least cost path by previously extracted lines)

Results: Compared to manual delineation, the number of clicks per 100m is reduced up to 86%
Tool integration

HL- To develop a technical platform for integrating the developed tools.

The implementation follows a toolbox approach – user can select the tools of his interest.

Following the idea for geocloud the tools will be encapsulated as services with an appropriate API.
Govern and Grow and Capitalize

- To understand how these technologies can be adopted and sustained
- To develop a sustainable business model for commercialization of the integrated suite of land tenure recording tools within the end-user markets.
Website – www.its4land.com

Kenyan Reconnaissance
6 days of learning and sharing

We’re creating seven new tools to make land rights mapping faster, cheaper, easier, and more responsible
Smart Surveyors for Land and Water Management