



SEN4LDN

LAND DEGRADATION NEUTRALITY

D1.2

Requirement Baseline

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Key takeaway messages

- This document provides an overview of the requirements for SDG 15.3.1 monitoring based on Earth Observation data.
- The report provides an overview of our Living Labs approach to stakeholder engagement and the integration of early adopters into the product development pipeline.
- The user requirements were collected based on a structured interview to three early adopters and provide an insightful overview of LD drivers as well as specific data requirements.
- All early adopters identified that improvements to spatial and temporal resolution would greatly benefit their ability to implement and monitor LDN policies.
- Access to open and free data was identified as of paramount importance for effective monitoring.
- A number of potential test sites were discussed and can be explored in the future both to test SEN4LDN algorithm but also can be scientifically relevant to explore drivers and impacts of LD.
- These first living labs provided valuable insights into the unique challenges that each country faces as well as insights into the data requirements that each country has.

Summary

This executive summary outlines the key user requirements for the SEN4LDN project based on a set of interviews that were carried out with our early adopters: **Busitema University** from **Uganda**, **Ministry of Environment and Sustainable Development** from **Colombia** and the **Institute for Conservation of Nature and Forest** from **Portugal**. These interviews were conducted as part of our Living Labs approach to product development where we will focus on continuous interaction with potential users of the data products that are to be developed within SEN4LDN. This first session focused on (i) identifying what are the drivers, (ii) what are the efforts being done in each country regarding Land Degradation and (iii) an overview of specific user requirements regarding Remote Sensing data.

While some of the drivers of Land degradation are the same between the three different SDG Early adopters, for example improper land use practices, lack of sustainable practices and often lack of capacity of the central governments to apply and enforce policies, many were very different which exemplifies the diversity of challenges that each country faces. For example, the Colombian partners identified deforestation and illegal mining activities as a driver while the Ugandan partners identified intensified livestock and agricultural practices as a significant driver. Portugal, which has not set any voluntary Land Degradation Neutrality targets, identified the expansion of greenhouse productions as a factor contributing to land degradation due to increasing demands in water.

In terms of the user requirements, of note was that all early adopters are very interested in Remote Sensing data at a higher spatial resolution with most identifying the spatial resolution of Sentinel-2, i.e. 10m, as their ideal target which is in-line with SEN4LDN objectives. Higher temporal resolution was also identified as critical but, in this case, annual or seasonal data was the most requested temporal resolution. In terms of temporal extent, the early adopters desire datasets that allowed them to report the SDG 15.3.1 indicator and therefore require data from the 2000 until present day. For SEN4LDN this would imply integrating Sentinel-2 data with previous missions such as Landsat or MODIS. Other requirements such as data licensed using an open license or creative commons was deemed important by all interviewees alongside extensive and detailed documentation regarding the data, its validation and accuracy.

Overall, these sessions provided a broad and clear overview of the user requirements for the SEN4LDN project and allowed us to identify a number of scientific and technical challenges to be addressed. Our expectation is that this information will help in the product development and we are looking forward to continuously integrating the feedback from our early adopters onto the data products being developed.

List of abbreviations

Institutions, organizations and general terms:

1OAO	One-out-all-out
BU	Busitema University
CCI	Climate Change Initiative
CEOS	Committee on Earth Observations
CI	Conservation International
CLGS	Copernicus Global Land Service
CLMS	Copernicus Land Monitoring Service
DGADR	Direção-Geral de Agricultura e Desenvolvimento Rural
DGT	Direção Geral do Território
EEA	European Environment Agency
EO	Earth Observation
ESA	European Space Agency
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GEO-LDN	Group on Earth Observation - Initiative on Land Degradation Neutrality
GFZ	German Research Centre for Geosciences
GPG	Good Practice Guidance
HR VPP	High Resolution Vegetation Phenology and Productivity
ICNF	Institute for Conservation of Nature and Forests
IHMEA	Instituto de Hidrología, Meteorología y Estudios Ambientales
IIAP	Instituto de Investigaciones Ambientales del Pacífico
IIRB	Instituto de Investigación de Recursos Biológicos Alexander von Humboldt
IPCC	Intergovernmental Panel on Climate Change
ISRIC	International Soil Reference and Information Centre
JRC	Joint Research Centre
LL	Living Labs
MESD	Ministry of Environment and Sustainable Development
NDC	Nationally Determined Contribution
PRAIS	Performance Review and Assessment of Implementation System by UNCCD
SDG	Sustainable Development Goals
SEN4LDN	Sentinels for Land Degradation Neutrality
UN	United Nations
UNCCD	UN Convention to Combat Desertification
VITO	VITO Remote Sensing
WG	Work group
WMZ	Water Management Zone

Earth observation:

AGB	Above ground biomass
CGLS-LC100	Copernicus Global Service Land Service - Dynamic Land cover at 100m resolution
COS	Carta de Uso e Ocupação do Solo

COSc	Carta de Ocupação do Solo Conjuntural
LC	Land Cover
LCLU	Land Cover Land Use
LD	Land degradation
LDN	Land Degradation Neutrality
LU	Land Use
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetation Index
NPP	Net Primary Productivity
PPI	Plant Phenology Index
SOC	Soil Organic Carbon
S2	Sentinel 2
SAR	Synthetic Aperture Radar
VI	Vegetation index
GPP	Gross Primary Production

1 Background

The 2030 Agenda for Sustainable Development was adopted by all United Nations (UN) members in 2015 as a “*shared blueprint for peace and prosperity for people and the planet, now and into the future*”¹. It is fundamentally based on 17 Sustainable Development Goals (SDG) which are targets agreed upon by the UN members regarding various interlinked objectives that must be ensured to achieve sustainable development. These range from combating poverty, ensuring access to education, to economic development and the protection of life on water and land.

Diminished overall productivity and reduced resilience in the face of climate and environmental change, have made addressing land degradation a global priority formalized by the United Nations Convention to Combat Desertification (UNCCD) and the SDG. To this end, the 2030 Agenda for Sustainable Development defined target 15.3 of SDG 15, called ‘*Life on Land*’, that strives to reach Land Degradation Neutrality (LDN) by 2030. Land degradation (LD) – is defined as “*the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from a combination of pressures, including land use and management practices*”² - poses a threat to the livelihoods of millions of people [1]. Given the increasing pressure introduced by climate change, population growth and hence also water and food demand, immediate actions are urgently required to reduce the land degradation extent and severity.

Efficient monitoring of LD requires constant monitoring of various biophysical and biochemical characteristics of the land. These disturbances can range from rapid land cover change (e.g., fire or logging) to continuous and slower degradation of soil and land quality [2]. While monitoring these at larger scale becomes a logistical impossibility if not using Earth Observation (EO) data, there are still a number of challenges and opportunities to address particularly related with increasing spatial and temporal resolution and diversity of sensor types [3]

Sentinels for Land Degradation Neutrality (SEN4LDN) aims to address these two limitations by developing and showcasing a novel approach for improving both the spatial and temporal resolution of the data required for LD monitoring. While LDN is agreed between the SDG signatories, each region/country will have its own specific challenges and drivers of LD and therefore the inclusion of local partners in the product development is extremely important from our perspective. These stakeholders will provide insights on the user requirements and feedback on the final product and its actual usability for SGD 15.3.1 reporting.

¹ United Nations Department of Economics and Social Affairs, The 17 Goals, <https://sdgs.un.org/goals>

² United Nations Department of Economics and Social Affairs, SDG Indicator 15.3.1 Metadata

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

2.1 Definition

As described by the Good Practices Guidance from the UNCCD, the SDG indicator 15.3.1: ‘Proportion of land that is degraded over total land area’ is the key measurement to monitor country progress towards LDN. This indicator is expressed as [4]:

$$P_{degraded\ land} = \frac{Area_{degraded}(ha)}{Area_{total}(ha)}$$

Where the total degraded area is calculated on the basis of 3 sub-indicators: Trends in (i) land cover ; (ii) land productivity; and (iii) carbon stocks. Analysis of these indicators towards the 2030 Agenda for Sustainable Development implies that reporting countries must show their improvements against a baseline period. The overall process then consists of monitoring the sub-indicators for an extended period of time before and after the implementation of policies. An overview of these steps is shown in Figure 1 (adapted from [5]).

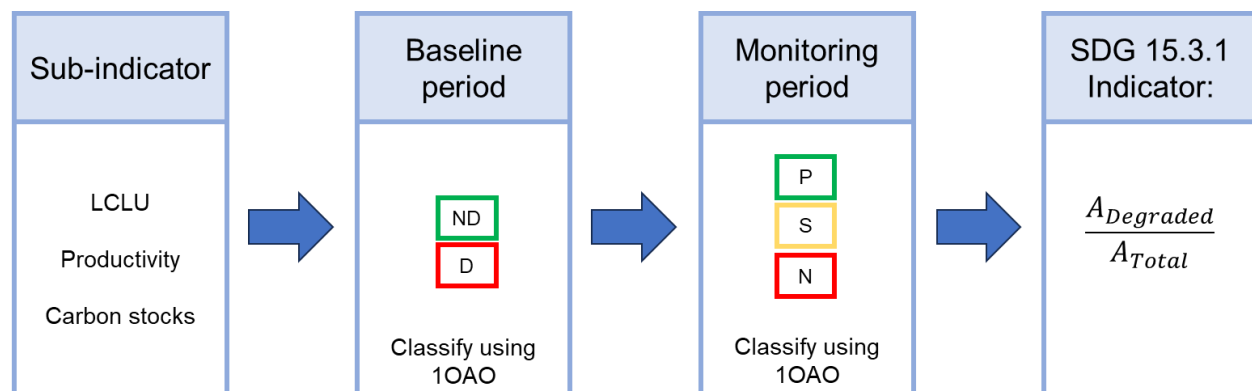


Figure 1: Steps to derive SDG indicator 15.3.1 adapted from the UNCCD Good Practice Guide [5]. The baseline period refers to a period used to establish the standard LD state to which monitoring/target period is going to be compared with.

Land cover (LC) as defined by the FAO is the “observed (bio) physical cover of the earth’s surface” and is a synthesis of the many processes taking place on the land” [6]. Land cover is typically described as a set of hierarchical classes, each denoting the dominant biotic and abiotic assemblages occupying the Earth’s surface [7].

Land productivity is the biological productive capacity of the land, the source of all the food, fiber and fuel that sustains humans [4]. Land productivity trends provide insight into the long-term change in health and biological productive capacity of the land. They reflect the net effect of ecosystem functioning change on biomass growth.

Carbon stocks above and below ground provide an integrated view on processes affecting plant growth and decomposition, which control dynamics of terrestrial organic matter and are crucial to a variety of ecosystem services. Currently, only changes in Soil Organic Carbon (SOC) are implemented in LDN monitoring.

For each of these sub-indicators there are specific opportunities and challenges in terms of their monitoring. For example, recent advancements in data availability, machine learning and computation have vastly improved the ability of monitoring land cover at increasing temporal and spatial resolutions [8].

2.2 SDG Indicator 15.3.1 and EO

Land cover change monitoring has improved greatly in recent years ever since the first global map was produced in 1994 [9] at 1 degree of resolution. Improvements include both improvements in terms of spatial resolution but also in terms of temporal resolution with yearly products such as the Copernicus Global Service Land Cover Maps (CGLS-LC100) at 100m. Since the advent of the Copernicus programme and the Sentinels, the bar has been raised, as it is now also possible to map land cover at 10 m resolution, using 5-daily optical Sentinel-2 time series possibly complemented with Sentinel-1 SAR data. At first, two prototype maps at continental scale covering Africa (20m resolution) and Mesoamerica (10m resolution) were produced in the framework of the CCI Land Cover project [10]. More recently, also the first global 10 m land cover products were released by ESRI [11], Gong et al. [12] and also the ESA WorldCover project [13].

Despite these advancements, most often efforts based on high resolution Sentinel data are constrained to single maps, therefore lacking the change component crucial for LDN monitoring. While there are data products produced at coarser resolution (e.g. ESA CCI land cover maps at 300m, since 1992) there is a clear lack of higher resolution data on LC change for the period between 2000 and 2015 which is critical for LDN reporting. Another problematic aspect of LC change monitoring is the lack of consistency between land cover map products [14]. In order to increase the quality of multi-temporal land cover maps, spatio-temporal cleaning is advised as a post-processing step.

In terms of Land productivity monitoring using EO, often the standard is to resort to the use of vegetation indices, in particular the use of the annual Normalized Difference Vegetation Index (NDVI) integrals as a surrogate for Net Primary Productivity. These annual integrals allow the computation of different productivity indicators such as trend, state and performance [4]. Generally, NDVI time series are derived from coarse to medium resolution datasets such as the Advanced Very High-Resolution Radiometer Global Inventory Monitoring and Modelling System or MODIS datasets.

However, there are a wide range of alternative vegetation indices (VIs) correlated with plant productivity that may be better suited to some countries than others. One such example is the Plant Phenology Index (PPI) which is a physically-based VI that was shown to have a linear relationship with green leaf area index, thus strongly correlated to plant gross primary productivity [15]. This VI has been shown to be specifically capable of disentangling remotely sensed plant phenology from snow background [16], [17] and to be superior to other indices for spring phenology retrieval [18] and for GPP estimation in African semi-arid ecosystems [19] and can increasingly be produced with high-resolution data. An example of new opportunities from Sentinel-2 data is the ESA High Resolution Vegetation Phenology and Productivity (HR VPP) service, developed in a collaboration between VITO and Lund University and offers 13 productivity

related parameters at an yearly frequency from January 1, 2017 onwards over the EEA39 region. The TIMESAT software was adapted to handle Sentinel-2 data and plays a fundamental role for this product and allows the estimation of a number of seasonal productivity parameters such as length of growing season, amplitude, seasonal minimums and maximums, etc. Within SEN4LDN, TIMESAT will also play a significant role in generating productivity data.

Trends in above and below ground carbon stocks provide an integrated view on processes affecting plant growth and decomposition, which control dynamics of terrestrial organic matter and are crucial to a variety of ecosystem services. Currently, only changes in SOC are implemented in LDN monitoring. The default solution to map SOC change is to map the change from the baseline level using a combination of land cover maps and transition coefficients. These approaches are consistent with the IPCC guidelines. In order to obtain an indication of default baseline SOC stocks, ISRIC's SoilGrids250m products of SOC percentage, bulk density, gravel fraction and depth to bedrock were used to calculate a predicted SOC stock for 0 – 30 cm (i.e., topsoil). SoilGrids250m is globally consistent and readily accessible and contains the modelled relationships between ca 150,000 soil profiles and 158 remotely sensed covariates and is at a suitable resolution for LDN target setting.

2.3 SDG Indicator 15.3.1 needs and challenges

One of the most significant challenges in terms of monitoring LD towards LDN implementation is the lack of data for the reference baseline and target periods [20]. Particularly, while the expectation in the near future is that the increasing availability of EO data [21] will greatly improve the ability to monitor LD, the periods between 1990 and 2015 have limited EO data available which creates a specific challenge regarding the baseline periods.

Fulfilling the 2030 Agenda for Sustainable Development regarding LDN implies a particular challenge for monitoring SDG 15.3.1 due to the potential lack of data for the reference periods especially regarding EO data in the environmental monitoring domain. Historically, the two most used satellites for environmental monitoring are Landsat and MODIS due to being freely accessible, but for both of these their data is available mostly from 1999 onwards. While data from these satellites is widely used for generating SDG 15.3.1 estimates for the reference period their spectral, spatial and revisit time affects the ability to generate data at higher temporal and spatial resolution for this period. Furthermore, reference data for these periods might be unavailable or insufficient for training and validating more advanced models. Addressing these challenges is then of paramount importance to empower governments and institutions on their efforts towards efficiently establishing accurate estimates of LD status for the reference periods.

Currently, there has been an extensive increase in access and production of EO data, especially after the launch of the Copernicus Programme by ESA which offers a vast array of EO solutions for environmental monitoring. This creates a novel challenge of integrating data from the reference period which is often based on decommissioned satellites such as Landsat 4, 5 and 7 or MODIS with the novel data coming from ongoing missions such as Sentinel 1 and 2. Integrating these older observations with novel sensors is also another challenge facing SDG 15.3.1 monitoring through EO. Nevertheless, the opportunity for improving temporal and spatial resolutions as well as extending the time intervals to monitor LD through EO is promising for aiding in the efforts of achieving LDN.

Each sub-indicator of SDG 15.3.1 has its own challenges and opportunities³. For example, while all sub-indicators benefit greatly from an increase in EO satellites targeting the environment, they also benefit from recent advances in machine learning and computation. In particular, high resolution LCLU mapping benefited greatly from this with new deep learning models improving model accuracy and performance alongside cloud-services enabling the ability to train and deploy these models at global scales. These benefits can also be applied to the other sub-indicators with novel algorithms for time-series analysis being applied in recent years to downscale and improve temporal time series of Productivity data⁴. Perhaps from the three, Carbon stocks pose the biggest challenge due to the limited ability of EO to monitor SOC but again here novel methods can be explored to improve the integration of field sampling, EO and proxy methods such as the Rothamsted Carbon Model [22] or the CENTURY model [23] that can be used to simulate soil dynamics .

Addressing these challenges by exploring novel methods to increase the resolution both in time and space of the sub-indicators of SDG 15.3.1 would improve the ability to implement management and policy decisions and is often identified as one of the most critical requirements [20]. This in turn could potentially allow a deeper exploration of the drivers of LD which can play a critical role in the ability to design effective and successful LDN policies [20] and to link changes in LD to ecosystem services and economic impacts [4].

3 Project overview, objective and test sites

3.1 Overview

The SEN4LDN aims to address the aforementioned challenges by developing higher temporal and spatial resolution data for LD monitoring, as written in the Statement of work:

“The primary objective of the SEN4LDN project is to 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 (principally the Sentinels 1 and 2 from the European Copernicus Program) 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 overall approach of project consists on the development of novel EO solution for improving the spatial and temporal resolution monitoring of SDG 15.3.1 which will be tested and validated globally (see §3.3) and benchmarked in close collaboration with a number of key stakeholders, in particular, the SDG Early adopters and the Advisory Board.

³ <https://www.tandfonline.com/doi/full/10.1080/20964471.2020.1711633>

⁴ <https://ieeexplore.ieee.org/abstract/document/9904574>, <https://www.sciencedirect.com/science/article/abs/pii/S1574954122000012>

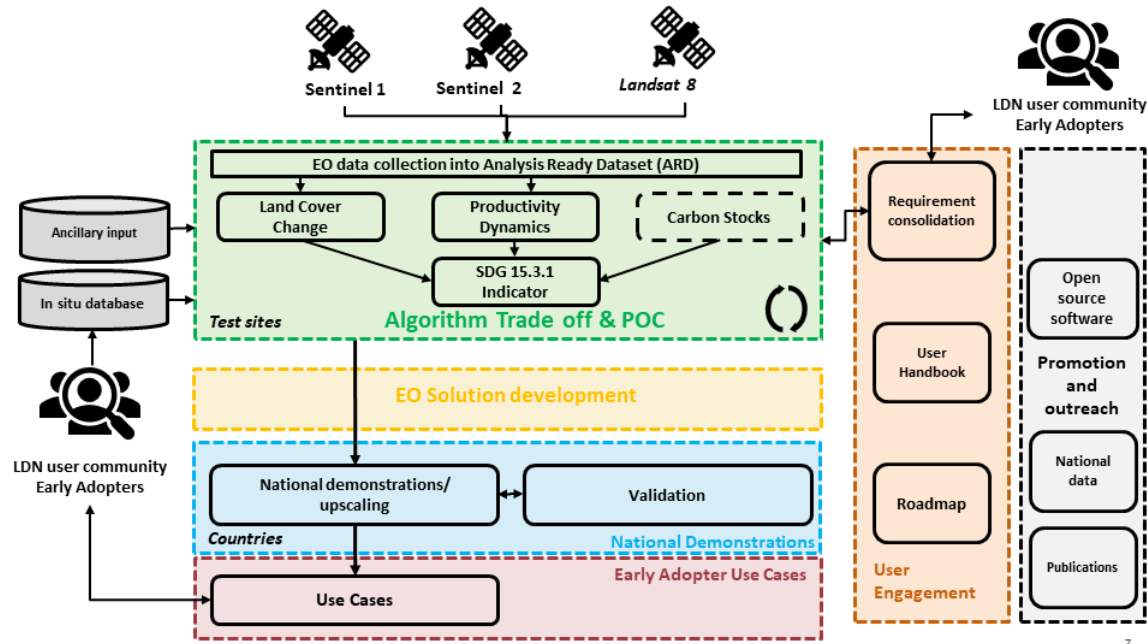


Figure 2: Conceptual overview of SEN4LDN

To the challenging objective set by this project, SEN4LDN will focus its development into two distinct phases: **1) User co-creation phase** and **2) the user uptake phase**. The first phase consists on designing a continuous feedback interaction with 3-4 early adopters in a Living lab (LL)⁵ approach. This will allow us to identify user and SDG requirements, technical limitations and expectations and to prototype the products and algorithms developed during the project. The second phase consists of actually implementing, delivering and showcasing the EO solution at national scale for the early adopters. A conceptual overview of how these challenges will be tackled is shown in the following Figure 2.

Central to the SEN4LDN development are the SDG Early Adopters. These are specific target stakeholders that have been invited to join SEN4LDN production development. These are allowed access to prototype data products and services and are expected to provide feedback on its quality and development as well as to facilitate efforts for validation of the products and participation on the LL. Their collaboration also entails the collection, consolidation and review of their requirements, selection of the geographical areas of the test sites, definition of use cases and the collection of national data for both phases of the project. The targeted early adopters are described more extensively later but currently we are at different phases of communication with the following SDG early adopters:

- European Environmental Agency (EEA)
- Busitema University (BU)
- Ministry of Environment and Sustainable Development (MESD)
- Institute of Conservation of Nature and Forests (ICNF)

⁵ What are living labs, European Network of Living Labs, <https://enoll.org/about-us/what-are-living-labs/>

The countries of these SDG Early Adopters will also be used to demonstrate the outcomes of the algorithms being developed by SEN4LDN.

In addition to the Early Adopters, an **advisory board** with leading experts in LDN has been set up at the start of the project. **Michael Cherlet** (DG JRC/Copernicus) and **Cesar Luis Garcia** (FAO/WOCAT) have agreed to participate in SEN4LDN's advisory board to provide guidance and advice to the project tasks and complement the experts from the UNCCD secretariat and members from GEO-LDN, i.e. **Antje Hechtjen**, **Neil Sims**, **Sara Minelli** and **Brian O'Connor**.

3.2 Objectives

The specific objectives are to:

- develop robust automated EO methods to map land cover and its changes (robust change detection for LDN) and land productivity dynamics (robust phenological analysis for LDN) at high spatial resolution;
- investigate methods to integrate the 10-30m data streams with the existing default 300m-1km datasets used in UNCCD 2015 land degradation baseline;
- develop an integrated EO-based solution to assess land degradation; and
- demonstrate the adequacy of the approach in a number of biomes representative of the diversity of land degradation processes.

3.3 Test sites

After the LL with the SDG Early Adopters and internal communications, significant changes have been discussed and are being evaluated internally within the project. This section reflects the test sites and validation approach as presented during the project proposal as during the writing of the Baseline Report, these changes were still not finalized. Nevertheless, although there are some significant changes expected in this section of the work, the overall approach and target use-case areas are similar and therefore this action provides an overview of the test sites and their hierarchy. The criteria to select test site locations was based on the following points:

- be representative for the diversity of land degradation processes and therefore test sites should be spread among a number of representative biomes;
- include several large geographical areas (i.e., large enough to include a number of imagery tiles) to verify the upscaling and transferability capabilities of the selecting algorithm(s) and their readiness for large-scale deployment;
- contain enough calibration and validation data to assess the robustness and accuracy of the selected algorithm(s);
- contain reference sites in the targeted demonstration sites (countries, see below) to ensure feedback & support of the SDG Early Adopters.

The demonstration sites (subject of phase 2) should contain:

- complete national coverage of the pilot countries, i.e., the Early Adopters, including one European Country and 2 countries from the developing world; and
- enough validation data to assess the robustness and accuracy of the final products.

Considering this, Figure 3, shows a tentative location of the test sites (phase 1; in red) and demonstration sites (phase 2; in green). Each test site contains at least an area of one Sentinel-2 tile (109,8 * 109,8 km) while additionally several test sites also contain multiple (4 neighboring) S2 tiles in order to verify the upscaling capability and transferability of the algorithms. A subset of these test sites will be subject of the core algorithm development while all test sites will be processed as part of the Proof of Concept of phase 1.

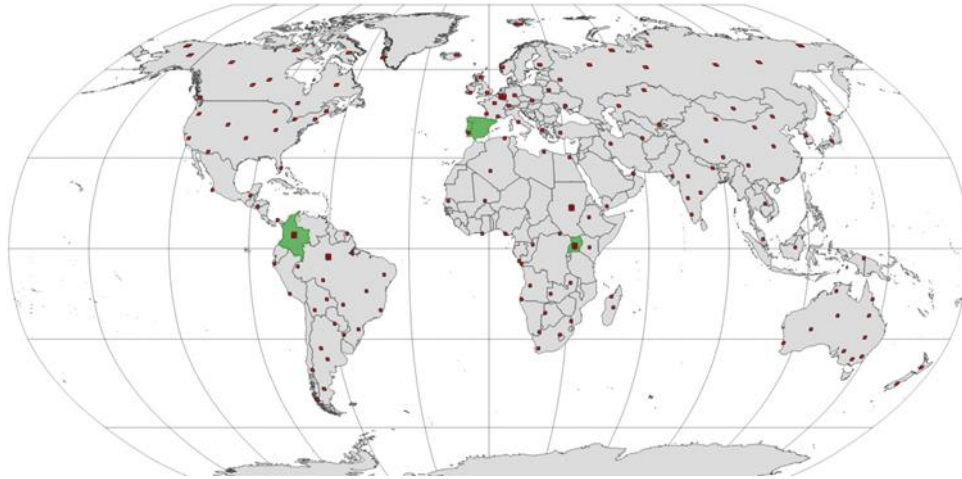


Figure 3: Test sites for SEN4LDN data products (red) and demonstration sites (green) for the SDG early adopters. The Iberian region will now focus only on Portugal as an SDG Early Adopter partnership was set with ICNF.

The rationale to select the test sites was (i) to maximize heterogeneity in biomes with (ii) a balanced spatial sampling and (iii) include as many flux towers as possible in different biomes and ecoregions in order to calibrate and validate the productivity algorithm.

4 Requirements baseline assessment

As described in the project proposal, this task consists of an in-depth analysis of the user requirements regarding SDG 15.3.1 monitoring. This in-depth analysis results from both extensive review of available literature and other related projects/research (e.g., CEOS⁶) but especially from our interactions with the SDG Early Adopters, Advisory Board, other relevant stakeholders and ultimately, general users of developed applications/products.

4.1 Review of existing user requirements

4.1.1 UNCCD – Good Practice Guidance

The Good Practice Guidance (GPG) is an important official written for the UNCCD by Sims et al. [4] which provides an overview and guidance on reporting LD for the UN SDG. It is the de facto standard for LD monitoring and reporting and has been adapted recently to a second version which includes both feedback from stakeholders' country recommendations as well as recent scientific advancements in the field.

Broadly, the GPG establishes the methods to measure and quantify trends in the three sub-indicators (land cover, land productivity and carbon stocks) and recommendations of what are significant levels of change that should be considered. Central concept is the use of the one-out-all-out (1OAO) approach to combine sub-indicators which implies that if one metric is negative, the overall indicator is negative. This is a conservative approach that encourages stakeholders to address all aspects of LD, since positive contributions in one indicator can be masked by no changes or negative contributions in other indicators [5]. It also provides an overview of what are the default data products that can be used for measuring each sub indicator as shown in Table 1.

Table 1: Global default datasets (GTG)

Sub-indicator	Default data (2018 reporting)	Alternative
Land cover	ESA-CCI-LC (300m)	Copernicus CGLS-LC100 (100m)
Land productivity	JRC Land productivity dynamics (1km)	MODIS vegetation index (250m)
OC	ISRIC SoilGrid (250m)	ISRIC SoilGrid v2 (250m) and FAO Global Soil Organic Carbon Map (1km)

Increasing the resolution of sub-indicators is paramount for LD accuracy and to assist countries in effectively implementing their policies [5] and it is the main challenge that SEN4LDN aims to address.

⁶ Satellite Data Requirements for SDG Indicator 15.3.1, CEOS

4.1.2 CEOS Data requirements for SDG 15.3.1

The Committee on Earth Observation Satellites (CEOS) uses the same approach to measure SDG 15.3.1 as proposed by the UN and produced a review document [24] describing the EO data requirements for monitoring SDG (summarized in Table 2) as well as pointing out some areas of improvement.

Table 2: CEOS EO Data requirements summary

SDG Requirement	Resolution	How? Measurement type	When?	Where?	Example data:
Land cover change	Minimum: 100m Target: 30m Best: 10m	Classification/change detection	Annual	Global, national	ESA-CCI-LC, SEEA-MODIS
Land Productivity	Minimum: 100m Target: 30m Best: 10m	Vegetation indices: NDVI, EVI2, MSAVI, SATVI (depending on region)	Weekly to monthly	Vegetation mask	MODIS or Copernicus NDVI products, SPOT-VGT NDVI
Soil Organic Carbon	100 – 250m (Minimum should be 100m but not always possible)	Soil inventory data, land use data and ideally land management data	Annual (LC change) while in-situ updated every 10 years	Global, national	HWSD, ISRIC SoilGrids, FAO GSOC

The CEOS requirements document provides an extensive list of available EO data that can be used for SDG 15.3.1 monitoring and provides a suggestion of the minimum values for different data characteristics. In Table 3 we summarize some of the more relevant.

Table 3: Most relevant of available EO data for SDG 15.3.1 monitoring

Topic	Suggested value
Grid cell size	100 m ²
Temporal coverage	Per sub-indicator
Land cover classes	User driven
LC change assessment	Accuracy > 85%
Productivity index	NDVI
Linking time series	Linear regression
Growing season definition	Proportional
SOC uncertainty	Pixel-based
Soil inventory update period	10 years

The CEOS report also identifies some opportunities for EO regarding SDG monitoring. For example, they point out that high resolution time series of EO datasets of land cover, productivity and carbon stocks is essential to improve SDG 15.3.1 monitoring. Furthermore, they consider that linking land condition and land use to climate data and planning information would be critical to identify areas susceptible to

degradation. They specifically point out the opportunity of using Landsat TM, ETM+ and OLI data to address the coarse resolution of LD estimates for the baseline period based on the default UNCCD products.

These opportunities are very much in line with the objectives of SEN4LDN which aims to improve both the spatial and potentially temporal resolution of LD estimates both for the baseline and target periods using a combination of Sentinel 1 and 2 data and advanced machine learning algorithms.

4.1.3 GEO-LDN Technical Note on LDN

The technical note on the SDG indicator 15.3.1 produced by GEO-LDN [25] reviews existing analytical tools, emerging data and analytical software, existing systems supporting the implementation of SDGs and guidance on the methods for collaborative and modular data analytic platforms. The aim is to support the GEO-LDN initiative data analytics platform that is to be used in addition to the solutions provided by UNCCD. They identify a number of projects and data analytics platforms that could be part of the GEO-LDN data analytics platform, including the SEN4LDN project.

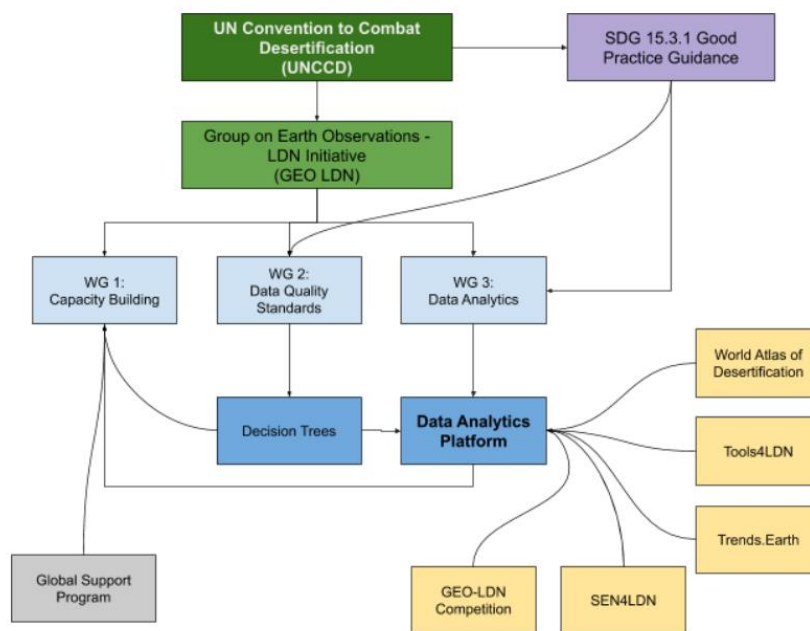


Figure 4: Wider context of a collaborative, modular data analytics platform [25]

Data was collected from a number of stakeholders and the following gaps were identified by GEO-LDN: Data hosting, discovery and suitability, trust and security of the implemented system, alongside the lack of cloud options vs local implementations. Furthermore, these stakeholders identified that it would be interesting for the platform to allow “sandbox” tools, cost assessment and a method for management of processing tools.

In terms of the data quality standard, an extensive report was also produced by the WG2 of GEO-LDN. In this case data from stakeholders was collected through a survey and also with the participants of five

workshops which counted with the participation of both data users and data producers. From this, the minimum data quality standard was identified for a broad number of topics regarding LDN monitoring (see overview table of the technical report).

4.2 SDG Early Adopters overview

From our perspective, the potential users of the products and applications planned for development by the SEN4LDN project can vary greatly from Governments and large international institutions, to research institutions and NGOs working on conservation and biodiversity, to private sector partners interested in carbon monitoring, and even other end-users that are interested in exploring LD data for their own private interests.

Nevertheless, our core target users are Governments and international institutions responsible for monitoring SDG indicator 15.3.1 towards achieving the 2030 Agenda for Sustainable Development, because the main aim of this project is to increase the spatial resolution of LD products which can be used for SDG indicator 15.3.1 monitoring. These users often require that both data and methods be of the highest scientific standards possible and standards which are widely accepted and that can be included into policy making processes. Furthermore, these users identify a number of bottlenecks within their own capacity of monitoring SDG indicator 15.3.1 which varies between data accessibility to capacity building and inconsistent definitions between international institutions and local institutions.

4.2.1 SDG Early Adopter engagement strategy

Our engagement with the core users requires an active effort from SEN4LDN to identify points of contact which can provide direct feedback to the prototype products and use-cases that can be used to drive the product development. The engagement strategy has three main aspects:

1. Initial contact

This initial contact happened before the proposal was submitted, and an overview of the SEN4LDN project was presented to the target potential SDG Early Adopter. They were then invited to provide a **support letter** that was also submitted with the proposal.

2. Kick-off meeting

A kick-off meeting is held with each SDG Early adopter, where we present our approach for the LL and invite the SDG Early Adopter to formalize their participation by signing a collaboration agreement that focuses on accessing the developed data products, providing feedback and actively participating in the LL and any user-oriented activity we will organize.

3. SDG Early Adopter Living Labs

As mentioned before, users play a central role on the SEN4LDN, meaning that during the algorithm trade-off phase, the SDG/user requirements will steer the design choices. Our approach to Living Labs (LL) consists of engaging with the SDG Early Adopters at different phases of the product development. In particular, the first session focused on collecting their user requirements and expectations using a structured interview approach (see Annex A). Once there are prototype products becoming available, we aim to prepare targeted surveys for each SDG Early Adopter use-case.

The LL are part of the agile development approach used by SEN4LDN through continuous interactions with the SDG Early Adopters and through some iterative development cycles with parallel and progressive refinements of the user requirements and of the EO solution. We will continue ongoing until the project/data product is finished and will be the main mechanism used to adapt the development to the **individual user requirements of the SDG Early Adopters** throughout the project. To broaden the scope of the data products, later in the project an *Open Stakeholder Living Lab* will be organized targeting not just the SDG Early Adopters but also other SDG practitioners. This will enable us to inspire and encourage an active engagement with the user community during the co-creation phase and will be key to enable and encourage uptake of the developed EO-solution.

During the first SDG Early Adopter LL we prepared a standard interview document (see Annex A) to collect an overview of the LDN activities in the country as well as the user requirements for each of the SDG 15.3.1 sub-indicators. The interview is divided into 4 blocks: 1. National activities for LDN, 2. Land cover data, 3. Productivity data and 4. Carbon stocks data. The first block aims to identify not just the activities but also the drivers of LD in the target country/region, while each of the remaining 3 blocks aims to specify the user requirements regarding the data products.

4.2.2 SDG Early adopters

So far, contacts have been established with **four** SDG Early Adopters, albeit the European Environmental Agency does not have a standard Early Adopter role and instead will interact with SEN4LDN as an external consultant role. These are:

- **Busitema University, Uganda**

BU is a public University involved in capacity building through research based teaching and rural community engagement. Through its Faculty of Natural Resources, the University contributes to sustainable land management research and community engagement activities. The University spearheads land use planning activities in the context of LDN including the UNCCD PRAIS4 reporting on land degradation for Uganda.

- **Ministry of Environment and Sustainable Development, Colombia**

The **MESD** is the national executive ministry of the Government of Colombia in charge of formulating, implementing, and orienting environmental policy to ensure the sustainable development of the country. The ministry is in charge of developing methodologies and guidelines within the framework of monitoring and tracking soil and land degradation, erosion, salinization, and desertification in Colombia and of reporting efforts towards Land Degradation Neutrality to UNCCD. Colombia is also the pilot country of the GEF funded project **Tools4LDN** "Strengthening Land Degradation Neutrality data and decision-making through free and open access platforms".

- **Institute for Conservation of Nature and Forests, Portugal**

The **ICNF** is the Portuguese public organization that is responsible for proposing, monitoring and ensuring the implementation of state policies regarding nature conservation and forests. One of ICNF responsibility is to monitor LD in Portugal and while the government has not defined LDN targets for the SDG 2030 agenda yet, there are a number of projects under the umbrella of this organization that

target ecosystem restoration and to combat desertification in mainland Portugal as well as PRAIS4 reporting for the United Nations.

- **The European Environment Agency, Europe**

The **EEA** has been addressing land degradation and the related SDG 15.3.1 target since 2016, with moderate success. EEA has organized several user meetings and published a related report to gather the knowledge base in order to best support **European policy making**. The cooperation established with the EEA is based more on them offering a consulting role while being allowed to explore the data prototypes produced by SEN4LDN. As such, this collaboration will not follow the standard LL approach that is to be used with the other three SDG Early Adopters.

4.3 First Living Labs session

As mentioned before, we have begun contacting and establishing a formal relation with various SDG Early Adopters. The first LL focused on identifying the user requirements for each of the Early Adopters to assist in the early stages of SEN4LDN product development.

To ensure that we collected similar information between all the selected early adopters as well as to encourage an active participation by them, SEN4LDN used a structured interview approach. This document was sent to every participant before the first Living Lab session and was then used as a “living document” during the session. By doing this, we ensured that we were able to get not just a broad overview of the user requirements, but also an understanding of LDN efforts by each of the participants.

As such, the SDG Early Adopter participants were invited to fill a questionnaire before the meeting to allow each question to be answered thoroughly. This was divided into 4 blocks, each pertaining to different aspects of SDG 15.3.1 monitoring:

- Block 1: National activities for LDN
- Block 2: Land cover data
- Block 3: Land productivity
- Block 4: Carbon stocks data

While the first block consists of general questions about LDN efforts in the country, the other 3 blocks are specific questions regarding each of the sub-indicators of LD. The document template can be viewed in Annex A. The first LL sessions with the 3 SDG early adopters were:

- BU from Uganda on the 8th of March, 2023
- MESD from Colombia on the 24th of May, 2023
- ICNF from Portugal on the 7th of June, 2023

A meeting was also held with the EEA but as mentioned before, this meeting did not follow the standard Living Lab approach being used for each of the countries being used for demonstration. In the next sections, we provide an overview of each of these first living labs with a focus on explicitly describing user requirements and activities regarding LD monitoring. Finally, we provide a summary of the meeting's outcomes.

4.3.1 Busitema University, Uganda

4.3.1.1 Requirements overview

Table 4: Overview of user requirements by Busitema University (Uganda). Not all these requirements are to be addressed by SEN4LDN but provide an overview of what would provide an ideal solution for the early adopter.

Busitema University (Uganda)						
Requirement	Land Cover		Productivity		Carbon stocks	
	Minimum	Desired	Minimum	Desired	Minimum	Desired
Spatial resolution	30x30 m ²	10x10 m ²	30x30 m ²	10x10 m ²	30x30 m ²	10x10 m ²
Temporal resolution	Annual	10 - day	Annual	Annual	Annual	Annual
Temporal Extent	2018 -	2000 -	2018 -	2000 -	2018 -	2000 -
Spatial coverage	National	National	National	National	National	National
CRS	WGS84/UTM	WGS84/UTM	WGS84/UTM	WGS84/UTM	WGS84/UTM	WGS84/UTM
Specific requirements	Standard LCLU classes for SDG reporting	Minimum + Plantations (oil palm, coffee, sugar cane, cacao, banana), Forest (national definition)	Standard VI data required for SDG reporting	10 - day time series of VI.	Standard SOC data product for SDG reporting	Standard SOC + Above-carbon data product (10 - day time series)
Processing level	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready
Delivery-mode	FTP, Web-service	FTP, Web-service	FTP, Web-service	FTP, Web-service	FTP, Web-service	FTP, Web-service
Data Format	GeoTiff	GeoTiff	GeoTiff	GeoTiff	GeoTiff	GeoTiff
Documentation	ATB Document	ATB Document	ATB Document	ATB Document	ATB Document	ATB Document
Licensing	GNU General Public License / Open source	GNU General Public License / Open source	GNU General Public License / Open source	GNU General Public License / Open source	GNU General Public License / Open source	GNU General Public License / Open source
Users	Technical staff	Wider SDG community	Technical staff	Wider SDG community	Technical staff	Wider SDG community

4.3.1.2 Voluntary LDN targets

As stated on the UNCCD page on Voluntary LDN targets⁷:

⁷ UNCCD Voluntary LDN targets, <https://www.unccd.int/our-work/country-profiles/voluntary-ldn-targets>

- At the national scale:
 - Land Degradation Neutral Uganda in 2030 compared to 2015 baseline i.e. LDN achieved by 2030 as compared to 2015 (no net loss);
 - 21% tree or forest cover by 2030 (in line with Vision 2040 and NDC);
 - 12 % wetland cover by 2030 (in line with Vision 2040 and NDC);
 - Areas of declining or stressed land productivity reduced by 50% by 2030;
 - Level of SOC at country level maintained or improved by 2030 compared to 2015 baseline.
- At the sub-national scale (Water Management Zones - WMZs and Highlands):
 - LDN is achieved in the four WMZs or watersheds and the highlands by 2030 as compared to 2015 (no net loss).
 - LDN is achieved in the four WMZs or watersheds and the highlands and 50% of areas of declining or stressed land productivity have improved by 2030 (net gain).

The full report from the Uganda government provided to UNCCD is accessible online⁸. This report provides further details on how LD monitoring has been performed in the country and their data requirements.

4.3.1.3 Living Labs summary

As mentioned before, this meeting occurred on the 8th of March, 2023 with Prof. Dr. Moses Isabirye (BU), David Kfumba (Univ. of Zambia), James Ssuuna (BU), Kaduuma Antony and Denis Maholo (Ministry of Agriculture, Industry and Fisheries) participated on the side of BU. For the SEN4LDN project, Martin Herold (GFZ), Nuno Cesar de Sa (GFZ), Ruben Van De Kerchove (VITO) and Tom Kiptenai (CI) were the participants.

The discussion with BU followed a more concrete approach, in line with our LL plan. This first meeting focused on (i) an in-depth discussion on user requirements based on a pre-prepared structured interview document (see Annex A) and (ii) discussion and agreement on a collaboration agreement that has been signed by both parties.

Block 1: National activities for LDN

While the responses can be viewed in Annex B, here we provide an overview of some of the main outcomes from this block:

- The main drivers of LD in Uganda are Deforestation, overgrazing, management, urban and population growth and poverty
- Challenges to implement LDN range from weak governance and lack of inter-departmental coordination to lack of budget and economic incentives for policy implementation
- In terms of EO data being used for LD reporting, BU reports that:
 - Coarser resolution cannot adequately and support LD reporting at local levels, especially Parish level which is the main development unit in Uganda
 - Increasing spatial resolution would be critical to address these challenges especially at the level of land cover change mapping
 - Furthermore, added spatial and temporal resolution could be critical in improving other ongoing analysis (e.g., livestock impact on productivity)

⁸ LDN Targets, Uganda, 2018, https://www.unccd.int/sites/default/files/ldn_targets/Uganda%20LDN%20TSP%20Country%20Report.pdf

- Ability to access the data and tools in offline mode is important as well as being able to include ground truthing and national Soil Organic Carbon data.
- Differences between forest definitions at a country level and REDD+ have to be addressed to avoid conflicting reports
- A number of test sites and use-cases were identified within Uganda which can be used for exploring both the feasibility of SEN4LDN algorithms but also link these to possible LD drivers. E.g., Karamora region where mineral exploration, plantation and transboundary movement of livestock are potentially leading to increasing LD.

Block 2: Land cover data

This block is set up to gather data product specifications and other general information regarding the land cover data. The product specifications table is provided in Annex B. The most important land cover classes for monitoring LD in Uganda are: Plantations, Forests, Wetlands, Built-up / artificial and grasslands.

There is a particular interest in the Plantations and Forests classes because of the significance these have in the case of LD. Being able to identify different Plantations would be important (e.g. palm oil, sugar cane, tea), and particularly being able to identify conversion to Plantations would be very important. In the case of Forests, it is important to consider both the national forest definition as well as the REDD+

Block 3: Productivity data

In Uganda, land productivity is assessed by using the Trends.Earth platform based on NDVI time series data. While the product specifications table is provided in Annex B, an important point made was the additional requirement of being able to link land productivity with specific agriculture lands, crops and grazing patterns.

Block 4: Carbon stocks data

Carbon stock data is also estimated using a combination of Land over and SOC data within the Trends.Earth application. If SEN4LDN can develop products based on AGB then it would be a significant improvement to current estimates, furthermore, plot data has been collected in permanent plots which could be used for the model development. Currently, SOC is also based on datasets with 250 m resolution and therefore there is a need for higher resolution data. More detailed product specifications are provided in Annex B.

4.3.2 Ministry of Environment and Sustainable Development, Colombia

4.3.2.1 Requirements overview

Table 5: User requirements for MESD from Colombia. Of note is that during the meeting not all data products were discussed in depth due to the lack of time. As such, the requirements were filled based on prior documents (e.g UNCCD reports) and the meeting itself.

Ministry of Environment and Sustainable Development (Colombia)						
Requirement	Land Cover		Productivity		Carbon stocks	
	Minimum	Desired	Minimum	Desired	Minimum	Desired
Spatial resolution	30x30 m ²	10x10 m ²	1 x 1 km ²	10x10 m ²	100x100 m ²	10x10 m ²

Temporal resolution	Trimester	Weekly	Annual	Annual	Annual	Annual
Temporal Extent	2015 -	2000 -	2015 -	2000 -	2015 -	2000 -
Spatial coverage	National	National/South America	National	National/South America	National	National/South America
CRS	EPSG:9377	EPSG:9377	EPSG:9377	EPSG:9377	EPSG:9377	EPSG:9377
Specific requirements	Standard LCLU classes for SDG reporting.	Minimum + Tropical Dry Forest, Savannah	Standard VI data required for SDG reporting	10 - day time series of VI.	Standard SOC data product for SDG reporting	Standard SOC + Above-carbon data product (10 - day time series)
Processing level	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready
Delivery-mode	FTP, Web/cloud service	FTP, Web/cloud service	FTP, Web/cloud service	FTP, Web/cloud service	FTP, Web/cloud service	FTP, Web/cloud service
Data Format	GeoTiff	GeoTiff	GeoTiff	GeoTiff	GeoTiff	GeoTiff
Documentation	ATB Document	ATB Document	ATB Document	ATB Document	ATB Document	ATB Document
Licensing	Open license	Open license	Open license	Open license	Open license	Open license
Users	Technical staff	Wider SDG community	Technical staff	Wider SDG community	Technical staff	Wider SDG community

4.3.2.2 Voluntary LDN targets

As stated on the UNCCD page on Voluntary LDN targets⁹:

- At the subnational level:
 - By 2030 at least 9,000 ha of pasture cover will be restored in forests in the Caribbean region
 - By 2030, at least 9,000 ha of pasture cover will be improved in silvo-pastoral systems.
 - By 2030, the productivity of at least 2,000 ha of soils with crops and/or pastures will be improved, with agroforestry production systems in the Caribbean and Andean regions (Sucre, Santander and Boyacá departments).
 - By 2030, 22,000 ha of dry forests will be conserved.
 - By 2030, the quality of natural vegetation will be compensated for with the promotion of plantation of forest species for 580 families in the Guajira region.
 - By 2030 some 3,200 ha of dry forest will be restored in the Guajira region.
 - Restoration of at least 100,000 hectares of degraded land at the national level within the framework of the national goal of Colombia under the LAC20x20 initiative.

⁹ UNCCD Voluntary LDN targets, <https://www.unccd.int/our-work/country-profiles/voluntary-ldn-targets>

- Incorporate in at least 5 planning instruments, criteria and measures that promote the adequate use of soil and the preservation of its functions and ecosystem services, within the framework of the integrated land management policy.

*An unofficial translation into English is provided for countries which articulated their targets in other languages. A deeper explanation of the methods how data is collected and processed for LDN monitoring in Colombia is provided in the report submitted to the UNCCD¹⁰.

4.3.2.3 Living Labs summary

In the case of the MESD from Colombia, the contacts had to be restarted due to a recent change in the Colombian government. This contact was re-initiated and the SEN4LDN project plans were presented to them and they were invited to participate as SDG Early Adopters.

The meeting was held on the 21st of March, 2023 with Gabriel Daldegan (CI), Martin Herold (GFZ), Nuno Cesar de Sa, (GFZ), Ruben Van De Kerchove (VITO) from the part of SEN4LDN. From the part of the Ministry of Environment and Sustainable development of Colombia the participants were Maria Ramirez, Laura Wilches, Jenny Santos, Claudia Escobar, Elmice Mora and Olga Ospina, all part of the ministry.

This meeting focused on general discussion about how the collaboration between SEND4LDN and the ministry could be established and it was agreed that upon the submission of a project description and objectives, these would be discussed internally in the ministry. Meanwhile a new meeting has been scheduled between the parties to proceed with the collaboration to the first LL which occurred on the 24th of May, 2023.

The following people participated in this session: Gabriel Daldegan (CI) and Nuno Cesar de Sa (GFZ) from the part of SEN4LDN. Claudia Daza, Álvaro Alexander Dávila Giraldo, Olga Lucia Ospina Arango from MESD, Geidy Asprilla, Edsson Nagle, Wilber Moreno and Pedro Rodriguez from the IIAP, Nidia Cristina Mayorga, Oscar Daniel Beltrán, Reinaldo Sánchez López from the IHMEA and Paola Johanna Isaacs Cubides from the IIRB. While the responses regarding the user Requirements can be seen in Annex C, the following section provides a summarized version of the dialogue that took place.

Block 1: National activities for LDN

Besides the need for a clearer definition of what LD means in the context of Colombia, there are a number of significant points made regarding its drivers and how its monitoring is currently performed.

- The participants identified a diverse number of causes for LD in Colombia, such as:
 - Inadequate agricultural practices and intensive uses
 - Lack of knowledge regarding how soil biology affects its productivity
 - Government policy that encourages agricultural techniques that deplete soil nutrients such as monocultures and unmanaged livestock systems in soils which are better for forests
 - Lack of knowledge at a technical level
 - Lack of knowledge regarding soil and how to develop and implement sustainable practices
 - Illegal mining practices

¹⁰ LDN Targets, Colombia, 2017, https://www.unccd.int/sites/default/files/ldn_targets/2018-12/Colombia%20LDN%20TSP%20Country%20Report.pdf

- Deforestation and forest fires
- Climate change and variability
- A more comprehensive report on the topic was provided on the National Restoration Plan¹¹
- The focus of the Colombian government regarding LDN efforts are on restoration and conversion towards sustainable and productive land uses alongside efforts towards prevention and mitigation of further degradation
- The sub-indicator of land cover is monitored using fieldwork and high-resolution photography alongside other products such as the CORINE land cover. The other sub-indicators are not monitored with the same consistency and efforts are Land cover but the MEDS is involved in Tools4LDN which aims to address this ¹².
- The partners consider that although the use of EO data offers an opportunity to map and cover large areas for LD monitoring, it still requires efforts for field data collection which are costly and lengthy.
- A point that requires development in the perspective of the Colombia partners is regarding the Soil Organic Carbon where they identify that data regarding its dynamics and chemistry would allow its improved monitoring.
- The following regions of interest were identified as potential sites for testing the algorithms developed by SEN4LDN:
 - Andean natural region (Region Andina) due to its very high diversity
 - The Choco region (El Choco) due to the high levels of land degradation occurring in the area

Block 2: Land cover data

The overall user specifications are shown in Annex C but here we provide an overview of the remaining answers. Currently, the main source of land cover data is the CORINE dataset and IDEAM is monitoring 54 land cover classes. For the entire country, the following land cover types are of most importance for LDN monitoring which are sometimes not available in the dataset: Tropical dry forest (Bosque seco tropical), Savannah, areas of agriculture and mineral exploration.

The following territory were considered of priority for monitoring: Insular, Ciénaga Grande- Sierra Nevada, Cartagena, La Mojana, Serranía de Perijá - Corredor minero del Cesar - Ciénaga Zapatosa, Catatumbo, Páramos, Sabana de Bogotá, Altilanura, Pacífico, Amazonía, Macizo Colombiano, Valle de Atríz, Bajo cauca.

Block 3: Productivity data

During the meeting there was not enough time to discuss this section so the following information was added based on data submitted to the UNCCD¹³ and the interview recordings. According to these reports, productivity data is calculated based on JRC Land productivity dynamics dataset [26] at a resolution of 1km with a temporal resolution of 10 days. Throughout the meeting it was clear that an improvement especially of the spatial resolution would be important for the Colombian government in terms of both

¹¹ National Restoration Plan,

https://archivo.minambiente.gov.co/images/BosquesBiodiversidadyServiciosEcosistemicos/pdf/plan_nacional_restauracion/PLAN_NACIONAL_DE_RESTAURACION_2023.pdf

¹² Tools4LDN, <https://www.tools4ldn.org/>

¹³ LDN Targets, Colombia, 2017, https://www.unccd.int/sites/default/files/ldn_targets/2018-12/Colombia%20LDN%20TSP%20Country%20Report.pdf

understanding the dynamics of LD as well as to be able to improve their ability to implement policies and monitor their efficiency.

Block 4: Carbon stocks data

In the case of Carbon Stocks monitoring, there was also not enough time to discuss the section and therefore the information on this section is also based on the data submitted to the UNCCD and the interview recordings. In the case of SOC, the approach used in Colombia is based on the FAO methodology¹⁴. This map was obtained from 4329 soil profiles sampled across the entire country between 1980 and 2012 using a kriging regression algorithm with a scale of 1:100000. The inclusion of higher resolution EO imagery could therefore improve the resolution of this data and empower the decision-making process of the Colombian government regarding LDN.

4.3.3 Institute for Conservation of Nature and Forests, Portugal

4.3.3.1 Requirements overview

Table 6: User requirements for the Institute for Conservation of Nature and Forest from Portugal. In this case, there are a number of important details regarding the temporal extent and resolution of carbon stocks. Regarding the temporal extent, Portugal also identified a minimum of specific years for each product so they are aligned with what is produced by the country: LU - 1995, 2007, 2010, 2015, 2018 and from here onwards at a 3-year periodicity. LC: 2018, 2020, 2021, 2022. For Portugal, the current minimum product is based on field sampling throughout the country and represents SOC (see IFN6¹⁵) and therefore its very high spatial resolution. Nevertheless, their interest is in monitoring both SOC and above carbon which is more tailored for RS practices and the resolution of the final product should align as much as possible with the other SDG 15.3.1 sub-indicators.

Ministry of Environment and Sustainable Development (Colombia)						
Requirement	Land Cover		Productivity		Carbon stocks	
	Minimum	Desired	Minimum	Desired	Minimum	Desired
Spatial resolution	10x10 m ²	< 10x10 m ²	500x500 m ²	250/30/10 m ²	*0.3 m ²	<= 10x10 m ²
Temporal resolution	Annual	3 to 6 months	Annual	Annual	Annual	Annual
Temporal Extent	*2015 -	2013 -	2018 -	2000 -	2015 -	2000 -
Spatial coverage	National	National	National	National	National	National
CRS	ETRS-89/PT-TM06	ETRS-89/PT-TM06	ETRS-89/PT-TM06	ETRS-89/PT-TM06	ETRS-89/PT-TM06	ETRS-89/PT-TM06
Specific requirements	Standard LCLU classes for SDG reporting	Minimum + increased detailed in all classes (e.g. forest, crop types)	Standard VI data required for SDG reporting	10 - day time series of VI.	Standard SOC data for SDG reporting	Standard SOC + Above-carbon data product (10 - day time series)

¹⁴ Soil organic carbon map, 2017, Colombia, <https://datos.icde.gov.co/maps/c480507823e04357a5bf3d5727635df9/about>

¹⁵ IFN6, <https://dados.gov.pt/en/datasets/6o-inventario-florestal-nacional-ifn6-rdf-projeto-cross-forest-6th-national-forest-inventory-ifn6-rdf-cross-forest-project/>

Processing level	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready	Analysis-ready
Delivery-mode	FTP, Web-service	FTP, Web-service	FTP, Web-service	FTP, Web-service	FTP, Web-service	FTP, Web-service
Data Format	Vector / raster format	Vector / raster format	Vector / raster format	Vector / raster format	Vector / raster format	Vector / raster format
Documentation	ATB Document	ATB Document	ATB Document	ATB Document	ATB Document	ATB Document
Licensing	Open license	Open license	Open license	Open license	Open license	Open license
Users	Technical staff	Wider SDG community	Technical staff	Wider SDG community	Technical staff	Wider SDG community

4.3.3.2 Voluntary LDN targets

The Portuguese government has not set any voluntary LDN targets but has been active in combating desertification which is considered a major threat in the country as well as encouraging and funding numerous projects towards combating it and towards ecosystem restoration.

4.3.3.3 Living Labs summary:

The meeting with the ICNF from Portugal occurred on the 7th of June, 2023 with the participation of Dr. Diana Almeida (ICNF), Teresa Leonardo (ICNF), Andre Trindade (DGADR), Isabel Santos (ICNF) and Pedro Benevides (DGT) from the part of the SDG Early Adopters. From SEN4LDN, the participants were Nuno Cesar de Sa (GFZ) and Ruben Van De Kerchove (VITO).

As mentioned before, the Living Labs interview document was sent to the participants before with an invitation for them to provide detailed answers to all questions. This document was then used to further discuss each of the answers in an attempt to address any detail or to identify other aspects that can be relevant for the product development at a later stage. In this particular case, the SDG Early Adopters also prepared a presentation showcasing their work and data used for LD monitoring as well as a number of potential examples to be used for later product demonstration. This proved to be particularly useful for SEN4LDN as these can prove to be excellent case-study areas for both product validation as well as research opportunities. The responses that refer to this section are provided in Annex D.

Block 1: National activities for LDN

Here we provide only an overview of what we consider to be the most significant points made during this section but the responses can be viewed in Annex D.

- According to the participants, the main drivers of LD in Portugal are LCLU change, drought, soil erosion, forest fires and unsustainable land management.
- Although the Portuguese government has not defined LDN targets there are a number of projects ongoing in Portugal to combat desertification in which ICNF, DGT and DGADR are involved. For example:

- Soiling: an ecosystem services restoration project targeting post-fire areas¹⁶
- +SOLO+VIDA: A pilot project for the design, implementation and evaluation of a territorial program to boost climate change adaptation¹⁷
- LandUnderPressure: aims to contribute to avoid, mitigate and restore land under pressure to combat desertification and increase resilience to climate change in the Montado¹⁸
- Regarding the three sub indicators of SDG 15.3.1, these are monitored within the following contexts:
 - Land cover change within the Desertification national observatory
 - Land productivity and Carbon stocks within the PRAIS4 reporting to the UN.
 - This implies that these are reporting following UN SDGS recommendations
- Remote sensing data plays a vital important role for measuring these 3 sub-indicators. In particular, the official Land Cover/Land Use data product (COS) produced by high resolution imagery plays a critical role.
- A very significant point of contention regarding RS monitoring of LD was stated by the participants. They point out that while there is “green growth” visible in this type of imagery, it does not necessarily reflect a positive outcome due to:
 - Large scale intensive monocultures
 - Post-fire regeneration (fire is part of the ecosystem)
 - The “green growth” often reflects spontaneous growth of herbaceous and sometimes invasive plants which not necessarily reflect a positive increment of land productivity
- A number of potential study areas were identified and shared with the SEN4LDN. These might potentially be included as a case study in later stages of the project. Of note, were ongoing efforts such as the Herdade da Parreira¹⁹ which is an example of conservation agriculture.

Block 2: Land cover data

While the product specifications of the Land Cover Data are shown in Annex D, here we summarize the main points regarding the most important land cover classes and what data products are currently used for monitoring this sub-indicator.

Portuguese officials stated that the Land Cover classes monitored are in compliance with the EU specifications and nomenclature and comprise a total of 83 classes within 4 levels of detail. Regarding LD, they pointed out the importance of increasing detail in Croplands, Pasture, Agroforestry systems and Shrublands and to especially monitor transitions in these land cover classes. In Portugal, transitions occur mainly between cropland/pastures/shrublands and forests and only small proportions in changes to artificial land cover which represents only approximately 5% of the Portuguese mainland land cover.

Although Portugal already produces a LCLU map in a 3-to-5-year cycle based on high resolution photo-interpretation and manual digitization at a minimum resolution of 1 ha (COS). This approach offers advantages for landscape planning but is unsuitable for seasonal variations or yearly cycles that are more

¹⁶ SOILING, <https://www.eeagrants.gov.pt/en/programmes/environment/projects/projects/soiling/>

¹⁷ +Solo+Vida, <https://www.eeagrants.gov.pt/en/programmes/environment/projects/projects/plussoloplusvida/>

¹⁸ LandUnderPressure, <https://www.eeagrants.gov.pt/en/programmes/environment/projects/projects/landunderpressure/>

¹⁹ Herdade da Parreira, <https://www.med.uevora.pt/pt/herdade-da-parreira-50-anos-a-construir-sustentabilidade-economica-e-ambiental-2/>

significant for nature or environmental analysis. The availability of the data from Copernicus Programme allowed the extension of the standard LCLU map to produce a Land cover-oriented solution using Artificial Intelligence (COsc)²⁰. This data product provides both a land cover product at a higher spatial resolution and temporal resolution (starting in 2018, yearly since 2020). Sentinel 2 A/B and COsc products also enable the production of intra-annual vegetation status maps at a monthly resolution which can be used for seasonal and intraseasonal variations²¹.

Block 3: Productivity data

In Portugal, land productivity for the last reporting period (2016-2019) as measured following the UNCCD Good Practice Guidelines [4] and PRAIS4 reporting manual²². The three metrics of Trend, State and Performance were measured using annual Net Primary Productivity data from 2000 to 2019 and the guide's look-up tables (PRAIS4 and UNCCD). Also, as recommended by the PRAIS4 manual, results were tested against alternative data using global data sources calculated from Trends.Earth (MOD17A3HGF v6.1 NPP annual time series). Because of the need for higher temporal and spatial resolutions alongside no-cost data, the interviewees consider that only MODIS products (MODIS13) can currently be used for this task. But they identify that the optimal scenario would be if a harmonized Landsat/Sentinel data product existed for the study period alongside an evapotranspiration data product. An explicit overview of the user requirements can be seen in Annex D.

Block 4: Carbon stock data

Regarding Carbon stocks, it is based on the National Forest Inventory (IFN6¹⁵) from 2015 which details Above Ground Biomass from both alive and dead biomass. This dataset is based on an extensive sampling throughout the country which providing an excellent coverage of the country. For SOC estimates for PRAIS4, Trends.Earth default data was used. An overview of the product specifications can be seen in Annex D.

4.3.4 European Environment Agency, European Union

A first meeting between SEN4LDN and the EEA was held on the 28th of February, 2023 with the objective of discussing the user requirements on the part of later regarding the products to be developed in the future. From the EEA, this meeting had the participation of Dr. Eva Ivits and Joanna Przystawska while from the SEN4LDN, Dr. Marc Paganini (ESA), Dr. Ruben Van De Kerchove (VITO), Dr. Martin Herold (GFZ) and Nuno Cesar de Sa (GFZ) participated.

In this case, the interview objectives were to collect an overview of how EEA do their work regarding LD and what bottlenecks they have identified. While much of discussion centered around the methodological aspects that are to be addressed by SEN4LDN, the following limitations were identified reading LD monitoring:

²⁰ Carta Ocupacao do Solo Conjuntural, <https://dados.gov.pt/pt/datasets/carta-de-ocupacao-do-solo-conjuntural-2021/>

²¹ Mapas Intra-anuais do estado da vegetacao <https://dados.gov.pt/pt/datasets/mapas-intra-anuais-do-estado-da-vegetacao/>

²² PRAIS4 Reporting Manual, <https://prais4-reporting-manual.readthedocs.io/en/latest/index.html>

- EEA clarified that while it's not their function to report on LD to the European Commission, instead the Eurostat is responsible for LD and SDG monitoring. Nevertheless, EEA provides methodological support to Eurostat on these aspects.
- In the particular case of the carbon stocks, there is lack of data especially regarding the baseline periods, implying that further developments of SEN4LDN should address this.
- Lack of clear definition of LD between various institutions and application which can often result in expectations that can't be measured
- The friction on these definitions of LD in the scientific community has led EEA to focus on specific aspects of land degradation, in particular land cover change.

And EEA stated a particular interest in the SEN4LDN outcomes, especially if they can assist on distinguishing between the drivers of LD (e.g., anthropogenic or climatic) given that this plays a critical role in policy making and also on improving the monitoring of both above and below carbon due to carbon accounting efforts by the EU and EEA and that is of paramount importance that any operational result can be included within their own processing pipelines.

Later, as prototype data products become available, EEA will be invited to test and provide feedback on their quality in a more structured approach. A first LL will be organized with this specific stakeholder at that time.

4.3.5 Overview of user requirements

Here we provide a comparative overview of the user requirements as reported on the first LL session. While the original tables are visible on Annex B, Annex C and Annex D, and extended interpretation was provided on the previous sections (see Table 4, Table 5 and Table 6) here we add only specific sections to help in providing a clearer context.

Overall, in terms of LCLU, all three standard SDG Early Adopters identified similar requirements in terms of extent and resolution (Table 7) with each expecting at least coverage at national level and the highest spatial resolution possible based on the free-to-use RS sensors such as Landsat and Sentinel 2. In the case of Portugal, LC and LU are monitored at a higher resolution because of a periodic effort of the government to collect higher resolution imagery for the entire country. The biggest variation is in terms of temporal resolution where Uganda and Portugal specify a minimum annual resolution while Colombia specifies a minimum trimester resolution but each desire a different temporal resolution. This is potential due to the specific challenges that each country faces in terms of LD monitoring.

*Table 7: User requirements for LCLU regarding spatial and temporal resolution. The * refer to specific points made by the ICNF stakeholder: in this case the SDG Early Adopter identified different requirements for Land Use (1 ha) and Land cover (10x10m²). Regarding the temporal extent, Portugal also identified a minimum of specific years for each*

product so they are aligned with what is produced by the country: LU - 1995, 2007, 2010, 2015, 2018 and from here onwards at a 3-year periodicity. LC: 2018, 2020, 2021, 2022.

SDG Early Adopter	SDG Sub-indicator: Land Cover Land Use							
	Spatial coverage		Spatial Resolution		Temporal extent		Temporal Resolution	
	Minimum	Desired	Minimum	Desired	Minimum	Desired	Minimum	Desired
Uganda (BU)	National	National	30x30 m ²	10x10 m ²	2018 -	2000 -	Annual	10 - day
Colombia (MESD)	National	South America	30x30 m ²	10x10 m ²	2015 -	2000 -	Trimester	Weekly
Portugal (ICNF)	National	National	*10x10 m ²	< 10 m ²	*	2013 -	Annual	3 to 6 months

Other aspects regarding data delivery and data formats were also provided (see Annex B, Annex C and Annex D for more details). In terms of the potential users of this data product, partners identify that at a minimum, the main users will be the government officials or technicians but the expectation is that these data products are to be disseminated to wider audiences such as private enterprises, academia and the general public. Overall, all partners expect data in projected coordinate systems such as UTM or national systems, at least having access to analyses-ready dataset (preferably GeoTIFF formats) which can be downloaded and, if possible, available in a cloud-service. In terms of licensing there is a desire for Open License or Creative Commons as this data being made available to wider audiences is considered to be important.

In the case of Land Productivity (Table 8) there was more diversity in the responses although it is important to note that, as mentioned before, in the case of Colombia there was no time during the first living labs to specifically address some of the answers for Land Productivity and Carbon Stocks. Nevertheless, adapting from their report to the UNCCD and also during the meeting itself, gave us the opportunity to infer some of their expectations.

All participants would like to see improvements in terms of spatial and temporal resolution, clearly identifying that 10m resolution is desired as well as increased revisited times. This is in line with the aims of SEN4LDN as well as the use of Sentinel-2 data to generate this product. Participants also showed interest in linking Land Productivity with land cover classes, especially if there is a possibility to increase the details of these. This would empower the government's ability to enforce and monitor policies on the field.

Table 8: Summary of responses of user requirements regarding Land Productivity. * Due to time constraints during the meeting the responses from Colombia (MESD) were adapted from their UNCCD report and their expectations based on what was inferred from the meeting

SDG Early Adopter	SDG Sub-indicator: Land Productivity							
	Spatial coverage		Spatial Resolution		Temporal extent		Temporal Resolution	
	Minimum	Desired	Minimum	Desired	Minimum	Desired	Minimum	Desired
Uganda (BU)	National	National	30x30 m ²	10x10 m ²	2018 -	2000 -	Annual	10 - day
Colombia (MESD)	National	South America	1x1 km ²	10x10 m ²	2015 -	2000 -	Annual	10 - day
Portugal (ICNF)	Global	Local	500x500 m ²	250/30/10 m ²	2000 - 2022	2013 -	Annual / seasonal	5 to 16 days

Although not all partners are using Trends.Earth to process this indicator, it is a commonly used tool which implies that their expectations are likely in-line with the data required to use Trends.Earth and the format of the data being produced by the app. As was in the case of Land Cover data, the expectation for data to be in a relevant UTM or a national coordinate reference system is an expectation

The ability to directly download the data into their own systems for further analysis/processing is an expectation by all participants albeit the use of cloud-services solutions was also specifically mentioned. In particular, Portugal referenced AppEARS²³ from NASA, GEE from Google and Planetary Computer from Microsoft as alternatives for data delivery. This would be in line with the expectations regarding users as all participants envisioned interest from diverse stakeholders from academia to corporations and enterprises, other government bodies and the general public.

The Carbon stocks data can be the most problematic data to acquire by RS and is often dependent on expensive and logistically complicated field campaigns. This is because while AGB has been mapped often using RS techniques, for SOC this data source is less effective and instead soil sample-based analysis or proxy methods have to be used²⁴. The SDG Early Adaptors face these same challenges to monitor Carbon Stocks and each has different approaches to address them. The Ugandan partners use Trends.Earth to estimate changes in SOC which is based on coarser soil grid data and land cover data while MESD from Colombia used the approach proposed by FAO and 4329 soil field samples to generate a 1:100000 map for the country. In the case of the ICNF from Portugal, the analysis for SOC is also performed based on field sampling throughout the country as part of the national forest inventory in combination with Trends.Earth data and methods but AGB is monitored through RS methods. Therefore, all recognized that SEN4LDN offering an alternative for monitoring this indicator would be crucial for their effective monitoring of LDN, and consider that simply increasing the resolution and accuracy of land cover maps can help to achieve this.

²³ AppEARS, <https://appears.earthdatacloud.nasa.gov/>

²⁴ https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2016-11-30_soil_organic_carbon_as_indicator_final.pdf

Overall, there is relative agreement in requirements between all partners in terms of spatial and temporal resolutions (see Table 9) with the desire for 10 x 10 m² spatial resolution with annual data being the standard request and this relates to interest in both AGB and SOC. This naturally relates with the need for evaluating the baseline and target periods as suggested in the SGD 15.3.1 good practices guideline [4].

Table 9: User requirements for Carbon stocks data. In the case of Colombia, some of the responses were adapted from the UNCCD report due to lack of time during the LL session. For Portugal, the current minimum product is based on field sampling throughout the country and represents SOC (see IFN6¹⁵) and therefore its very high spatial resolution. Nevertheless, their interest is in monitoring both SOC and above carbon which is more tailored for RS practices and the resolution of the final product should align as much as possible with the other SDG 15.3.1 sub-indicators.

SDG Early Adopter	SDG Sub-indicator: Carbon stock							
	Spatial coverage		Spatial Resolution		Temporal extent		Temporal Resolution	
	Minimum	Desired	Minimum	Desired	Minimum	Desired	Minimum	Desired
Uganda (BU)	National	National	100x100 m ²	10x10 m ²	2018 -	2000 -	Annual	10 - day
Colombia (MESD)	National	South America	100x100 m ²	10x10 m ²	2015 -	2000 -	Annual	Annual
Portugal (ICNF)	National	National	0.3 m ²	≤ 10x10 m ²	1995/2005 /2015	2000 -	Annual	Annual

Again, all partners expect data to be downloadable, with relevant documentation explaining the methodology, hopefully at the level of an Algorithm Theoretical Basis as well as in relevant UTM or national coordinate reference systems so that it can be easily integrated to their own analysis. The expectation from the partners is that at least their own technicians will use the data but not only, as they envision interest from Academia, enterprises and corporate stakeholders as well as other government bodies or institutions. This implies that the data being publicly available or accessible in an open or creative commons license is significant.

5 Conclusion

This report provides an overview of the ongoing activities relating to WP1: on user characterization, engagement and requirements. An engagement strategy was defined based on a LL approach which consists of continuous engagement with potential users and stakeholders during the various phases of the project development.

In our case, we defined a core group of SDG Early Adopters: Busitema University (Uganda), the Ministry of Environment and Sustainable Development (Colombia) and the Institute for Conservation of Nature and Forest (Portugal). On one side, these early adopters will have access to prototype versions of the SEN4LDN LDN monitoring data products and be invited to periodically meet and discuss them in order to provide feedback and insights that can be used for product development. On the other hand, they will assist us in identifying areas of interest and relevant data sources that can be used for validating our products in their areas of interest which will further help us to demonstrate their applicability and to develop ready-to-use SDG 15.3.1 indicator data products.

Contacts with the SDG Early Adopters from Portugal and Colombia had to be re-initiated due to changes in the contact persons. After this minor setback, communication was re-established and the first LL was held with each of the SDG Early Adopters. The first LL aimed to gather an overview of the user requirements and in our view, provided an excellent overview of these.

A very significant outcome was that all early adopters provided an insightful overview of what are the drivers of LD in their countries and how diverse the challenges to monitor it can be. For example, both Colombia and Uganda identified illegal activities such as illegal logging or mining as playing a significant impact in LD for their countries. Portugal, on a different note, stated that increasing high intensity greenhouse agriculture is potentially reducing the amount of water availability in other locations which in their view is impoverishing the ecosystem and increasing LD. Another interesting point made by the Portuguese early adopters was that much of the “greening” in Portugal is not necessarily as positive as is expected by the current models because these often reflect growth of monocultures, unmanaged shrubs and forest and potentially invasive alien plants. Another very important outcome from the LL sessions was that each of the early adopters identified a number of potentials “case-studies” in their countries that have both a technical value for SEN4LDN but also a potential scientific value for the field of LD monitoring through EO.

Overall, there was a relative agreement for a need for higher temporal and spatial resolutions products as proposed by SEN4LDN, especially based on Sentinel-2 data. Improving the ability to monitor each of the SDG 15.3.1 sub-indicators have different challenges and opportunities. LCLU mapping has seen great improvements in recent years with the advent of novel AI methods and computational solutions alongside new commercial and non-commercial EO sensors. Improvements in this sub-indicator can affect all other sub-indicators by allowing stakeholders to more accurately discriminate classes and identify areas of negative or positive changes in the landscape. SEN4LDN aims to address these challenges by improving on the established ESA WorldCover algorithm [13] and to provide an improved ability to generate accurate and meaningful LCLU datasets at Sentinel 2 resolutions which will be aligned with the requirements of the SDG Early Adopters of this project.

In terms of Productivity because it is required a continuous monitoring of a VI temporal resolution has been the main bottleneck for long term monitoring as optical EO data is particularly vulnerable to cloud cover and other atmospheric effects. Again, the increase of the number of EO platforms offers a significant opportunity of improving productivity monitoring in the future but it's only through the development of novel methods that we can monitor SDG reference periods that start in the 1990s or early 2000s. These methods will have to rely on sensors such as MODIS and Landsat to improve both the temporal and spatial resolution of this sub-indicator during the reference period as well as to integrate them with novel platforms such as Sentinel-2 for the target period and future monitoring. Furthermore, all SDG Early Adopters showed interest in having intra-seasonal estimates of productivity as this is important to identify classes such as crop types, seasonal variations and changes in vegetation covers. Here SEN4LDN offers an integrated approach based on TIMESAT and Landsat/Sentinel data alongside auxiliary datasets such as rainfall and temperature to generate time series of productivity at resolutions of 10m and sub-annual data products which is in-line with the aforementioned user requirements.

Carbon stocks are the most challenging SDG 15.3.1 sub-indicator to monitor as these can be interpreted as a combination of two different estimates: AGB and SOC. Each of these aspects has different challenges to monitor and estimate, for example while AGB can vary greatly within a year, e.g. a crop growing season, it can also be monitored through EO. SOC on the other hand, can be hard to monitor through EO often varies slower than AGB and can remain relatively consistent with big changes in SOC being often caused by human driven LC change (e.g. deforestation or agriculture interventions). AGB monitoring can be improved with using specific satellite mission data and products (i.e. CCI Biomass, GEDI) and higher spatial and temporal resolution of both LCLU and Productivity monitoring which are both objectives of the SEN4LDN. SOC estimates can benefit both by these higher resolution products by increasing the ability to discriminate between classes and inter-seasonal variations of crops but will necessarily benefit by the integration of field sampling data collected by national authorities, an avenue that SEN4LDN can explore for further improving the estimates of Carbon stocks in time and space.

Furthermore, all SDG Early Adopters stated that increasing the temporal resolution would improve their ability to monitor seasonal and sub-seasonal changes which can be critical to effectively identify land degradation and its causes. In this context, examples provided related to the ability to detect events such as seasonal crops or catastrophic events such as fires are very relevant for effective monitoring of LD. Our aim is that the data products developed by SEN4LDN will assist not just in monitoring the status of LD but in providing the data necessary for understanding the root causes of LD for each stakeholder. This is of paramount importance as we observed from our interviews that the drivers and how LD expresses itself can vary a lot between different regions or countries. For example, in Portugal with the risk of desertification, water management plays a critical role in quantifying LD even if there is an overall “greening” of the country in other regions and here, for example, catastrophic events such as wildfires can often be seen as part of the ecosystem and not necessarily an indication of increasing LD. Being able to correctly identify what is actual LD is very important for effective management, and for that, accurate high temporal and spatial resolution is critical for successful LDN policies.

Regarding other aspects of the data products, such as validation procedures, delivery mode, data formats, licensing and documentation there was a lot of agreement between all the interviewed SDG Early Adopters:

- In terms of preference for Coordinate Reference Systems, most SDG Early Adopters would prefer delivery in the official national coordinate system or in a relevant UTM format.
- All of them showed preference for scientifically validated methods and metrics for validating the product quality as this facilitates not just the trust of the potential users but also empowers their ability to encourage LDN policy.
- While a web system for exploring, area selection and general operations on the data is welcome, all stakeholders showed more interest in being able to directly download the data and to be able work with it in their own internal systems.
- GeoTIFFs were the most commonly requested data formats for raster data types
- Regarding licensing a preference was shown for open licenses or FAIR compliant licensing as this will facilitate their access to the data itself and encourage its integration to their own pipelines.
- In terms of interoperability, the expectation is that data products can be used in combination with other data products already being used by the institutions for LD monitoring. Examples of these are CORINE, Trends.Earth, STAC data assets.
- Regarding documentation there is the expectation that there is clear documentation of the methods and datasets used to generate the final LD sub-indicator products but the desire is of a document at the level of an ATB as seen in other similar products.
- Some specific requirements also occurred, such as ICNF pointing out that metadata should follow INSPIRE compliant formats.

These requirements are indicative of the needs that the SDG Early Adopters have. It's clear that there is a desire for an ability to freely access and download the SDG 15.3.1 data products produced by SEN4LDN. Open data is fundamental for LDN monitoring efforts at a governmental level since any added costs might limit their ability to budget proper monitoring efforts. And this constraint also affects many of the other requirements such as the interoperability which is linked with the final product being interoperable with other open data sources. Scientific validation of the methodologies developed through peer-reviewed publications would significantly encourage these partners to use novel data products and this is an important aspect to take into consideration by SEN4LDN. It's also clear that the stakeholders prefer an ARD product with clear metadata and documentation which can quickly be added into their own processing pipelines for LD monitoring. We foresee then that future LL sessions will play a critical role in tailoring the data products developed to the needs of each specific stakeholder.

We considered our first experience with the SDG Early Adopters to have been very successful in identifying the user requirements and the key drivers of land degradation for each of the “case-study” countries which will help us in defining goals and targets for the product development. These first sessions also helped us to identify a number of alternatives for validating our products at a local level and a number of scientifically interesting research opportunities which we hope to be able to explore.

Lastly, we also identified a number of issues regarding our approach to engage with the SDG Early Adopters which we will address in the future, in particular, when prototype data products are accessible, we have to ensure that each stakeholder has a fair chance to interact and experiment with it prior or during the Living Labs session in order to facilitate the communication and their ability to provide feedback.

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Annex A. Living Labs interview document

Block 1: National activities for LDN

- 1.1) Which are the main drivers for Land Degradation in <country>?
- 1.2) In face of the aforementioned challenges, what is the approach that is used in <country> to identify and define targets to reach LDN?
- 1.3) Can you identify specific constraints or limitations (e.g. government, cultural) that affect the implementation of the LDN targets in <country>?
- 1.4) Can you provide a description of the implementation of the LDN targets for <country>?
- 1.5) What are the main strengths and weaknesses of this strategy (in particular with regards to monitoring and reporting)?
- 1.6) Which of the three sub-indicators (land cover, land productivity, Carbon stocks) of SGD 15.3.1 are being actively used for monitoring LDN in <country> at the moment?
- 1.7) How is the validation of each of the aforementioned sub-indicators of SDG 15.3.1 being performed in <country>?
- 1.8) Are these sub-indicators being reported following the recommendations of the UN SGDS? If not, why not?
- 1.9) Are you using any remote sensing data in the reporting process?
 - 1.9.1) What are the main strengths and weaknesses of the Remote Sensing data sources?
 - 1.9.2) What would be the main benefits of increasing spatial and temporal resolution of the remote sensing data? (e.g. 10 m or daily estimates)
- 1.10) Are there any tools or resources that you find particularly helpful in your reporting on SDG 15.3.1?
 - 1.10.1) What improvements would you like to see in those tools or resources?
- 1.11) Do you have access to any national data on land cover, productivity or carbon stocks which can be shared with SEN4LDN and used to calibrate and validate the developed algorithms?
 - 1.11.1) If so, can you describe how this data was collected and processed?
- 1.12) Can you think of any reference sites in your country which would be suited to prototype our algorithms?
- 1.13) Can you think of any use case in your country to showcase that the project can help you to better identify hotspots of land degradation & restoration?

Block 2: Land cover data

2.1) What are the land cover classes of interest for LDN monitoring in <country>?

2.2) What are the data products required to generate land cover information for LDN monitoring?

2.3) Please fill in the following specifications table(s) regarding the data necessary for Land cover data used for LDN monitoring:

Table 10: Specifications table for Land cover data

Land cover product	
Specification:	Minimum requirement Target/desired requirements
Product	E.g. Map of forest cover change
Units:	(e.g. Tons)
Spatial coverage	(e.g., global)
Spatial resolution	(e.g., 30x30m ²)
Temporal extent	(e.g.,2000- 2030)
Temporal resolution	(e.g., daily)
Processing level	(e.g. analysis-ready)
Coordinate Reference system	(e.g. WGS84)
Validation procedure	(e.g. field data, high resolution imagery)
Accuracy metrics	(e.g. 90% OA or 0.8 RMSE)
Delivery mode	(e.g. FTP, web-service, hard-copy)
Data format	(e.g. .tif)
Metadata	(e.g. datum, provenance)
Documentation	(e.g. Algorithm theoretical basis, or tutorial)
Interoperability	(e.g. STAC)
Licensing	(e.g. CC-By-4)
Users	(e.g. our technical staff)
Other requirement deemed significant	< add any requirement that is significant >

Block 3: Productivity data

3.1) How is Land productivity measured for LDN monitoring in <country>?

3.2) What are the data products required to generate land productivity estimates for LDN application?

3.3) Please fill in the following specifications table(s) regarding the data necessary for Land productivity data used for LDN monitoring:

Table 11: Specifications table for Land productivity data

Productivity data		
Specification:	Minimum requirement	Target/desired requirements
Product	E.g. Map of forest cover change	
Units:	(e.g. Tons)	
Spatial coverage	(e.g., global)	
Spatial resolution	(e.g., 30x30m ²)	
Temporal extent	(e.g.,2000- 2030)	
Temporal resolution	(e.g., daily)	
Processing level	(e.g. analysis-ready)	
Coordinate Reference system	(e.g. WGS84)	
Validation procedure	(e.g. field data, high resolution imagery)	
Accuracy metrics	(e.g. 90% OA or 0.8 RMSE)	
Delivery mode	(e.g. FTP, web-service, hard-copy)	
Data format	(e.g. .tif)	
Metadata	(e.g. datum, provenance)	
Documentation	(e.g. Algorithm theoretical basis, or tutorial)	
Interoperability	(e.g. STAC)	
Licensing	(e.g. CC-BY-4)	
Users	(e.g. our technical staff)	
Other requirement deemed significant	< add any requirement that is significant >	

Block 4: Carbon stocks data

4.1) How are Carbon stocks measured for LDN monitoring in < country >?

4.2) What data is available and being used for monitoring Soil Organic Carbon (SOC) and aboveground carbon stocks?

4.3) Please fill in the following specifications table(s) regarding the data necessary for Carbon stocks data used for LDN monitoring:

Table 12: Specifications table for Carbon stock data

Carbon stock data		
Specification:	Minimum requirement	Target/desired requirements
Product	E.g. Map of forest cover change	E.g. LCLU change map
Units:	(e.g. Tons)	
Spatial coverage	(e.g., global)	
Spatial resolution	(e.g., 30x30m ²)	
Temporal extent	(e.g.,2000- 2030)	
Temporal resolution	(e.g., daily)	
Processing level	(e.g. analysis-ready)	
Coordinate Reference system	(e.g. WGS84)	
Validation procedure	(e.g. field data, high resolution imagery)	
Accuracy metrics	(e.g. 90% OA or 0.8 RMSE)	
Delivery mode	(e.g. FTP, web-service, hard-copy)	
Data format	(e.g. .tif)	
Metadata	(e.g. datum, provenance)	
Documentation	(e.g. Algorithm theoretical basis, or tutorial)	
Interoperability	(e.g. STAC)	
Licensing	(e.g. CC-By-4)	
Users	(e.g. our technical staff)	
Other requirement deemed significant	< add any requirement that is significant >	

Annex B. Interview: Uganda – Busitema University

Date/location: 08/03/2023, Zoom meeting

SEN4LDN participants: Martin Herold, GFZ (PD), Nuno Cesar de Sa, GFZ, Ruben Van De Kerchove, VITO, Tom Kiptenai, CI

Interviewee details: Prof. Dr. Moses Isabirye, Busitema University (MI), David Kfumba, James Ssuuna, Kaduuma Antony, Denis Maholo (DM)

Block 1: National activities for LDN

1.1) Which are the main drivers for Land Degradation in Uganda?

Deforestation; Overgrazing; Improper soil management; Urbanisation; Population pressure; Poverty;

1.2) In face of the aforementioned challenges, what is the approach that is used in Uganda to identify and define targets to reach LDN?

The SLM platform was used to identify and define targets to achieve LDN. The SLM platform is composed of the Inter-Ministerial National Steering Committee, The National Technical Committee, The CSO-SLM Network, Faith Based Organisations and Cultural Institutions, Private sector. The SLM Multi-stakeholder approach was used in the identification and definition of targets

1.3) Can you identify specific constraints or limitations (e.g. government, cultural) that affect the implementation of the LDN targets in Uganda?

Policy inconsistency and administrative changes in government.

- Unpredictable policy changes
- Weak enabling environments toward harmonisation and coordination of policy, legal and regulatory frameworks.
- Lack of harmonised economic and environmental policies
- Ineffective regulatory environment
- Weak governance and enforcement of Land Management related legislation.

Lack of cross-sector coordination and cross-sectoral

budgetary planning. Predominance of sectorial and

compartmental approach for land management planning, budgeting and intervention.

- Sectors competing for different land management approaches, land areas and natural resources.

Lack of a coherent framework for coordination on policy and practice related to land use and management.

Gap between planning and implementation

- Gap between centralised and territorial planning and implementation processes.
- Top-down planning processes, local planning is not enhanced.

Strategies and action plans formulated but not implemented.

Lack of priority provided to combating land degradation in national planning and finance frameworks.

- Multiplicity of actors acting with conflicting interests.
- Lack of national and subnational data and information on land degradation;
- Difficulties to integrate LDN and environmental knowledge in economic and social sectors

Low understanding of the importance of SLM at all levels;

- Concept of “development” usually favours infrastructure, market development and short term economic benefit;
- Lack of effective participation mainly from local level stakeholders.
- Insufficient budgetary allocation, misuse or limited access to financial resources, mainly at local levels;
- Low investment and micro-entrepreneurships opportunities.
- Lack of economic incentives for shifting towards SLM.

1.4) Can you provide a description of the implementation of the LDN targets for Uganda?

First is the need to integrate the LDN concept in the national development agenda and scaling it out at the national, sub national, local and project level of planning. Similarly there are arrangements of integrating the LDN concept in the Guidelines for land use planning. This activity is underway. But we are also encouraging the integration of the concept at project formulation and implementation level. The land use planning process of the just ended Karamoja Sustainable land use and Resilient livelihoods project integrated the LDN concept in the land use planning process with Land use map legends depicting LDN balance sheet at the Parish level.

1.5) What are the main strengths and weaknesses of this strategy (in particular with regards to monitoring and reporting)?

The mismatch in the details (resolution) on observations at a parish level and the 1 km reporting resolution. Makes integration of local information into the reporting platform rather difficult

1.6) Which of the three sub-indicators (land cover, land productivity, Carbon stocks) of SGD 15.3.1 are being actively used for monitoring LDN in Uganda at the moment?

All the three sub indicators are used

1.7) How is the validation of each of the aforementioned sub-indicators of SDG 15.3.1 being performed in Uganda?

In view of the limited financial resources, we have relied on google satellite to validate the sub indicators- especially the land cover maps

1.8) Are these sub-indicators being reported following the recommendations of the UN SDGS? If not, why not?

Yes and we basically use default datasets

1.9) Are you using any remote sensing data in the reporting process?

1.9.1) What are the main strengths and weaknesses of the Remote Sensing data sources?

The data is of coarse resolution and cannot adequately support reporting at local levels e.g. parish or village. The parish is now the development unit in Uganda

1.9.2) What would be the main benefits of increasing spatial and temporal resolution of the remote sensing data? (e.g. 10 m or daily estimates)

This data can adequately support planning and reporting at parish level

Less challenges with false positives or negatives

More accurate reporting on the parcel areas.

Daily estimates can be good at predictive studies that can support early warning systems etc

MI: To be able to do analysis after the reporting, because once the reporting is done we would like to be able to access the data so we can continue with further analysis and even other analysis which would use this data.

DM: We need increased resolution because we need this data to be used in other projects and analysis. We are looking into productivity changes in in livestock system as part of a work with FAO

1.10) Are there any tools or resources that you find particularly helpful in your reporting on SDG 15.3.1?

Yes; We have been using Trends.Earth

1.10.1) What improvements would you like to see in those tools or resources?

An interactive robust phase that supports ground truthing and classification activities

A tool that can work offline and allow uploading of results to the reporting platform online

Possibility of integrating national SOC datasets

1.11) Do you have access to any national data on land cover, productivity or carbon stocks which can be shared with SEN4LDN and used to calibrate and validate the developed algorithms?

Yes. From the national biomass program at the National Forestry Authority

1.11.1) If so, can you describe how this data was collected and processed?

Imagery used is Landsat / spot

a. Image procurement, b.Cloud removal, c.Subdividing images into tiles, d. Image segmentation, e. Calculation of segment statistics, f. Generating training data, g. Image classification, h. Assigning

class names i. Merging the tiles, j. Compilation of statistics, k.Verification/ground truthing, l. Final edits/final compilation of statistics, m. Map production, n. Production and publication of the technical report²⁵.

It is worth noting that maps of the National Biomass Study and NFA have considered woody stands of 4 metres and above that are not cropland or grassland as forests (woodlands) and those below 4 metres are considered bush. Taking into account the above circumstances, Uganda's forest definition for the construction of FRL for REDD+ programme shall be: A minimum area of 1 Ha, minimum crown cover of 30%, and comprising trees able to attain a height of 4 metres and above²⁶.

In addition there exists biomass monitoring plots 50 m x 50 m distributed throughout the country.

1.12) Can you think of any reference sites in your country which would be suited to prototype our algorithms?

Oil Palm plantation and forest sites in Kalanga islands

Sugarcane plantation in Jinja

Murchison Game Park

Cattle corridor in Nakasongola District

Grasslands in the hills of Ankole

Woodlands in Acholi sub region

Karamoja Cluster Landscape

(Forest landscape) Albertine Landscapes - one of the largest forests in Uganda - Budongo Forest (National Forest Authority has useful data, incl. permanent plots 50x50m incl. recording changes)

1.13) Can you think of any use case in your country to showcase that the project can help you to better identify hotspots of land degradation & restoration?

All these are possibilities

-Mt. Elgon region under this ongoing GEF project: Promoting integrated landscape management approach for conservation of the Mt. Elgon Ecosystem in Eastern Uganda

-Lake Victoria Catchment restoration- another GEF project under preparation

-Lake Kyoga Catchment- largely grazing with mixed cropping

-Assessing Land condition in the Game Parks of Uganda

- Karamoja region - livestock and game (transboundary movement leads to livestock number going up), also mineral exploration, oil,

- Mabira forest - sugar can expansion

²⁵ <https://www.nfa.go.ug/index.php/publications/reports/biomass-reports>

²⁶ https://redd.unfccc.int/files/uganda_frel_final_version_16.01.pdf

- Semiliki ecosystem / Rwenzori foots - high stock numbers, deforestation, wetlands

Block 2: Land cover data

2.1) What are the land cover classes of interest for LDN monitoring in Uganda?

Plantations (Commercial farmlands) - includes oil palm, coffee, sugar cane, tea, cacao, banana - important of extend of crops, conversion of land to these crops incl. deforestation, a lot sugar cane expansion - datasets available training ? Some from national biomass monitoring, agr. Reports (Moses could provide data on request)

Croplands

Forest (Tree cover), national forest definition (>30% cover, min. 2 m, 5ha? of continuous cover), used for reporting to UNCCD praise platform - also some shrublands included as forests in trends.earth assessment, height difference is important for separating trees and shrubs - Definition: A minimum area of 1 Ha, minimum crown cover, of 30% of trees able to attain a height of 4 metres and above (https://redd.unfccc.int/files/uganda_frel_final_version_16.01.pdf) (see page 6 of report)

Wetlands

Built Up / Artificial

Wetlands

Grasslands

2.2) What are the data products required to generate land cover information for LDN monitoring?

NDVI

2.3) Please fill in the following specifications table(s) regarding the data necessary for Land cover data used for LDN monitoring:

Land cover product		
Specification:	Minimum requirement	Target/desired requirements
Product	LCLU change map	LCLU change map
Units:	Land cover classes	Land cover classes
Spatial coverage	national	national
Spatial resolution	30x30m ²	10x10m
Temporal extent	2018-2023	2000-2023
Temporal resolution	annual	10-day
Processing level	analysis-ready	analysis-ready
Coordinate Reference	WGS84/UTM	WGS84/UTM

system		
Validation procedure	high resolution imagery Field data	high resolution imagery Field data
Accuracy metrics	0.5 overall accuracy (as high as possible)	0.8 overall accuracy
Delivery mode	FTP , Web-service	FTP , Web-service
Data format	Tif	Tif
Metadata	Comprehensive data properties	Comprehensive data properties
Documentation	Algorithm theoretical basis and tutorial	Algorithm theoretical basis and tutorial
Interoperability	STAC or others to ease accessibility	STAC or others to ease accessibility
Licensing	GNU General Public License / Open source	GNU General Public License / Open source
Users	our technical staff	other potential users
Other requirement deemed significant		Land cover validation in reference regions, on the ground visits?

Block 3: Productivity data

3.1) How is Land productivity measured for LDN monitoring in Uganda?

Land productivity is assessed in Trends.Earth using measures of change derived from NDVI time series data.

Units kg/ha/yr

3.2) What are the data products required to generate land productivity estimates for LDN application?

NDVI

3.3) Please fill in the following specifications table(s) regarding the data necessary for Land productivity data used for LDN monitoring:

Productivity data product		
Specification:	Minimum requirement	Target/desired requirements
Product	Land Productivity	Land Productivity Trends map
Units:	kg/ha/yr	kg/ha/yr
Spatial coverage	national	national
Spatial resolution	30x30m ²	10x10m
Temporal extent	2018-2023	2000-2023

Temporal resolution	annual	10-day
Processing level	analysis-ready	Analysis ready
Coordinate Reference system	WGS84	WGS84 / UTM
Validation procedure	high resolution imagery field data	high resolution imagery field data
Accuracy metrics	0.8 RMSE	0.8 RMSE
Delivery mode	hard-copy	FTP, web-service
Data format	Tif	Tif
Metadata	Comprehensive	Comprehensive
Documentation	Algorithm theoretical basis, or tutorial	Algorithm theoretical basis, or tutorial
Interoperability	STAC or others to ease accessibility	STAC or others to ease accessibility
Licensing	GNU General Public License / Open source	GNU General Public License / Open source
Users	our technical staff	other potential users
Other requirement deemed significant		Can productivity be linked to agricultural lands/zones and different cropping systems. Adding more detail using the different land cover categories. For examples land use grazing biomass

Block 4: Carbon stocks data

4.1) How are Carbon stocks measured for LDN monitoring in Uganda?

A combined land cover/SOC method was used in Trends.Earth to estimate changes in SOC and identify potentially degraded areas.

One focus on AGB would be nice, it would be possible to make use of biomass plot data - Mr. John Diisi would be important contact - could not join meeting today, follow up meeting to be planned

4.2) What data is available and being used for monitoring Soil Organic Carbon (SOC) and aboveground carbon stocks?

Default data Soil grid 250m and landcover in trends.Earth - is there an option to go more detailed?

Some soil surveys are being done in the country by scientists - can the data be used? Maybe to use with EO approaches, i.e. Worldsoils, hyperspectral

MH: do you have a map of where these permanent plots are located?

MI: Look in the technical reports to see if they are there, if not, let me know and I will link up with Mr. John to take the location of these plots.

4.3) Please fill in the following specifications table(s) regarding the data necessary for Carbon stocks data used for LDN monitoring:

Carbon stock data		
Specification:	Minimum requirement	Target/desired requirements
Product	Biomass & SOC map	Biomass & SOC change map
Units:	tons/ha	tons/ha
Spatial coverage	national	national
Spatial resolution	100x100m ²	10x10m ²
Temporal extent	2018-2023	2000-2023
Temporal resolution	annual	10-day
Processing level	analysis-ready	analysis-ready
Coordinate Reference system	WGS84/UTM	WGS84/UTM
Validation procedure	field data, high resolution imagery	field data, high resolution imagery
Accuracy metrics	0.8 RMSE	0.8 RMSE
Delivery mode	FTP, web-service	FTP, web-service
Data format	Tif	Tif
Metadata	Comprehensive	Comprehensive
Documentation	Algorithm theoretical basis, or tutorial	Algorithm theoretical basis, or tutorial
Interoperability	STAC or others to ease accessibility	STAC or others to ease accessibility
Licensing	GNU General Public License / Open source	GNU General Public License / Open source
Users	our technical staff	other potential users
Other requirement deemed significant	< add any requirement that is significant >	

Annex C. Interview: Colombia – Ministry of Environment and Sustainable Development

Date/Location: 21st of March, 2023. Zoom meeting.

SEN4LDN participants: Gabriel Daldegan, CI, Nuno Cesar de Sa, GFZ

Interviewee details:

- Ministerio de Ambiente y Desarrollo Sostenible: Claudia Daza- Enlace Oficina de Asuntos internacionales, Álvaro Alexander Dávila Giraldo, Olga Lucia Ospina Arango
- Instituto de Investigaciones Ambientales del Pacífico – IIAP: Geidy Asprilla, Edsson Nagle, Wilber Moreno, Pedro Rodriguez
- Instituto de Hidrología, Meteorología y Estudios Ambientales: Nidia Cristina Mayorga, Oscar Daniel Beltrán, Reinaldo Sánchez López
- Instituto de Investigación de Recursos Biológicos Alexander von Humboldt: Paola Johanna Isaacs Cubides

Bloque 1: Actividades nacionales para neutralidad de la degradación de las tierras - NDT

[EN: Block 1: National activities for LDN]

1.1) Cuáles son las principales causas de la degradación del suelo en Colombia? *[EN: Which are the main drivers for Land Degradation in Uganda?]*

Degradacion de la tierra segun la CLD: “La degradación de las tierras se caracteriza por la reducción y pérdida de la capacidad de producción biológica y económica de la tierra.”

- P. Isaacs:
 - Es importante definir lo que es degradación.
 - Usos inadecuados, prácticas como el arado, aplicación de agroquímicos cambian la composición del suelo
 - Usos intensivos del suelo
 - Desconocimiento del componente biológico de la tierra y cómo afecta la productividad
 - Poca disponibilidad de acceso a la tierra o predios muy pequeños que obligan a la intensificación
 - Desconocimiento de prácticas productivas menos degradadoras que no requieren de incrementar frontera agrícola
 - Agendas de gobierno que promueven prácticas que agotan el suelo, como por ejemplo monocultivos o sistemas ganaderos sin manejo en zonas con suelos para uso forestal.
 - Brechas de conocimiento entre los técnicos, los tomadores de decisiones y los que usan el suelo en terreno.
- R. Sanches (IDEAM)
 - Desconocimiento de los suelos y como mejor trabajar con ellos - es necesario comprender mejor el potencial de los tipos de suelo y cuales las actividades que son sostenibles a desarrollar

- Tenencia de la tierra
- *Las formas de ocupación del territorio.*
- *La tenencia de la tierra.*
- *El uso inadecuado.*
- *Minería ilegal.*
- *La deforestación.*
- *Variabilidad y el cambio climático.*
- Minería
 - Tenemos información sobre eso en los mapas oficiales - link: <http://www.ideam.gov.co/capas-geo> (buscar por la palabra cobertura). <http://www.ideam.gov.co/web/siac/catalogo-de-mapas> (es posible identificar minería ilegal)
- Incendios forestales y quemas para disponibilizar nutrientes
- Deforestación
- Olga Ospina:
 - En general se están listando los diferentes disturbios que se identificaron para el plan nacional de restauración que incluye minería, procesos productivos no sostenibles, cambio de uso del suelo que se evidencia en deforestación también,
 - Link: https://archivo.minambiente.gov.co/images/BosquesBiodiversidadyServiciosEcosistemas/pdf/plan_nacional_restauracion/PLAN_NACIONAL_DE_RESTAURACION_2.pdf
- La erosión, la salinización (esto son consecuencias)

1.2) Frente a los retos mencionados, cuál es el enfoque que se utiliza en Colombia para identificar y definir los objetivos para alcanzar la NDT? [EN: *In face of the aforementioned challenges, what is the approach that is used in Colombia to identify and define targets to reach LDN?*]

- Olga: Restauración y reconversión productiva (pastos, sistemas agropastoriles...)
 - Adoptar prácticas sostenibles
 - Lista de ocho metas de NDT registradas ante la UNCCD:
- IDEAM: *Reducir la degradación de los suelos y las tierras en cuanto a magnitud y severidad.*
 - *Restaurar lo degradado.*
 - *Prevenir y mitigar la degradación.*

1.3) Se pueden identificar restricciones o limitaciones específicas (por ejemplo, gubernamentales, culturales) que afecten a la implementación de los objetivos de la NDT en Colombia? [EN: *Can you identify specific constraints or limitations (e.g. government, cultural) that affect the implementation of the LDN targets in Colombia?*]

- Olga: falta recursos para implementar las actividades.
- IDEAM: No se conoce la importancia, la gravedad la dimensión y localización del problema de la degradación de la tierra a todo nivel.
- Las acciones realizadas son insuficientes frente a la gravedad y magnitud del problema.

1.4) Se puede proporcionar una descripción de la implementación de los objetivos de NDT para Colombia? *[EN: Can you provide a description of the implementation of the LDN targets for Colombia?]*

1.5) Cuáles son las principales puntos fuertes y debilidades de esta estrategia (en particular con respecto al seguimiento y la presentación de informes)? *[EN: What are the main strengths and weaknesses of this strategy (in particular with regards to monitoring and reporting)?]*

1.6) Cuáles de los tres subindicadores (cobertura terrestre, productividad de la tierra, reservas de carbono orgánico) del ODS 15.3.1 se están utilizando activamente para el monitoreo de la NDT en Colombia en este momento? *[EN: Which of the three sub-indicators (land cover, land productivity, Carbon stocks) of SGD 15.3.1 are being actively used for monitoring LDN in Colombia at the moment?]*

- Validation data for LULC is made by field work and high resolution photography and these data are publicly available - link?
- Cobertura terrestre
 - Como Colombia tiene condiciones muy específicas en términos de topografía tenemos muchas dificultades en algunas clases (listen recording!)
- Se han venido empleando para los reportes
- Aun no se está monitoreando el NDT, apenas se presentó el VII reporte, y es cobertura terrestre aunque los otros dos subindicadores se utilizaron con el apoyo que nos dieron desde el proyecto Tools 4LDN
- IDEAM: *El subindicador de cobertura terrestre generado a nivel nacional es ampliamente conocido y utilizado (Corine Land Cover) y se utiliza para realizar homologaciones de uso como indicador proxi de degradación.*
- *Los indicadores de productividad y reservas de carbono son muy importantes y se requiere de complementación y actualización de datos e información y en especial de suelos.*
- El monitoreo de Carbono orgánico no tiene monitorización tan activa como el cobertura de suelo

1.7) Cómo se está realizando la validación de cada uno de los sub indicadores mencionados del ODS 15.3.1 en Colombia? *[EN: How is the validation of each of the aforementioned sub-indicators of SDG 15.3.1 being performed in Colombia?]*

- Nidia: Si, hay validación en campo y también utilizando imágenes satelitales de alta resolución. MMA: 25ha, escala 1:100.000
- El subindicador de cobertura se está validando con la información nacional y finalmente se está utilizando la información nacional en los reportes de país.

1.8) Se están reportando estos subindicadores siguiendo las recomendaciones de los [SDGS de la ONU](#)? En caso negativo, ¿por qué no? *[EN: Are these sub-indicators being reported following the recommendations of the UN SDGS? If not, why not?]*

1.9) Están ustedes utilizando datos de teledetección/sensoriamento remoto en el proceso de reporte de informes a la CLD? *[EN: Are you using any remote sensing data in the reporting process?]*

- IDEAM: Los reportes de informes se realizaron con datos nacionales (PRAIS 2023)

1.9.1) Cuáles son los principales puntos fuertes y débiles de las fuentes de datos de teledetección? [EN: *What are the main strengths and weaknesses of the Remote Sensing data sources?*]

- Como punto fuerte se destaca la oportunidad y el cubrimiento de datos como una primera aproximación.
- Como debilidad, se requiere necesariamente validación de campo y de laboratorio la cual es dispendiosa y costosa.

1.9.2) Cuáles serían las principales ventajas de aumentar la resolución espacial y temporal de los datos de teledetección? (por ejemplo, 10 m o estimaciones diarias) [EN: *What would be the main benefits of increasing spatial and temporal resolution of the remote sensing data? (e.g. 10 m or daily estimates)*]

1.10) Hay alguna herramienta o recurso que le resulte especialmente útil para informar sobre el ODS 15.3.1? [EN: *Are there any tools or resources that you find particularly helpful in your reporting on SDG 15.3.1?*]

- IDEAM: Se requiere mejorar y avanzar en las técnicas y metodologías para la identificación de la dinámica del carbono en el suelo, las cuales deben incluir necesariamente la dinámica de la materia orgánica del suelo, MOS, como principal fuente de carbono.

1.10.1) Qué mejoras le gustaría ver en esas herramientas o recursos? [EN: *What improvements would you like to see in those tools or resources?*]

- IDEAM: La identificación y monitoreo de la dinámica de procesos de degradación física y química de los suelos y las tierras como la erosión y la salinización. De igual manera, de la dinámica de la Materia orgánica del suelo, lo cual permite el monitoreo del Carbono en el suelo.

1.11) Ustedes tienen acceso a datos nacionales sobre la cubierta terrestre, la productividad de la tierra o las reservas de carbono que puedan compartirse con SEN4LDN y utilizarse para calibrar y validar los algoritmos desarrollados? [EN: *Do you have access to any national data on land cover, productivity or carbon stocks which can be shared with SEN4LDN and used to calibrate and validate the developed algorithms?*]

- Tenemos datos para LUCL (ver arriba)
- Datos de productividad e potencial de captura de carbono existen capas de para el país (see recording for description)
- Desarrollados con apoyo de la FAO

1.11.1) En caso afirmativo, ¿puede describir cómo se recopilaron y procesaron estos datos? [EN: *If so, can you describe how this data was collected and processed?*]

1.12) Se le ocurre algún lugar de referencia en su país que sea adecuado para crear prototipos de nuestros algoritmos? [EN: *Can you think of any reference sites in your country which would be suited to prototype our algorithms?*]

- IDEAM: Por la diversidad (climática, geológica, geomorfológica, biológica, de suelos, de uso y ocupación del territorio, por accesos) de Colombia, la región Andina podía ser un lugar ideal para generar prototipos.
- Para validación se puede utilizar Corine 2018

- Humboldt: Desde la revisión de insumos pasada, el Chocó tiene unas zonas que muestran elevada degradación pero su mayoría es bosque, sería bueno validar si es por la saturación del sensor o si está evidenciando degradación que desde la cobertura no es evidente. También tiene amplias zonas de minería. Región de las sabanas de la orinoquia, desde los satélites no siempre se ve el cambio de cobertura y tiene transformaciones fuertes por fuego.

1.13) Se le ocurre algún caso de uso en Colombia que demuestre que el proyecto puede ayudarle a identificar mejor los puntos críticos de degradación y restauración del suelo? *[EN: Can you think of any use case in your country to showcase that the project can help you to better identify hotspots of land degradation & restoration?]*

Bloque 2: Datos sobre la cubierta terrestre

[EN: Land cover data]

2.1) Cuáles son las clases de cobertura del suelo de interés para el monitoreo de NDT en Colombia? *[EN: What are the land cover classes of interest for LDN monitoring in Colombia?]*

- IDEAM monitors 54 classes
- Humbolt defines priority ecosystems
- Bosque seco tropical (en corine it is not clearly defined and mixed within other classes)
- Minambiente: Bosque seco tropical, sabanas
- Estrategia de Cooperación de minambiente: Programas integrales que articulan la acción del estado y la cooperación a partir de las necesidades del territorio: Coordinación interinstitucional SINA+ y cooperación internacional; Metas comunes con monitoreo y seguimiento
- Territorios priorizados
 1. Insular
 2. Ciénaga Grande- Sierra Nevada
 3. Cartagena
 4. La Mojana
 5. Serranía de Perijá - Corredor minero del Cesar - Ciénaga Zapatosa
 6. Catatumbo
 7. Páramos
 8. Sabana de Bogotá
 9. Altillanura
 10. Pacífico
 11. Amazonía
 12. Macizo colombiano
 13. Valle de Atríz
 14. Bajo cauca

2.2) Cuáles son los productos de datos requeridos para generar información sobre la cobertura del suelo para el monitoreo de la NDT? *[EN: What are the data products required to generate land cover information for LDN monitoring?]*

2.3) Por favor, rellene la(s) siguiente(s) tabla(s) de especificaciones relativas a los datos necesarios para los datos de cobertura del suelo utilizados para el monitoreo de NDT: [EN: Please fill in the following specifications table(s) regarding the data necessary for Land cover data used for LDN monitoring:]

Especificaciones mínimas y deseadas del producto para los datos de cobertura terrestre: [EN: Minimum and desired product specifications for Land cover data]

Cobertura terrestre		
Especificación	Requerimiento mínimo	Objetivo/requisitos deseados
Producto	Mapa de cobertura terrestre	Cambio de cobertura terrestre
Unidades:		
Cobertura espacial	Colombia/Sudamerica	
Resolucion espacial	30 x 30 m ²	10 x 10 m ²
Extensión temporal	2015 - hoy	2000 - hoy
Resolución temporal	Trimester	Weekly Reporte temprano de deforestación
Nivel de procesamiento	ARD/Datos listos para el análisis	
Sistema de coordenadas	Colombia national reference system Sistema Nacional de Colombia EPSG:9377	
Procedimiento de validación	de verificación en campo, como en libro/informe/publicación	
Métricas de precisión	Erro de classificacion	
Modo de entrega	Descargar los datos, e tambien acceder en "cloud" service.	
Formato de datos	(ejemplo: GeoTiff)	
Metadatos		
Documentación		
Interoperabilidad	Corine land cover;	
Licencia		Open License
Usuarios(as)		
Otros requisitos necesarios		

The other tables should follow the same/similar to this one.

Bloque 3: Datos sobre Productividad de la tierra

[EN: Productivity data]

3.1) Cómo se mide la productividad de la tierra para el monitoreo de NDT en Colombia? [EN: How is Land productivity measured for LDN monitoring in Colombia?]

3.2) Cuáles son los productos de datos necesarios para generar estimaciones de productividad de la tierra para la aplicación de NDT? [EN: What are the data products required to generate land productivity estimates for LDN application?]

3.3) Por favor rellene la(s) siguiente(s) tabla(s) de especificaciones sobre los datos necesarios para los datos de Productividad de la tierra utilizados para el monitoreo de LDN: [EN: Please fill in the following specifications table(s) regarding the data necessary for Land productivity data used for LDN monitoring:]

Especificaciones mínimas y deseadas del producto para los datos de productividad de la tierra: [EN: Minimum and desired specifications for Land productivity monitoring data products]

Productividad de la tierra		
Especificación	Requerimiento mínimo	Objetivo/requisitos deseados
Producto	Land productivity dynamics	
Unidades:		
Cobertura espacial	National	National / south america
Resolucion espacial	1x1 km ²	10 x 10 m ²
Extensión temporal	2015 -	2000 -
Resolución temporal	Annual	10 day
Nivel de procesamiento	ARD	
Sistema de coordenadas	Colombia national reference system Sistema Nacional de Colombia EPSG:9377	
Procedimiento de validación	de verificación en campo, como en libro/informe/publicación	
Métricas de precisión	Classification or regression error metrics	
Modo de entrega	Downloadable and explorable in cloud-service	
Formato de datos	GeoTiff	

Metadatos	
Documentación	ATB documentation
Interoperabilidad	Corine land cover and JRC Land productivity dynamics
Licencia	Creative commons or open license
Usuarios(as)	Technical stuff and other wider audiences
Otros requisitos necesarios	

Bloque 4: Datos sobre reservas de carbono

[EN: Carbon stocks data]

El Mapa Nacional de Stock de Carbono Orgánico de Colombia (2017), se desarrolló mediante la metodología de mapeo digital de suelos propuesta por la FAO, mediante la Alianza Mundial por el Suelo. El mapa elaborado es el resultado del análisis de la información de los suelos de cada uno de los de 32 departamentos que integran el territorio colombiano, los cuales se encuentran a escala general (1:100.000) y fueron recopilados entre los años 1980 y 2012. En total fueron analizados 4.329 perfiles de suelos de toda la geografía nacional a partir de regression kriging.

<https://datos.icde.gov.co/maps/c480507823e04357a5bf3d5727635df9/about>

<https://www.igac.gov.co/es/ide/estrategia-y-gobierno-geoespacial/estandares/agrologia>

4.1) Cómo se miden las reservas de carbono orgánico para el seguimiento de la NDT en Colombia? [EN: How are Carbon stocks measured for LDN monitoring in Colombia?]

4.2) Qué datos están disponibles y se utilizan para el monitoreo del Carbono Orgánico del Suelo (COS) y las reservas de carbono por encima del suelo? [EN: What data is available and being used for monitoring Soil Organic Carbon (SOC) and aboveground carbon stocks?]

4.3) Por favor, rellene la(s) siguiente(s) tabla(s) de especificaciones relativas a los datos necesarios para los datos sobre reservas de carbono utilizados para el monitoreo de la NDT: [EN: Please fill in the following specifications table(s) regarding the data necessary for Carbon stocks data used for LDN monitoring:]

Especificaciones mínimas y deseadas para los productos de datos sobre reservas de carbono: [EN: Minimum and desired specifications for Land productivity monitoring data products]

Reservas de carbono orgánico		
Especificación	Requerimiento mínimo	Objetivo/requisitos deseados
Producto	Soil Organic carbon	
Unidades:	t/ha	
Cobertura espacial	National	South america

Resolucion espacial	100 x 100 m ²	10 x 10 m ²
Extensión temporal	2015 -	2000 -
Resolución temporal	Annual	
Nivel de procesamiento	ARD	
Sistema de coordenadas	Colombia national reference system	
Procedimiento de validación	Field validation	
Métricas de precisión	Classification/regression error	
Modo de entrega	Downloadable link, FTP, or a cloud service	
Formato de datos	(ejemplo: GeoTiff)	
Metadatos		
Documentación	Algorithm Theoretical Basis	
Interoperabilidad	Corine land cover	
Licencia	Open license, creative commons	
Usuarios(as)		

Annex D. Interview: Portugal – Institute for Conservation of Nature and Forests

Date/location: 07/06/2023, Zoom meeting

SEN4LDN participants: Nuno Cesar de Sa, GFZ, Ruben Van De Kerchove, VITO

Interviewee details: André Trindade, DGADR, Diana Almeida, ICNF, Teresa Leonardo, ICNF, Isabel Santos, ICNF, Pedro Benevides, DGT

Block 1: National activities for LDN

1.1) Which are the main drivers for Land Degradation in Portugal?

- Main drivers are:
 - land use/cover change
 - droughts
 - soil erosion
 - forest fires
 - unsustainable land management (agriculture/forestry)
- Nuno: Ask for more details regarding unsustainable land management

1.2) In face of the aforementioned challenges, what is the approach that is used in Portugal to identify and define targets to reach LDN?

- Until this moment, the government of Portugal has not defined LDN targets. Although, several projects related to ecosystems restoration, and desertification combat are being set in motion in all the five regions of mainland Portugal.
- Nuno: Can they provide some examples of these projects? Could they be interesting for SEN4LDN as a case study also?

1.3) Can you identify specific constraints or limitations (e.g. government, cultural) that affect the implementation of the LDN targets in Portugal?

- We cannot point specific constrains that have affected the definition of LDN targets these are of political competence.

1.4) Can you provide a description of the implementation of the LDN targets for Portugal?

- Not applied

1.5) What are the main strengths and weaknesses of this strategy (in particular with regards to monitoring and reporting)?

- Not applied

1.6) Which of the three sub-indicators (land cover, land productivity, Carbon stocks) of SGD 15.3.1 are being actively used for monitoring LDN in Portugal at the moment?

- Land Cover change is used to monitor desertification in the context of the Desertification National Observatory, and for the National Programme of Territorial Planning (PNPOT) but the other two were used in the context of PRAIS4 reporting.

1.7) How is the validation of each of the aforementioned sub-indicators of SDG 15.3.1 being performed in Portugal?

- The validation is being made by the official data producers (Directorate General of Territory – DGT and Statistics Portugal).

1.8) Are these sub-indicators being reported following the recommendations of the UN SGDS? If not, why not?

- This three indicators were reported in the context of PRAIS4 and therefore UN SGDS recommendations were accommodated.

1.9) Are you using any remote sensing data in the reporting process?

- Official Land Cover/Use Mapping (COS) uses satellite data, ortophotomaps and remote sensing - DGT Open data ; <https://snig.dgterritorio.gov.pt/rndg/srv/por/catalog.search#/home>
- RS were used to calculate national Land Productivity
- For organic soil carbon we used default data by trends.earth
- Nuno: are there methodological documents describing how these are being calculated? If so, where can they be accessed? (see 2.1, 3.1 which are detailed. 4.1 perhaps not (carbon stocks))

1.9.1) What are the main strengths and weaknesses of the Remote Sensing data sources?

- Specifically for land productivity and the 3 sub indicators (trend, performance and state) we have encountered some difficulties in the methodology provided – some landscape transformations are contributing to a miss picture the real state of land productivity in mainland Portugal, especially due to desertification, land degradation and drought. Those transformations are related to afforestation campaigns and subsidies, large scale intensive monoculture, which impacts severely soil degradation and the future of land productivity, post-fire regeneration, in which RS captures the “green growth”, although it does not represent effectively an improvement of land productivity. The “green growth” that is captured are a bunch of herbaceous annual spontaneous species growth, which does not represent a real increment of productivity of land. These soils, rather affected by forest fires or with highly intensive monocultures, are not in good condition because the topsoil horizon is compromised due to the loss of soil biodiversity, loss in water retention capacity, with consequences to the loss of soil organic carbon. Nuno: is another weakness the spread of invasive species? From my experience working in IAS in Portugal, these often “explode” after forest fires or in abandoned lands.

1.9.2) What would be the main benefits of increasing spatial and temporal resolution of the remote sensing data? (e.g. 10 m or daily estimates)

- Increase spatial and temporal resolution improves, in any sense the quality of the data, but in our opinion the statistical thresholds should be revised. Nuno: Which thresholds should be revised and why?,

1.10) Are there any tools or resources that you find particularly helpful in your reporting on SDG 15.3.1?

- Nuno: ask for response

1.10.1) What improvements would you like to see in those tools or resources?

- Statistical thresholds especially in what regards the 3 subindicators of land productivity as mentioned above.

1.11) Do you have access to any national data on land cover, productivity or carbon stocks which can be shared with SEN4LDN and used to calibrate and validate the developed algorithms?

- Yes

1.11.1) If so, can you describe how this data was collected and processed?

- Described in 1.9. Nuno: COS validated in orthophotos but what about field data for validation of productivity and carbon stocks?

1.12) Can you think of any reference sites in your country which would be suited to prototype our algorithms?

- Areas where land productivity is improving – western central Portugal...
- Nuno: Ask to specify location, perhaps show region on map (costa de prata? Pinhal de leiria?)

1.13) Can you think of any use case in your country to showcase that the project can help you to better identify hotspots of land degradation & restoration?

- Herdade da Parreira is a agro-pasture-forest system in Alentejo, located in southern Portugal, that have recently been awarded by ELO in 2018. This property has 75% of litoral soils and 35% of Mediterranean paralydromorphic soils. In terms of land cover, more than 50% is occupied by traditional forests of Quercus Suber, and agriculture represents 20% of the land cover. This is an example of agriculture of conservation as a response to LD.
- To reverse land degradation, it was crucial to improve soil functions above all.
- In 20 years, the whole productive structure was reorganized, bringing the land and soil to the center of concerns. The owner started to implement direct seeding, and crops rotation, using pea, wheat and ryegrass. In this system haulm is maintained in the soil for cattle grazing (cows), fertilizing the soil and contributing to increase soil organic matter. Is important to highlight that through conservation agriculture, soil erosion has been significantly reduced and bellow ground carbon sequestration has increased 1% per year - this is a form of efficiently combating desertification. With these changes, also complementarity between economic activities – agro-forest-pasture brought a self improving system: (i) Fixing soil functions allowed a better response to drought and simultaneously mitigation climate change; (ii) Biodiversity has gained significantly with the control in soil erosion, having contributed to reverse land degradation and to a positive carbon cycle.
- EEA Grants project areas:
 - Soiling: ecosystem services restoration using NbS in post fire areas (Picões) - shapefile available

- +Solo+Vida: increase resilience in Montado ecosystems through the adoption of good practices of agroforest and livestock in various areas in Guadiana Valey (shapefile available)
- Land Under Pressure: avoid, mitigate and restore areas under pressure due to desertification – increase resilience in Montado areas (Herdade da Coitadinha) shapefile available

Block 2: Land cover data

2.1) What are the land cover classes of interest for LDN monitoring in Portugal?

- Land Cover classes comply with EU specifications and are aligned with the CLC nomenclature. The last version of COS2018 has 83 classes within 4 levels of detail. Previous versions are consecutively updated accordingly. For specifically monitor LDN, at least the first level of disaggregation is of interest of all classes: 1-artificial land; 2-cropland (agriculture); 3-pasture; 4-agroforest systems (SAF – by dominant specie); 5-forests (by dominant specie); 6-shrubland; 7-bareland or sparsely vegetated areas; 8-wetlands; 9-water bodies.
- For assessing LDN, is crucial to increase the detail in classes' 2-croplands, 3-pasture, 4-SAF, 5-forests and 6-shrublands, especially for monitor transition between land cover classes. Nuno: What increase would you “dream” to see? Species level? Community level?
- In what respects to gains and loss of non-artificial land, major transformations occur primarily between cropland-pastures-shrubland-forest, and secondly losses for artificial land, although in small proportions – artificial land represents 5% of mainland Portugal land cover.

2.2) What are the data products required to generate land cover information for LDN monitoring?

- PT already has the official Land Use/Cover Map – COS, which has been produced every 3-5 years through photo-interpretation of orthophotos and manual delimitation of polygons with a minimum mapping unit of 1 ha. The map is mainly focused on land use, which is advantageous for long-term analysis such as landscape planning, but not suitable seasonal variation analysis such as vegetation greenness and yearly cycles associated to some classes such as annual agriculture. Its MMU is also too coarse for very detailed applications.
- The data availability offered by the Copernicus programme and the DGT's experience in image classification made it possible to build the Portuguese land cover monitoring system SMOS (Sistema de Monitorização da Ocupação do Solo). SMOS includes LULC products such as COSc (Carta de Ocupação do Solo Conjuntural), an annual land cover map in raster format based on automatic classification of Sentinel-2 data with Artificial Intelligence. COS and COSc provide complementary information and can be used together or independently. COS is more focused on land use whereas COSc focuses on land cover. COSc is being produced since 2018, although with less detail in the nomenclature it has significantly more land cover detail and is suitable for inter-annual variability studies.
- In what concerns intra-annual variability assessment the product MIAEV (Mapas Intra-Anuais do Estado da Vegetação), is more suitable. MIAEV are raster maps produced every month from the Normalized Difference Vegetation Index (NDVI) to represent the vegetation greenness, allowing the analysis seasonal variations at shorter time scale.

2.3) Please fill in the following specifications table(s) regarding the data necessary for Land cover data used for LDN monitoring:

Minimum and desired product specifications for Land cover data:

Land cover product			
Specification:	Minimum requirement	Minimum requirement	Target/desired requirements
Product	Land Use Map (COS)	Land Cover Map (COSc)	Land Use/Cover
Units:	hectars	meters	meters
Spatial coverage	PT mainland (other similar products for RAM)	PT mainland	PT mainland
Spatial resolution	1ha – space between lines $\geq 20m$	10m (pixel) [15 classes]	10m or better
Temporal extent	1995, 2007, 2010, 2015, 2018 – 3 years	2018, 2020, 2021, 2022	Latest 10 years
Temporal resolution	Ortho images of the year of production	annual	Every 3 to 6 months
Processing level	Manually, aided by automatic auxiliary data processing	Automatic classification and supervised of Sentinel imagery with expert verification	Automatic
Coordinate Reference system	ETRS-89/PT-TM06	ETRS-89/PT-TM06	ETRS-89/PT-TM06
Validation procedure	Orthophoto maps	Ortophoto maps + aux.data	Ortophoto maps + aux.data
Accuracy metrics	Thematic $\geq 85\%$; positional $\geq 5,5m$	-82% at the 95% CI	$\geq 90\%$
Delivery mode	web-service and download	web-service and download	web-service and download
Data format	vector	raster	Raster or grid
Metadata	https://www.dgterritorio.gov.pt/sites/default/files/documentos-publicos/2019-12-26-11-47-32-0__ET-COS-2018_v1.pdf	https://snig.dgterritorio.gov.pt/rndg/srv/por/catalogo.g.search#/metadata/fe5c557-2cc6-4efd-aab8-761f45b46f3c	SNIG

Documentation	Metadata record and Technical specifications	Metadata record and nomenclature	Not defined
Interoperability	viSMOS , COScid	viSMOS	Not defined
Licensing	Directorate-General of Territory	Directorate-General of Territory	Not defined
Users	Great dissemination – public administrations, enterprises, academic, general public	same	Not defined
Other requirement deemed significant	Not applicable	Not applicable	Not defined

Block 3: Productivity data

3.1) How is Land productivity measured for LDN monitoring in Portugal?

- In the latest reporting period (2016-2019) the land productivity was measured according to the methodologies described in the UNCCD Good Practice Guidance and following the indications in the PRAIS4 reporting manual. The three metrics (Trend, State, Performance) were assessed by measuring the z-scores of the annual Net Primary Productivity (NPP; 2000-2019 time series) by the Mann-Kendall trend test, and the land productivity sub-indicator was determined by combining the classified results (using the two guides look-up tables) of the metrics. As suggested by the PRAIS4 reporting manual, an attempt was made to test the methodology with alternative data to the global data sources (MOD13Q1-NDVI and GIMMS3g-NDVI) precalculated by default available in Trends.Earth, so it was used the MOD17A3HGF v6.1 annual time series NPP. With regard to the performance of productivity calculation the USGS World Terrestrial Ecosystems dataset (Sayre, et al., 2022) was used to stratify the landscape into LCEUs (Land Cover/Ecosystem Functional Unit).

3.2) What are the data products required to generate land productivity estimates for LDN application?

- As requirements for estimating land productivity, both spatial and temporal resolution should be prioritized (the best compromise between the two), spectral resolution should only ensure that the product has the necessary bands to calculate the vegetation indices (NDVI or EVI). Of the no-cost sensors datasets available, only the MODIS products (MOD13) have an acceptable longevity for calculating the trend metric. An analysis-ready high resolution harmonized multi-mission dataset (Landsat-Sentinel) of the EVI annual/seasonal mean time series, and additionally a similar evapotranspiration time series would be the optimal scenario.

3.3) Please fill in the following specifications table(s) regarding the data necessary for Land productivity data used for LDN monitoring:

Minimum and desired specifications for Land productivity monitoring data products:

Productivity data		
Specification:	Minimum requirement	Target/desired requirements
Product	NPP annual /seasonal mean time series - MOD17A3HGF Version 6.1	Annual /seasonal mean time series: Moderate resolution Vegetation index - MOD13; High Resolution Vegetation indices – Sentinel 2 and Landsat 7/8 (harmonized multi-mission datasets)
Units:	kgC/m ² /year	Normalized / Enhanced infrared/red ratio
Spatial coverage	Global	Global; Local – 5/16 days Revisit period
Spatial resolution	500m	250m; 10m; 30m
Temporal extent	2000- 2022	2000-present; 2015-present;1999-present
Temporal resolution	Annual / Seasonal	Annual / Seasonal
Processing level	pre-processed using a Savitzky-Golay filter (remove noise/smooth outliers)	analysis-ready
Coordinate Reference system	Sinusoidal	WGS84 or ETRS TM06
Validation procedure	Trends.Earth Tier1 (global default) results comparison; Visual interpretation of very high-resolution satellite images; Field work data.	Trends.Earth Tier1 (global default) results comparison; Visual interpretation of very high-resolution satellite images; Field work data.
Accuracy metrics	Quality control percentage (Npp_QC; %)	(e.g. 90% OA or 0.8 RMSE)
Delivery mode	AppEEARS	GEE; Planetary Computer and/or others
Data format	GeoTIFF	GeoTIFF
Metadata	(e.g. datum, provenance)	
Documentation	MOD17A3HGF v6.1 (user guide) ; Prais4 (reporting manual) ; UNCCD SDG15.3.1 (good practice guide) ; ArcGIS pro 3.1 (Mann-Kendall trend analyses) .	Prais4 (reporting manual) ; UNCCD SDG15.3.1 (good practice guide) ; ArcGIS pro 3.1 (Mann-Kendall trend analyses) .
Interoperability	Trends.Earth	OND online platform (ESRI framework); Trends.Earth; OGC web services (WCS)
Licensing	LP DAAC (no restrictions on subsequent use)	

Users	our technical staff	Public institutions, academia...
Other requirement deemed significant	< add any requirement that is significant >	

Block 4: Carbon stocks data

4.1) How are Carbon stocks measured for LDN monitoring in Portugal?

- Carbon stocks are measure within the National Forest Inventory, the last is from 2015. It measures the above ground biomass alive and dead by specie and other non-forest uses in Gg CO2e. Digital soil maps being produced, planned to be released in october. Based on Soil profiles and random forest algorithm.

4.2) What data is available and being used for monitoring Soil Organic Carbon (SOC) and aboveground carbon stocks?

- For PRAIS4 reporting we used default data available on Trends.earth.

4.3) Please fill in the following specifications table(s) regarding the data necessary for Carbon stocks data used for LDN monitoring:

Minimum and desired specifications for Land productivity monitoring data products:

Carbon stock data		
Specification:	Minimum requirement	Target/desired requirements
Product	National Forest Inventory IFN6	LCLU change map
Units:	ton/ha	Hectars or m ²
Spatial coverage	PT (mainland and regions)	PT
Spatial resolution	0,3m	10m or better
Temporal extent	1995-2005-2015(mainland); RAA2007, RAM2004-2011)	Last 20 years up to now
Temporal resolution	...? year	Annual
Processing level	Photopoints – photo interpretation	Automatic
Coordinate Reference system	ETRS89/PT-TM06	ETRS89/PT-TM06
Validation procedure	(e.g. field data, high resolution imagery)	Field data, high resolution imagery
Accuracy metrics	95%	At least 85%
Delivery mode	hard-copy	Hard-copy

Data format	TIFF	TIFF
Metadata	https://www.icnf.pt/api/file/doc/c8cc40b3b7ec8541	Metadata in SNIG
Documentation	Technical specifications of IFN6	Technical specifications of the satellite data provider
Interoperability	?	Not applicable
Licensing	Institute of Nature Conservation and Forest	
Users	technical staff	Public Administration Technical staff
Other requirement deemed significant	500x500m grid	10x10m grid