

Enhancing Land Degradation Neutrality Reporting Through EO-Based Woody Weed Monitoring

Midterm Progress Report

Project Code: 02_EOWM_KE_DE_EOAC4

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Project Overview



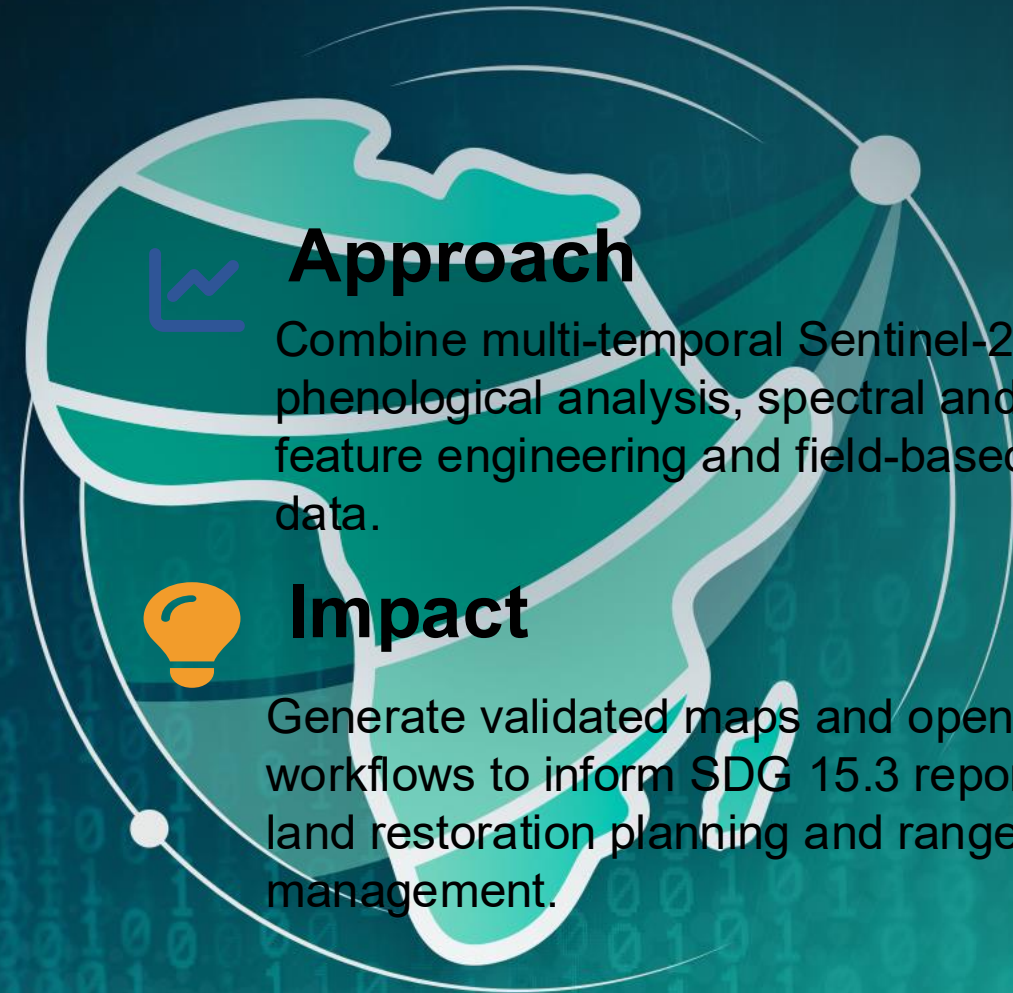
Objective

Develop an EO-based routine to detect invasive *Prosopis juliflora* and refine Land Degradation Neutrality (LDN) reporting in Kenya.



Challenge

Evergreen invaders produce misleading productivity signals in satellite data, masking ecological degradation and loss of ecosystem services.



Approach

Combine multi-temporal Sentinel-2 data with phenological analysis, spectral and harmonic feature engineering and field-based reference data.

Impact

Generate validated maps and open workflows to inform SDG 15.3 reporting, land restoration planning and rangeland management.

Problem Setting: LDN & SDG 15.3.1 LD indicator

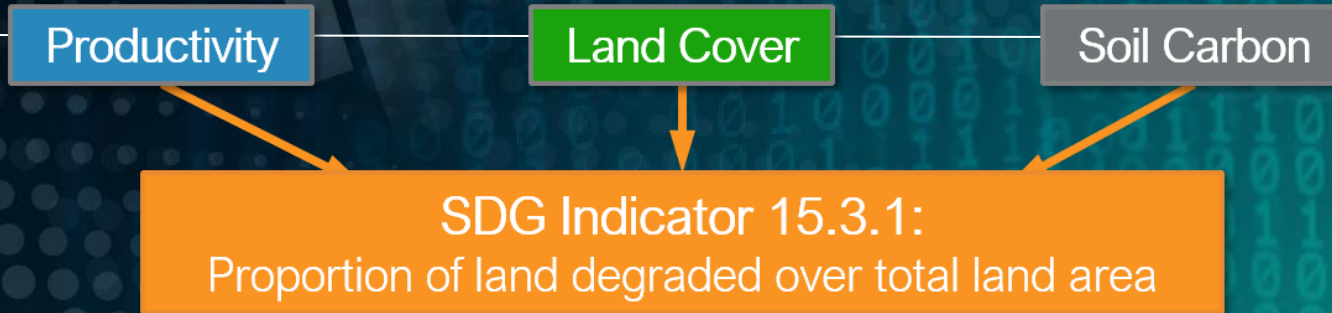
Land Degradation Neutrality (LDN)

A state where the amount and quality of land resources necessary to support ecosystem functions and services remain stable or increase. Achieved by balancing avoided, reduced and reversed degradation and maintaining natural capital to support food, water security and climate mitigation.

SDG Indicator Land Degradation (LD) 15.3.1

Proportion of degraded land over total land area

Three sub-indicators: trends in land cover, land productivity (including trend, state and performance) and carbon stocks are integrated via a one-out-all-out rule; **negative trends** counts as degradation.



Indicator 15.3.1
Proportion of land that is degraded over total land area

Problem Setting: Prosopis juliflora Invasion



Prosopis juliflora is an **evergreen invasive woody species** introduced for land rehabilitation but now considered one of the world's worst weeds, occupying ~2 % of Kenya's land area.



Dense thickets displace native vegetation, alter soil chemistry (higher salinity & nitrogen) and suppress herbaceous cover, thereby degrading rangeland ecosystems.



High evapotranspiration leads to increased water consumption, reduced groundwater recharge and siltation of riverbeds, exacerbating floods and causing water scarcity.



Invasion blocks livestock routes and water points, reduces pasture and forces pastoralists to migrate, threatening livelihoods and potentially leading to resource-based conflicts.



Fig. 1 Field photos of Prosopis juliflora in Nguruman, Magadi Ward, Kenya (October 2025 – February 2026)

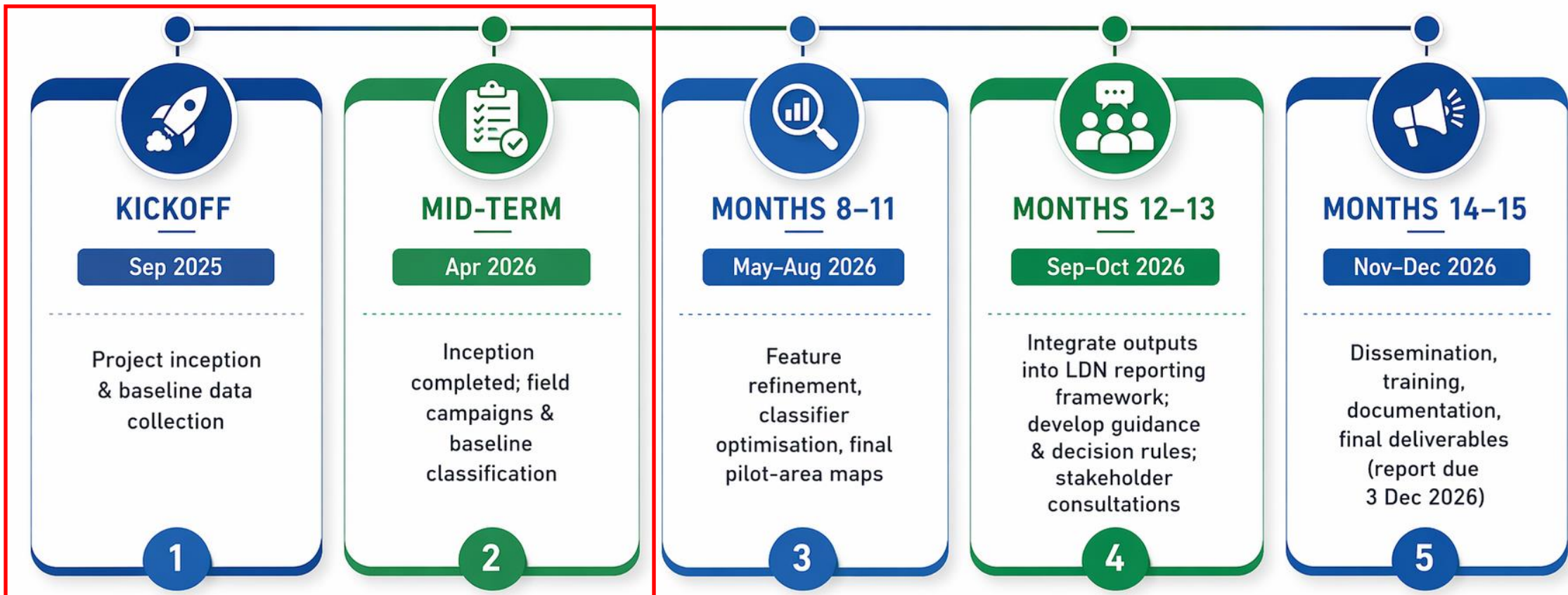
Problem Setting: Impact Prosopis on SDG 15.3.1

STANDARD EO/LDN INTERPRETATION		ACTUAL ECOLOGICAL REALITY	
<p>Increasing greenness / NDVI Stronger vegetation signal over time</p>	<p>Invasive woody encroachment Expansion of <i>Prosopis juliflora</i> and other shrubs</p>		
<p>Higher biomass productivity More biomass captured by satellite sensors</p>	<p>Loss of native grasslands Replacement of grasses by woody species</p>		
<p>“Stable or improving” land condition LDN metrics suggest stable or improving condition</p>	<p>Reduced forage availability Less grass for livestock and wildlife</p>		
<p>Positive vegetation trends Time-series indicates positive change</p>	<p>Water stress & ecosystem degradation Higher water use by shrubs, reduced water availability</p>		
<p>Improved productivity indicator Indicators interpreted as positive performance</p>	<p>Declining livelihood resilience Lower livestock productivity, income and food security</p>		

Key Takeaway: Greener does not always mean healthier ecosystems.

Project Timeline & Planned Activities

PROJECT TIMELINE & PLANNED ACTIVITIES



Progress till May 2026 & Preliminary Outputs

Coordination

icipice & University of Hamburg established roles, data handling protocols and use of the EO AFRICA Innovation Lab.

Data Compiled

Multi-year Sentinel-2 data (2023–2025) accessed; ground-truth and ancillary datasets assembled for training & validation.

Field Campaigns

In-situ observations collected in Oct 2025 & Feb 2026 verifying Prosopis occurrence and supporting model training.

Stakeholder Engagement

Local elders & community members consulted on invasion impacts and management priorities, ensuring contextual relevance.

Workflow Established

EO pre-processing & feature engineering pipeline built: cloud masking, composites, indices, harmonic & texture features.

Baseline Classification

Random Forest experiments initiated to evaluate separability of Prosopis from surrounding vegetation using a 38-feature predictor stack.

Study Area: Nguruman, Southern Kenya

Location

- 35°53'E–36°23'E & 1°38'S–2°08'S in Magadi Ward, Kajado County, southern Rift Valley.
- Topographic heterogeneity creates diverse microclimates.

Climate

- Arid to semi-arid: rainfall 400-600 mm per year with bimodal seasonality (long rains March–May, short rains Oct–Dec).
- Temperatures exceed 25 °C and variability is high.

Ecosystem & Land Use

- Acacia-Commiphora bushland and deciduous grasslands support pastoral and agro-pastoral livelihoods.
- Invasion of *Prosopis* has altered the landscape, reducing pasture and obstructing access to water.

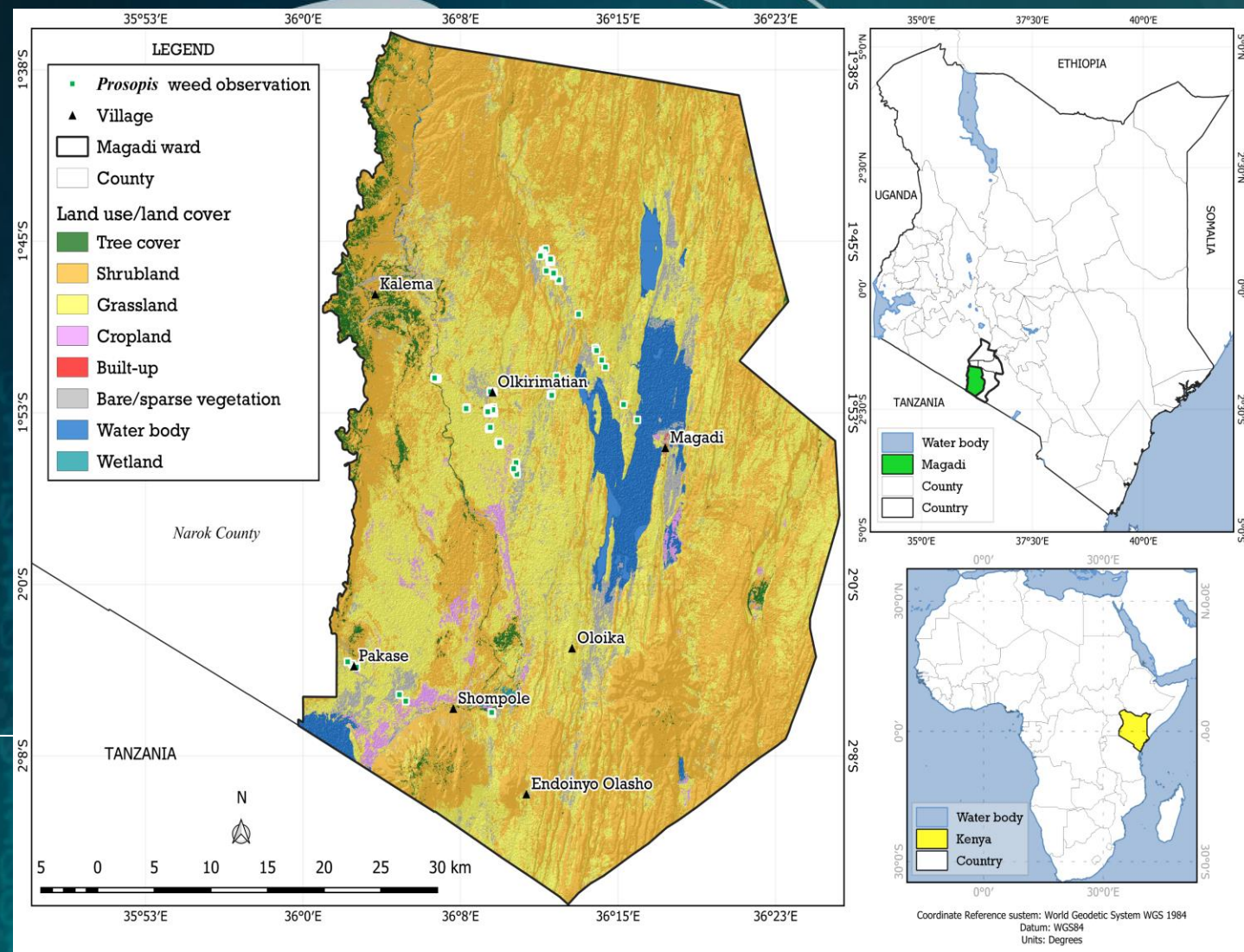


Fig. 2 The study area of the project of in Nguruman, Magadi Ward, Kenya.



Stakeholder Meeting

On 21 Oct 2025 local elders and pastoral community representatives shared knowledge on invasion dynamics, grazing impacts and management priorities.



*Fig. 3 Stakeholder engagement workshop in Magadi, Kenya, including focused discussions with local elders on the impacts of *Prosopis juliflora* (mathenge) and community perspectives on sustainable management solutions.*



Stakeholder Meeting

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Fig. 4 Post-workshop meeting in Nguruman with project partners and local community members, Magadi, Kenya.

Field Data & Stakeholder Engagement



Field Campaigns

Two campaigns (Oct 2025 & Feb 2026) collected presence-absence observations of *Prosopis juliflora* to support classification and validation.



Fig. 3. Field sampling exercise of *Prosopis* weed conducted in Nguruman, Magadi Ward, Kenya.

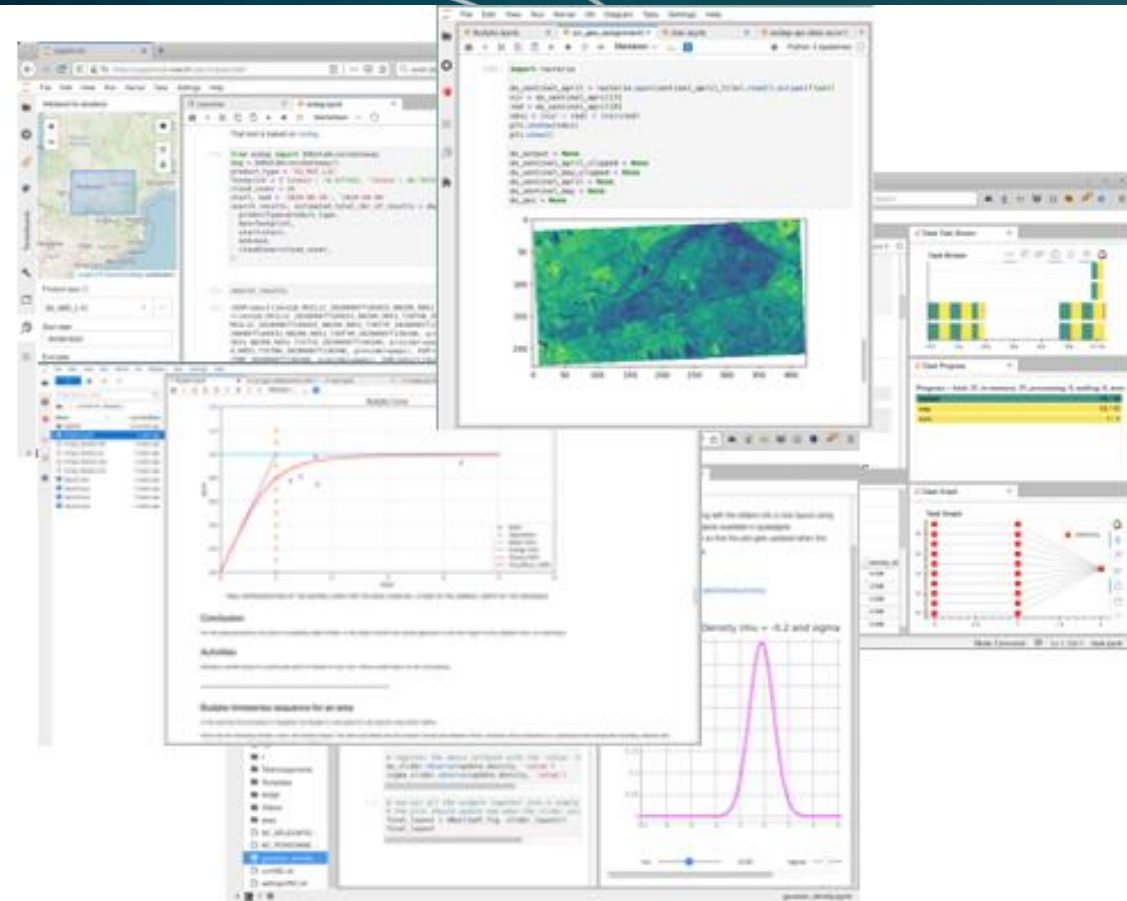
Field Data & Stakeholder Engagement

Capacity Building

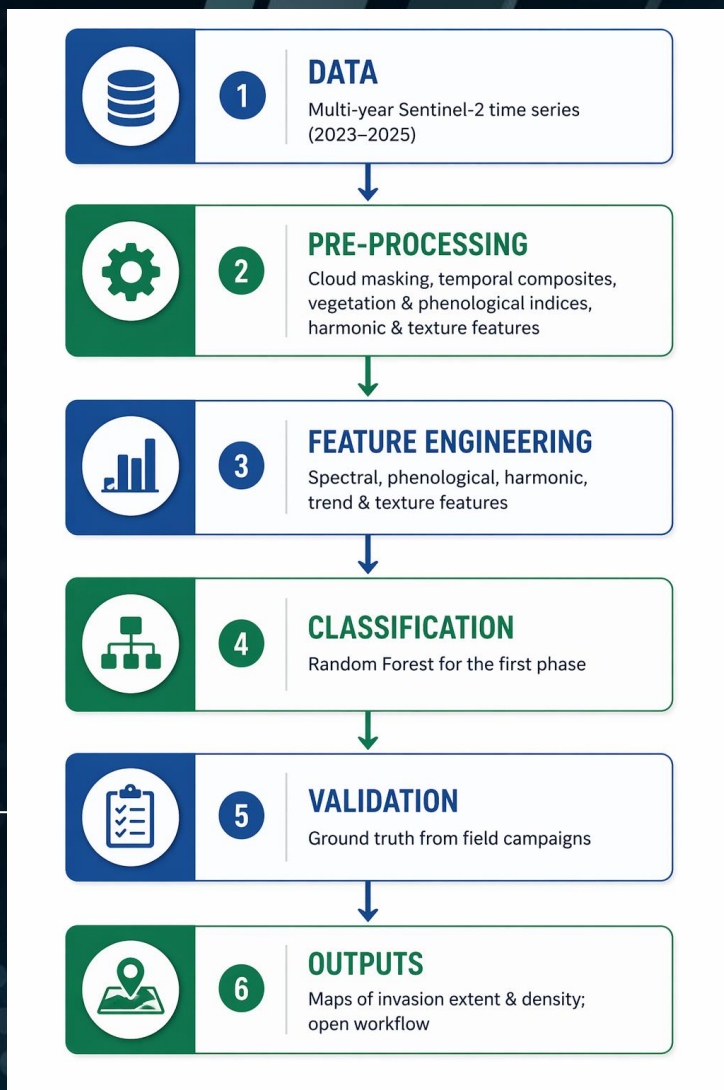
Team (icipe) attended EO AFRICA course on cloud computing and algorithms in Tunis (Dec 2025), enhancing technical capability for cloud-based EO processing.



Cloud Computing and Algorithms for EO Analyses



EO-Based Prosopis Classification Workflow

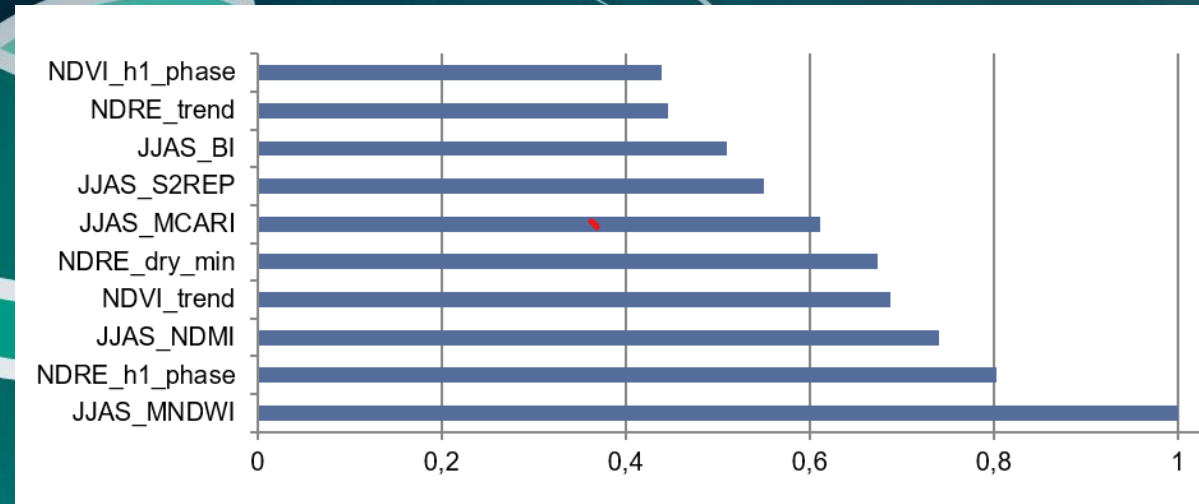
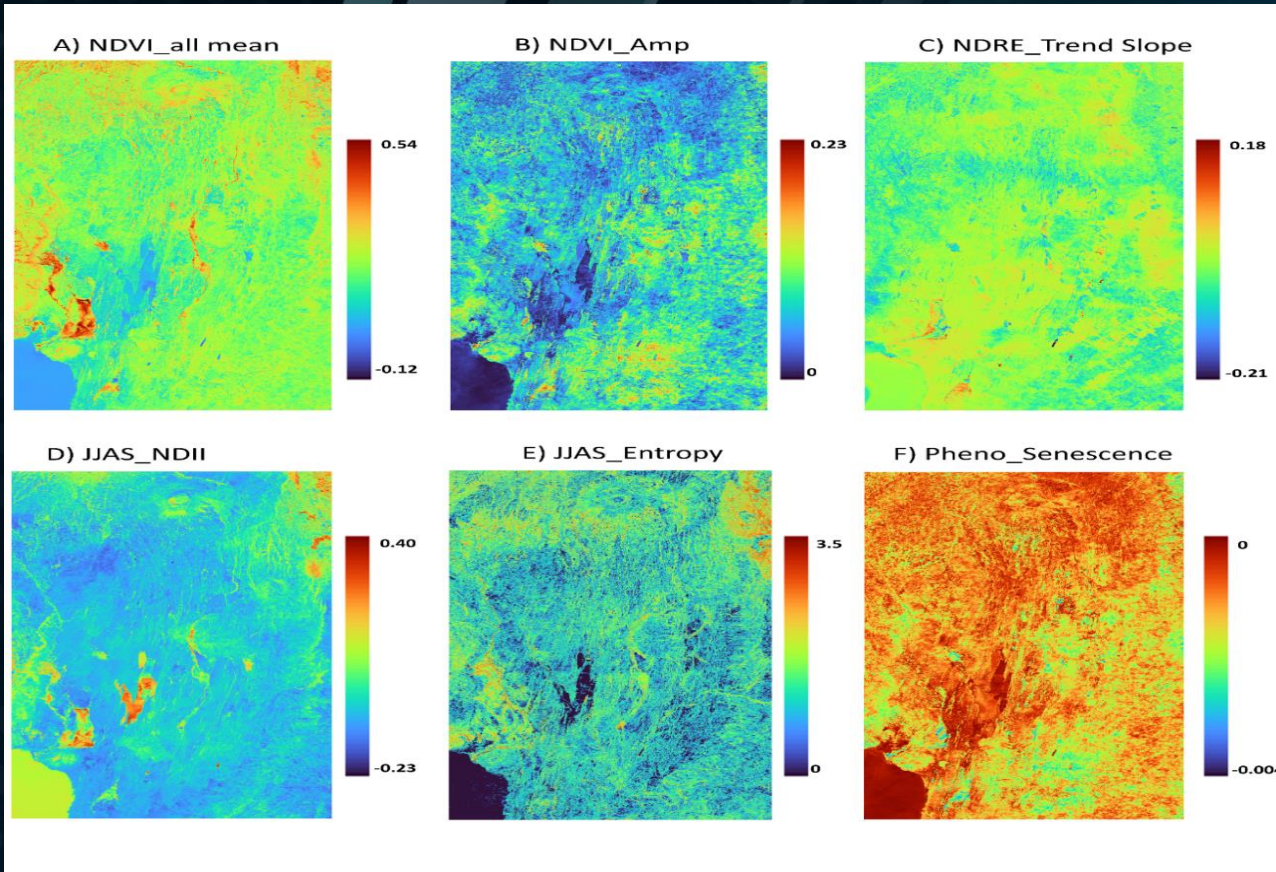


Parameter	Description
Sensor	Sentinel-2 MSI (A/B)
Dates	8 Jan 2023 – 25 Dec 2025; 142 scenes
Resolution	10 m (resampled)
Bands	B2–B8A, B11–B12
Cloud threshold	< 30%

- ### Ancillary Variables
- DEM, slope, aspect & TWI
 - NDVI/NDRE temporal metrics (mean, min, max, harmonic)
 - Distance to rivers (future)
- ### Training & Validation
- 241 labelled points (121 Prosopis / 120 background) with ≥ 100 m separation; positional uncertainty buffered by 10 m.



Variables Importance



- Dry-season moisture indices (MNDWI, NDMI) and red-edge timing are the strongest discriminators of Prosopis invasion.
- Trend and phenological parameters capture persistent greenness;
- Texture metrics provide additional context.

Fig. 5. Example EO-derived feature layers used for Prosopis mapping from multi-temporal Sentinel-2 analysis: (A) annual mean NDVI, (B) NDVI seasonal amplitude, (C) NDRE trend slope, (D) JJAS NDII composite, (E) NDVI texture entropy, and (F) phenological senescence metric.

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Baseline Random Forest Classification Result

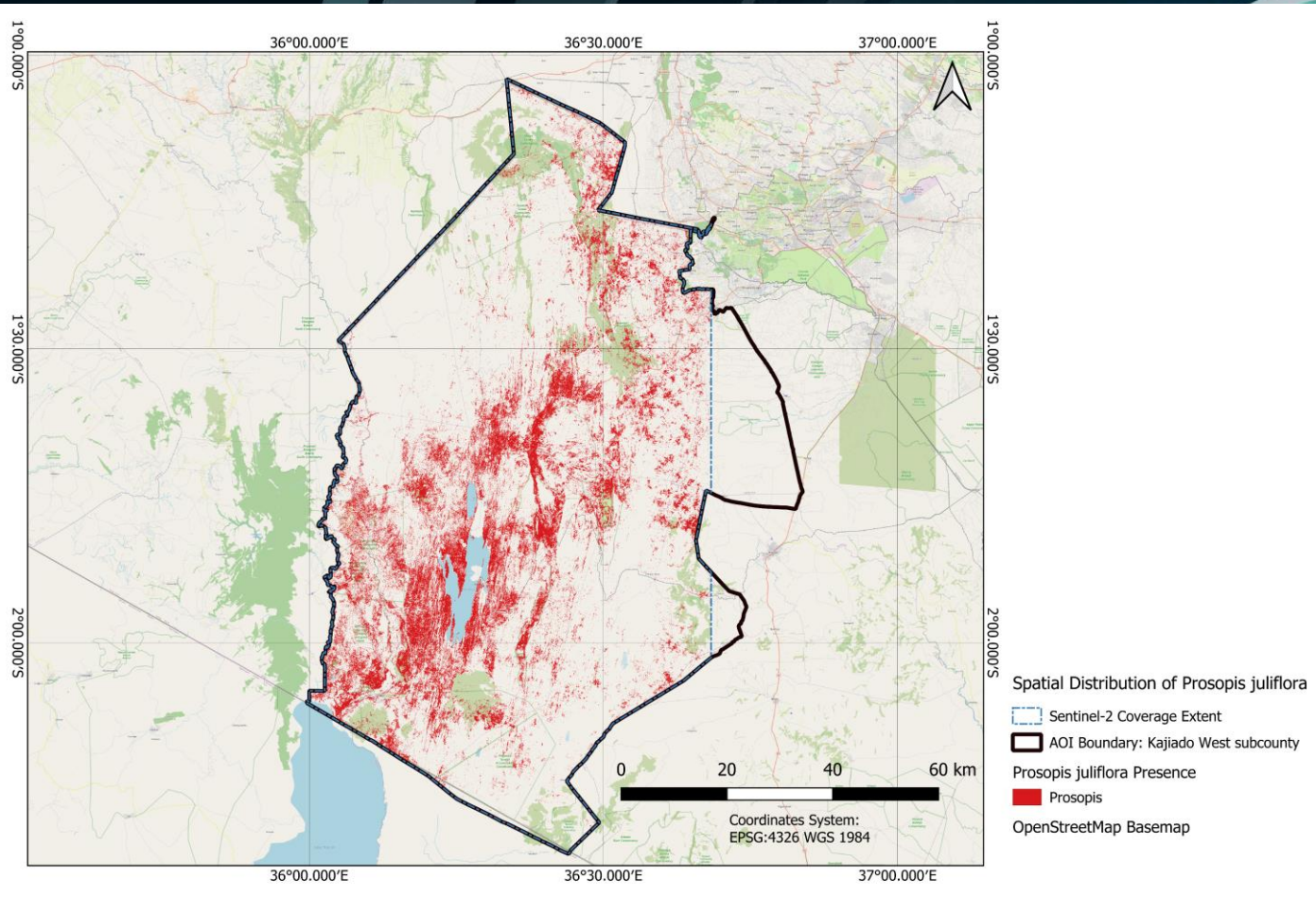


Fig. 6. Random Forest binary classification map of *Prosopis juliflora* distribution generated using the complete 38-feature Sentinel-2 predictor stack.

CLASSIFICATION PERFORMANCE

Metric	Value	Interpretation
ROC-AUC	0.758	Good separability between <i>Prosopis</i> and <i>non-Prosopis</i> classes
Overall Accuracy	71.4%	Reliable overall classification performance
Precision	0.710	Most predicted <i>Prosopis</i> pixels are correctly classified
Recall	0.727	Strong ability to detect existing <i>Prosopis</i> occurrences
F1-score	0.718	Balanced trade-off between precision and recall

CLASS-WISE PERFORMANCE

Class	Precision	Recall	F1-score	Support
Non- <i>Prosopis</i> (0)	0.718	0.700	0.709	120
<i>Prosopis</i> (1)	0.710	0.727	0.718	121

Persistent greenness of *Prosopis juliflora* enables detection during the dry season; phenological contrasts with native species illuminate invasion fronts.

Key challenges and Further work

Key Challenges

- Limited memory & storage required tile-based processing
- Sparse and uneven reference data; positional uncertainty near mixed pixels
- Spectral mixing between Prosopis, Acacia & grasses leads to false positives
- Frequent clouds & aggressive masking reduce usable scenes
- Spatial autocorrelation inflates random CV; grouped CV needed

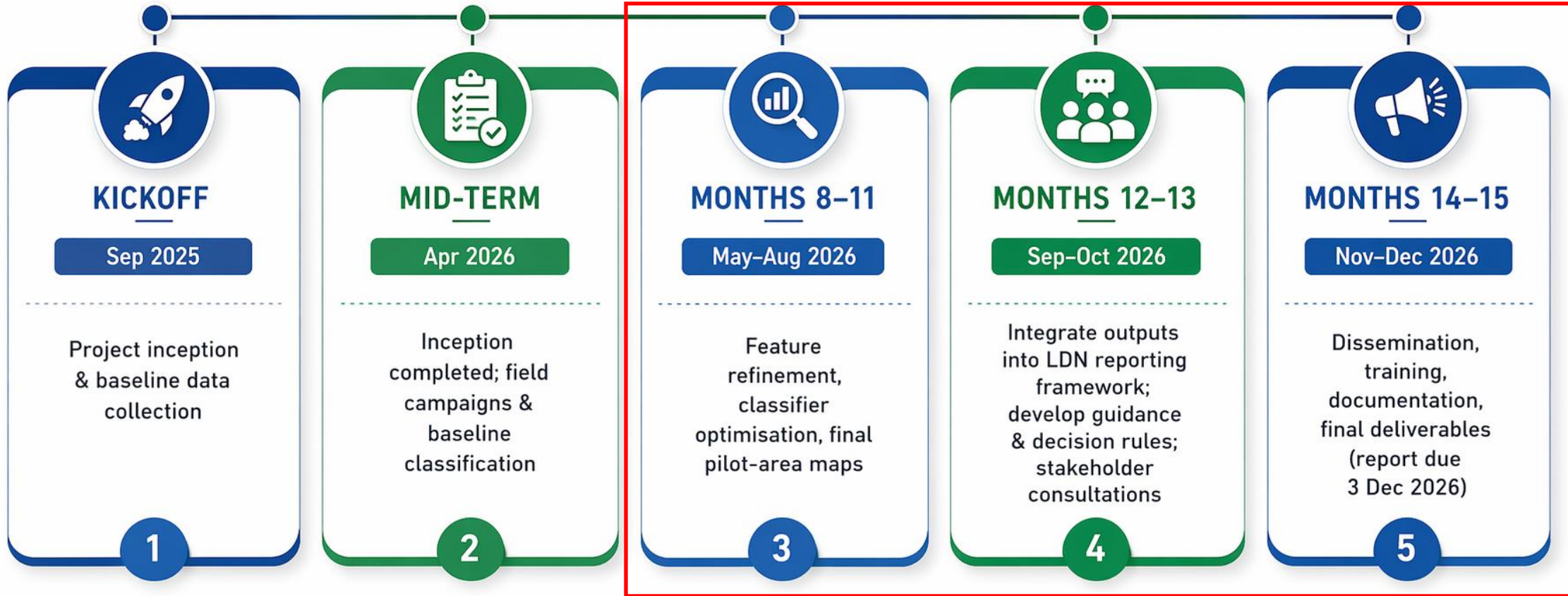
Future Directions

- Explore temporal models (Temporal RF, 1-D CNN) & integrate Sentinel-1 SAR
- Implement Positive-Unlabelled learning for uncertain absence labels
- Develop invasion-aware corrections for SDG 15.3.1 to flag false greening
- Expand field campaigns & citizen science contributions



Project Timeline & Planned Activities

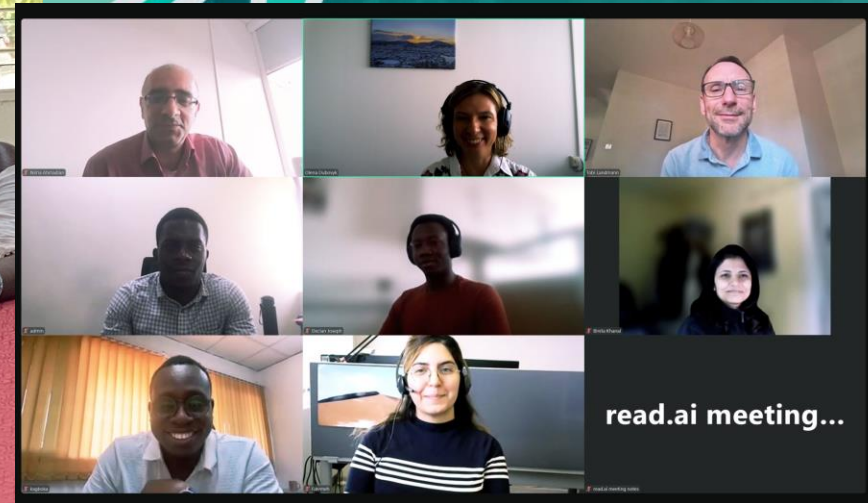
PROJECT TIMELINE & PLANNED ACTIVITIES



Conclusions & Implications

- *Prosopis juliflora* invasion in Kenya's drylands threatens ecosystems and livelihoods by displacing native vegetation, depleting water resources and obstructing rangeland access.
- Accurate detection of this evergreen invader using multi-temporal Sentinel-2 data and machine learning is essential to avoid misinterpreting positive vegetation signals in EO-derived LDN indicators.
- The mid-term progress demonstrates successful coordination, data acquisition, field campaigns, stakeholder engagement and the establishment of an open, reproducible EO workflow.
- Validated invasion maps and methodological guidance will enhance SDG 15.3 reporting, inform land restoration planning and support context-specific rangeland management in Kenya and beyond.
- Continued community involvement and integrated management strategies are crucial for controlling *Prosopis* and achieving Land Degradation Neutrality.





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Budget Utilisation

