FIG Joint Land Administration Conference

UNIVERSIDADE FEDERAL DE SANTA CATARINA

TU Delft

AI Opportunities for Cadastre in Support of Integrated Land Administration

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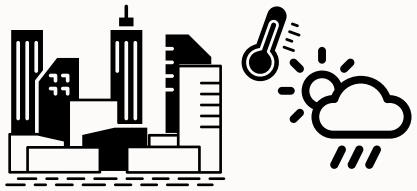
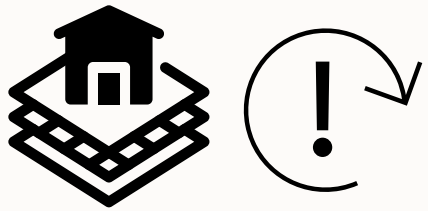
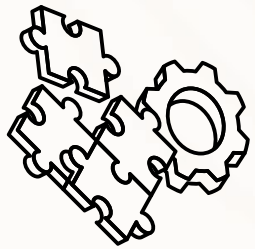
CONTEXT & MOTIVATION



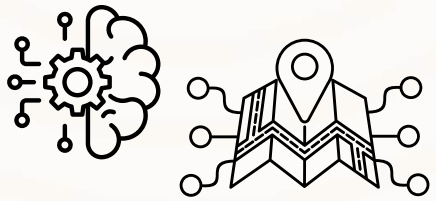
Rapid urbanisation and climate pressures demand **modernised cadastral systems**



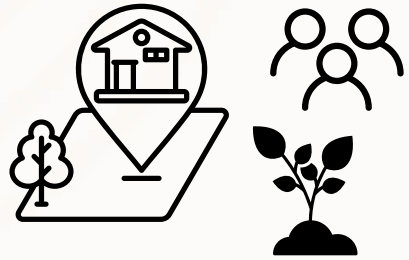
Municipal inequalities → **limited capacity to maintain up-to-date land data**



Standards such as **LADM (ISO 19152-1:2024)** help to ensure semantic consistency across cadastral systems.



AI and **GeoAI** enable automation, integration and data-driven decision-making



Responsible AI use can promote **inclusion, transparency, climate-resiliente** and **land governance**

OBJECTIVES & APPROACH

General Goal: Explore how AI can strengthen integrated land administration aligned with LADM principles

Present two exploratory **AI-driven applications** for modernising the **multipurpose cadastre:**

1. **Deep-learning** pipeline using **360° terrestrial mobile mapping imagery** for building usage types classification
2. **LLM-powered geospatial chatbot** for cadastral management and citizen services

Discuss the **benefits**, **limitations** and **ethical aspects** of **AI adoption** to foster a **responsible** and **inclusive digital transformation** of **cadastral systems**

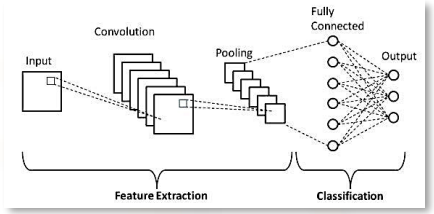
USE CASE 1

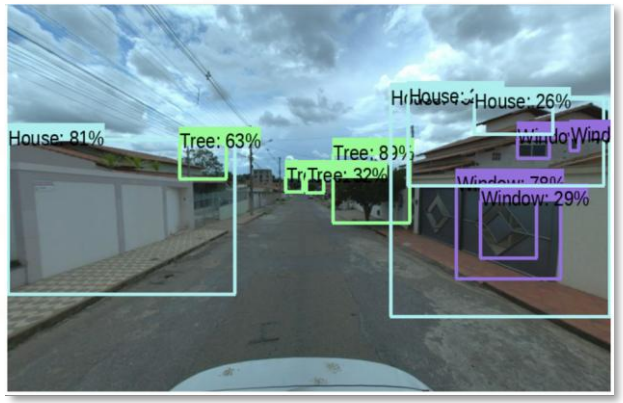
ENHANCING CADASTRAL DATA ACQUISITION AND UPDATE THROUGH AUTOMATED FEATURE EXTRACTION

Deep-learning pipeline using **360° terrestrial mobile mapping imagery** for **building usage-type** classification

- **CNN**-based workflow using **Inception-ResNet-v2** and **EfficientNet-B7**.
- **Detects façades** and **classifies building usage types**:
  - *residential, commercial, industrial, other*
- Enhances multipurpose cadastre by supporting **automated updates** from **360° imagery** and **GeoAI.**
- **Improves efficiency** and reduces subjectivity in **urban-use mapping.**
- ***Limitations***: 360° complexity, occlusions, high computational cost, limited generalisation.

Source: GENTE – UFV (2025)





a) Detection task (Inception-ResNet-v2)

b) Examples of results of automated building usage types classification (EfficientNet-B7)

91,5%
Train accuracy

83,7%
Test accuracy

USE CASE 2 SEMANTIC INTEGRATION AND INTELLIGENT INTERACTION WITH CADASTRAL INFORMATION

LLM (*Large Language Model*)-powered **geospatial chatbot** for **cadastral management**

- Prototype **LLM chatbot** connected to an **LADM-compliant database**.
- Retrieves **cadastral information** (**property, infrastructure, zoning** and **valuation data**) from the **database** through **NATURAL-LANGUAGE QUERIES**.
- Enables **applications** for **cadastral management** and **citizen services**.
- Promotes **semantic integration, transparency** and **accessibility.**
- ***Limitations***: Depends on **well-structured** and **standardised databases** (e.g. LADM); requires **human oversight** to ensure **semantic accuracy** and prevent **AI misinterpretation.**

NLP ⇄ SQL
Qwen 2.5 (OpenAI GPT-4o)

PostgreSQL PostGIS

```
SELECT
    COUNT(*) AS total_unpaved,
    ROUND(
        (COUNT(*) * 100.0 / (SELECT
COUNT(*) FROM streets)),
        1
    ) AS percentage_unpaved
FROM streets
WHERE surface_type = 'unpaved';
```

GEOAI-DRIVEN STUDIES IN LAND ADMINISTRATION

Some Research and Applications of AI in Land Administration (Brazil and beyond)

Application Area	Key Technologies	Main Contribution	References
Literature Review & Trend Analysis	AI, Machine Learning, Structural Topic Modelling	AI-assisted review highlighting key LADM trends and research focus.	McCord, 2022 Aditya et al., 2024 Uşak et al., 2024 Hosseini et al., 2025 Mehmood et al., 2025
3D Cadastre & BIM Integration	BIM, 3D Cadastral Data, Sensors	Low-cost 3D Digital Twin for urban management and sustainability.	Aditya et al., 2024 Andritsou et al., 2024 Shahidinejad et al., 2025 Widyastuti et al., 2025
Land Consolidation & Management	GIS, Automated Algorithms	Method to assess complexity in land consolidation processes.	Maciąg et al., 2024 Mango et al., 2023
Mass Property Valuation	GeoAI, Machine Learning (XGBoost, LightGBM)	GeoAI model for fair and accurate property tax valuation.	Droj et al., 2024 Gao et al., 2022 Mete, 2025
Cadastral Data Integration with LADM (Brazil)	LADM	Framework for integrating urban, rural and asset cadastres in Brazil.	Santos et al., 2013 Marra et al., 2017 Purificação et al., 2019 Vasquez et al., 2019
Multipurpose Cadastre Implementation (Brazil)	3D/4D Cadastre	Discussion on benefits and challenges of implementing 3D/4D cadastres.	Panchiniak et al., 2009 Carneiro et al., 2012 Paixão et al., 2012 Latawiec et al., 2017 Cabral et al., 2020

GEOAI-DRIVEN STUDIES

Are National Spatial Data Infrastructures Adequate for Achieving the 2030 Agenda?A Case Study of Brazil's NSDI from the Perspective of UN-GGIM Fundamental Themes

Transactions in GIS

Collaborative Toponyms in OpenStreetMap: an open-source framework to investigate the relationship with intrinsic quality parameters

Cartography and Geographic Information Science

Forthcoming

Is AI-Based Toponym Extraction of Street-Level Imagery a Reliable Approach for Validating OpenStreetMap Toponyms?

Boletim de Ciências Geodésicas

FINAL REMARKS

1. **AI and GeoAI are reshaping land administration**
   Enhancing efficiency, accuracy, and interoperability across cadastral systems

2. **GeoAI-based pipelines**
   Enable automated feature extraction and continuous updating of cadastral data from imagery

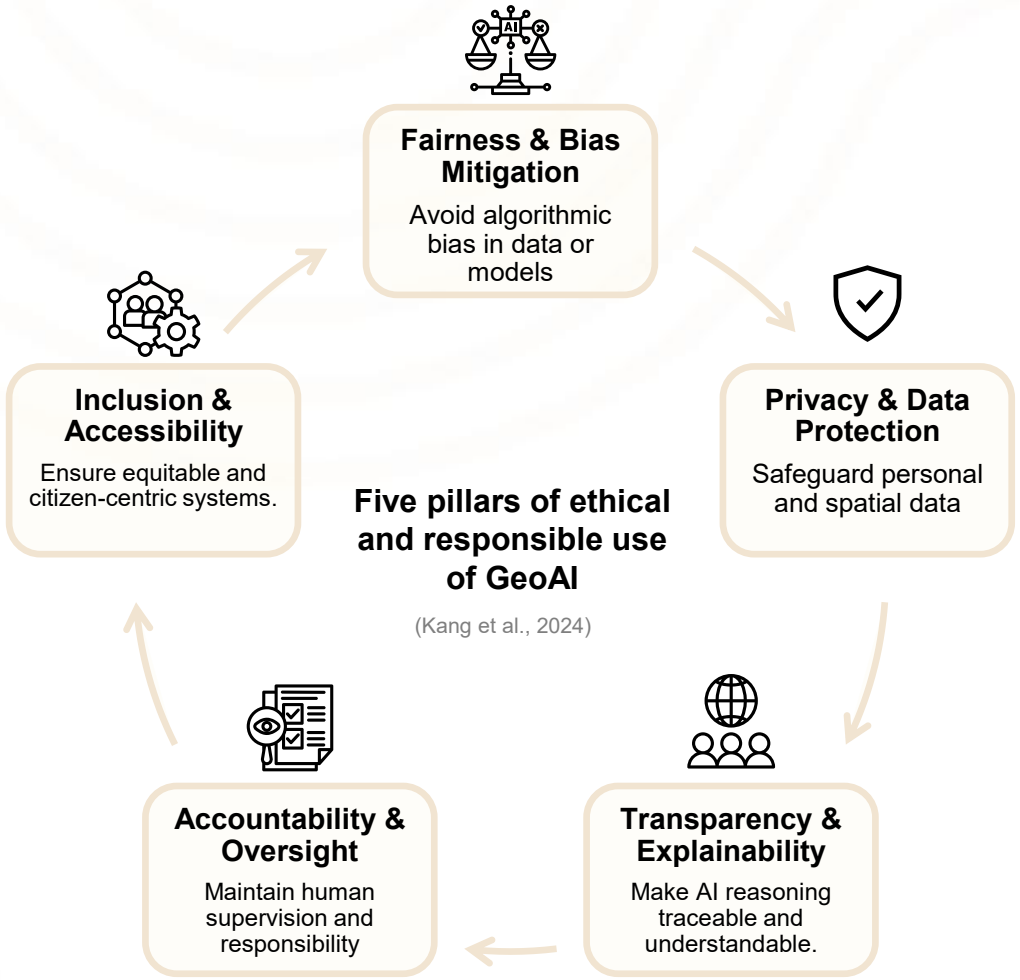
3. **LLM-powered tools**
   Improve semantic integration and natural interaction with cadastral information

4. **Structured models such as LADM**
   Essential to ensure data consistency, interoperability, and legal traceability

5. **Ethical, transparent, and responsible AI adoption**
   It is critical to maintain public trust in land Governance in the era of AI

6. **Interdisciplinary collaboration**
   Between technical, legal, and institutional actors is key to scaling AI integration

7. **Future research**
   Should advance standardisation, open data practices, and equitable access to AI technologies



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THANK YOU ALL!

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