DIGITAL TRANSFORMATION FOR RESPONSIBLE LAND ADMINISTRATION

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Toward Large Scale Cadastral Mapping with Deep Learning

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AGENDA

1. Introduction
2. Literature review + research gap
3. Results
4. What's next

Questions

1. INTRODUCTION

1.1 Problem Introduction

- Approx. 70-75 percent of the people in the world do not have access to a legal land administration system
- Negative impact on:
  - Tenure security
  - Agricultural productivity
  - Sustainable development
- Related to several targets of the sustainable development goals (SDGs) of 2030.

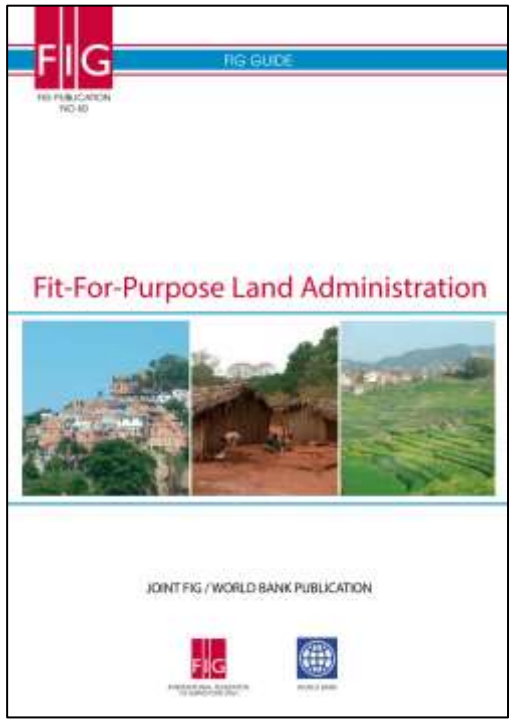
https://www.unsustainabledevelopmentgoals.org/podcast/sdg-target-14

1.2 Problem Introduction

- The lack of a formal system is partially caused by technological issues
- Conventional ground-based survey methods have helped developed countries build up countrywide cadastre with high accuracies
- This approach is too labor-intensive and expensive for most developing countries and could take several decades to complete

1.3 Possible solution

- The fit-for-purpose land administration (FFPLA) tries to solve this problem [1]
- Two of the main principles of FFPLA:
  - Visible cadastral boundaries
  - Acquiring these cadastral boundaries with satellite images and aerial photography
- Growing demand for automated cadastral boundary extraction methods
- Recent studies on cadastral boundary extraction primarily use deep learning and remote sensing imagery and show promising results



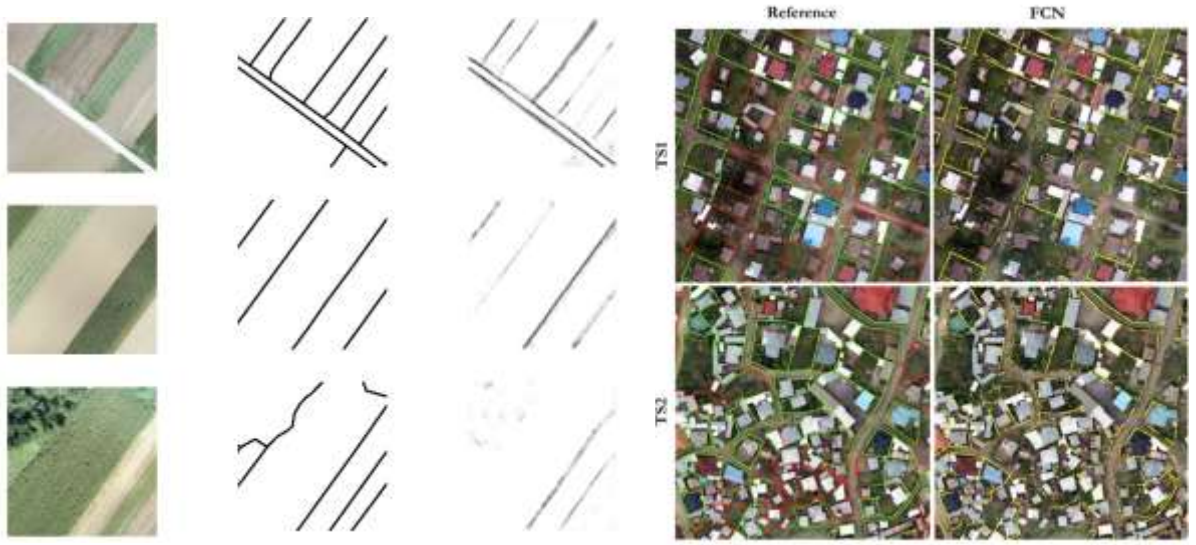
[1] FIG, & The World Bank. (2014). *Fit-For-Purpose Land Administration*.

2. LITERATURE REVIEW

2.1 Automated (visible) cadastral boundary delineation

- Crommelinck et al. 2019 [1]
- Xia et al. 2019 [2]
- Fetai et al. 2021 [3]

- Results:
  - 38% less processing time
  - 80% less clicks
  - Invisible boundaries are hard to detect



[1] Crommelinck, S., Koeva, M., Yang, M. Y., & Vosselman, G. (2019). Application of Deep Learning for Delineation of Visible Cadastral Boundaries from Remote Sensing Imagery. *Remote Sensing*, *11*(21)
[2] Xia, X., Persello, C., & Koeva, M. (2019). Deep fully convolutional networks for cadastral boundary detection from UAV images. *Remote Sensing*, *11*(14).
[3] Fetai, B., Račič, M., & Lisec, A. (2021). Deep Learning for Detection of Visible Land Boundaries from UAV Imagery. *Remote Sensing*, *13*(11)

2.2 Research gap

- Only a **small number of deep learning architectures** have been investigated for cadastral boundary extraction
- Current applications of cadastral boundary extraction by using deep learning and remote sensing are mainly providing **raster output**
- There is **no cadastral benchmark dataset** available for cadastral boundary extraction
- Relatively small datasets have been used in cadastral boundary extraction studies. Because of these relatively area-specific datasets, it is not clear how the trained algorithms **perform on new geographic locations**
- Delineated **cadastral boundaries were not used to improve the predictions** made by the deep learning model

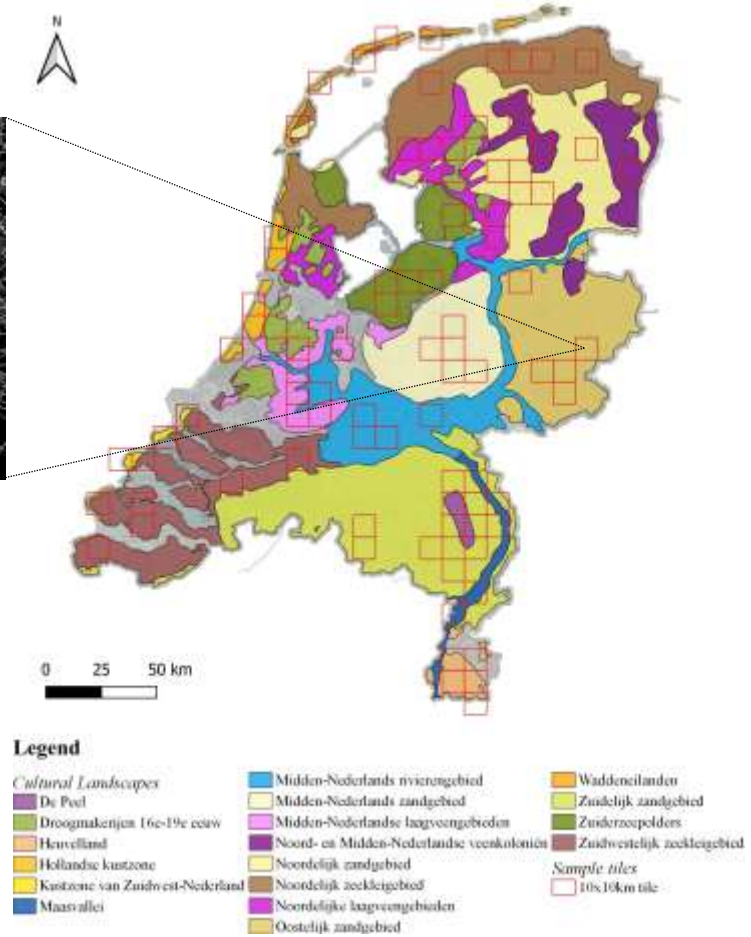
3. RESULTS: BENCHMARK DATASET

3.1 Benchmark dataset

- Data collected from the Netherlands:
  - Aerial imagery (25cm)
  - SuperView (50cm)
  - PlanetScope (+/- 3m)
  - Sentinel-2 (10m)

- Cadastral reference data:
  - Basisregistratie Kadaster (BRK)
  - Buffered 0.5m

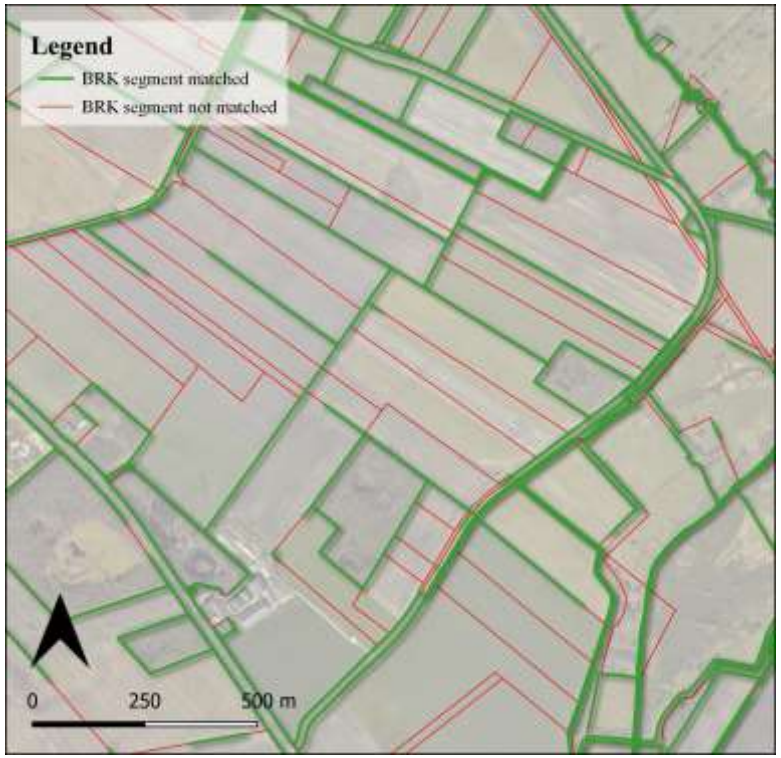
- Processing:
  - Grid of 10x10km tiles
  - Tiles sampled per cultural landscape (boundary diversity)
  - 90 tiles in total
  - Clipped images and reference binary masks for all data sources



4. RESULTS: VISIBLE/NON-VISIBLE CADASTRAL BOUNDARIES

4.1 Overlap analysis

- To interpret the results of deep learning predictions, it is important to know the proportion of visible/non-visible cadastral boundaries
- Calculate overlap between:
  - Basisregistratie Kadaster (BRK)
  - Visible objects in topographic maps (BGT, BRT, BAG, BRP)
- GIS analysis:
  - Buffer distance
  - Percentage overlap
  - Angle difference
- Results:
  - 72.2% of total length of the cadastral boundaries is matched
  - Visible/non-visible cadastral boundary geometries (image)



5. WHAT'S NEXT

5.1 Future developments

- Train state-of-the-art models on the cadastral benchmark dataset
- Test the transferability of models trained with the benchmark dataset to other geographical locations.
- Add other imagery data sources to the benchmark datasets (sensors, seasons) to make it more diverse
- Add reference data from other countries to the benchmark dataset, to make it more diverse

Questions