swisstopo Colloquium on “Spatial Data Science” 11.03.2022

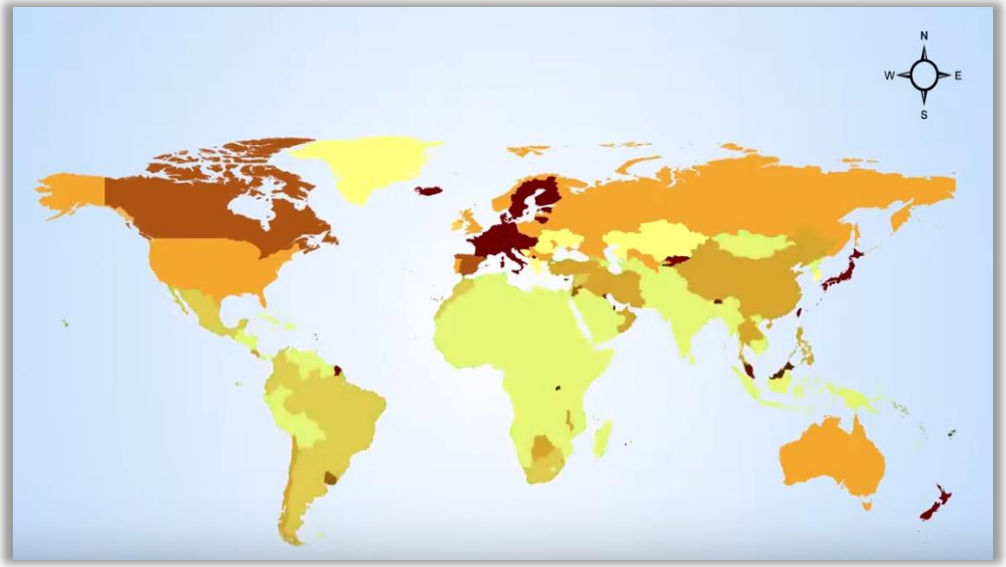
INNOVATIVE GEOSPATIAL SOLUTIONS FOR LAND RIGHTS MAPPING

Mila Koeva

Associate Professor
University of Twente (NL)
ITC Faculty Geo-Information Science and Earth Observation
m.n.koeva@utwente.nl

Land tenure security

The first goal of the sustainable development goals (SDGs), target 1.4, set by the United Nations (UN) aims for equal rights and access to economic resources (tenure security for all).



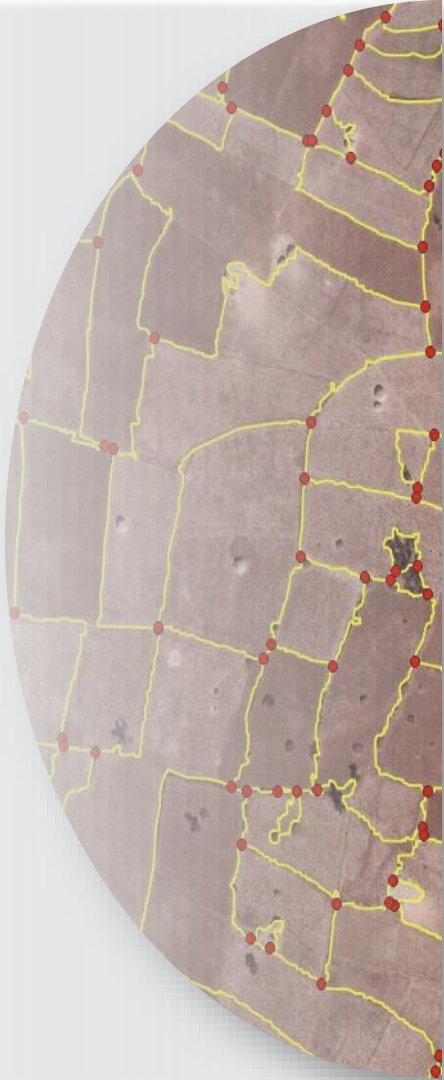
70% of the land rights are not recorded

ITC

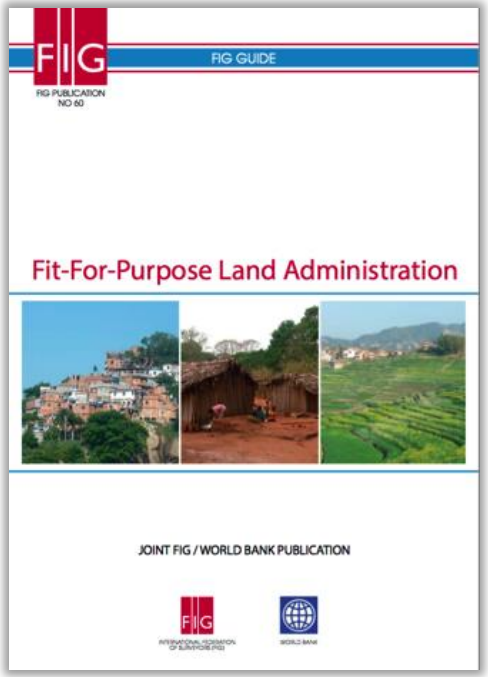
Aim

To develop innovative solutions to make land rights mapping

faster, cheaper, and easier

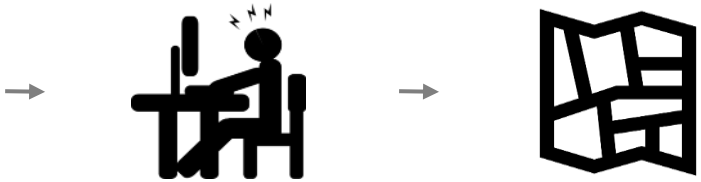


The Land Tool Evolution



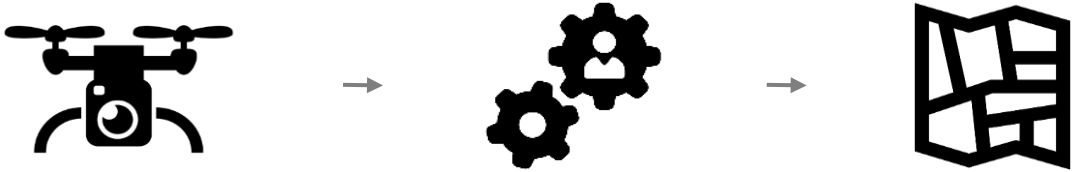
Cadastral boundaries based on RS data

Current Approach



- Cadastral boundaries are visually detected and manually digitized from low resolution aerial/satellite imagery

Proposed Approach



- Cadastral boundary features are automatically detected and interactively delineated from high-resolution imagery

ITC

Remote Sensing (RS) for cadastral boundaries

Visual boundaries

Automated approaches mainly depend on the quality of images visibility of the boundaries on tese images and their match with the real cadastral boundaries

Visible boundaries

(a) Strip of stone

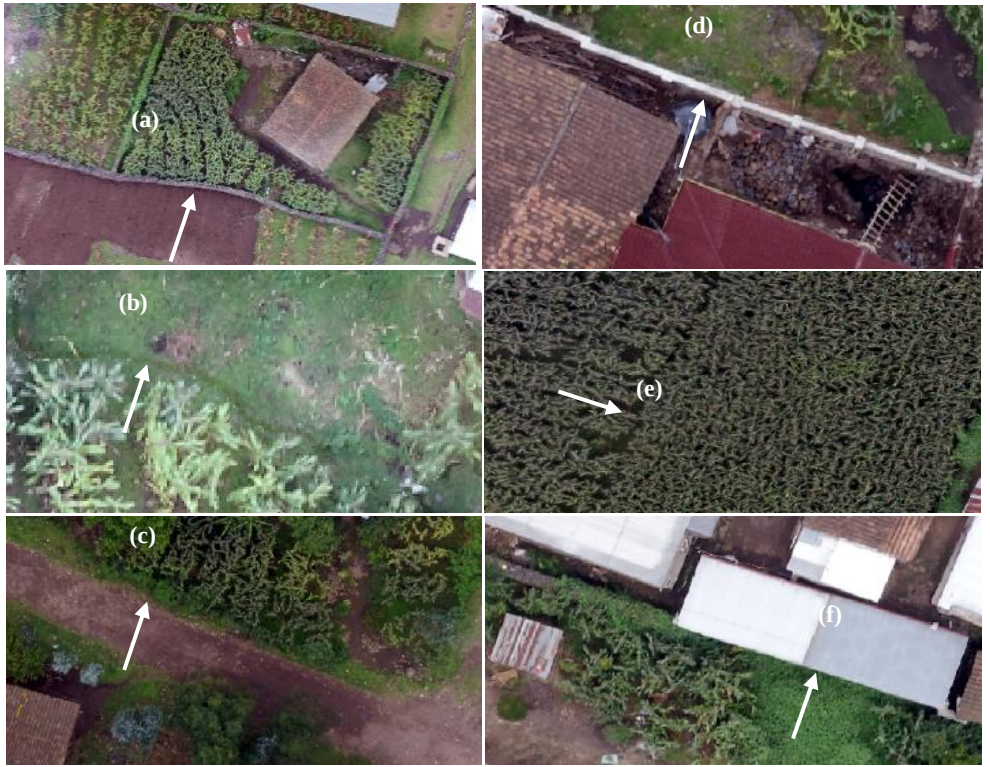
(b) Water drainage

(c) Road ridges

(d) Fences

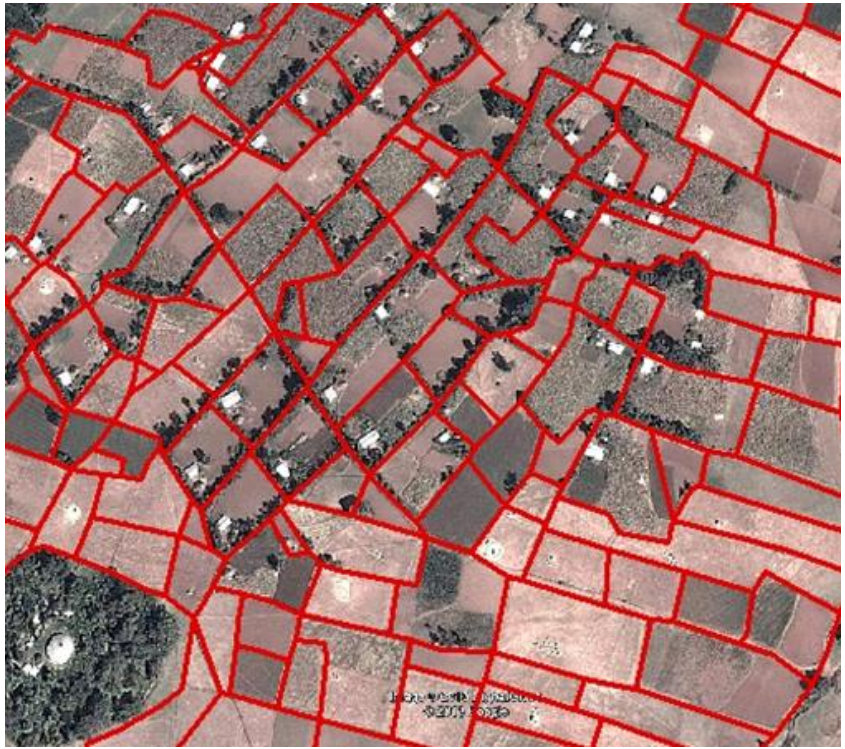
(e) Textural pattern transition

(f) Edge of rooftop



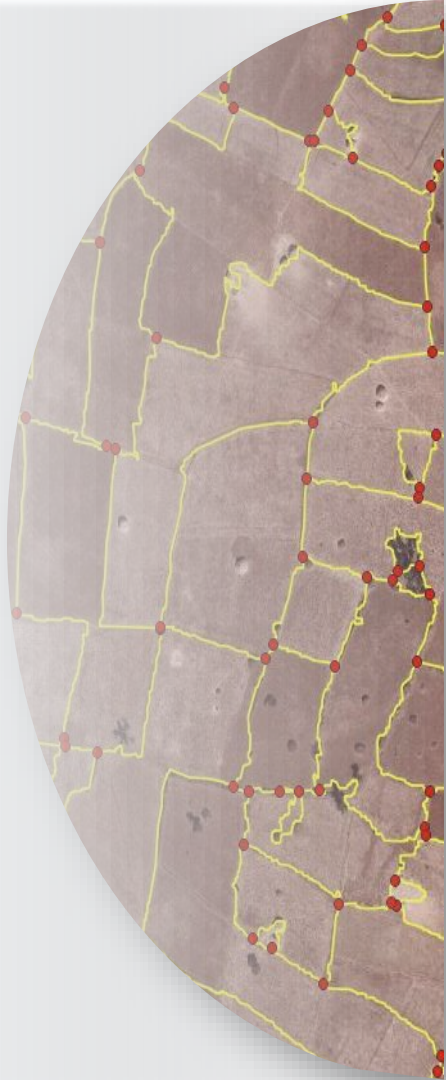
Completely visible cadastral

Place	Total Parcels	Fully visible		Landscape
		Number	Percentage	
Ethiopia	128	92	71%	Rural
Rwanda	151	33	22%	Rural
Guatemala	172	47	27%	Urban
Ghana	200	25	12.5%	Rural
Mozambique	190	47	24.7%	Urban
Nepal	164	0	0	Rural-hilly
Kenya	179	23	12.8%	Peri-urban/informal

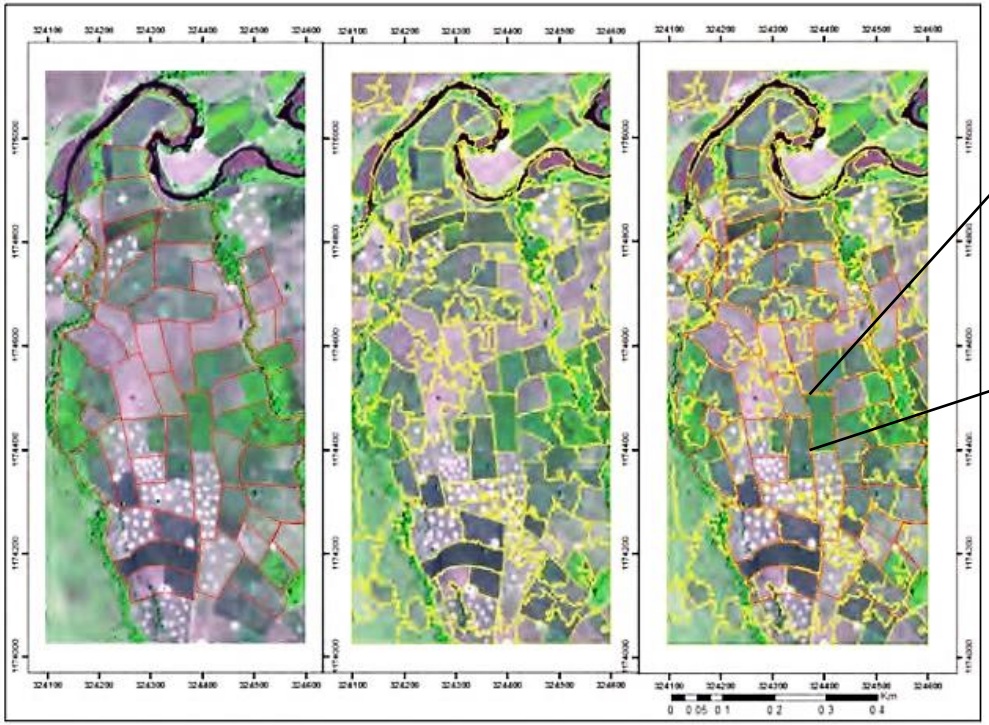


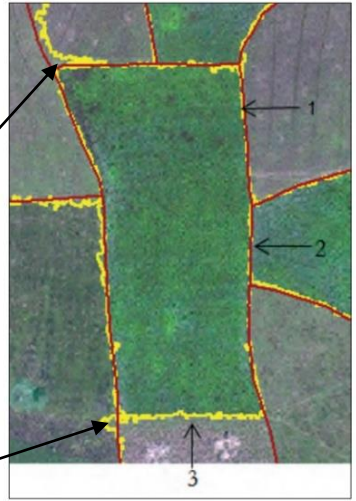
Methods

- Mean-shift segmentation algorithm
- eCognition software
- Machine learning (Random Forest, Fully Convolutional Networks etc.)
- Interactive boundary registration (QGIS)



Mean-shift segmentation algorithm



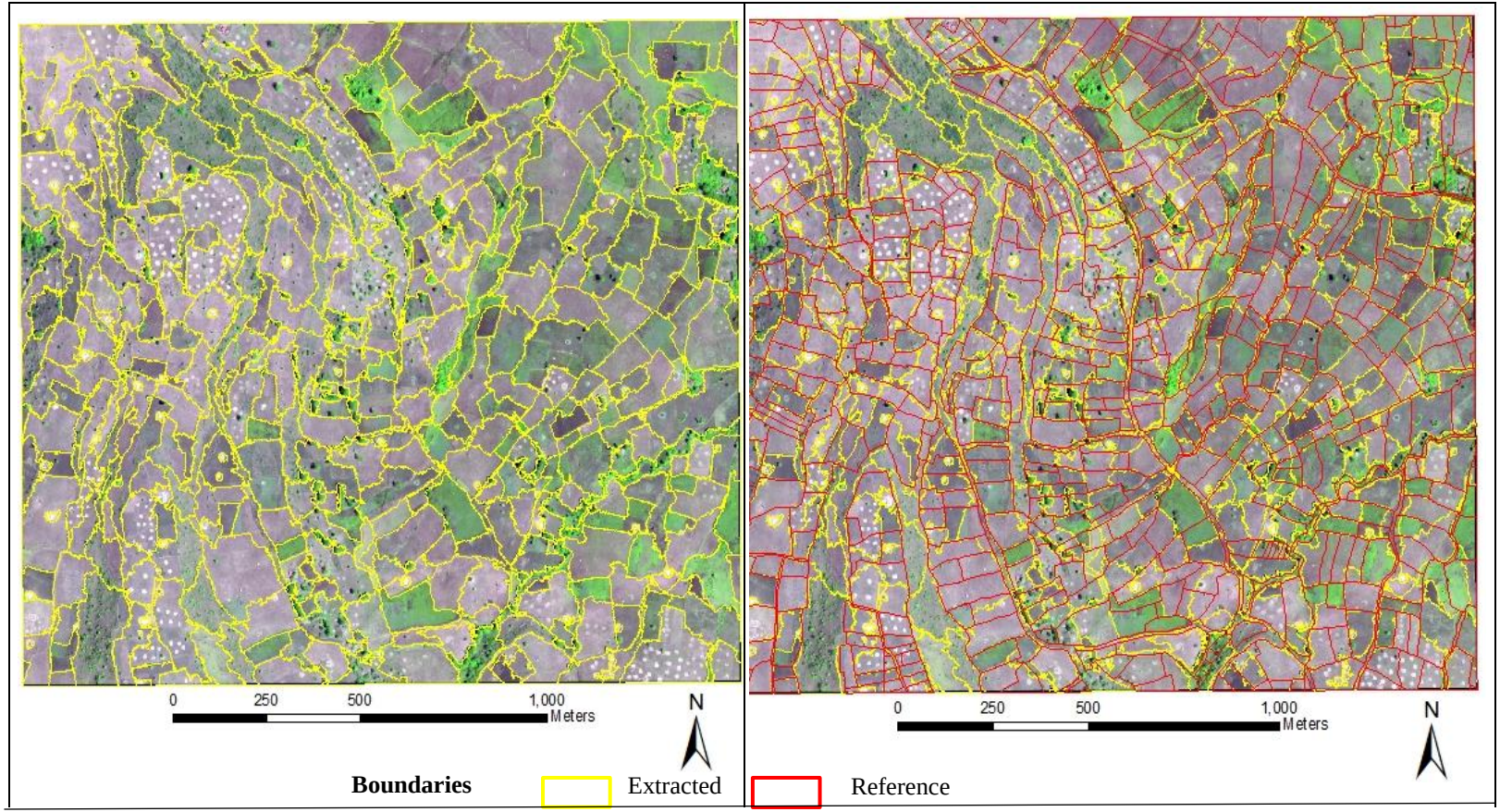


Buffer width	Completeness	Correctness	Quality
0.5m	55.39	16.26	14.65
1m	71.46	24.69	23.07
2m	82.75	34.29	32.89

Reference Extracted Reference + extracted

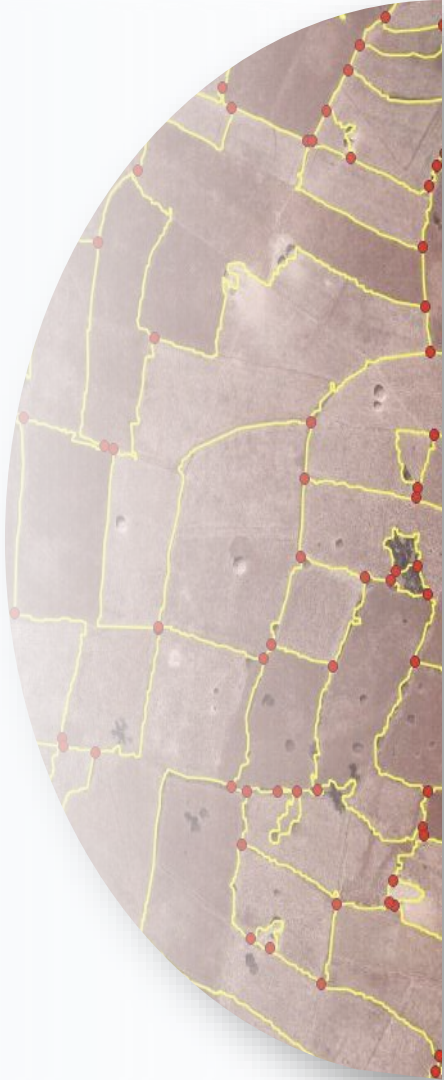
Wassie, Y.A., Koeva, M.N. and Bennett, R.M. (2016) Towards automated detection of visual cadastral boundaries : initial investigation of imagery, algorithms and perceptions. In: GIM International, 30 (2016)8 pp. 23-25

eCognition


0
250
500
1,000
Meters
N
Boundaries
Extracted
0
250
500
1,000
Meters
N
Reference

ITS 4 LAND

innovations for land tenure



ITC

Its4land project

EU H2020 – ICT – 2015
Research and Innovation Action
Duration: 48 months 2016-2020
Consortium: 8 partners
Budget: 3.9 M Euro

Rwanda – New Era, New Norms, Keeping Up, and Up Keep

Ethiopia – Transforming Society, Ensuring Equality

Kenya – Sustaining Livelihoods, Conserving Environments

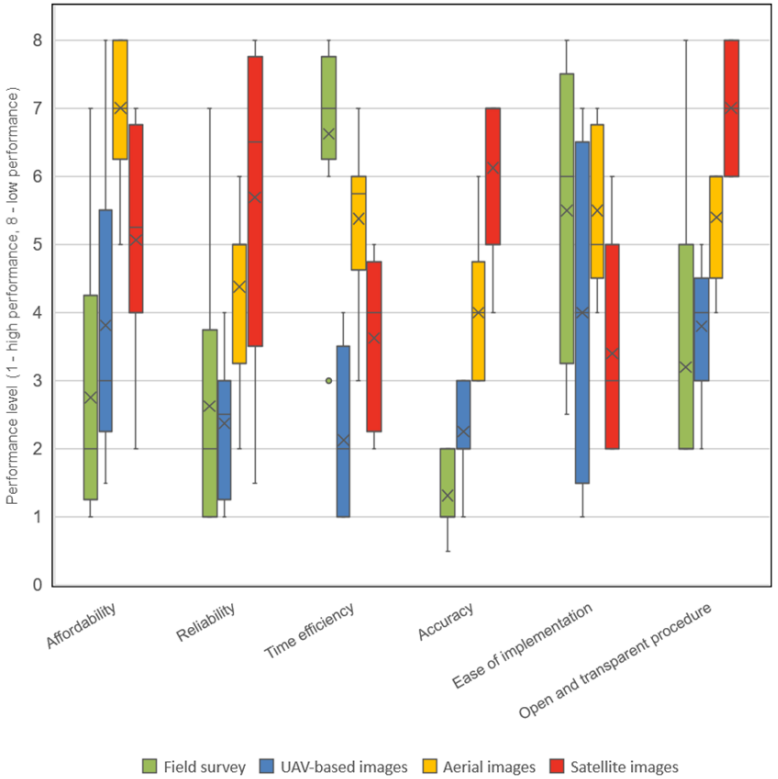
ITC

UAV data collection

https://www.youtube.com/watch?v=xyJ6nIDUiPM

RS data comparison

- UAV selection, purchase, training
- Review of the regulations
- Explored the stakeholders perspective through interactive gaming

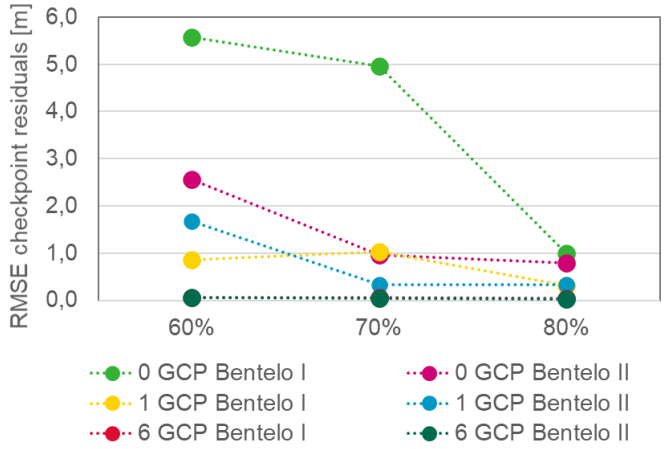


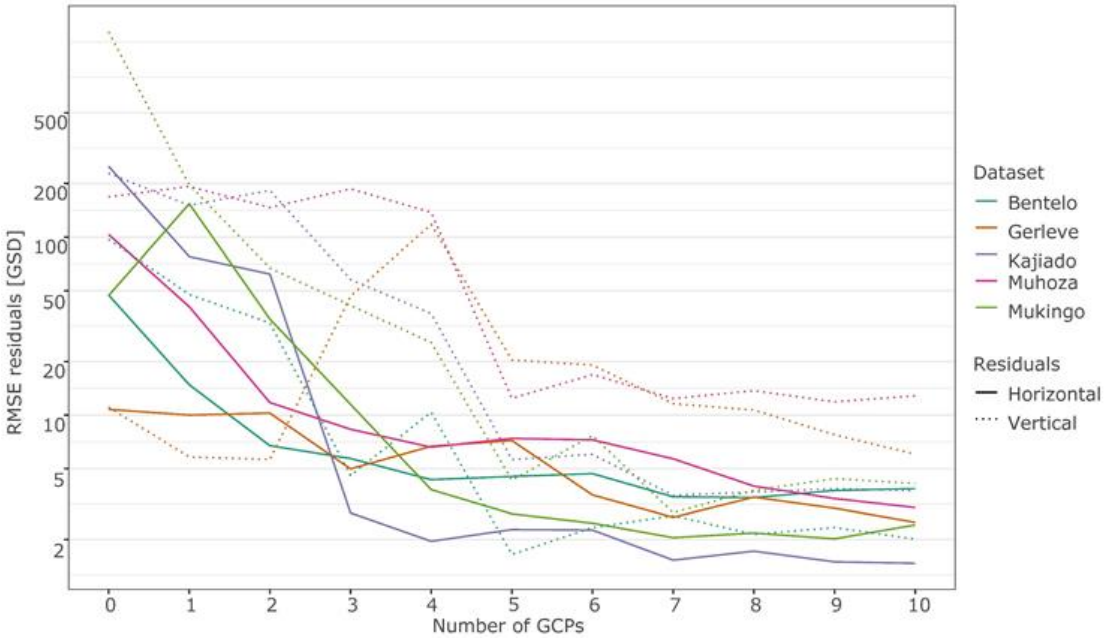
- *Stöcker C, Bennett R, Nex F, Gerke M, Zevenbergen J. Review of the Current State of UAV Regulations. Remote Sensing. 2017; 9(5):459.*
- *C Stöcker, M Koeva, R Bennett, J Zevenbergen. Evaluation of UAV-based technology to capture land rights in Kenya: Displaying stakeholder perspectives through interactive gaming. World Bank Conference*

UAV - data quality assessment



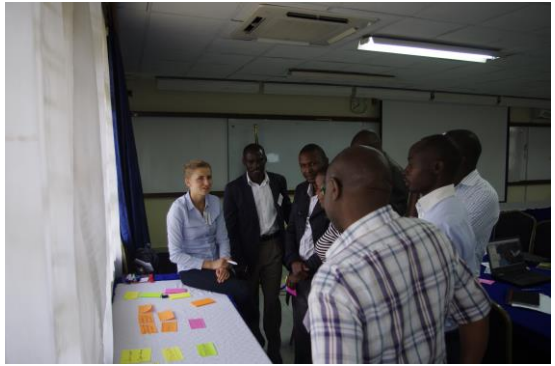

UAV	Camera	Resolution
Phantom 4	FC330	12.4 MP
Germap G180	Ricoh GR	16 MP
DT18	DT 3bands	5 MP
Inspire 2 Pro	DJI FC6520	20.1 MP
FireFly 6	SONY ILCE-6000	24 MP





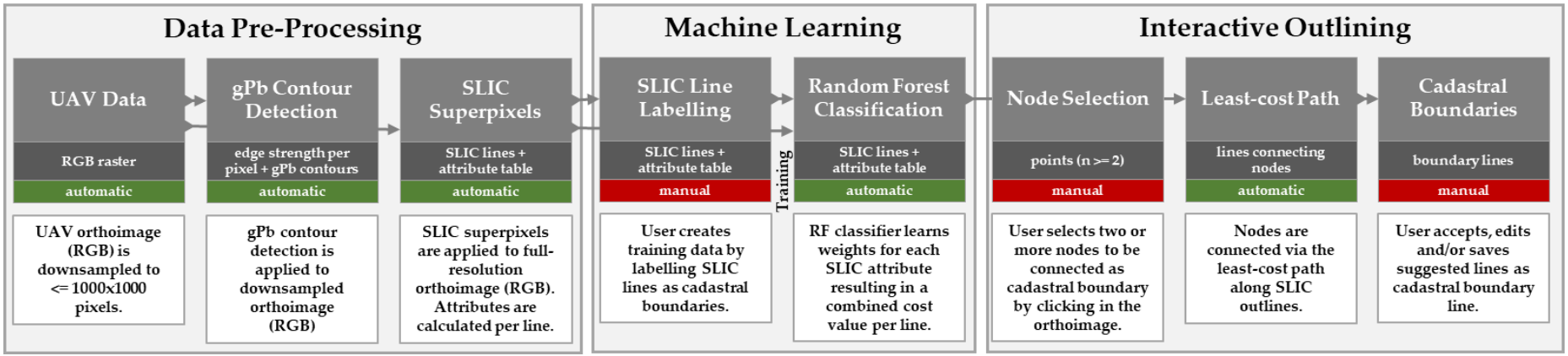
Stöcker C, Nex F, Koeva M, Gerke M. High-Quality UAV-Based Orthophotos for Cadastral Mapping: Guidance for Optimal Flight Configurations. Remote Sensing. 2020; 12(21):3625.

User needs and requirement/feedback



ITC

Methods



- The two 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%

Xia X, Persello C, Koeva M. Deep Fully Convolutional Networks for Cadastral Boundary Detection from UAV Images. Remote Sensing. 2019; 11(14):1725 https://doi.org/10.3390/rs11141725

Crommelinck, S., Bennett, R.M., Gerke, M., Yang, M.Y. and Vosselman, G. (2017) Contour detection for UAV-based cadastral mapping. In: Remote Sensing : open access, 9 (2017)2article no. 171, 13 p.

S. Crommelinck, R. Bennett, M. Gerke, M. N. Koeva, M. Y. Yang, G. Vosselman. SLIC superpixels for object delineation from UAV data. International Conference on Unmanned Aerial Vehicles in Geomatics, 4–7 September 2017, Bonn, Germany.

https://www.youtube.com/watch?v=9Bwld4iwNtY

QGIS plug-in - **https://its4land.com/automate-it-wp5/**

Its4land website: https://its4land.com/

Its4land videos:

Promotional video: https://www.youtube.com/watch?v=lNJwyGUwH38

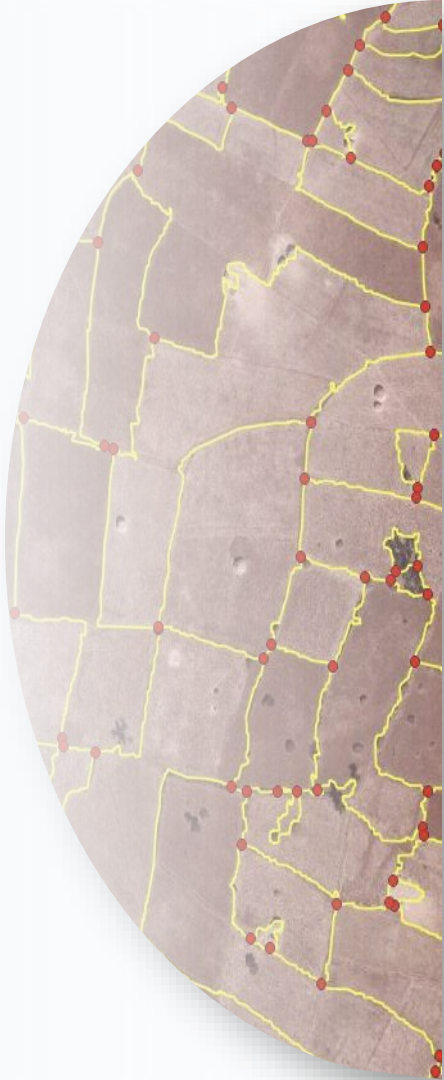
- UAV data acquisition flights in Africa to secure land rights: https://www.youtube.com/watch?v=JdStA7RneYI
- Semi-automatic delineation of visible cadastral boundaries from high-resolution remote sensing data: https://its4land.com/automate-it-wp5/
- Demo Use Case for its4land toolbox: https://its4land.com/wp-content/uploads/2020/01/its4land-land-administration-toolbox-instruction-demo.mp4

Its4land output: https://its4land.com/things/

Its4land publications: https://its4land.com/publications/

This project has received funding from the European Union's Horizon 2020 research and innovation programme, under Grant Agreement No 687828

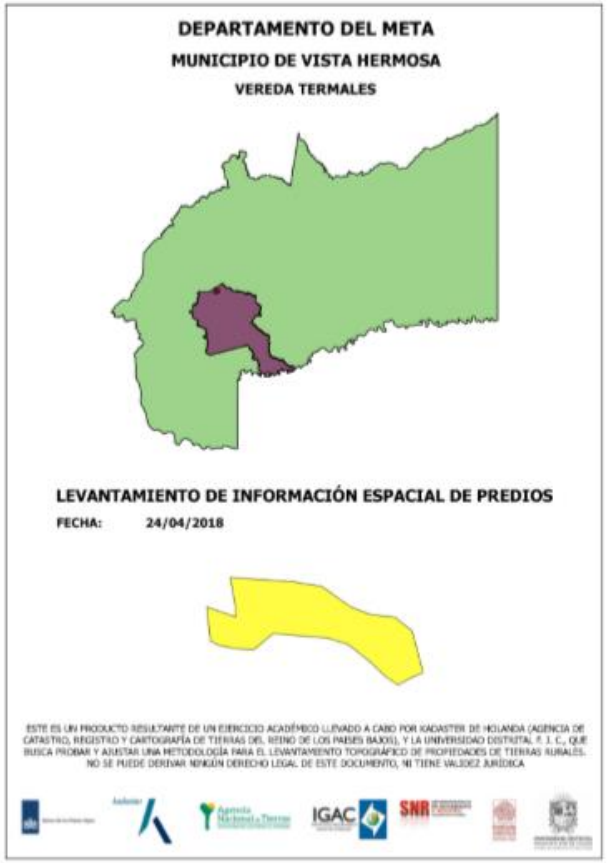
Mobile mapping



Cadastral boundaries - mobile mapping

- Satellite images (3m) & Orthophoto (30cm)
- Tablets & Trimble R1/R2
- ESRI Collector & ArcGIS

Cadastral boundaries - mobile mapping - Colombia



DEPARTAMENTO DEL META

MUNICIPIO DE VISTA HERMOSA

VEREDA TERMALES

LEVANTAMIENTO DE INFORMACIÓN ESPACIAL DE PREDIOS

FECHA: 24/04/2018

ESTE ES UN PRODUCTO RESULTANTE DE UN EJERCICIO ACADÉMICO LLEVADO A CABO POR KADASTER DE HOLANDA (AGENCIA DE CATASTRO, REGISTRO Y CARTOGRAFÍA DE TIERRAS DEL REINO DE LOS PAISES BAJOS), Y LA UNIVERSIDAD DISTRITAL F. J. C., QUE BUSCA PROBAR Y AJUSTAR UNA METODOLOGÍA PARA EL LEVANTAMIENTO TOPOGRÁFICO DE PROPIEDADES DE TIERRAS RURALES. NO SE PUEDE DERIVAR NINGÚN DERECHO LEGAL DE ESTE DOCUMENTO, NI TIENE VALIDEZ JURÍDICA

DEPARTAMENTO DEL META

MUNICIPIO DE VISTA HERMODA

VEREDA TERMALES

Nombre o identificación del Predio: LAS CAMELIAS

Área (aproximada): 28 ha

Pag. 2/4

Cadastral boundaries - mobile mapping - Kenya

Cadastral boundaries - mobile mapping - Indonesia

Carta method ("drawing")

Digital participatory parcel delineation on tablets using drone imagery basemap

Terra method ("mapping")

Using Low-cost L1 GNSS and trilateration using low cost laser range finders

Digital registration

Digitising data collection, data processing and document generation

One integrated package

Integration of both these approaches in a single fit-for-purpose product suite

ITC

Thank you for your attention!