Cross-border cropland indicators and field-scale rice system mapping from multi-sensor Earth observation in the Senegal River Valley

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Motivation/Background

- Sub-Saharan Africa faces currently multiple risks (**climatic**, **social**, **economical**, **ecological**)

→ **Food Security**

- Projected population development in West Africa from 400 million to 1.2 billion in 2100
- Rising population as driver for:
  - Increase in cropland
  - Increase in livestock
- Intensification of currently used agriculture area is needed
- Solution: Sustainable Intensification (SI) → **monitoring!**

Goal:

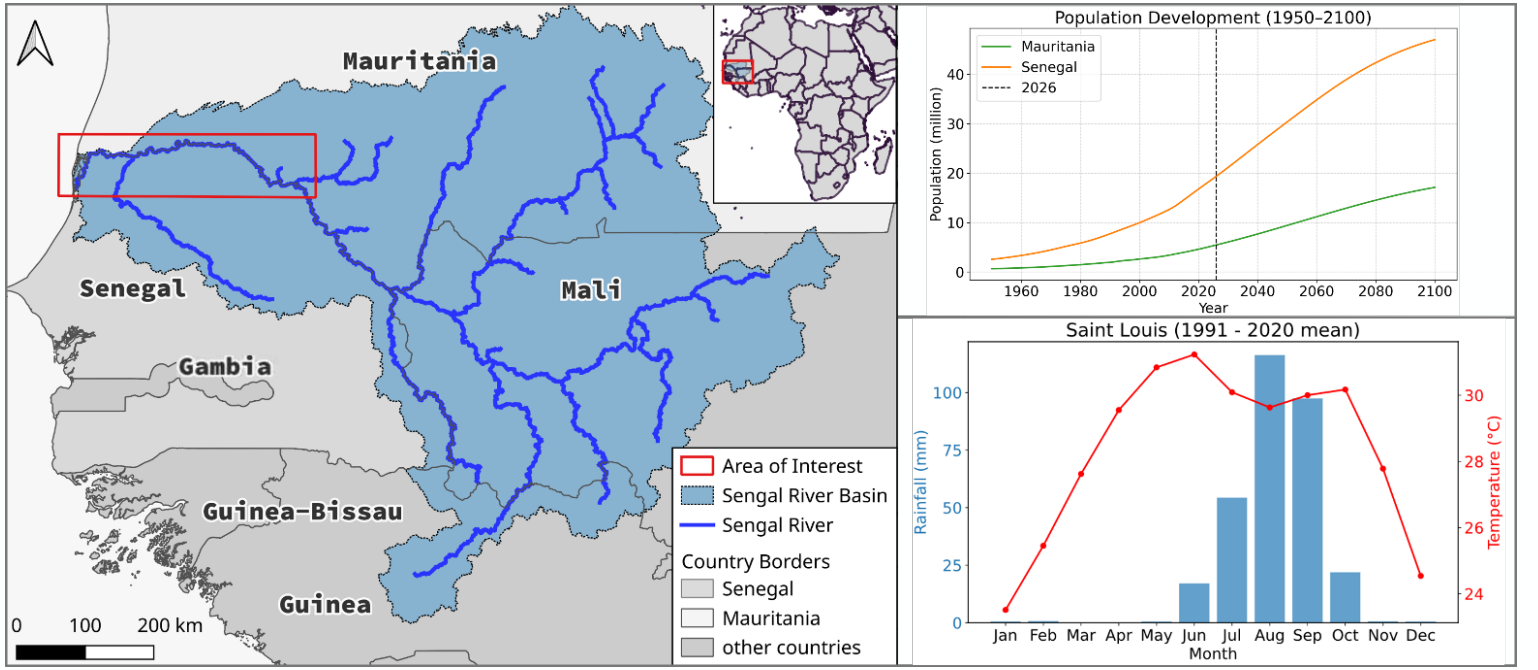
- Operational **agriculture monitoring** on spatial and temporal dynamic of agricultural area
- Information on management, intensity and fallow land
- Statistics to organize **targeted managment solutions** on field scale

Study area

Senegal River Valley

- focusing on the lower valley
- Senegal:
  - Departments of Saint-Louis, Dagana, Podor, and parts of Matam
- Mauritania:
  - Trarza, Gorgol, and Brakna regions
- Dominated by ariculture
- **Irrigated rice** cultivation (often double cropping)
- **Irrigated vegetables**
- Rainfed maize, sorghum, cowpea
- Predominantly **smallholder structure**
  - Small parcel size, irregular geometries, similar neigbouring fields, small edge contrast

Monitoring at field scale → challenging!

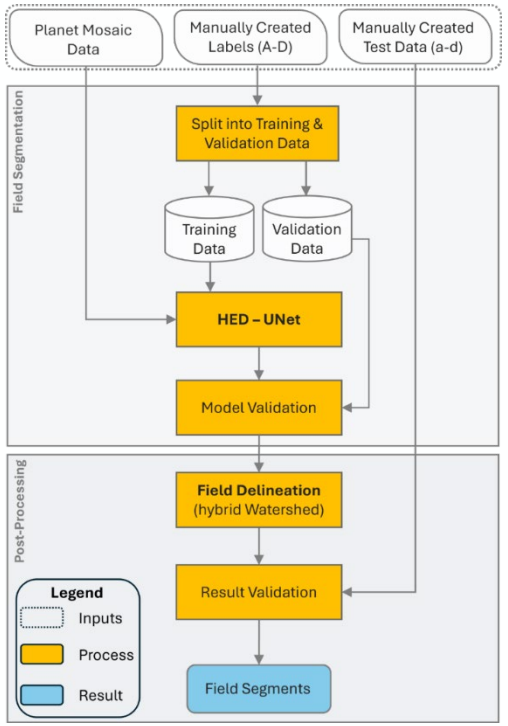


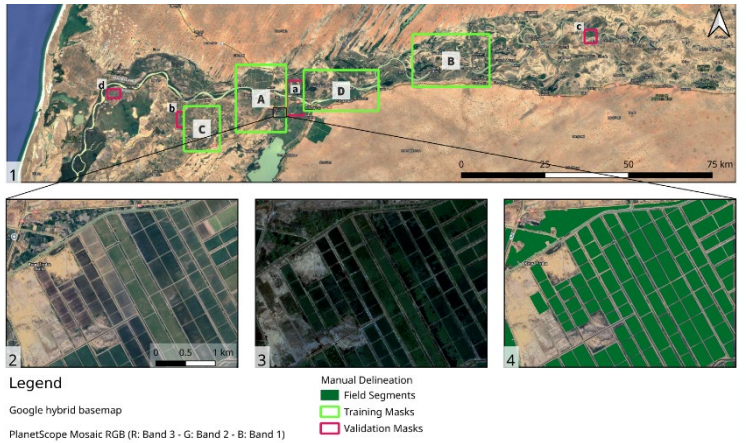
Heiss, N., Meier, J. et al., 2026 (submitted)

Methodology

Field boundary delineation

- High resolution PlanetScope mosaics (NICFI), monthly composites
- 2016-2025, maxNDVI, corresponding R, G, B, NIR, 5-band
- 5,467 fields manually delinated in 4 regions
- HED-Unet CNN architecture



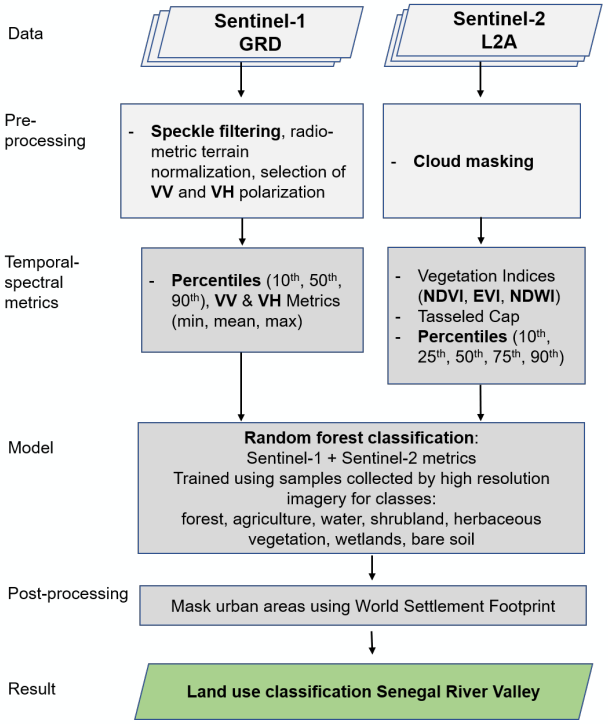


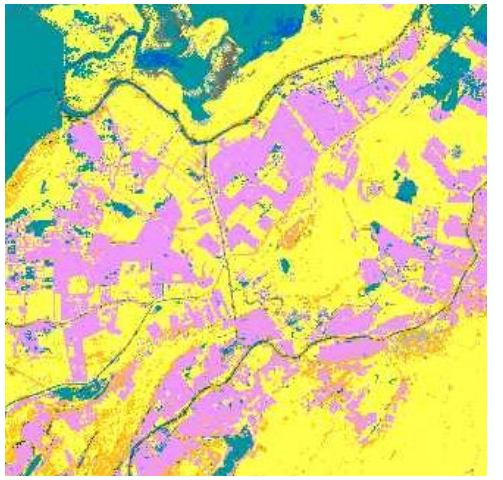
Post processing

- Watershed delineation
- Evaluation

Land use and Land Cover

- Sentinel-1 & Sentinel-2
- 2016-2024
- Sampling using high resolution Google Maps data
- Random Forest Classifier





Post processing

- Mask urban areas using WSF
- Evaluation

Results I

Senegal River Valley – Field boundary

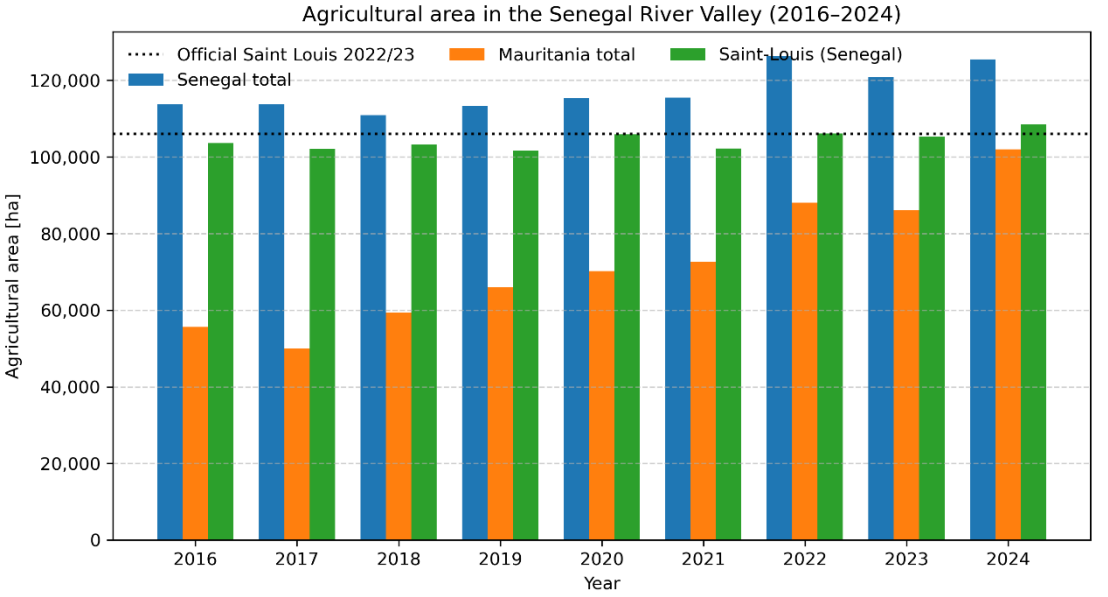
- First high-resolution (4.77 m) field dataset for the entire Senegal River Valley (covering ~26,000 parcels, 2017–2025).
- Pixel-wise evaluation showed **high accuracy** performance
  - **IoU** = 0.73, **F1** = 0.84, **Recall** = 0.97 (few missed fields)
  - confirms the model successfully captured diverse geometries
- **Visual validation** confirmed close alignment
- **Challenges**: Lower precision due to difficulty separating adjacent fields in dense areas.
- **Limitations**: Poor detection in wetlands and very small/irregular fields and in complex or low-contrast environments.
- **Agricultural extent**: 307,971 ha total (179,891 ha in Senegal, 128,080 ha in Mauritania), with highest intensity in Dagana and Rosso.

Country	District	District area (ha)	Agricultural area (ha)	Agricultural share (%)
	Keur-Macène	261,509	38,469	14.71
	Rosso	130,258	27,210	20.89
	R'Kiz	554,750	36,099	6.51
	Boghé	162,432	13,080	8.05
	Bababé	84,594	1,451	1.72
	M'Bagne	64,740	1,893	2.92
	Kaédi	421,608	9,878	2.34
Mauritania	total	1,679,891	128,080	
	Saint-Louis	87,431	6,252	7.15
	Louga	568,739	10,827	1.90
	Dagana	555,758	109,966	19.79
	Podor	1,381,493	42,783	3.10
	Matam	511,735	10,063	1.97
Senegal	total	3,105,156	179,891	

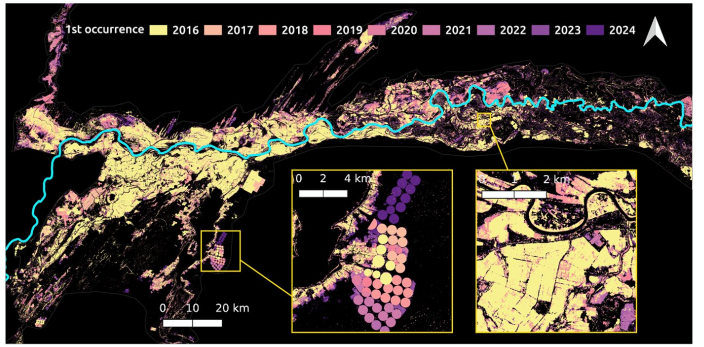
Results II

Senegal River Valley – expansion of cropland

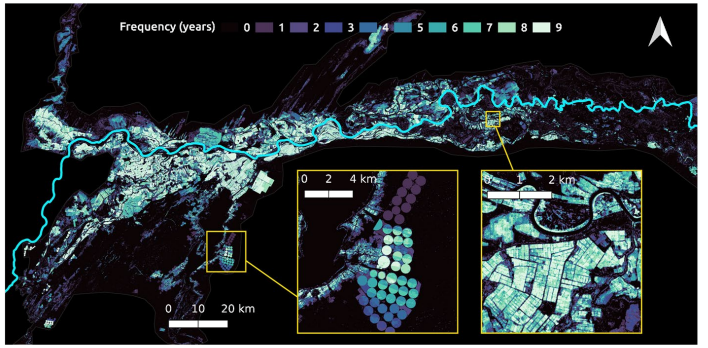
- Strong cross-border contrast (2016–2024):
  - Senegal SRV cropland remains stable (~120,000 ha/yr)
  - Mauritania shows rapid expansion (~60,000 → >100,000 ha).
- **Expansion hotspot**: Growth on the Mauritanian side is concentrated in Keur-Macène and R'Kiz (Rosso more stable).
- Development in Mauretania in the last years.
- **Different farming structures**: Mauritania exhibits larger, more consolidated fields (commercial perimeters); Senegal shows smaller, fragmented smallholder parcels.
- **Frequency:** high frequency in Mauritania while fallow fields in Senegal.
- No clear **climatic influence** can be derived → fallow land due to lack of **finance** or **labor**.
- Results in line with the **official statistics**.



First occurence:



Frequency:



Relevance for policy

Official statistics:

- Provides the first spatially explicit, high-resolution agricultural parcel dataset for the entire Senegal River Valley — enabling accurate, granular statistics on land use, crop distribution, and farming systems.
- Supports national and regional agricultural monitoring, improving the accuracy of official statistics on cultivated area, productivity, and land use change.

Targeted policy:

- Enables design by revealing spatial patterns of agricultural intensity, smallholder dynamics, and vulnerability hotspots.

Decision-Making:

- Facilitates evidence-based decision-making in water management, climate adaptation, and rural development planning.
- Serves as a foundation for digital agriculture, land tenure mapping, and climate-smart subsidy targeting in West Africa.

Future work & recommendations

Future Work:

- Using the **field boundaries** as bench mark product for **expansion analysis** and **cropping intensity**.
- Calculate **water consumption** of irrigated fields and water use efficiency.
- Automatically reporting on active and fallow land to **local authorities**.
- Monitoring system to gap bridge between farmers and **financial institutions**.

Recommendations:

- Prioritize **operational** high-temporal-resolution missions, continuing S1 and S2.
- Besides the existing and upcoming global or continental products, **regional studies** in complex environments are further necessary to guide the **transformation to sustainable agriculture**.
- Support **capacity building** in West Africa through targeted training and co-development of tools for local users, ensuring **long-term sustainability** of Earth observation applications.

COINS
co-developing innovations for sustainable land management in West African smallholder farming systems

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Thank you!

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