SEN4LDN objective

Develop, **demonstrate** and **validate** a robust and scientifically-sound **EO methodology** that exploits the **high frequency and spatial resolution** of open and free-of-charge satellite imagery to increase **the spatial details of national assessments of land degradation and restoration**, and provide synoptic information for countries to plan LDN interventions at appropriate scales.

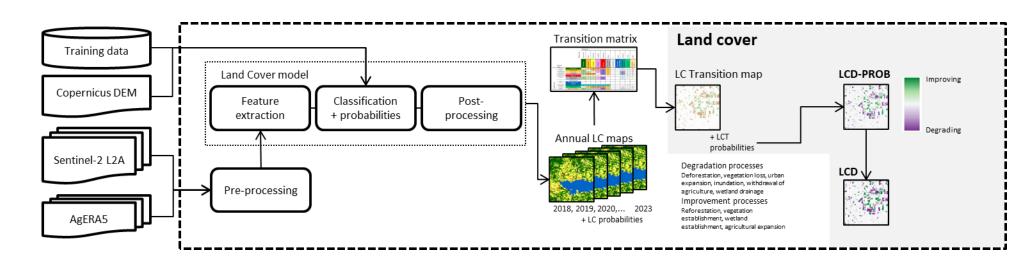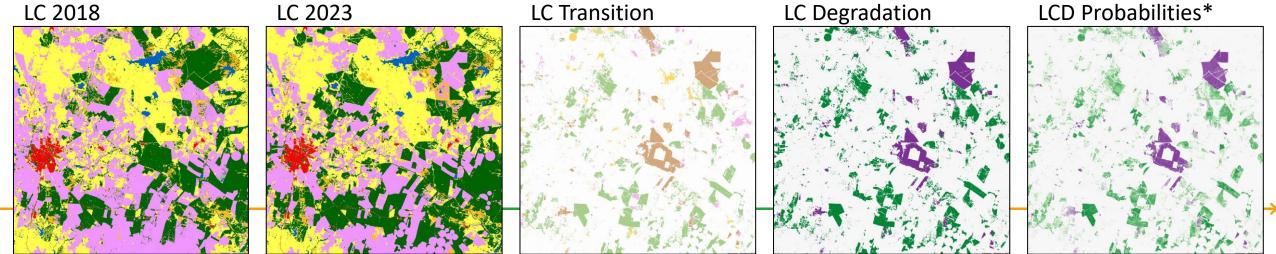| User Characterisation, Engagement and Requirement Engineering	Algorithm trade-off and Proof of Concept	EO Solution Development	National Demonstrations	Promotion and Outreach
Input Data Collection and Pre-processing			Early Adopter Use Cases	Roadmap

Trends in Land Cover

Automated, global land cover change algorithm generating discrete and continuous land cover degradation products at 10m resolution
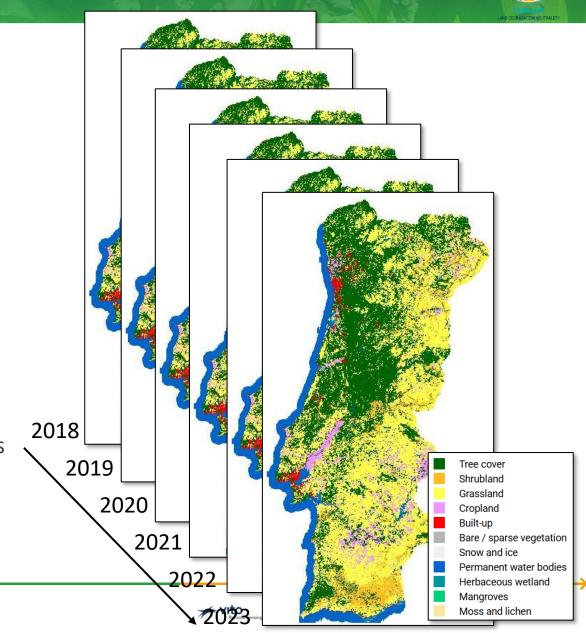

LC 2018   LC 2023   LC Transition   LC Degradation   LCD Probabilities*

Trends in Land Cover – Algorithm summary

Land Cover time series

- Updated **global Land Cover algorithm** (WorldCover V300) with focus on consistent Land Cover timeseries

- Pre-processing
  - Sentinel-2 L2A: improved clouds detection, interpolation and temporal compositing
  - Climatic regions embeddings based on AgERA5

- Improved inter-annual consistency
  - New multi-year training dataset
  - Multi-year training/algorithm calibration
  - Deep learning features + pixel classifier (spatial accuracy and context)

- Change detection + Post-processing to stabilize class fluctuations on Land Cover Timeseries

- Land Cover Probabilities used to derive continuous Land cover transition probabilities instead of using discretized maps
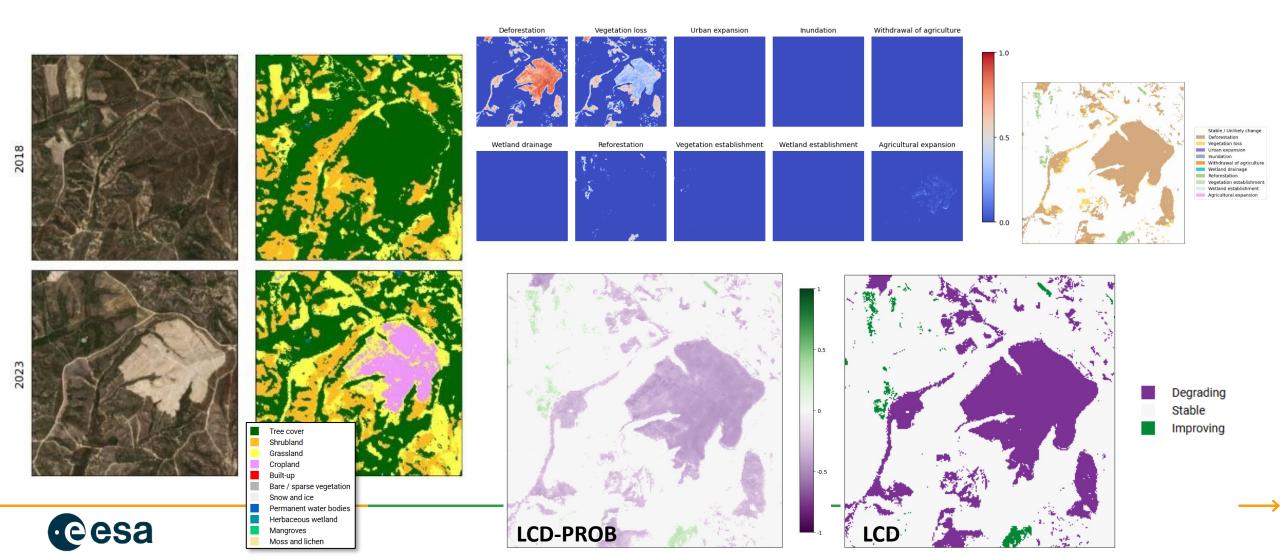

2018
2019
2020
2021
2022
2023

Tree cover
Shrubland
Grassland
Cropland
Built-up
Bare / sparse vegetation
Snow and ice
Permanent water bodies
Herbaceous wetland
Mangroves
Moss and lichen

Trends in Land Cover – Algorithm summary

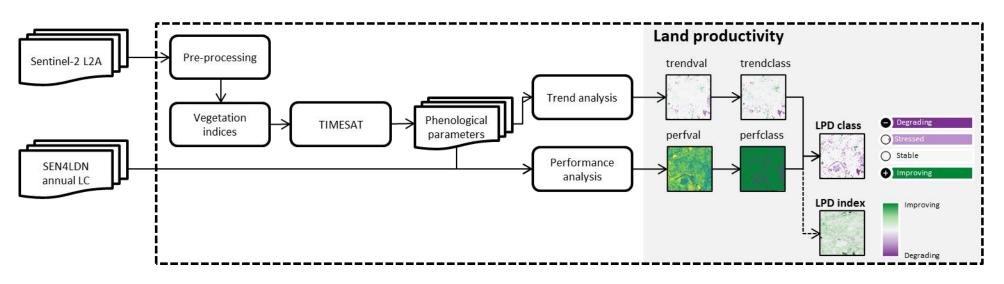- Transitions, transition probabilities → Discrete transition maps, LCD, LCD-PROB
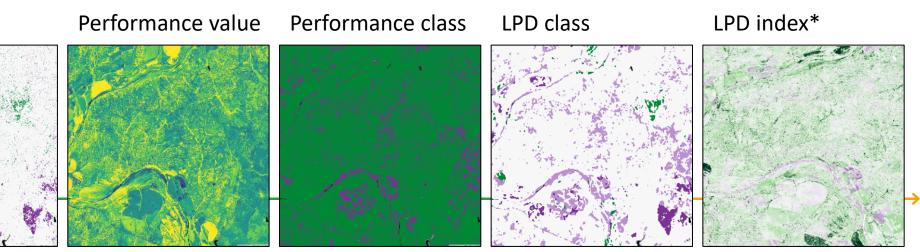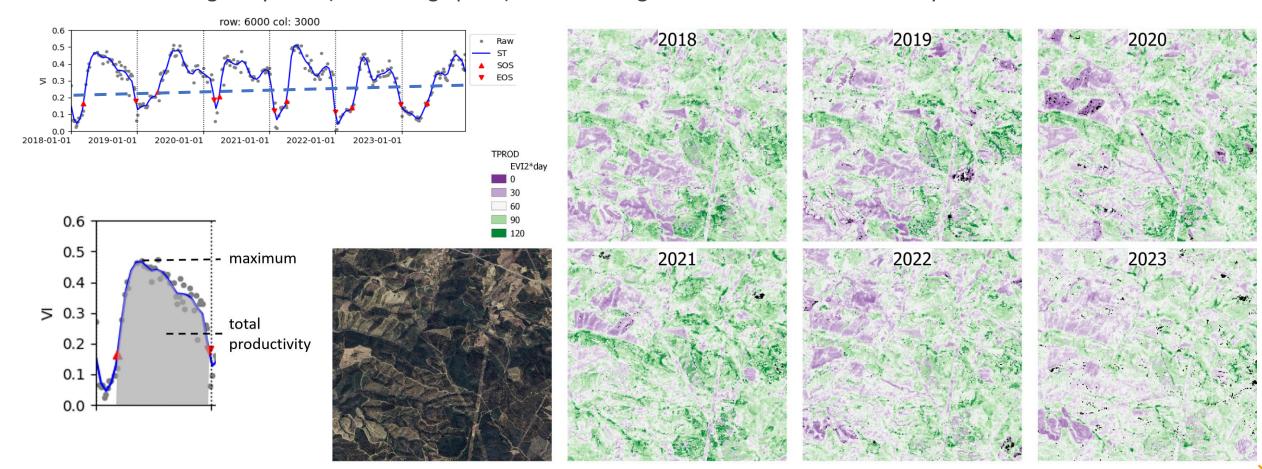
Trends in Land Productivity

Automated, global algorithm using TIMESAT to generate Land Productivity Degradation classes and continuous values at 10m spatial resolution

Trend value   Trend class   Performance value   Performance class   LPD class   LPD index*

- TIMESAT processing → Seasonal Total Productivity (TPROD)
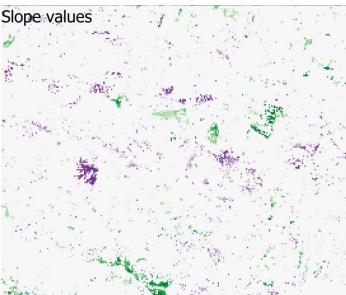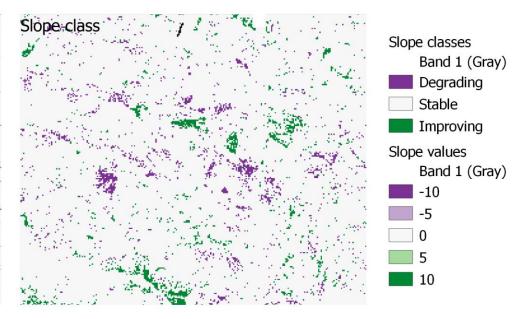 - ➢ Generating Daily EVI2 (Smoothing Spline) → Estimating of Seasonal Total Productivity

Trends in Land Productivity – Algorithm summary

- **Trend** of Seasonal Total Productivity
  - ➤ slope: the Theil-Sen robust statistical regression
  - ➤ P-value: the Mann-Kendall test
  - → Slope values and classes

Class	Criteria	Digital code
Degrading	Slope (-) and p ≤ 0.1	1
Stable	Slope (0) or p > 0.1	2
Improving	Slope (+) and p ≤ 0.1	3

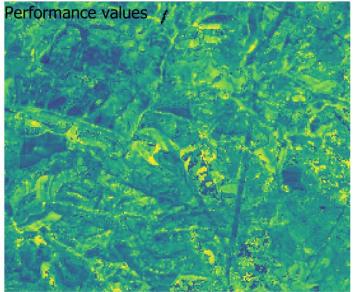# Trends in Land Productivity – Algorithm summary

- **Performance** estimation
  - ➤ Performance indicator I: Productivity Performance (PP)
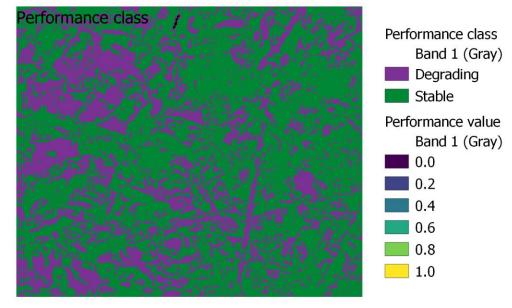
$$PP = \frac{TPROD_{max,p}}{TPROD_{ref,c}},$$

PP	Category	Code
$0.0 - 0.5$	Degrading	1
> 0.5	Stable	2

- $TPROD_{max,p}$ is the maximum 2021-2023 $TPROD$ value for a pixel belonging to a certain land cover class.
- $TPROD_{ref,c}$ is the reference TPROD value for all pixels of the same stable land cover class in the country. The 90'th upper percentile is used to determine the national reference TPROD of each land cover class.
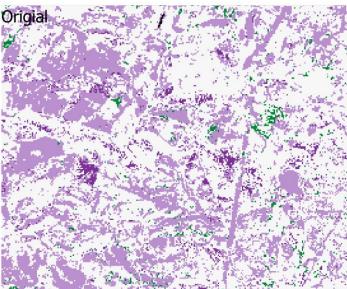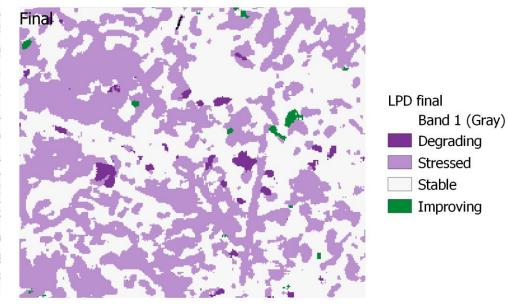
Trends in Land Productivity – Algorithm summary

- Land Productivity Degradation indicator: **LPD** (4 classes)

- Apply spatial filter to the final product

- Generate **LPD index**, products of normalized slope values and performance values

Trend	Performance	LPD
Degrading	Degrading/Stable	Degrading
Stable/Improving	Degrading	Stressed
Stable	Stable	Stable
Improving	Stable	Improving

LPD final
Band 1 (Gray)
- Degrading
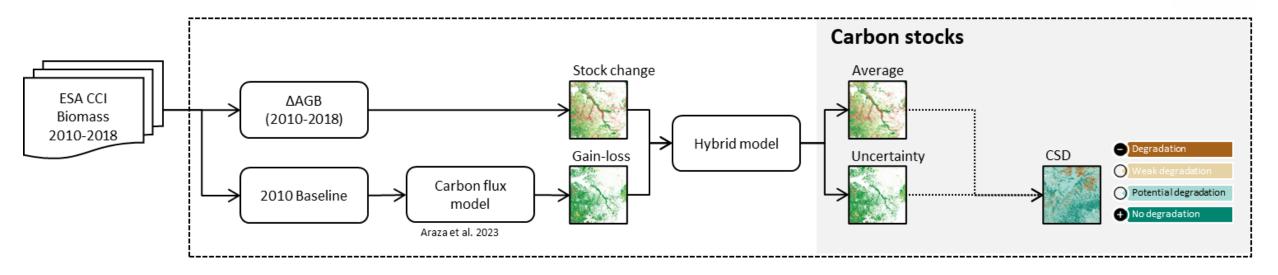- Stressed
- Stable
- Improving

Trends in Carbon Stocks

Focus on above ground carbon stocks

- Hybrid AGB mapping approach was developed as prototype demonstration case, based on two research demonstration models (*gain-loss WRI flux model and ESA CCI stock change*).

- Retrieval uncertainties are given indicating model fidelity.

- Net flux estimates provided (country statistics and whether carbon sinks or sources).
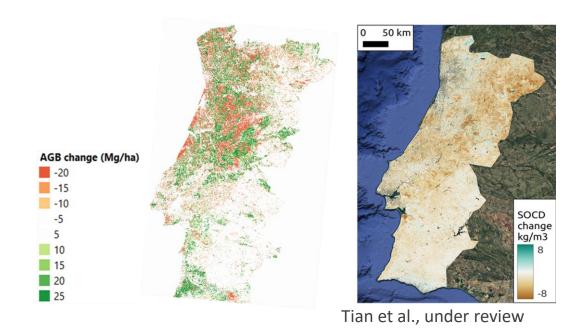
Trends in Carbon Stocks

AGB change (Mg/ha)
- -20
- -15
- -10
- -5
- 5
- 10
- 15
- 20
- 25

SOCD change kg/m3
- 8
- -8

0 50 km

Tian et al., under review

Limitations

- Spatial resolution lower & time span different than LC and Productivity sub-indicators (100 m)

- Absence of high-resolution global trend data of SOC derived from EO data: needed to assess total carbon stocks

- Potential biases in both AGB models

Roadmap

- Research efforts needed in estimation of total carbon stocks, integrating both SOC and AGB methodologies:

- For SOC: follow-up WorldSoils project, and exploration of other SOC research lines ongoing
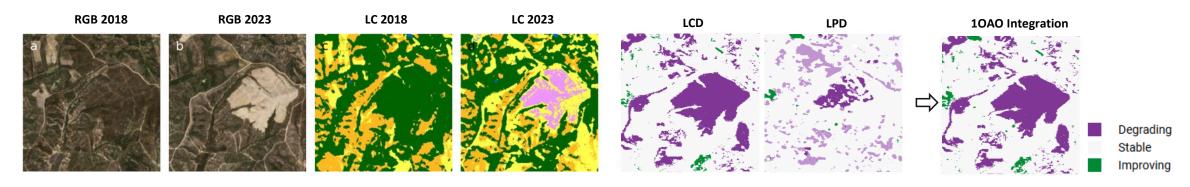 For AGB: further model development, refining & optimizing – BIOMASS and other missions…
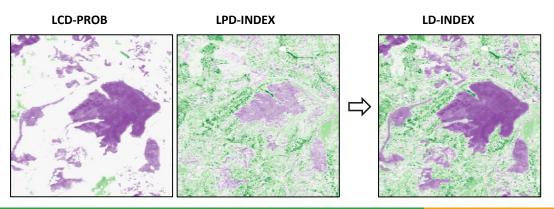
Integration for SDG 15.3.1 indicator on LDN

Proportion of land that is degraded over total land area

- One Out, All Out (1OAO)

RGB 2018 · RGB 2023 · LC 2018 · LC 2023 · LCD · LPD · 1OAO Integration

Degrading / Stable / Improving

- Exploration of continuous sub-indicator aggregation using LCD-PROB and LPD values to generate LD probabilities

LCD-PROB · LPD-INDEX · LD-INDEX

SEN4LDN Key outcomes

- **EO method for national assessments** of land degradation and restoration
  - at **high temporal frequency** (annual) and **high spatial resolution** (10 m)
  - **validated** using ground sampling data and through consistency evaluation
  - in a more **continuous** way

- Automated, **global land cover change** algorithm generating **discrete and continuous** land cover degradation products at **10m resolution**

- Automated, **global algorithm using** TIMESAT to generate **land productivity** degradation **classes and continuous values** at **10m spatial resolution**

- Exploration of the use of **aboveground biomass** for evaluation of trends in carbon stocks

- **Integration for SDG 15.3.1** on LDN: **One-Out-All-Out** and **testing of continuous sub-indicator** integration

- **User engagement**
  - living lab workshops with three SDG Early Adopters
  - national demonstrations and use cases in Portugal, Uganda and Colombia

- **Implementation into CDSE/openEO** (still ongoing) will enhance user uptake
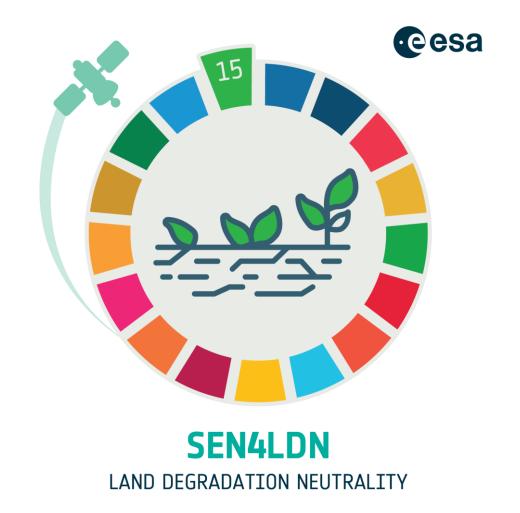

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https://esa-sen4ldn.org

Thank you
Questions?

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SEN4LDN

LAND DEGRADATION NEUTRALITY