SEN4LDN

LAND DEGRADATION NEUTRALITY

Land Degradation Neutrality

Land degradation is the result of human-induced actions which exploit land, causing its utility, biodiversity, soil fertility, and overall health to decline. **Land Degradation Neutrality** (LDN) is defined by the United Nations Convention to Combat Desertification (UNCDD) as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services to enhance food security remain stable, or increase, within specified temporal and spatial scales and ecosystems."

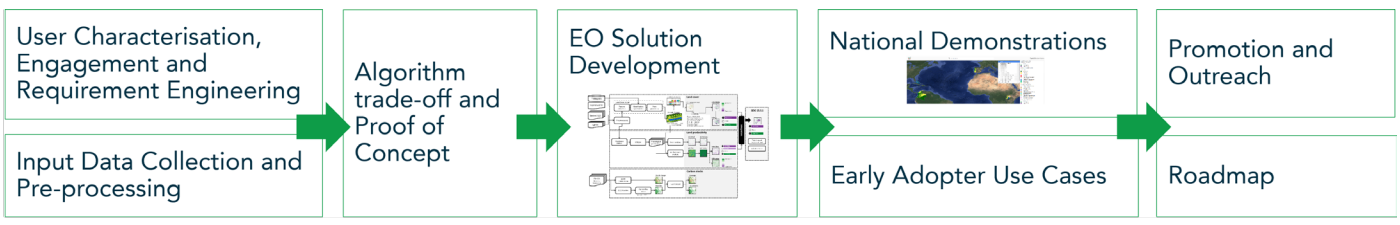
Sentinels for Land Degradation Neutrality Monitoring: Objectives

The primary objective of the European Space Agency's (ESA) Sentinels for Land Degradation Neutrality Monitoring (SEN4LDN) project was to **develop**, **demonstrate** and **validate** a robust and scientifically-sound **Earth observation (EO) methodology** that exploits the **high-frequency and spatial resolution** of open, 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. The SEN4LDN outcome consists of an EO solution encompassing globally applicable algorithms that were demonstrated over three use case countries: **Colombia**, **Uganda**, and **Portugal**.

SUSTAINABLE DEVELOPMENT GOALS

SDG 15.3.1

United Nations' **Sustainable Development Goal (SDG) 15 "Life on Land"** calls for the protection, restoration, and sustainable management of land-based ecosystems.
Target 15.3 states: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world."
SDG indicator 15.3.1 measures the proportion of degraded land relative to the total land area.



SEN4LDN project workflow

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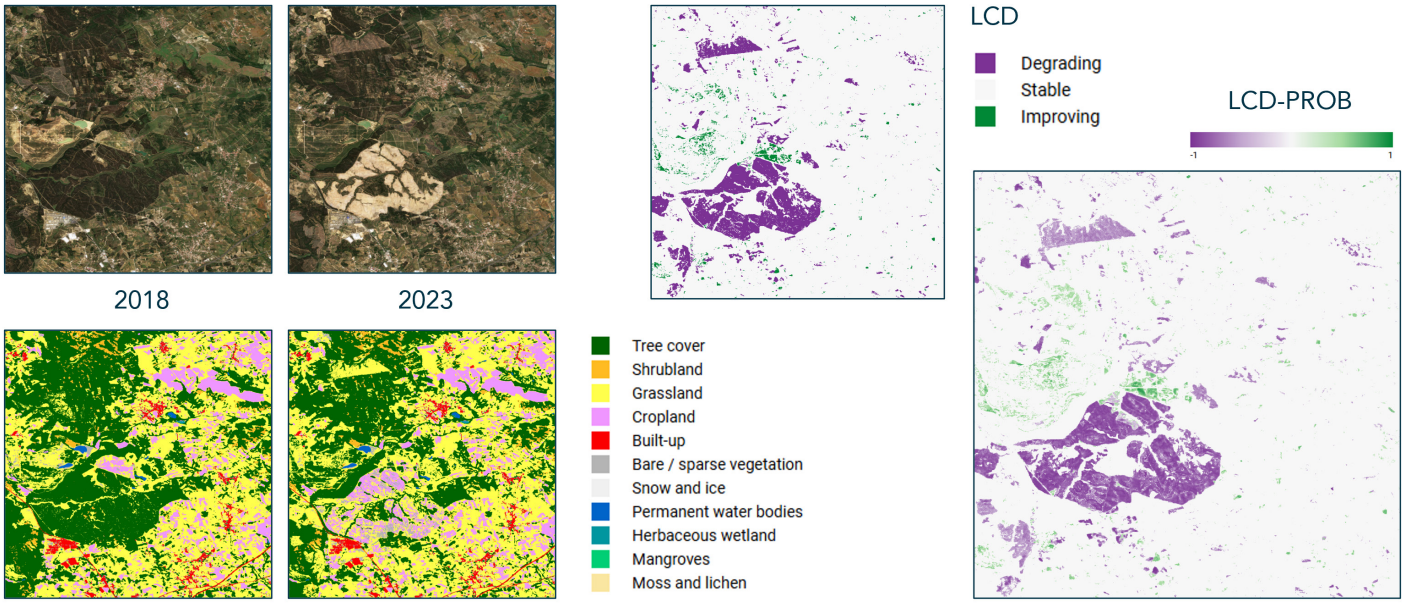
Trends in Land Cover

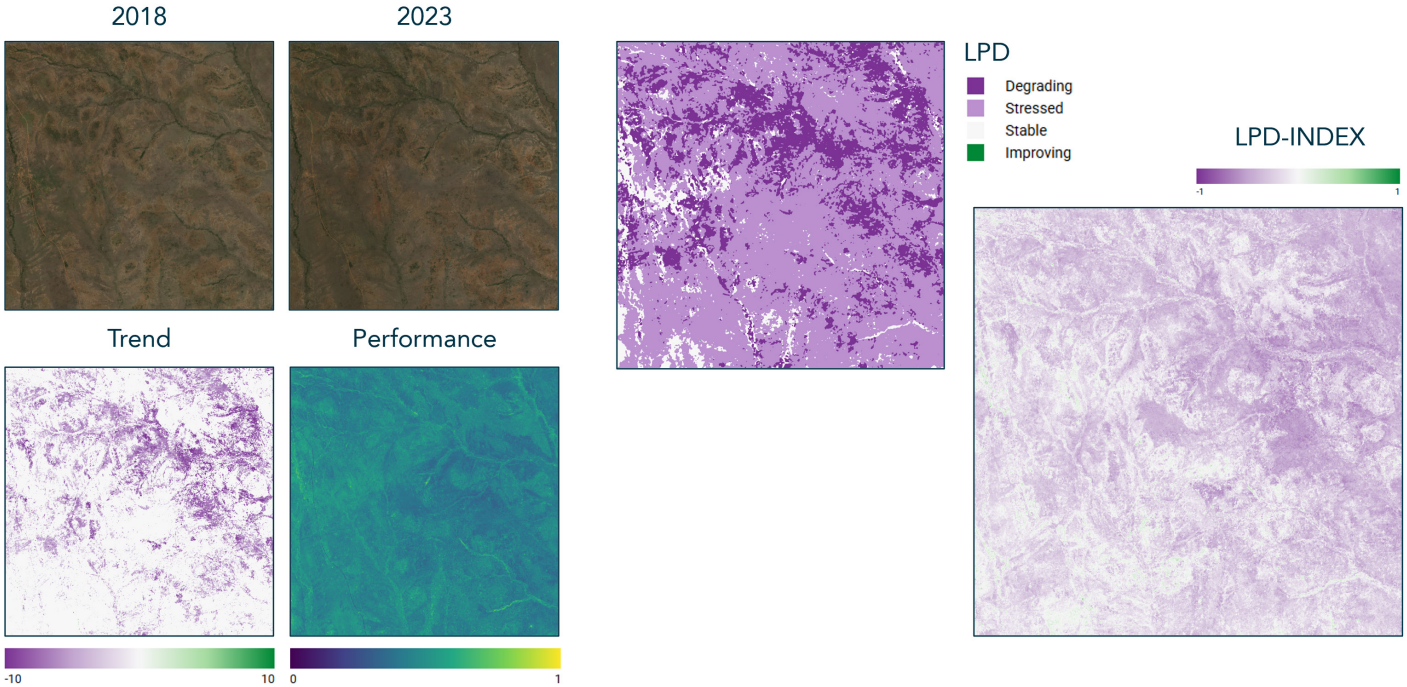
SEN4LDN developed an **automated, globally applicable land cover change algorithm** that generates discrete and continuous **land cover degradation (LCD)** products at 10 m spatial resolution, mainly based on Sentinel-2. The algorithm focuses on inter-annual consistency to reliably detect land cover change. Land cover class probabilities are used to derive land cover transitions and land cover degradation probabilities (LCD-PROB).



Example of Trends in Land Cover – Land degradation due to deforestation in a ~10 km x 10 km use case area around 39.2°N, 8.9°W (Aveiras de Cima, Portugal)

Trends in Land Productivity

The seasonally accumulated **green biomass production** is estimated using TIMESAT processing on a Sentinel-2 derived vegetation index. **Discrete (LPD) and continuous (LPD-INDEX) land productivity dynamics** maps are generated at 10 m spatial resolution based on the combination of the trend (rate of change in productivity) and performance (comparison with productivity of the same ecosystem types) metrics of vegetation productivity.

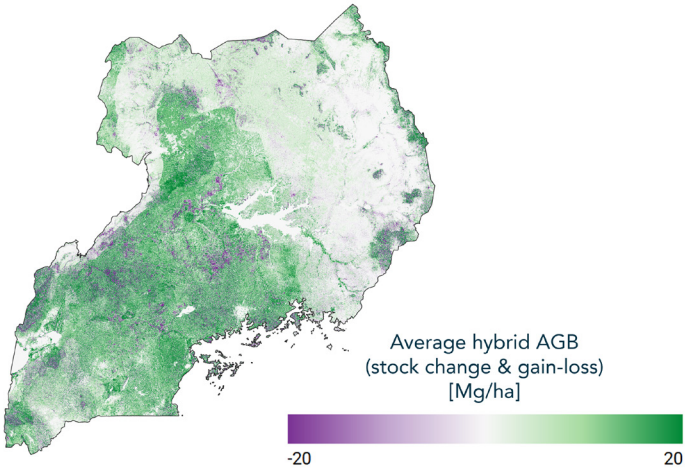


Example of Trends in Land Productivity – Land degradation due to a negative trend in land productivity in a ~40 km x 40 km use case area around 2.8°N, 34.3°E (Karamoja region, Uganda)

Trends in Carbon Stocks

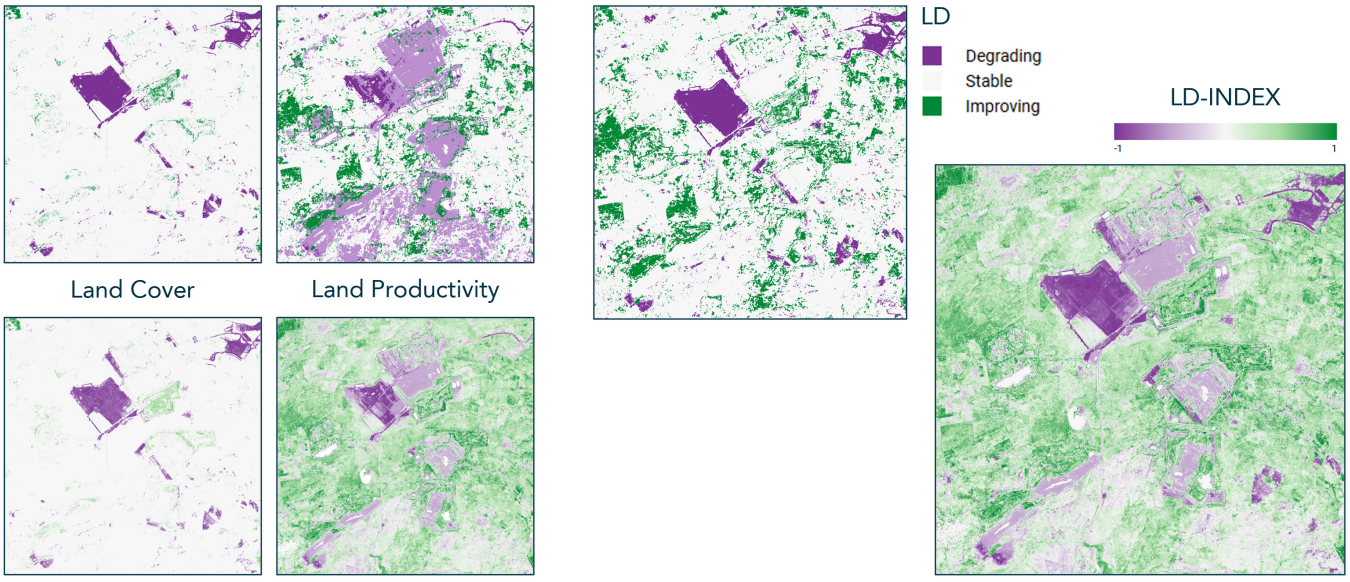
Due to the ongoing absence of high-resolution global trend data of Soil Organic Carbon (SOC) derived from EO data, the SEN4LDN team explored the **above-ground biomass (AGB) mapping** using ESA CCI and WRI flux models. The algorithm combines stock change and gain-loss approaches to create hybrid AGB change maps.

Example of hybrid AGB change mapping method 2010-2018, Uganda case study >

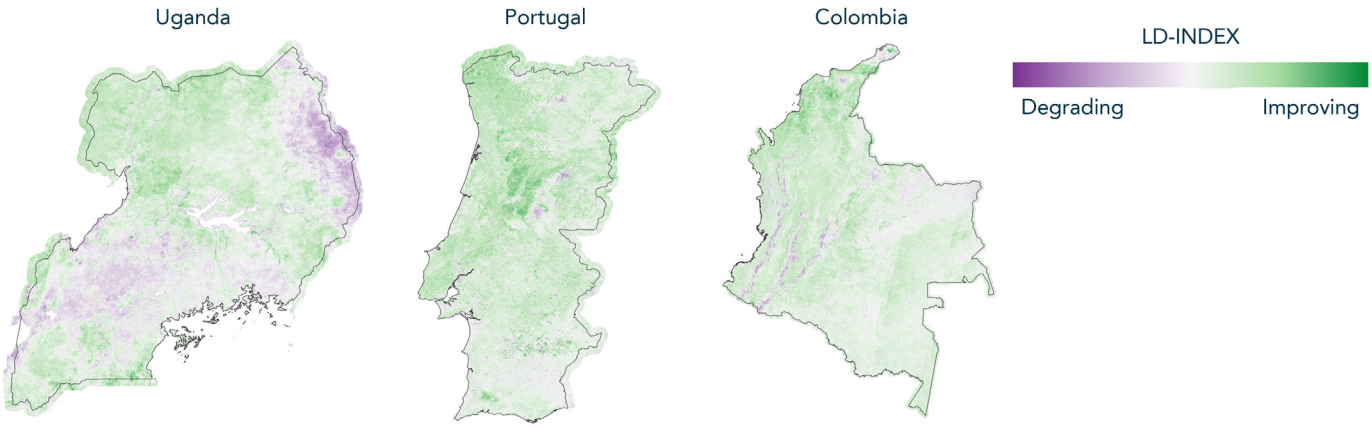


Sub-Indicator Integration

Two integration algorithms have been developed to estimate the extent of land degradation for reporting on UN SDG indicator 15.3.1. Firstly, the default **one-out-all-out (1OAO) integration method**, as described in the UNCCD Good Practice Guidance for SDG 15.3.1. Secondly, a **continuous sub-indicator integration method**, which combines the continuous Land Cover Degradation and Land Productivity Degradation products into a continuous Land Degradation Probability Index (LD-INDEX), allowing assessment of the magnitude or probability of degradation or improvement processes.



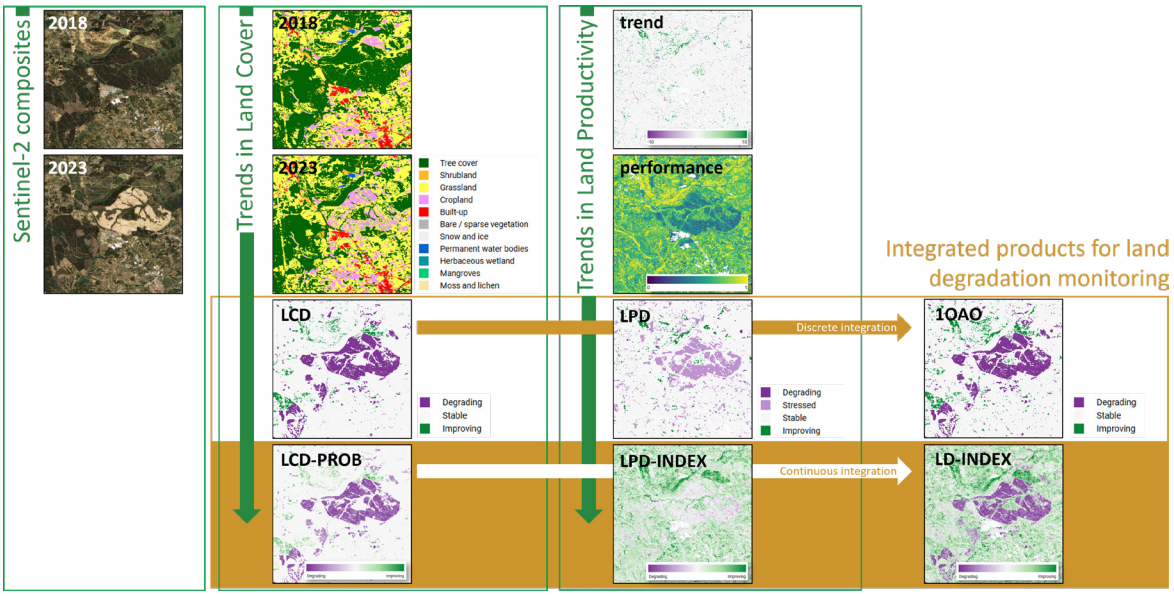
Example of discrete and continuous LDN sub-indicator integration – Land degradation due to mining expansion in a ~20 km x 20 km use case area around 9.7°N, 73.5°W (Corredor minero del Cesar, Colombia)



The continuous Land Degradation probability index (LD-INDEX) over Uganda, Portugal and Colombia. The LD- INDEX is based on a continuous sub-indicator integration method that combines the continuous land cover degradation and land productivity degradation products.

Conclusions

SEN4LDN has provided tangible results to **support the UNCCD and GEO-LDN** in defining the next steps to **increase the spatial details of national assessments of land degradation and improvement.**
SEN4LDN has **advanced the monitoring of land degradation and improvement** by developing methods to map the SDG 15.3.1 sub-indicators and create an integrated indicator at high **spatial resolution** (10 m), in a **continuous** way. The project also attempted to go beyond what exists in **mapping trends in carbon stocks**. Algorithms were co-designed based on **intensive discussions with feedback from the early adopters** during multiple living labs.
The resulting EO solution was **demonstrated** and **validated** in three countries (Colombia, Uganda, Portugal) and its usability was assessed. Explore the national demonstration products in the Google Earth Engine application.



Example of the complete SEN4LDN workflow to generate integrated products for land degradation monitoring

Recommendations

Recommendations from SEN4LDN experiences and ideas for future evolutions:

- **Explore and use Sentinel-2** for deriving land cover and land productivity sub-indicators at 10 m spatial resolution. Expand the historical archive with harmonised Landsat data. Incorporate Sentinel-1 to improve the quality of temporal composites in frequently cloud-covered areas.
- **Move towards continuous land degradation-improvement indicators**, providing (a proxy for) uncertainty estimations in the identification of ongoing land degradation or improvement processes.
- Develop procedures to apply **globally applicable methods for region-specific land degradation / improvement processes**.
- **Evaluate aboveground biomass mapping** as a proxy for carbon stocks monitoring. Evaluate if the combination of AGB and SOC products can provide a measure to monitor total carbon stocks.

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