Horizon 2020
European Union funding
for Research & Innovation

ITS4LAND
innovations for land tenure

“its4land" - innovative geospatial tools for fit-for-purpose land rights mapping

Bahir Dar University 4th Land Conference

May 25th, 2019
Bahir Dar, Ethiopia

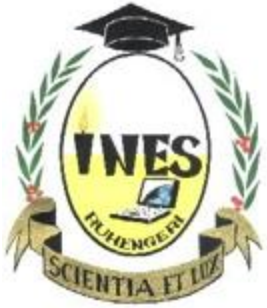
Project Snapshot

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 EU

UNIVERSITY OF TWENTE.

Hansa Luftbild
German Air Surveys

WESTFÄLISCHE
WILHELMS-UNIVERSITÄT
MÜNSTER



KU LEUVEN

Objective of its4land:

Developing an innovative suite of land tenure recording tools inspired by geo-information technologies that responds to end-user needs and market opportunities in sub Saharan Africa, reinforcing an existing strategic collaboration between EU and East Africa.

its4land - Innovations

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

- Smart sketchmaps
- Unmanned Aerial Vehicles (UAVs)
- Feature extraction
- Sharing and publishing through geocloud services

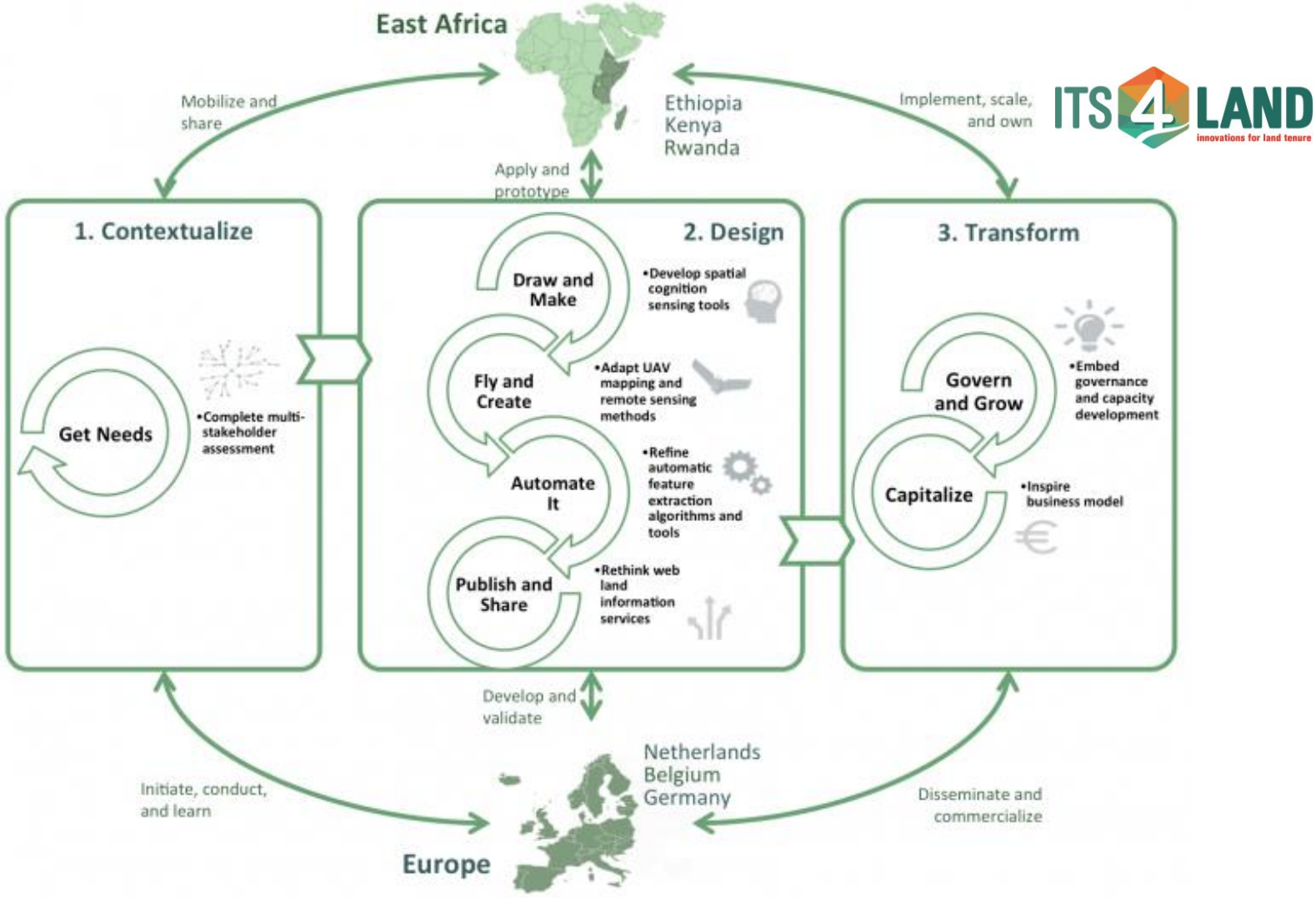
The aim was to combine these innovative approaches with the specific needs, market opportunities and readiness of end-users in the domain of land tenure information recording in East Africa.

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)


East Africa
Ethiopia
Kenya
Rwanda
Mobilize and share
Implement, scale, and own
Apply and prototype
1. Contextualize
Get Needs
•Complete multi-stakeholder assessment
2. Design
Draw and Make
•Develop spatial cognition sensing tools
Fly and Create
•Adapt UAV mapping and remote sensing methods
Automate It
•Refine automatic feature extraction algorithms and tools
Publish and Share
•Rethink web land information services
3. Transform
Govern and Grow
•Embed governance and capacity development
Capitalize
•Inspire business model
Develop and validate
Netherlands
Belgium
Germany
Europe
Initiate, conduct, and learn
Disseminate and commercialize

Results of its4land

its4land project created different results which can be exploited by the land administration community in developing countries

Key Exploitable Results of its4land

KER Type	KER Name	KER Brief Description
Consultancy	Needs Assessment	Consultancy services for needs assessment
Software	Smart Sketchmap (Smart SkeMa) Data Collection Tool	Smart Sketchmap is a tool to record aspects of people to land relationships where the spatial component is captured using hand drawn sketch maps and described in a qualitative way (not surveyed) and then automatically transformed for further usage in a GIS
Consultancy	UAV-based Data Acquisition	Consultancy services for UAV-based data acquisition for land tenure recording
Software	Semi-automatic Visible Boundaries Delineator	A tool that facilitates image-based cadastral mapping by extracting visible boundaries automatically and by supporting the delineation procedure.
Software	Publish and Share	Platform with integrated tools to publish and share land information.
Consultancy	Governance and Capacity Building	Consultancy services to apply the governance and capacity development models for the use of the its4land geospatial tools

its4land Land Administration Toolbox

All the its4land KERs are bundled in the its4land toolbox, a box which offers services and software tools which can be ordered separately or jointly

Consultancy Services for Needs Assessment

Land administration projects often don't explicitly include an assessment about the needs. Where such assessments do take place, feedback has highlighted the difficulty in quantifying these needs into a substantive basis that can inform project or policy decision-making. One of the methodological approaches which can applied to contextualize the requirements is the Nominal Group Technique (NGT), which has proven to be a simple and straightforward method that responds to quantifying the needs by both elucidating qualitative needs and translating these as quantitative outcomes.

Consultancy Services for Needs Assessment

The NGT method for conducting the needs assessment in land administration projects was employed in the its4land project. Employing the method in this project in East Africa during the contextualisation work presented a valuable addition to needs assessment strategies.

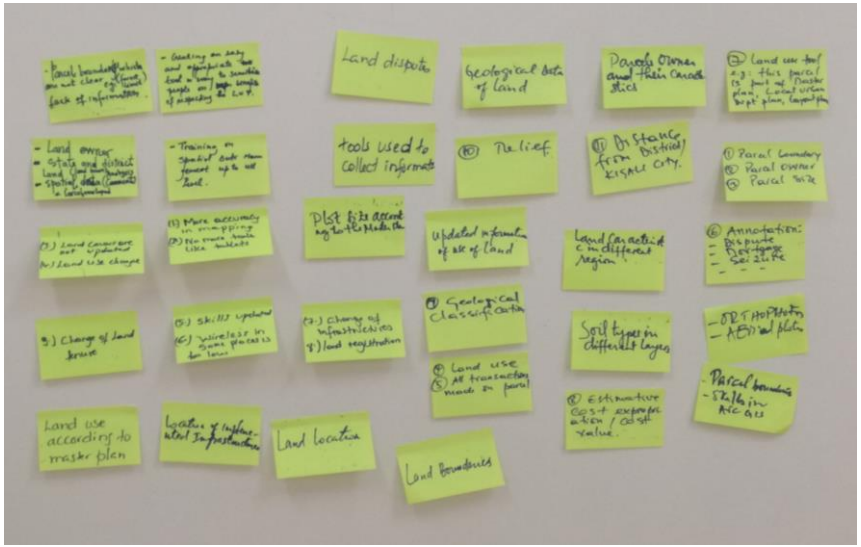
Consultancy Services for Needs Assessment

NGT application in its4land by its4land project partner KU Leuven:

57 organizations and community groups across the three case countries were engaged
(more than 100 individuals) in Ethiopia, Kenya and Rwanda

Main activities

- Semi-structured group interviews
- Workshops
- Qualitative and quantitative analysis
- Dissemination and communication



Pref.	Ethiopia	Kenya	Rwanda
Data input needs			
1	**Cadastral data (63%)** (Spatial attributes; socio-economic attributes; tenure type/RRRs; other ownership evidence; property attributes; accurate data; geodetic control points)	**Cadastral data (42%)** (Accurate data; tenure type/RRRs; spatial attributes; other ownership evidence)	**Non-cadastral data (30.2%)** (Infrastructure; development plans; land use; land use zone; geology; topographic data; climate)
2	**Non-cadastral data (19.5%)** (Land use zone; land use; administrative boundaries)	**Non-cadastral data (28.4%)** (Land use zone; natural resources; infrastructure; cultural sites; land injustices)	**Cadastral data (22.2%)** (Spatial attributes; accurate data; other ownership evidence; property attributes; socio-economic attributes)
3		Stakeholder engagement (2.7%) (Legal aspects; women's land rights)	Stakeholder engagement (3.2%) (Consultation)
Data use and management			
1	**Data management (10.9%)** (data maintenance; data security; LIS)	**Data analysis (10.8%)** (Data integration; analytical functions; digital data; multipurpose use)	**Data management (22.2%)** (Data accessibility; data maintenance; data ownership/availability; open source; mobile tools)
2		**Land transactions (5.4%)** (Dispute resolution; affordability)	**Data analysis (15.9%)** (GIS software; data integration; digital data)

What did we learn?

Regional outcomes

- Land info needs: cadastral data vs. non-cadastral data
- Data analysis and management needs: ET, RW
- All agree on potential of UAVs, but….
- other technologies also have potential, but with greater variation
- Governance conditions: federated systems vs. central government
- Market opportunities difficult to identify but broad agreement on the fundamental role of good quality land information in public service delivery

What did we learn?

Ethiopia:

- Concerns around improving integrity, transparency and equitability of land transaction processes
- Cadastral data a priority + other types of evidence
- (1) geocloud services, (2) smart sketchmaps, (3) UAVs
- Challenges for adoption and scaling e.g. land governance, differing levels of maturity in land administration

What did we learn?

Kenya:

- Need for improved cadastral data, but also better quality non-cadastral data
- UAVs clearly preferred
- Challenges for adoption and scaling e.g. lack of regulatory framework

What did we learn?

Rwanda:

- Need non-cadastral data prioritised
- Need to improve data management capabilities
- Still a need to improve cadastral data elements
- (1) UAVs, (2) geocloud services
- Significant practical challenges e.g. governance, capacity, etc.

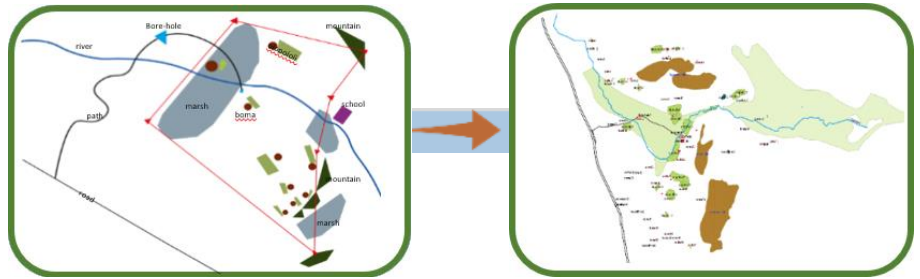
Tool preferences

Preference	Ethiopia	Kenya	Rwanda
1	Geocloud services	UAVs	UAVs
2	Smart sketchmaps	Automated feature extraction	Geocloud services
3	UAVs	Geocloud services	Smart sketchmaps
4	Automated feature extraction	Smart sketchmaps	Automated feature extraction

Smart Sketchmaps Data Collection Tool

Smart Sketch Maps (SmartSkeMa) a set of linked sub-tools which can be applied to two workflows:

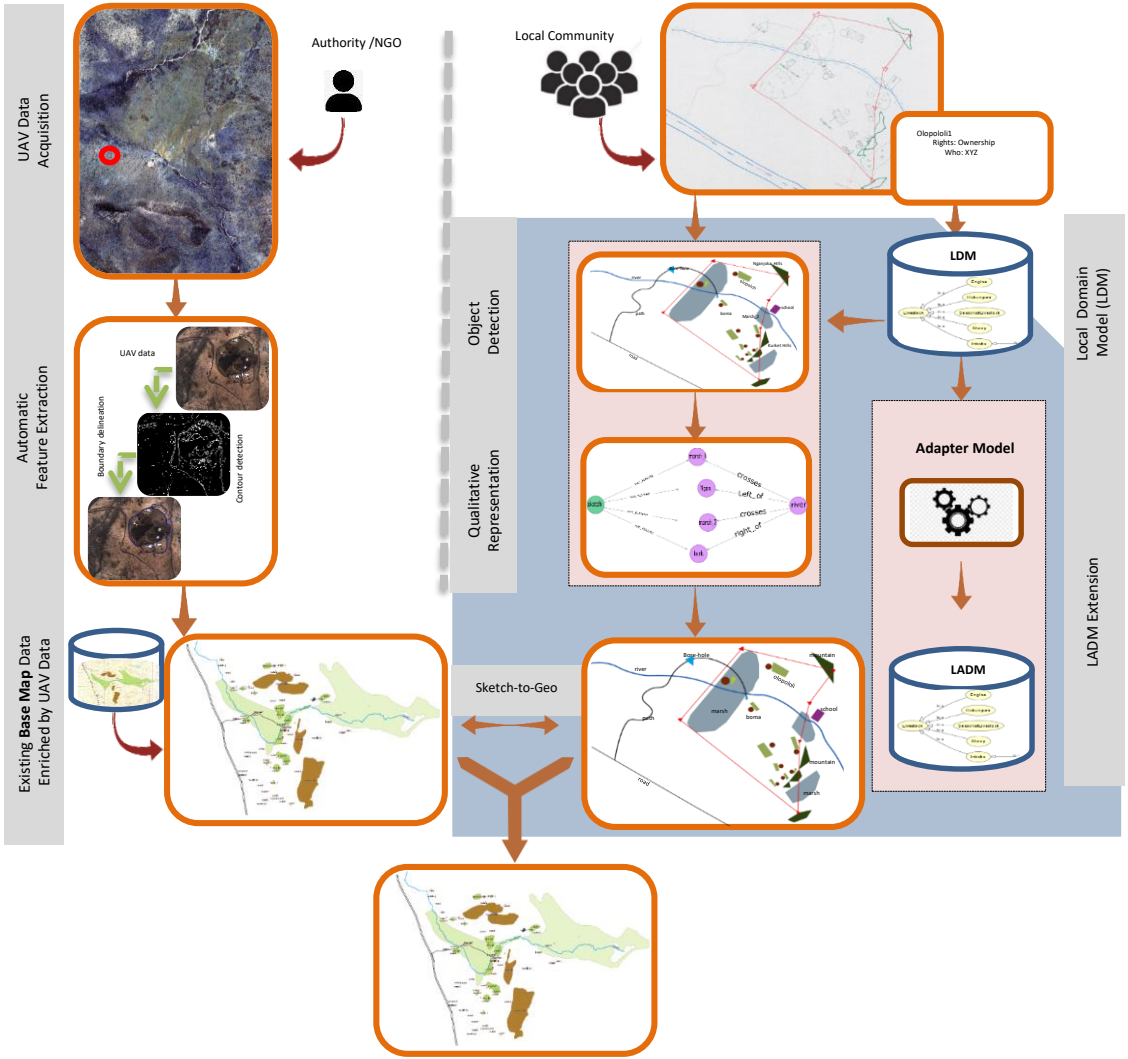
1. workflow covers the alignment of sketched information to base map data,
2. workflow concerns the alignment of sketched information to existing ortho-imagery.



Smart Sketchmaps Data Collection Tool

SmartSkeMa:
Sub-tools target NGOs, private organizations, research institutions, and government agencies using sketching as part of their work in the land/natural resources sectors.

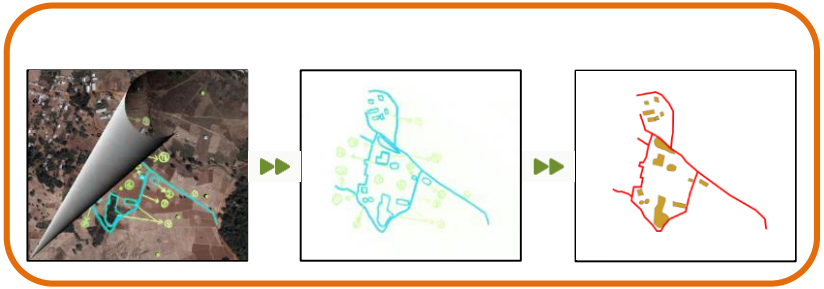
its4land project partner, University of Muenster (WWU), implemented the sketch based geospatial data recording tool

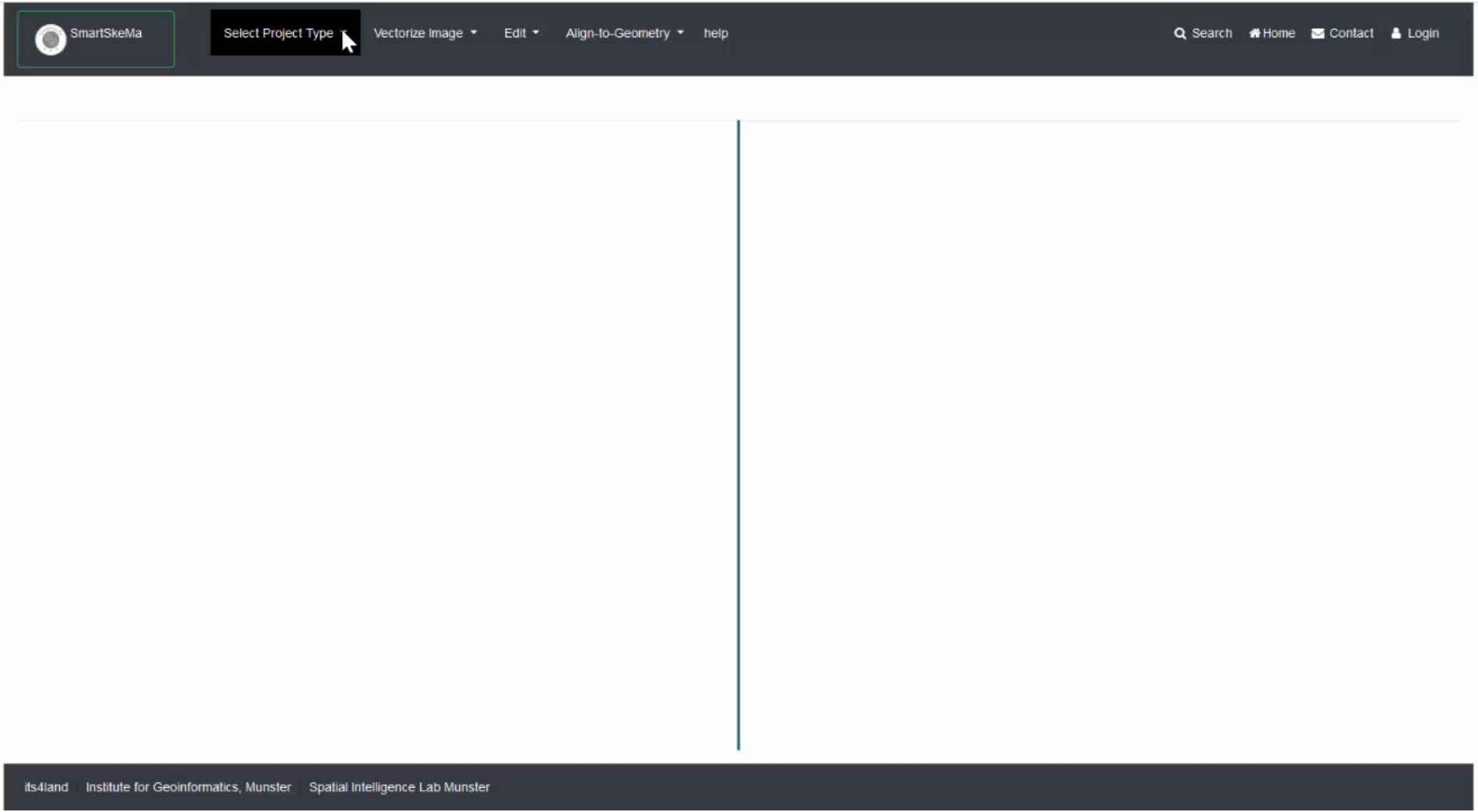

UAV Data Acquisition
Authority /NGO
Local Community
Olopololi1
Rights: Ownership
Who: XYZ
Automatic Feature Extraction
UAV data
Boundary delineation
Contour detection
Object Detection
Qualitative Representation
LDM
Local Domain Model (LDM)
Adapter Model
LADM
LADM Extension
Existing Base Map Data Enriched by UAV Data
Sketch-to-Geo

1. Workflow

2. Workflow

Extract features **drawn** on top of ortho-images and convert them into geo-referenced objects.




SmartSkeMa
Select Project Type
Vectorize Image
Edit
Align-to-Geometry
help
Search
Home
Contact
Login
its4land
Institute for Geoinformatics, Munster
Spatial Intelligence Lab Munster

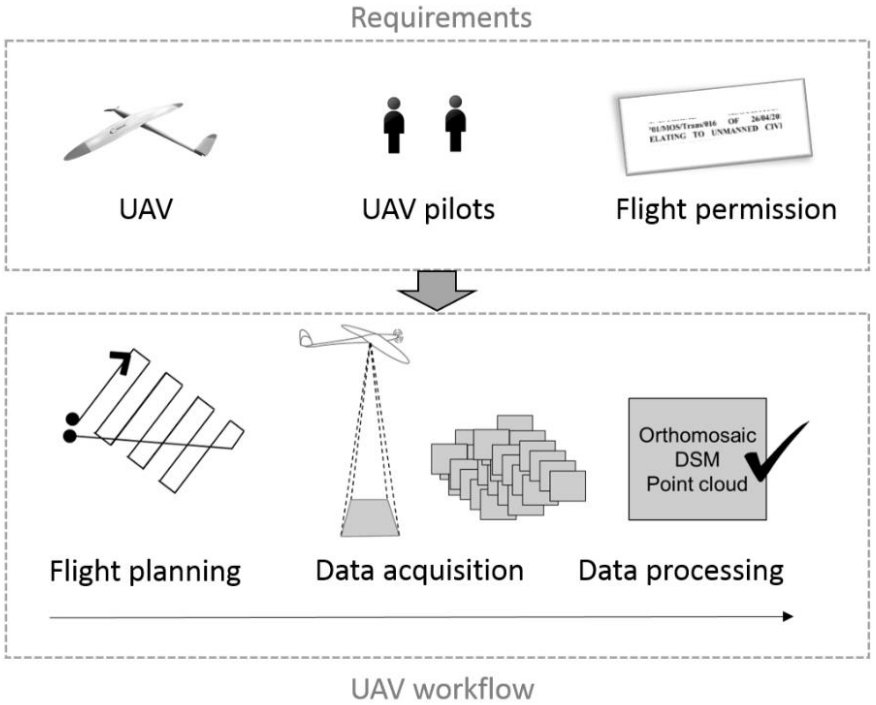
Consultancy Services for UAV Data Acquisition

Services include guidelines and a customizable workflow for UAV-based data acquisition in the context of land administration

Workflow designed, tested and validated by University of Twente (ITC) in Kenya and Rwanda (and Zanzibar - Tanzania)

Consultancy Services for UAV Data Acquisition

All requirements have to be fulfilled before starting the UAV data collection.



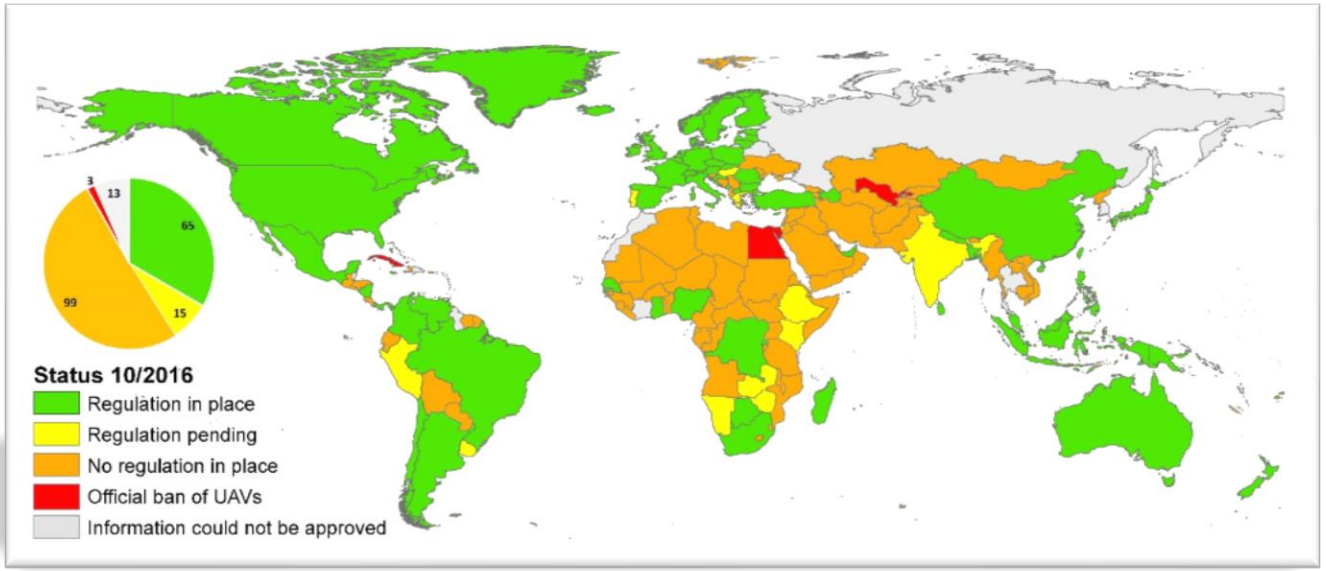
UAV Workflow

- Selection of a suitable UAV
- Purchase, shipping and import UAVs
- Pilot training

delair-tech
AIRBORNE SENSORING

- Fixed wing UAV, 60 min of endurance
- Payload:
  - Industrial grade RGB camera
  - IMU/GNSS Applanix APX-15

Flight Permission

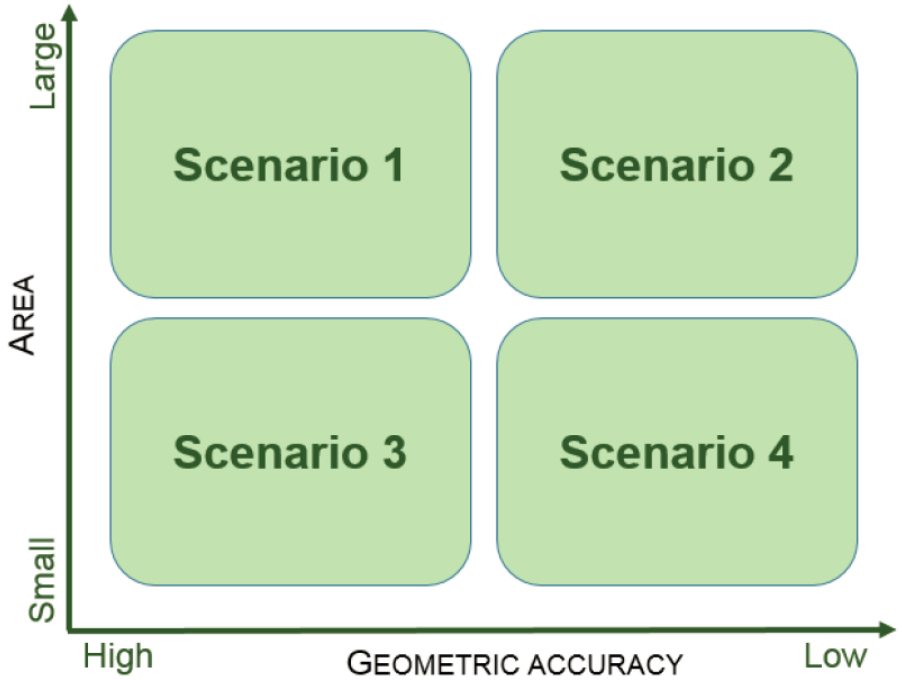


Significant impact on **how**, **where**, and **when** data can be captured

UAV workflow

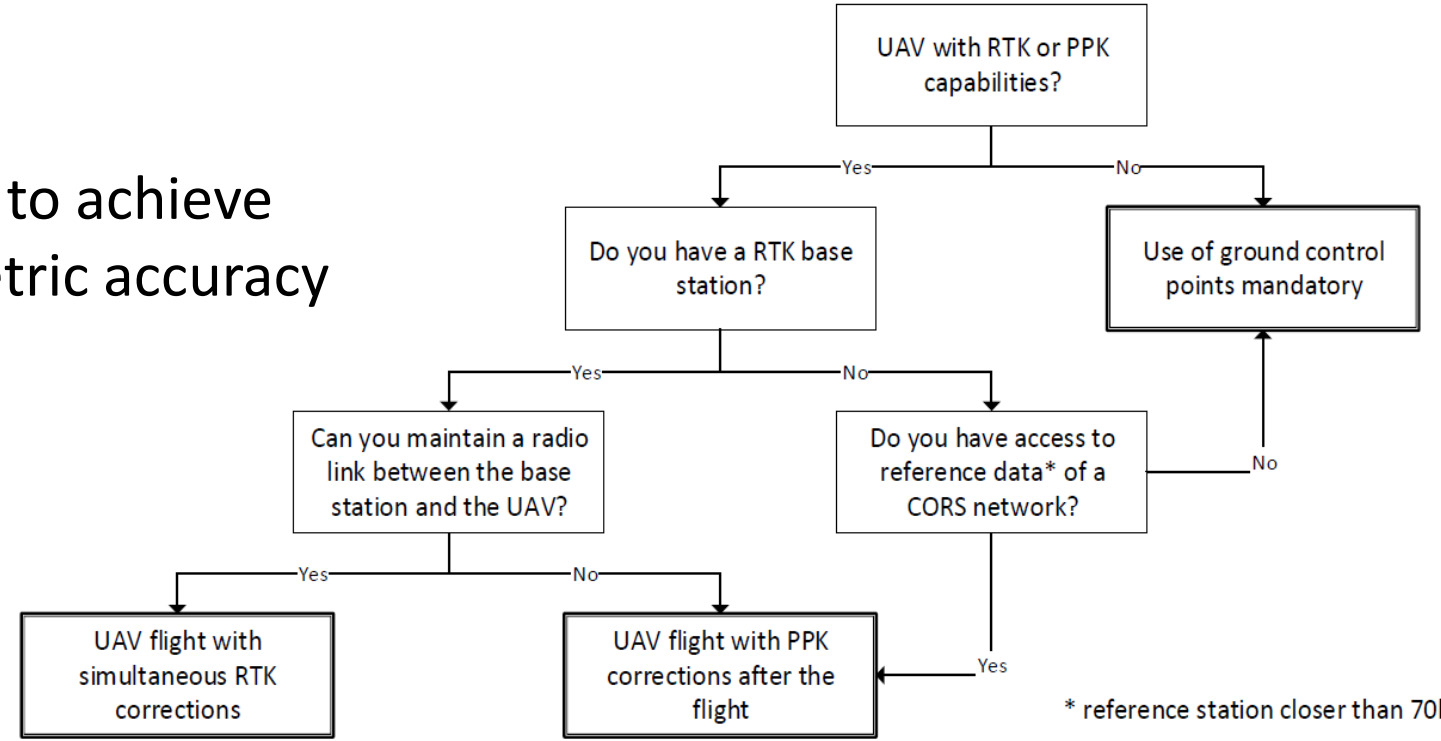
Scenario analysis:

- UAV equipment
- Flight planning
- Ground truthing
- Operational requirements



UAV workflow

Procedures to achieve high geometric accuracy

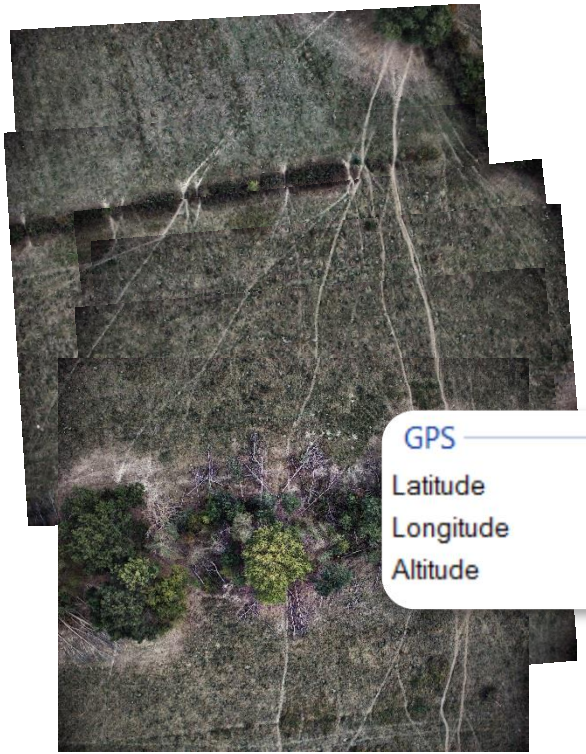


What can be provided by UAV imagery?

- High resolution orthophotos
- Digital surface models
- 3D point clouds

→ Derive information on land use, land tenure and land value
→ Automated image analysis to extract visible boundaries or land information

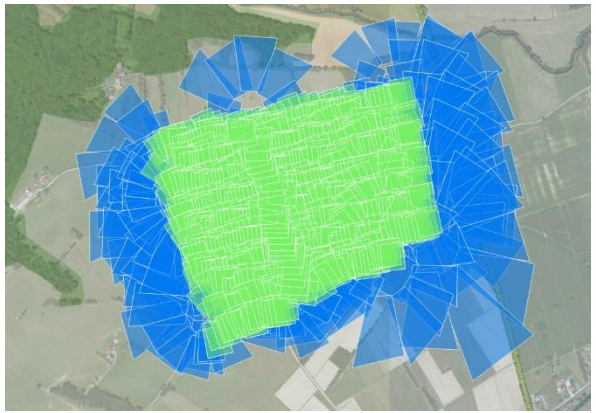
What can be provided by UAV imagery?



GPS	
Latitude	43; 13; 4.2147000000113977
Longitude	0; 59; 57.274920000000122
Altitude	416.136749

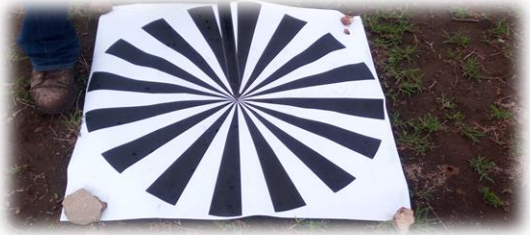
Metadata information: Geotag locations

Post-processing of images



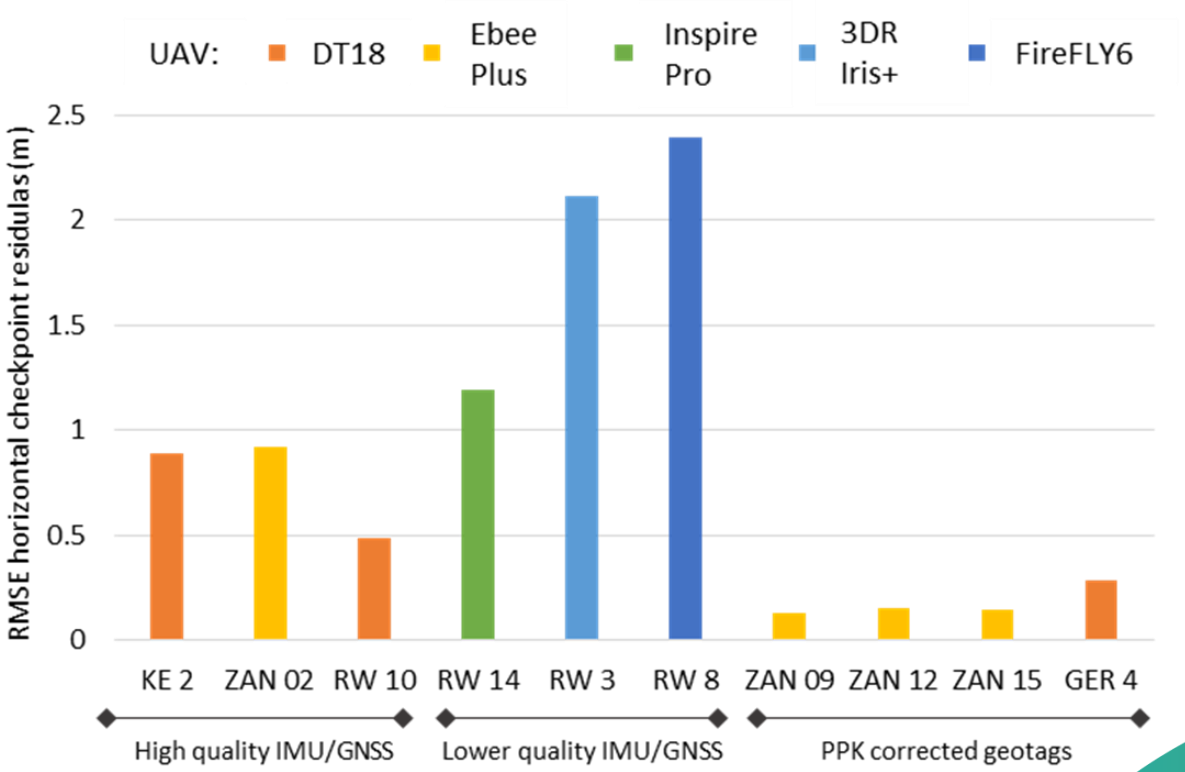
Rwanda

Kenya



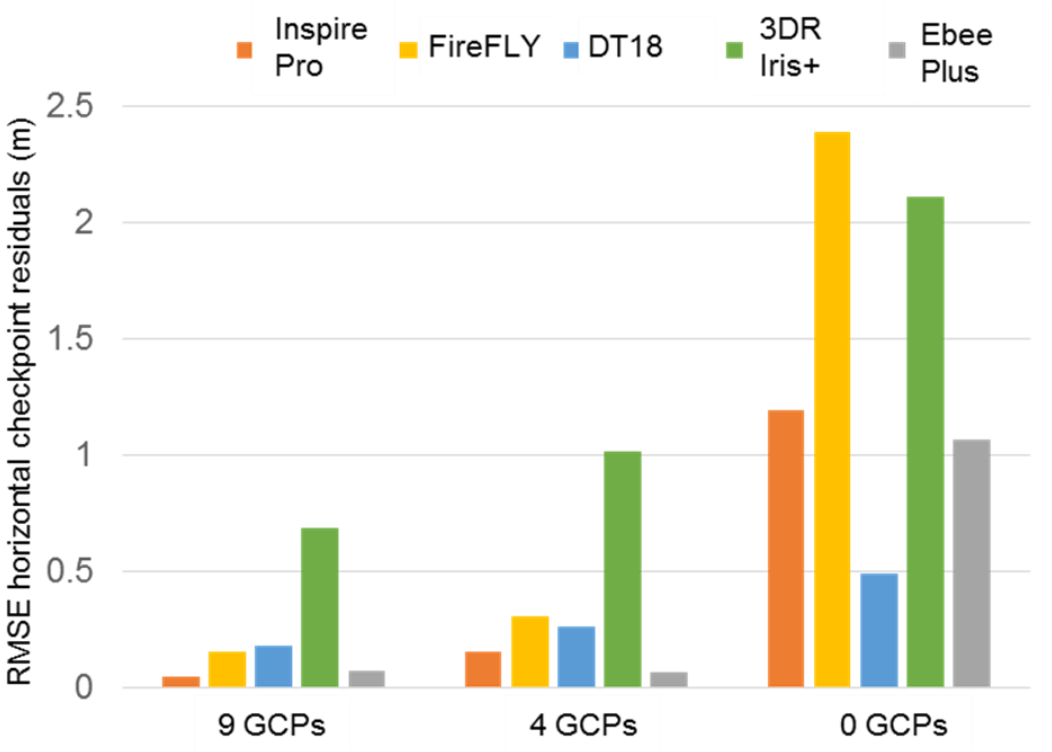
Tanzania

Data quality



- DT18 and Ebee plus operate with multi-frequency receiver
- InspirePro, 3DR Iris+ and FireFLY6 are equipped with a single frequency GNSS receiver

Data quality



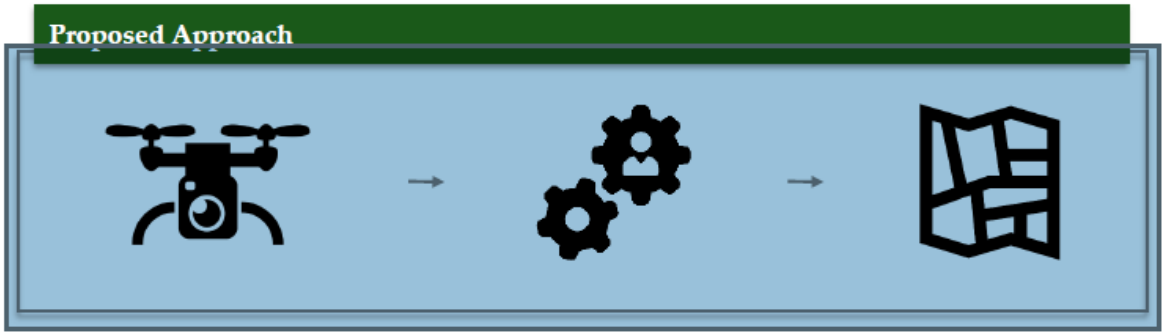
- Already 4 GCPs reduce systematic errors due to GNSS ambiguities
- High quality of DT18 GNSS with 0 GCPs
- If image quality is weak, even 9 GCPs cannot compensate poor block robustness

Semi-automatic Visible Boundaries Delineator

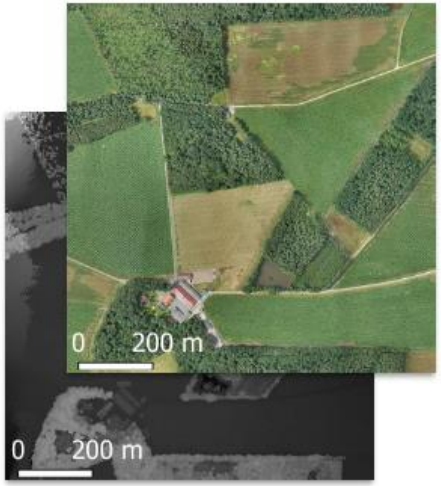
Tool designed for delineation of visible cadastral boundaries based on airborne /satellite images

Semi-automatic delineation of visible cadastral boundaries from aerial imagery

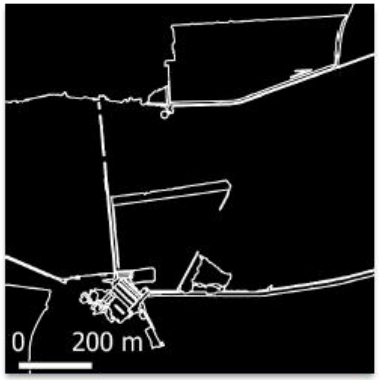
- Facilitate indirect cadastral surveying
  - by extracting visible boundary features
  - by making delineation more efficient



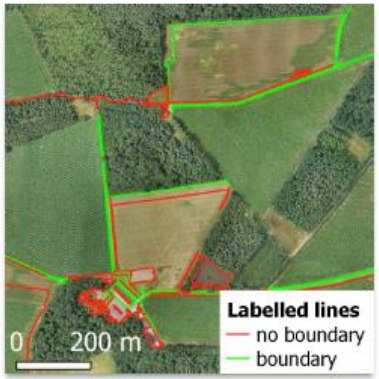
Feature Extraction Workflow



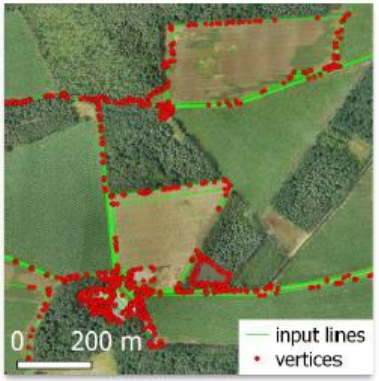
Input UAV data
RGB + DSM



(a) Image Segmentation



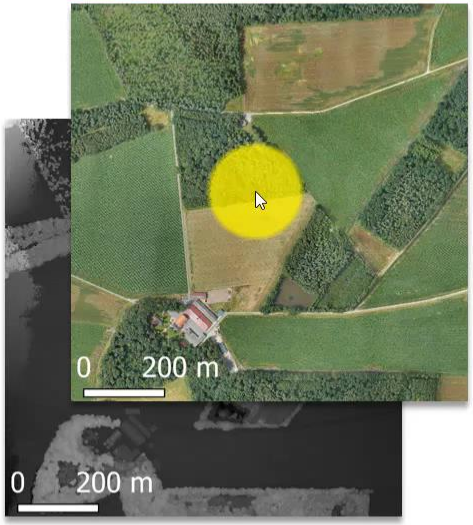
(b) Boundary Classification



(c) Interactive Delineation

Applied workflow to detect and extract linear features considered for boundary delineation using airborne and satellite imagery

Workflow Delineation Tool



Input UAV data
RGB + DSM

Publish and Share Software Platform

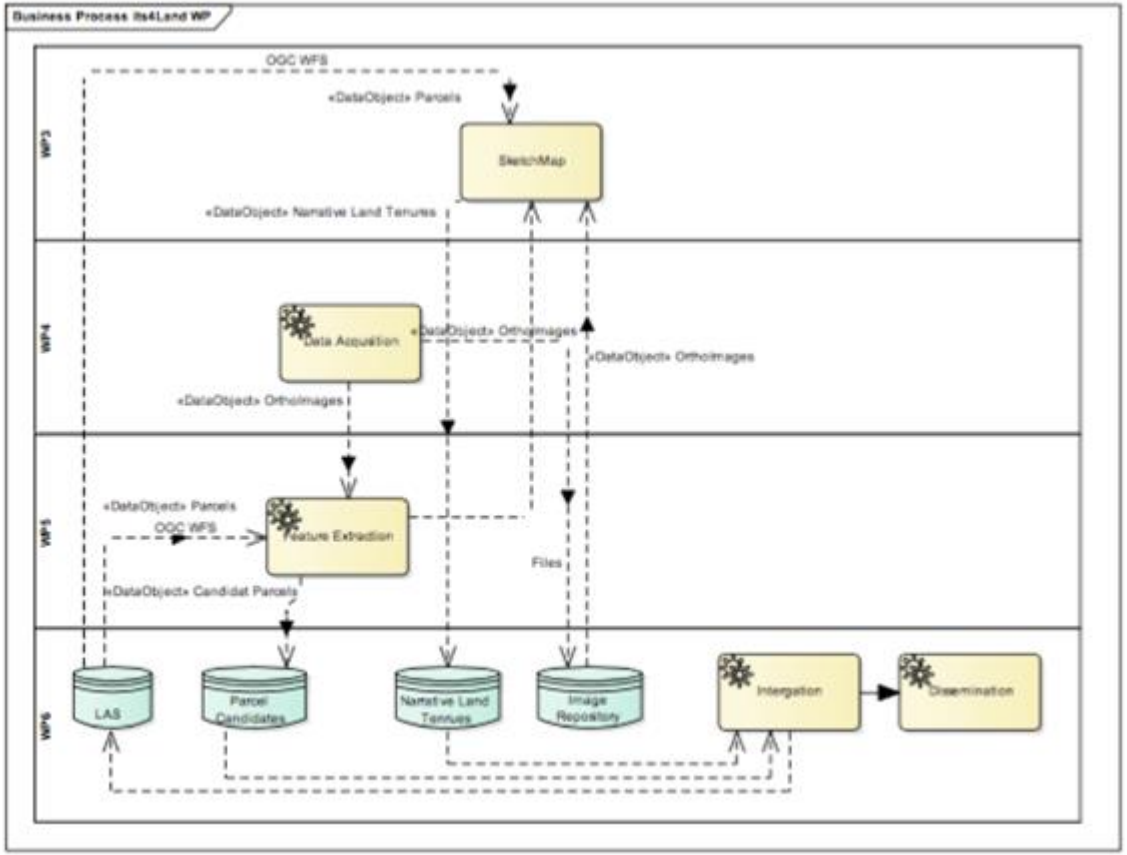
Publish and Share is a geocloud platform for hosting and integrating tools and data which facilitates land tenure recording services and applications

It comes with the its4land software tools UAV image processing, qualitative data processing (SmartSkeMa) and boundary delineation already integrated in it

Its4land project partner, Hansa Luftbild, developed the Publish and Share platform

Publish and Share Software Platform

Software tools integrated in publish and share software platform

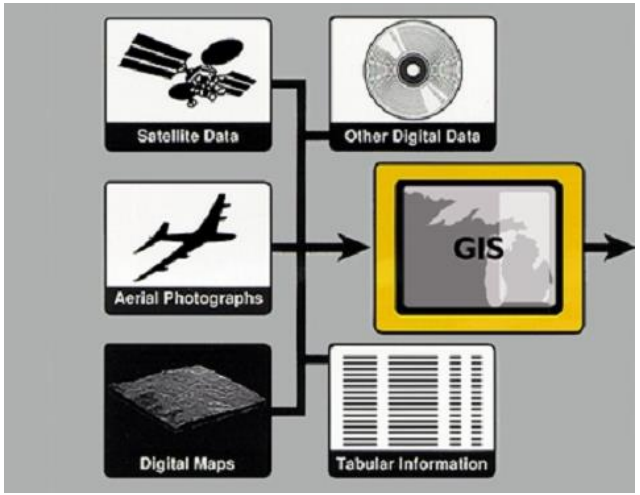


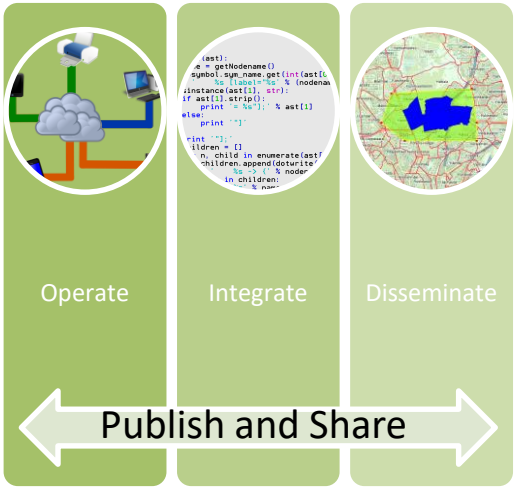
Publish and Share Platform

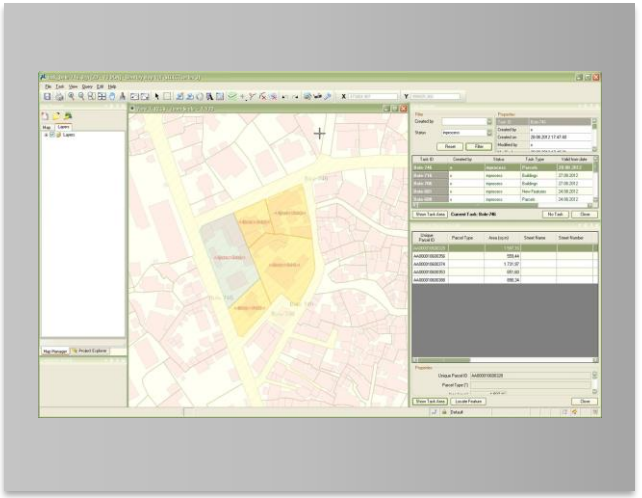
Publish and Share

- helps integrators or independent software vendors to efficiently build land administration workflows,
- provides different usage models for developing land administration tasks, and
- can be used in combination with the existing its4land tools or it can be extended by 3rd party tools

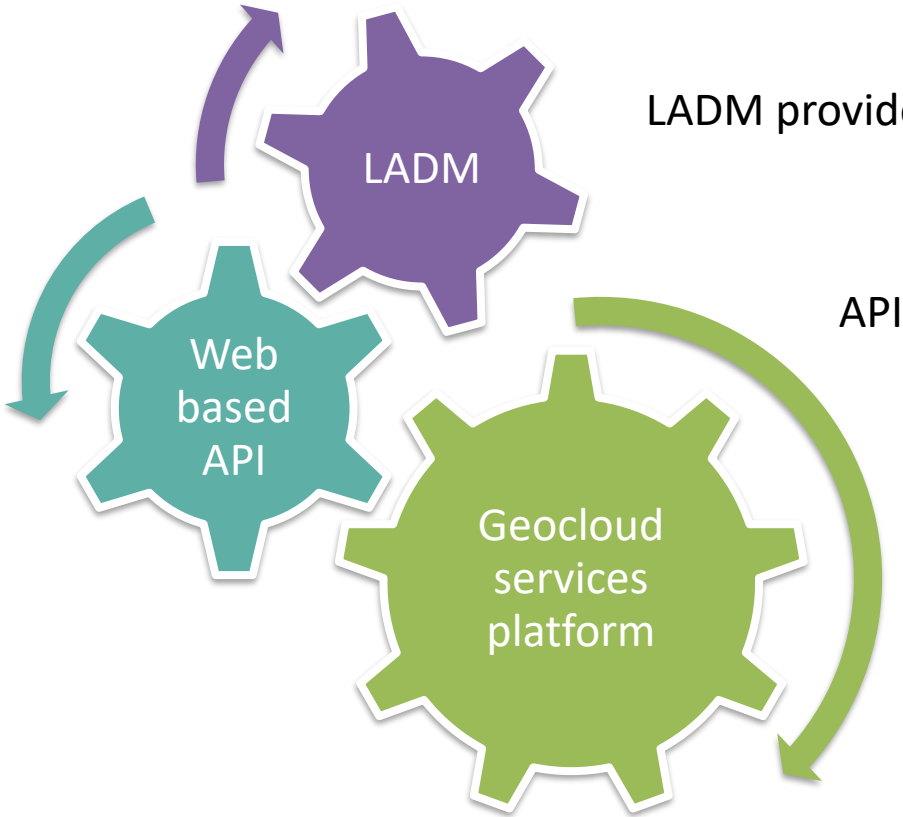
Publish and Share Software Platform







Core Concepts

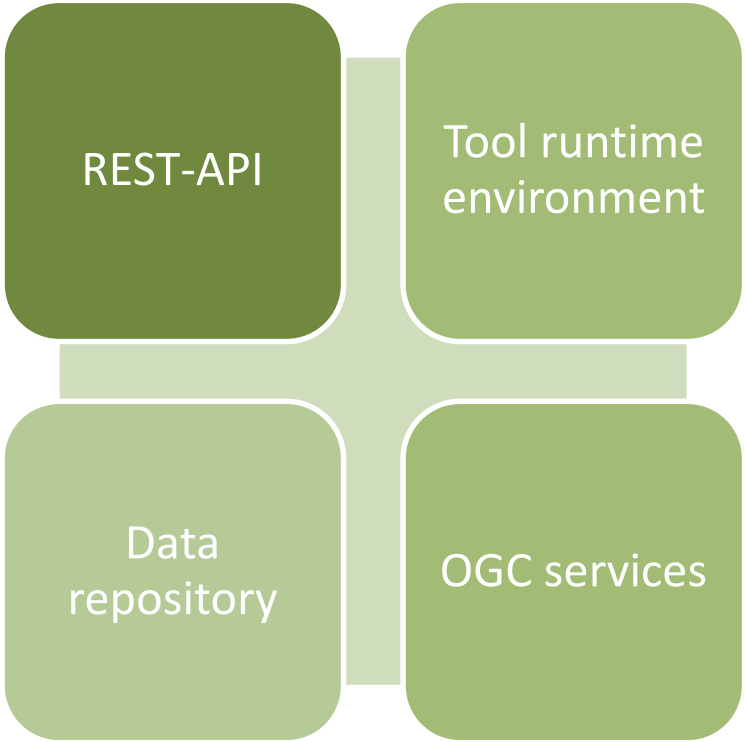


LADM provides the conceptual framework of terms

API based on state of the art standards

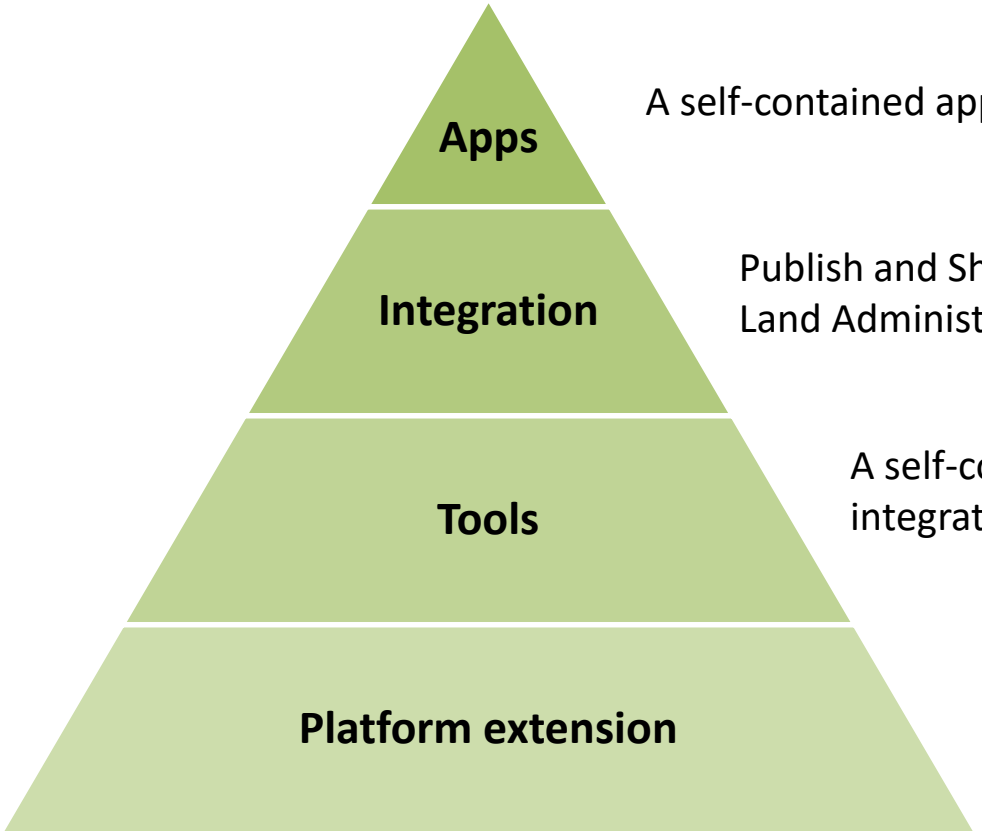
Cloud based computing for flexibility

Publish and Share Building Blocks



1. A set of public REST-APIs that allows tools and applications to interact with the Publish and Share platform
2. A tool runtime environment for smart sketchmaps, UAV image processing, boundary delineation and other tools
3. A data repository for alphanumeric, geo, binary and image data
4. OGC services for data dissemination

Publish and Share Usage Models



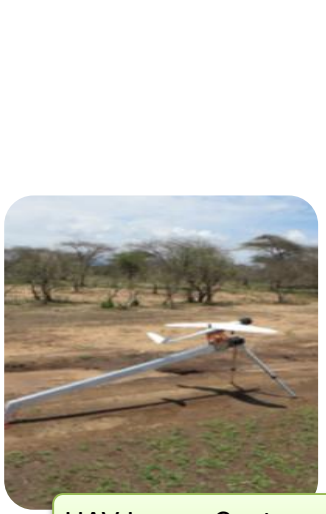
A self-contained application for an end-user.

Publish and Share functionality is integrated into a Land Administration workflow

A self-contained functionality used for integration or Apps

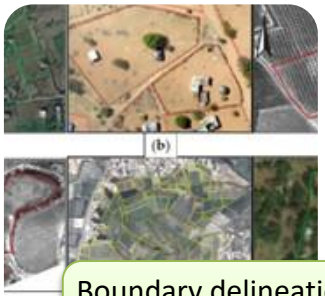
New core functionalities of the platform

Publish and Share Integration in LAS



UAV Image Capture
- Raw Images

Image processing (Fly and Create)
- Orthomosaics



Boundary delineation (Automate it)
- Boundaries as LADM LA_BoundaryFaceStrings

Qualification and registration in a Land Administration System
- Specific Spatial Units
- Legal registration

Common User Interface

* Publish and Share

* Publish and Share API and OGC Services

Publish and Share Platform

The components can be hosted in a cloud environment such as Amazon Web Services, Microsoft Azure or any private cloud environment

Publish and Share API

Implemented as a REST Web API

- Endpoints implement LADM concepts
  - Spatial Units, Spatial Source, Admin Source, etc.
- Fully documented by an interactive API reference
- Can be used with any programming language on all major operating systems

its4land Public API 0.0.2

[Base URL: platform.its4land.com/]
swagger.yaml

The its4land Public API provides access to the services of the its4land Publish and Share platform.

its4land - Website
Send email to its4land
MIT

Schemes
HTTPS

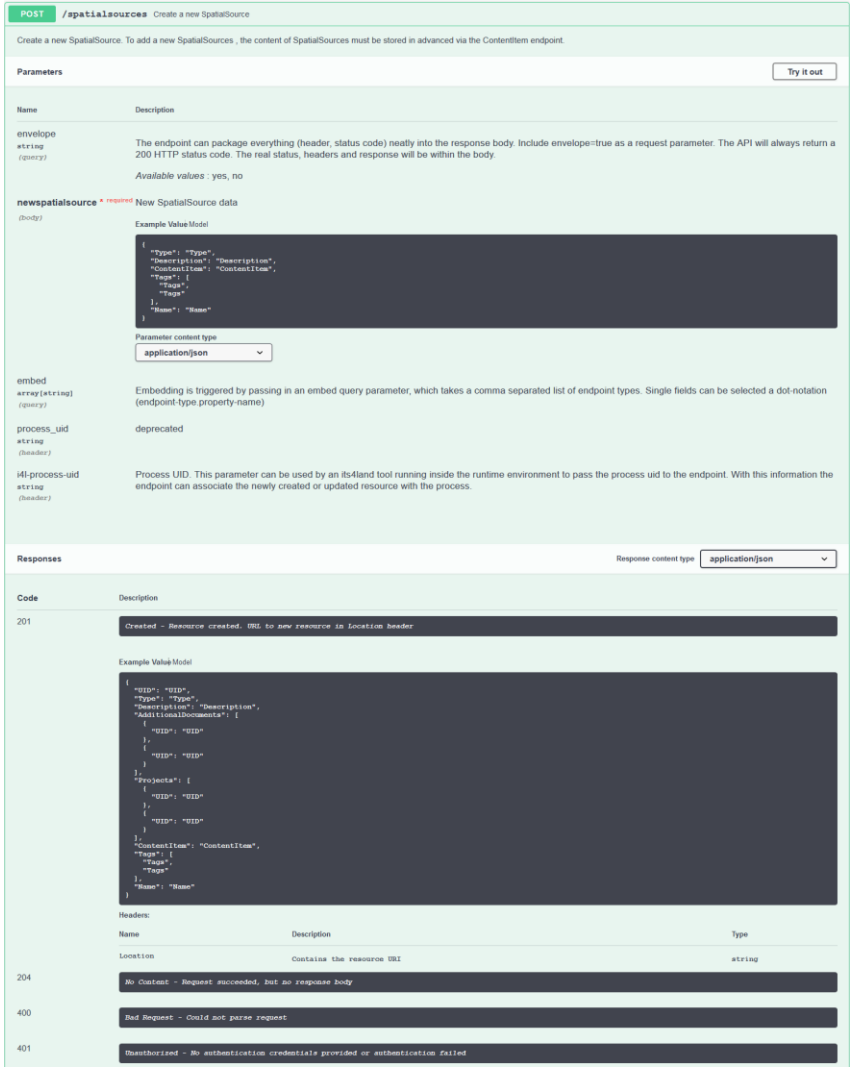
Site	Everything about Site. A site corresponds to an installation of the Publish and Share platform.	Find out more: https://plaform.its4land.com
Projects	Everything about projects. A project is the central structure in Publish and Share to organize task. A project has at least a Name and a AOI. Every data processed by tools in Publish and Share are accessible via the project	Find out more: https://plaform.its4land.com
Models	Everything about models. A model stores all data related to any kind of classification process based on any kind of TrainingSets. A Model is related to one or Project.	Find out more: https://plaform.its4land.com
TrainingSets	Everything about TrainingSets. A TrainingSet is part of Model and the base for a classifier	Find out more: https://plaform.its4land.com
SpatialSources	Everything about SpatialSources. A SpatialSource documents the evidence for as SpatialUnit. A SpatialSource can be a SketchMap, Orthoimages, etc. An SpatialSource may have several manifestations at the same time. See LADM for more details.	Find out more: https://plaform.its4land.com
Classifier	Everything about Classifier. A Classifier is part of a Model. The Classifier itself is defined by the Application.	Find out more: https://plaform.its4land.com
ModelClasses	Everything about ModelClasses. Assigned to Models. Describe the different class that can be detected by the Classifier of the Model.	Find out more: https://plaform.its4land.com
ContentItems	Everything about ContentItems. Any form of digital content, like files, images or other binary and non-binary structures.	Find out more: https://plaform.its4land.com
MetricMapFeatures	Everything about MetricMapFeatures. Handel of Point-, Line- and Polygon-TopographicFeature.	Find out more: https://plaform.its4land.com

SpatialSources

Everything about SpatialSources. A SpatialSource documents the evidence for as SpatialUnit. A SpatialSource can be a SketchMap, Orthoimages, etc. An SpatialSource may have several manifestations at the same time. See LADM for more details.

Find out more: https://plaform.its4land.com

GET	`/spatialsources`	Returns a list of SpatialSources
POST	`/spatialsources`	Create a new SpatialSource
GET	`/spatialsource/{spatialsource_uid}`	Returns a single SpatialSource
GET	`/spatialsource/{spatialsource_uid}/AdditionalDocument`	Returns the additional documents of a spatial source
POST	`/spatialsource/{spatialsource_uid}/AdditionalDocument`	Add a new additional document to a spatial source
GET	`/spatialsource/{spatialsource_uid}/AdditionalDocument/{adddoc_uid}`	Returns the additional documents of a spatial source
DELETE	`/spatialsource/{spatialsource_uid}/AdditionalDocument/{adddoc_uid}`	Removes an additional document for a spatial source.



POST `/spatialsources` Create a new SpatialSource

Create a new SpatialSource. To add a new SpatialSources , the content of SpatialSources must be stored in advanced via the ContentItem endpoint.

Parameters Try it out

Name	Description
envelope string (query)	The endpoint can package everything (header, status code) neatly into the response body. Include envelope=true as a request parameter. The API will always return a 200 HTTP status code. The real status, headers and response will be within the body. *Available values :* yes, no
newspatialsource * required (body)	New SpatialSource data Example Value Model `{ "Type": "Type", "Description": "Description", "ContentItem": "ContentItem", "Tags": [ "Tags", "Tags" ], "Name": "Name" }` Parameter content type application/json
embed array[string] (query)	Embedding is triggered by passing in an embed query parameter, which takes a comma separated list of endpoint types. Single fields can be selected a dot-notation (endpoint-type.property-name)
process_uid string (header)	deprecated
i4l-process-uid string (header)	Process UID. This parameter can be used by an its4land tool running inside the runtime environment to pass the process uid to the endpoint. With this information the endpoint can associate the newly created or updated resource with the process.

Responses Response content type application/json

Code	Description
201	Created - Resource created. URL to new resource in Location header Example Value Model `{ "UID": "UID", "Type": "Type", "Description": "Description", "AdditionalDocuments": [ { "UID": "UID" }, { "UID": "UID" } ], "Projects": [ { "UID": "UID" }, { "UID": "UID" } ], "ContentItem": "ContentItem", "Tags": [ "Tags", "Tags" ], "Name": "Name" }` Headers: Name: Location — Description: Contains the resource URI — Type: string
204	No Content - Request succeeded, but no response body
400	Bad Request - Could not parse request
401	Unauthorized - No authentication credentials provided or authentication failed

Consultancy Services for Governance and Capacity Building

Services in the development of governance and capacity building models which support the implementation and evaluation of innovative tools

Models developed by its4land project partner KU Leuven

Relevant ICT/land governance and capacity development models

The three “Good Governance” models are:

- Multi-level Governance Assessment of OECD (OECD, 2011),
- Framework and Guidelines in Land Policy Africa (African Union, African Development Bank, & Economic Commission for Africa, 2010), and
- Land Governance Assessment Framework (World Bank, 2015).

its4land Governance and Capacity Development Models

Initial Governance and Capacity Development Model (IGCDM) has three blocks:

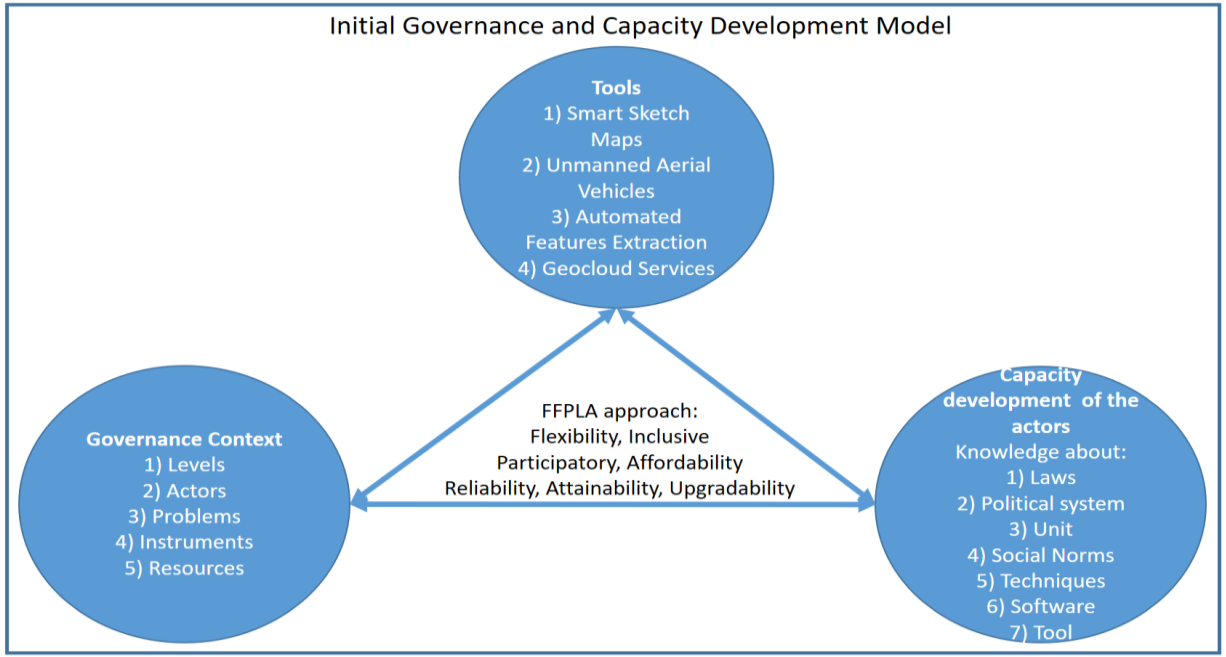
1) its4land tools

2) governance context, and

3) capacity development.

Building blocks aligned with the seven Fit-for Purpose Land Administration (FFPLA) elements: 1) Flexibility, 2) Inclusive, 3) Participatory, 4) Affordability, 5) Reliability, 6) Attainability and 7) Upgradability.

its4land Governance and Capacity Development Models



Alignment between the its4land tools and the FFPLA elements

FFP conditions	Smart Sketchmaps	Unmanned Aerial Vehicles	Automated Feature Extraction	Geocloud Services
Flexibility	The tool can provide information according to the users' needs	The tool can provide information according to the users' needs. It is flexible in spatial resolution and spectral information	The tool can be applied to delineate different types of boundaries, according to the user needs	The tool can be adapted for different usages and scenarios, according to the user needs
Inclusive	The tool has the capacity to capture the different land tenure practices	The tool has the capacity to cover the different types of land (spatial) information.	The tool supports image based identification and vectorization of visible cadastral boundaries	The tool provides information for registration in land administration systems
Participatory	The community is engaged in the adoption of the tool	The community is engaged in the adoption of the tool	The tool is intuitive and open to be used by different stakeholders	There is participation of the users
Affordability	The adoption of the tool is affordable in cost	The adoption of the tool is affordable	The adoption of the tool is affordable	The adoption of the tool is affordable
Reliability	The collected information could be updated and is recognized by the government	The collected information could be updated and officially recognized by the government	The created information can be updated and is recognized as reliable by the government	The collected information is recognized reliable by the government
Attainability	The SSM adoption can be made with the available resources in an efficient manner	The UAV adoption can be made with the available resources in an efficient manner. Cloud services can support its adoption	The AFE adoption can be made with the available resources in an efficient manner	The geocloud adoption can be made with the available resources in an efficient manner
Upgradability	The SSM could be upgraded by the users according to their needs. They can extend the domain of the models	The UAV's information could be upgraded according to the users' needs by flying again over the same area	The tool is developed in a modular fashion allowing partial adaptation and improvements	The geocloud service could be upgraded by the users according to their needs

its4land Land Administration Toolbox Demonstration

- Geospatial Week at ITC in Enschede 10 – 14 June 2019
- RCMRD International Conference & 4th AfriGEOSS Symposium in Nairobi 13 – 16 August 2019
- Africa GIS in Kigali 18 – 22 November 2019

Thank you for your attention.