Trends.Earth - User Guide

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Conservation International

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Trends.Earth User Guide

Preamble

Trends.Earth is a toolkit designed to monitor land change using Earth observation data. Trends.Earth is available as plugin to desktop QGIS spatial-analytical GIS software.

The tool allows users to assess time series of key indicators of land change to produce maps and other graphics that can support monitoring and reporting, and to track the impact of sustainable land management. The tool supports monitoring progress on land degradation neutrality (SDG 15.3.1), land consumption (SDG 11.3.1), modeling carbon emissions from deforestation, and modeling potential carbon sequestration from restoration activities. Trends.Earth supports monitoring and reporting on Sustainable Development Goals (SDGs) 15.3.1 (Proportion of land that is degraded over total land area (%)) and 11.3.1 (ration of land consumption rate to population growth) by providing a platform for analyzing data for reporting commitments to the United Nations Convention to Combat Desertification (UNCCD) and UN-Habitat.

The development of Trends.Earth was funded by the Global Environment Facility (GEF) and the United States National Aeronautics and Space Agency (NASA), led by Conservation International and its partners. Conservation International works to spotlight and secure the critical benefits that nature provides to humanity.

Monitor land change

Trends.Earth (formerly the Land Degradation Monitoring Toolbox) is a platform from Conservation International for monitoring land change using Earth observations in an innovative desktop and cloud-based system.

Lear more at:

Track achievement of the sustainable development goals

The three sub-indicators for monitoring achievement of Land Degradation Neutrality (LDN, Sustainable Development Goal (SDG) Target 15.3), are supported by TRENDS.EARTH: productivity, land cover, and soil organic carbon. The tool also supports countries in analyzing data to prepare for their reporting commitments to the United Nations Convention to Combat Desertification (UNCCD).

Trends.Earth allows users to plot time series of key indicators of land change (including degradation and improvement), to produce maps and other graphics that can support monitoring and reporting, and to track the impact of sustainable land management or other projects.

More information

For more information about the toolbox, see the General Information section. For toolbox users, see the User Guide. For developers, see the Developers Guide.

Features

Land degradation and SDG 15.3.1

As part of the “2030 Agenda for Sustainable Development”, Sustainable Development Goal (SDG) 15 is to:

> “Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss”

Each SDG has specific targets addressing different components, in this case, of life on land. Target 15.3 aims to:

> “By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world”

Indicators will be used then to assess the progress of each SDG target. In the case of SDG 15.3 the progress towards a land degradation neutral world will be assessed using indicator 15.3.1:

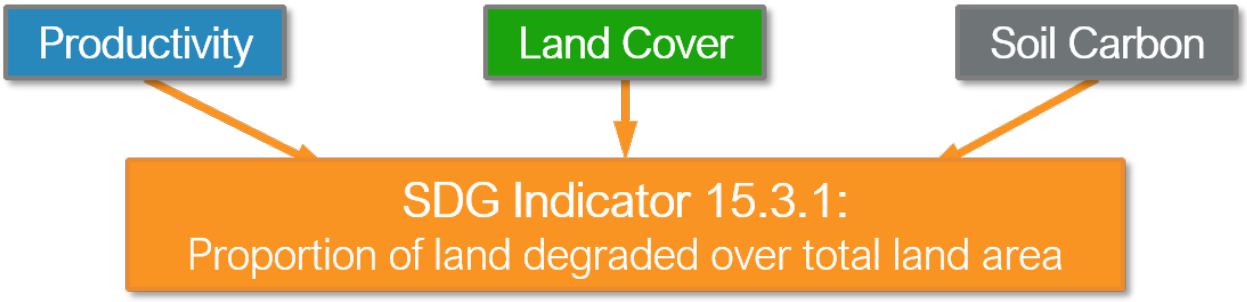
> “proportion of land that is degraded over total land area”

As the custodian agency for SDG 15.3, the United Nations Convention to Combat Desertification (UNCCD) has developed a Good Practice Guidance (GPG) providing recommendations on how to calculate SDG Indicator 15.3.1.

This page provides a brief introduction to SDG Indicator 15.3.1 and describes how each indicator is calculated by TRENDS.EARTH.

In order to assess the area degraded, SDG Indicator 15.3.1 uses information from 3 sub-indicators:

1. Vegetation productivity
2. Land cover
3. Soil organic carbon



TRENDS.EARTH allows the user to compute each of these sub-indicators in a spatially explicit way generating raster maps which are then integrated into a final SDG indicator 15.3.1 map and produces a table result reporting areas potentially improved and degraded for the area of analysis.

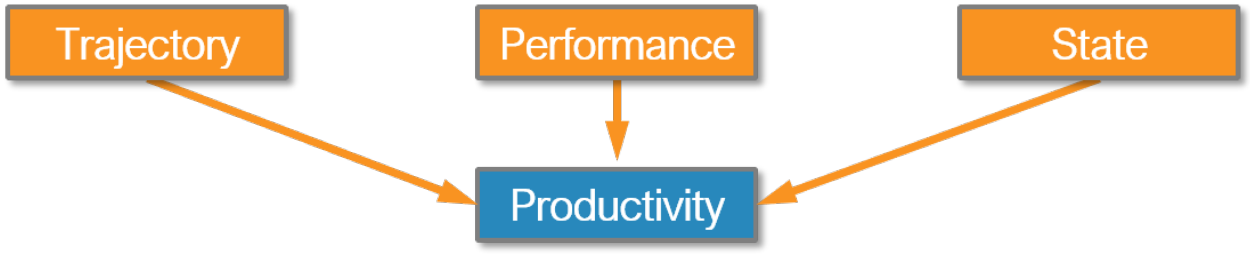
Sub-indicators

Productivity

Land productivity is the biological productive capacity of the land, the source of all the food, fiber and fuel that sustains humans (United Nations Statistical Commission 2016). Net primary productivity (NPP) is the net amount of carbon assimilated after photosynthesis and autotrophic respiration over a given period of time (Clark et al. 2001) and is typically represented in units such as kg/ha/yr. NPP is a variable time consuming and costly to estimate, for that reason, we rely on remotely sensed information to derive indicators of NPP.

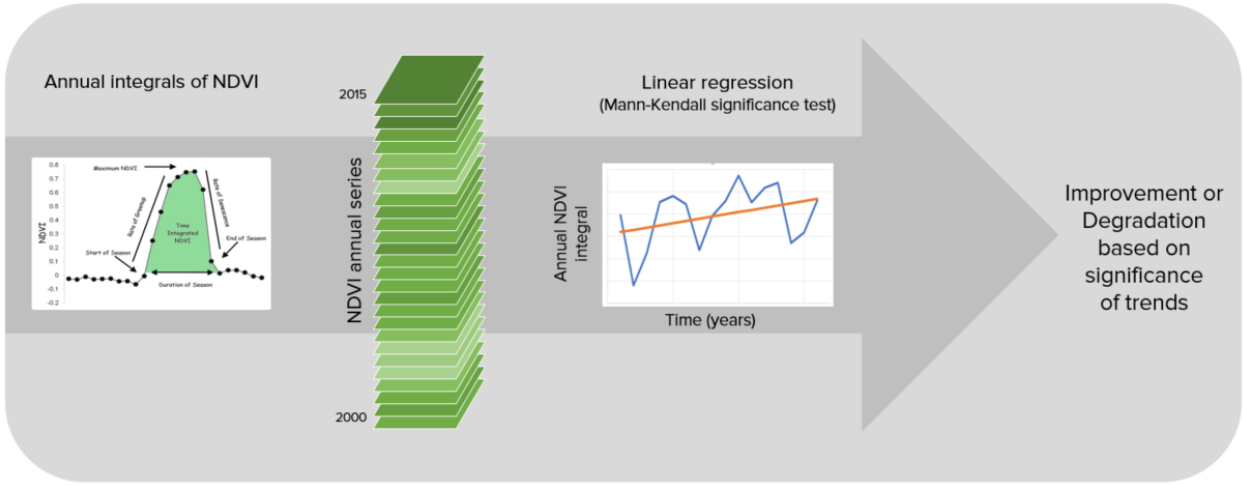
One of the most commonly used surrogates of NPP is the Normalized Difference Vegetation Index (NDVI), computed using information from the red and near- infrared wavelengths of the electromagnetic spectrum. In TRENDS.EARTH we make use of bi-weekly products from MODIS and AVHRR to compute annual integrals of NDVI (computed as the mean annual NDVI for simplicity of interpretation of results). These annual integrals of NDVI are then used to compute each of the productivity metrics explained below.

Land productivity is assessed in TRENDS.EARTH using three measures of change derived from NDVI time series data: trajectory, performance and state



Productivity Trajectory

Trajectory measures the rate of change in primary productivity over time. As indicated in the figure below, TRENDS.EARTH computes a linear regression at the pixel level to identify areas experiencing changes in primary productivity for the period under analysis. A Mann-Kendall non-paremetric significance test is then applied, considering only significant changes those that show a p-value ≤ 0.05. Positive significant trends in NDVI would indicate potential improvement in land condition, and negative significant trends potential degradation.



Correcting for the effects of climate

Within a given ecosystem, primary productivity is affected by several factors, such as temperature, and the availability of light, nutrients and water. Of those, water availability is the most variable over time, and can have very significant influences in the amount of plant tissue produced every year. When annual integrals of NDVI are used to perform the trajectory analysis, it is important to interpret the results having historical precipitation information as a context. Otherwise, declining productivity trends could be identified as human caused land degradation, when they are driven by regional patterns of changes in water availability.

TRENDS.EARTH allows the user to perform different types of analysis to separate the climatic causes of the changes in primary productivity, from those which could be a consequence of human land use decisions on the ground. The methods currently supported for climate corrections are:

Residual Trend Analysis (RESTREND): RESTREND uses linear regression models to predict NDVI for a given rainfall amount. Trends in the difference between the predicted NDVI and the observed NDVI (the residual) are interpreted as non-climatically related productivity change. Please refer to the following citation more more details on the method and its limitations: *Wessels, K.J.; van den Bergh, F.; Scholes, R.J. Limits to detectability of land degradation by trend analysis of vegetation index data. Remote Sens. Environ. 2012, 125, 10–22.*

Rain Use Efficiency (RUE): RUE Is the ratio of annual NPP to annual precipitation. TRENDS.EARTH uses the annual integrals of NDVI as a proxy for annual NPP, and offers the possibility of choosing among different precipitation products to compute RUE. After RUE is computed for each of the years under analysis, a linear regression and a non-parametric significance test is applied to the trend of RUE over time. Positive significant trends in RUE would indicate potential improvement in land condition, and negative significant trends potential degradation. Please refer to the following publication for details on the methods and its limitations: *Wessels, K.J.; Prince, S.D.; Malherbe, J.; Small, J.; Frost, P.E.; VanZyl, D. Can human-induced land degradation be distinguished from the effects of rainfall variability? A case study in South Africa. J. Arid Environ. 2007, 68, 271–297.*

Water Use Efficiency (WUE): RUE assumes that there is a linear relationship between the amount of water that falls in the form of precipitation in a particular place and the amount of water which will be actually used by the plants. This assumption does not hold true for every system. WUE tries to address this limitation by using total annual evapo-transpiration (ET) instead precipitation. ET is defined as precipitation minus the water lost to surface runoff, recharge to groundwater and changes to soil water storage. The rest of the analysis follows as described for RUE: a linear regression and a non-parametric significance test is applied to the trend of WUE over time. Positive significant trends in WUE would indicate potential improvement in land condition, and negative significant trends potential degradation.

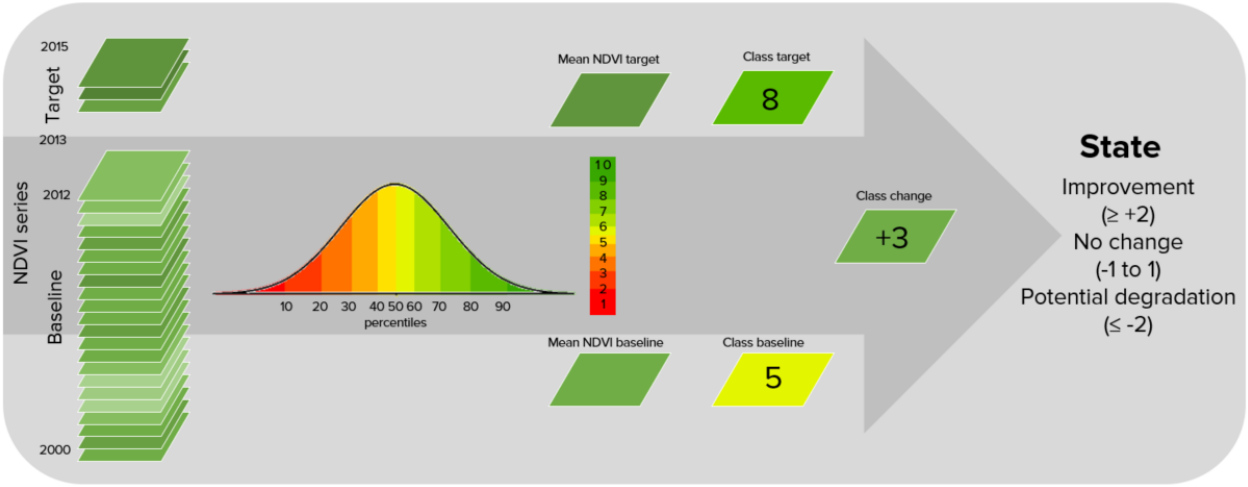
The table below list the datasets available in TRENDS.EARTH to perform NDVI trend analysis over time using the original NDVI data or with climatic corrections:

Variable	Sensor/Dataset	Temporal	Spatial Res.	Extent	Units/Description
NDVI	AVHRR/GIMMS	1982-2015	8 km	Global	Mean annual NDVI * 10000
NDVI	MOD13Q1-coll6.1	2001-2024	250 m	Global	Mean annual NDVI * 10000
Soil moisture	MERRA 2	1980-2019	0.5° x 0.625°	Global	Water root zone m^3m^{-3} *10000
Soil moisture	ERA I	1979-2016	0.75° x 0.75°	Global	Volumetric Soil Water layer m^3m^{-3} (0-7 cm)
Precipitation	GPCP v2.3.1 monthly (Global Precipitation Climatology Project)	1979-2019	2.5° x 2.5°	Global	mm/year
Precipitation	GPCC V6 (Global Precipitation Climatology Centre)	1891-2019	1° x 1°	Global	mm/year
Precipitation	CHIRPS	1981-2024	5 km	50°N x 50°S	mm/year
Precipitation	PERSIANN-CDR	1983-2024	25 km	60°N x 60°S	mm/year
Evapotranspiration	MOD16A2.GF	2000-2024	500 m	Global	Annual ET kg/m^2 (=mm)*10

Productivity State

The Productivity State metric allows for the detection of recent changes in primary productivity as compared to a baseline period. The State metric is computed as follows:

1. Define the baseline period (historical period to which to compare recent primary productivity).
2. Define the comparison period (recent years used to compute comparison). It is recommended to use a 3-year to avoid annual fluctuations related to climate.
3. For each pixel, use the annual integrals of NDVI for the baseline period to compute a frequency distribution. In case the baseline period missed some extreme values in NDVI, add 5% on both extremes of the distribution. That expanded frequency distribution curve is then used to define the cut-off values of the 10 percentile classes.
4. Compute the mean NDVI for the baseline period, and determine the percentile class it belongs to. Assign to the mean NDVI for the baseline period the number corresponding to that percentile class. Possible values range from 1 (lowest class) to 10 (highest class).
5. Compute the mean NDVI for the comparison period, and determine the percentile class it belongs to. Assign to the mean NDVI for the comparison period the number corresponding to that percentile class. Possible values range from 1 (lowest class) to 10 (highest class).
6. Determine the difference in class number between the comparison and the baseline period (comparison minus baseline).
7. If the difference in class between the baseline and the comparison period is ≤ 2, then that pixel could potentially be degraded. If the difference is ≥ 2, that pixel would indicate a recent improvement in terms of primary productivity. Pixels with small changes are considered stable.



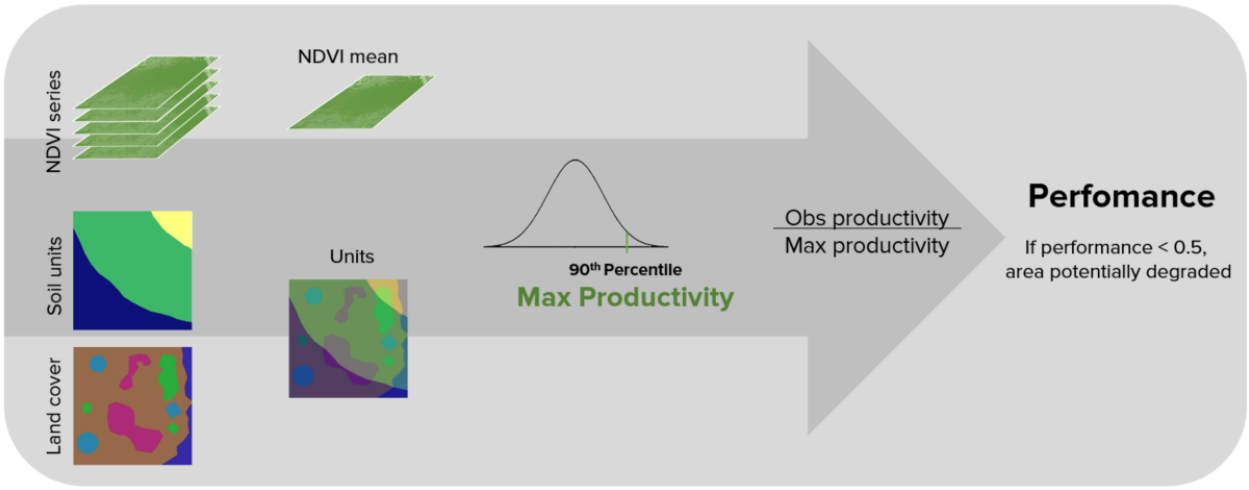
The table below list the datasets available in TRENDS.EARTH to compute the Productivity State metric:

Variable	Sensor/Dataset	Temporal	Spatial Res.	Extent	Units/Description
NDVI	AVHRR/GIMMS	1982-2015	8 km	Global	Mean annual NDVI * 10000
NDVI	MOD13Q1-coll6.1	2001-2024	250 m	Global	Mean annual NDVI * 10000

Productivity Performance

The Productivity Performance metric measures local productivity relative to other similar vegetation types in similar land cover types or bioclimatic regions throughout the study area. TRENDS.EARTH uses the unique combination of soil units (soil taxonomy units using USDA system provided by SoilGrids at 250m resolution) and land cover (full 37 land cover classes provided by ESA CCI at 300m resolution) to define this areas of analysis. The Performance metric is computed as follows:

1. Define the analysis period, and use the time series of NDVI to compute mean the NDVI for each pixel.
2. Define similar ecologically similar units as the unique intersection of land cover and soil type.
3. For each unit, extract all the mean NDVI values computed in step 1, and create a frequency distribution. From this distribution determine the value which represents the 90th percentile (we don't recommend using the absolute maximum NDVI value to avoid possible errors due to the presence of outliers). The value representing the 90th percentile will be considered the maximum productivity for that unit.
4. Compute the ratio of mean NDVI and maximum productivity (in each case compare the mean observed value to the maximum for its corresponding unit).
5. If observed mean NDVI is lower than 50% than the maximum productivity, that pixel is considered potentially degraded for this metric.



The table below list the datasets available in TRENDS.EARTH to compute the Productivity Performance metric:

Variable	Sensor/Dataset	Temporal	Spatial Res.	Extent	Units/Description
NDVI	AVHRR/GIMMS	1982-2015	8 km	Global	Mean annual NDVI * 10000
NDVI	MOD13Q1-coll6.1	2001-2024	250 m	Global	Mean annual NDVI * 10000
Land Cover	ESA CCI	1992-2022	300 m	Global	Land cover thematic classes
Soil taxonomic units	SoilGrids - USDA	Static	250 m	Global	Soil units

Combining Productivity Metrics

The three productivity metrics are then combined as indicated in the tables below. For SDG 15.3.1 reporting, the 3-class indicator is required, but TRENDS.EARTH also produces a 5-class one which takes advantage of the information provided by State to inform the type of degradation occurring in the area.

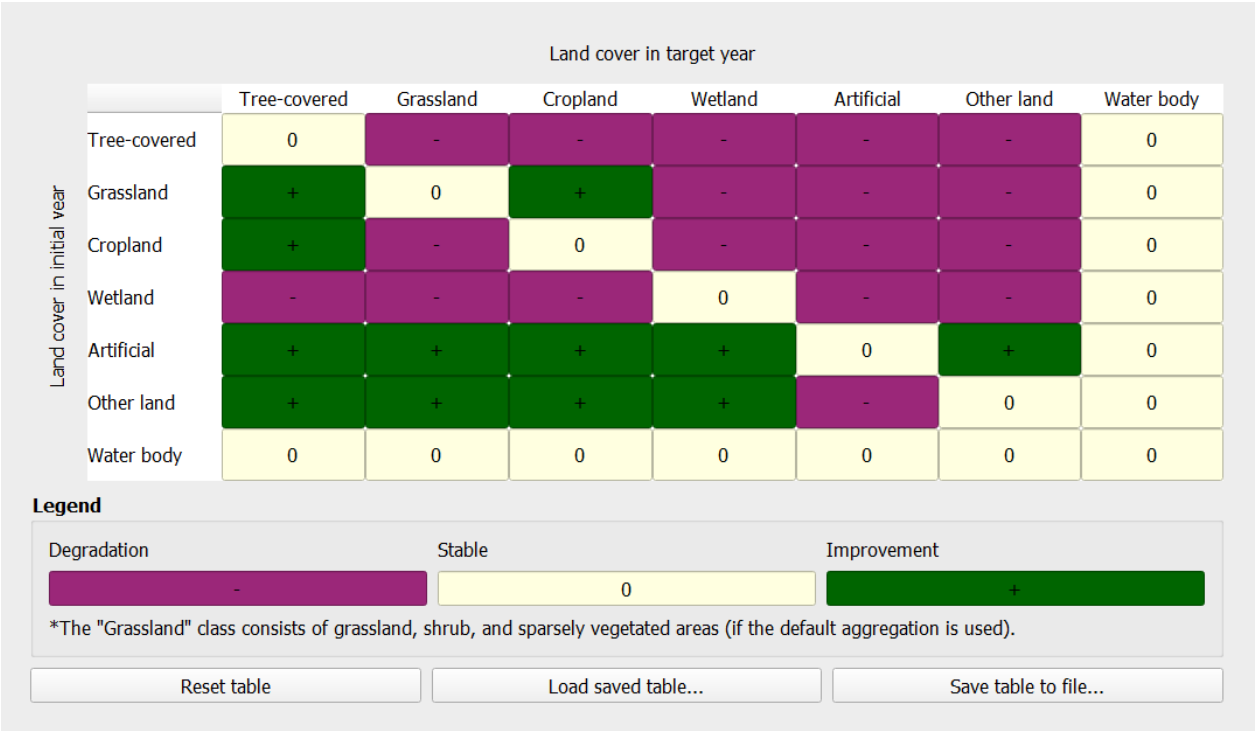
Aggregating Land Productivity metrics

Trend	State	Performance	5 Classes	3 Classes
Improving	Improving	Stable	Improving	Improving
Improving	Improving	Degrading	Improving	Improving
Improving	Stable	Stable	Improving	Improving
Improving	Stable	Degrading	Improving	Improving
Improving	Degrading	Stable	Improving	Improving
Improving	Degrading	Degrading	Moderate decline	Degrading
Stable	Improving	Stable	Stable	Stable
Stable	Improving	Degrading	Stable	Stable
Stable	Stable	Stable	Stable	Stable
Stable	Stable	Degrading	Stressed	Stable
Stable	Degrading	Stable	Moderate decline	Degrading
Stable	Degrading	Degrading	Degrading	Degrading
Degrading	Improving	Stable	Degrading	Degrading
Degrading	Improving	Degrading	Degrading	Degrading
Degrading	Stable	Stable	Degrading	Degrading
Degrading	Stable	Degrading	Degrading	Degrading
Degrading	Degrading	Stable	Degrading	Degrading
Degrading	Degrading	Degrading	Degrading	Degrading

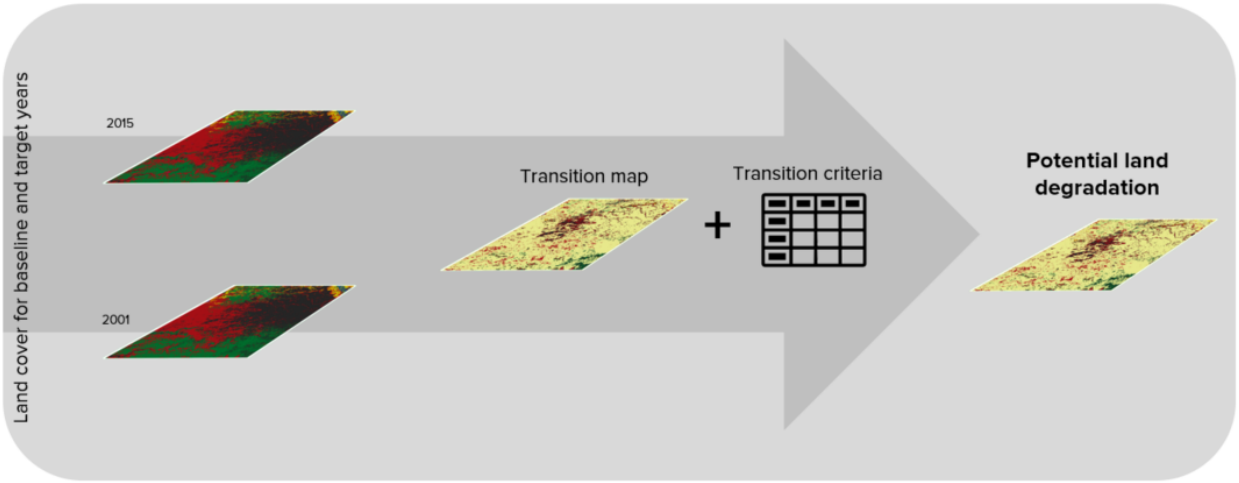
Land cover

To assess changes in land cover users need land cover maps covering the study area for the baseline and target years. These maps need to be of acceptable accuracy and created in such a way which allows for valid comparisons. TRENDS.EARTH uses ESA CCI land cover maps as the default dataset, but local maps can also be used. The indicator is computed as follows:

1. Reclassify both land cover maps to the 7 land cover classes needed for reporting to the UNCCD (forest, grassland, cropland, wetland, artificial area, bare land and water).
2. Perform a land cover transition analysis to identify which pixels remained in the same land cover class, and which ones changed.
3. Based on your local knowledge of the conditions in the study area and the land degradation processed occurring there, use the table below to identify which transitions correspond to degradation (- sign), improvement (+ sign), or no change in terms of land condition (zero).



1. TRENDS.EARTH will combine the information from the land cover maps and the table of degradation typologies by land cover transition to compute the land cover sub-indicator.



Soil organic carbon

The third sub-indicator for monitoring land degradation as part of the SDG process quantifies changes in soil organic carbon (SOC) over the reporting period. Changes in SOC are particularly difficult to assess for several reasons, some of them being the high spatial variability of soil properties, the time and cost intensiveness of conducting representative soil surveys and the lack of time series data on SOC for most regions of the world. To address some of the limitations, a combined land cover/SOC method is used in TRENDS.EARTH to estimate changes in SOC and identify potentially degraded areas. The indicator is computed as follows:

1. Determine the SOC reference values. TRENDS.EARTH uses SoilGrids 250m carbon stocks for the first 30 cm of the soil profile as the reference values for calculation (NOTE: SoilGrids uses

information from a variety of data sources and ranging from many years to produce this product, therefore assigning a date for calculations purposes could cause inaccuracies in the stock change calculations).

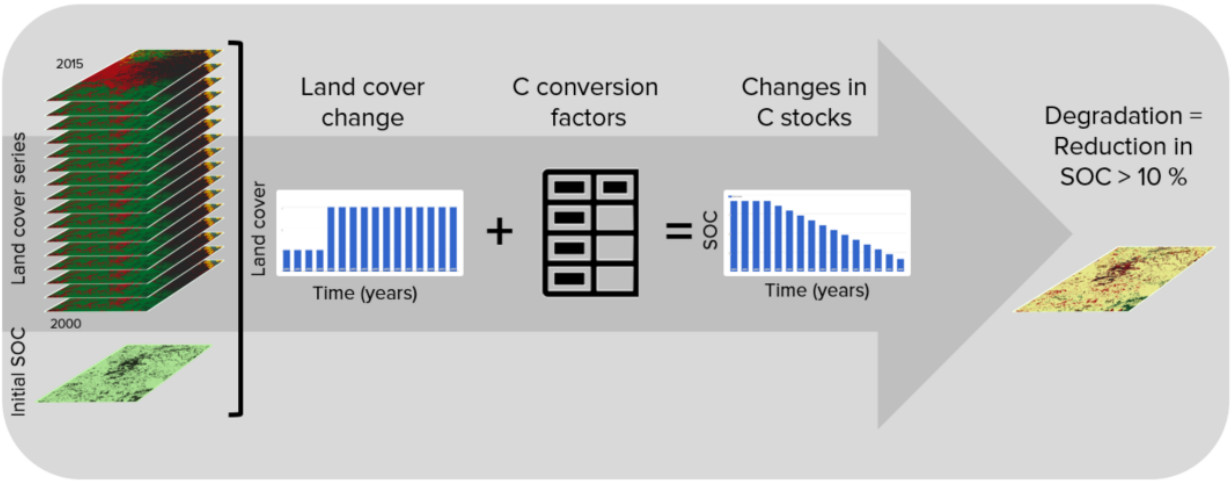
2. Reclassify the land cover maps to the 7 land cover classes needed for reporting to the UNCCD (forest, grassland, cropland, wetland, artificial area, bare land and water). Ideally annual land cover maps are preferred, but at least land cover maps for the starting and end years are needed.

3. To estimate the changes in C stocks for the reporting period C conversion coefficients for changes in land use, management and inputs are recommended by the IPCC and the UNCCD. However, spatially explicit information on management and C inputs is not available for most regions. As such, only land use conversion coefficient can be applied for estimating changes in C stocks (using land cover as a proxy for land use). The coefficients used were the result of a literature review performed by the UNCCD and are presented in the table below. Those coefficients represent the proportional in C stocks after 20 years of land cover change

LU coefficients	Forest	Grasslands	Croplands	Wetlands	Artificial areas	Bare lands	Water bodies
Forest	1	1	f	1	0.1	0.1	1
Grasslands	1	1	f	1	0.1	0.1	1
Croplands	1/f	1/f	1	1/0.71	0.1	0.1	1
Wetlands	1	1	0.71	1	0.1	0.1	1
Artificial areas	2	2	2	2	1	1	1
Bare lands	2	2	2	2	1	1	1
Water bodies	1	1	1	1	1	1	1

Changes in SOC are better studied for land cover transitions involving agriculture, and for that reason there is a different set of coefficients for each of the main global climatic regions: Temperate Dry (f = 0.80), Temperate Moist (f = 0.69), Tropical Dry (f = 0.58), Tropical Moist (f = 0.48), and Tropical Montane (f = 0.64).

4. Compute relative different in SOC between the baseline and the target period, areas which experienced a loss in SOC of 10% of more during the reporting period will be considered potentially degraded, and areas experiencing a gain of 10% or more as potentially improved.



Combining indicators into SDG Indicator 15.3.1

The integration of the three SDG 15.3.1 sub-indicators is done following the one-out all-out rule(1OAO), this means that if an area/pixel was identified as potentially degraded by any of the sub-indicators, then that area/pixel will be considered potentially degraded for reporting purposes.

Aggregating SDG 15.3.1 sub-indicators - 1OAO

Land Productivity	Land Cover	SOC	SDG 15.3.1
Improving	Improving	Improving	Improving
Improving	Improving	Stable	Improving
Improving	Improving	Declining	Declining
Improving	Stable	Improving	Improving
Improving	Stable	Stable	Improving
Improving	Stable	Declining	Declining
Improving	Declining	Improving	Declining
Improving	Declining	Stable	Declining
Improving	Declining	Declining	Declining
Stable	Improving	Improving	Improving
Stable	Improving	Stable	Improving
Stable	Improving	Declining	Declining
Stable	Stable	Improving	Improving
Stable	Stable	Stable	Stable
Stable	Stable	Declining	Declining
Stable	Declining	Improving	Declining
Stable	Declining	Stable	Declining
Stable	Declining	Declining	Declining
Declining	Improving	Improving	Declining
Declining	Improving	Stable	Declining
Declining	Improving	Declining	Declining
Declining	Stable	Improving	Declining
Declining	Stable	Stable	Declining
Declining	Stable	Declining	Declining
Declining	Declining	Improving	Declining
Declining	Declining	Stable	Declining
Declining	Declining	Declining	Declining

Calculating Status map

According to the Good Practice Guidance Addendum SDG Indicator 15.3.1, the Status map “refers to the final condition (considering the baseline) of land at the end of each reporting period, classified as either degraded, stable, or improved”. It combines the SDG Indicator 15.3.1 layer calculated for a given period of assessment with the Baseline SDG Indicator 15.3.1. By combining these two layers, the Status map shows changes that happened over the period assessment integrated with land conditions (degradation, stabilily, improvement) mapped at the Baseline period, providing a more complete understanding of the land condition trajectory over time.

Note

The Status layer for the Baseline period is equivalent the SDG Indicator 15.3.1 calculated for the Baseline assessment (i.e. Baseline Assessment == Status 2015).

For combining a given period assessment with the Baseline SDG Indicator 15.3.1 it is necessary to apply the 3 x 3 Status Matrix

		PERIOD ASSESSMENT		
		DEGRADED	STABLE*	IMPROVED*
BASELINE	DEGRADED	Degraded	Degraded	Improved
	STABLE*	Degraded	Stable	Improved
	IMPROVED*	Degraded	Improved	Improved

** Not Degraded areas.*

Note

For further information on how to derive the Status map, please refer to the Good Practice Guidance Addendum SDG Indicator 15.3.1 which offers a dedicated section on “Assessing Status for each reporting process” starting on page 19.

Expanded Status Matrix

While the status map resulting from the above comparison provides a snapshot of land condition at the end of the reporting period in three broad categories (Degraded, Stable, and Improved), the underlying dynamics that lead to this final status can be complex - there are nine different types of changes (given it is a 3x3 matrix) in land condition. Understanding these different pathways enables a deeper interpretation of the land condition changes, allowing for the identification of gains and losses of natural capital that have occurred relative to a baseline state. For example, degradation and improvement can correspond to recent changes, a continuation of ongoing trends in areas previously degraded or improved, or stability in areas that were already degraded or improved in a prior period.

The below status matrix can be used instead of the 3x3 matrix above to capture these different types of changes in land condition that can occur. This expanded version of the status matrix allows for a more detailed classification of land condition changes, providing insights into the nature and timing of degradation and improvement processes.

		PERIOD ASSESSMENT		
		DEGRADED	STABLE	IMPROVED
BASELINE	DEGRADED	1 - Persistent Degradation	3 - Baseline Degradation	6 - Recent Improvement
	STABLE	2 - Recent Degradation	4 - Stability	6 - Recent Improvement
	IMPROVED	2 - Recent Degradation	5 - Baseline Improvement	7 - Persistent Improvement

Expanded version of the "Status Matrix" showing land condition that results from the comparison of the baseline (rows) and the period assessment (columns): degraded (purple), stable (yellow), and improved (green).

Each type of change represented in the expanded Status Matrix is detailed below. The table captures the nine possible combinations in the 3 × 3 matrix, reflecting transitions from the baseline assessment to the current period assessment. For each combination, a brief interpretation of the change is provided, along with its classification as either a recent or baseline improvement or degradation. This classification helps in understanding whether the observed changes represent new developments that have occurred during the current reporting period or whether no changes in status have taken place.

Note

For further information on how to derive the expanded status map, please refer to the Good Practice Guidance Addendum SDG Indicator 15.3.1 which offers a dedicated section on “Further characterization of land degradation and improvement” starting on page 29.

UNCCD Strategic Objective 2 (SO 2)

To improve the living conditions of affected populations

Addressing the global challenges of desertification, land degradation, and drought (DLDD) and their impacts on coupled human-environmental systems is a key component of the 2030 Agenda for Sustainable Development. In particular, Sustainable Development Goal (SDG) 15.3 aims to, by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. Addressing this challenge is essential for improving the livelihoods of those most affected by DLDD and for safeguarding against the most extreme effects of climate change.

The livelihoods of people in degraded areas include multiple human and natural characteristics of local environments, including adequate access to food and water, either directly through subsistence livelihoods, through sufficient income to purchase food and water security, or a combination of both. If food and water security are achieved, outmigration from affected areas should no longer be forced but rather voluntary in nature. Socially and economically marginalized populations, communities and households tend to be disproportionally vulnerable to climate change and the combined effects of DLDD. The ability to identify and quantify the makeup, distribution, and relative vulnerability of such populations,communities, and households is critical in reinforcing livelihood resilience in order to enhance positive adaptations to DLDD

How population exposure is calculated

TRENDS.EARTH allows users to monitor UNCCD’s Strategic Objective 2 indicator on **Trends in Population Exposure to Land Degradation Disaggregated by Sex (SO 2-3)** by calculating the proportions of population, disaggregated by sex, exposed to land degradation. TRENDS.EARTH uses gridded data representing the spatial distribution of the population over the SDG 15.3.1 Indicator map to establish its exposure to land degradation.

The (SO 2-3) indicator uses the following metrics:

- Percentage of the female population exposed to land degradation
- Percentage of the male population exposed to land degradation
- Percentage of the total (female and male) population exposed to land degradation

To calculate the SO 2-3 indicator, TRENDS.EARTH uses gridded population data from the WorldPop project. WorldPop provides separate raster layers for male and female population, each representing the estimated number of people per grid cell for a given year. TRENDS.EARTH overlays these population grids with the final SDG 15.3.1 indicator map, which classifies every pixel as **degraded**, **stable**, or **improved**. For each degradation class the tool sums the number of people — separately for males and females — whose grid cell falls within that class. Areas classified as water bodies are masked out and excluded from the totals, in line with UNCCD reporting requirements.

The resulting totals are then expressed as percentages of the total population within the area of interest, producing the three SO 2-3 metrics: the percentage of the female population, the male population, and the combined population exposed to land degradation. In the output map, pixels in degraded areas retain their population count as a positive value, pixels in improved areas are shown as negative values (indicating

population in areas where conditions have improved), and water areas are marked as no-data. This sign convention makes it straightforward to distinguish, at a glance, populations living on degraded land from those on improving land.

UNCCD Strategic Objective 3 (SO 3)

To mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems.

Drought and land degradation

Land degradation as defined by the UNCCD refers to any reduction or loss in the biological or economic productive capacity of the land resource base. It is generally caused by human activities, exacerbated by natural processes, and often magnified by and closely intertwined with climate change and biodiversity loss.Land degradation reduces agricultural productivity and increases the vulnerability of those areas already at risk of impacts from climate variability and change, especially in regions of the world.

Drought is a complex, slow-onset phenomenon that happens over different time scales. It is characterized by a reduction in water availability, leading to cascading effects on people's livelihoods and economic sectors. Drought is sometimes simplistically defined as a period of dry weather long enough to cause a hydrological imbalance, although a globally agreed upon definition for drought does not exist. Moreover, drought hardly occurs as a single risk event but rather interlinked with other hazards such as heatwaves, wildfires, sand/dust storms, or floods.

The International Panel on Climate Change (IPCC) defines drought as "a period of abnormally dry weather long enough to cause a serious hydrological imbalance". Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. See also Soil moisture (IPCC Assessment Report 5, 2014). The United Nations Disasters Risk Reduction (UNDRR) defines drought as a slow-onset hazard, often referred to as a creeping phenomenon. The absence of a precise, universally accepted definition of drought adds to the confusion. Definitions must be region specific because each climate regime has distinctive climatic characteristics (UNDRR GAR Chapter 6). The lack of agreed upon definition complicates monitoring efforts, as the definition and monitoring approach are typically context specific. where poverty rates remain high despite efforts to reduce poverty, inequality, and enhance the socio-economic well-being of all people worldwide.

Drought increasingly impacts larger numbers of people, livelihoods, ecosystems, and economies worldwide. When it occurs concomitantly with land degradation, it can expose already vulnerable populations to deleterious livelihood, environmental, socio-economic, and health risks and decrease population and community resilience.

The UNCCD has adopted a monitoring framework with three levels for SO 3:

> Level I SO 3-1 Trends in the proportion of land under drought over the total land area(Hazard), Level II SO 3-2 Trends in the proportion of the total population exposed to drought(Exposure), Level III SO 3-3 Trends in the degree of drought vulnerability (Vulnerability).

Under the IPCC framework:

Hazard is the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Exposure characterizes the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability is defined as the propensity or predisposition to be adversely affected by climate change and related processes.

In order to assess the SO 3 indicators, TRENDS.EARTH uses information from 3 sub-indicators:

- Standardized Precipitation Index (SPI), alternatively the Standardized Precipitation Evapotranspiration Index (SPEI)
- Gridded global population dataset
- Drought Vulnerability Index (DVI)

TRENDS.EARTH allows the user to compute each of these indicators in a spatially explicit way generating raster maps and producing a summary table reporting areas potentially improved and degraded for the area of analysis. SO 3-1 “Trends in the proportion of land under drought over the total land area”.

The United Nations Convention to Combat Desertification (UNCCD) has developed a Good practice guidance for national reporting on UNCCD Strategic Objective 3 (GPG-SO3). providing recommendations on how to calculate indicators of SO3.

This document provides a brief introduction to the UNCCD Strategic Objective 3 and describes how each indicator is calculated by TRENDS.EARTH, following the Strategic Objective 3 Good Practice Guidance.

SO3 Level I indicator (SO 3-1 Hazard)

Steps to calculate Level I indicator following the UNCCD GPG-SO3:

1. Calculate SPI using an accumulation period of 12 months (SPI-12) and gridded precipitation data
2. Identify the drought intensity class of each pixel based on the previously calculated SPI
3. Calculate proportion of land within each drought intensity class.

Standardized Precipitation Index (SPI)

The Standardized Precipitation Index (SPI) has been widely used to characterize meteorological drought or precipitation deficit, and was recognized through the Lincoln Declaration on Drought as the internationally preferred index for calculating and monitoring meteorological drought. SPI is calculated as standard deviations that the observed precipitation over a specified period would deviate from the long-term mean over periods of that duration considered over typically 30 years of data, for a normal distribution and fitted probability distribution for the actual precipitation record. The primary advantages for using the SPI for global drought monitoring, prediction, and risk assessment is that it is currently in use in many countries globally and is endorsed by the World Meteorological Organization. Other key advantages are that the SPI represents both precipitation deficits and surpluses, and it can be calculated at different timescales (e.g., SPI-3, SPI-6, SPI-12, with the number indicating the number of months over which the index is calculated). Thus, it indirectly considers effects of accumulating precipitation deficits, which are critical for soil moisture and hydrological droughts.

By default, TRENDS.EARTH offers access to SPI calculated from the Global Precipitation Climatology Centre (GPCC) Monitoring Product, a raster representing precipitation and derived from rain gauge data featuring spatial resolution of ~27 sq km and covering the entire globe. Users have also the option to use an alternative SPI calculated from the Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS), with precipitation estimates based on satellite observations combined to gauged station data at ~5 sq km. While CHIRPS features higher spatial resolution, it has a “quasi-global” coverage that spans 50°S to 50°N. Therefore, users interested in calculating SO3-1 Hazard for areas outside this range will not be able to use the CHRIPS dataset.

Step 1. Calculating SPI

The SPI quantifies observed precipitation as a standardized departure from a selected probability distribution function that models the raw data. The raw data can be fitted to a gamma or a Pearson Type III distribution, and then transformed to a normal distribution. The transformed precipitation data are then used to compute the dimensionless SPI value, defined as the standardized anomaly of the precipitation.

The detailed equations for computing this index are described in the following steps using the gamma distribution:

1. **The transformation of the precipitation value into SPI has the purpose of:**
    a. Transforming the mean of the precipitation value adjusted to 0;
    b. Standard deviation of the precipitation is adjusted to 1.0; and
    c. Skewness of the existing data must be readjusted to zero.

When these goals have been achieved the standardized precipitation index can be interpreted as mean 0 and standard deviation of 1.0.

2. Mean of the precipitation can be computed as:

$$Mean = \bar{X} = \frac{\Sigma X}{N}$$

where N is the number of precipitation observations.

3. The standard deviation for the precipitation is computed as:

$$s = \sqrt{\frac{\Sigma (X - \bar{X})^2}{N}}$$

4. The skewness of the given precipitation is computed as:

$$Skew = \frac{N}{(N-1)(N-2)} \sum \left(\frac{X - \bar{X}}{s} \right)^3$$

5. The precipitation is converted to lognormal values and the statistics U, shape and scale parameters of gamma distribution is computed:

$$\log mean = \bar{X}_{ln} = ln(\bar{X})$$

$$U = \bar{X}_{ln} - \frac{\Sigma\, ln(X)}{N}$$

$$shape\ parameter = \beta = \frac{1 + \sqrt{1 + \frac{4U}{3}}}{4U}$$

$$scale\ parameter = \alpha = \frac{\bar{X}}{\beta}$$

6. The resulting parameters are then used to find the cumulative probability of an observed precipitation event. The cumulative probability is given by:

$$G(x) = \frac{\int_0^x x^{\alpha-1} e^{\frac{-x}{\beta}} dx}{\beta^\alpha \Gamma(\alpha)}$$

7. Since the gamma function is undefined for x = 0 and a precipitation distribution may contain zeros, the cumulative probability becomes:

$$H(x)=q+(1-q)G(x)$$

where the probability from q is zero.

8. The cumulative probability H(x) is then transformed to the standard normal random variable Z with mean zero and variance of one:

$$Z = SPI = -\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \quad 0<H(x)\leq 0.5$$

$$Z = SPI = +\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \quad 0.5<H(x)\leq 1.0$$

where:

$$t = \sqrt{\ln\left(\frac{1}{H(x)^2}\right)} \quad 0<H(x)\leq 0.5$$

$$t = \sqrt{\ln\left(\frac{1}{1-H(x)^2}\right)} \quad 0.5<H(x)\leq 1.0$$

$c_0 = 2.515517$

$c_1 = 0.802583$

$c_2 = 0.010328$

$d_1 = 1.432788$

$d_2 = 0.189269$

$d_3 = 0.001308$

Step 2. Identifying drought intensity classes

The dimensionless SPI values are interpreted as the number of standard deviations by which the observed anomaly deviates from the long-term mean and are typically labeled categorically based on condition (i.e., extremely wet, extremely dry, normal) as shown in the table below. A drought occurs when the SPI is consecutively negative, and its value reaches an intensity of -1 or less and ends when the SPI becomes positive.

Description	Precipitation Category
2.0 or more	Extremely wet
1.5 to 1.99	Severely wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2.0 or less	Extremely dry

Drought intensity classes are identified by assessing the December SPI-12 values for ear year of time-series. The December SPI-12 values represent the precipitation deficits (or excesses) over the

Gregorian (January-December) calendar year. Positive SPI values are discarded, since they indicate that there was no drought in the given period.

For further details on SPI, see the Good practice guidance for national reporting on UNCCD Strategic Objective 3. We also recommend reading the Tools4LDN Technical Report on Monitoring Progress Towards UNCCD Strategic Objective 3 A review of Publicly Available Geospatial Datasets and Indicators in Support of Drought Monitoring.

Step 3. Calculating the proportion of land within each drought intensity class.

The equation to estimate the percentage of land within drought intensity classes takes the land area under the each drought intensity class identified in the previous step over the the total land area, as follows:

$$P_{ij} = \frac{area_{ij}}{Total\ area}\ x\ 100$$

Where:

Pij is the proportion of land under the drought intensity class i in the year j

areaij is the land area under the drought intensity class i in the reporting year j

Total area is all the total land area.

SO3 Level II indicator (SO 3-2 Exposure)

The UNCCD SO3 Level III drought Exposure indicator is built upon the SO 3 Level I Hazard indicator by overlaying a gridded population data. Using the overlaying population as a proxy for calculating drought exposure is a straight-forward method. Knowing how many people are directly affected by drought can help aid get allocated to the most needed areas, based on percent of population exposed and strength of that exposure (drought severity). This method can also serve as a proxy for socioeconomic drought.The gender disaggregation calculation for the SO3 Level II population indicator is computed based on percent male and percent female in each grid cell. The outputs include exposure information by gender (percent male and percent female) exposed to each Level I drought intensity class. This produces two comparable grids that could be aggregated to administrative boundaries if desired, where global and local spatial relationships between gender and drought occurrence and/or severity can be better quantified and visualized.

The WorldPop collection is a global gridded high resolution geospatial dataset on population distributions,demographics, and dynamics. WorldPop's spatially disaggregated layers are gridded with an output resolution of 3 arc-seconds and 30 arc-seconds (approximately 100 m & 1 km, respectively at the equator) and incorporates inputs such as population census tables & national geographic boundaries, roads, land cover, built structures, urban areas, night-time lights, infrastructure, environmental data, protected areas, and water bodies. The strengths of WorldPop are that the population estimation method of dasymetric mapping is multivariate, i.e., highly modeled, and therefore tailored to match data conditions and geographical nature of each individual country and region. Gender information is also available. The weakness of WorldPop is that the utilization of such complex interpolation models with sparse census data may lead to highly uncertain and imprecise population estimates in some sub-national and rural regions. In spite of the aforementioned limitation, WorldPop remains the most ideal gridded population dataset as it satisfies all our inclusion criteria, including spatial resolution, global coverage, frequency of data updates, and inclusion of a gender-disaggregated component.

The percentages of population Exposure to drought are calculated by the number of people within each drought intensity classes over of the total population.

How population exposure to drought is represented in Trends.Earth

The SO 3-2 Exposure summary output in Trends.Earth is a multi-band raster file. Bands are organised in pairs, one pair per drought reporting period (each period is by default 4 years). Within each pair:

- The **first band** contains the most severe SPI value recorded during that period — the minimum SPI across all years in the period. A negative SPI indicates a precipitation deficit relative to the long-term mean, i.e., drought conditions.
- The **second band** contains the population count for the pixel at the time of the most severe drought, with the *sign* of the value encoding drought exposure:
    - A **negative** population value indicates that the pixel experienced drought during that period (minimum SPI < 0).
    - A **positive** population value indicates that the pixel experienced above-average precipitation during that period (SPI ≥ 0 throughout the entire period).
    - Pixels over water bodies are set to no-data, in line with UNCCD reporting requirements.

For the final drought period only, if sex-disaggregated population data are available, two additional bands follow the standard pair: a female population band and a male population band, both using the same sign convention described above.

This encoding makes it straightforward to derive exposure statistics from a single band: the absolute values of all valid pixels give the total population, while the absolute values of the negative pixels alone give the drought-exposed population.

SO3 Level III indicator (SO 3-3 Vulnerability)

Drought Vulnerability assessment is based on the Drought Vulnerability Index (DVI), a composite index incorporating three components reflecting the vulnerability of the population to drought: i) social, ii) economic and iii) infrastructural. Currently DVI does not feature components on ecological or ecosystem vulnerability. TRENDS.EARTH offers access to the global default DVI dataset produced by the Joint Research Centre (JRC). The JRC has developed a framework which integrates 15 economic, social, and infrastructural components related to drought vulnerability derived from global data sources. This framework recommends that drought vulnerability indicators should encompass orthogonal social, infrastructural, and economic factors that are generic and valid for any region.

The JRC framework for monitoring drought risk as described in Carrão et al., 2016 adopts an approach for SO3 assessing drought vulnerability that was initially proposed by the United Nations Office for Disaster Risk Reduction (UNDRR - formerly the United Nations International Strategy for Disaster Reduction or UNISDR) that reflects the state of the individual and collective social, economic, and infrastructural factors of a region [61]. This methodology has also been operationally implemented within the JRC Global Drought Observatory (GDO) to document and map global risk of drought impact for agriculture. The authors state that the factors that have been included do not represent a complete description of vulnerability in relation to a specific exposed element but can be viewed as the foundation for building a regional plan for reducing vulnerability and facilitating adaptation.

The methodology used in Carrão et al., 2016 follows the concept that individuals and populations require a range of semi-) independent factors characterized by a set of proxy indicators to achieve positive resilience to impacts. The methodology uses a two-step composite model that derives from the aggregation of 15 proxy indicators (show in the Table below) that represent social, economic, and infrastructural vulnerability at each geographic location (a similar methodology as the DVI, discussed subsequently) and are derived from both at the national level and very high spatial resolution gridded data.

Proxy indicators for vulnerability to drought used in Carrao et al. 2016 (Table 1). With the exception of gROADS and FAO's Irrigated Agricultural Lands which are both gridded data, all data are available only at the national level. (Also draws on Table 14 from the Good practice guidance for national reporting on UNCCD Strategic Objective 3.)

Indicator	Source	Link
ECONOMIC		
Energy consumption per capita (millions Btu per person)	US Energy Information Administration (U.S. EIA)	http://www.eia.gov/
Agriculture (% of GDP)	World Bank	http://data.worldbank.org/products/wdi
GDP per capita (current US$)	World Bank	http://data.worldbank.org/products/wdi
Poverty headcount ratio at $1.25 per day (PPP) (% of total population)	World Bank	http://data.worldbank.org/products/wdi
SOCIAL		
Rural population (% of total population)	World Bank	http://data.worldbank.org/products/wdi
Literacy rate (% of people age 15 and above)	World Bank	http://data.worldbank.org/products/wdi
Improved water resources (% of rural population with access)	World Bank	http://data.worldbank.org/products/wdi
Life expectancy at birth (years)	World Bank	http://data.worldbank.org/products/wdi
Population ages 15-64 (% of total population)	World Bank	http://data.worldbank.org/products/wdi
Refugee population by country or territory of asylum (% of total population)	World Bank	http://data.worldbank.org/products/wdi
Government effectiveness	Worldwide Governance Indicators (WGI)	https://www.worldbank.org/en/publication/worldwide-governance-indicators/interactive-data-access
Disaster prevention & preparedness (US$/year/capita)	Organization for Economic Cooperation and Development (OECD)	http://stats.oecd.org/
INFRASTRUCTURAL		
Agricultural and irrigated land (% of total agricultural land)	Food and Agricultural Administration (FAO)	http://www.fao.org/nr/water/aquastat/main/index.stm
% of retained renewable water	Aqueduct	http://www.wri.org/our-work/project/aqueduct

Indicator	Source	Link
Road density (km of road per 100 sq.km. of land area)	gROADSv1	https://data.nasa.gov/dataset/global-roads-open-access-data-set-version-1-groadsv1

This process involves first combining the indicators presented in the Table for each factor using a Data Envelopment Analysis (DEA) model, a deterministic and non-parametric linear programming technique that can be used to quantify the relative exposure of a region to drought from a multidimensional set of indicators. Secondly, arithmetically aggregating the individual factors resulting from the DEA model into a composite model of drought vulnerability such that:

$$dv_i = \frac{Soc_i + Econ_i + Infr_i}{3}$$

where Soc i, Econ i, and Infr i are the social, economic, and infrastructural vulnerability factors for region i.

Land Consumption and SDG 11.3.1

Background

Note

Source: UN-Habitat (2019) SDG Indicator 11.3.1 Training Module: Land Use Efficiency. United Nations Human Settlement Programme (UN-Habitat), Nairobi.

Human settlements, in all their diverse forms, appropriate land in varied ways. Just like living organisms, urban settlements (cities) evolve, transform, adapt, innovate and change with emerging trends. Urban settlements expand, shrink, densify, intensify, age, and sometimes their functions even migrate to areas that are more conducive to their survival. All these trends in urban settlements are closely associated with such factors as changes in population, economic potential and productivity, prevailing physical and social conditions, presence of enabling policies, among other things.

A country that maximizes the many benefits associated with urbanization is one that is able to understand, measure and predict the growth trends of its urban areas; and in turn put in place the necessary actions/interventions to tap on the benefits of such growth, while minimizing the equally diverse challenges associated with unplanned urbanization. Pro-active planning - which is a major pre-requisite for sustainable urbanization - requires that city authorities and other relevant actors predict the direction of growth of a city, and/or shape this growth by providing the required facilities, services and policy and legal frameworks ahead of development. This results in planned and equitable growth in which majority of the city residents have access to the basic services, economic and social opportunities, and where environmental sustainability prevails. At the center of all these is the need for generation and dissemination of up-to-date and accurate data on growth trends across cities and urban settlements.

Target 11.3 aims to enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries by 2030. To monitor progress towards the achievement of target 11.3 the UN established indicator 11.3.1, which measures how efficiently cities utilize land, which is measured as a ratio of the rate at which cities spatially consume land against the rate at which their populations grow. **Empirical evidence has shown that,**

cities that are compact use land more efficiently and are better placed to provide public goods and basic services at a lower cost. Such cities can consume less energy, manage waste better, and are more likely to maximize the benefits associated with economics of agglomeration. On the other hand, sprawling cities (non-compact cities) experience increased demand for mobility; increased energy consumption; environmental degradation; increased cost of providing basic services per capita (e.g. water, sanitation, drainage); increased cost of infrastructure per capita; reduction in economies of agglomeration; and decreased urban productivity.

By measuring the rate at which cities consume land against their rate of population growth, city authorities and decision makers can project demand for public goods and services, identify new areas of growth, and pro-actively influence sustainable urban development. This is needed to provide adequate infrastructure, services and amenities for the improvement of living conditions to all. Generation and dissemination of data on this indicator is thus not only crucial for understanding urban growth dynamics and formulation of informed policies and guidelines, but is also at the core of promoting sustainable urbanization.

Rationale for Monitoring

Note

Source: UN-Habitat (2019) SDG Indicator 11.3.1 Training Module: Land Use Efficiency. United Nations Human Settlement Programme (UN-Habitat), Nairobi.

Understanding how a city/urban area expands spatially against its rate of population change is critical to determining, among other things, the nature of human settlements growth (formal versus informal) and the speed of conversion of outlying land to urbanized functions. These two elements have significant implications on the demand for and cost of providing services, as well as on environmental preservation and conservation.

To attain sustainable development, countries need to understand how fast their urban areas are growing, and in which direction. This will not only help them understand growth trends and effectively address demand for basic services but also help create policies that encourage optimal use of urban land, effectively protecting other land uses (natural environments, farmlands, etc). In addition, achievement of inclusive and sustainable urbanization requires that the resources be utilized in a manner that can accommodate population growth from migration and natural increase while preserving environmentally sensitive areas from development.

The purpose of monitoring progress against the SDG indicator 11.3.1 is therefore to provide necessary and timely information to decision makers and stakeholders in order to accelerate progress towards enhanced inclusive and sustainable urbanization. **Meeting Target 11.3 by 2030 requires, at the minimum, slowing down urban sprawl and if possible, ensuring that the compactness of cities is maintained or increased over time**.

Indicator and data needs

Indicator 11.3.1 is defined as the **ratio of land consumption rate to population growth rate** (Figure 1). In order to compute this indicator, information on the urban extent and population in at least two moments in time are needed, and even more if we are interested in assessing the change in the indicator over time.

$$\text{SDG } 11.3.1 = \frac{\text{ALCR}_{t1-t2}}{\text{APGR}_{t1-t2}}$$

$$\text{ALCR}_{t1-t2} = \frac{\text{Ln}(\frac{\text{Urb}_{t2}}{\text{Urb}_{t1}})}{t_2 - t_1}$$

$$\text{APGR}_{t1-t2} = \frac{\text{Ln}(\frac{\text{Pop}_{t2}}{\text{Pop}_{t1}})}{t_2 - t_1}$$

Figure 1: Sustainable development goal (SDG) indicator 11.3.1 is computed as the ratio of the annual land consumption rate (ALCR) to the annual population growth rate (APGR) between times 1 and 2. Ln: natural logarithm, Urb: urban area, pop: population, t: time in years.

Assessing changes in SDG 11.3.1. over time requires a significant amount of information, since it requires knowing urban extent and population count for multiple years. Earth observation data allow us to estimate the extent of built-up area within a city, and then using spatial analysis algorithms estimate the extent of the different elements within the urban environment (e.g. buildings, open space, water bodies, etc.). In ▲TRENDS.EARTH we have adopted the work-flow below (Figure 2) to facilitate the process. Making use of Google Earth Engine's super computers, the full Landsat archive between 1997 and 2019, and the GMIS dataset (Brown de Colstoun et al 2017), ▲TRENDS.EARTH computed a series of impervious surface indices globally available at 30m resolution to inform on urban extent for the years 2000, 2005, 2010, and 2015. Combined with user input and population data, the tool computes SDG 11.3.1 both in the form of maps and tables for ease of interpretation and reporting.

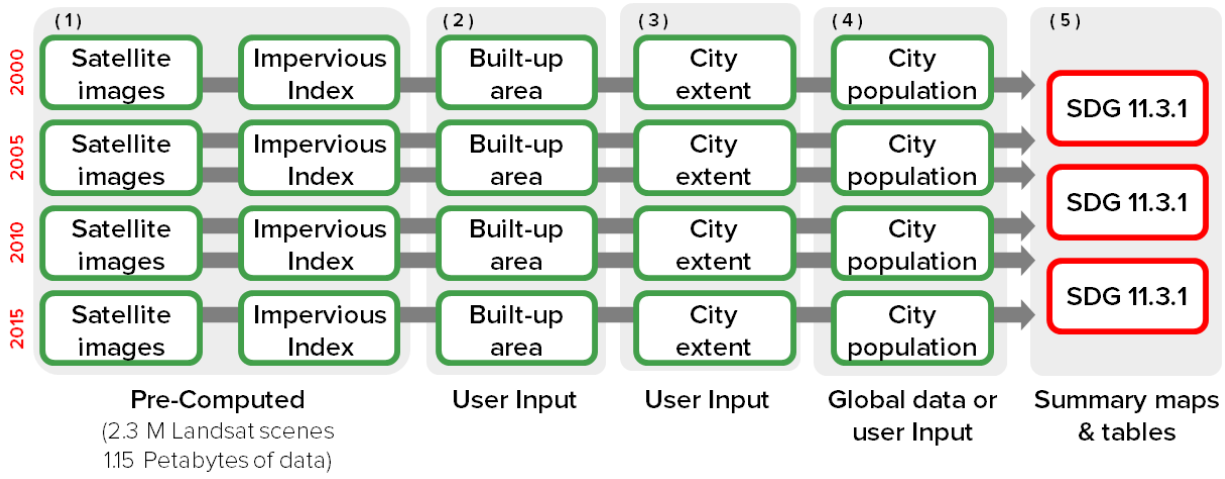


Figure 2: Trends.Earth works-flow to computing SDG 11.3.1. Global 30m impervious surface indices have been pre-computed and are available for the users to explore in the Trends.Earth Urban Mapper where the user defines built-up extent by simply assigning a series of thresholds.

Land consumption

To estimate land consumption in ▲TRENDS.EARTH, a pre-computed time series of impervious surface indicators are available globally at 30 m resolution. In the section below, you will learn how the indicators were computed, and some recommendation how to use them to compute the indicator for SDG 11.3.1.

ISI in Trends.Earth

Given the lack of availability of a time series of impervious surface dataset at fine spatial resolution to capture urban changes globally, we computed one making use of the best impervious surface dataset available, the Global Man-made Impervious Surface for the year 2010 (GMIS, Brown de Colstoun et al 2017) to train a series of global random forest models (Breiman 2001) in Google Earth Engine (Gorelick et al 2017) making use of 2.3 million Landsat images (1.15 Peta-bytes of data) between the years 1997 and 2019. To make sure that the models were trained only with high quality data, we combined GMIS with ESA CCI land cover data for the year 2010 as indicated in Figure 3. This dataset allowed us to train random forest models, which where then applied to a set of 24 band stacks derived from Landsat surface reflectance data to generate impervious surface indicators for the years 1998, 2000, 2005, 2010, 2015, and 2018. A series of 846 models were run, one per eco region as defined by the RESOLVE dataset (Dinerstein et al 2017).

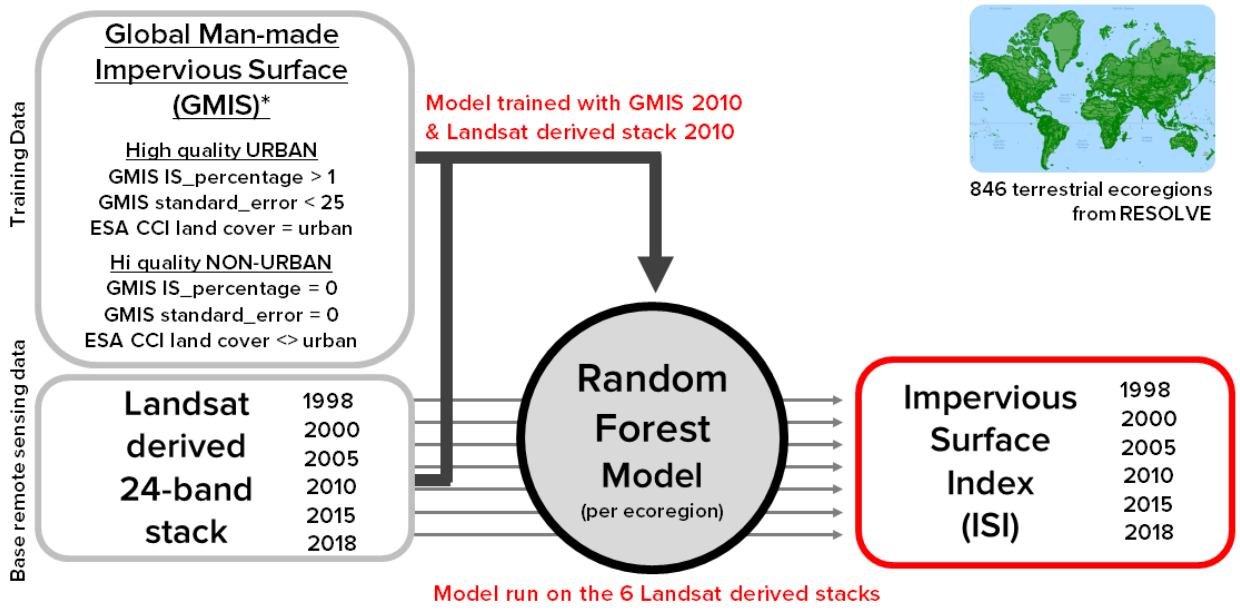


Figure 3: A series of 846 random forest models were run. Each model was trained using the GMIS and ESA CCI datasets, and then applied to a stack of 24 bands derived from Landsat imagery to predict impervious surface area for the years 1998, 2000, 2005, 2010, 2015, and 2018.

Since image availability is limited, in some areas, we included for each year images from the previous and posterior years (e.g. stack for 2005 includes images from 2004, 2005, and 2006). Each of the 24 band stacks contained the 7 reflectance bands (median for the 3 year period), 15 normalized difference indices representing all the possible combinations of the 7 original bands, and then 2 NDVI specific bands representing the maximum and the standard deviation of NDVI for each particular pixel during the 3-year period. Six of these stacks were generated for 1998, 2000, 2005, 2010, 2015, and 2018, and were the input to the random forest models.

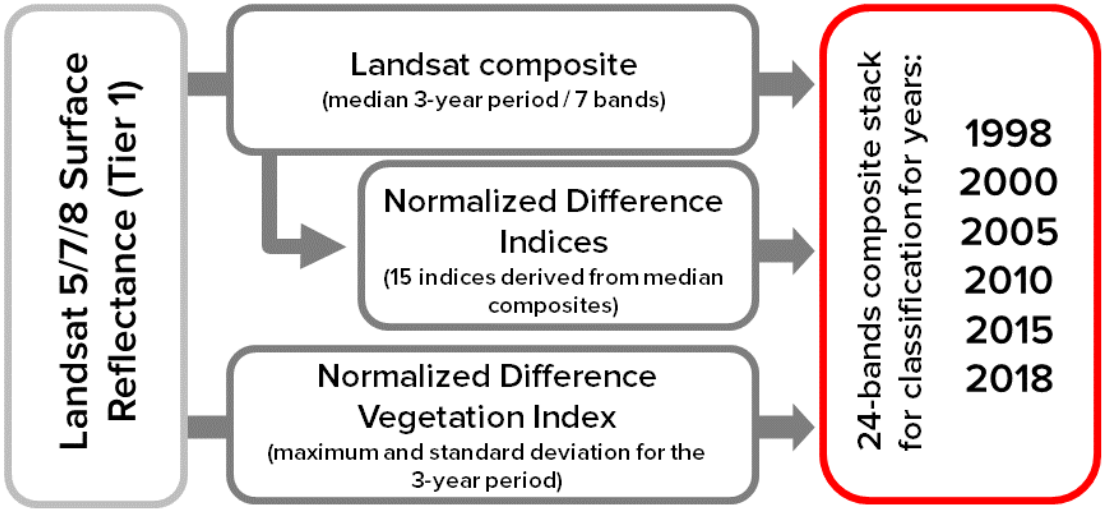


Figure 4: Description of the bands in the 24-band stack used in the random forest models.

It is hard to assess the accuracy of such dataset, given the lack of reference or comparable datasets globally. We compared the results of the 2010 ISI dataset to the GMIS original dataset for a subset of cities globally to assess its accuracy. We found that the root-mean-squared-error (RMSE) ranged between 9.9 and 14.4%, which for an indicator that varies between 0% (no impervious surface) to 100% (completely impervious), is a very acceptable result. We urge the users, however, to evaluate the results visually inspecting the Trends.Earth Urban Mapper for their area of interest.

From ISI to built-up

In order to estimate the area occupied by impervious surfaces in a city, we need to convert the continuous impervious surface index (ISI) into a binary map separating areas built from those not built. This process is done by defining a series of threshold values in the Trends.Earth Urban Mapper, which will vary by region.

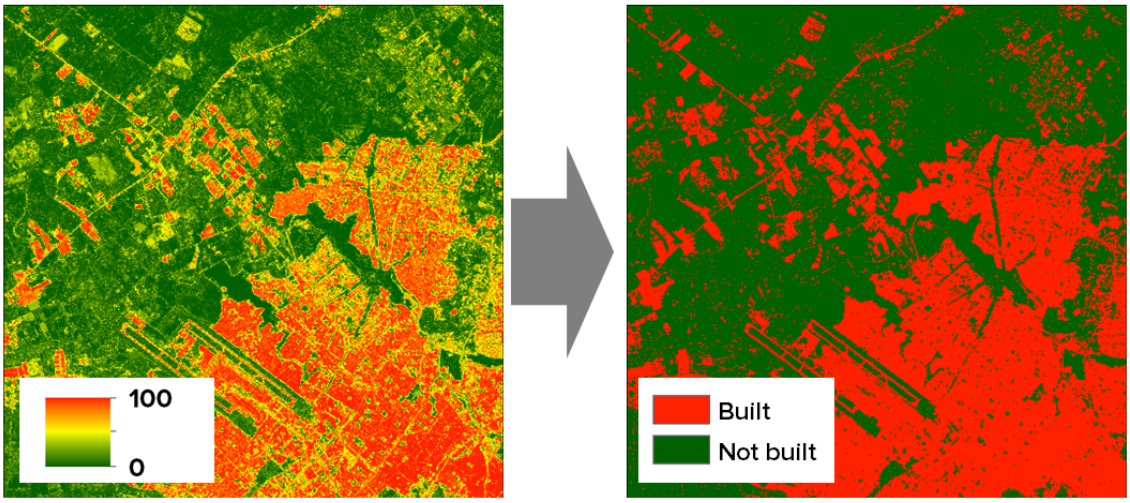


Figure 5: In Trends.Earth Urban Mapper the user has control on how the conversion from the continuous Impervious Surface Index (ISI, right) to the binary built up area map (built, left) will ocurr for their city of interest.

In TRENDS.EARTH the user needs to define 3 threshold values which will be used by the tool to estimate the built-up area for the area of interest. Those thresholds are:

- **Impervious Surface Index (ISI, 0-100)**: This is an index which varies between 0 and 100, with higher values being indicative of a higher percentage of impervious surface in the 30 m pixel. Setting the ISI threshold value lower will mean that your final built-up area dataset will include areas with low density of construction, usually found in the peripheries of the cities. Setting this value higher will make the assessment to focus on the high density city centers.
- **Night Time Lights Index (NTL, 0-100)**: The impervious surface index can, in some cases, present high values for areas covered with dry bare soil or rocks, since these type of surfaces have similar spectral properties as those of man-made impervious surfaces. To filter these areas we use night time lights, removing areas with high ISI and low night time lights present outside of city boundaries. The lack of a time series of night time lights of consistently calibrated for the time period considered (2000-2015), means that we can't mask year with its corresponding year, so we use VIIRS Nighttime Day/Night Band Composites Version 1 for the year 2015 (NOA, 2019). Setting the NTL threshold value lower will mean that your final built-up area dataset will include areas with low light density, usually found in the peripheries of the cities. Setting this value higher will make the assessment to focus on the high density city centers.
- **Water Frequency Index (WFI, 0-100)**: Water presence is a very dynamic feature of coastal or riverine environment, in some cases water will inundate land areas, and in others, humans will encroach into water bodies to occupy the space. To capture some of those dynamics, we have integrated into the tool a water frequency dataset (Pekel et al 2016). By adjusting the water frequency threshold, the user can choose to highlight these land-water dynamic areas. Setting the water frequency threshold value lower will mean that your final built-up area dataset will consider as covered by water areas with lower water frequencies throughout the time series, such as intermittent rivers or lakes. Setting this value higher will restrict water bodies to areas with a high frequency of water occurrence (i.e. permanent rivers and lakes).

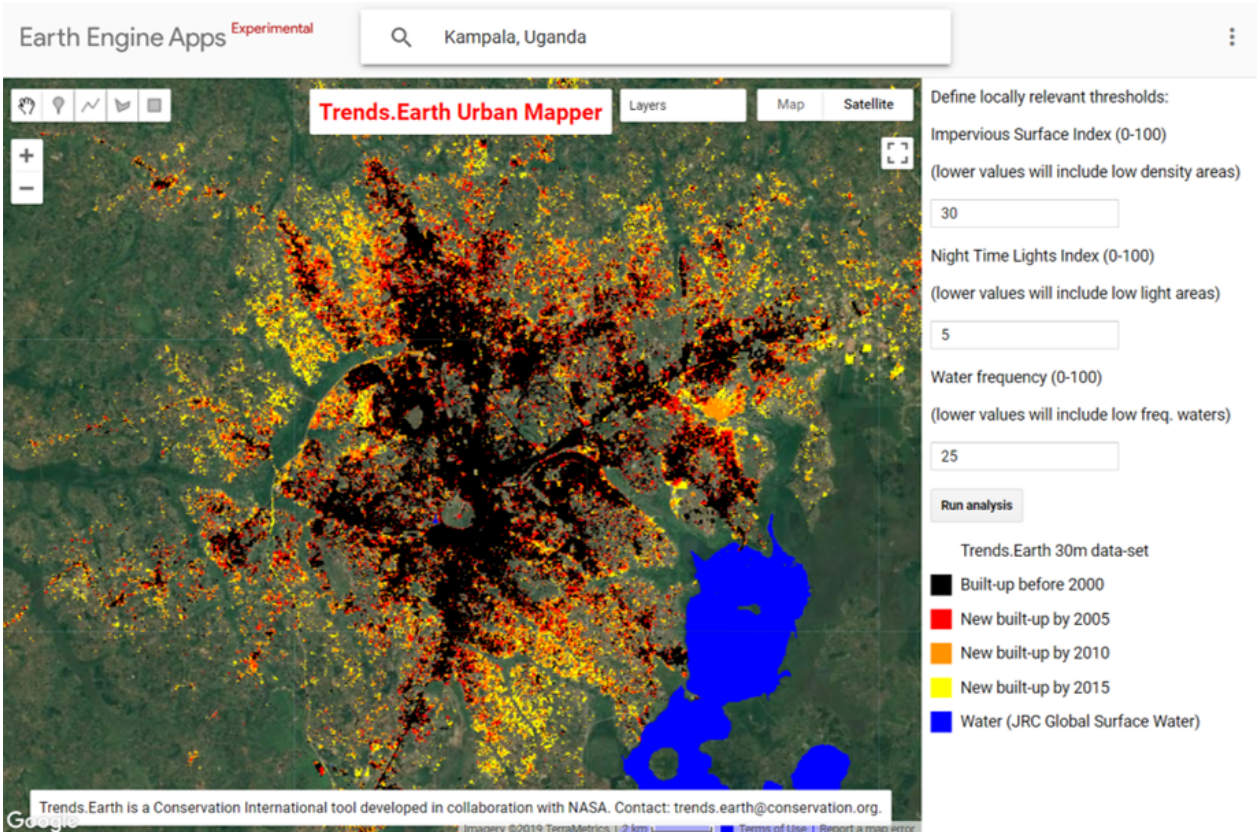


Figure 6: In Trends.Earth Urban Mapper the user defines a series of thresholds to go from the continuous Impervious Surface Index (ISI, right) to the binary built up area map (built, left).

Consistency test

When classifying remote sensing data into derived products, such as the impervious surface index computed by TRENDS.EARTH, omission and commission errors occur. One of the advantages of performing time series analysis is that the images from different years can be used to identify inconsistencies in the analysis. For that reason, 1998 and 2018 ISI layers were computed in this analysis, to add pre and post data points to filter possible errors in the classifications of the 2000 through 2015 series.

The thresholds defined in the previous section (ISI, NTL, and WFR) are applied to each of the individual layers of 1998, 2000, 2005, 2010, 2015, and 2018, generating a series of binary maps. The six binary maps are later combined into a time series dataset which contains information on the nature of each pixel for each year as “built-up” or “not-built”. One main rule is later applied to that series:

- A pixel is considered built only if 50% or more of data points after the first built detection identify the same area as built. For such pixels, the first detection as built will be considered the year of conversion. Areas with less than 50% built after the first detection will be considered as errors in the classification, and as a consequence, not built. we recognize that by applying this rule we are limiting the capability of the dataset to detect transitions from built to not-built. However, given the low likelihood of that transition to occur in urban environments, we feel comfortable making that assumption. Visual inspection of the results support the approach.

Global testing

TRENDS.EARTH provides through the Urban Mapper and the QGIS plug-in access to the global 30m time series of impervious surface indices. It is important however understand that the dataset has its limitations, and user’s input and control is needed to assess changes in indicator SDG 11.3.1 accurately. To test the performance of the indicator, we run the analysis on 224 cities globally (200 national capitals + 24 large cities in the Unites States of America, Figure 7). Using the Urban Mapper and visually comparing the product to very high spatial resolution images, we were able to define the thresholds appropriate for each city (ISI, NTL, and WFI) and also assess the quality of the product in a scale from 0 to 5. The results show that for 83% of the cities assessed Trends.Earth data can be used for estimating indicator SDG 11.3.1. The biggest limitation remains in small island states (for which no training data was available), hyper arid areas, and areas with low image availability.

1. **No data**: Cities for which no training data was available to build the impervious surface data set. These cities represent 6.2% of the sample assessed.
2. **Unusable**: Cities for which results are available, but due to low Landsat images availability prevented the production of a good quality product. These results should not be used for computing SDG 11.3.1 indicator. These cities represent 0.9% of the sample assessed.
3. **Problematic**: Cities with results of potential use for visually understating spatial patterns of built-up area expansion, but with significant errors. These results should not be used for computing SDG 11.3.1 indicator. These cities represent 4.0% of the sample assessed.
4. **Some issues**: Cities with results showing some issues confusing bare soil surfaces with built up area, could be used for computing SDG 11.3.1 after detailed inspection of the data. These cities represent 6.2% of the sample assessed.
5. **Minor issues**: Cities with high quality data but with the presence of some small areas of confusion. This data could be used for computing SDG 11.3.1. These cities represent 12.5% of the sample assessed.
6. **High quality**: Cities with high quality data showing perfect agreement between built-up area using Trends.Earth data and high resolution images available in Google Earth, high confidence for estimating SDG 11.3.1. These cities represent 70.1% of the sample assessed.

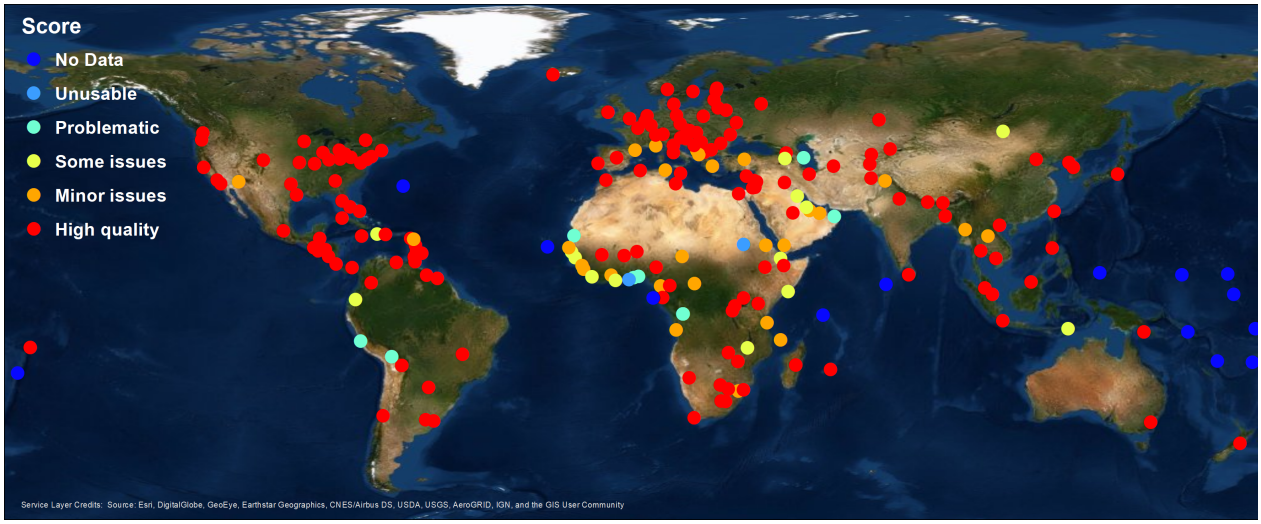
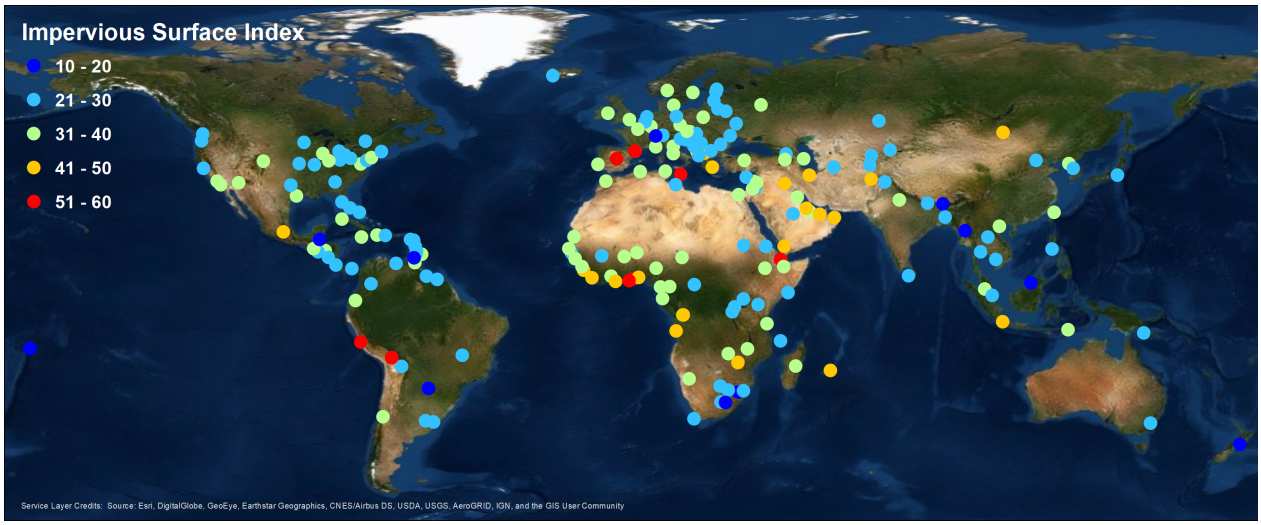
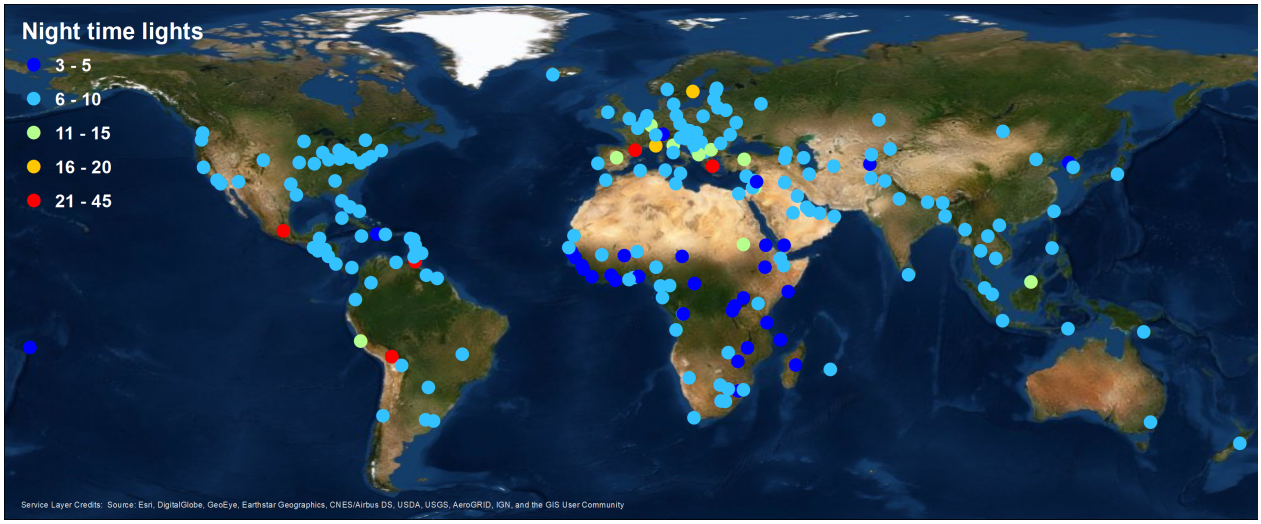


Figure 7: After testing in 224 large cities around the globe, the results show that for 83% of the cities assessed Trends.Earth data can be used for estimating indicator SDG 11.3.1. The biggest limitation remains in small island states (for which no training data was available), hyper arid areas, and areas with low image availability.





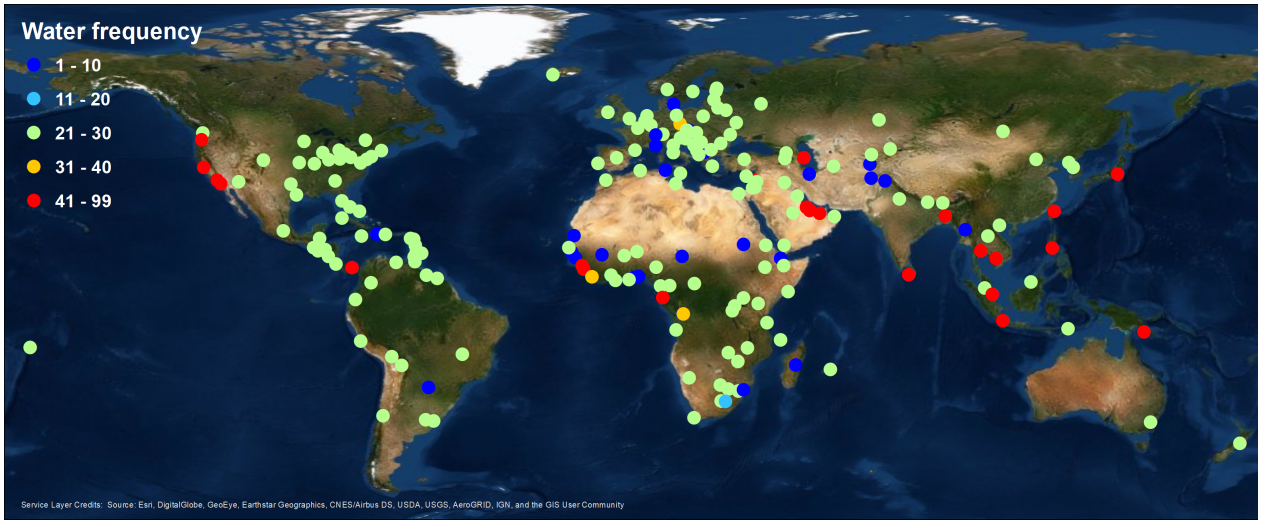


Figure 8: Spatial distribution of threshold parameters selected for the sample of 224 cities tested. Top: Impervious surface area indicator, Middle: Nighttime lights indicator, and Bottom: Water frequency indicator.

From the analysis of 224 cities globally we were able to estimate the range of parameters most commonly used. The most frequent values used were: **ISI = 30, NTL = 10, WFR = 25**. Those were the default parameters defined in the Trends.Earth Urban Mapper and QGIS plugin, but it is important to remember that for each city, careful inspection of the dataset should be perform, in order to find the set of parameters which better work for each site.

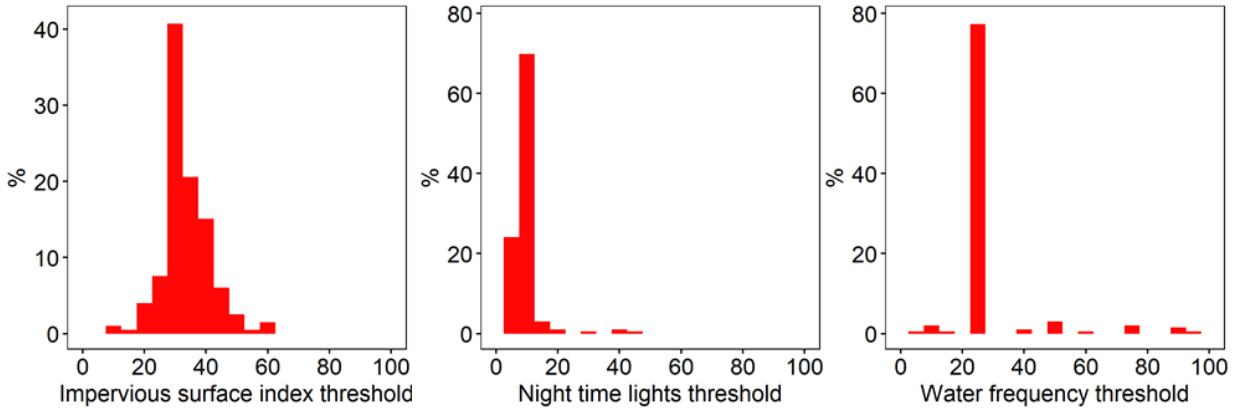


Figure 9: Frequency distribution of threshold parameters selected for the sample of 224 cities tested. Left: Impervious surface area indicator, Middle: Nighttime lights indicator, and Right: Water frequency indicator.

Urban zones

The urban extent is the proposed area of study that comprises of the built-up area and urbanized open space of the city, along with areas added by proximity analysis (UN-Habitat, 2019). UN-Habitat suggests classifying the area of interest into the 6 following classes in order to identify the area which will be used in the estimation of the annual land consumption rate (Figure 1):

Built-up areas will be classified based on the density within a 500 m of each pixel radius:

1. Urban: > 50% built-up in the 500 m radius.
2. Suburban: 25-50% built-up in the 500 m radius.
3. Rural: < 25 % built-up in the 500 m radius.

The non-built up areas will be considered open space (OS), and will be classified as follows:

4. Fringe open space: open space < 100 m from urban and suburban.
5. Captured open space: open space fully surrounded by fringe open space.
6. Rural open space: All other open space.

In TRENDS.EARTH, we have added to the scheme above by differentiating land from water open space, since the uses citizens can do of each space are very different.

7. Fringe open space - water: Fringe open space covered by water
8. Captured open space - water: Captured open space covered by water
9. Rural open space - water: Rural open space covered by water

Urban extent is determined by the combined area of classes 1, 2, 4, 5, 7, and 8 (urban, suburban, and fringe and captured open space).

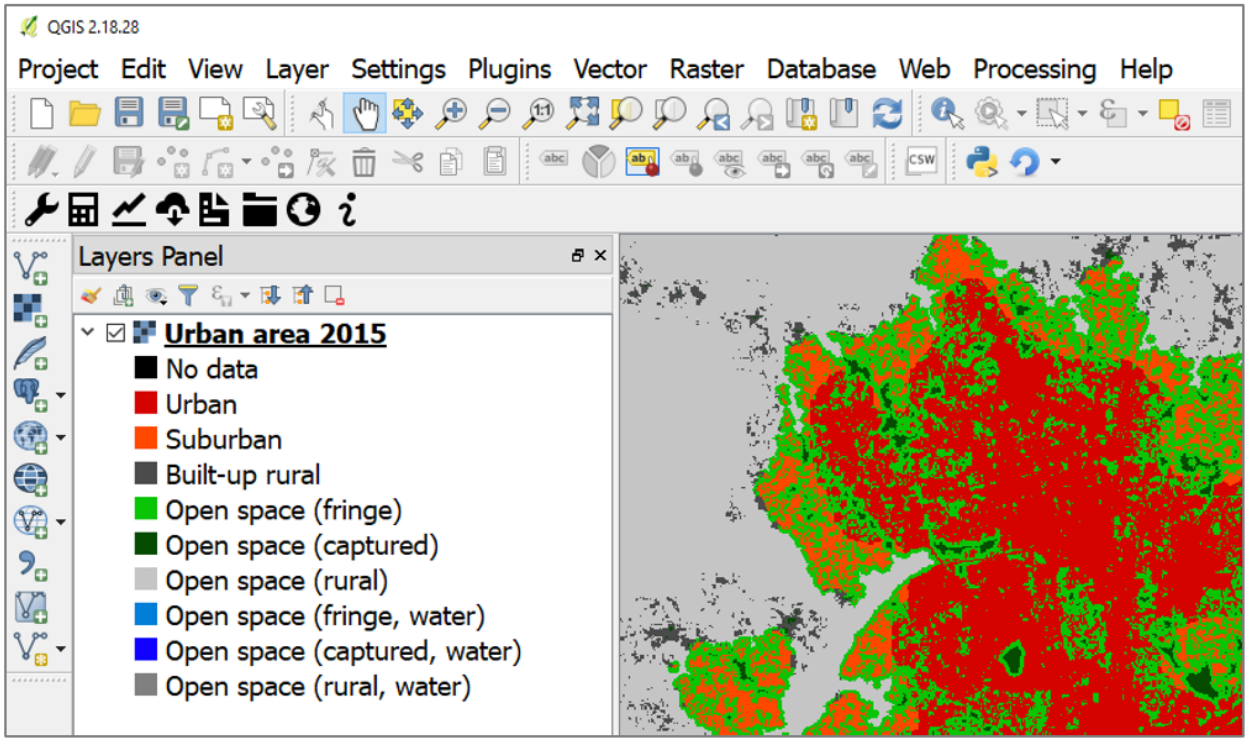


Figure 10: Result of the SDG 11.3.1 analysis displaying the different elements which comprise the urban space.

With this information we can now estimate the rates of urban expansion over time for the periods 2000-2005, 2010, and 2010-2015 needed to estimate the annual land consumption rate.

Population growth

Note

Source: UN-Habitat (2019) SDG Indicator 11.3.1 Training Module: Land Use Efficiency. United Nations Human Settlement Programme (UN-Habitat), Nairobi.

Once the urbanized areas have been defined, the next step is to establish how many people live within those areas for each analysis year. This information is then used to compute the annualized population growth rate. The estimation of the number of people living within each service area can be achieved through two broad approaches:

1. **Use of high-resolution data from national statistical offices (NSOs)**: In this option, census data is used to aggregate the number of people living in all households within the urban boundaries. Projections and extrapolations can also be easily undertaken based on the household characteristics to particular reporting years. The process is much easier where dynamic census units are used to identify the urbanized area, particularly because these are well aligned with the official population data architecture. This option provides the most accurate and authoritative population data for the indicator computation and is highly encouraged.
2. **Use of gridded population**: In this option, a population grid is made by distributing population to the entire administrative or census area unit. Attributes such as presence of habitable areas (land use classes) can be used to distribute the population, such that grid cells in tracks of undeveloped land or in industrial areas will have less population than high density residential areas. In the resulting grid, each grid cell will have a unique value, which is dependent on factors such as the total population within the enclosing administrative/census unit, and the number and/or quantity of the habitable land use classes. Figure 5 illustrates the general logic of population grids using only one land use class – the built-up areas. The population grid should always cover an area larger than the defined urban boundaries. Once the population grids are created, estimation of the population living within the urban boundaries can then be achieved by aggregating populations of the enclosed grid cells. In the absence of high-resolution data from NSOs, this option produces better estimates for population, although high quality input data and multi-level analysis are essential for enhanced data accuracy. Global datasets representing populations at 1km² and 250m grids are available (e.gs GPWv4, GHS-POP, WorldPop); most of which assume equal distribution of population to the habitable classes (e.g built up areas). This approach is proposed for the indicator computation where high resolution data from national statistical offices is not available or readily accessible.

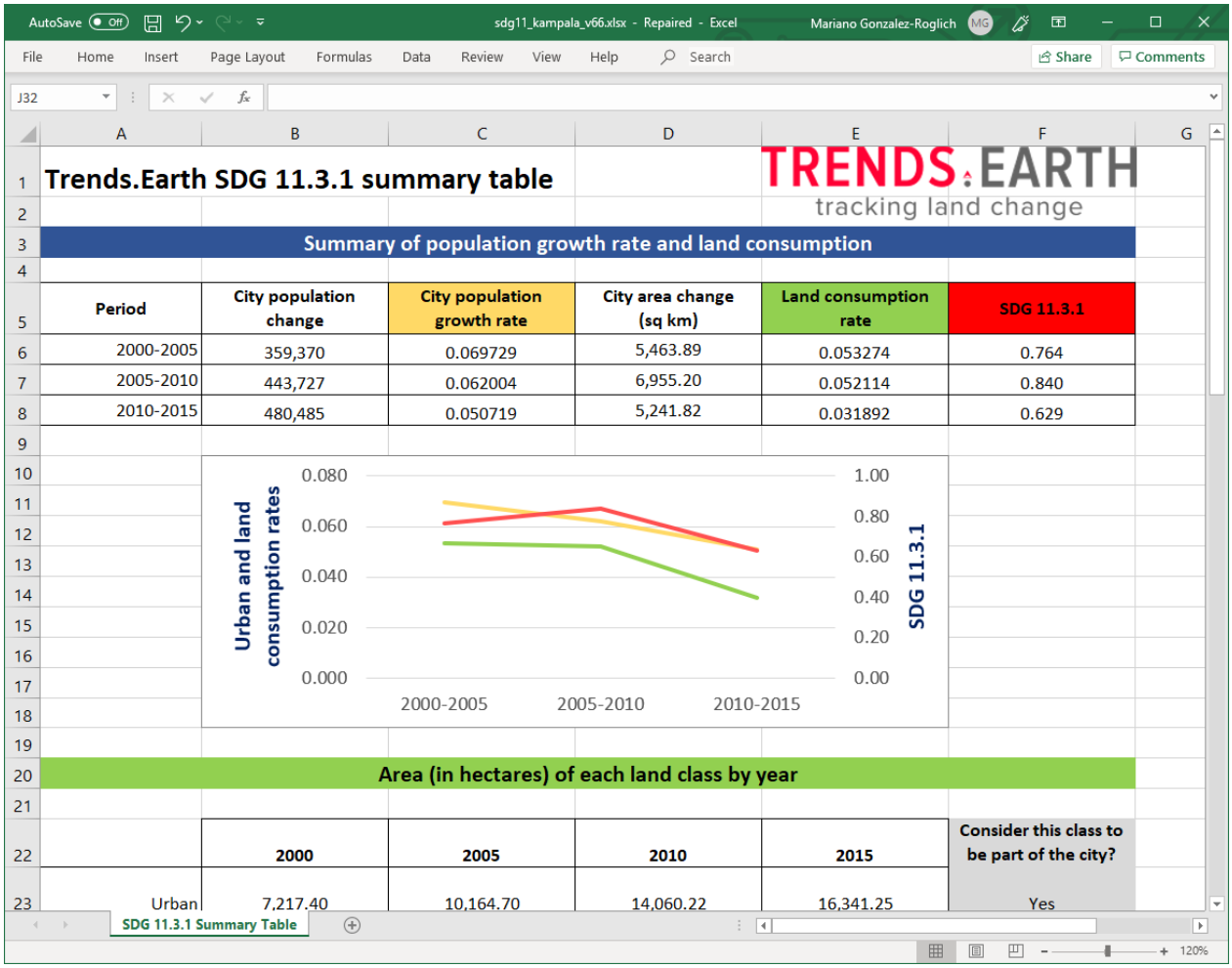
Population in Trends.Earth

In TRENDS.EARTH we recommend users to use option 1, since ate city scales the accuracy of high-resolution data provided by national statistical offices will always be higher than those obtained by global raster products which were, in most cases, produced for national level analysis. However, recognizing that in some areas population data will not be readily available to most users, we do provide data from the Gridded Population of the World V4 (GPWv4, CIESIN, 2016) as a reference. Even if the option to use GPWv4 in TRENDS.EARTH, the population data can be easily replaced by locally relevant high quality data by simply replacing the corresponding cells in the final tabular output.

Trends in SDG 11.3.1

The final outputs of the SDG 11.3.1 computations in TRENDS.EARTH will be:

1. The maps as presented Figures 10 and 11, which will allow for a visual interpretation of the changes occurred in the urban space between 2000 and 2015 at 5-year intervals.
2. A table which summarizes the area calculations for the different spaces within the city space (urban, suburban, and the different classes of open space), and also the corresponding population numbers. In this table the SDG 11.3.1 will also be computed automatically, and a trend of the indicator over time will be provided.



Trends.Earth SDG 11.3.1 summary table

TRENDS.EARTH tracking land change

Summary of population growth rate and land consumption

Period	City population change	City population growth rate	City area change (sq km)	Land consumption rate	SDG 11.3.1
2000-2005	359,370	0.069729	5,463.89	0.053274	0.764
2005-2010	443,727	0.062004	6,955.20	0.052114	0.840
2010-2015	480,485	0.050719	5,241.82	0.031892	0.629

Area (in hectares) of each land class by year

	2000	2005	2010	2015	Consider this class to be part of the city?
Urban	7,217.40	10,164.70	14,060.22	16,341.25	Yes

Figure 11: One of the final outputs of the SDG 11.3.1 analysis in |trends.earth| is a tabular outputs displaying the area, population and the indicator for SDG 11.3.1 for the city analyzed.

Note

For a step-by-step guide on how to run the analysis in TRENDS.EARTH, please refer to the following tutorial: Land Consumption (SDG 11.3.1).

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UN-Habitat (2019) Module 3: Land consumption. Accessed on 05/10/2019 from: https://unhabitat.org/wp-content/uploads/2019/02/Indicator-11.3.1-Training-Module_Land-Consumption_Jan-2019.pdf

Carbon emissions from deforestation

Background

Global forests store carbon, which can be released as carbon dioxide back into the atmosphere from degradation or deforestation, driving climate change. Between 2001-2020, global forests lost 10% area coverage, or 411 million hectares, releasing 165 Gt of carbon dioxide emissions (UMD & WRI, 2022). There is an increasing trend where high losses on tropical primary forests are shifting areas, like the Amazon rainforest, from a carbon sink to a carbon source (Bacchini et al., 2017). Drivers of this loss are attributed to wildfires, shifting agriculture, forestry, urbanization and commodity driven deforestation (Curtis et al., 2019).

Rationale for Monitoring

Monitoring deforestation is the first step to understand the cause of tree cover loss and to plan interventions for preventing it.

Note

Refer to the Forest and Carbon Change Tool for the tutorial to use this methodology and data.

Indicator and data needs

Trends.Earth allows the user to analyze the area of forest cover, carbon stored in forests, forest loss and estimated emissions from deforestation within an area of interest in terrestrial forests anywhere on Earth. The user is first prompted to select the years for monitoring their specified area for the analysis. In order to define the baseline forest area, they will assign a threshold to define forests.

Note

The definition of canopy cover should be changed to accommodate the specific area of interest.

The dataset maps global tree cover based on percent canopy cover in the year 2000. Many studies cite 25% - 30% threshold to define forest, however this definition can change for arid regions. For more information, please see the publication: Quantification of global gross forest cover “

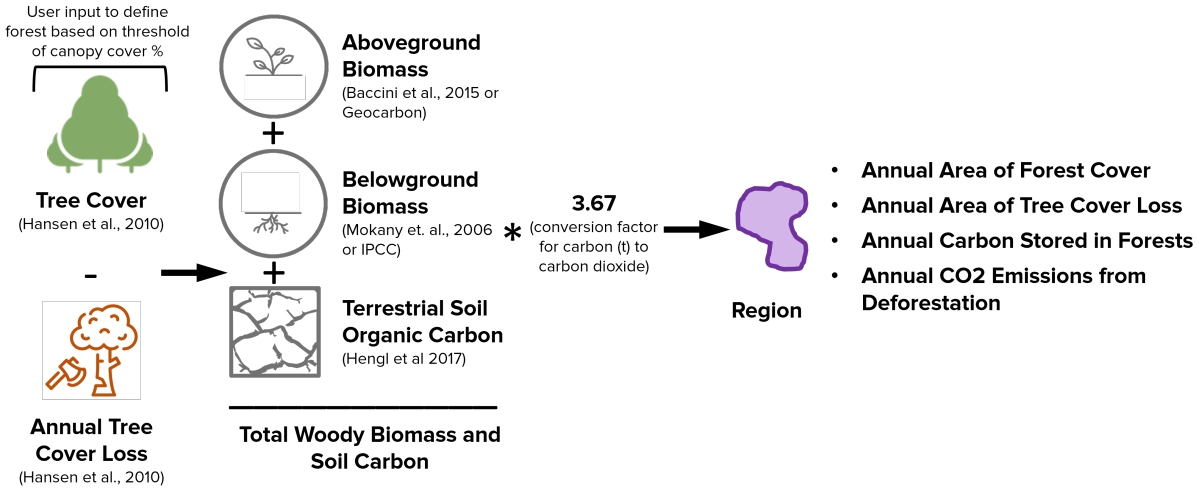
The region is then selected using the pre-existing national/sub-national boundaries, a coordinate or a custom uploaded dataset.

Note

The geoBoundaries Administrative Boundaries provided in Trends.Earth are under the CC BY 4.0 license. The boundaries and names used, and the designations used, in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

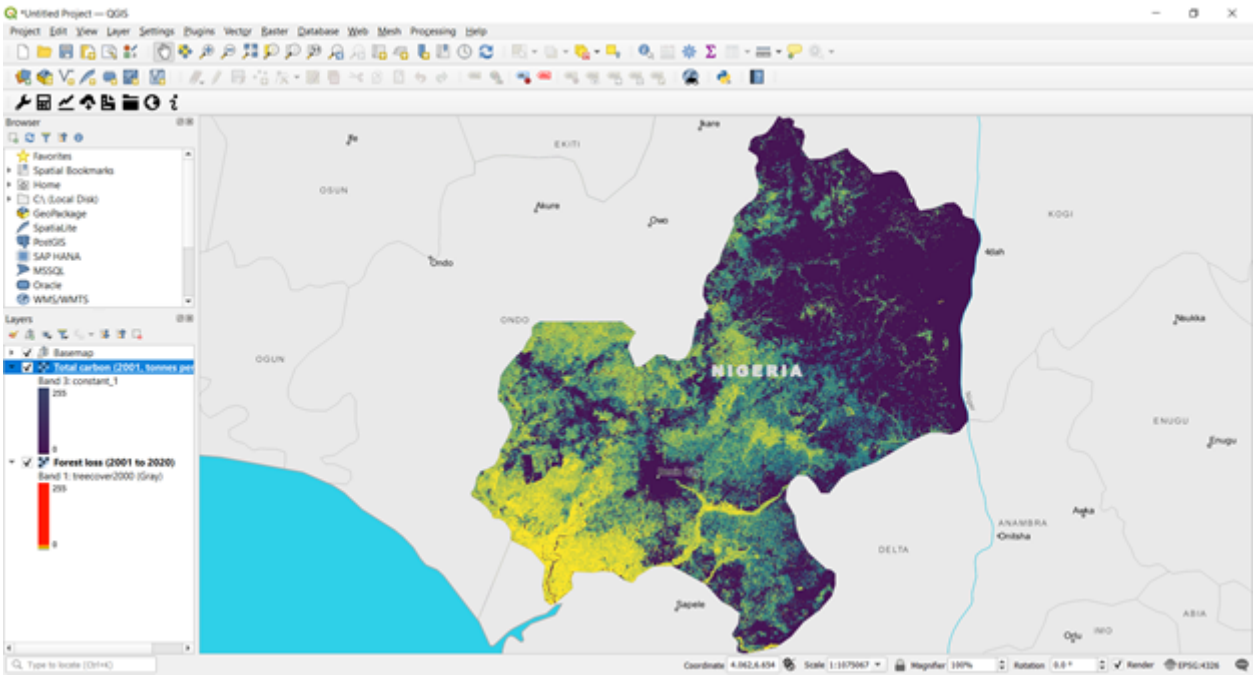
Users can set up ***Advanced configuration** to use a different biomass dataset, or upload a custom biomass dataset and to select the method for calculating the root to shoot ratio for below ground biomass.



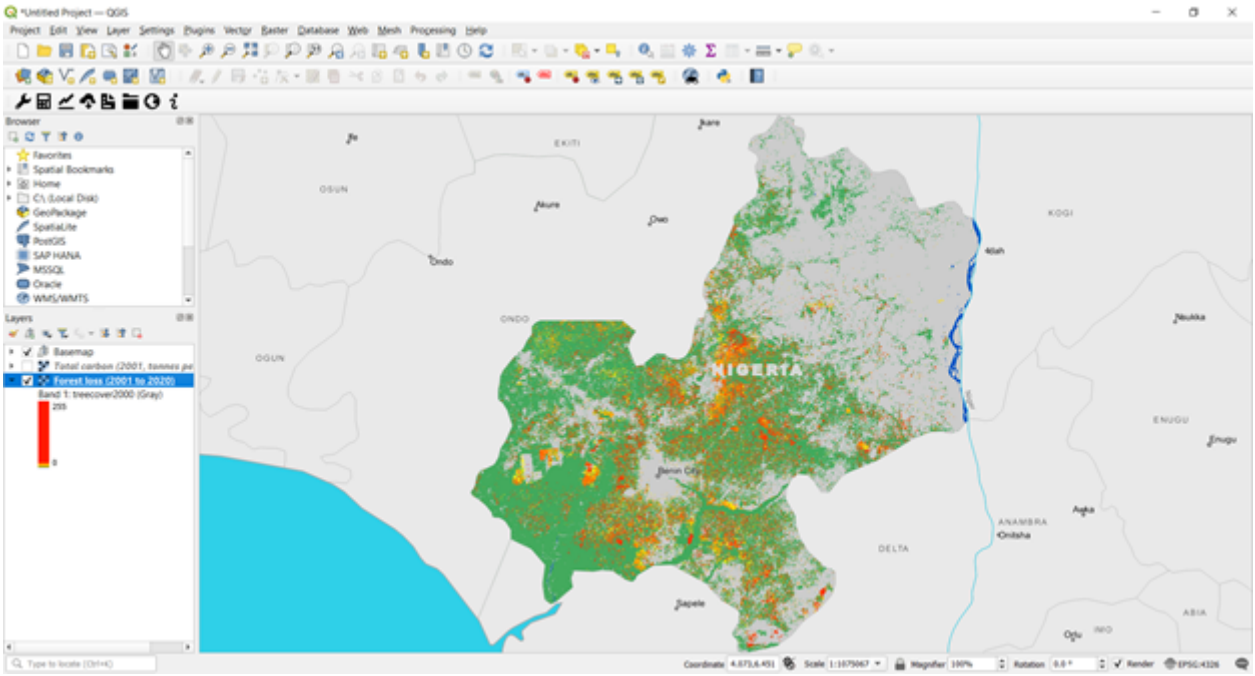
The table below list the biomass datasets available in Trends.Earth:

Dataset	Spatial	Extent	Units/Description
Woods Hole Research Center	30m	Global	A global map of aboveground live woody biomass (AGB) density for the year 2000, estimated by calculating thousands of points using LiDAR with regional allometric equations, then using those to train a wall-to-wall model based on Landsat imagery.
GEOCARBON	1 km	Global	Harmonized map of aboveground biomass in forests, using integrated pan-tropical map of aboveground biomass in woody vegetation and the boreal forest biomass map.

The results provide annual breakdowns of forest cover, forest loss, carbon (tC) stored and carbon emissions (tCO2) for the region, summarizing the baseline and final year land cover, forest area loss, carbon loss and carbon emissions over the entire period. There are two spatial outputs from the analysis. The first is the dataset visualizing the estimated change in biomass:



The second is the forest loss layer for the region:



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Potential carbon sequestration from restoration

Background

Restoration could remove 400 Gt of CO2 by 2100 (Griscom et. al., 2017), putting us on the pathway to reduce carbon emissions to keep us within the Paris Climate Agreement goal to limit “the increase in the global average temperature to well below 2 °C above preindustrial levels” (UNFCCC 2015). Forest landscape restoration is a natural climate solution for removing carbon dioxide from the atmosphere through different reforestation efforts.

Rationale for Monitoring

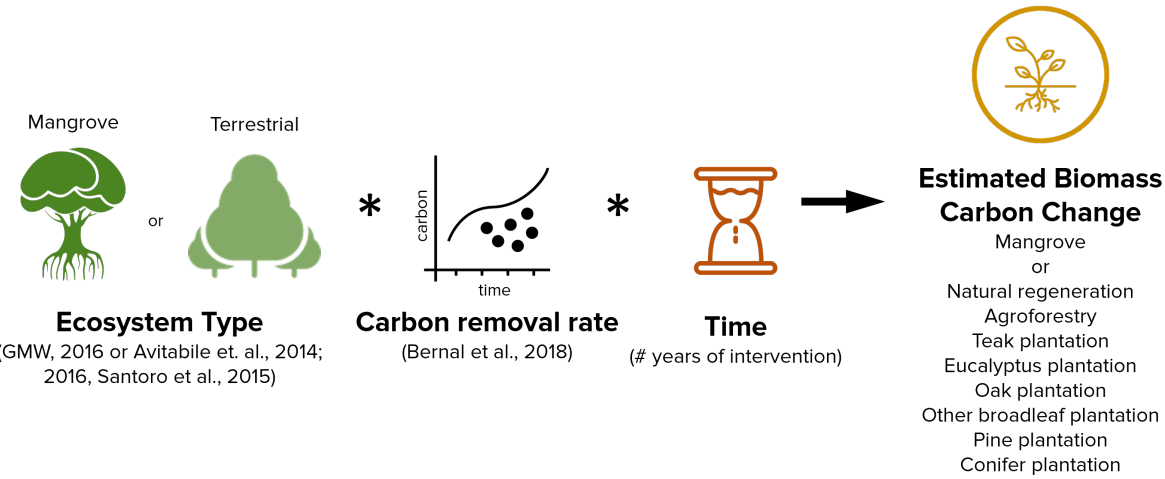
There is a need for tools to support restoration prioritization, and planning restoration activities on the ground. This module in Trends.Earth allows users to estimate the potential climate benefits of different forest landscape restoration approaches.

Note

Refer to the Potential Carbon Sequestration under Restoration for the tutorial to use this methodology and data.

Indicator and data needs

This module allows users to select a restoration type (terrestrial or mangrove) within a region and length of restoration activity to estimate change in biomass (CO2 equivalence) for 8 different restoration activities.



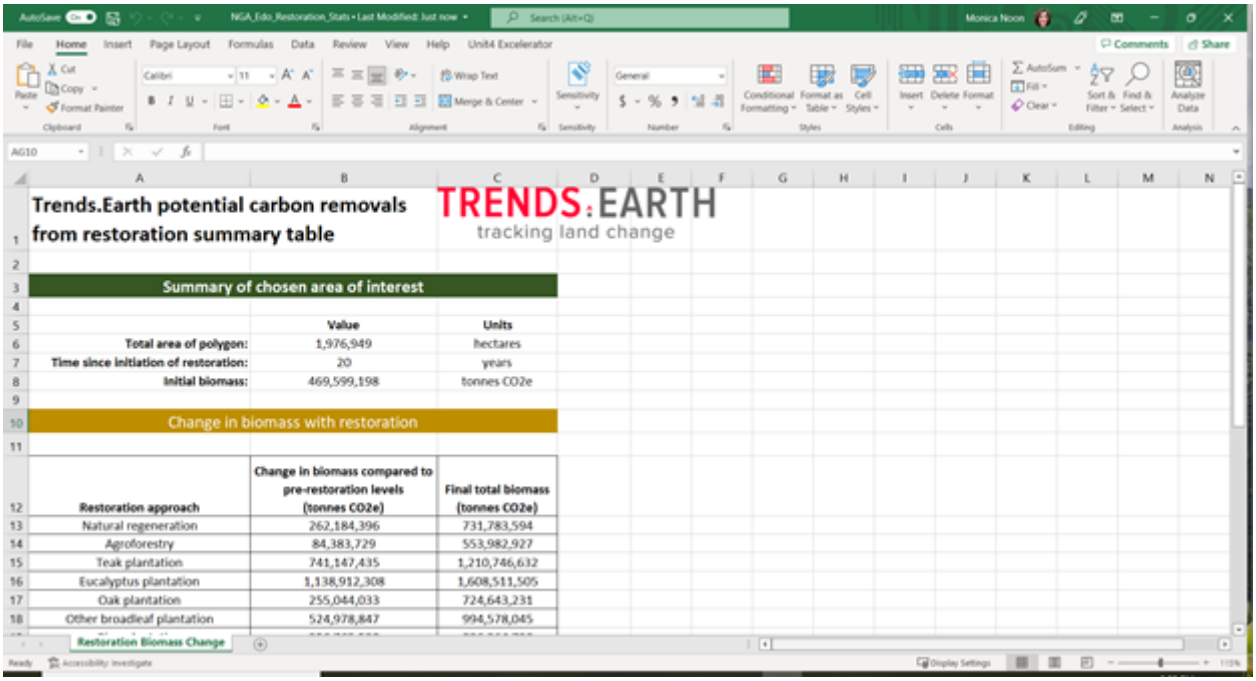
The years of intervention and region is then selected using the pre-existing national/sub-national boundaries, a coordinate or a custom uploaded dataset.

Note

The geoBoundaries Administrative Boundaries provided in Trends.Earth are under the CC BY 4.0 license. The boundaries and names used, and the designations used, in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

Trends.Earth gives the change in biomass under the 8 scenarios and a tabular output with the change in biomass compared to pre-restoration levels and final total biomass in tons CO2 equivalence.



Trends.Earth potential carbon removals from restoration summary table

TRENDS.EARTH
tracking land change

Summary of chosen area of interest

	Value	Units
Total area of polygon:	1,976,949	hectares
Time since initiation of restoration:	20	years
Initial biomass:	469,599,198	tonnes CO2e

Change in biomass with restoration

Restoration approach	Change in biomass compared to pre-restoration levels (tonnes CO2e)	Final total biomass (tonnes CO2e)
Natural regeneration	262,184,396	731,783,594
Agroforestry	84,383,729	553,982,927
Teak plantation	741,147,435	1,210,746,632
Eucalyptus plantation	1,138,912,308	1,608,511,505
Oak plantation	255,044,033	724,643,231
Other broadleaf plantation	524,978,847	994,578,045
Pine plantation	356,765,530	826,364,728
Conifer plantation	393,579,376	863,178,574

Sources:

Biomass accumulation rates are from: Bernal, B., Murray, L. T. & Pearson, T. R. H. Global carbon dioxide removal rates from forest landscape restoration activities. Carbon Balance and Management 13, 22 (2018).

Citations:

Avitabile, V., Herold, M., Heuvelink, G. B. M., Lewis, S. L., Phillips, O. L., Asner, G. P., Armston, J., Ashton, P. S., Banin, L. et al., 2016. An integrated pan-tropical biomass map using multiple reference datasets. Global Change Biology, 22, pp. 1406–1420.

Avitabile, V., Herold, M., Lewis, S.L., Phillips, O.L., Aguilar-Amuchastegui, N., Asner, G. P., Brienen, R.J.W., DeVries, B., Cazzolla Gatti, R. et al., 2014. Comparative analysis and fusion for improved global biomass mapping. Global Vegetation Monitoring and Modeling, 3 – 7 February 2014, Avignon (France).

Bernal, B., Murray, L. T. & Pearson, T. R. H. Global carbon dioxide removal rates from forest landscape restoration activities. Carbon Balance and Management 13, 22 (2018).

Bunting P, Rosenqvist A, Lucas RM, Rebelo L-M, Hilarides L, Thomas N, Hardy A, Itoh T, Shimada M, Finlayson CM. The Global Mangrove Watch—A New 2010 Global Baseline of Mangrove Extent. Remote Sensing. 2018; 10(10):1669. https://doi.org/10.3390/rs10101669

Griscom, B. W., et. al., 2017. Natural climate solutions. PNAS. 114(44) 11645-11650. https://doi.org/10.1073/pnas.1710465114

Santoro, M., Beaudoin, A., Beer, C., Cartus, O., Fransson, J.E.S., Hall, R.J., Pathe, C., Schmullius, C., Schepaschenko, D., Shvidenko, A., Thurner, M. and Wegmüller, U., 2015. Forest growing stock volume of the northern hemisphere: Spatially explicit estimates for 2010 derived from Envisat ASAR. Remote Sensing of Environment, 168, pp. 316-334.

United Nations Framework Convention on Climate Change, COP 21 Climate Agreement (UNFCCC, Paris). 2015. Available at unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf.

Getting Started

Installing Trends.Earth

QGIS installation

Before installing the plugin, QGIS version 3.44 or higher needs to be installed on your computer.

Download QGIS

To install the plugin, you must have QGIS version 3.44 or higher. For that, access the QGIS Download page and select the appropriate installer depending on your operating system (i.e. Windows, MacOS, Linux).

Install QGIS

Once the installer is downloaded from the website, it needs to be run (double click on it). Select the Default settings for all options.

Installing older versions of QGIS

Older versions of QGIS can be accessed at the below links. We recommend the latest version of QGIS (see instructions above) but the below links might be useful if you have a specific need for accessing an older version of QGIS (for example if you need to install an older version of TRENDS.EARTH).

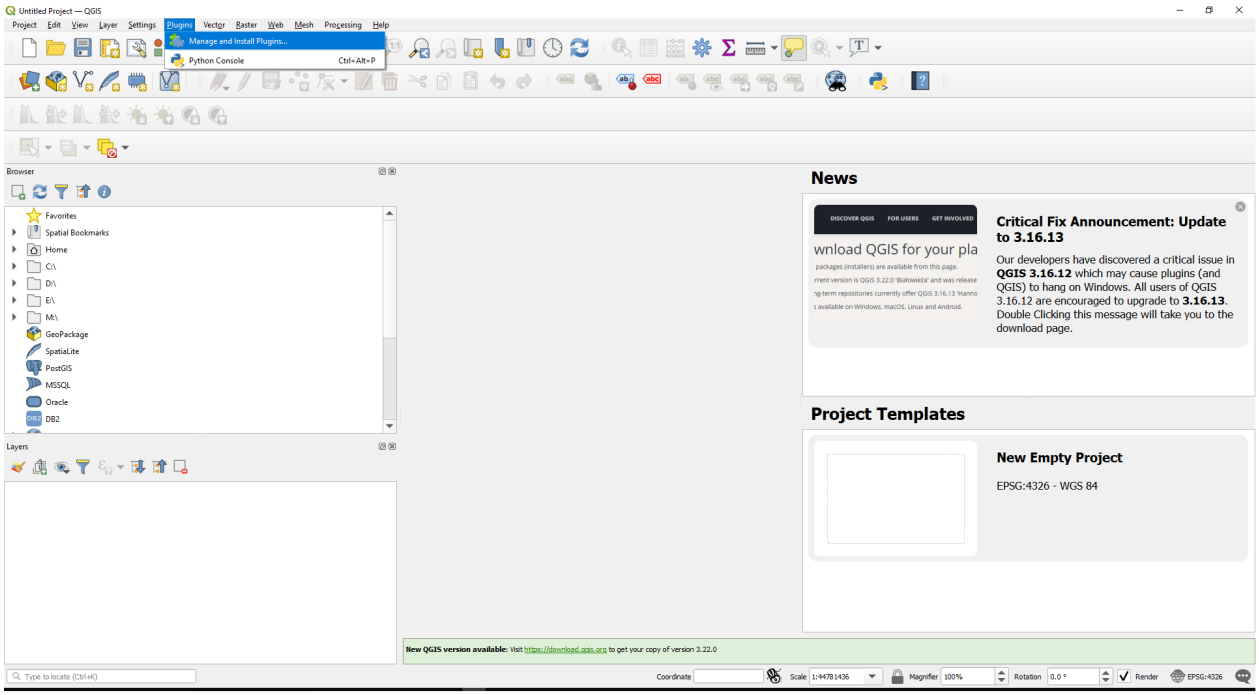
- Windows: Download older versions of QGIS for Windows here.
- MacOS: Download older versions of QGIS for MacOS here.

Trends.Earth installation

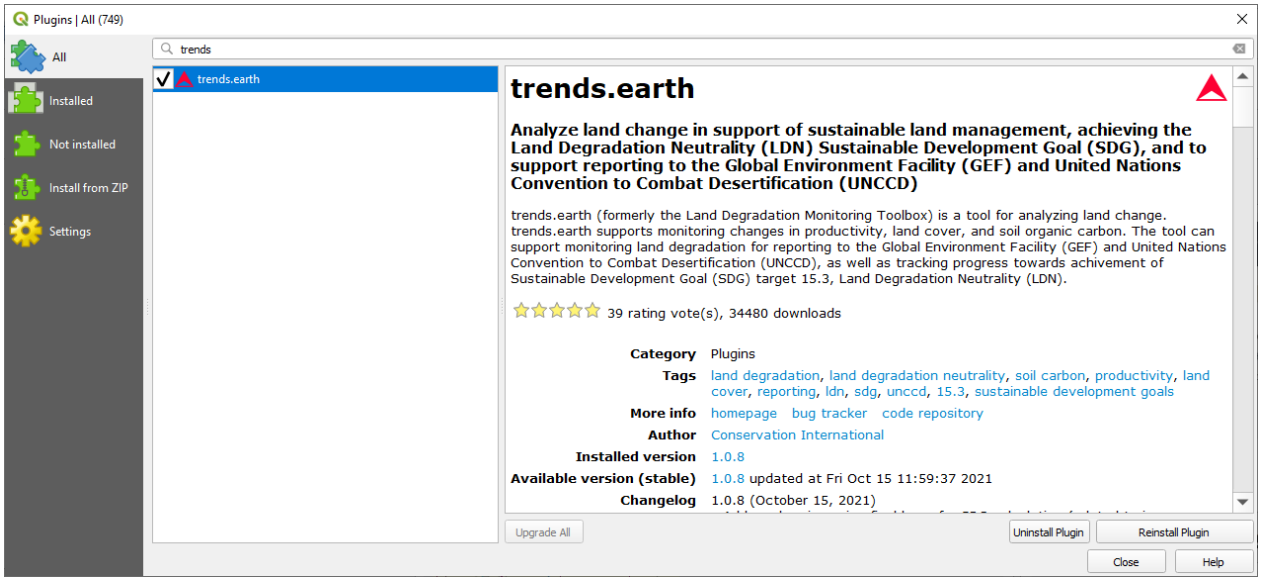
There are different ways to install TRENDS.EARTH, depending on whether you want to install the stable version (recommended) or the development version.

Installing the stable version (recommended)

The preferred way to install the TRENDS.EARTH is through QGIS. To install from within QGIS, first launch QGIS, and then go to *Plugins* in the menu bar at the top of the program and select *Manage and install plugins*.



Then search for a plugin called *trends.earth* and select *Install plugin* at the bottom right of the screen.



If your plugin has been installed properly, there will be a menu bar in the top left of your browser that looks like this:



If problems arise during installation

If you encounter any issues when installing or upgrading the plugin, we recommend you try the following before contacting the developers of TRENDS.EARTH:

- Try restarting QGIS after installing or upgrading the plugin - this can solve many common installation issues.

- If you are having a problem upgrading the plugin, try uninstalling the old version of Trends.Earth before installing the new one. This can be done from within the Installed tab of the plugins window.

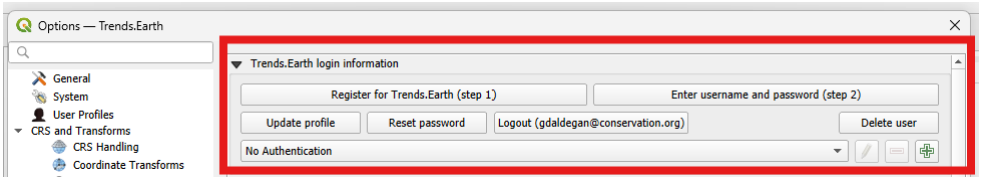
If the above don't work, please contact us at trends.earth@conservation.org.

Installing the development version (advanced users)

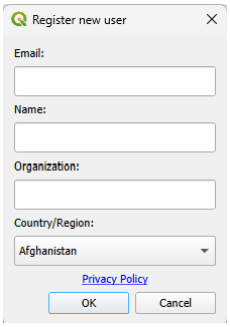
There are two ways to install the development version of the plugin. For more details, see the README for TRENDS.EARTH.

Trends.Earth registration

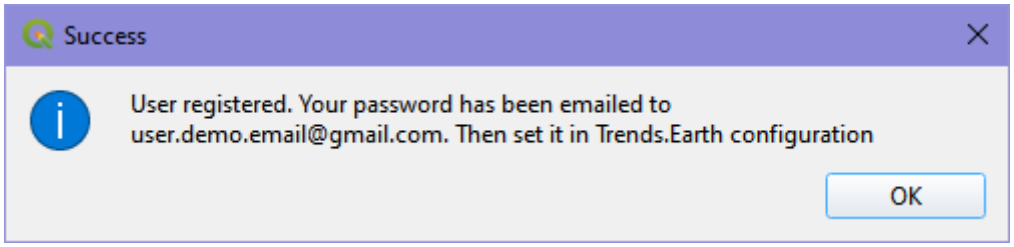
1. To Register, click the **Register for Trends.Earth (step 1)** button from the "Settings" dialog box under **Trends.Earth login information**.



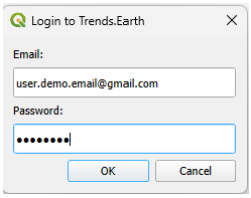
2. Enter your email, name, organization and country of residence.



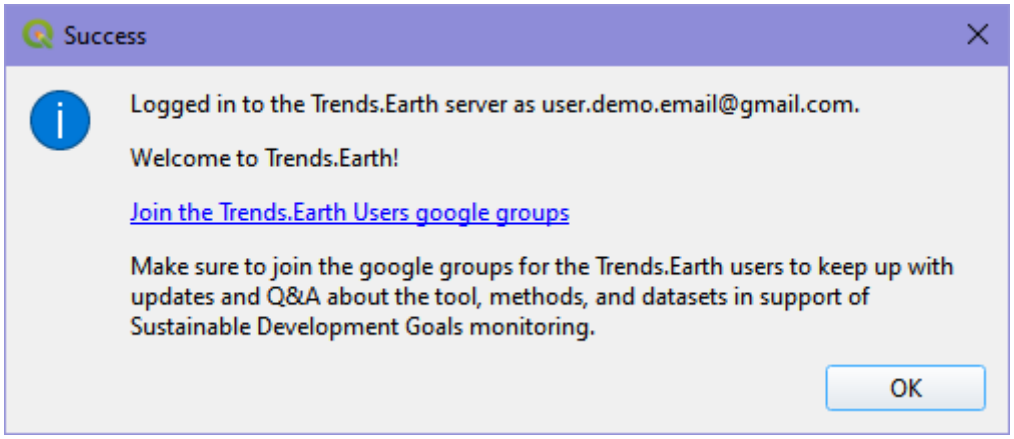
3. Select **Ok** and you will see a message indicating your user has been registered.



4. After registering, you will receive an email from api@trends.earth with your password. If you don't see the email in your inbox after 15-20 seconds, please check your spam folder in case the email was sent there. Once you receive this email , click on "Enter username and password (step 2)". Enter the password you received from api@trends.earth and click "OK": :



5. You will see a message indicating you have successfully been logged in:



You are now ready to start using Trends.Earth!

Browser

Trends.Earth Browser Application

Coming soon!

Training Manual

Settings

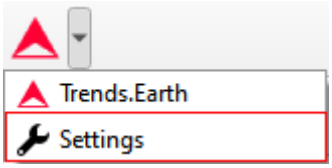
- **Objective**: Learn how to set up the environment for your analysis using Trends.Earth.
- **Estimated time of completion**: 5 minutes
- **Internet access**: Required

Introduction

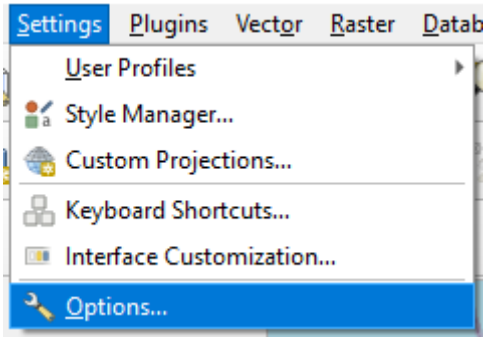
This guide provides instructions on the settings the user can set, accompanied by short explanations of each setting. Screenshots is included to make it easier for the user to know what each description refer to.

There are two approaches to open the Trends.Earth settings:

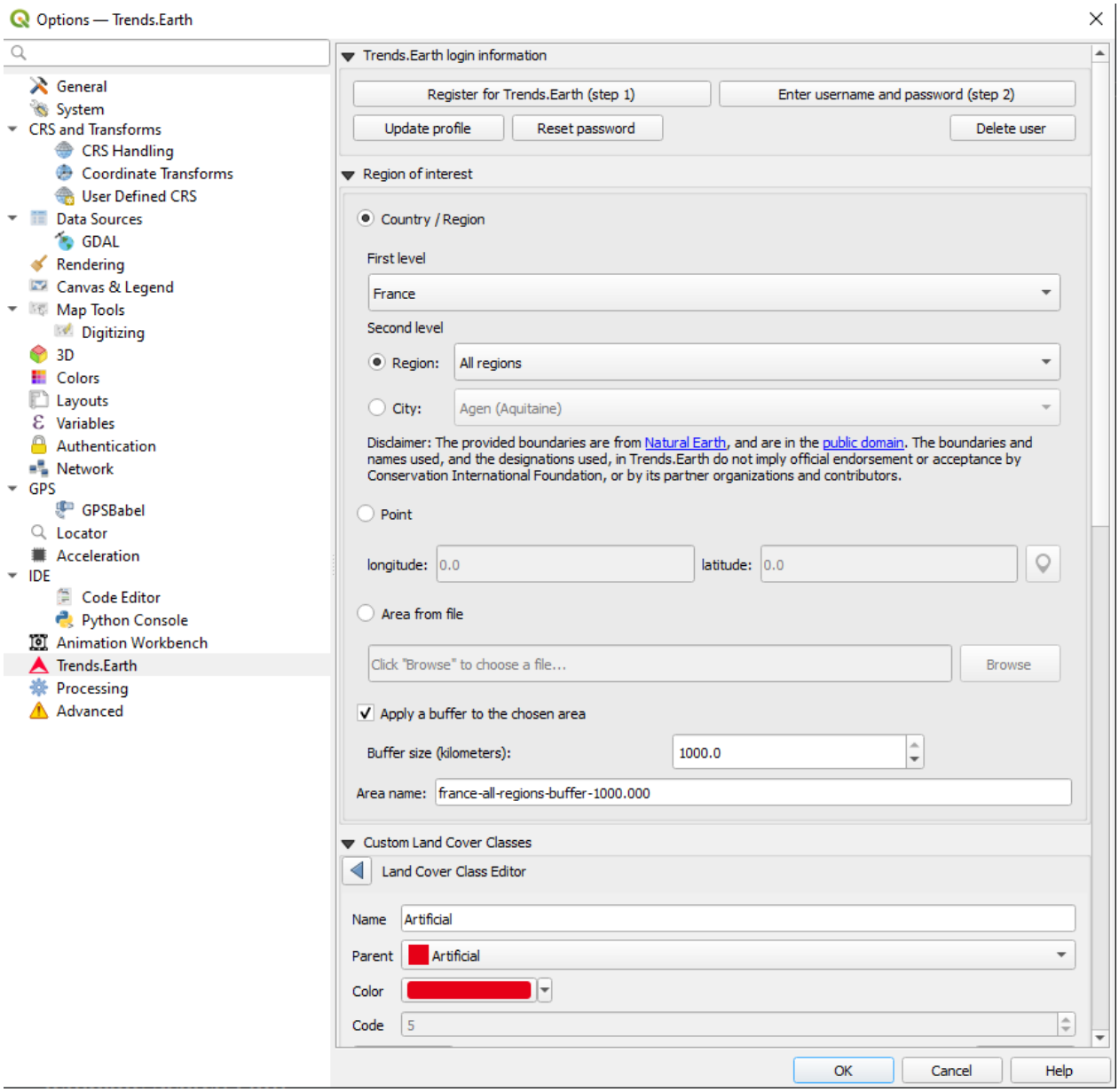
1a. Click on the Trends.Earth toolbar within QGIS, and click on **Settings**.



1b. Another approach is to click on **Settings** and then **Options**.



2. The **Settings** menu will open in a new window.



Trends.Earth login information

Use this area to register and login to your Trends.Earth account. You can update your profile, reset a password or delete your account. Once you login, your login credentials will be saved.

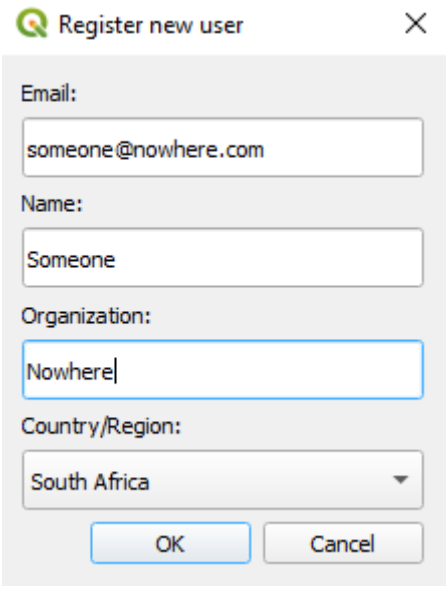


To register or login do the following:

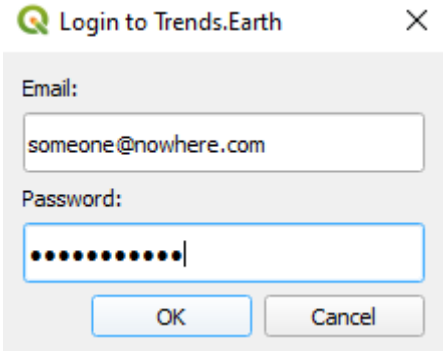
1. Click on Register for Trends.Earth to create an account. Provide the required information and click **OK**. You will receive an email.

Note

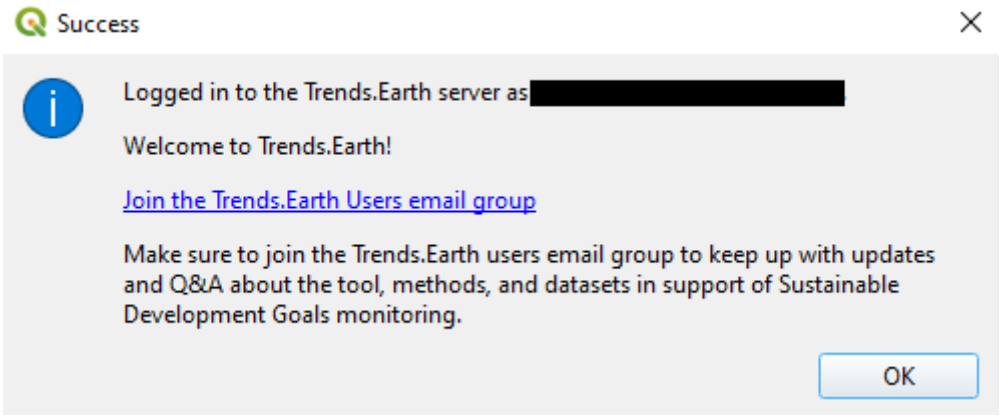
This step can be skipped if you already have an account.



2. Once you have received confirmation that your account has been created, click on **Enter username and password**. Provide your credentials and click **OK**.



3. When the login is a success you will receive the following message:



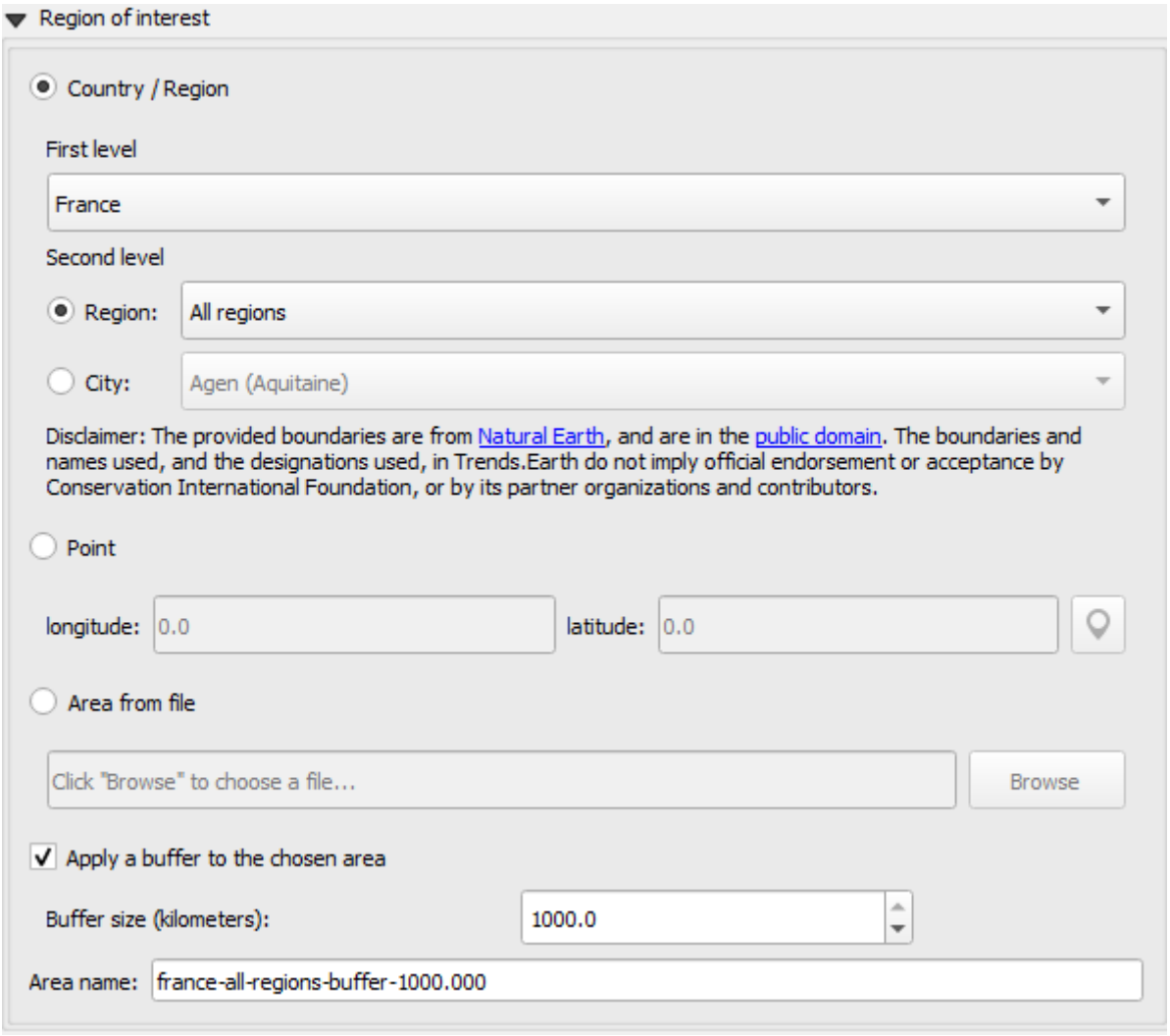
Note

Refer to the Trends.Earth registration for details on registering and logging into your Trends.Earth account.

Region of Interest

The region of interest can be set using one of three approaches:

1. **Country**: Select a country as the region of interest.
2. **Point**: Latitude and longitude coordinates. This can be manually typed in, or selected as a point in the QGIS canvas.
3. **Area from file**: Provide a vector file for the region of interest.



Country/Region

Select a country from the **First level** drop-down list. Sub-national analysis is possible using the **Second level** selections to identify a province or city for your region of interest.

Note

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If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

Point

Select this option to manually add coordinates or select a point on the map canvas.

Area from file

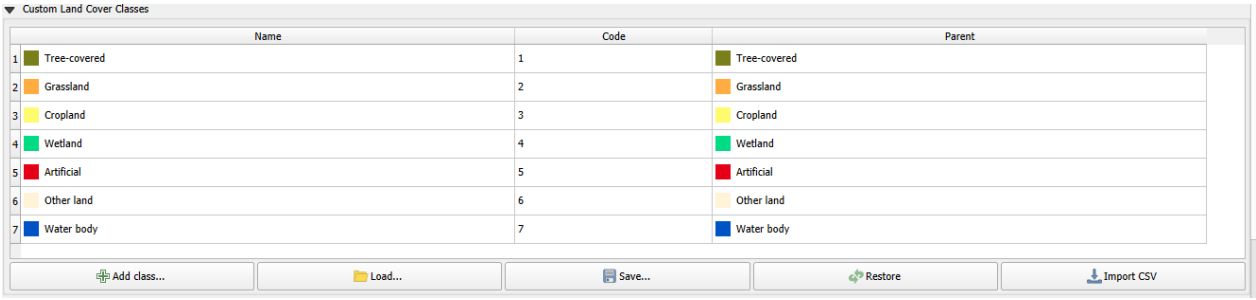
Select this option to upload a point or polygon of your choice. Supported formats includes shapefile, kml, kmz and geojson.

Note

Select Apply a buffer to the chosen area if you experience issues with geometries or want to add a buffer around a point entered in the city or coordinates options.

Custom land cover classes

Add, remove, or edit landcover classes. The landcover scheme can be exported using the **Save** option, and loaded from an existing file using the **Load** button.



The landcover class editor will open when the user clicks on the **Add class** or select a class in the table. Changes can be applied to the following parameters:

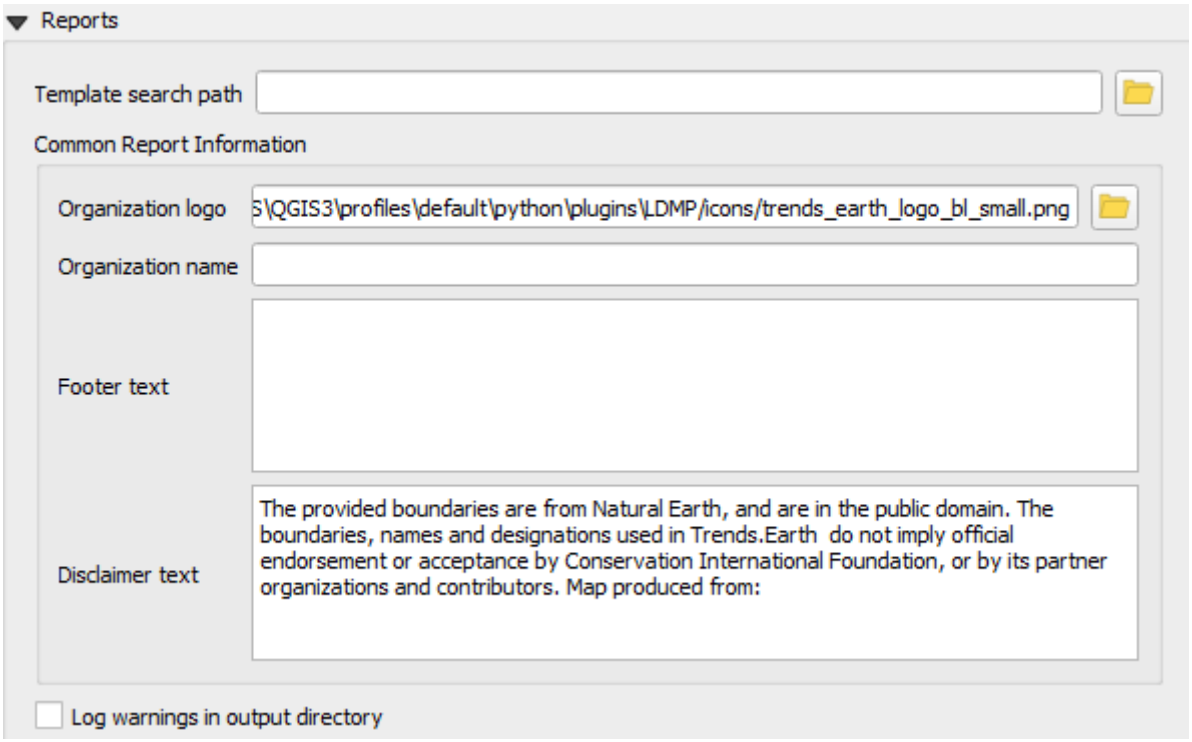
- **Name**: Title of the class
- **Parent**: Parent class of the selected class
- **Color**: Legend color for the class
- **Code**: Unique ID given to the class

Click **Done** once the changes has been made.



Reports

This contains configuration options for the Reports module.



Template Search Path

An additional directory containing report templates (qpt files). If there are templates with the same name to those in *[base_data_directory]/reports/templates*, then the system will prioritize and use the ones in the search path.

Common Report Information

Common contextual information that can be modified to suit the reporting context. Any changes to the settings under this category, will be applied in subsequent report generation tasks.

Note

These are only applicable in those report templates where the corresponding variables are used. For the default templates (that ship with the toolbox), only the organization logo and disclaimer text variables are used.

a. Organization Logo - This is a path to an image file that can be used as a logo in the reports. By default,

it points to *trends_earth_logo_bl_small.png* that ships with the toolbox. It is available as a QGIS layout variable named `te_report_organization_logo`.

b. Organization Name - Free text corresponding to the name of the organization. It is empty by default. It is

available as a QGIS layout variable named `te_report_organization_name`.

c. Footer Text - Free text that can be used in the footer section of reports. It is empty by default. It is

available as a QGIS layout variable named `te_report_footer`.

d. Disclaimer Text - Disclaimer statement that applies to one or more elements in the reports such as data.

The default statement reads:

The provided boundaries are from geoBoundaries (www.geoboundaries.org), and areunder the CC BY 4.0 license. The boundaries, names and designations used in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

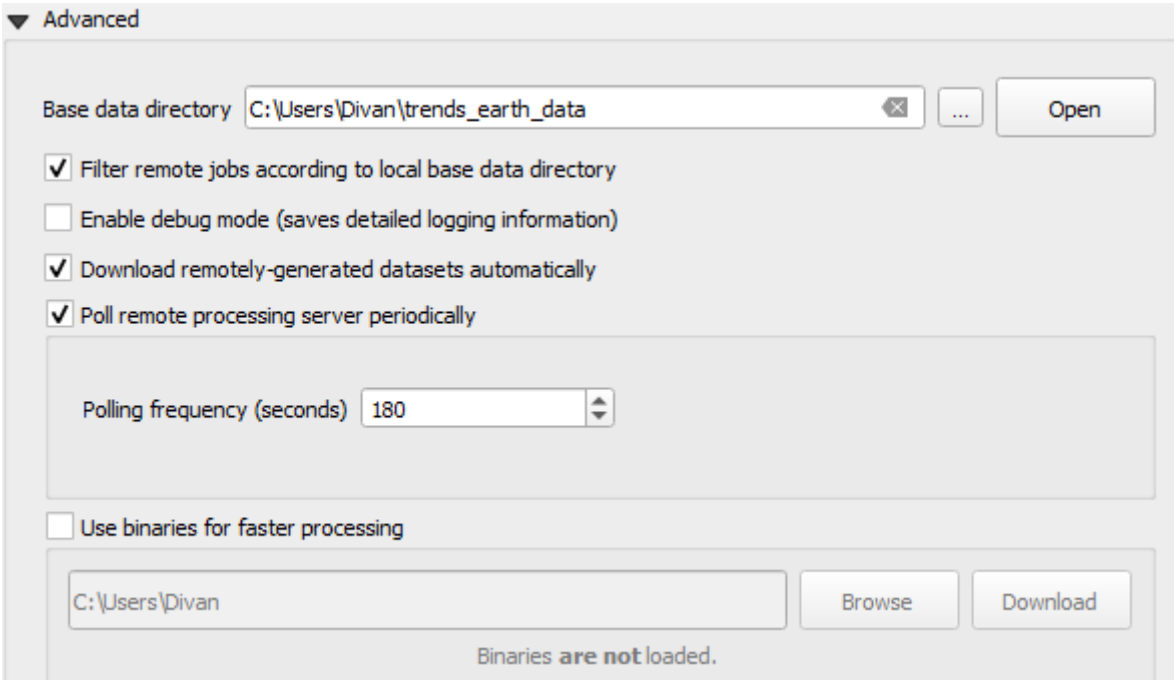
It is available as a QGIS layout variable named `te_report_disclaimer`.

Log warnings in output directory

When checked, the output report folder will contain a html file with details of any warning or errors that arose during the report generation process. It is useful for debugging purposes. By default, it is unchecked.

Advanced

Select the *Advanced* drop-down list to view more options within the Trends.Earth toolbox.



Base data directory

All data will be saved in the Base Data Folder. To change where data from Trends.Earth is stored select … button next to the Base data directory and select a folder to store your data.

There are several check boxes to set your preference under the Base data directory selection.

Check the boxes to:

1. Filter remote jobs according to local base directory
2. Enable debug mode - saves detailed logging information from your session
3. Download remotely-generated datasets automatically
   - Do not check this if you have limited bandwidth or are working offline
4. Poll remote processing server periodically

- This sets the frequency that the server will check for finished analyses to download automatically
- Do not check this if you have limited bandwidth or are working offline

5. Use binaries for faster processing: Select folder to store binaries

LandPKS login information

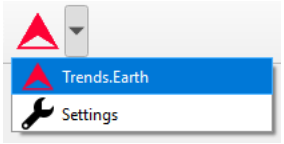
- **Coming soon**

Land Degradation

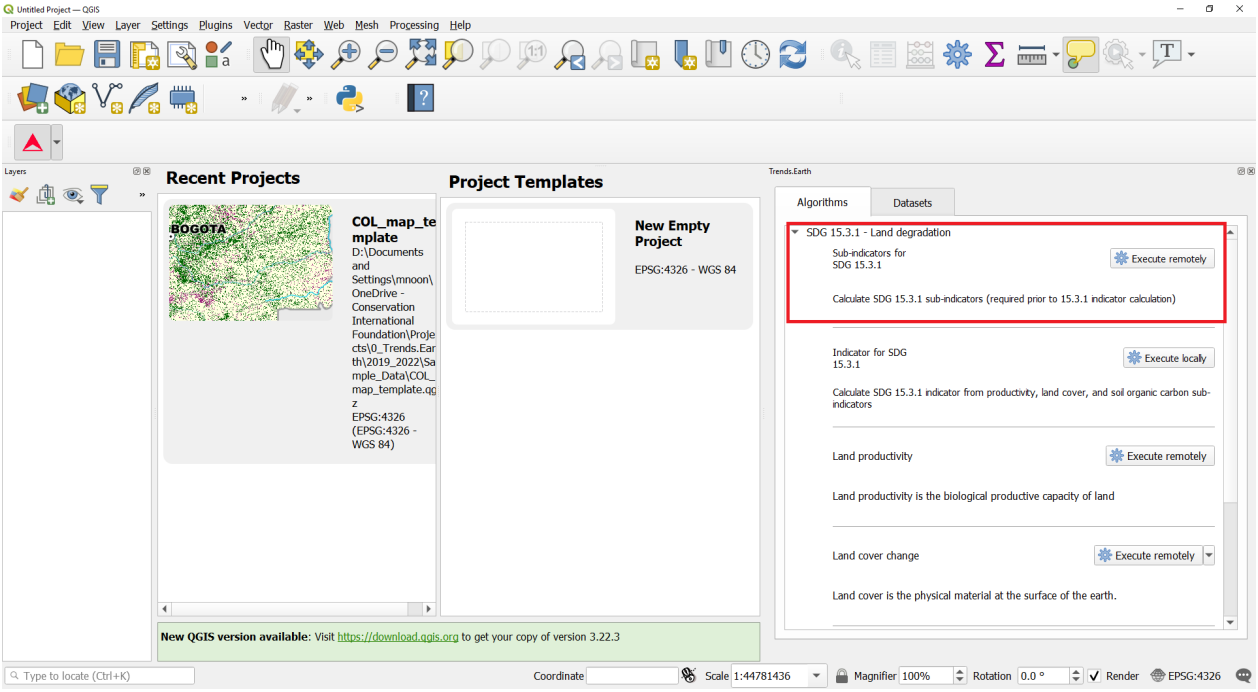
Land Degradation Sub-indicators

- **Objective**: Learn how to run SDG 15.3.1 sub-indicators (changes in land productivity, land cover and soil organic carbon) using Trends.Earth and the default data: Trends.Earth (trend, performance and state) for land productivity, ESA CCI for land cover, and SoilGrids for soil organic carbon. In this tutorial we will use Belize as an example, but you can choose any study area.
- **Estimated time of completion**: 35 minutes
- **Internet access**: Required

1. Click on the Trends.Earth toolbar within QGIS, and click on the **Trends.Earth** icon.



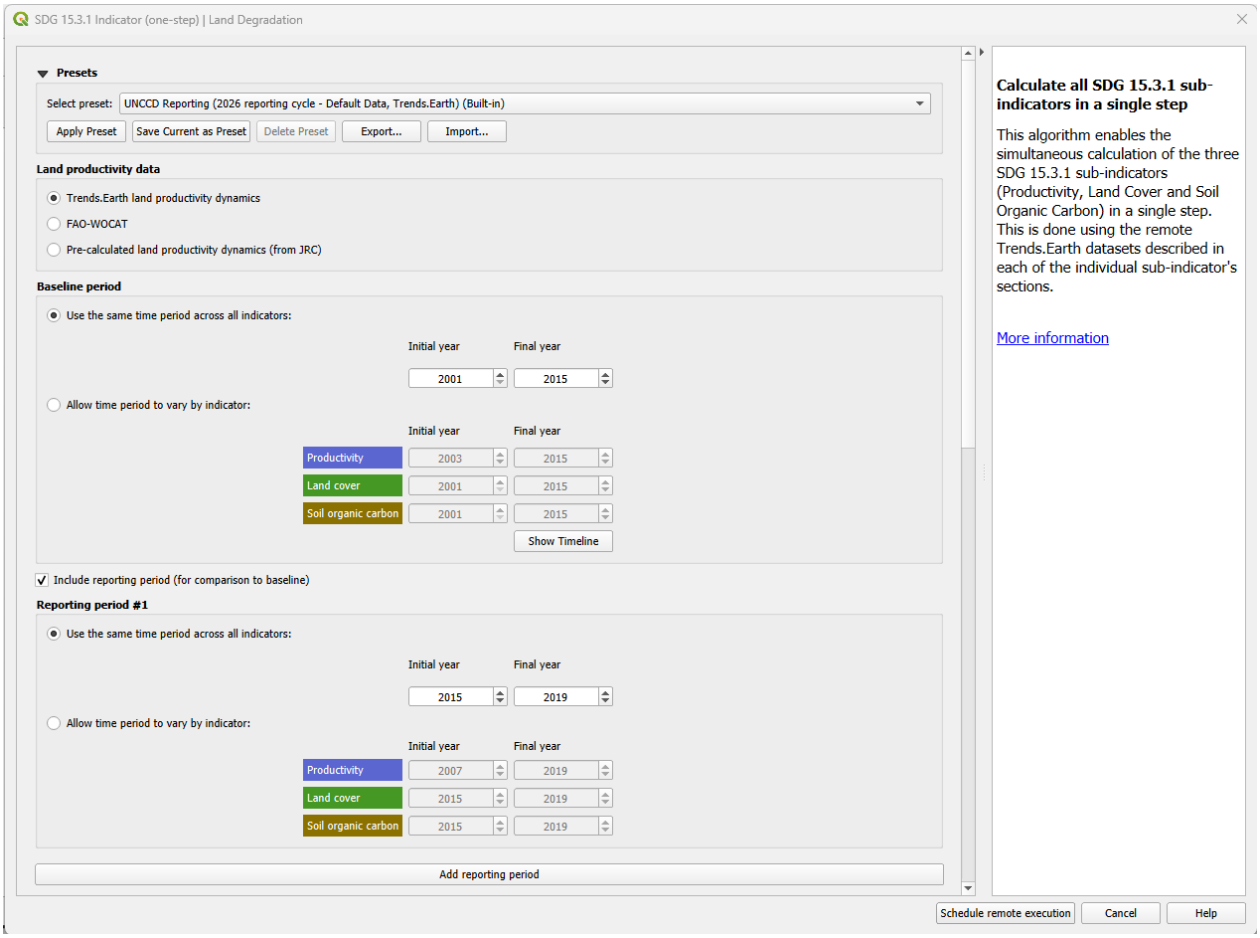
2. The **Trends.Earth** menu will open. In the **Algorithm** window, click on **SDG 15.3.1 - Land degradation** and select **Execute remotely** button.



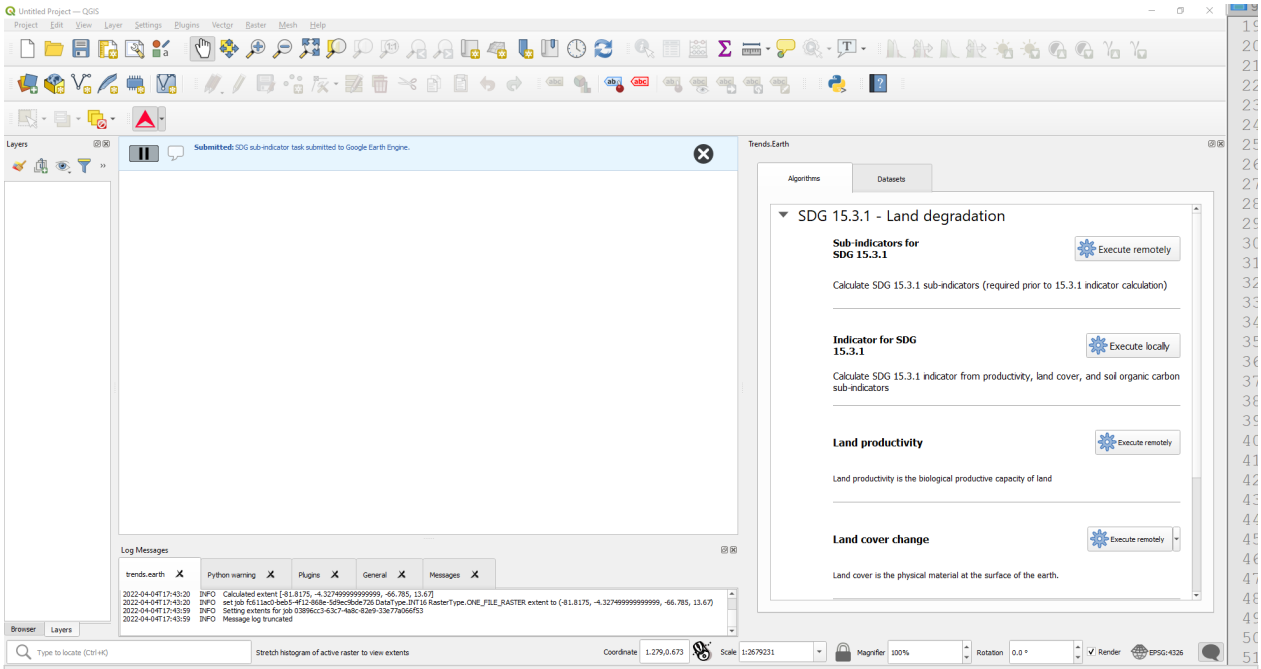
- The region of interest is already set up in Settings. If you need to change, select the **Change region** button.

> **Note**
>
> Refer to the Settings section of this manual for more information on setting up your area of interest.

3. In the **SDG15.3.1 Indicator (one-step) | Land Degradation** dialog, select the **Trends.Earth land productivity dynamics** data. Select also the **Include reporting period (for comparison to baseline)** check box to set the progress period for the first reporting period. If you want to add yet another reporting period, click on **Add reporting period**



4. Type in the Execution name and notes.
5. Click on **Schedule remote execution** button.
6. A light blue bar will temporarily show, indicating that the task was successfully submitted. The analysis will be run in Google servers and could take between a few to several minutes depending on the size of the study area (larger areas tend to take longer).



Note

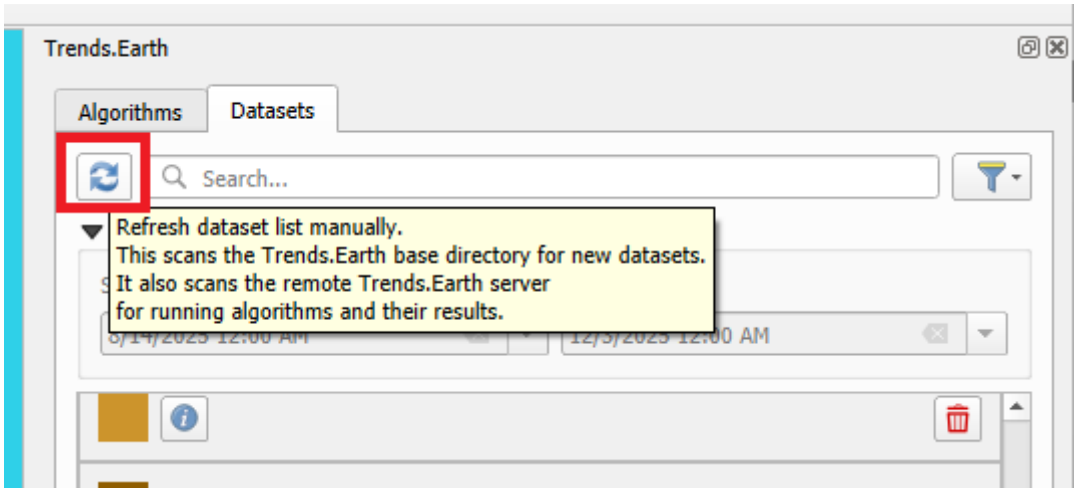
Refer to the Land Degradation section of this manual to learn about custom sub-indicators or Land degradation and SDG 15.3.1 section of this manual to learn about the Trends.Earth productivity indicators developed following the UNCCD Good Practice Guidance (GPG).

7. In the **Trends.Earth** panel, select the **Datasets** window. The task submitted will appear in the menu if the **Download remotely-generated datasets automatically** is checked in **Advanced settings**.

Note

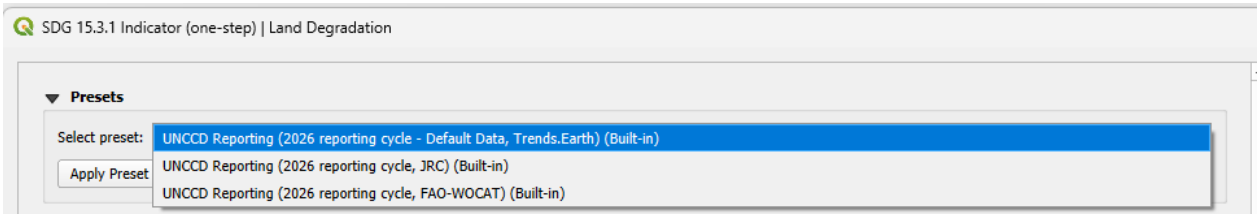
Refer to the Settings section of this manual to learn more about **Advanced settings**

- Click on the Refresh button if the analysis does not appear in the menu.

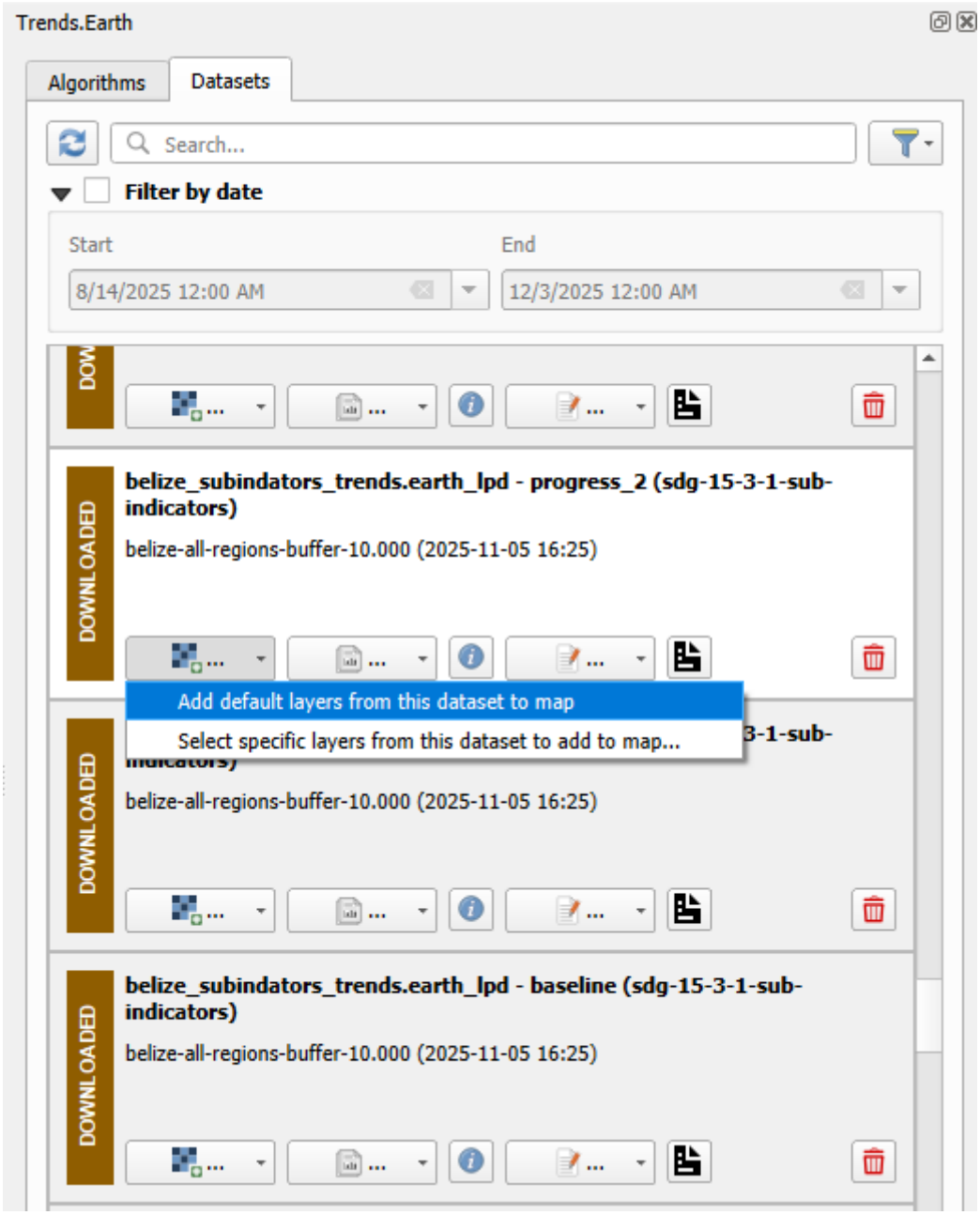


Note

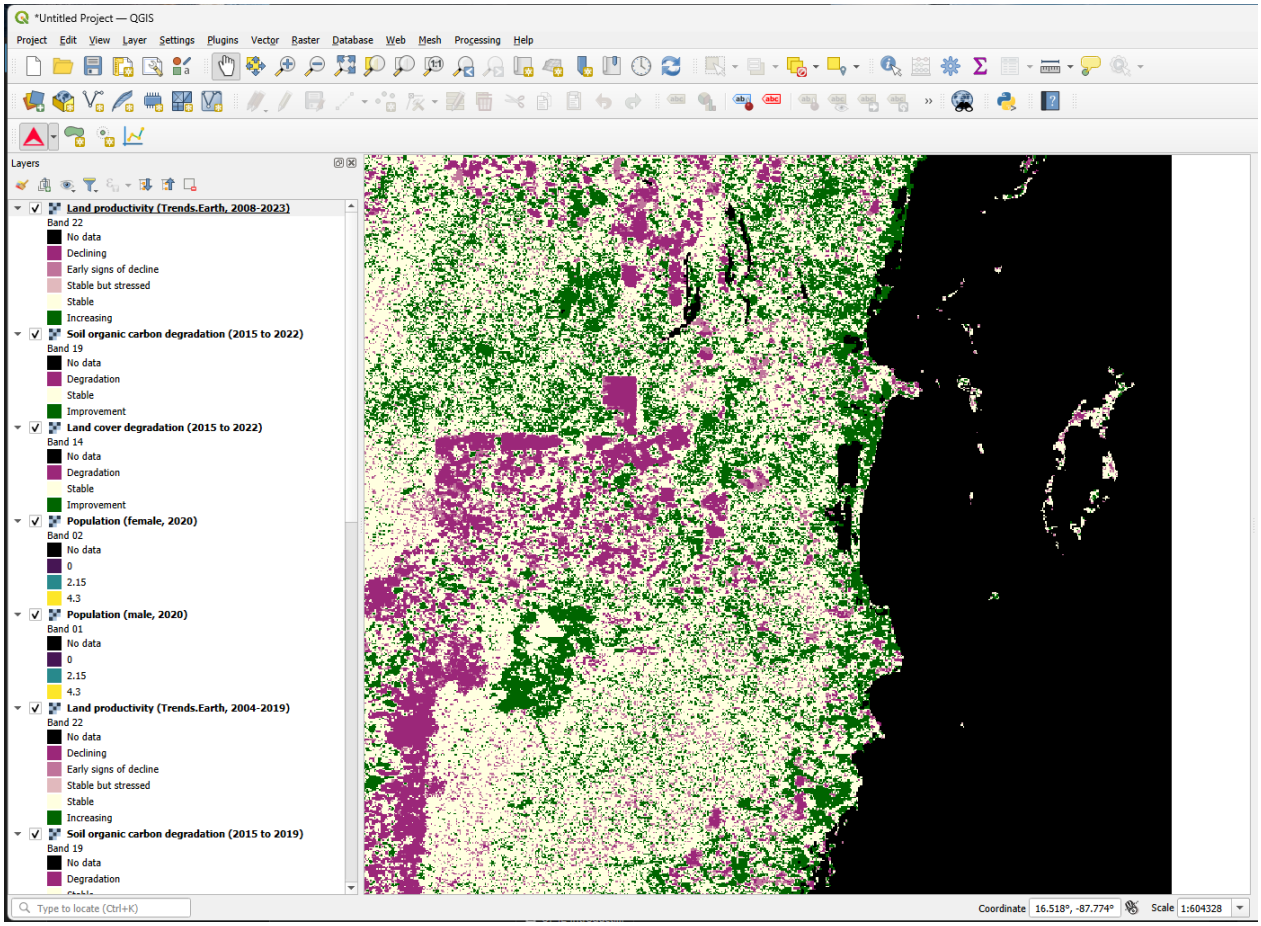
If you are preparing data for reporting to the UNCCD, **Trends.Earth** offers **Presets** that allow you to easily apply the official UNCCD reporting periods by the selecting the prefered option for the land productivity dynamics dataset. Select the preset of preference (i.e. Default Data, Trends.Earth; 2026 reporting cycle, JRC; 2026 reporting cycle, FAO-WOCAT) and click on **Apply Preset**. Other options available are to **Save Current as Preset** for saving a custom preset of preference; **Delete Preset** for deleting a previously saved preset; **Export** a preset to a JSON file; and **Import** a JSON file defining a preset.



8. Once the task is done, select the add layer drop-down button to **Add default layers from this dataset to the map**



9. The default data: Soil organic carbon degradation, land cover degradation, land productivity dynamics, and population disaggregated by gender, will be added to the map for the region of interest.



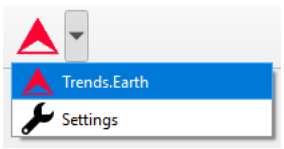
Calculate SDG 15.3.1 Indicator and UNCCD's SO 2-3

- **Objective**: Learn to integrate the land cover, land productivity and soil organic carbon sub-indicators to compute **SDG 15.3.1 Indicator** and **UNCCD's SO 2-3 Indicator** on proportion of population exposed to land degradation disaggregated by sex, in raster format and tabular outputs with areas estimated.
- **Estimated time of completion**: 20 minutes
- **Internet access**: Not required

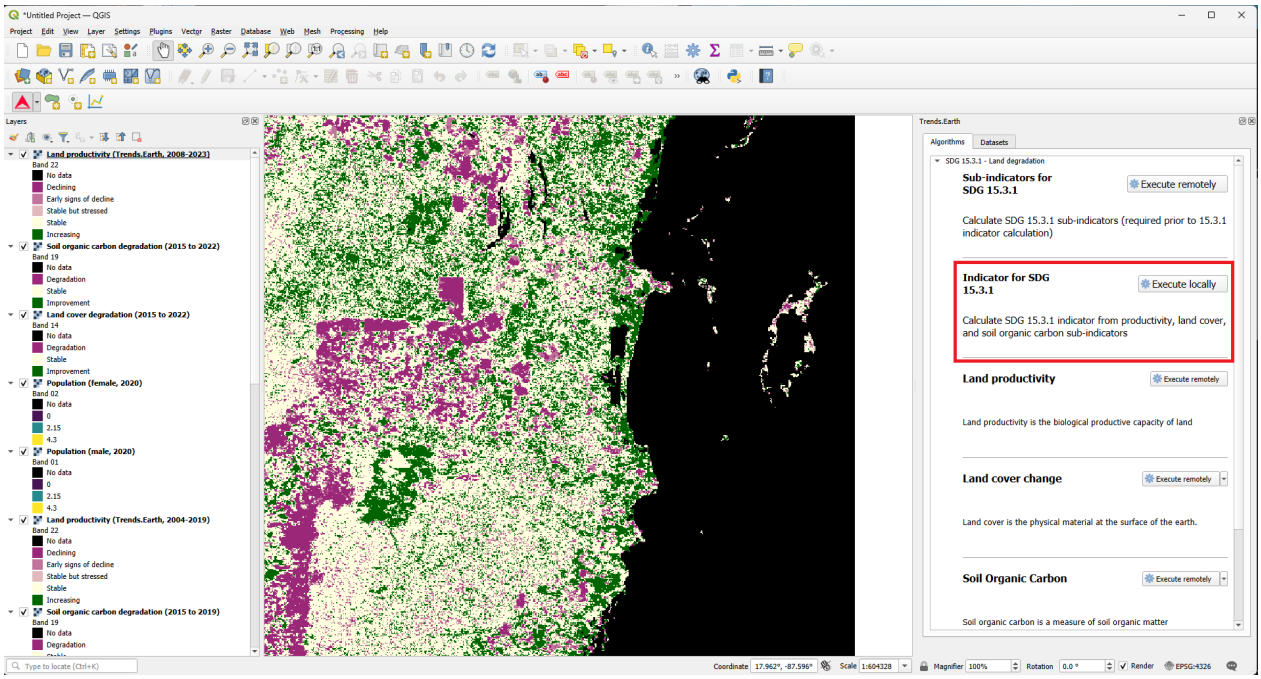
Note

You will need to have previously computed the sub-indicators prior to running this tool. If you have not, please refer to the following specific tutorials to compute them: Land Degradation, Custom Data - Land Cover, Custom Data - Productivity, and Custom Data - SOC.

1. Search for the Trends.Earth toolbar within QGIS, and click on the Trends.Earth icon.



2. The **Trends.Earth** panel will open. In the **Algorithm** window, click on **SDG 15.3.1- Land Degradation** and select **Execute locally** under **Indicator for SDG 15.3.1**.

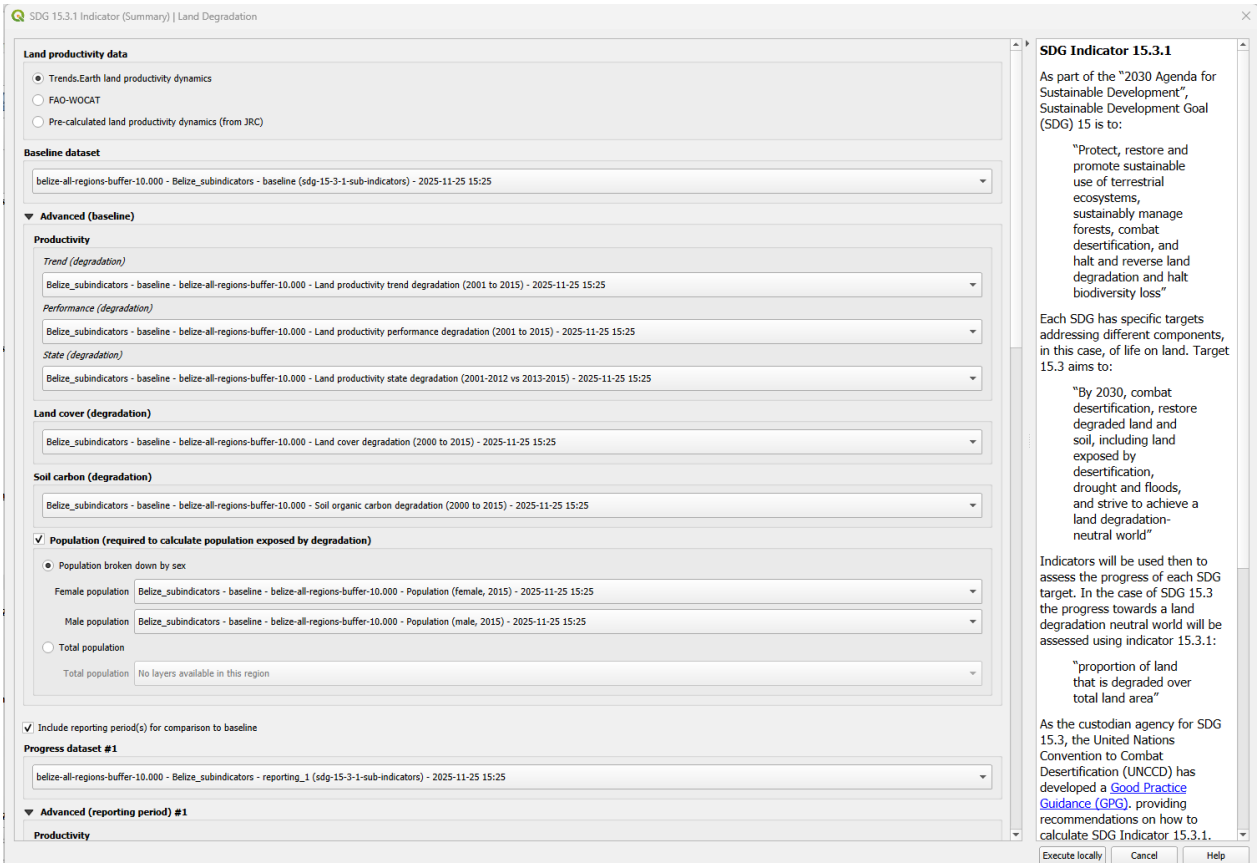


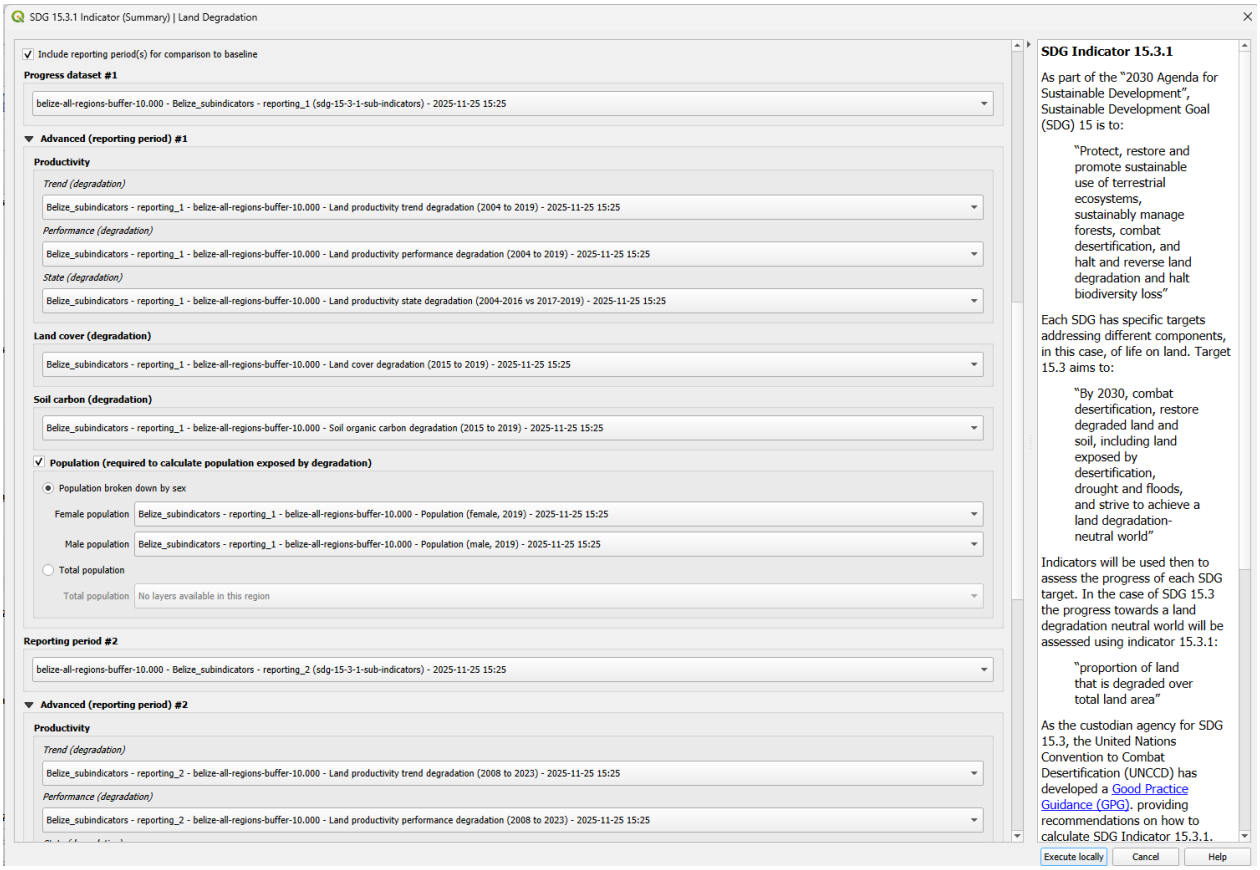
3. The region of interest is already set up in Settings. If you need to change, select the **Change region** button.

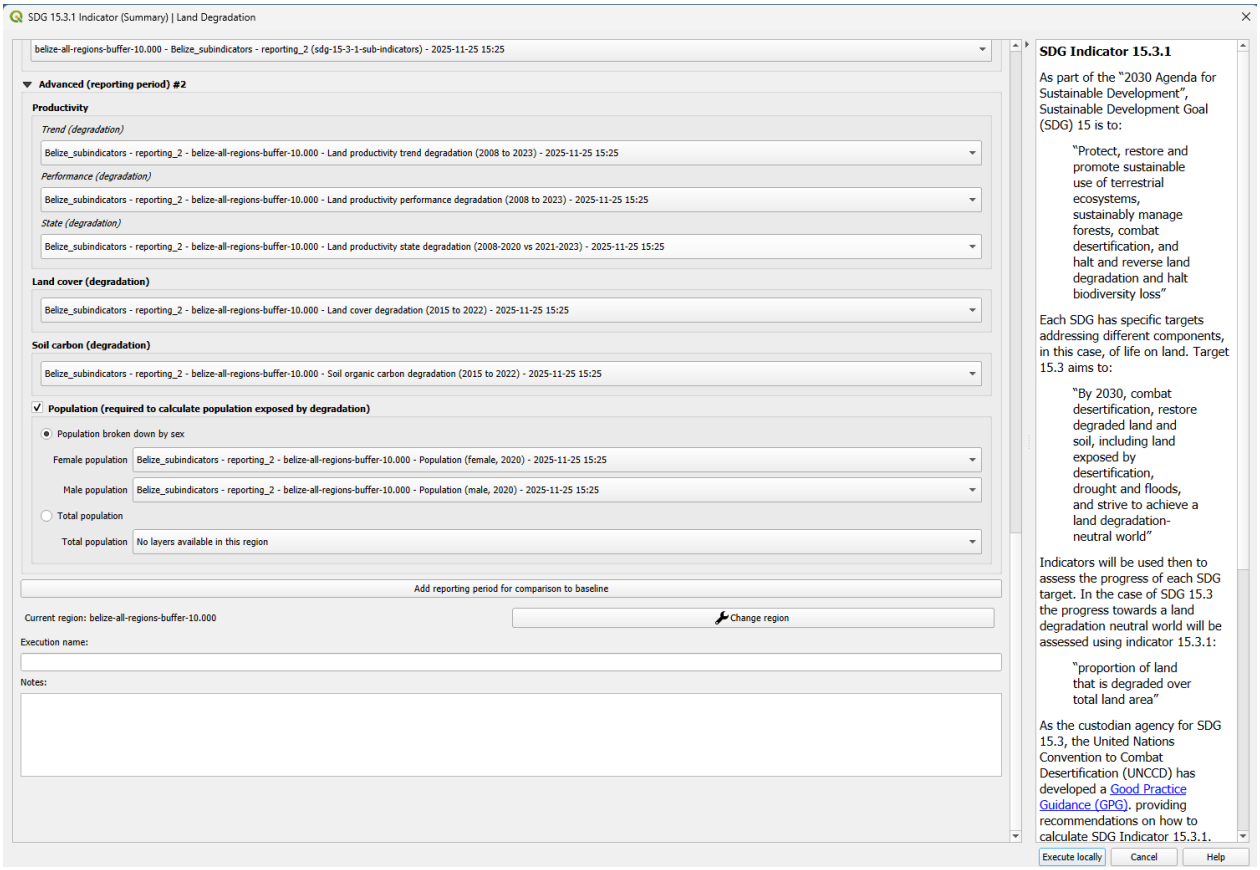
   Select the datasets from **Baseline dataset** and **Progress dataset** drop-down lists according to your selections in the sub-indicator analysis.

Note

Refer to the Settings section of this manual for more information on setting up your area of interest.


SDG 15.3.1 Indicator (Summary) | Land Degradation
Land productivity data
Trends.Earth land productivity dynamics
FAO-WOCAT
Pre-calculated land productivity dynamics (from JRC)
Baseline dataset
belize-all-regions-buffer-10.000 - Belize_subindicators - baseline (sdg-15-3-1-sub-indicators) - 2025-11-25 15:25
Advanced (baseline)
Productivity
Trend (degradation)
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Land productivity trend degradation (2001 to 2015) - 2025-11-25 15:25
Performance (degradation)
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Land productivity performance degradation (2001 to 2015) - 2025-11-25 15:25
State (degradation)
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Land productivity state degradation (2001-2012 vs 2013-2015) - 2025-11-25 15:25
Land cover (degradation)
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Land cover degradation (2000 to 2015) - 2025-11-25 15:25
Soil carbon (degradation)
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Soil organic carbon degradation (2000 to 2015) - 2025-11-25 15:25
Population (required to calculate population exposed by degradation)
Population broken down by sex
Female population
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Population (female, 2015) - 2025-11-25 15:25
Male population
Belize_subindicators - baseline - belize-all-regions-buffer-10.000 - Population (male, 2015) - 2025-11-25 15:25
Total population
Total population
No layers available in this region
Include reporting period(s) for comparison to baseline
Progress dataset #1
belize-all-regions-buffer-10.000 - Belize_subindicators - reporting_1 (sdg-15-3-1-sub-indicators) - 2025-11-25 15:25
Advanced (reporting period) #1
Productivity
SDG Indicator 15.3.1
As part of the "2030 Agenda for Sustainable Development", Sustainable Development Goal (SDG) 15 is to:
"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"
Each SDG has specific targets addressing different components, in this case, of life on land. Target 15.3 aims to:
"By 2030, combat desertification, restore degraded land and soil, including land exposed by desertification, drought and floods, and strive to achieve a land degradation-neutral world"
Indicators will be used then to assess the progress of each SDG target. In the case of SDG 15.3 the progress towards a land degradation neutral world will be assessed using indicator 15.3.1:
"proportion of land that is degraded over total land area"
As the custodian agency for SDG 15.3, the United Nations Convention to Combat Desertification (UNCCD) has developed a Good Practice Guidance (GPG). providing recommendations on how to calculate SDG Indicator 15.3.1.
Execute locally
Cancel
Help


SDG 15.3.1 Indicator (Summary) | Land Degradation
Include reporting period(s) for comparison to baseline
Progress dataset #1
belize-all-regions-buffer-10.000 - Belize_subindicators - reporting_1 (sdg-15-3-1-sub-indicators) - 2025-11-25 15:25
Advanced (reporting period) #1
Productivity
Trend (degradation)
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Land productivity trend degradation (2004 to 2019) - 2025-11-25 15:25
Performance (degradation)
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Land productivity performance degradation (2004 to 2019) - 2025-11-25 15:25
State (degradation)
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Land productivity state degradation (2004-2016 vs 2017-2019) - 2025-11-25 15:25
Land cover (degradation)
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Land cover degradation (2015 to 2019) - 2025-11-25 15:25
Soil carbon (degradation)
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Soil organic carbon degradation (2015 to 2019) - 2025-11-25 15:25
Population (required to calculate population exposed by degradation)
Population broken down by sex
Female population
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Population (female, 2019) - 2025-11-25 15:25
Male population
Belize_subindicators - reporting_1 - belize-all-regions-buffer-10.000 - Population (male, 2019) - 2025-11-25 15:25
Total population
Total population
No layers available in this region
Reporting period #2
belize-all-regions-buffer-10.000 - Belize_subindicators - reporting_2 (sdg-15-3-1-sub-indicators) - 2025-11-25 15:25
Advanced (reporting period) #2
Productivity
Trend (degradation)
Belize_subindicators - reporting_2 - belize-all-regions-buffer-10.000 - Land productivity trend degradation (2008 to 2023) - 2025-11-25 15:25
Performance (degradation)
Belize_subindicators - reporting_2 - belize-all-regions-buffer-10.000 - Land productivity performance degradation (2008 to 2023) - 2025-11-25 15:25
SDG Indicator 15.3.1
As part of the "2030 Agenda for Sustainable Development", Sustainable Development Goal (SDG) 15 is to:
"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"
Each SDG has specific targets addressing different components, in this case, of life on land. Target 15.3 aims to:
"By 2030, combat desertification, restore degraded land and soil, including land exposed by desertification, drought and floods, and strive to achieve a land degradation-neutral world"
Indicators will be used then to assess the progress of each SDG target. In the case of SDG 15.3 the progress towards a land degradation neutral world will be assessed using indicator 15.3.1:
"proportion of land that is degraded over total land area"
As the custodian agency for SDG 15.3, the United Nations Convention to Combat Desertification (UNCCD) has developed a Good Practice Guidance (GPG). providing recommendations on how to calculate SDG Indicator 15.3.1.
Execute locally
Cancel
Help

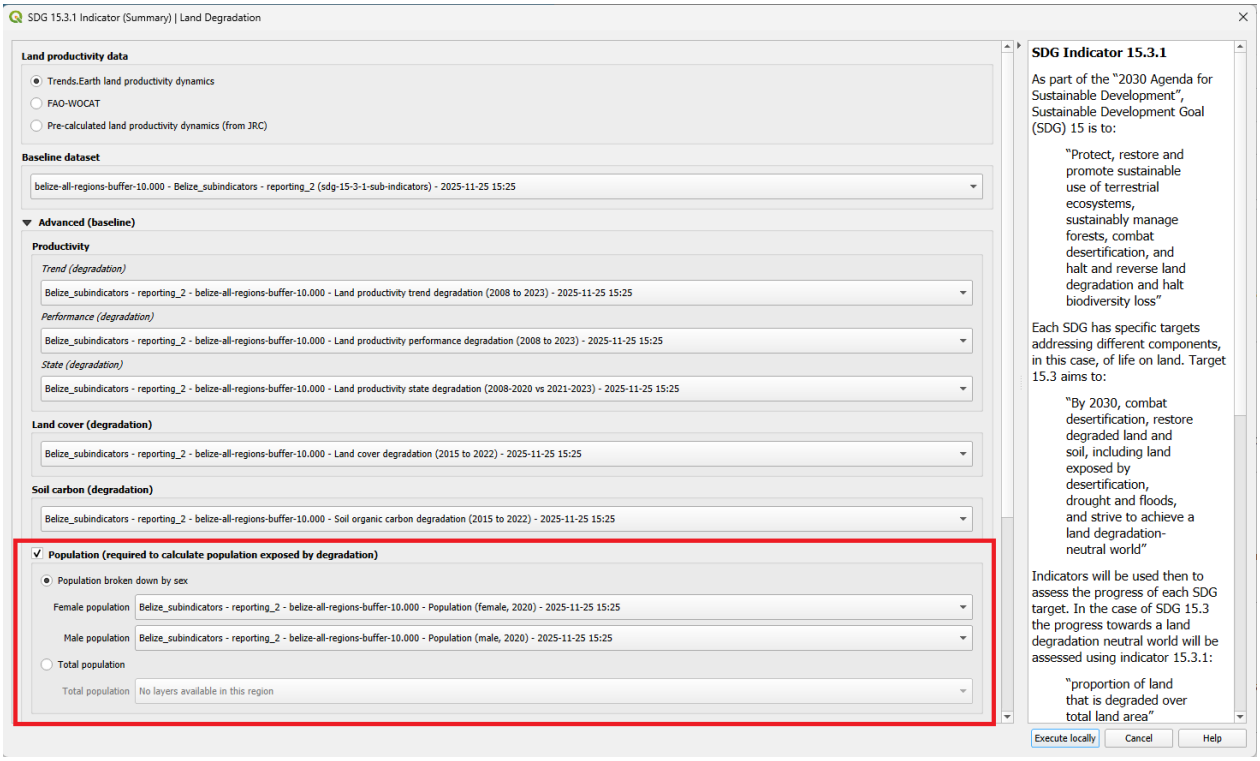


-If you have the sub-indicators loaded into the QGIS map, the tool will recognize them and they will show up pre-filled in each corresponding section.

Note

Maje sure to carefully verify that the available layers are correctly pre-filled to the corresponding fields.

4. Click on **Advanced** to expand it and show advanced options then select the **Population (required to calculate populations exposed by degradation)** check box to calculate UNCCD's SO 2-3, proportion of population exposed to land degradation disaggregated by sex. Make sure to check the **Population** box both for **Baseline** and **Progress Period** in case you are interested in having summary results for both periods. TRENDS.EARTH provides access the **WorldPop** dataset, which is used by default by the UNCCD for calculating indicator SO2-3.



To use custom population data instead of WorldPop:

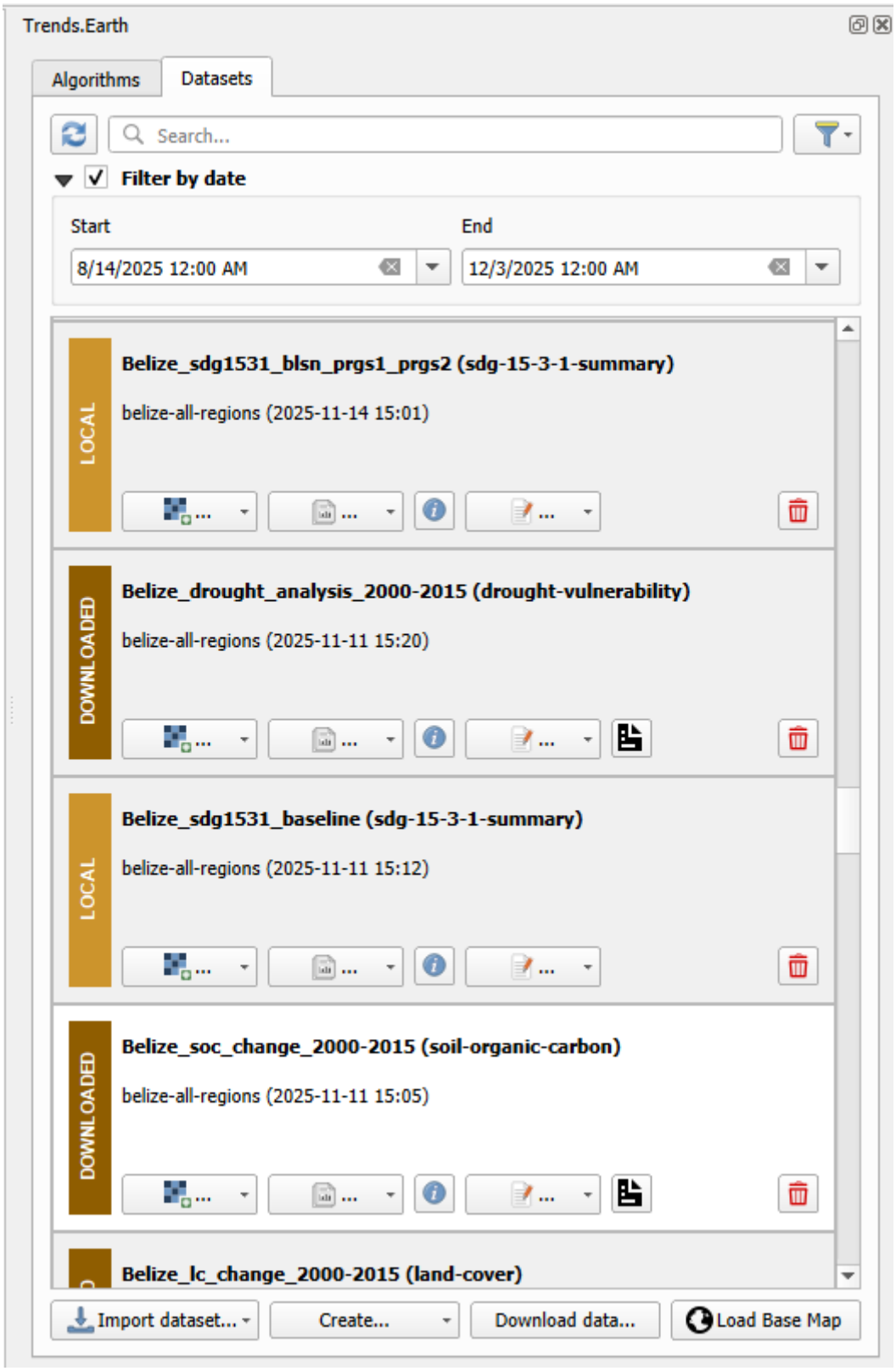
- Import the data through **Import custom Population dataset** in the Trends.Earth import menu. Specify the population year, whether the data represents total, male, or female population, and the correct input units: **People per pixel**, **People per hectare**, or **People per square kilometre**. Import male and female layers separately when using sex-disaggregated data.
- Open or reopen the land degradation summary dialog, select the baseline and any reporting datasets first, then expand **Advanced** for each period. Keep the **Population** box checked and select **Total population** to enable the total-population dropdown, or **Population broken down by sex** to enable the male and female dropdowns. Select the corresponding imported layers instead of the automatically selected population layers.
- Configure population separately for the baseline and each reporting period. Choose population years appropriate to the periods being summarized. For male and female layers, use data from the same year and with matching coordinate systems and pixel resolutions.

Note

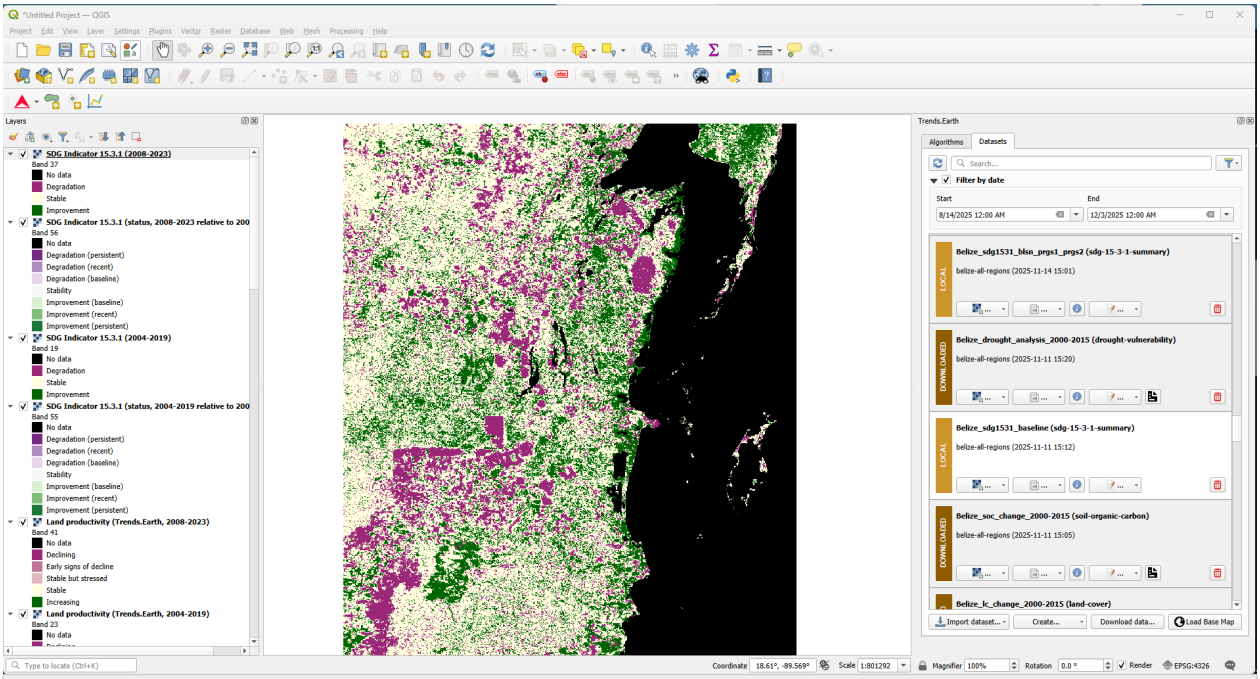
The import dialog defaults to **Total population**, while the summary dialog defaults to **Population broken down by sex**. A total-population import will appear only in the total-population dropdown, not in the male or female dropdowns. Select **Total population** in the summary dialog to use it. Total population supports overall exposure estimates, but not sex-disaggregated exposure estimates.

Population layers must cover the selected region of interest to appear in the dropdowns. If a layer is missing, check its imported population type and region coverage.

5. Select **Execute locally** button.
6. When the analysis is completed a **Success** message will notify you.
7. In the **Datasets** window, click on **Load dataset onto QGIS map area**



8. The SDG 15.3.1 data will be added to the map for the region of interest.



Note

Refer to the Land degradation and SDG 15.3.1 background for interpreting the results of this analysis.

SDG 15.3.1 Land Degradation Summary

- **Objective**: Learn how to open and interpret the summary tables produced by Trends.Earth when calculating the final SDG 15.3.1 Indicator layer.
- **Estimated time of completion**: 25 minutes
- **Internet access**: Not required

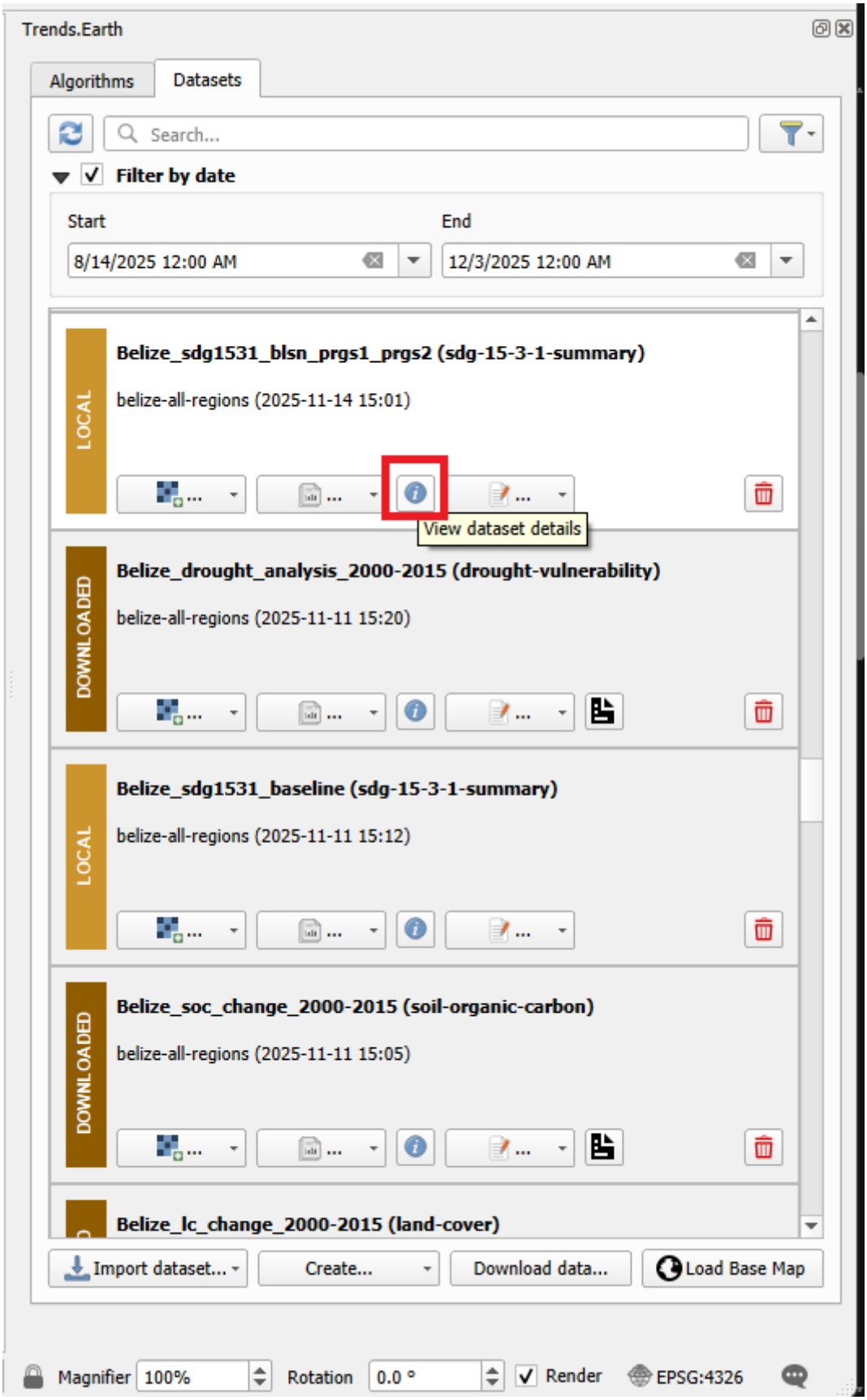
Note

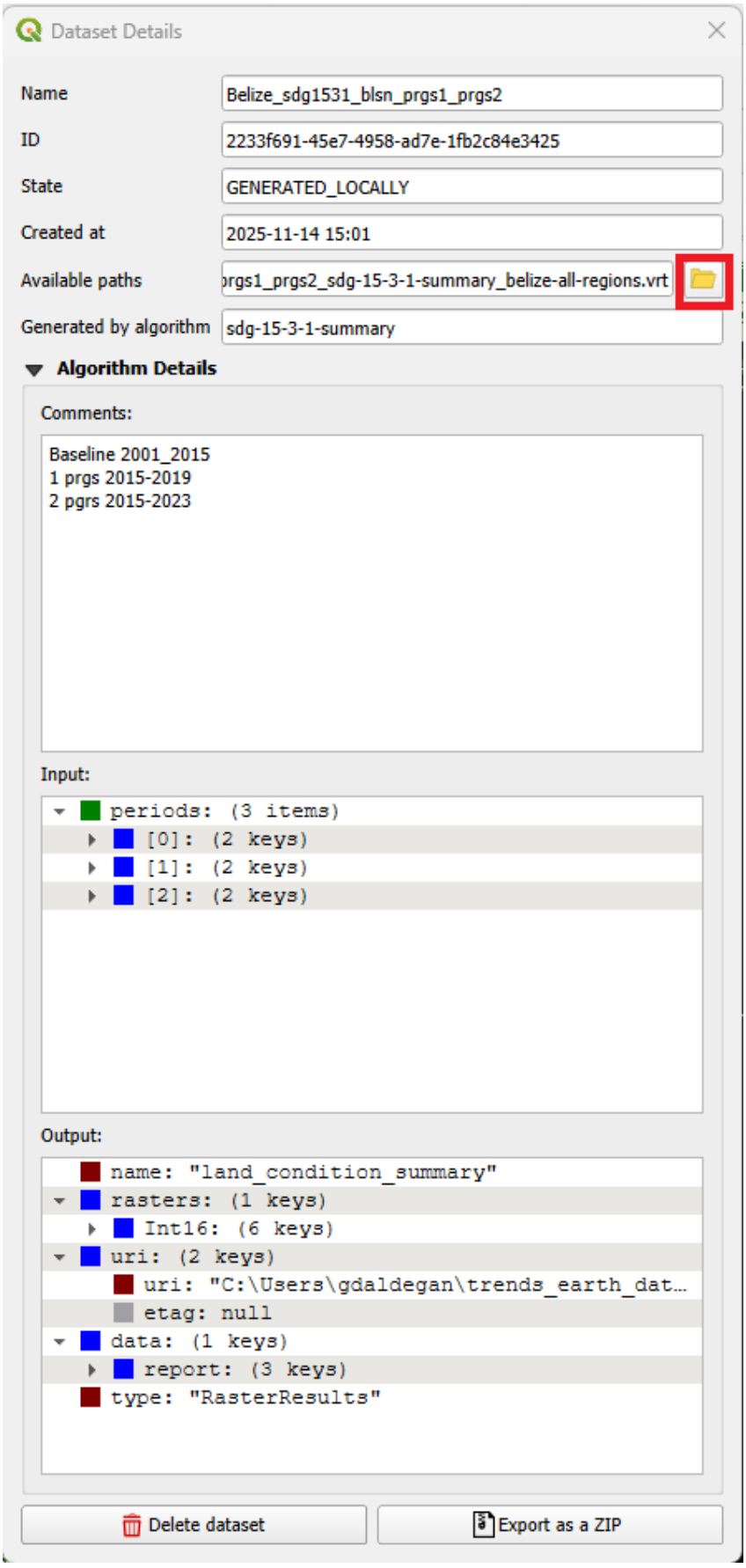
Download this page as a PDF for offline use

Note

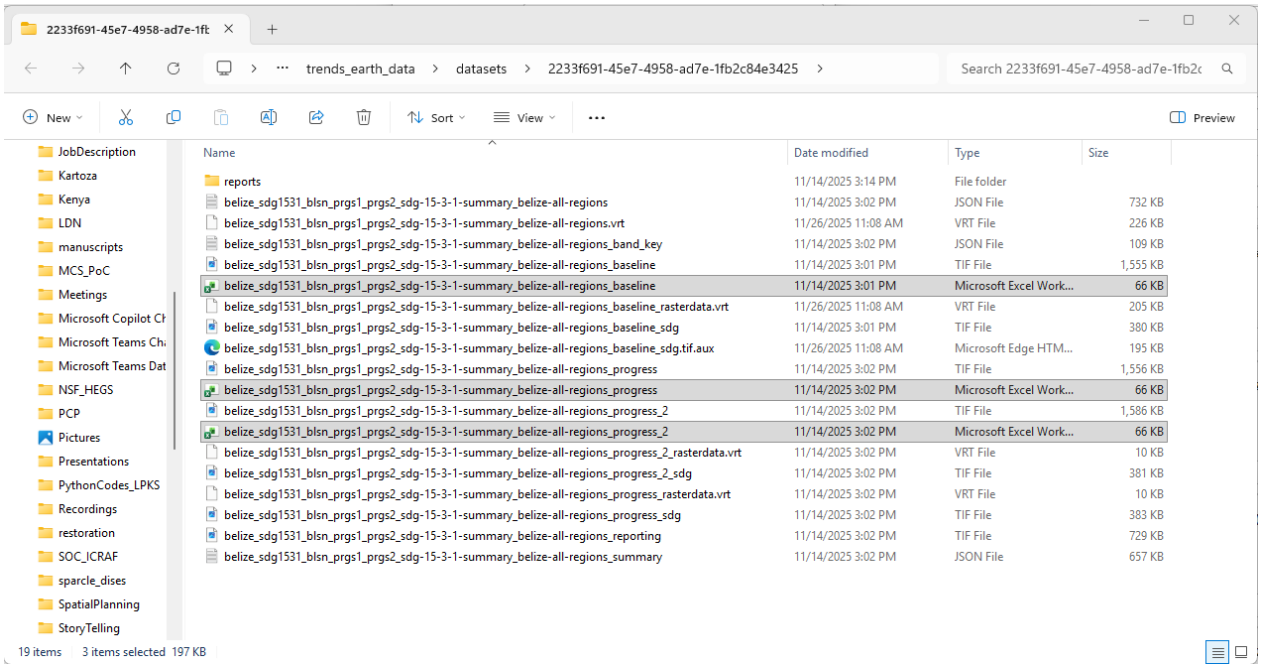
You will need to have previously computed SDG 15.3.1 using the **Indicator for SDG 15.3.1** tool. Refer to the section Calculate SDG 15.3.1 Indicator and UNCCD's SO 2-3 for instructions on how to run this analysis.

1. When you calculate Indicator for SDG 15.3.1 an Excel file is created with the summary table. In the **Datasets** window, click on click on **Open Dataset Directory**


Trends.Earth
Algorithms
Datasets
Search...
Filter by date
Start
End
8/14/2025 12:00 AM
12/3/2025 12:00 AM
LOCAL
Belize_sdg1531_blsn_prgs1_prgs2 (sdg-15-3-1-summary)
belize-all-regions (2025-11-14 15:01)
View dataset details
DOWNLOADED
Belize_drought_analysis_2000-2015 (drought-vulnerability)
belize-all-regions (2025-11-11 15:20)
LOCAL
Belize_sdg1531_baseline (sdg-15-3-1-summary)
belize-all-regions (2025-11-11 15:12)
DOWNLOADED
Belize_soc_change_2000-2015 (soil-organic-carbon)
belize-all-regions (2025-11-11 15:05)
Belize_lc_change_2000-2015 (land-cover)
Import dataset...
Create...
Download data...
Load Base Map
Magnifier
100%
Rotation
0.0 °
Render
EPSG:4326


Dataset Details
Name
Belize_sdg1531_blsn_prgs1_prgs2
ID
2233f691-45e7-4958-ad7e-1fb2c84e3425
State
GENERATED_LOCALLY
Created at
2025-11-14 15:01
Available paths
rgs1_prgs2_sdg-15-3-1-summary_belize-all-regions.vrt
Generated by algorithm
sdg-15-3-1-summary
Algorithm Details
Comments:
Baseline 2001_2015
1 prgs 2015-2019
2 pgrs 2015-2023
Input:
periods: (3 items)
[0]: (2 keys)
[1]: (2 keys)
[2]: (2 keys)
Output:
name: "land_condition_summary"
rasters: (1 keys)
Int16: (6 keys)
uri: (2 keys)
uri: "C:\Users\gdaldegan\trends_earth_dat...
etag: null
data: (1 keys)
report: (3 keys)
type: "RasterResults"
Delete dataset
Export as a ZIP

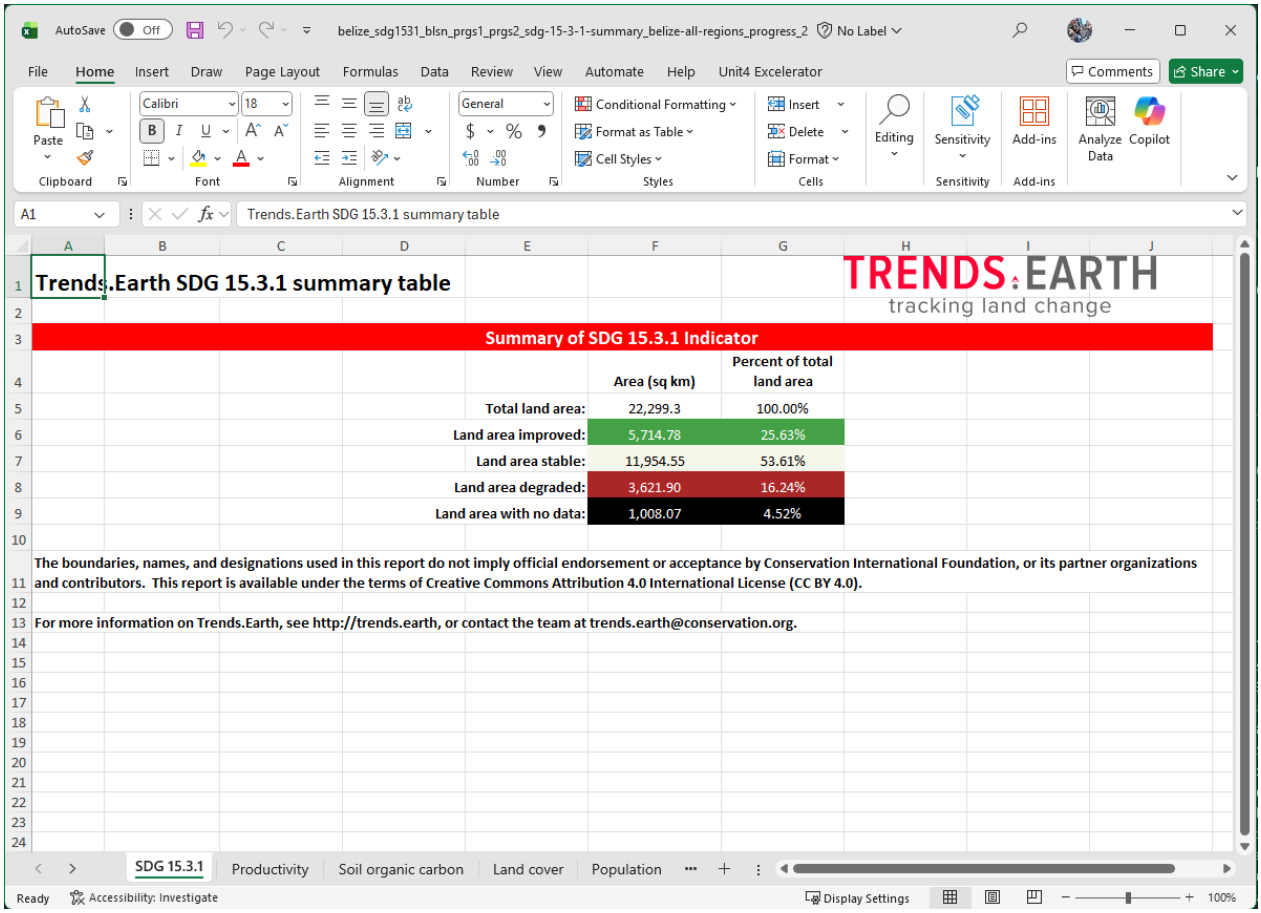
- The directory where the summary table was saved along with the geospatial data will open. You will see two summary tables in case both Baseline and Progress period SDG 15.3.1 were calculated



2. The summary table file contains 6 tabs, which you can explore by clicking on each of the different names the bottom of the screen: SDG 15.3.1, Productivity, Soil organic carbon, Land Cover, Population and UNCCD SO1-1.

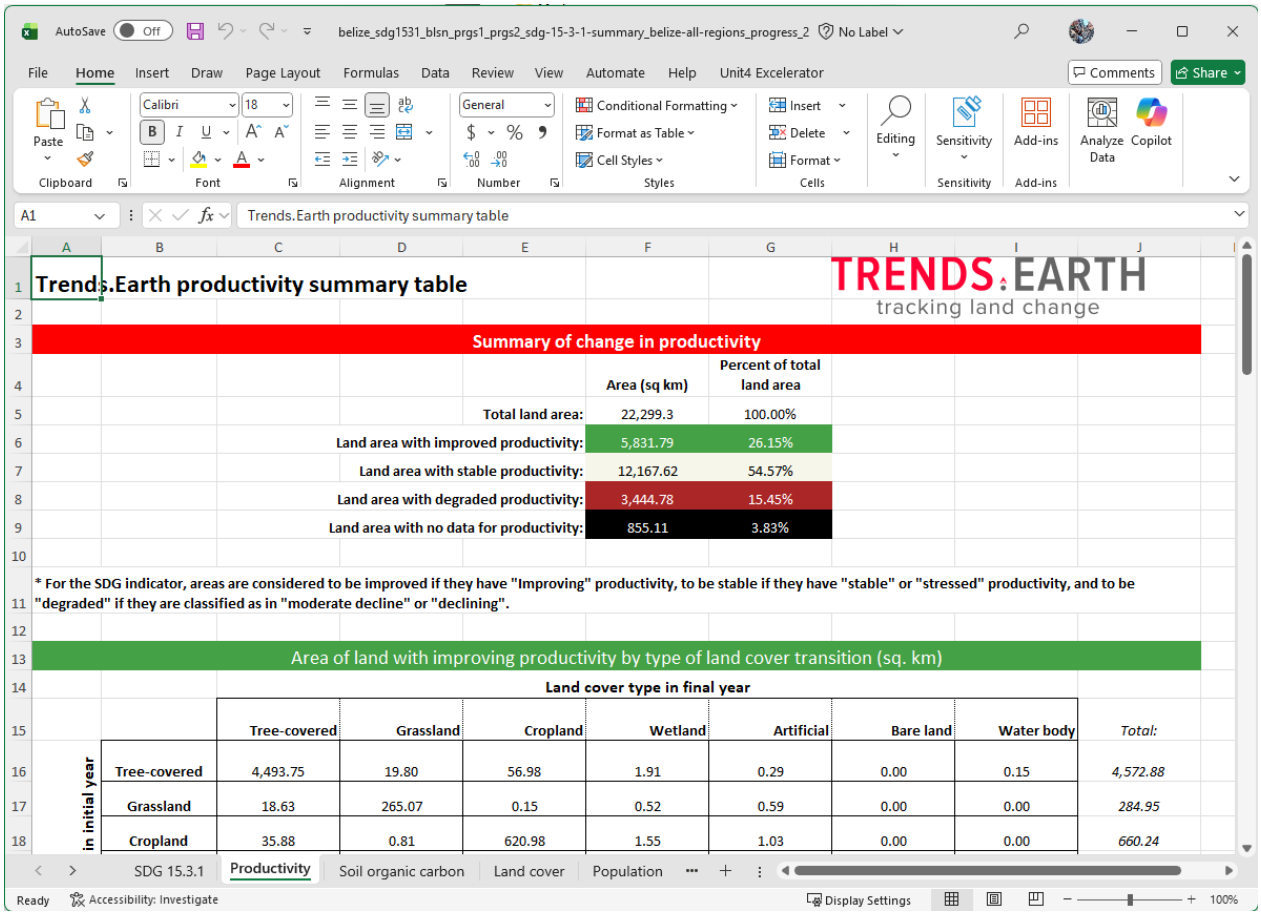
3. In the **SDG 15.3.1** tab you will find the area calculations derived from the indicator map you explored in QGIS.

   For the area you run the analysis, you will see the total land area (excluding water bodies): land that experienced improvement, which remained stable, areas degraded, and also information on the areas with no data for the period selected. No data in the SDG 15.3.1 is an indication of no data in some of the input datasets used in the analysis.



4. In the **Productivity** tab you will find at the top, a similar summary as previously explained, but in this case representing the results of the land productivity sub-indicator alone.

   In the sections below you will find two tables, each containing area information (in sq. km) for each of the land cover transitions found in the study are during the period analyzed broken by each of the 5 final land productivity classes: Increasing, Stable, Stable but stressed, Early signs of decline, and Declining.



Trends.Earth productivity summary table

TRENDS.EARTH tracking land change

Summary of change in productivity

	Area (sq km)	Percent of total land area
Total land area:	22,299.3	100.00%
Land area with improved productivity:	5,831.79	26.15%
Land area with stable productivity:	12,167.62	54.57%
Land area with degraded productivity:	3,444.78	15.45%
Land area with no data for productivity:	855.11	3.83%

* For the SDG indicator, areas are considered to be improved if they have "Improving" productivity, to be stable if they have "stable" or "stressed" productivity, and to be "degraded" if they are classified as in "moderate decline" or "declining".

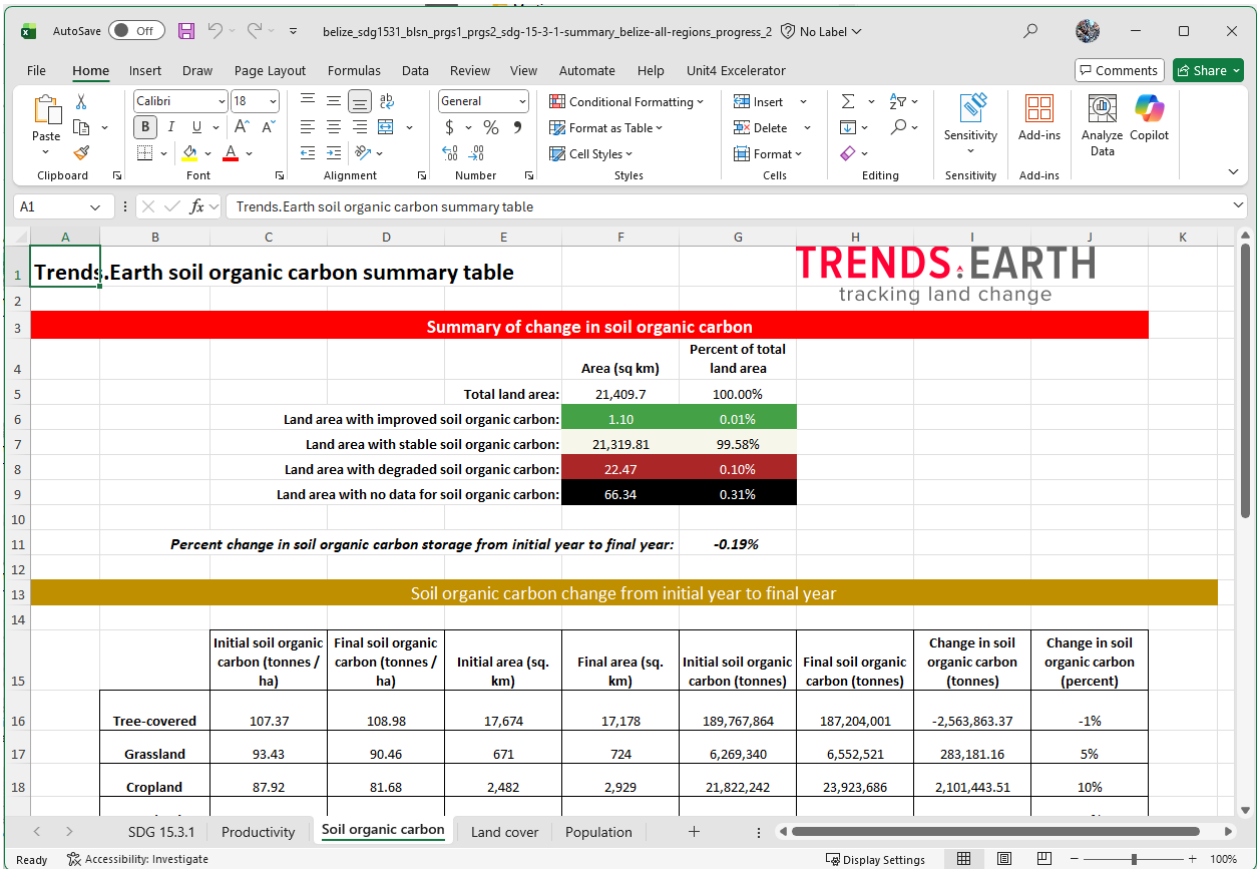
Area of land with improving productivity by type of land cover transition (sq. km)

		Land cover type in final year							
		Tree-covered	Grassland	Cropland	Wetland	Artificial	Bare land	Water body	*Total:*
in initial year	Tree-covered	4,493.75	19.80	56.98	1.91	0.29	0.00	0.15	*4,572.88*
	Grassland	18.63	265.07	0.15	0.52	0.59	0.00	0.00	*284.95*
	Cropland	35.88	0.81	620.98	1.55	1.03	0.00	0.00	*660.24*

5. In the **Soil organic carbon** tab you will find at the top, a similar summary as previously explained, but in this case representing the results of the soil organic carbon sub-indicator alone.

   In the sections below you will find two tables:

   - The first one contains information on changes in carbon stocks from the baseline (initial year of analysis) to the target (final year of analysis).
   - The second presents information soil organic carbon change from baseline to target by type of land cover transition (as percentage of initial stock).



Trends.Earth soil organic carbon summary table

TRENDS.EARTH tracking land change

Summary of change in soil organic carbon

	Area (sq km)	Percent of total land area
Total land area:	21,409.7	100.00%
Land area with improved soil organic carbon:	1.10	0.01%
Land area with stable soil organic carbon:	21,319.81	99.58%
Land area with degraded soil organic carbon:	22.47	0.10%
Land area with no data for soil organic carbon:	66.34	0.31%

Percent change in soil organic carbon storage from initial year to final year: *-0.19%*

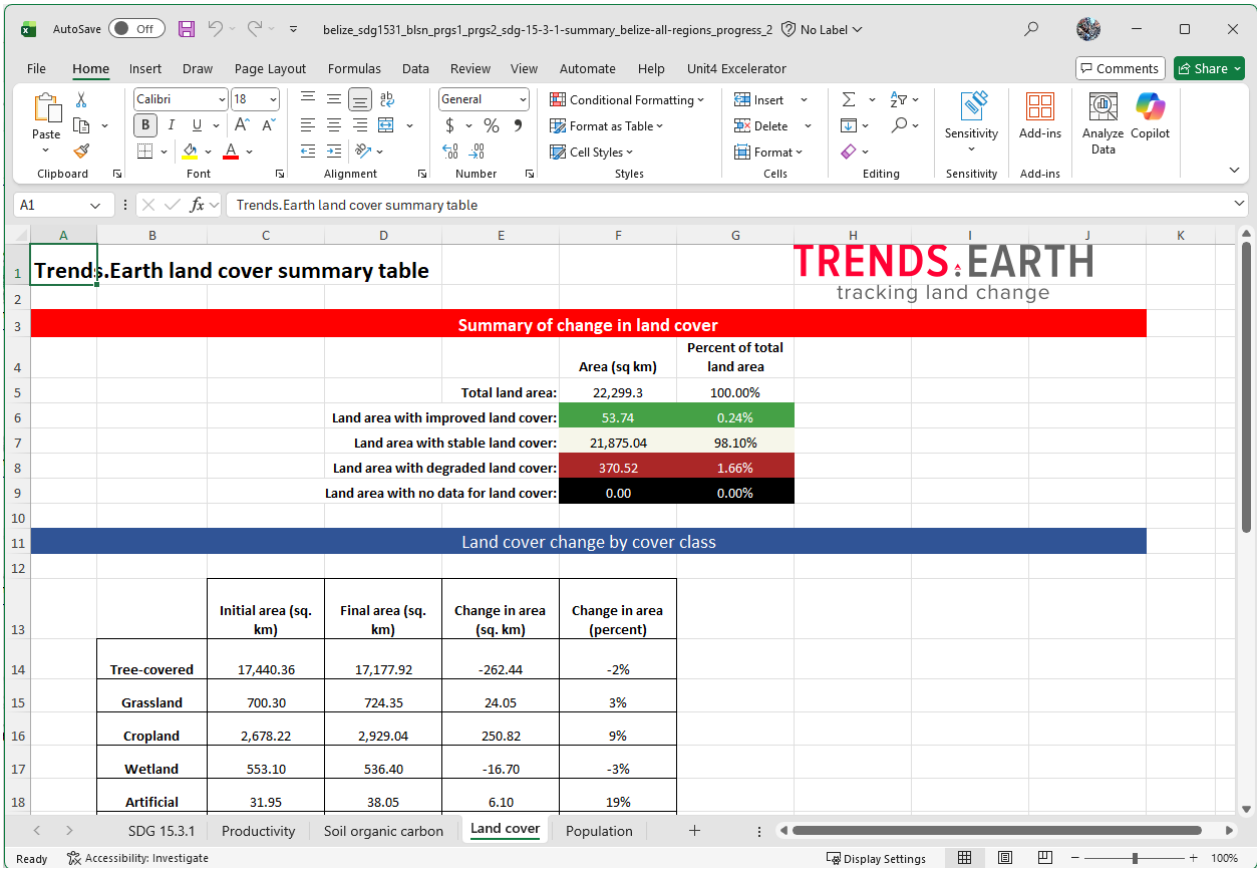
Soil organic carbon change from initial year to final year

	Initial soil organic carbon (tonnes / ha)	Final soil organic carbon (tonnes / ha)	Initial area (sq. km)	Final area (sq. km)	Initial soil organic carbon (tonnes)	Final soil organic carbon (tonnes)	Change in soil organic carbon (tonnes)	Change in soil organic carbon (percent)
Tree-covered	107.37	108.98	17,674	17,178	189,767,864	187,204,001	-2,563,863.37	-1%
Grassland	93.43	90.46	671	724	6,269,340	6,552,521	283,181.16	5%
Cropland	87.92	81.68	2,482	2,929	21,822,242	23,923,686	2,101,443.51	10%

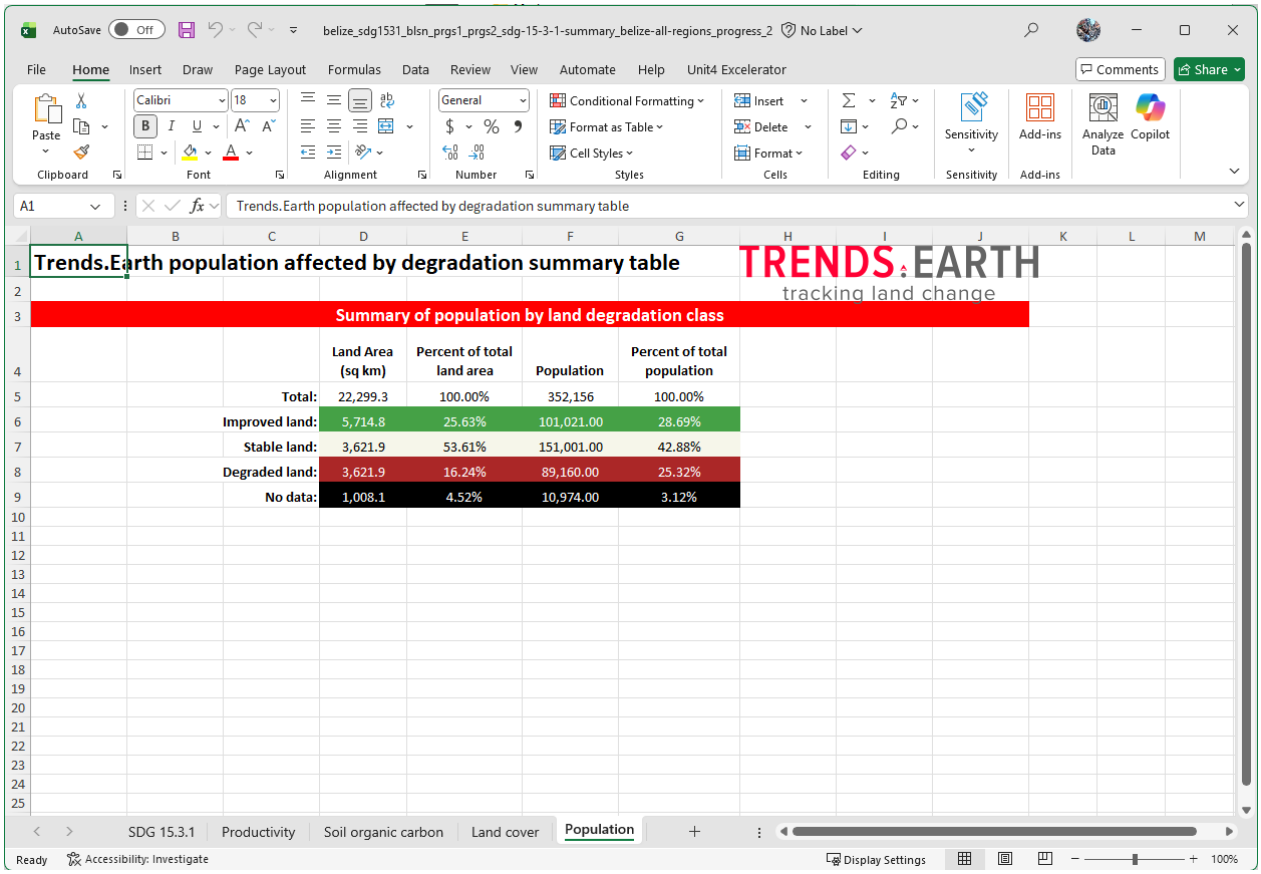
6. In the **Land cover** tab you will find at the top, a similar summary as previously explained, but in this case representing the results of the land cover change sub-indicator alone.

   In the sections below you will find two tables:

   - The first contains information on land cover change by cover class (sq, km and %).
   - The second contains information on land area by type of land cover transition (sq. km).



7. In the **Population** tab you will find a summary of population affected by land degradation classes, with absolute and percent values reported.



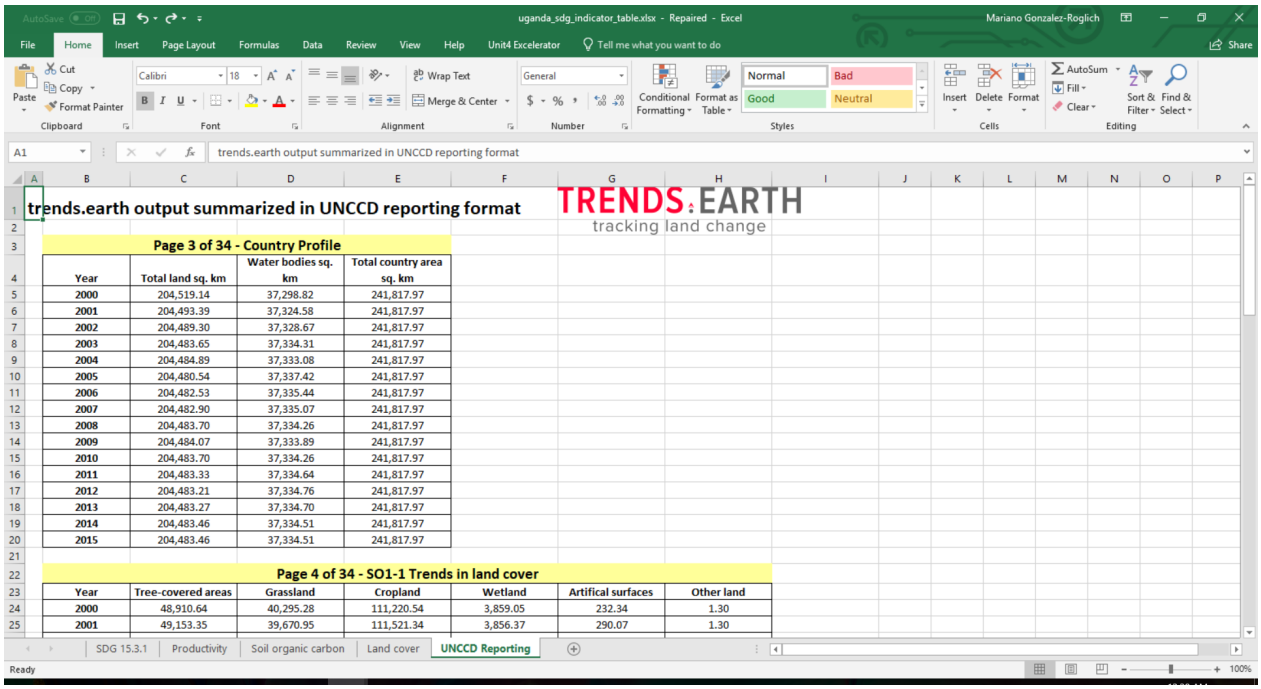
Trends.Earth population affected by degradation summary table

TRENDS.EARTH tracking land change

Summary of population by land degradation class

	Land Area (sq km)	Percent of total land area	Population	Percent of total population
Total:	22,299.3	100.00%	352,156	100.00%
Improved land:	5,714.8	25.63%	101,021.00	28.69%
Stable land:	3,621.9	53.61%	151,001.00	42.88%
Degraded land:	3,621.9	16.24%	89,160.00	25.32%
No data:	1,008.1	4.52%	10,974.00	3.12%

8. In the **UNCCD SO1-1** tab you will find five tables containing similar information as the one presented in the previous tabs, but in this case specifically formatted to match the reporting template required by the UNCCD. Each table indicates at the top the page number and section of the template the information is referring to.



trends.earth output summarized in UNCCD reporting format

TRENDS.EARTH tracking land change

Page 3 of 34 - Country Profile

Year	Total land sq. km	Water bodies sq. km	Total country area sq. km
2000	204,519.14	37,298.82	241,817.97
2001	204,493.39	37,324.58	241,817.97
2002	204,489.30	37,328.67	241,817.97
2003	204,483.65	37,334.31	241,817.97
2004	204,484.89	37,333.08	241,817.97
2005	204,480.54	37,337.42	241,817.97
2006	204,482.53	37,335.44	241,817.97
2007	204,482.90	37,335.07	241,817.97
2008	204,483.70	37,334.26	241,817.97
2009	204,484.07	37,333.89	241,817.97
2010	204,483.70	37,334.26	241,817.97
2011	204,483.33	37,334.64	241,817.97
2012	204,483.21	37,334.76	241,817.97
2013	204,483.27	37,334.70	241,817.97
2014	204,483.46	37,334.51	241,817.97
2015	204,483.46	37,334.51	241,817.97

Page 4 of 34 - SO1-1 Trends in land cover

Year	Tree-covered areas	Grassland	Cropland	Wetland	Artifical surfaces	Other land
2000	48,910.64	40,295.28	111,220.54	3,859.05	232.34	1.30
2001	49,153.35	39,670.95	111,521.34	3,856.37	290.07	1.30

> **Note**
>
> Refer to the Productivity to learn more on land productivity.

Custom Data - Productivity

- **Objective**: Learn how to load custom land productivity data computed outside of Trends.Earth.
- **Estimated time of completion**: 20 minutes
- **Internet access**: Not required

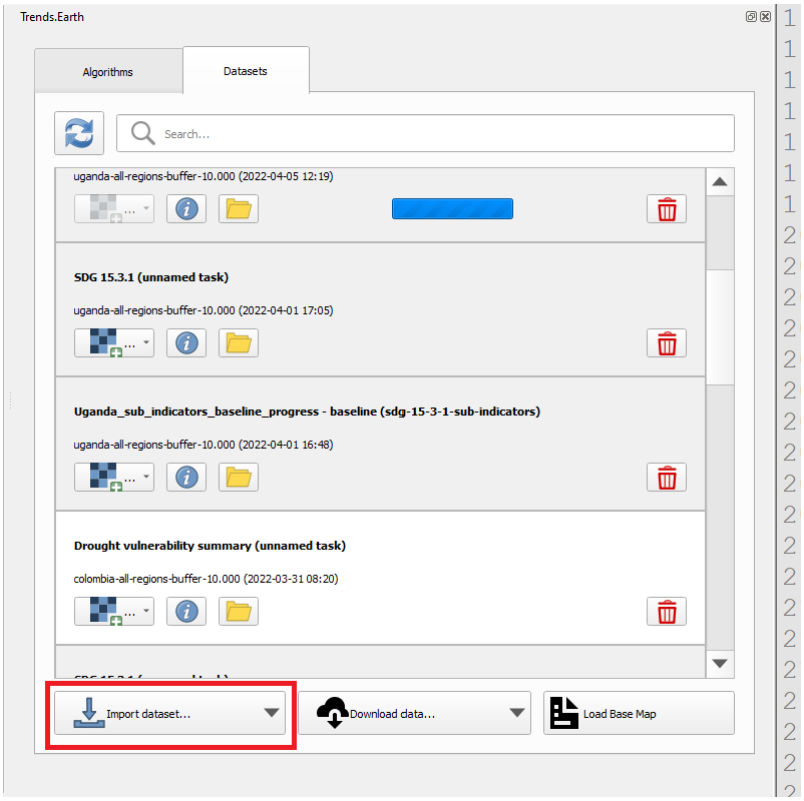
> **Note**
>
> Land productivity data should be formatted following UNCCD guidelines for reporting indicating areas of Declining, Moderate decline, Stressed, Stable, or Increasing.

For the productivity data to be used in Trends.Earth the file need to be coded in the following way:

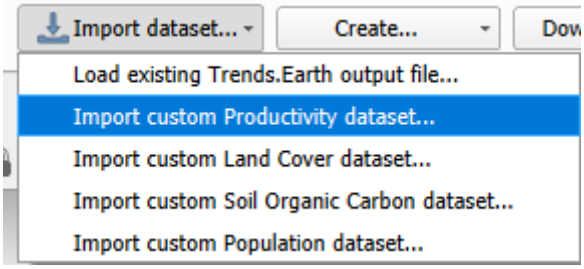
- Declining = 1
- Moderate decline = 2
- Stressed = 3
- Stable = 4
- Increasing = 5
- No data = 0 or -32768

If your layer is not coded in such a way, please do the necessary adjustments/reclassification prior to importing it into Trends.Earth.

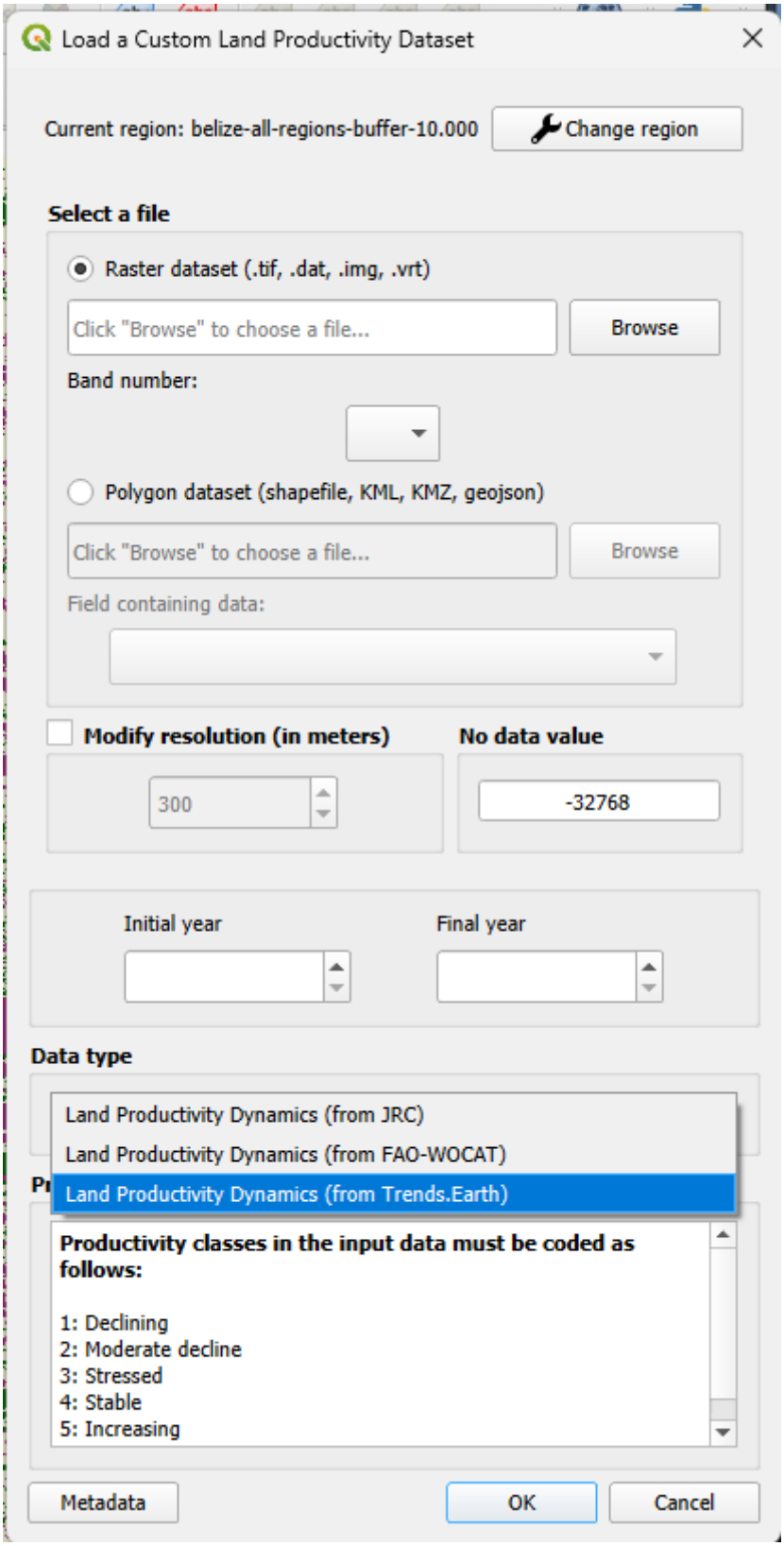
1. To load a **custom productivity data** click on the **Datasets** window, and then click on **Import dataset**.



2. Several options will appear. Select **Import custom Productivity dataset** from the list.

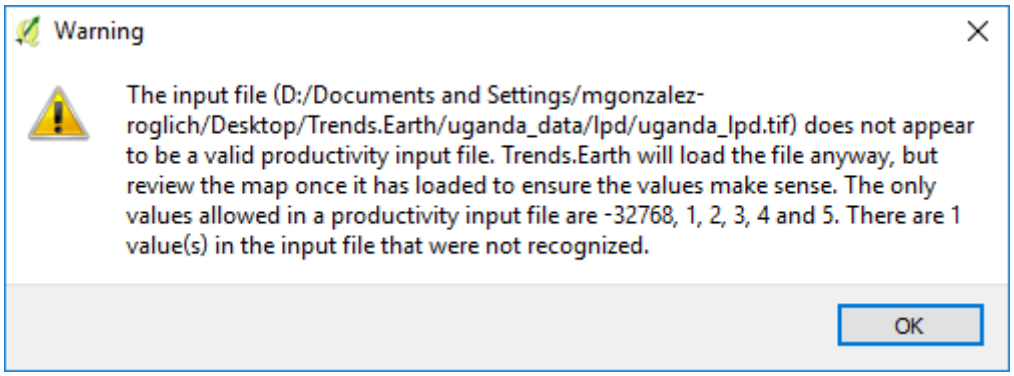


3. In the **Load a Custom Land Productivity Dataset** use the radio button to select the format of the input file (raster or vector). For this tutorial select raster, since the data distributed by the UNCCD is in raster format. Click on **Browse** to navigate to the productivity file you wish to import.

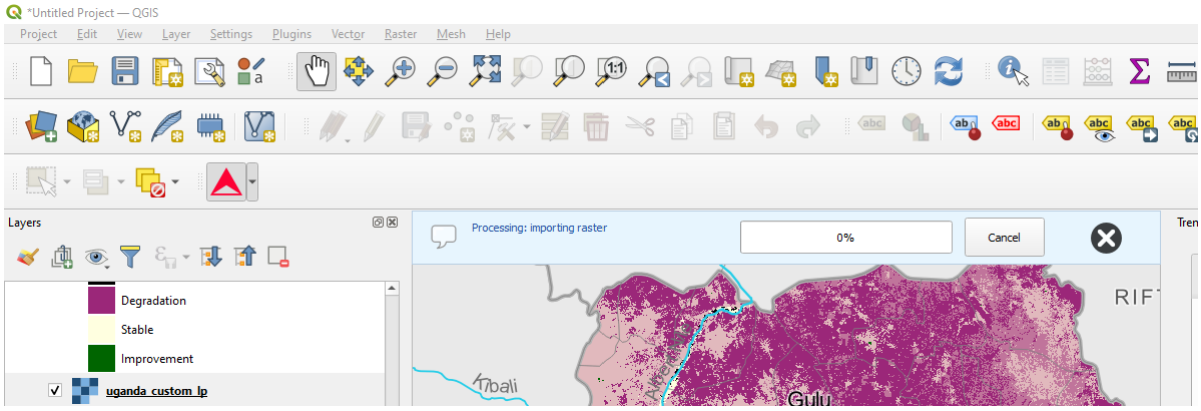


4. In the **Load a Custom Land Productivity Dataset** window you have options for selecting the band number in which the productivity data is stored, in case your input file is a multi-band raster. You also have the option of modifying the resolution of the file. We recommend leaving those as defaults unless you have valid reasons for changing them.

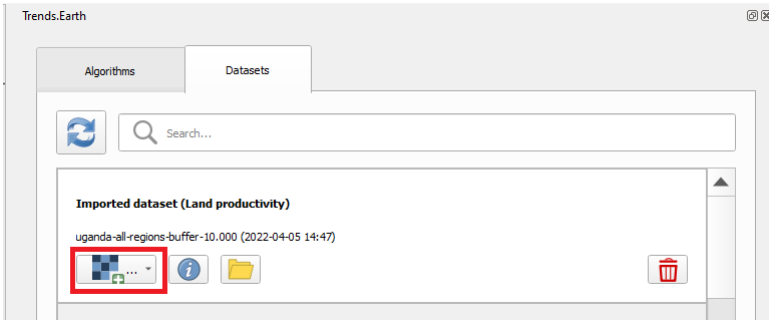
5. Click **Browse** at the bottom of the window to select the **Output raster file** and navigate to the folder where you want to save the file. Type in a name and click **OK**.
6. Back at the **Load a Custom Land Productivity Dataset** window click **OK** on the lower right corner to process the data.
7. If the values of the input file do not exactly match the requirements described above, you will see a warning message. In many cases the warning is triggered by the definition of NoData, but the tool will still try to import it. For that reason, it is **extremely important** for you to explore the output layer to make sure the results are mapped as expected.



8. Once you click **OK** a progress bar will appear showing the percentage of the task completed.



9. In the **Datasets** window, find the **Imported dataset (land productivity)** on click on **Load dataset onto QGIS map area**.



Note

Refer to the Land cover to learn more on land cover.

Custom Data - Land Cover

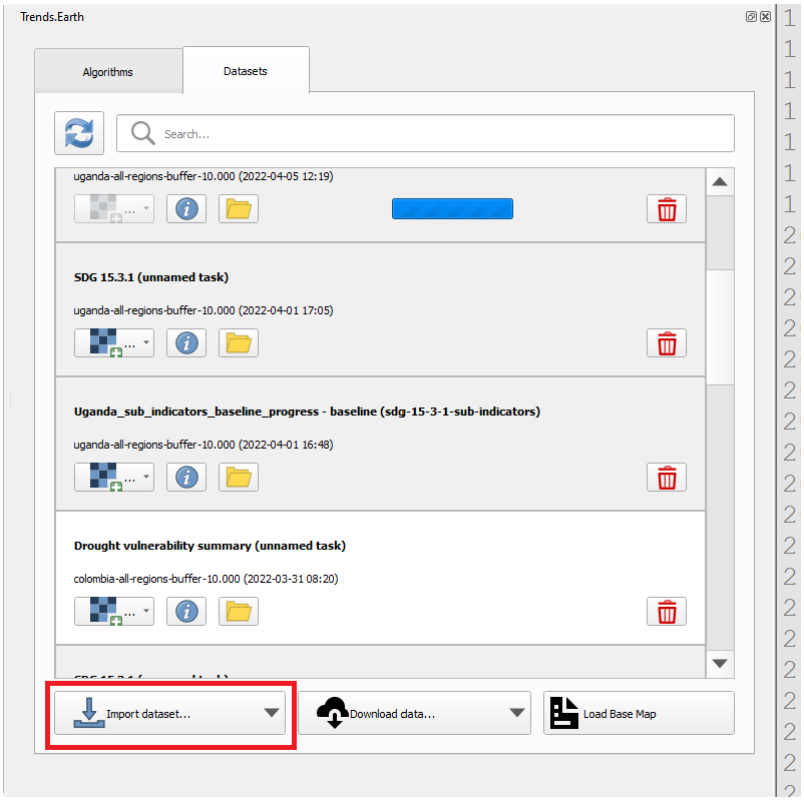
Objective: Learn how to load custom land cover data and to compute the land cover change sub-indicator using Trends.Earth.

- **Estimated time of completion**: 40 minutes
- **Internet access**: Not required

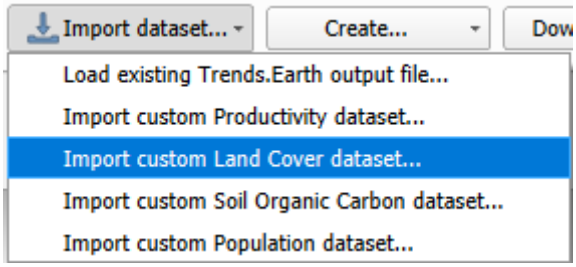
Note

The land cover dataset for this tutorial were provided by the Regional Centre For Mapping Resource For Development and can be downloaded from this link.

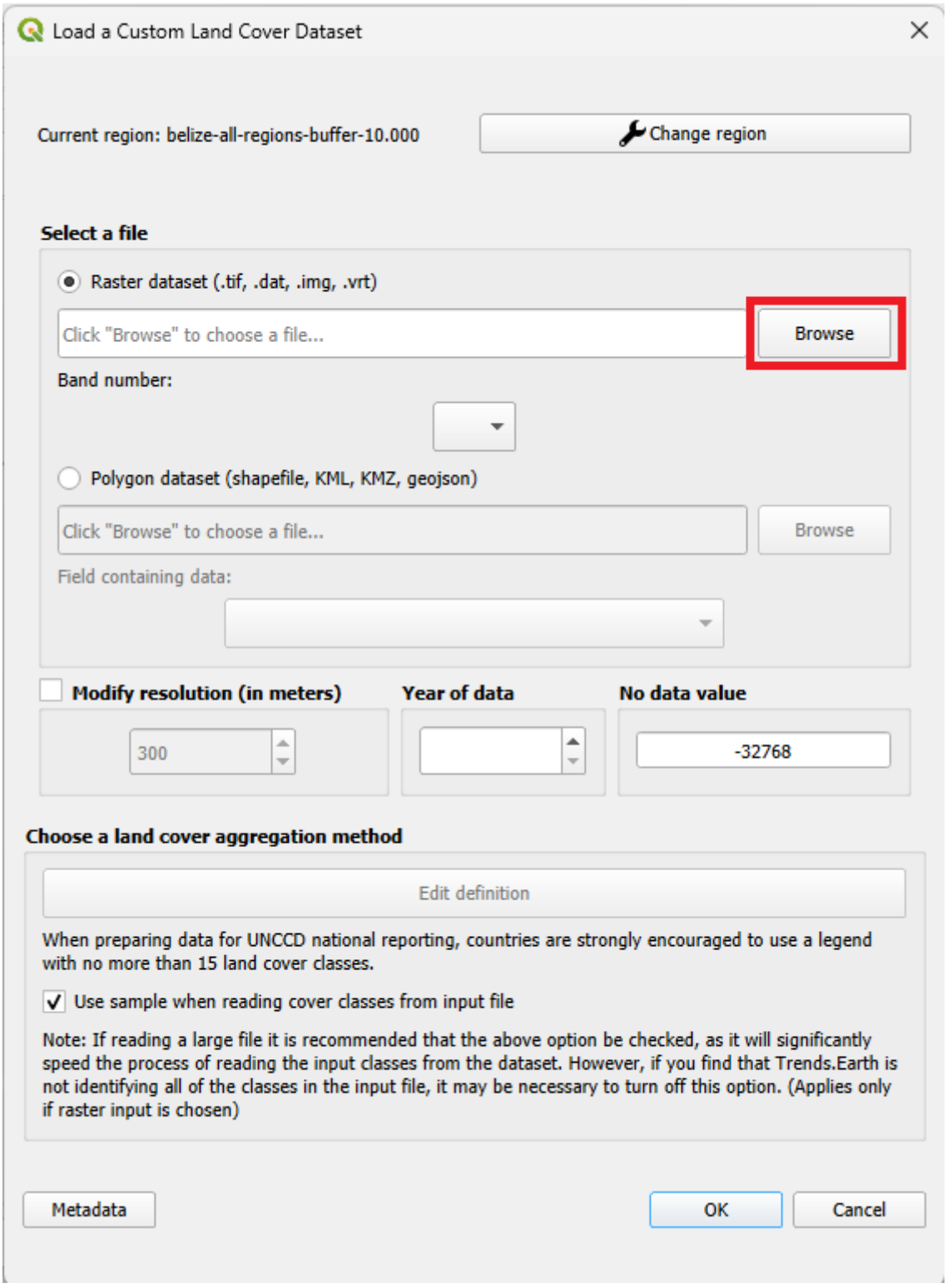
1. To load a custom productivity data click on the **Datasets** window, and then click on **Import dataset**.



2. Several options will appear. Select **Import custom Land Cover dataset** from the list.



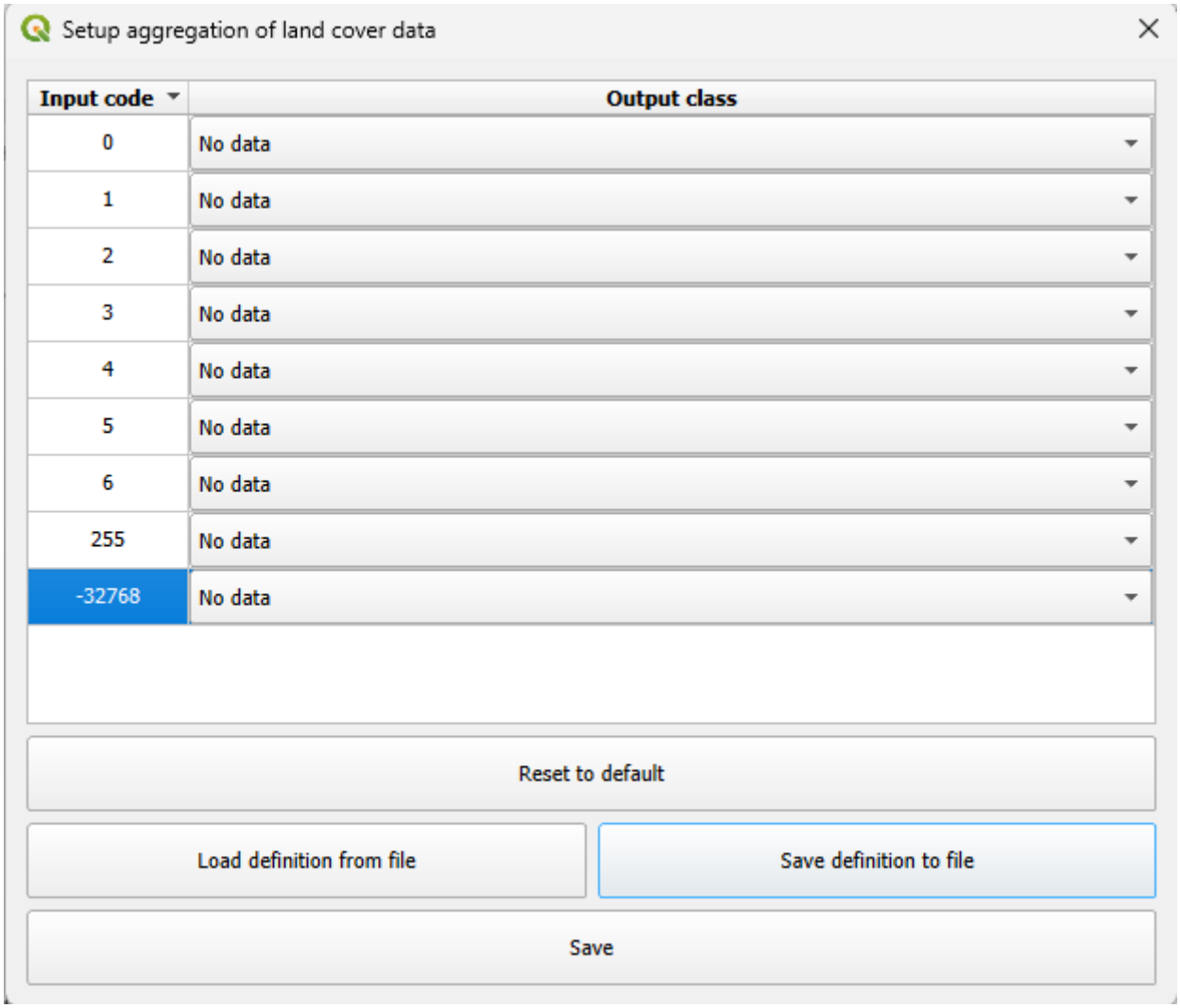
3. In the **Load a Custom Land Cover Dataset** window, use the radio button to select the format of the input file (raster or vector). For this tutorial select raster, since the data distributed by the UNCCD is in raster format. Click on **Browse** to navigate to the land cover file you wish to import.



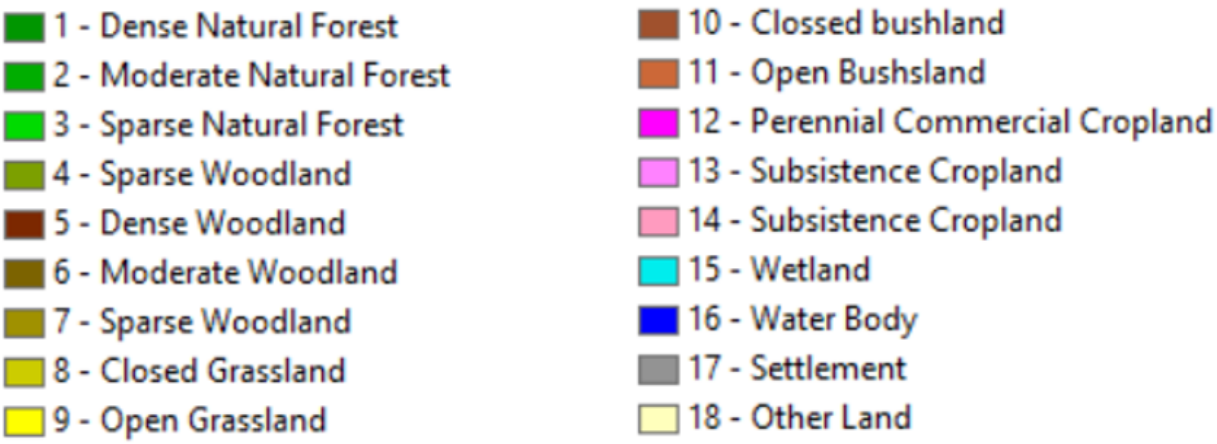
4. In the **Load a Custom Land Cover Dataset** window you also have options for selecting the band number in which the land cover data is stored, in case your input file is a multi-band raster. You also have the option of modifying the resolution of the file. We recommend leaving those as defaults unless you have valid reasons for changing them.

Define the year of reference for the data. In this case, since the land cover dataset for Uganda was developed for the **year 2000**, define it as such. Make sure you are assigning the correct **Year of data**.

5. Click on the **Edit definition** button, this will open the **Setup aggregation of land cover data menu**. Here you need to assign each of the original input values of your dataset to one of the 7 UNCCD recommended land cover classes.



- For this example, the Uganda dataset has 18 land cover classes:

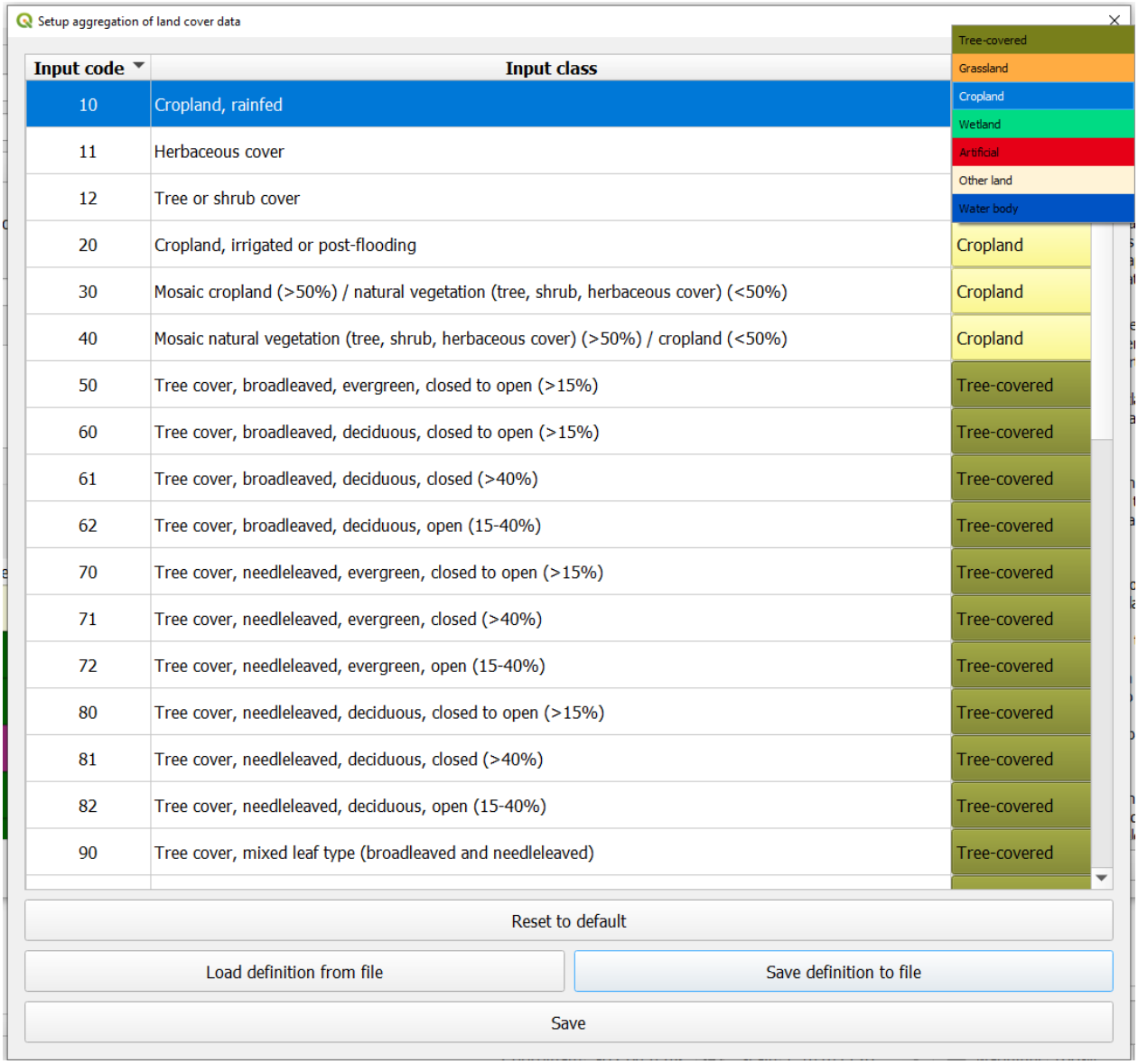


- **From the Metadata of the land cover dataset, we know that the best aggregation approach is the following:**
    - No data = 0
    - Tree covered = 1 through 7
    - Grassland = 8 through 11
    - Cropland = 12 through 14
    - Wetland = 15
    - Water body = 16
    - Artificial = 17
    - Other land = 18

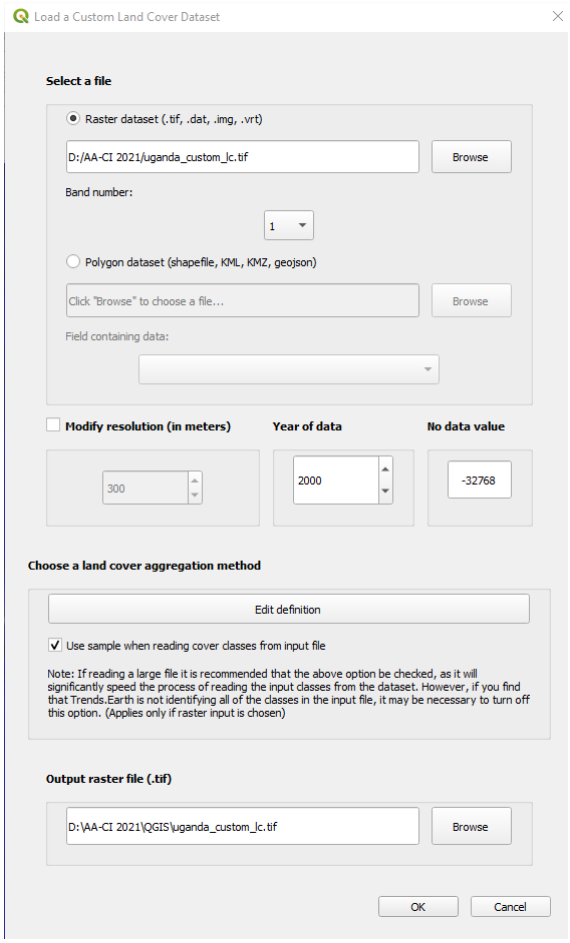
6. Use the **Setup aggregation of land cover data menu** to assign to each number in the **Input class** its corresponding **Output class**.

   When you are done editing, click **Save definition file**. This option will save you time next time you run the tool, by simply loading the definition file you previously saved.

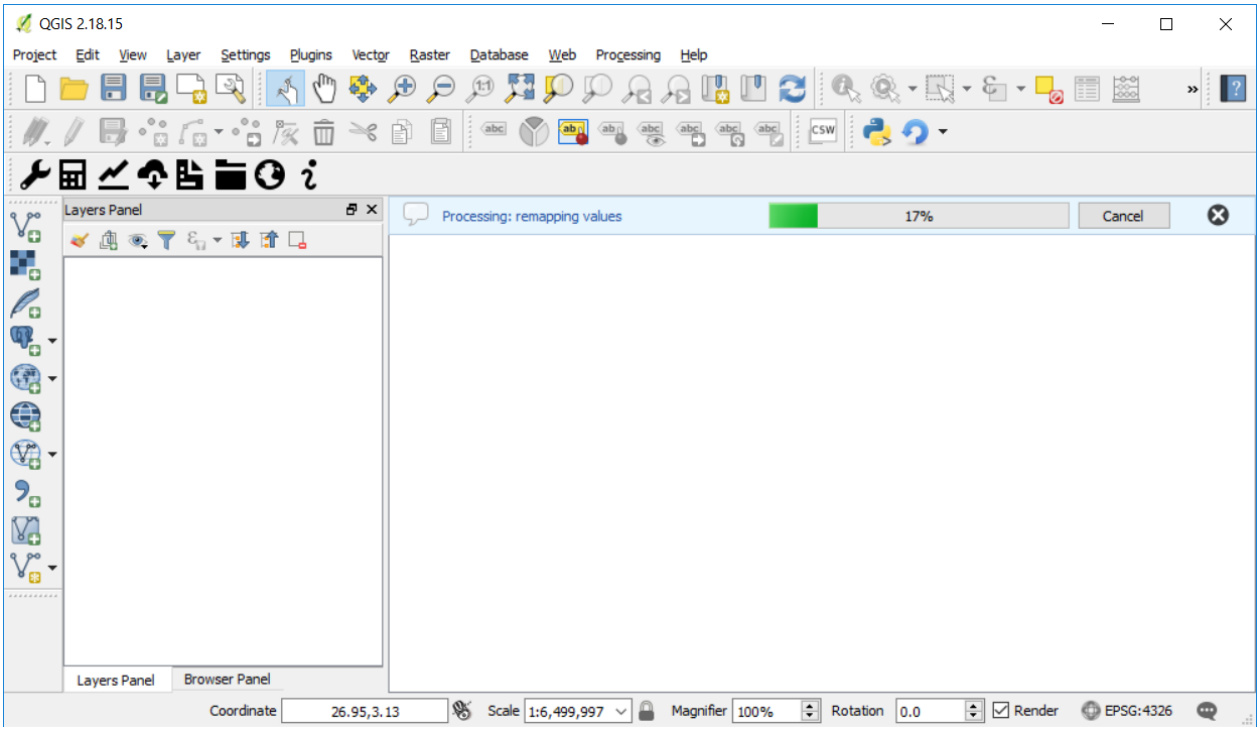
   Click **Save** to continue



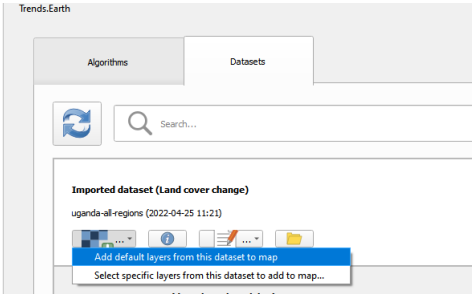
7. Back at the **Load a Custom Land Cover dataset** window, click **Browse** at the bottom of the window to select the **Output raster file** and navigate to the folder where you want to save the file. Type in a name and click **OK**.



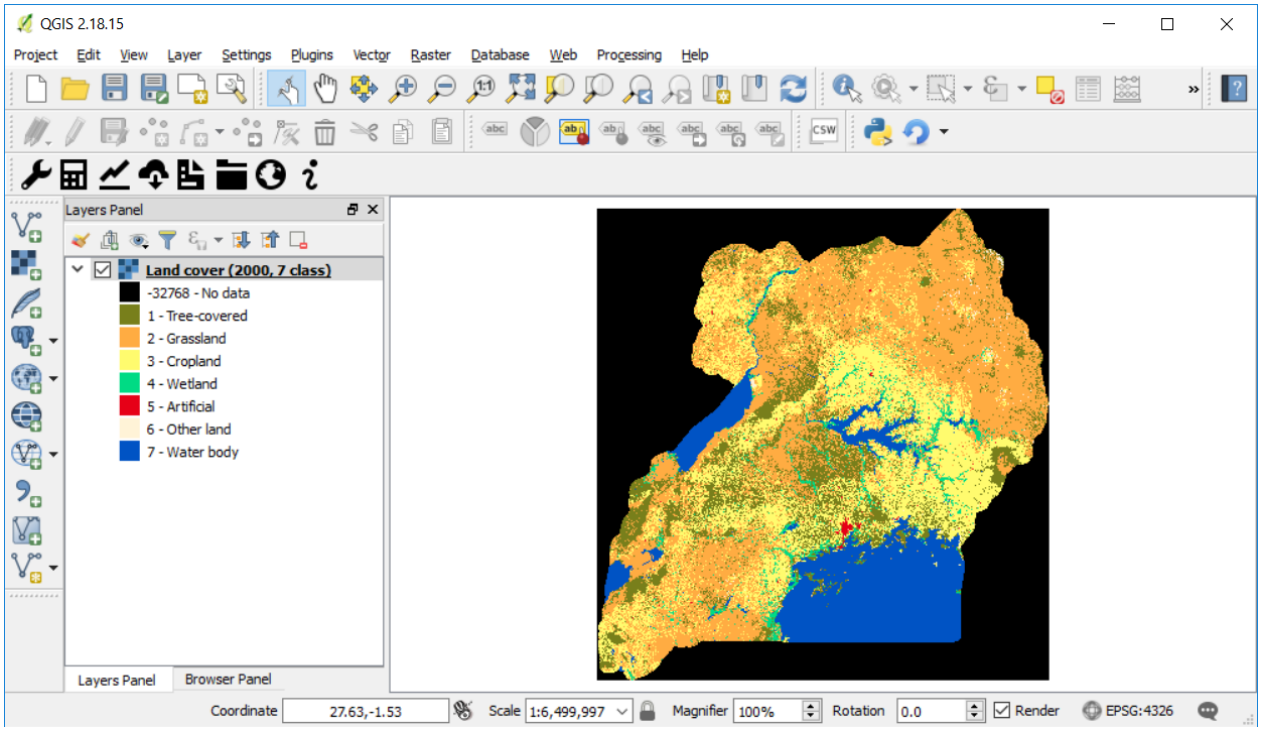
8. A progress bar will appear showing the percentage of the task completed.



9. In the **Datasets** window, find the **Imported dataset (land cover change)** on click on **Load dataset onto QGIS map area**.



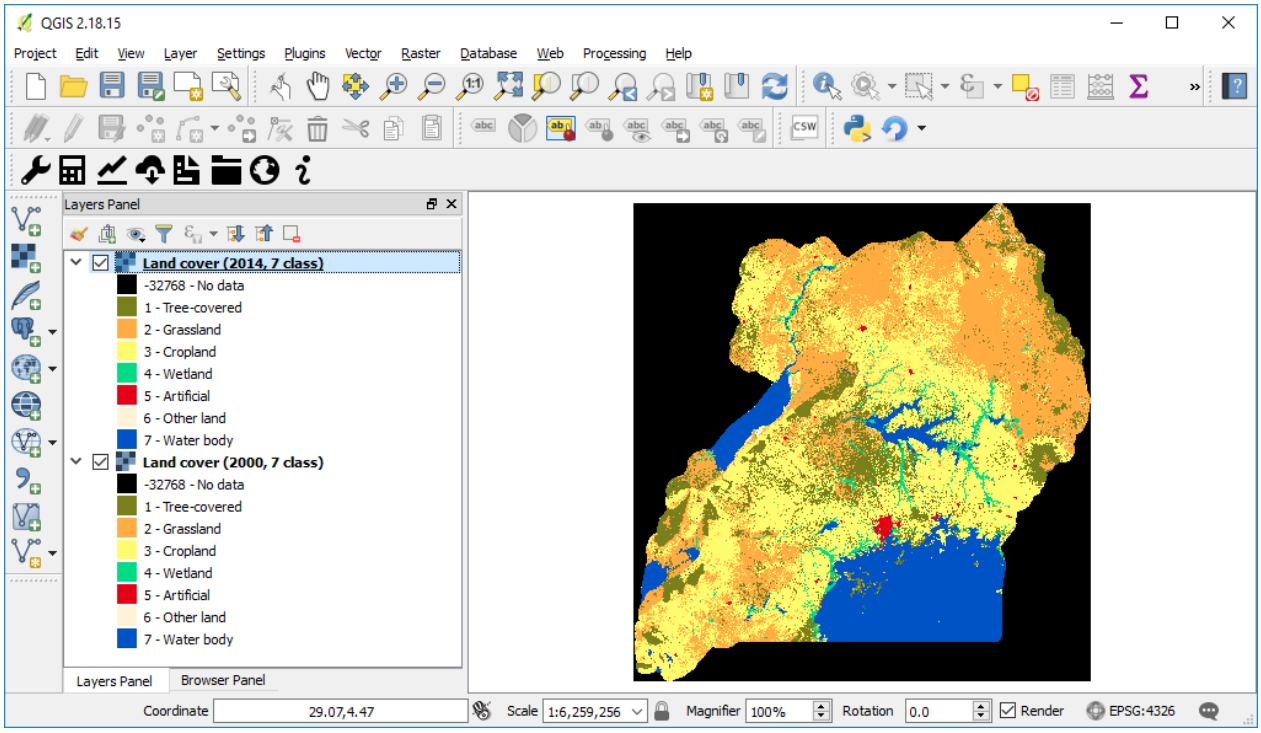
.The imported land cover dataset will be loaded to QGIS.



Note

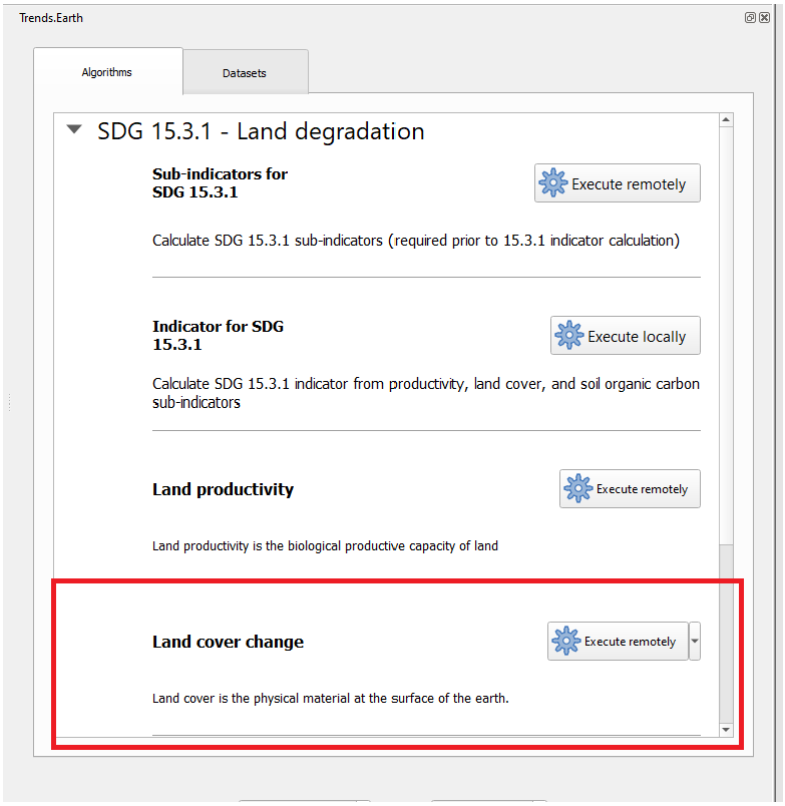
You have one imported custom land cover data for one year (2000), but two are needed to perform the land cover change analysis. Repeat now steps 1 through 8, but this time with the most recent land cover map. For this tutorial, we will use another land cover map from Uganda from the year 2015. **Make sure to change the year date in the import menu**.

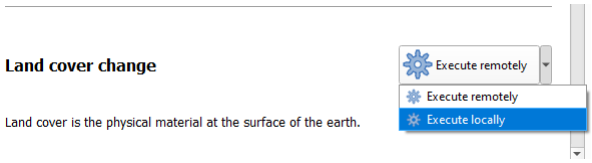
10. Once you have imported the land cover maps for years 2000 and 2015, you should have them both loaded to QGIS.



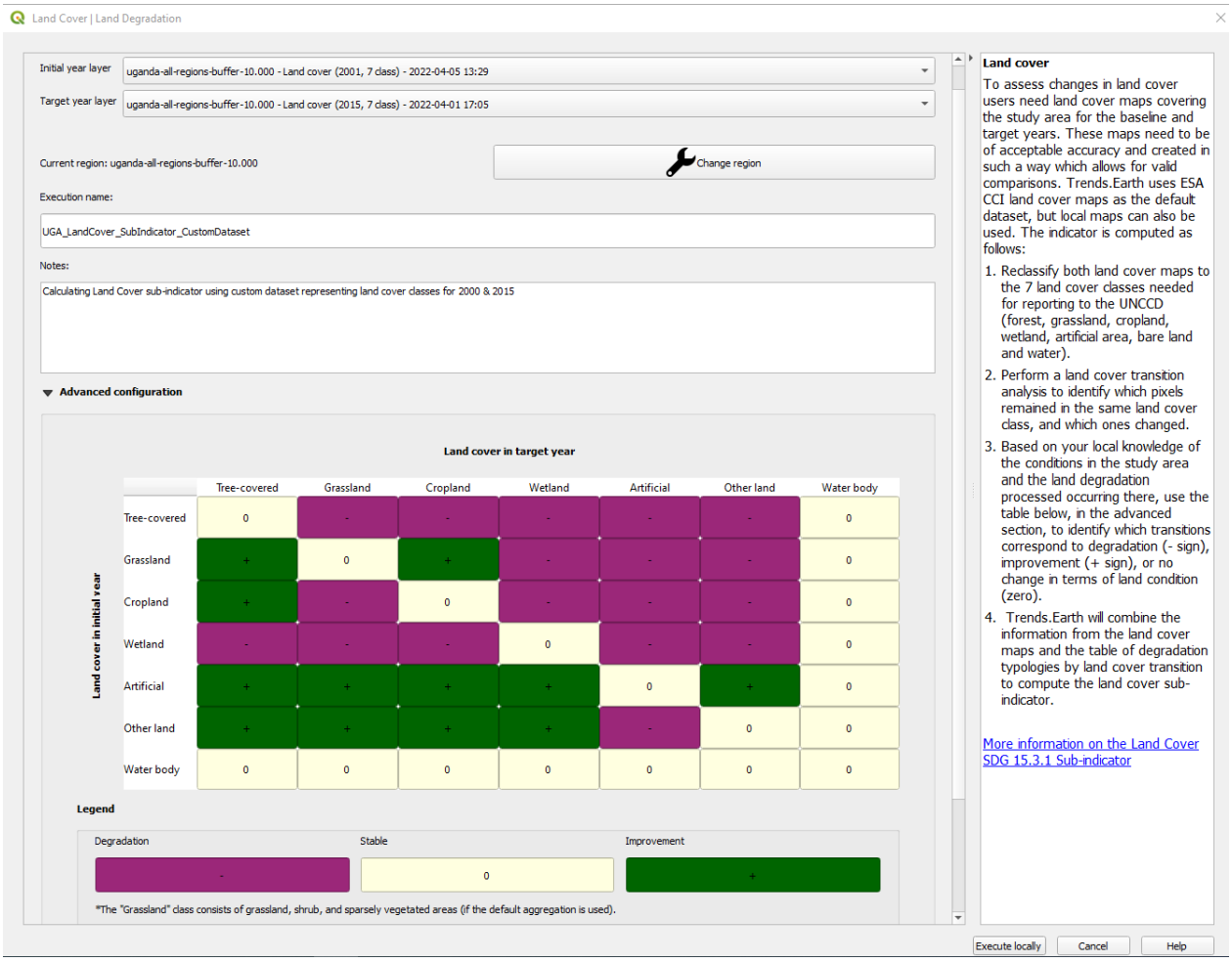
Calculating Land Cover sub-indicator with custom data

1. Now that both land cover datasets have been imported into Trends.Earth, the land cover change analysis tool needs to be run. In the **Algorithm window**, click on **Execute locally** under **Land cover change**.





2. The **Land Cover | Land Degradation** window will open. Use the drop down option next to **Initial year layer** and **Target year layer** to change the dates accordingly.



- The region of interest is already set up in Settings. If you need to change, select the **Change region** button.

Note

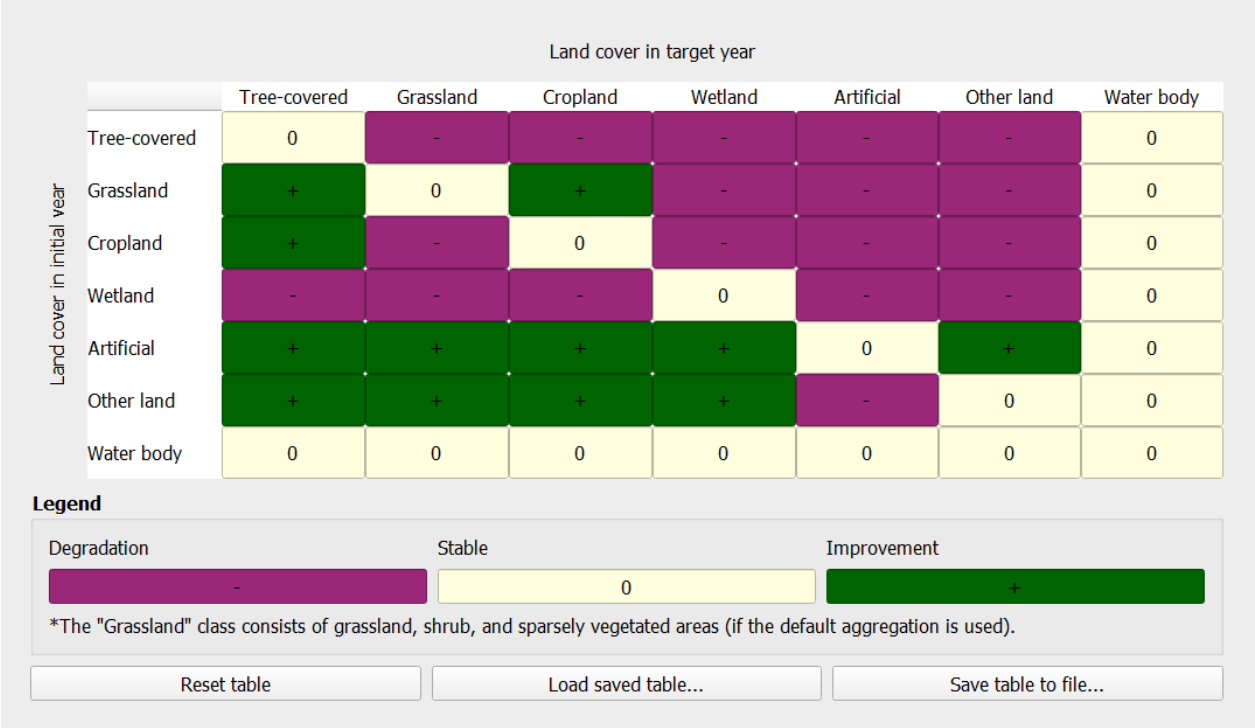
Refer to the Settings section of this manual for more information on setting up your area of interest.

3. Click on **Advanced** to expand it. Here you will define the meaning of each land cover transition in terms of degradation. Transitions indicated in purple (minus sign) will be identified as degradation in the final output, transitions in beige (zero) will be identified as stable, and transitions in green (plus sign) will be identified as improvements.

   For example, by default it is considered that a pixel that changed from **Grassland** to **Tree-covered** will be considered as improved. However, if in your study area woody plant encroachment is a

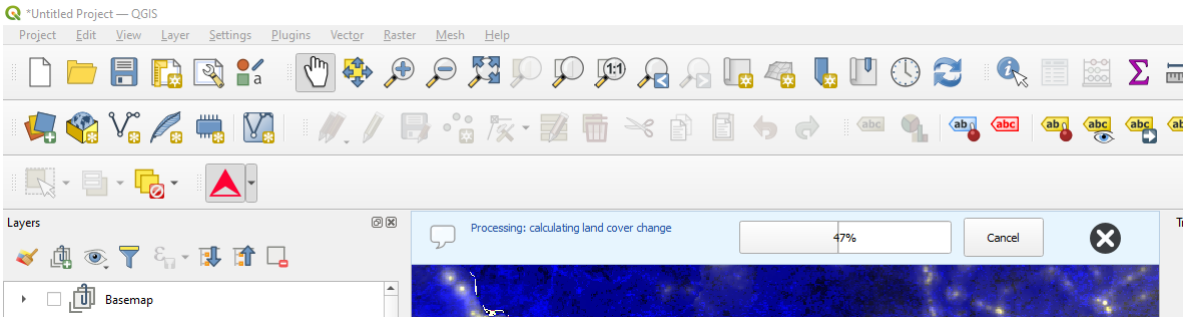
degradation process, that transition should be changed for that particular study area to degradation (minus sign).

If you did change the meaning of some of the transitions, click on **Save table to file…** to save the definition for later use.

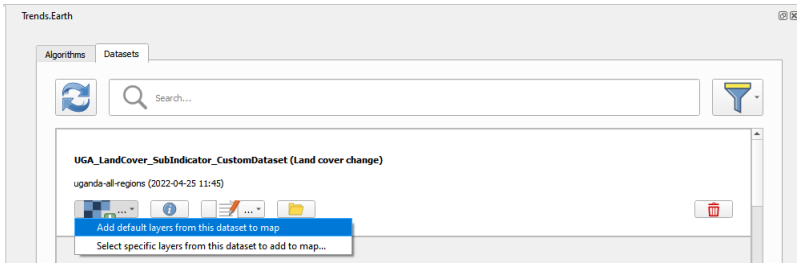


. If you have made no changes to the default matrix, simply click **Execute locally**.

4. When you click **Execute locally**, a progress bar will appear showing the percentage of the task completed.



5. In the **Datasets** window, find the **Land cover change** sub-indicator dataset calculated using custom Land Cover data and click on click on **Add default layers from this dataset to map**.



Custom Data - SOC

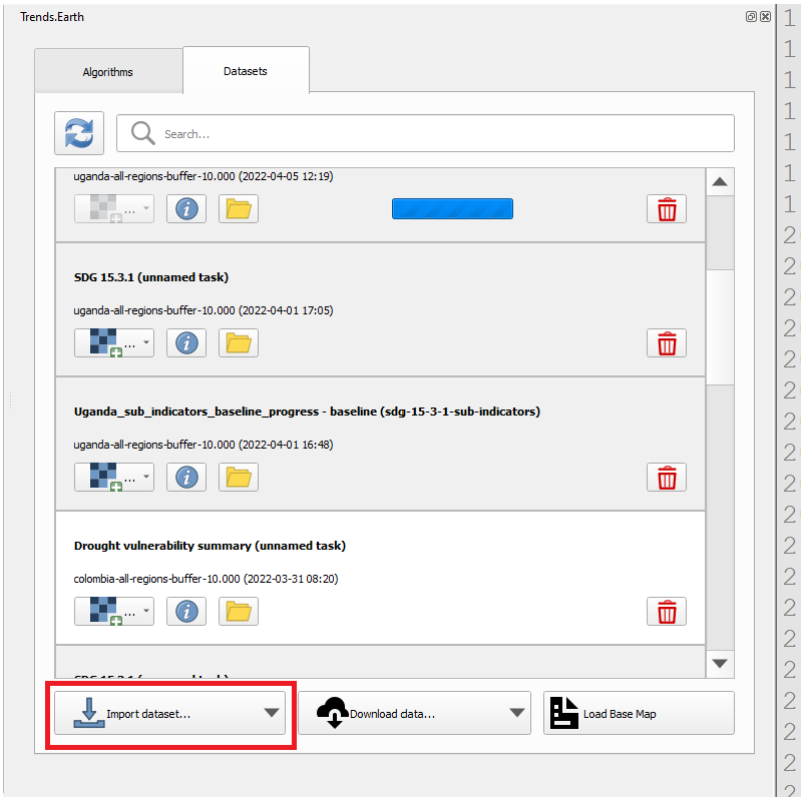
- **Objective**: Learn how to load custom soil organic carbon data to compute the carbon change sub-indicator using Trends.Earth.
- **Estimated time of completion**: 20 minutes
- **Internet access**: Not required

Loading custom soil organic carbon data

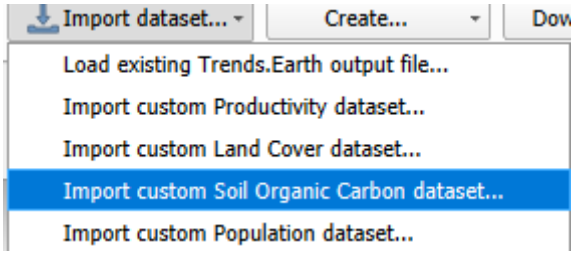
Note

This tool assumes that the units of the raster layer to be imported are **Metrics Tons of organic carbon per hectare**. If your layer is in different units, please make the necessary conversions before using it in Trends.Earth.

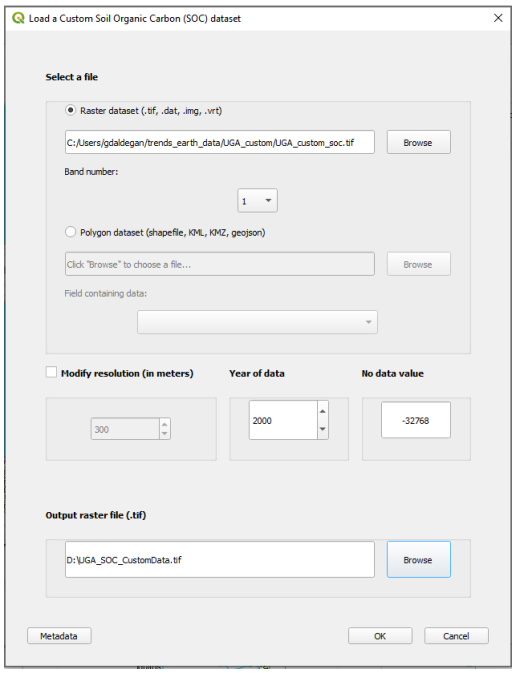
1. To load a custom Soil Organic Carbon data click on the **Datasets** window, and then click on **Import dataset**.



2. Several options will appear. Select **Import custom Soil Organic Carbon** from the list.



3. In the **Load a Custom Soil Organic Carbon (SOC) dataset** window, use the radio button to select the format of the input file (raster or vector). For this tutorial select raster, since the data distributed by the UNCCD is in raster format. Click on **Browse** to navigate to the SOC file you wish to import.

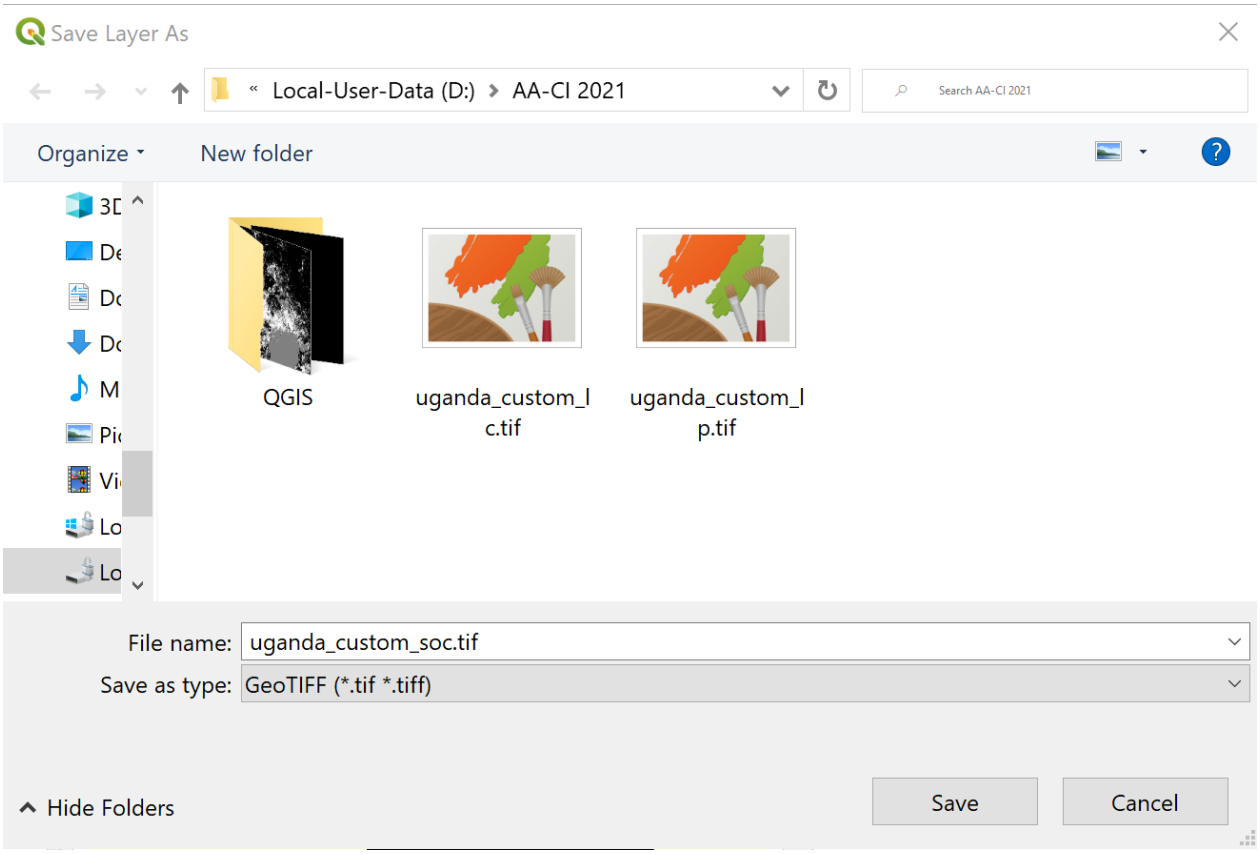


4. In the **Load a Custom Soil Organic Carbon (SOC) dataset** window you also have options for selecting the band number in which the SOC data is stored, in case your input file is a multi-band raster. You also have the option of modifying the resolution of the file. We recommend leaving those as defaults unless you have valid reasons for changing them.

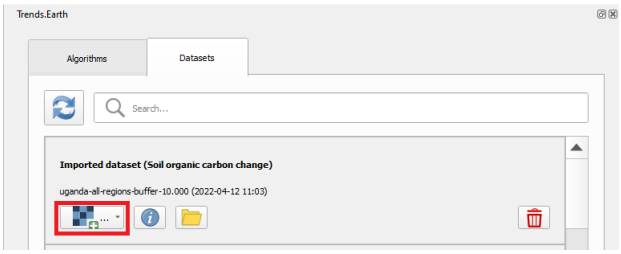
   Define the year of reference for the data. In this case, since the SOC dataset for Uganda was developed for the **year 2000**, define it as such. Make sure you are assigning the correct year.

6. Click **Browse** at the bottom of the window to select the **Output raster file**.

7. Navigate to the folder where you want to save the file. Assign it a name and click **Save**.



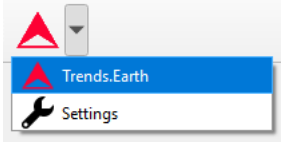
8. Back at the **Load a Custom Soil Organic Carbon (SOC) dataset** click **OK** for the tool to run.
9. When you click **Execute locally**, a progress bar will appear showing the percentage of the task completed.
10. In the **Datasets** window, find the **Imported dataset (Soil Organic Carbon) and click on click on **Load dataset onto QGIS map area**.



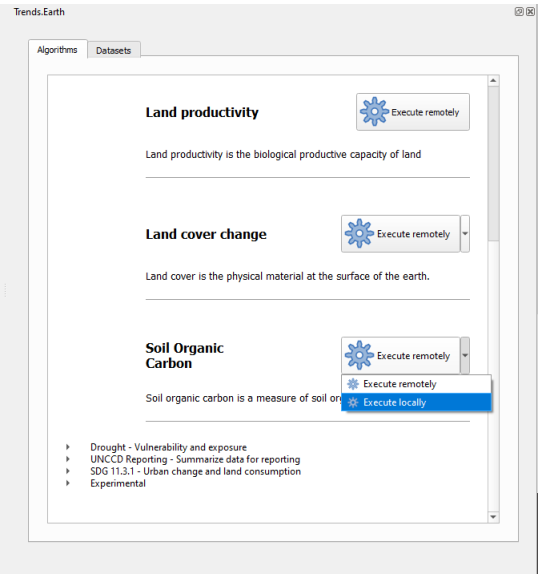
Calculating soil organic carbon sub-indicator with custom data

Once you have imported a custom soil organic carbon dataset, it is possible to calculate soil organic carbon degradation from that data. To do so, first ensure the custom soil organic carbon data is loaded within QGIS (see:ref:*load_custom_soc*).

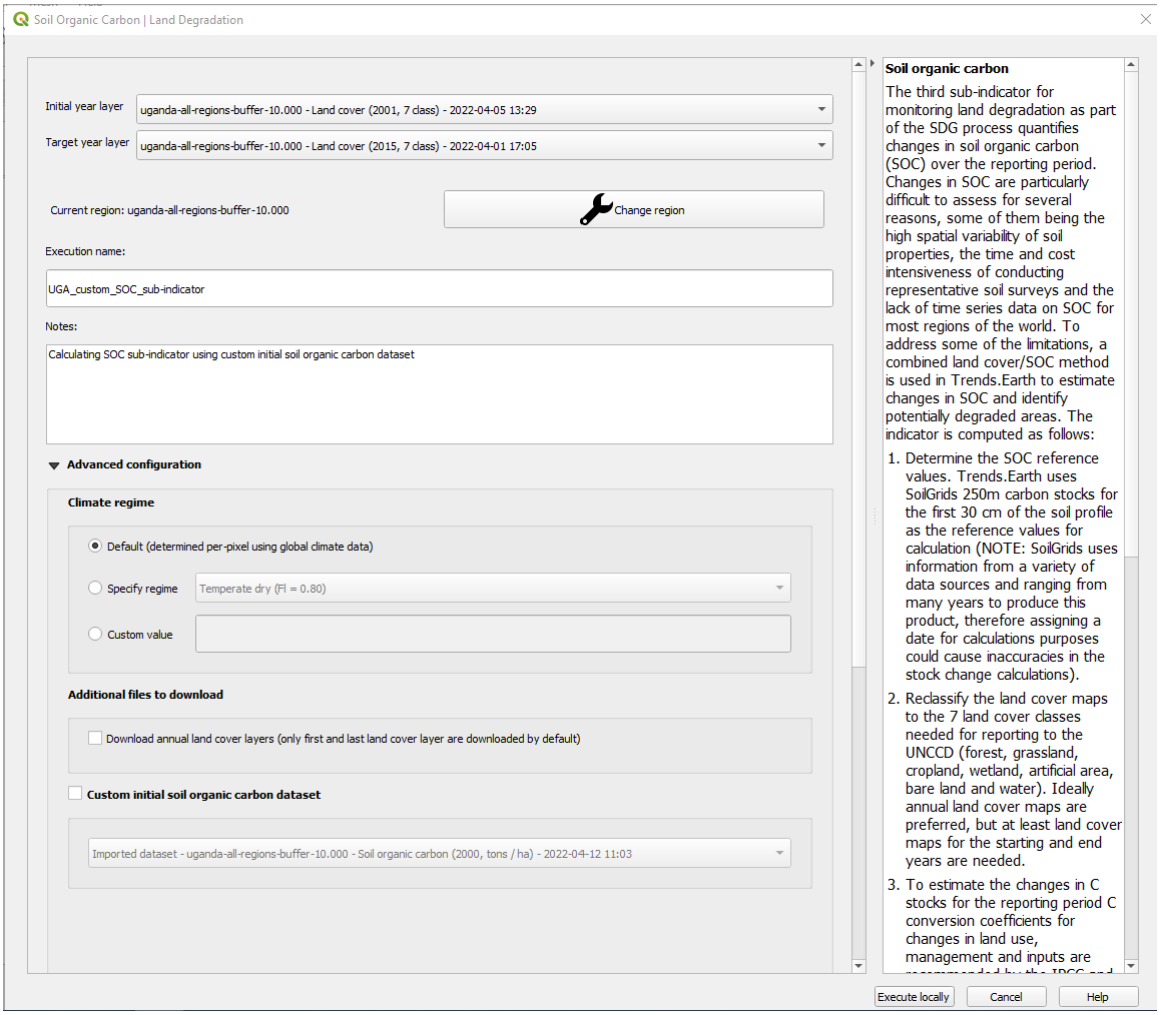
1. Search for the Trends.Earth toolbar within QGIS, and click on the Trends.Earth icon.



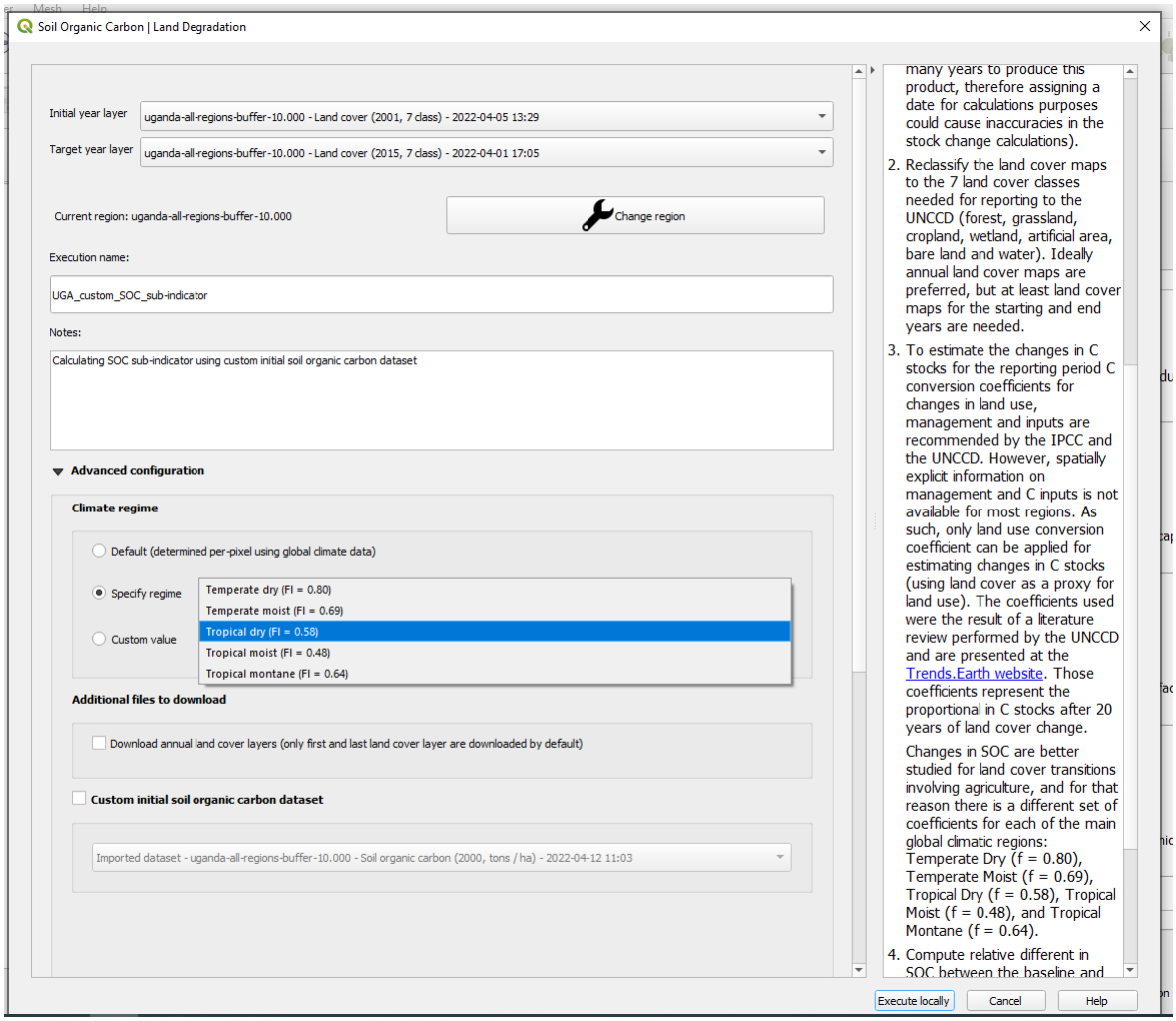
2. The **Trends.Earth** panel will open. In the **Algorithm** window, click on **SDG 15.3.1- Land Degradation** and select **Execute locally** under **Soil Organic Carbon**.



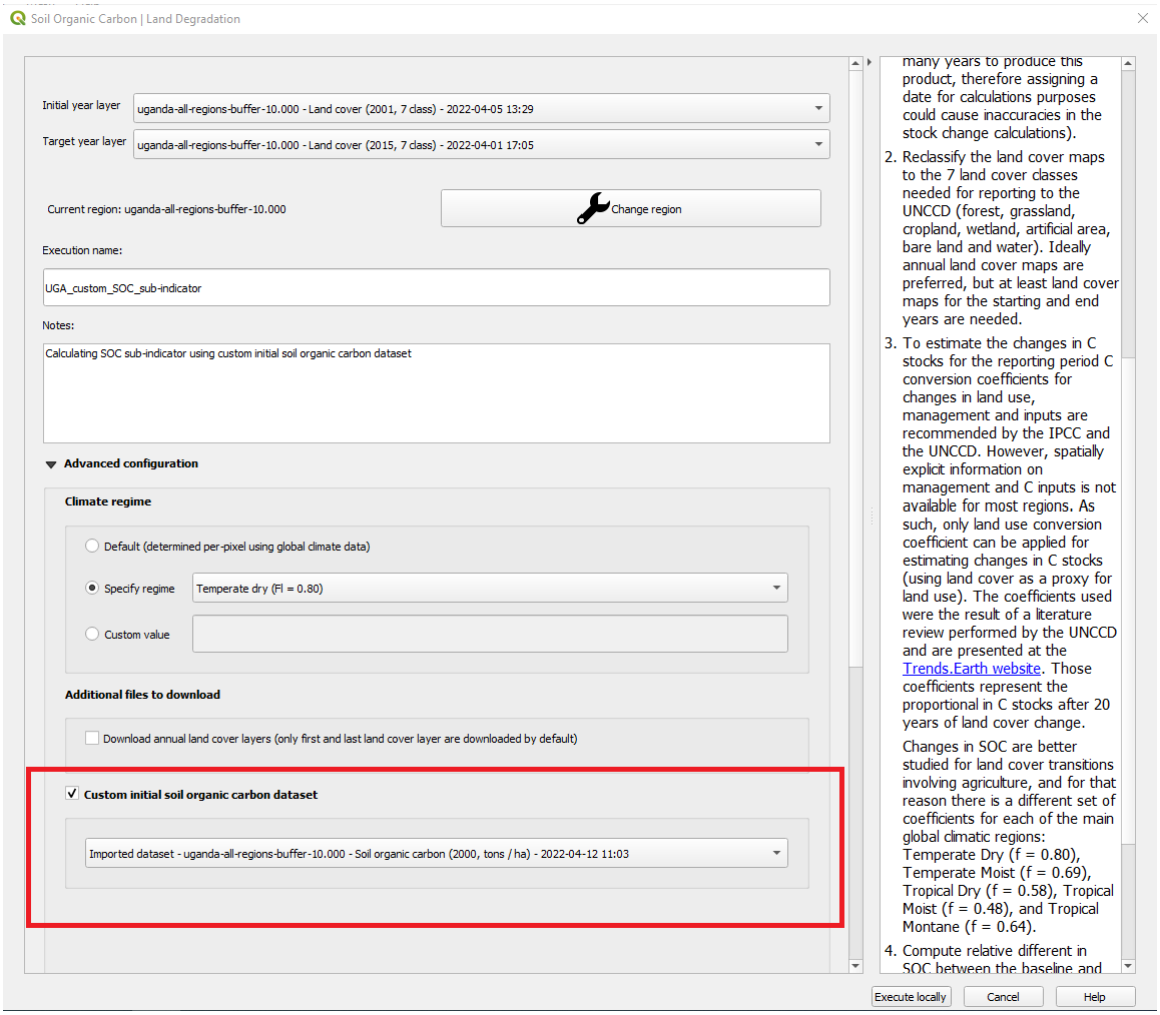
3. The **Soil Organic Carbon | Land Degradation** window will open. Click on the drop-down lists and select the **Initial year layer** and the **Target year layer** to load land cover dataset you have already processed in Trends.Earth representing the initial and target years of the time-series for which the SOC sub-indicator will be calculated. See the Custom Data - Land Cover tutorial for more information on loading land cover datasets. Enter a **Execution name** and make sure to type in some notes for future reference.



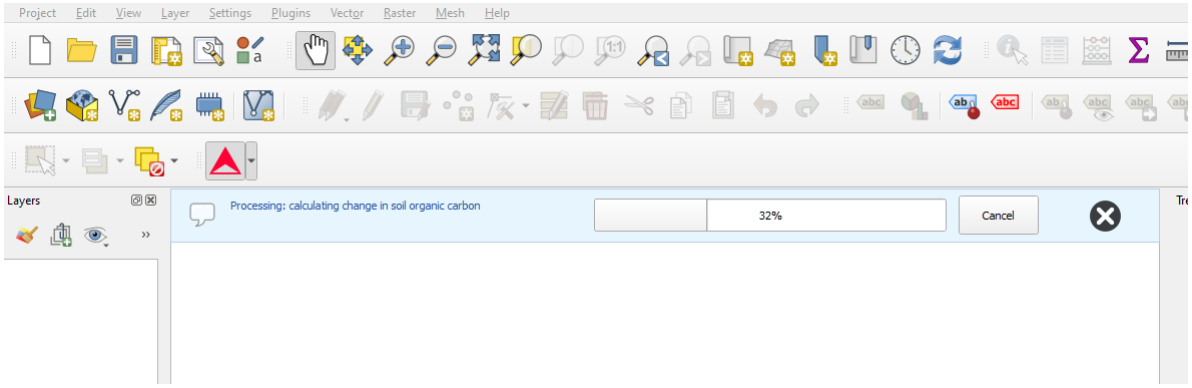
4. Under **Advanced configuration**, you have the options to set a **Climate regime** that is most appropriate for you region of interest. You can leave this option as defaults, **Specify regime** by selecting one of the Global Climatic Regions listed under the drop-down menu, or either enter a **Custom value** in case you have valid reasons for changing them.



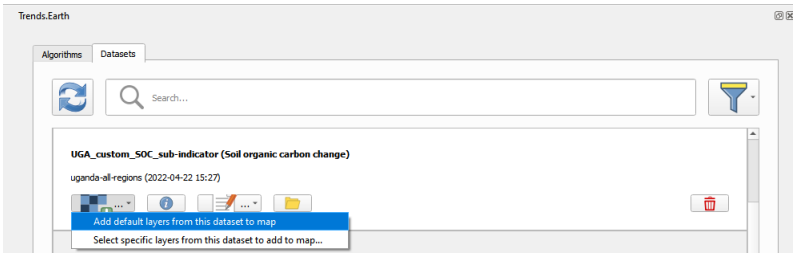
5. Still under **Advanced configuration**, check the **Custom initial soil organic carbon dataset** box and select the custom dataset representing SOC you just imported as **Initial year layer**



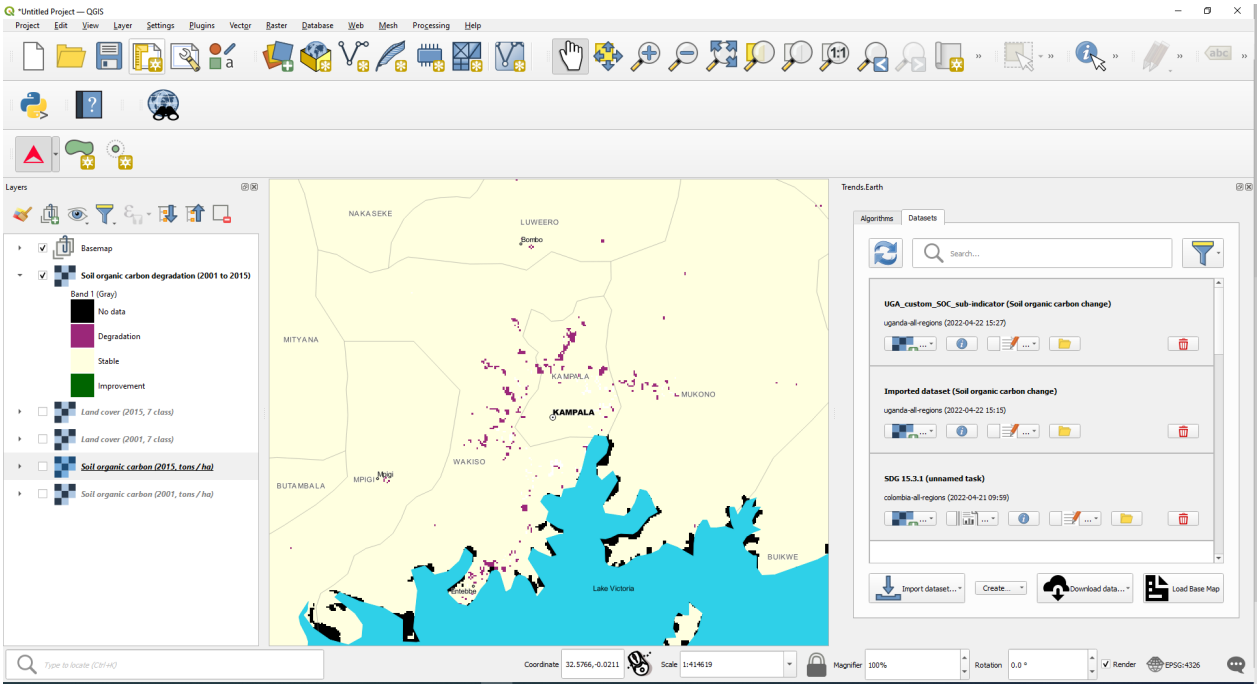
6. Click **Execute locally**. A progress bar will appear on your screen. Do not quit QGIS or turn off your computer until the calculation is complete.



7. In the **Datasets** window, find the **Soil organic carbon change** task and click on click on **Add default layers from this dataset to map** under **Load dataset onto QGIS map area**.



9. For example, we can see areas of degradation in soil carbon around Kampala:



Note

Refer to the Soil organic carbon tutorial for instructions on how to use the imported soil organic carbon data to compute the final SDG 15.3.1 after integration with land cover and land productivity.

Exploring NDVI (Plot Data)

- **Coming soon**

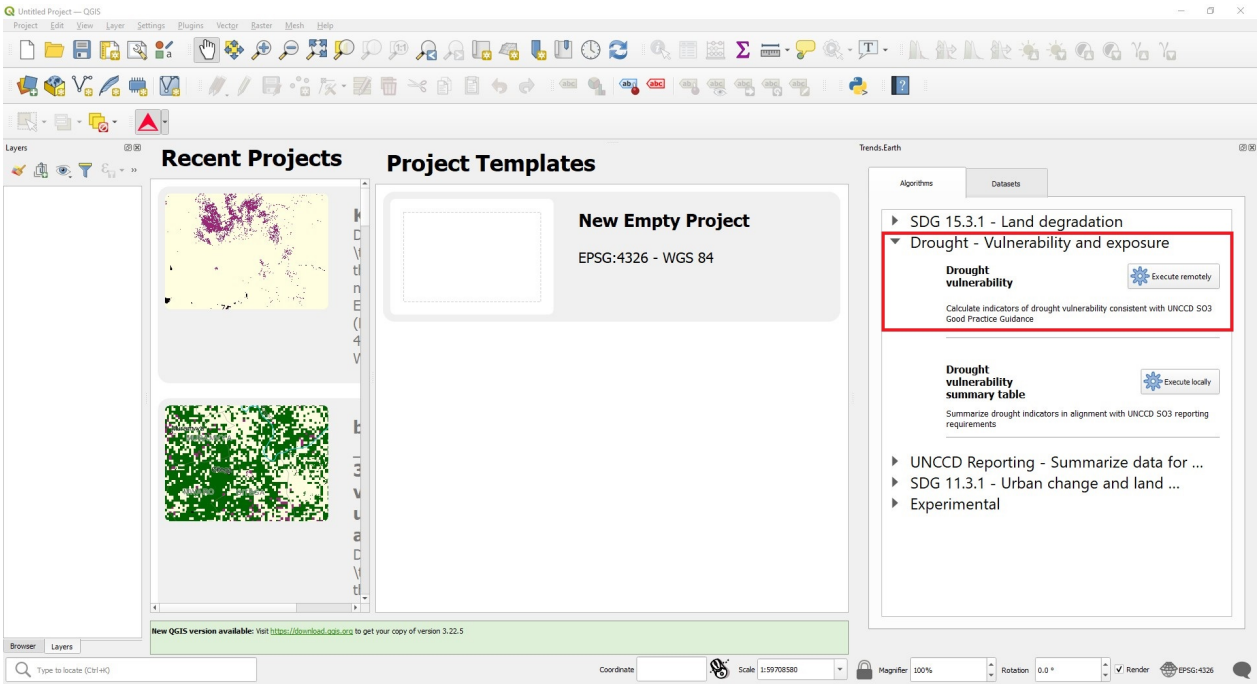
Drought hazard, exposure, and vulnerability

Default data for UNCCD SO 3

- **Objective**: : Learn how to calculate SO 3 indicators of drought Hazard, Exposure and Vulnerability using Trends.Earth and the default data: monthly precipitation dataset from the Global Precipitation Climatology Center -GPC, gridded population count from WorldPop and Vulnerability to drought from the European Commission's Joint Research Centre - JRC. In this tutorial we will use Colombia as an example, but you can choose any study area.
- **Estimated time of completion**: 15 minutes

- **Internet access**: Required

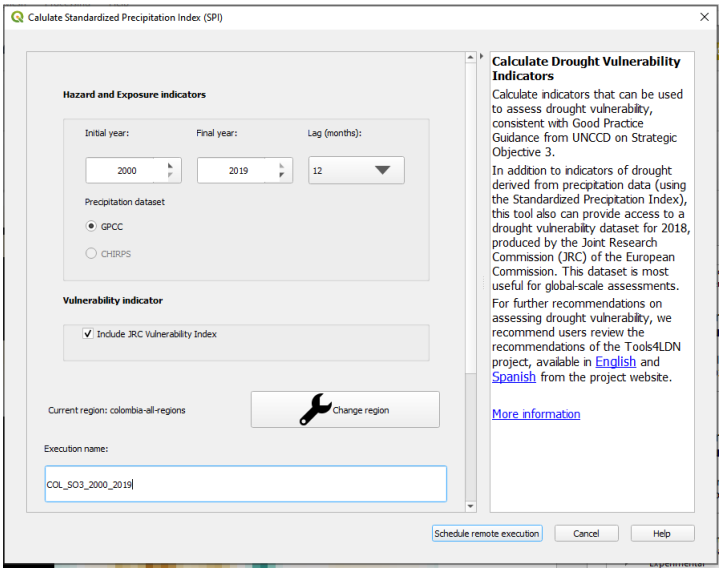
1. In the **Algorithm** window, click on **Drought - Vulnerability and exposure** and select **Execute remotely** under **Drought vulnerability**.



- The region of interest is already set up in Settings. If you need to change, select the **Change region** button.

> **Note**
>
> Refer to the Settings section of this manual for more information on setting up your area of interest.

3. Set the **Initial** and **Final** year and the **Lag(months)** that will be applied to the Precipitation Dataset for calculating drought Hazard and Exposure. Select the **Include JRC Vulnerability Index** check box to calculate drought Vulnerability for the region of interest. The default Precipitation dataset is the Global Precipitation Climatology Centre (GPCC) v2020 at roughly 27 sq km spatial resolution. Soon users will have the option to select the CHIRPS dataset from the Climate Hazard Group – although featuring finer spatial resolution, at approximately 5 sq km, the CHIRPS dataset does not offer complete global coverage, extending from 50 South to 50 North. Type in an **Execution name** and make sure to leave some notes about this step for future reference.



4. Select **Schedule remote execution** button.

Note

Refer to the Land degradation and SDG 15.3.1 section of this manual to learn about drought Hazard, Exposure and Vulnerability.

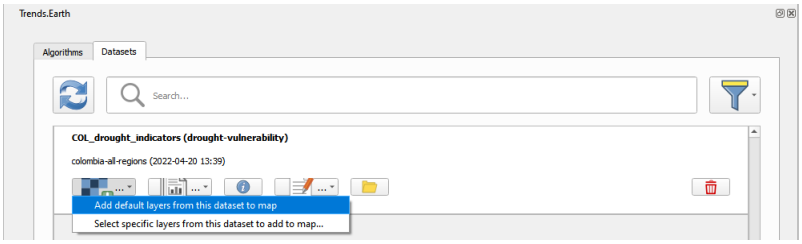
5. In the **Trends.Earth** panel, select the **Datasets** tab. The task submitted will appear in the menu if the **Download remotely-generated datasets automatically** is checked in settings.

Note

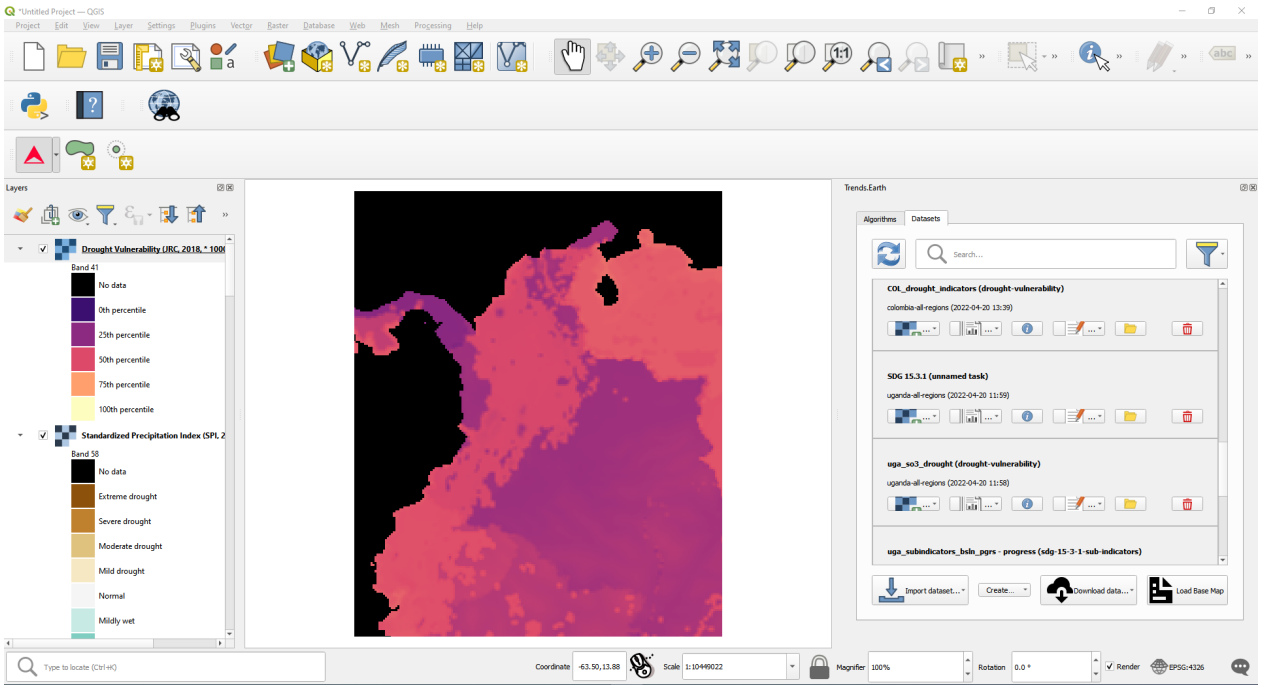
Refer to the Settings section of this manual to learn more about **Advanced settings**

. Select the Refresh button if the analysis does not appear in the menu.

6. Select the add layer drop-down button to **Add default layers from this layer to the map**



7. The default data: Standardized Precipitation Index for all epochs, JRC's Drought Vulnerability Index for 2018, and population disaggregated by gender, will be added to the map for the region of interest.



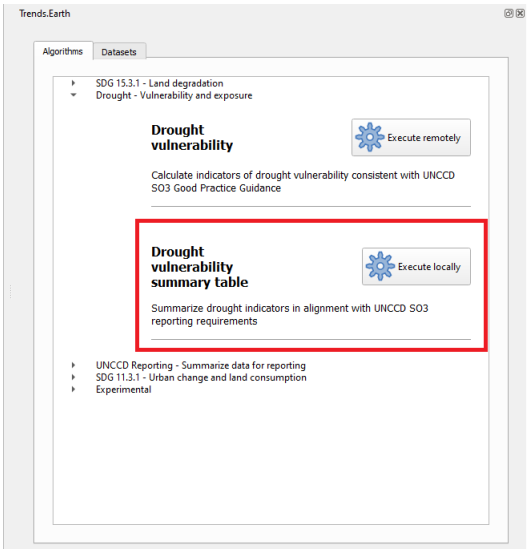
Summarizing SO 3 indicators for reporting to UNCCD

- **Objective**: Learn to integrate the drought indicators in alingment with UNCCD SO3 reporting requirements.
- **Estimated time of completion**: 15 minutes
- **Internet access**: Not required

Note

You will need to have previously calculated the indicators of drought hazard, exposure and vulnerability. If you have not, please refer to the previous step on this tutorial.

1. Click on the Trends.Earth toolbar within QGIS, and click on the Trends.Earth icon.
2. The **Trends.Earth** panel will open. In the **Algorithm** window, click on click on **Drought - Vulnerability and exposure** and select **Execute locally** under **Drought vulnerability summary table**.

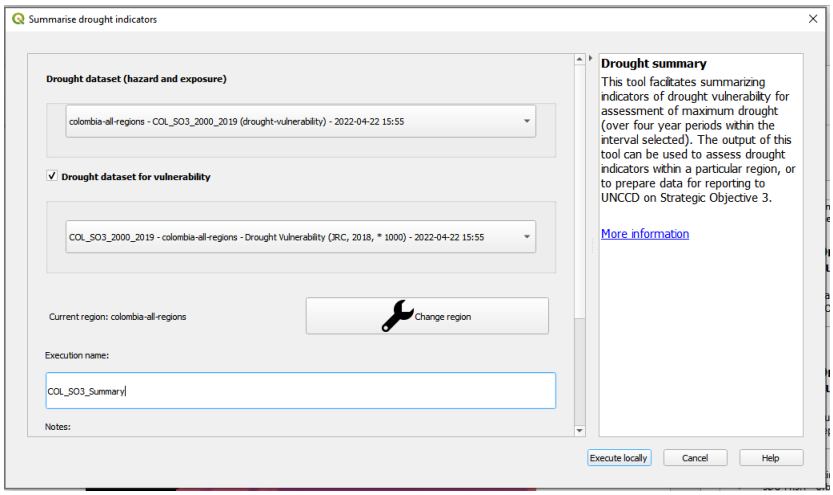


The region of interest is already set up in Settings. If you need to change, select the **Change region** button.

Note

Refer to the Settings section of this manual for more information on setting up your area of interest.

3. Select the **Drought dataset (hazard and exposure)** from the drop-down list
4. Make sure to check the **Drought dataset for vulnerability** box so this dataset set is also included in the summary calculation. If you have the drought indicator datasets loaded to the QGIS map canvas, Trends.Earth will automatically select them



5. In **Population exposed to drought**, choose the population data to use:
    - **Use annual population from the drought dataset** is selected by default. Keep this option to use the annual population series included in the selected drought dataset.
    - To use custom data, first import it through **Import custom Population dataset** in the Trends.Earth import menu. Specify the population year, whether the data represents total, male, or female population, and the correct input units: **People per pixel**, **People per hectare**,

or **People per square kilometre**. For sex-disaggregated data, import the male and female layers separately.

- Return to the drought summary dialog and choose **Total population** to enable the total-population dropdown, or **Population broken down by sex** to enable the male and female dropdowns. Select the corresponding imported layers. Male and female layers must represent the same year.

Each selected population layer must cover the region of interest. The dropdowns filter layers by population type and region coverage; a total population import will not appear in the male or female dropdowns.

Important

Selecting population layers defines a **fixed-population scenario**. The selected population is reused for every drought year, even when its source year differs from the drought years. This measures exposure under a constant population distribution, not annual population change. The source population year is retained in the job parameters. To restore the original annual series, select **Use annual population from the drought dataset**.

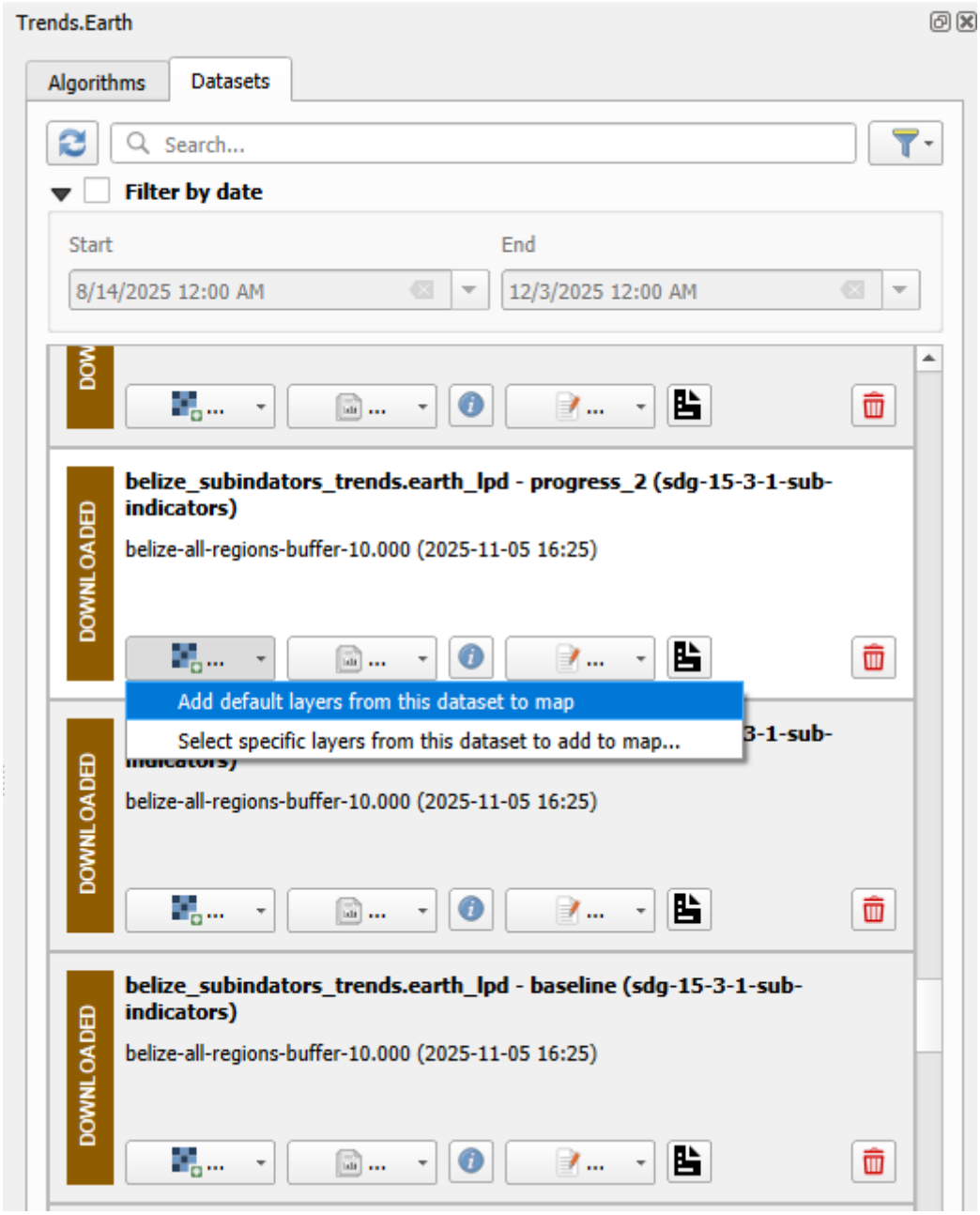
6. Select **Execute locally** button.
7. In the **Trends.Earth** panel, select the **Datasets** tab. The task submitted will appear in the menu if the **Download remotely-generated datasets automatically** is checked in settings.

Note

Refer to the Settings section of this manual to learn more about **Advanced settings**

Select the Refresh button if the analysis does not appear in the menu.

8. Select the add layer drop-down button to **Add default layers from this layer to the map**



9. The data for SO 3 Indicators will be added to the map for the region of interest.

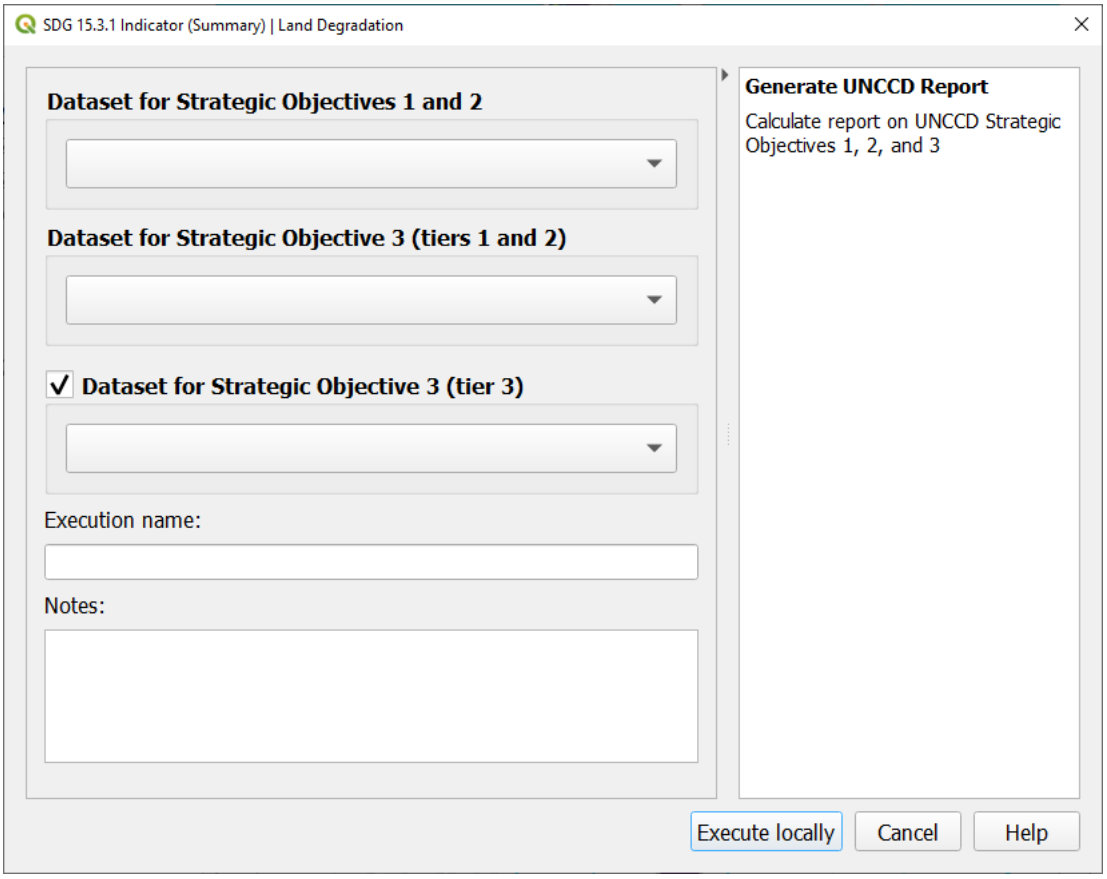
Note

Population values remain floating point from the remote download through the local summary raster, preserving fractional people per pixel. In the population-at-maximum-drought layers, negative values indicate exposure to drought; missing population data remains nodata (-32768).

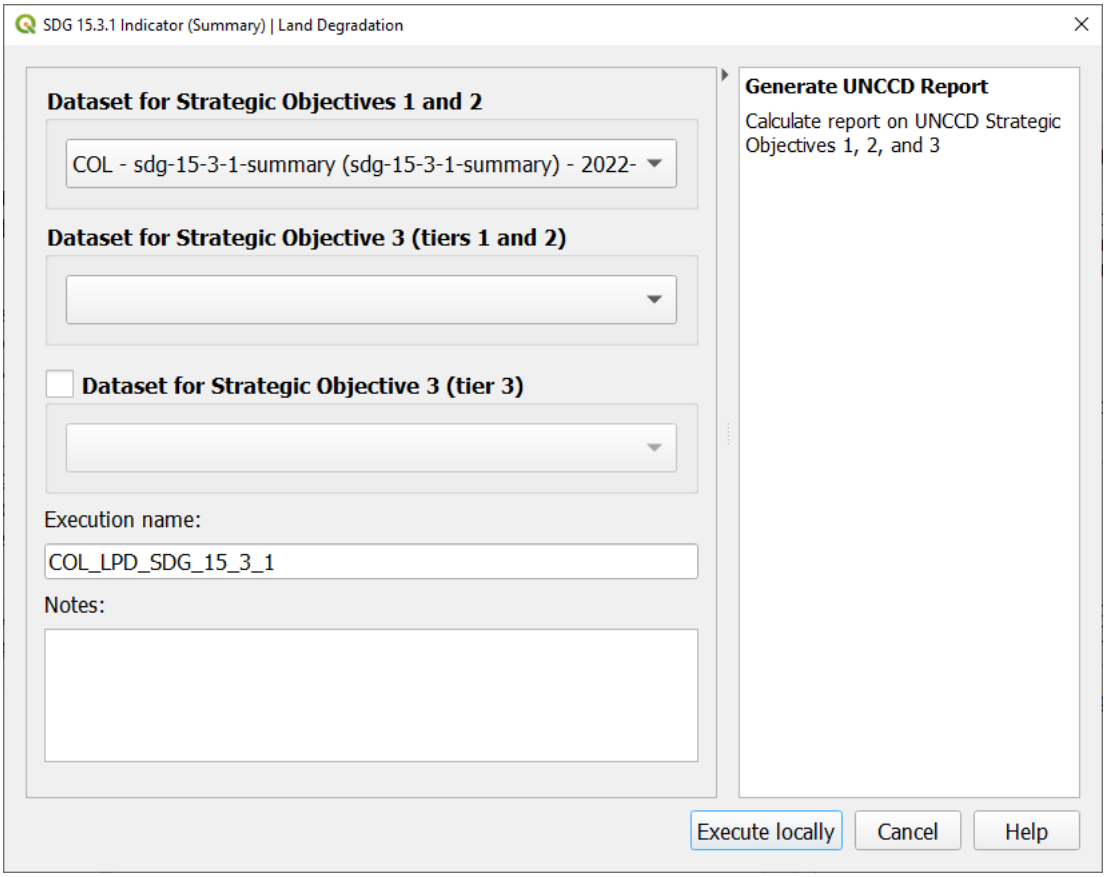
UNCCD Reporting

Generate data package for UNCCD reporting

1. In the **Trends.Earth** panel, select the **Algorithm** window, click on **UNCCD Reporting - Generate data package for UNCCD reporting** and select **Execute locally**.



2. The window will appear with the default data populated in the drop-down lists for the region of interest. Enter **Execution name** and **Notes**. Select **Execute locally**.



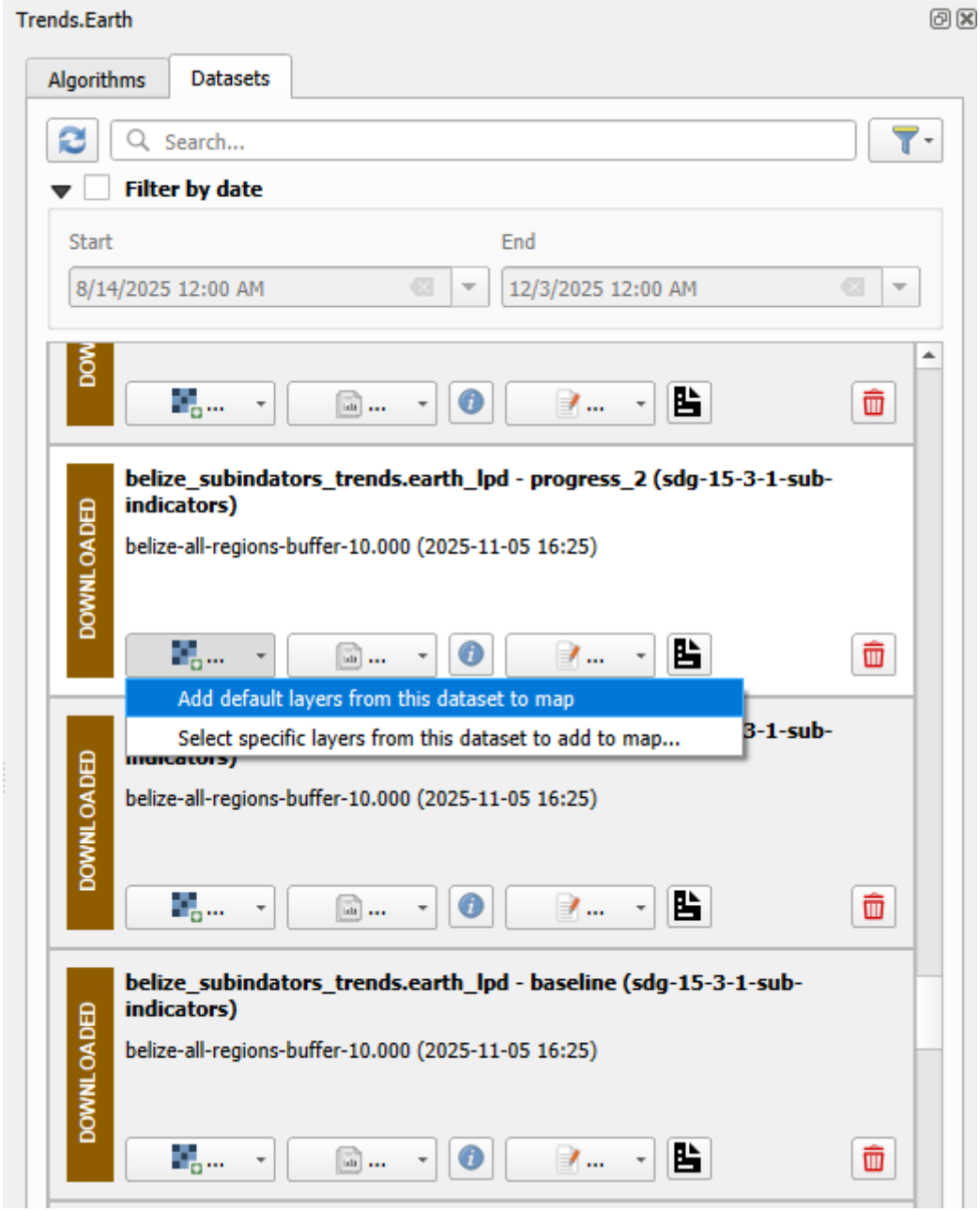
3. In the **Trends.Earth** panel, select the **Datasets** tab. The task submitted will appear in the menu if the **Download remotely-generated datasets automatically** is checked in settings.

Note

Refer to the Settings section of this manual to learn more about **Advanced settings**

Select the Refresh button if the analysis does not appear in the menu.

4. Select the add layer drop-down button to **Add default layers from this layer to the map**



5. The final SDG 15.3.1 Indicator using default data will be added to the map for the region of interest.

Note

Refer to the Land degradation and SDG 15.3.1 background for interpreting the results of this analysis.

Land Consumption (SDG 11.3.1)

- **Objective**: Learn how to compute urban extent and population for 2000, 2005, 2010, 2015 in raster format and tabular outputs with areas estimated.
- **Estimated time of completion**: 40 minutes

- **Internet access**: Required

> **Note**
>
> For a description on the concepts behind SDG 11.3.1, the data needs and methods used in TRENDS.EARTH, please refer to the background section: Land Consumption and SDG 11.3.1.

> **Note**
>
> On July 20th 2019 we launched an updated version of the ISI dataset. We recommend using the most current version. However, if you run any analysis of SDG 11.3.1 in TRENDS.EARTH before that date and would like to replicate them, please use the previous plug in version available here and refer to this website for instruction on how to install it.

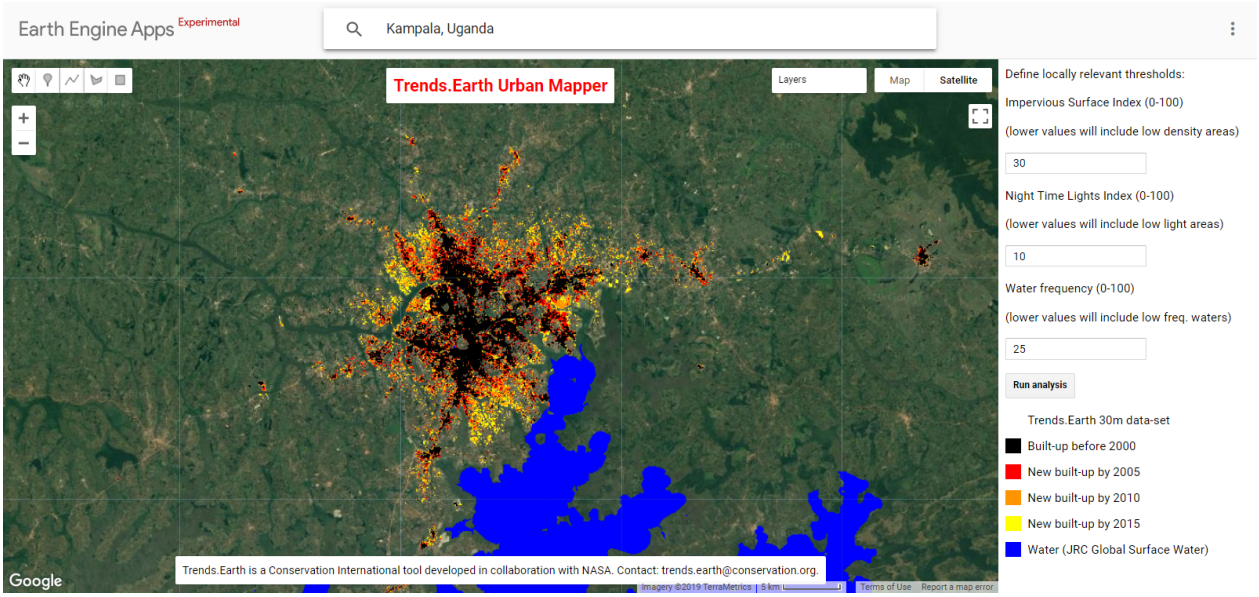
Exploring the Urban Mapper

The first step before analyzing urban change is to define the extent of built up areas. For that, we have created an interactive web interface called Trends.Earth Urban Mapper. This step is fundamental to make sure that the built up area identified by the indicators accurately reflects the conditions in your area of study. The Trends.Earth Urban Mapper allows users to explore how changing different parameters impact the extent of the built up area data which will be then used to define changes in urban extent.

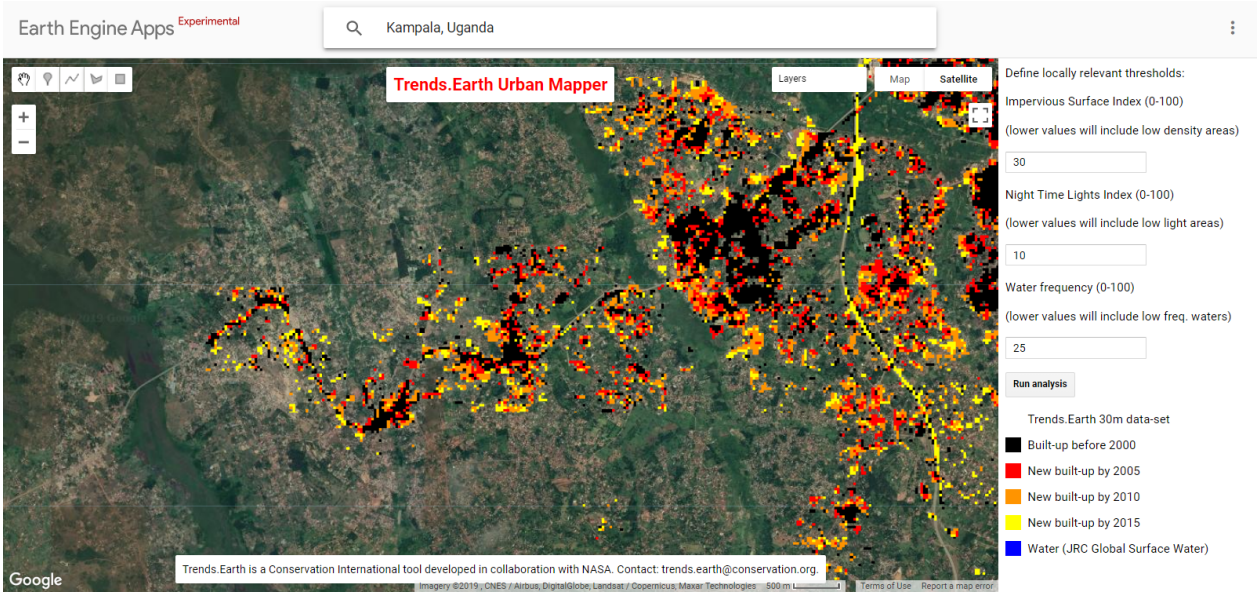
1. Navigate to the Trends.Earth Urban Mapper before you run the analysis in QGIS.
2. This tool can be used to analyze changes in built up area in almost any city of the world. Click on the **Search Places** window in the top center of the page and type the city you want to analyze. For this tutorial, type **Kampala, Uganda** and click on the option showing right underneath.
3. This tool allows you to change three parameters in order to correctly identify the most appropriate built up extent for your city: **Impervious surface index, night time lights index, and water frequency**. The first time you run the tool in a new city, click **Run analysis** to see how the default parameters perform, and from there you can customize the analysis. You can use the high spatial resolution images in the background to evaluate the product.

Now the map with the built up area defined by the default parameters will load into the map color coded in the following way:

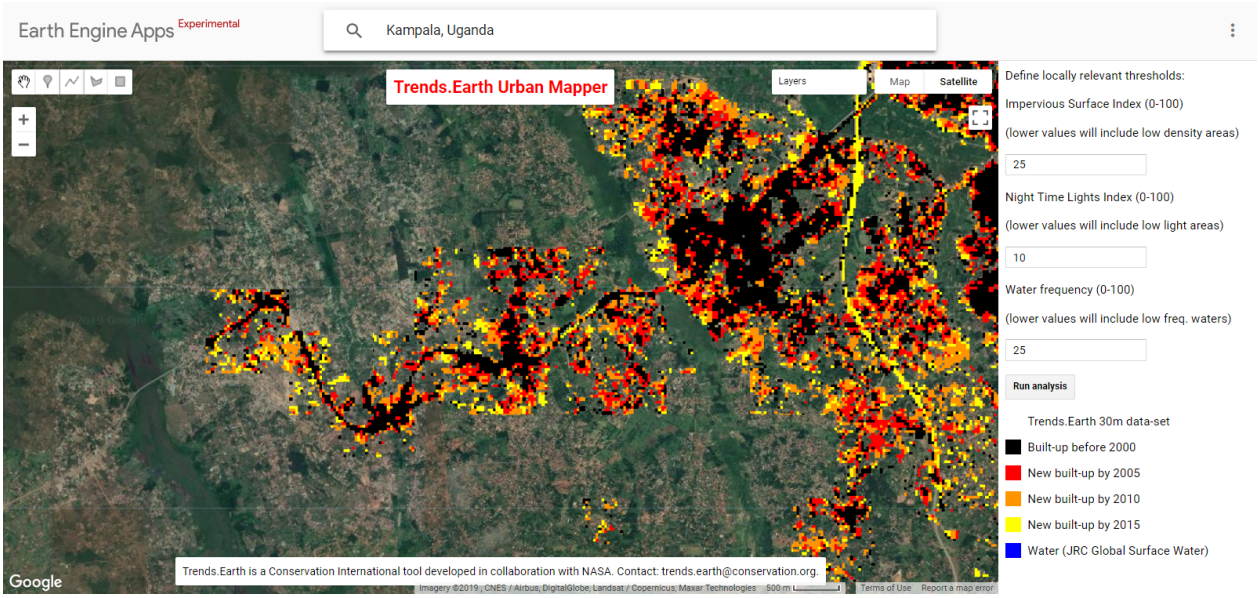
- Black: Built-up areas present since before 2000
- Red: Built-up areas constructed between 2000 and 2005
- Orange: Built-up areas constructed between 2005 and 2010
- Yellow: Built-up areas constructed between 2010 and 2015



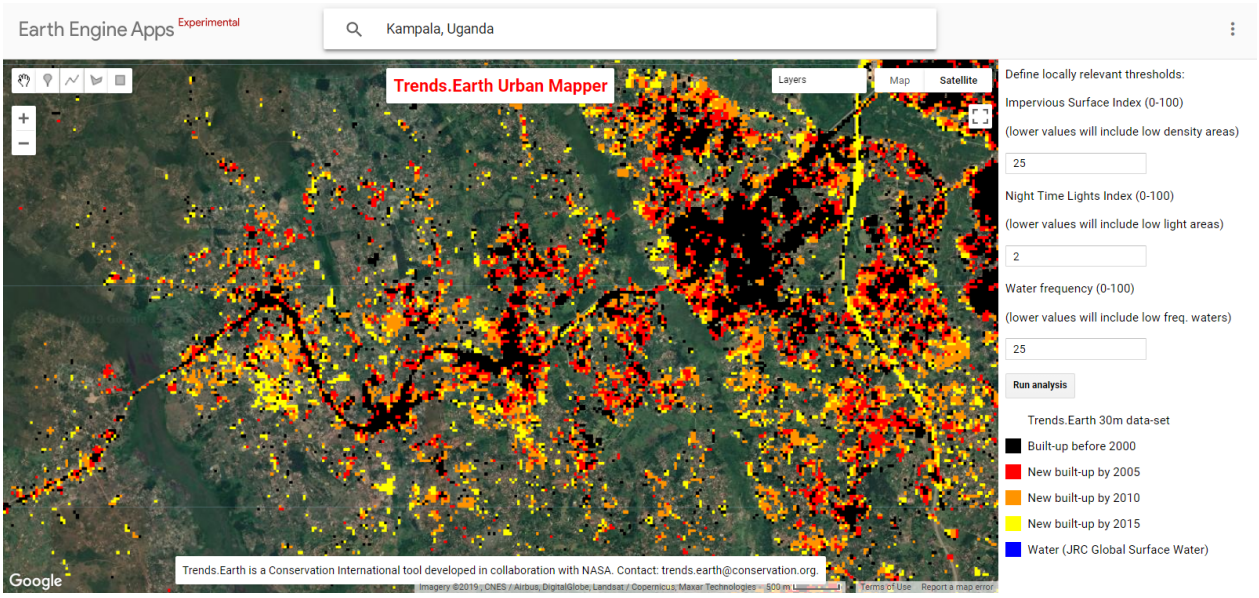
4. Now you should use your knowledge of the city to explore the data set. We can, for example, zoom in to an area in western Kampala to see how the default parameters perform (ISI: 30, NTL: 10, WFR: 25):



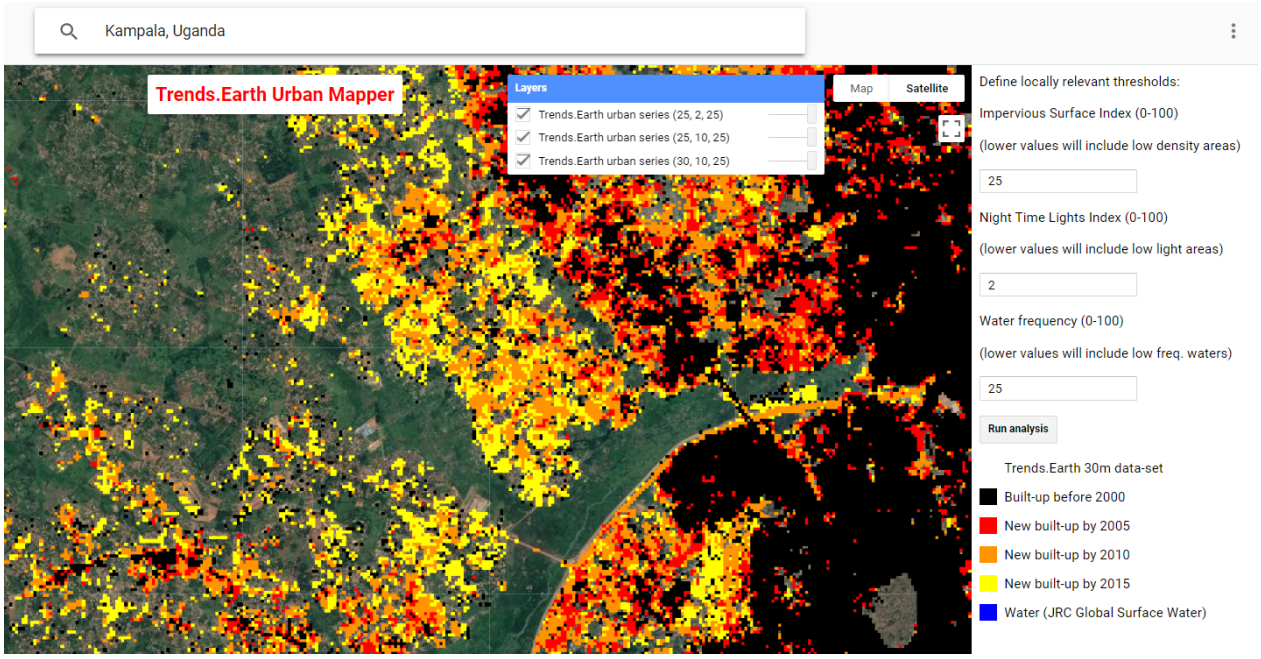
5. In this area, the data set seems to be missing some constructions, so we can adjust the ISI threshold to a lower value to include areas with lower density of impervious surface into our definition of built-up for Kampala. Let's **change the Impervious Surface Indicator threshold from 30 to 25 and click Run Analysis**



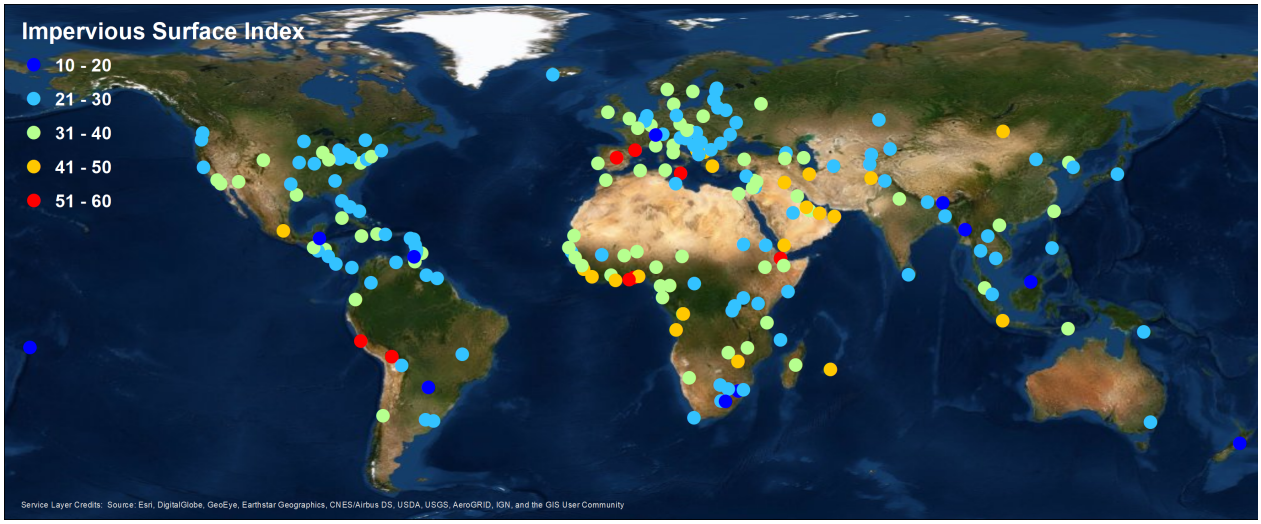
6. This seems to have increased the built-up area in the direction we wanted, but we can now see some straight discontinuity lines in the outskirts of the city after which there is no information. This is a sign that the Night Time Lights threshold is being too restrictive. If we set the parameter to a lower value, we will allow the analysis to include areas with low night time light density. **Change the Night Time Light threshold from 10 to 2 and click Run Analysis.**

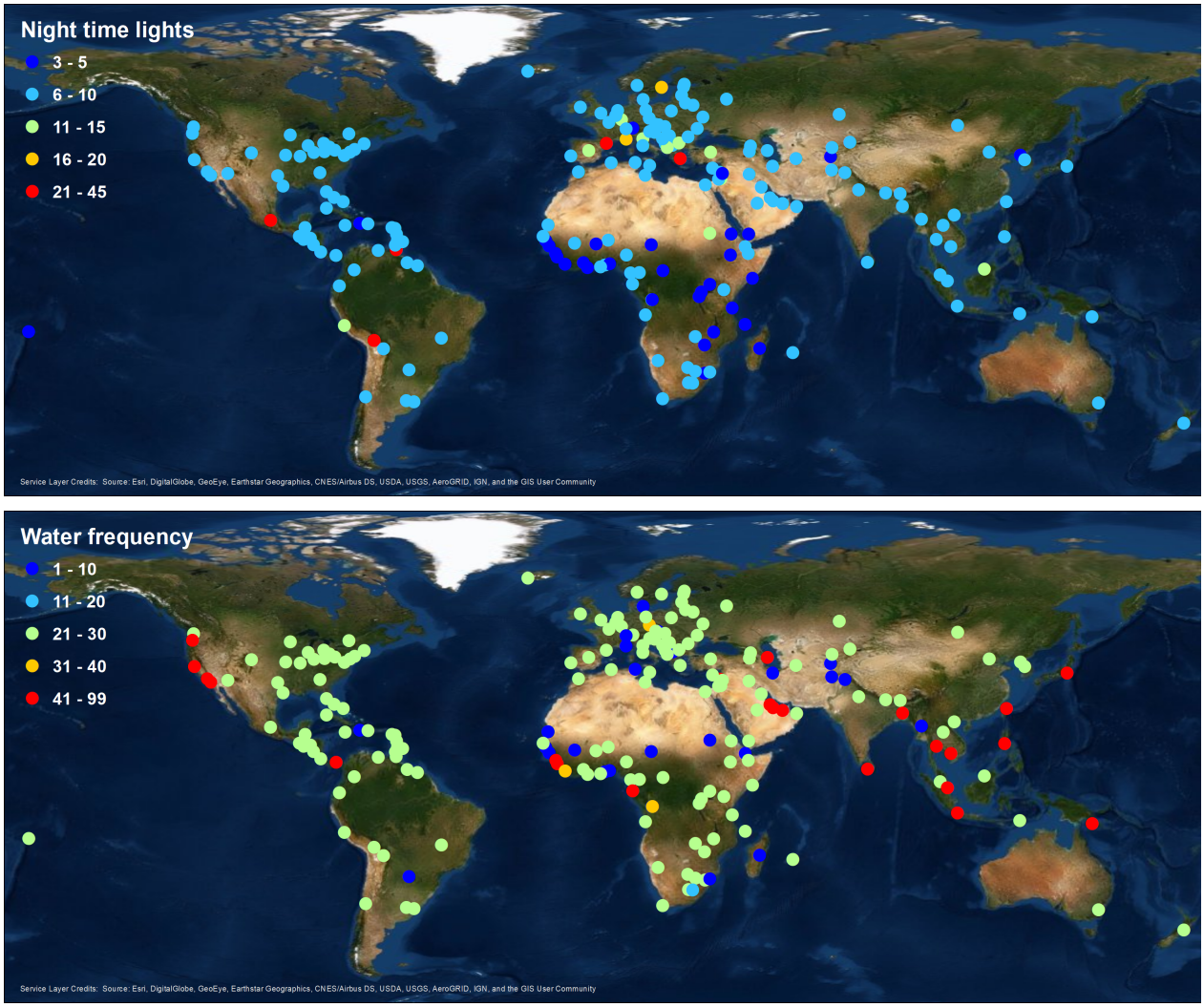


7. We can now see that the built up area information extends too all the area we were exploring. We can run the analysis as many times as we need. Each time we click **Run Analysis** a new layer will be added to the map. You can turns the different layers on and off or change the transparency of each of them in the **Layers Menu** on the top right section of the map.



8. We recommend you spend some time exploring the effect of the different values in each parameter for your city, since your results will greatly depend on them. Make sure to navigate to different parts of the city to make sure the parameters work well in areas the high density areas close to downtown and also in moderate and low density areas. You can find below the spatial distribution of threshold parameters selected for the sample of 224 cities tested which may serve you as a guide for identifying which values may be most relevant for your city of interest. Once you feel like you have identified the best values for the city you want to analyze, you are ready to go to QGIS to run the analysis.



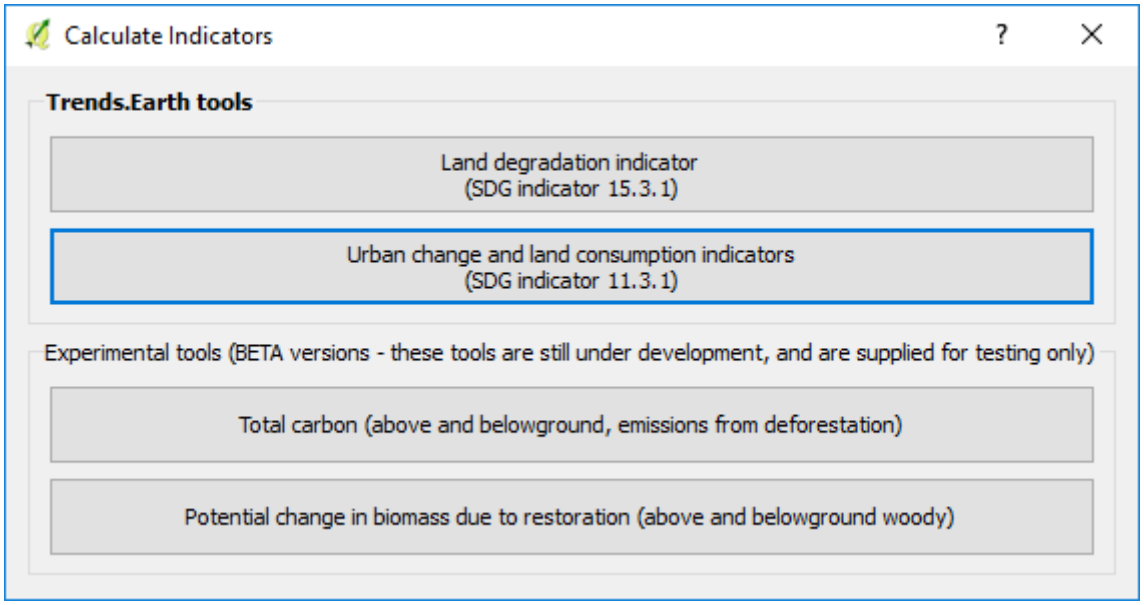


Step 1: Built-up series

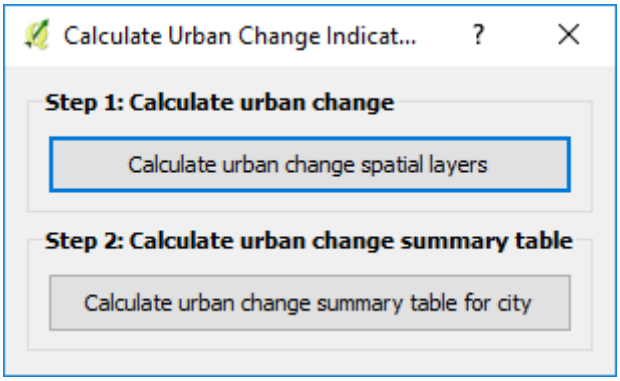
1. Select the Calculate icon ( ) from the Trends.Earth plugin in QGIS.



2. The **Calculate Indicators** menu will open. In that window, click on **Urban change and land consumption indicators (SDG indicator 11.3.1)** button.



3. Select Step 1: Calculate urban change spatial layers

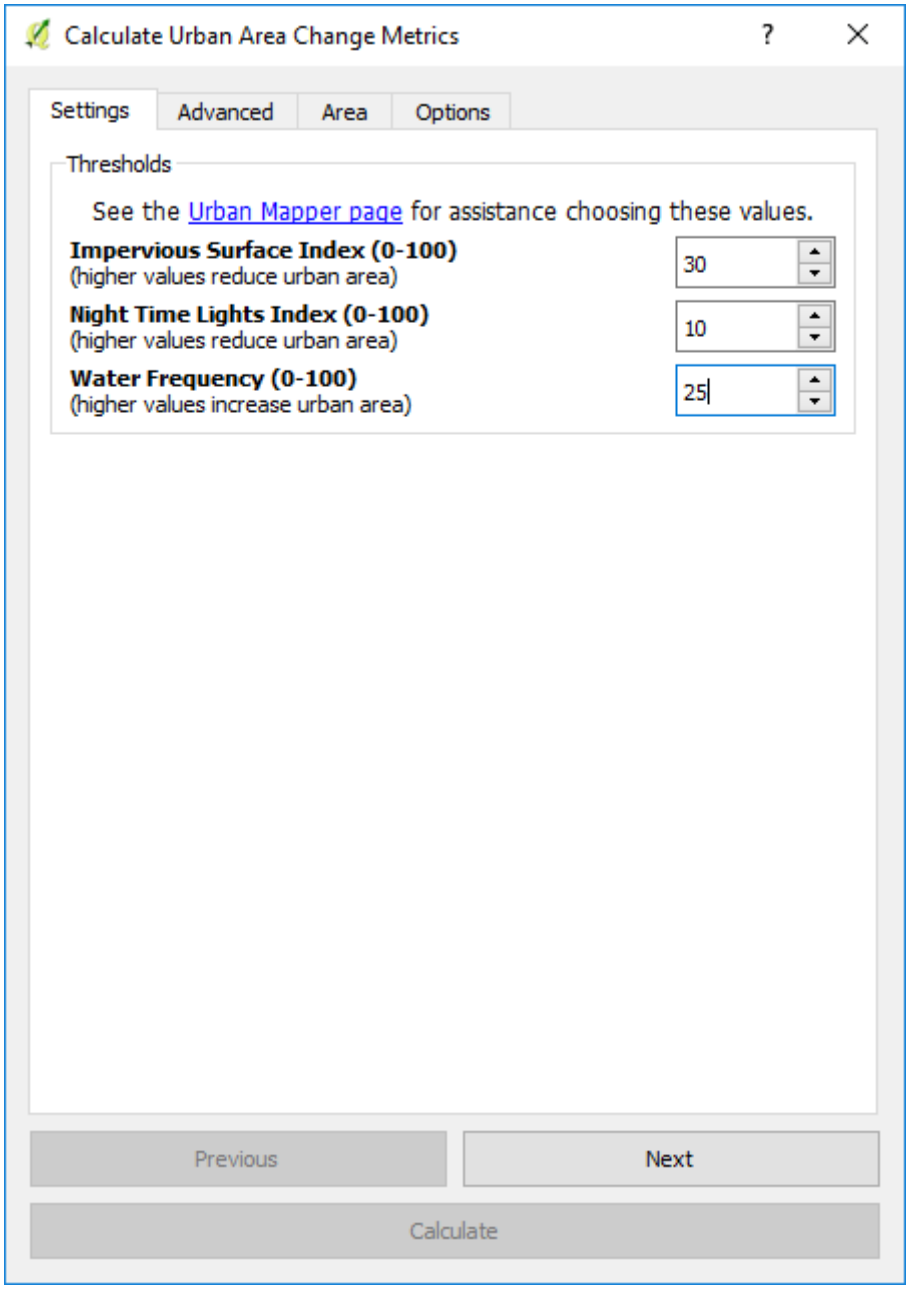


4. The **Calculate Urban Area Change Metrics** menu will open. In that window, you will step through the four tabs to set the parameters for your analysis. In the settings tab you will input the parameters you have determined as most appropriate for the city by exploring the Trends.Earth Urban Mapper.

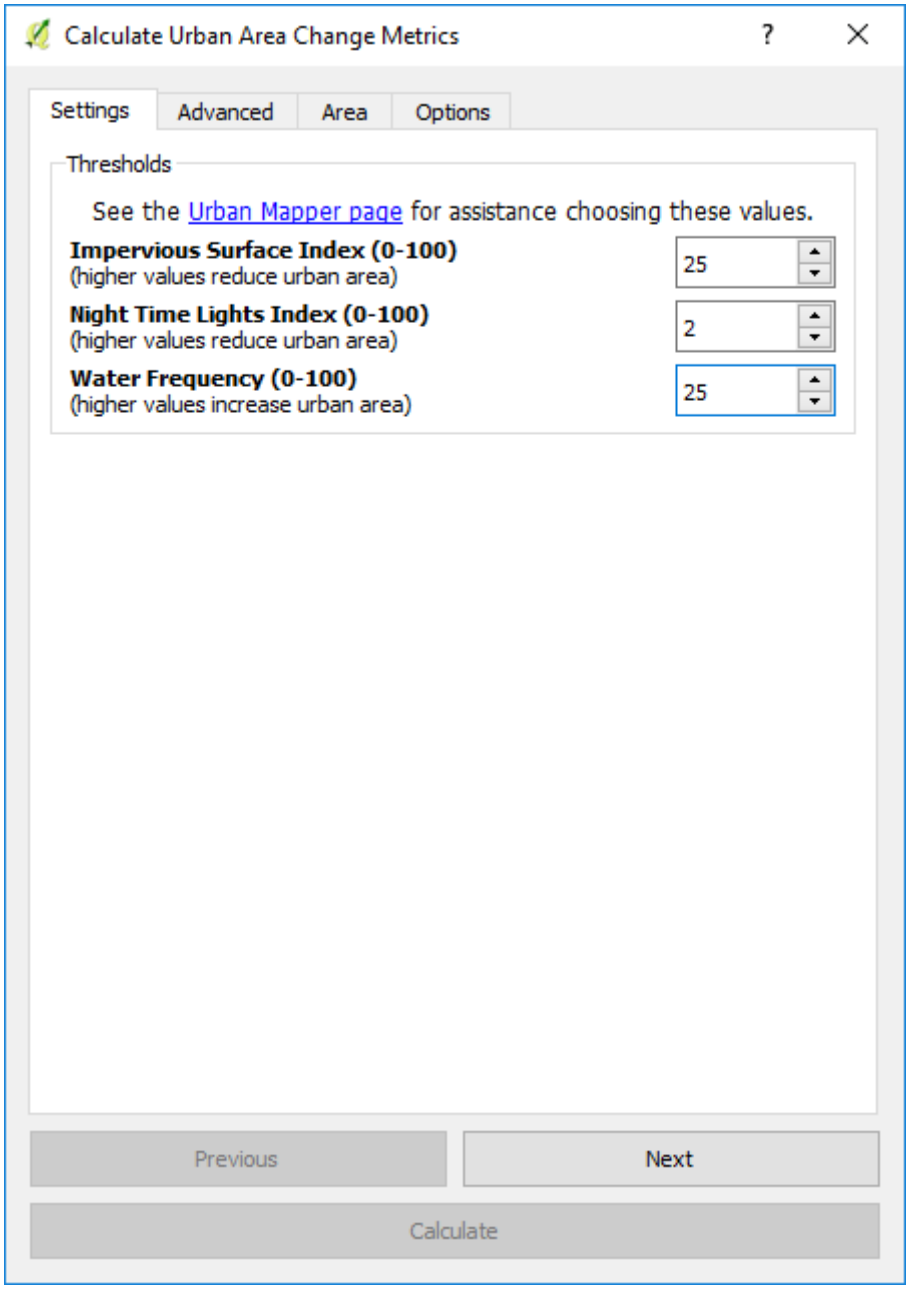
A. Select the Impervious Surface Index (ISI) by choosing a value between 0-100. Lower values will include low density areas.

B. Select the Night Time Lights Index (NTL) by choosing a value between 0-100. Lower values will include low light areas.

C. Select the Water Frequency (WFR) by choosing a value between 0-100. Lower values will include low frequency water bodies.



In this case, we will change them to: ISI = 25, NTL = 2, and WFR = 25 and click Next.

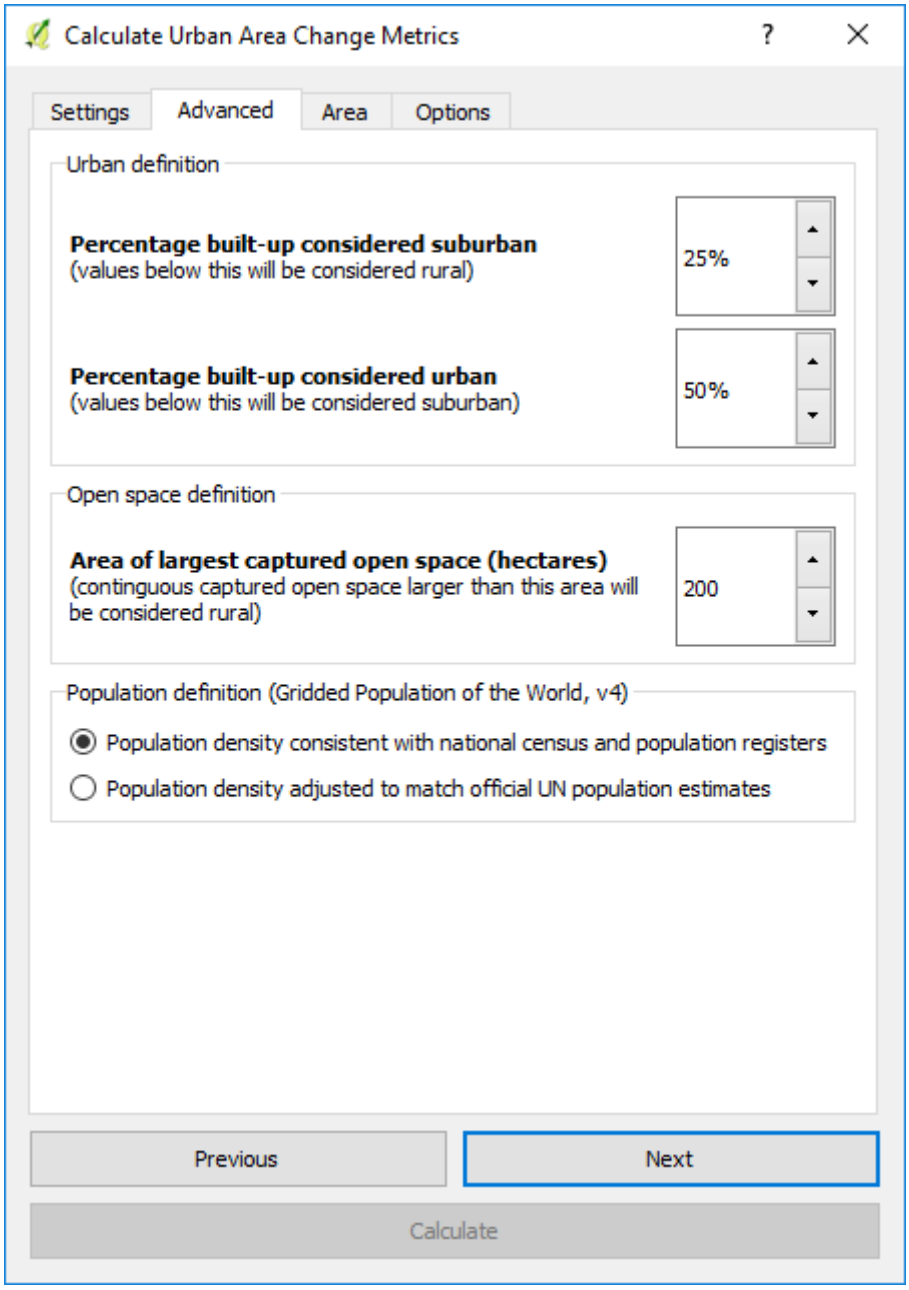


6. On the Advanced tab, you will need to define:

A. The thresholds for suburban and urban built up areas.

B. Define the area of largest captured open space (ha) which is the contiguous captured open space larger than this area that will be considered rural.

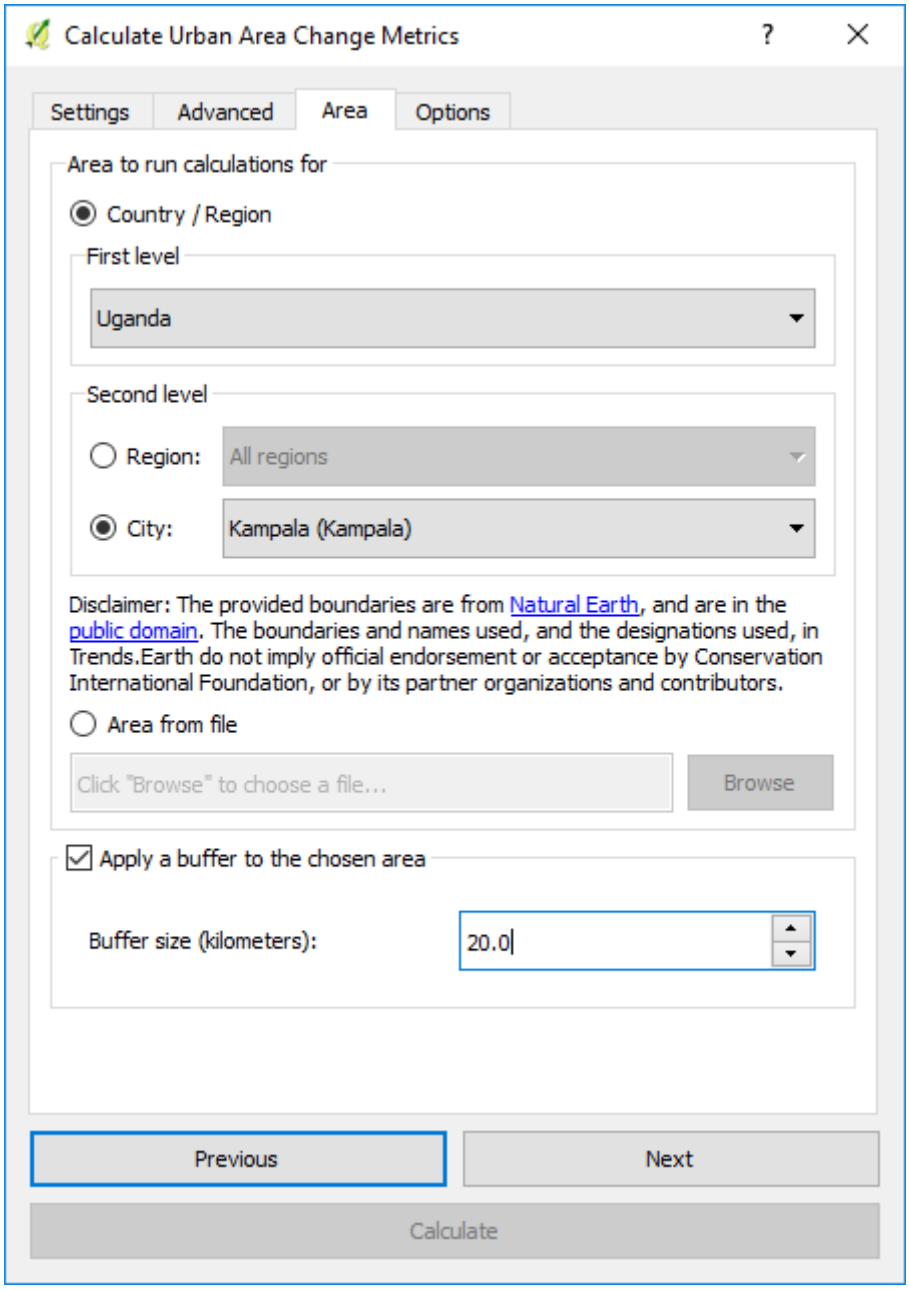
C. Select which population density dataset you would like to use for the analysis.



We'll use the default options for now, but you can change them to fit the needs of your analysis. Click Next.

7. On the Area tab you can select a country, region or city from the drop-down lists or upload an area from a file. If you select a city or upload a point location of a city, apply a buffer to the chosen area so that analysis encompasses all potential urban areas.

If you are using your own polygon for analysis, we recommend you do not use buffers, since that will affect the area of analysis and the final area calculation.



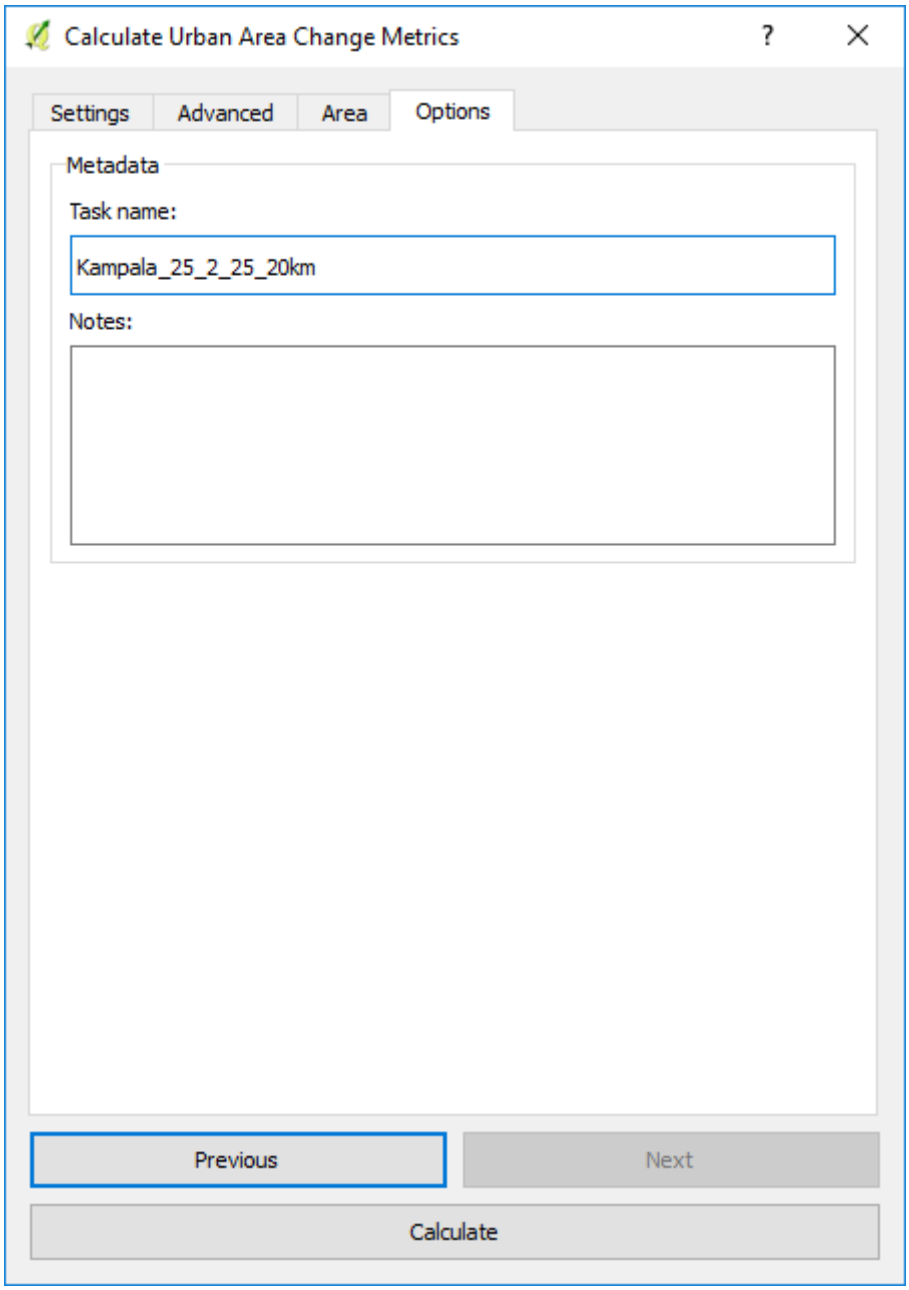
Note

The geoBoundaries Administrative Boundaries provided in Trends.Earth are under the CC BY 4.0 license. The boundaries and names used, and the designations used, in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

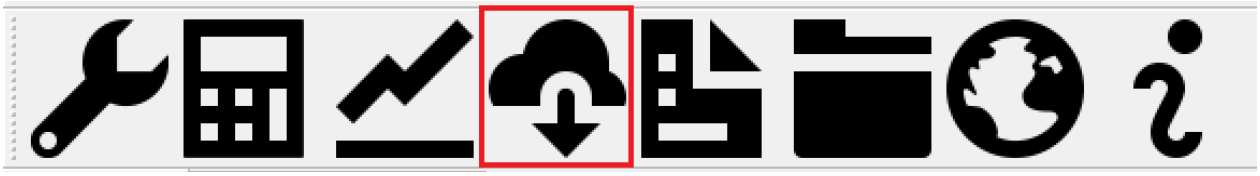
If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

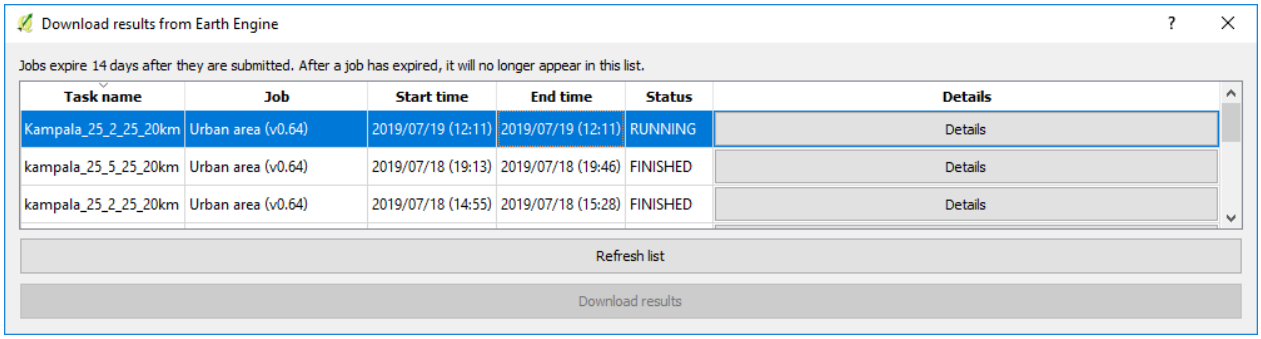
8. On the Options tab you have to assign a name the task and some notes on how you customized the parameters for your analysis for future reference.

When all the parameters have been defined, click “Calculate”, and the task will be submitted to Google Earth Engine for computing.

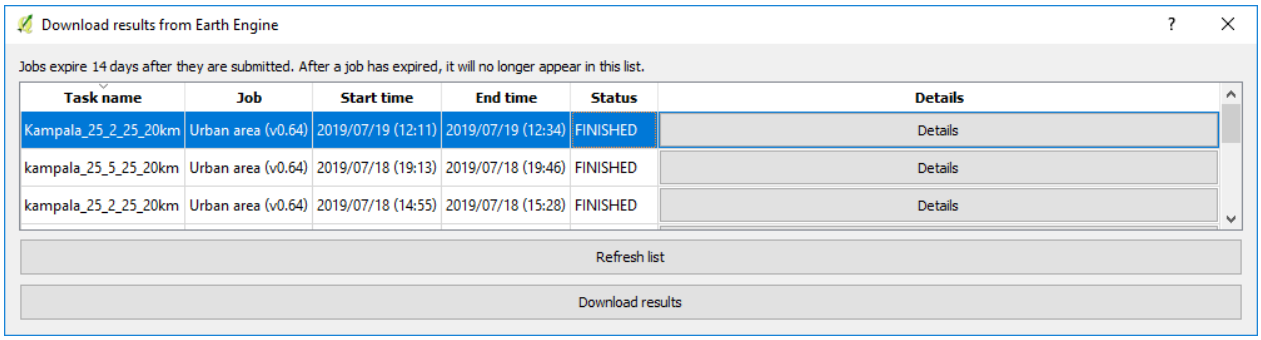


9. The analysis for cities takes approximately 30 min to run, depending on the size of the area and the servers usage. To check the status of the task you can click on the Download button on the ▲TRENDS.EARTH tool-bar. When the windows open, click **Refresh list**.

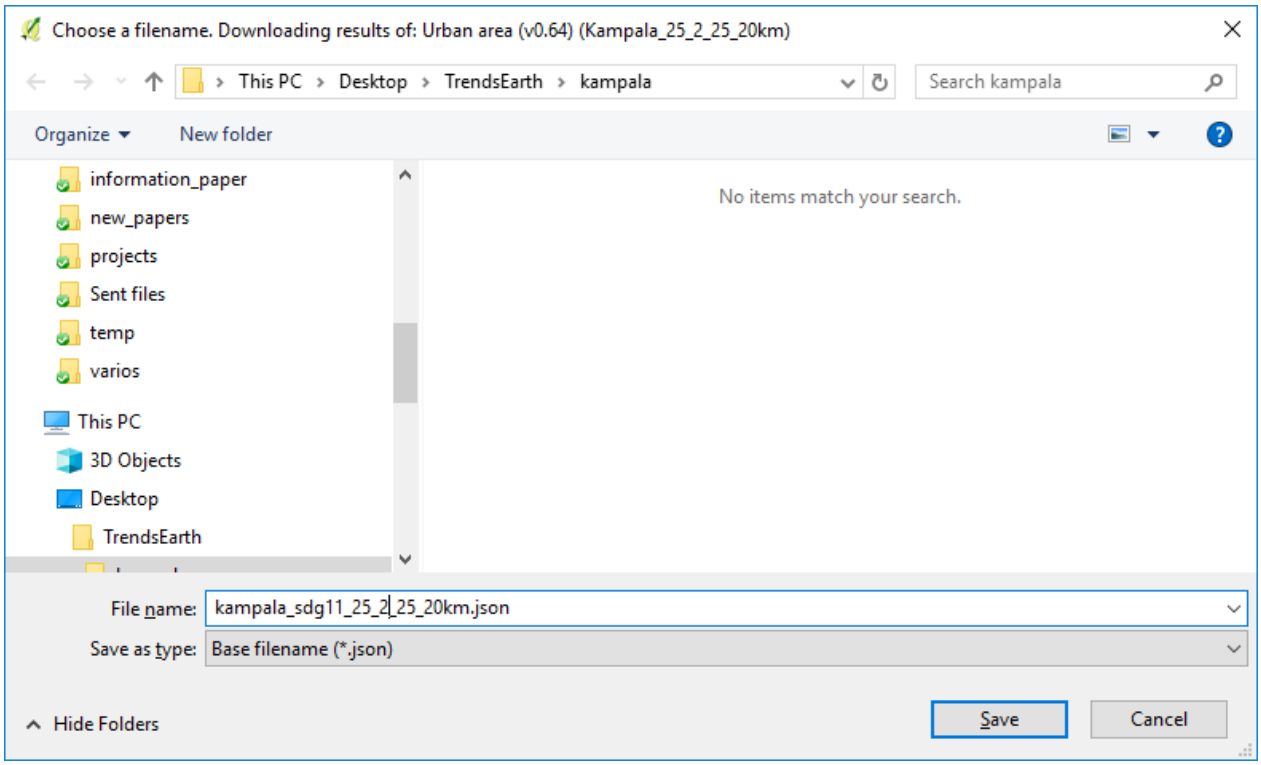




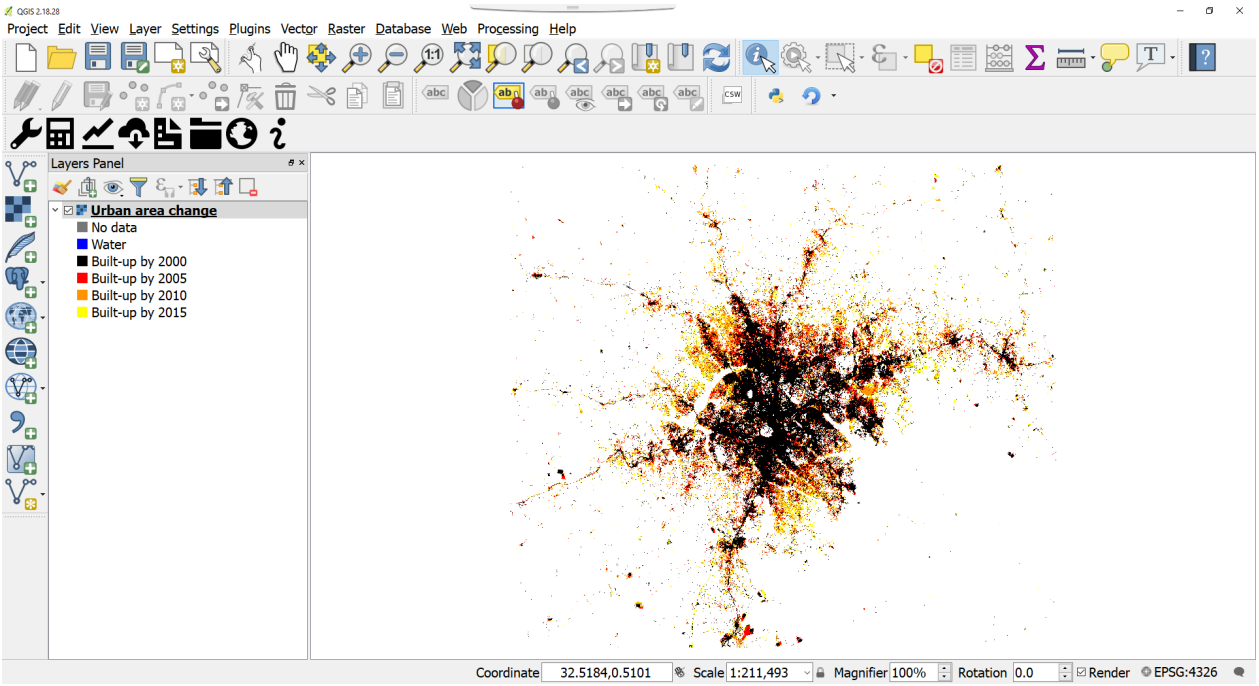
When the Google Earth Engine task has completed and you received the email, click “Refresh List” and the status will show FINISHED.



10. To download the results, click on the task and select “Download results” at the bottom of the window. A pop up window will open for you to select where to save the layer and to assign it a name.

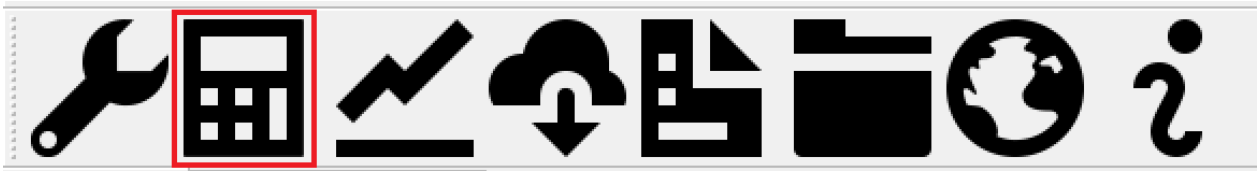


Then click “Save”. The layer will be saved on your computer and automatically loaded into your current QGIS project.

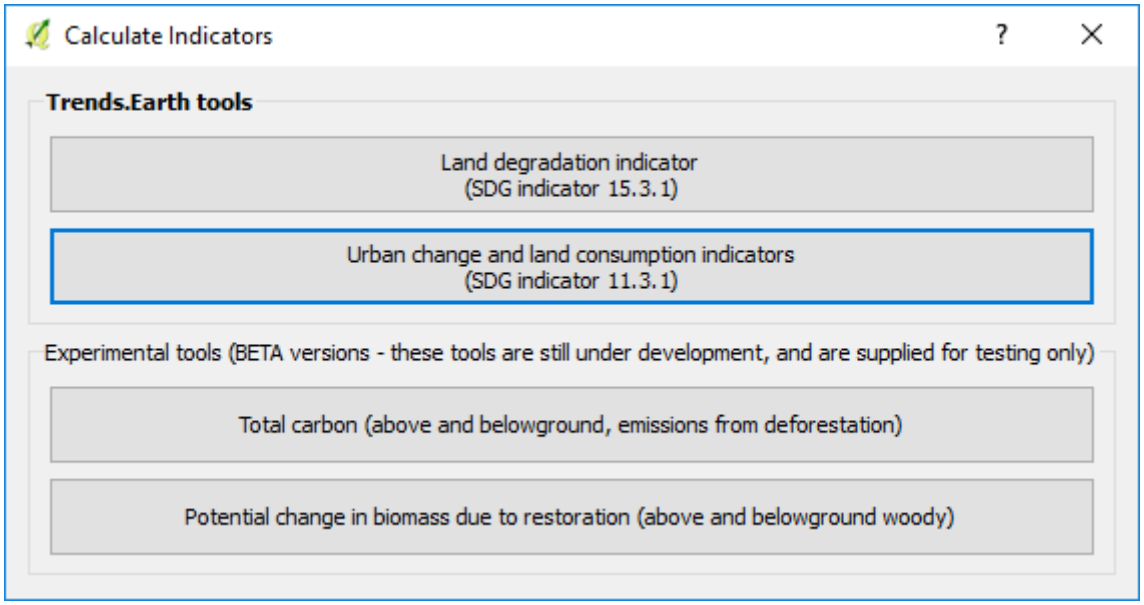


Step 2: Urban change

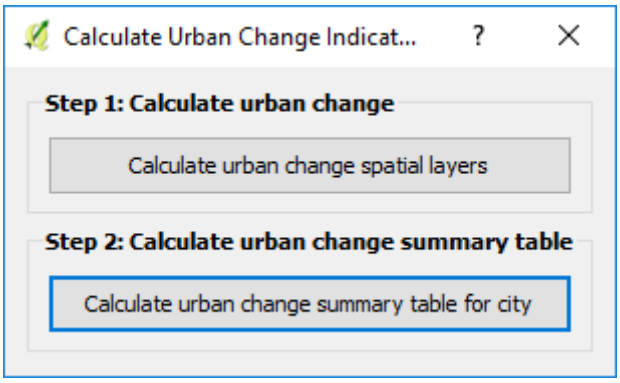
1. You have now downloaded the dataset to your local computer, but we still need to estimate the change over time in order to compute the SDG indicator 11.3.1. For that, select the Calculate icon ( ) from the Trends.Earth plugin in QGIS.



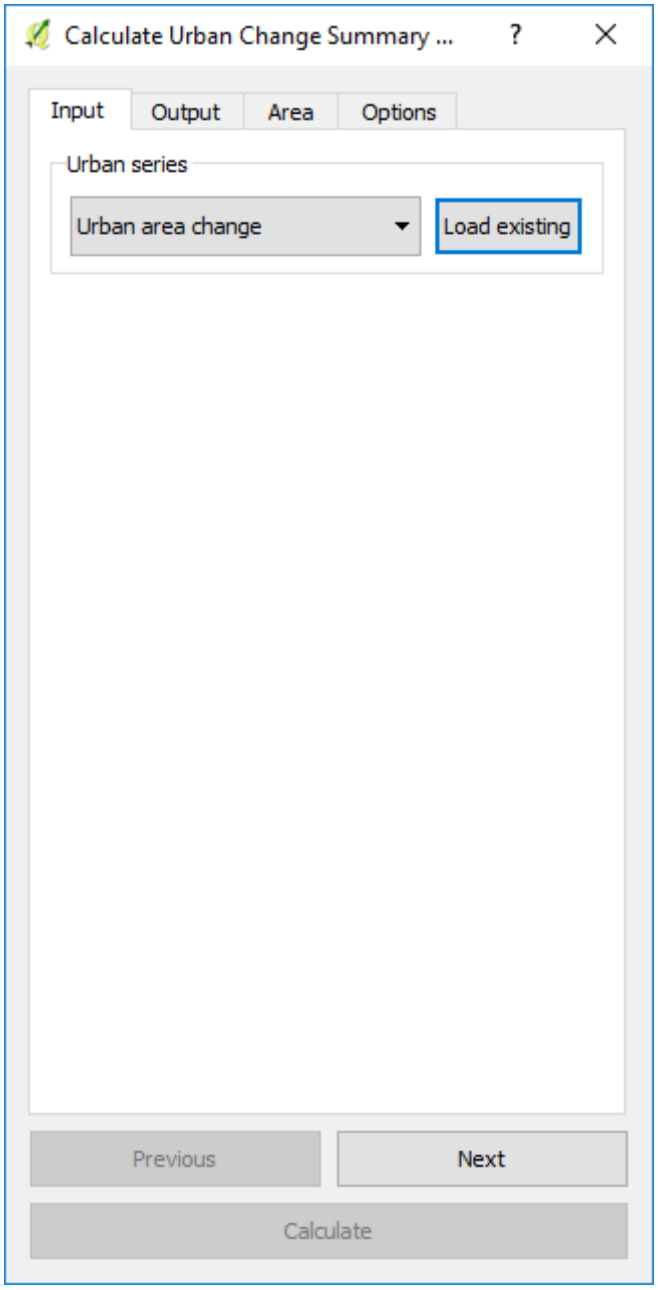
2. The **Calculate Indicators** menu will open. In that window, click on **Urban change and land consumption indicators (SDG indicator 11.3.1)** button.



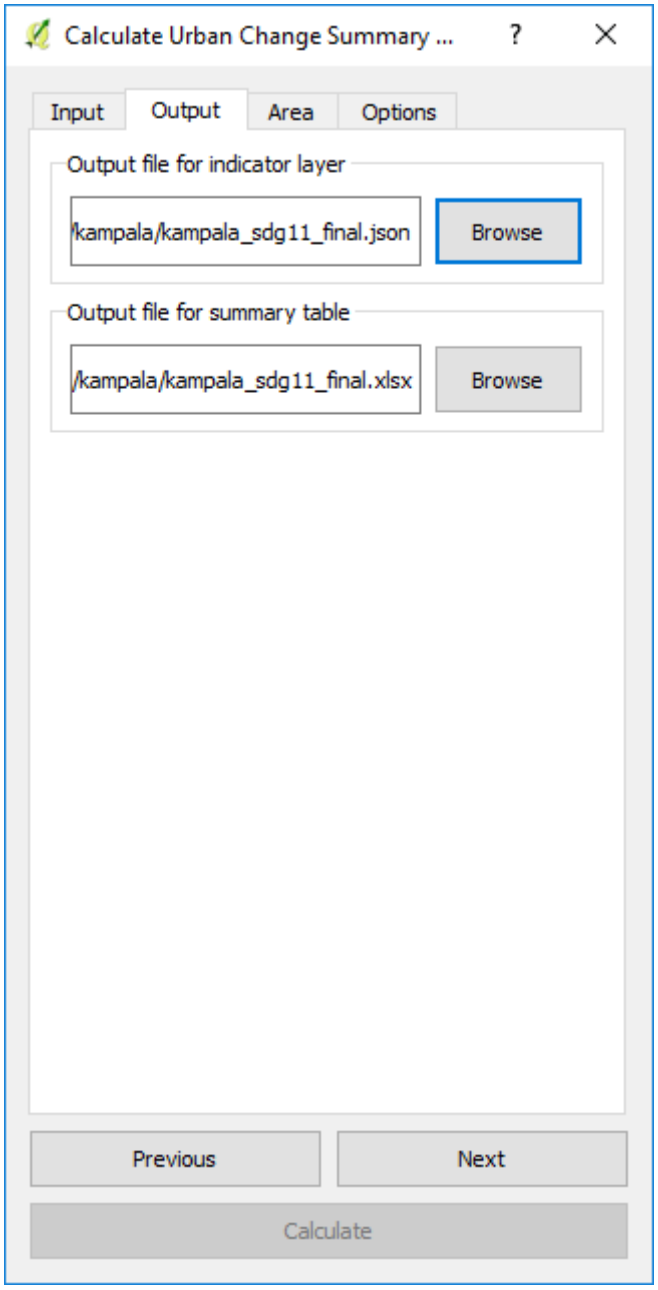
3. Select Step 2: Calculate urban change summary table for city.



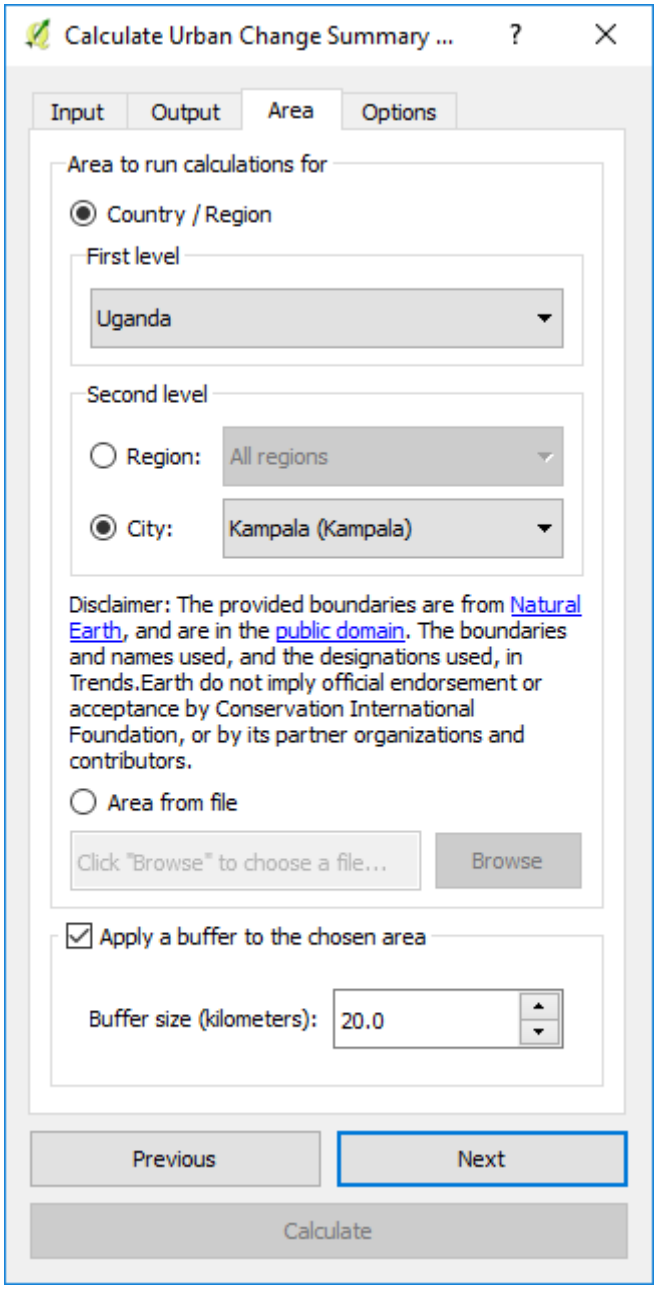
4. Input: Load an existing .json file if it has not been populated within the drop-down list automatically from your QGIS project.



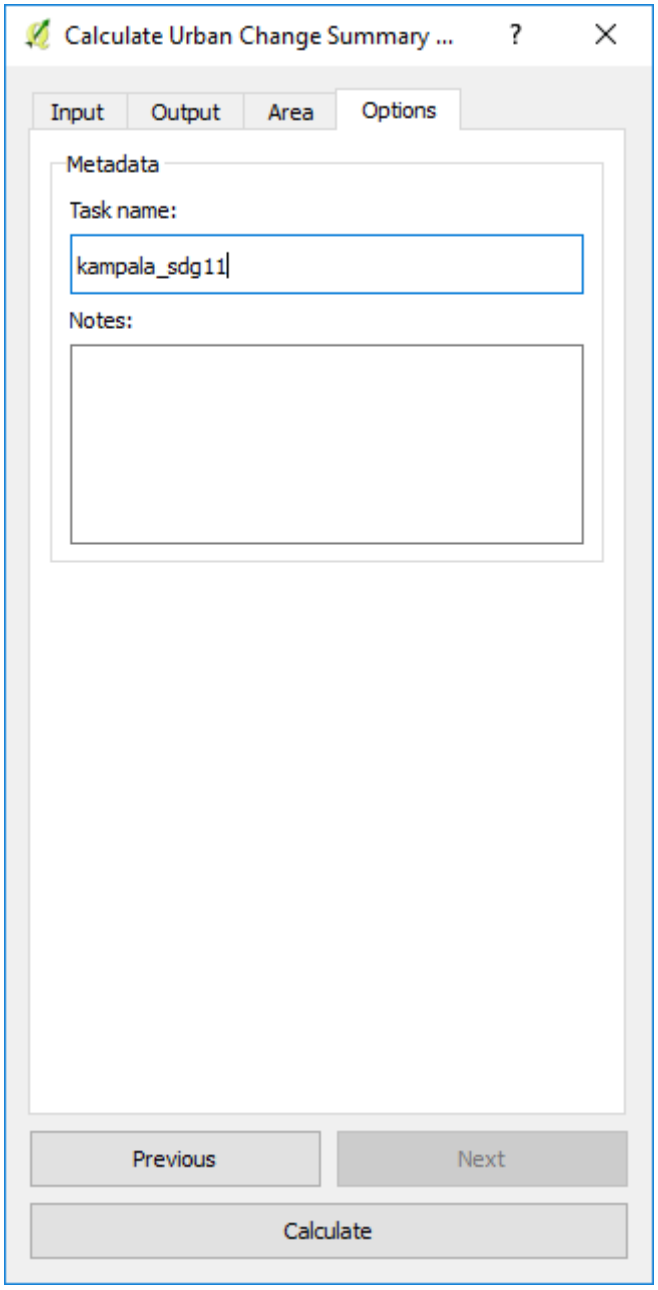
5. Output: Select browse to navigate to a file on your computer and save the json file and excel table.



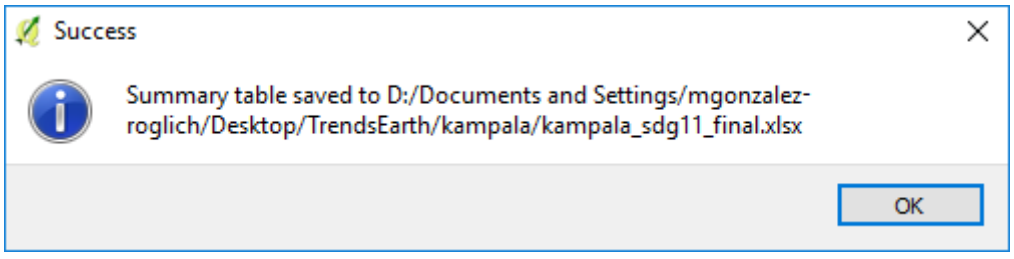
6. Area: Define the area for your analysis



7. Options: Enter a task name and notes for the analysis. This final step is calculated locally on your computer, it will load automatically in your QGIS project window.



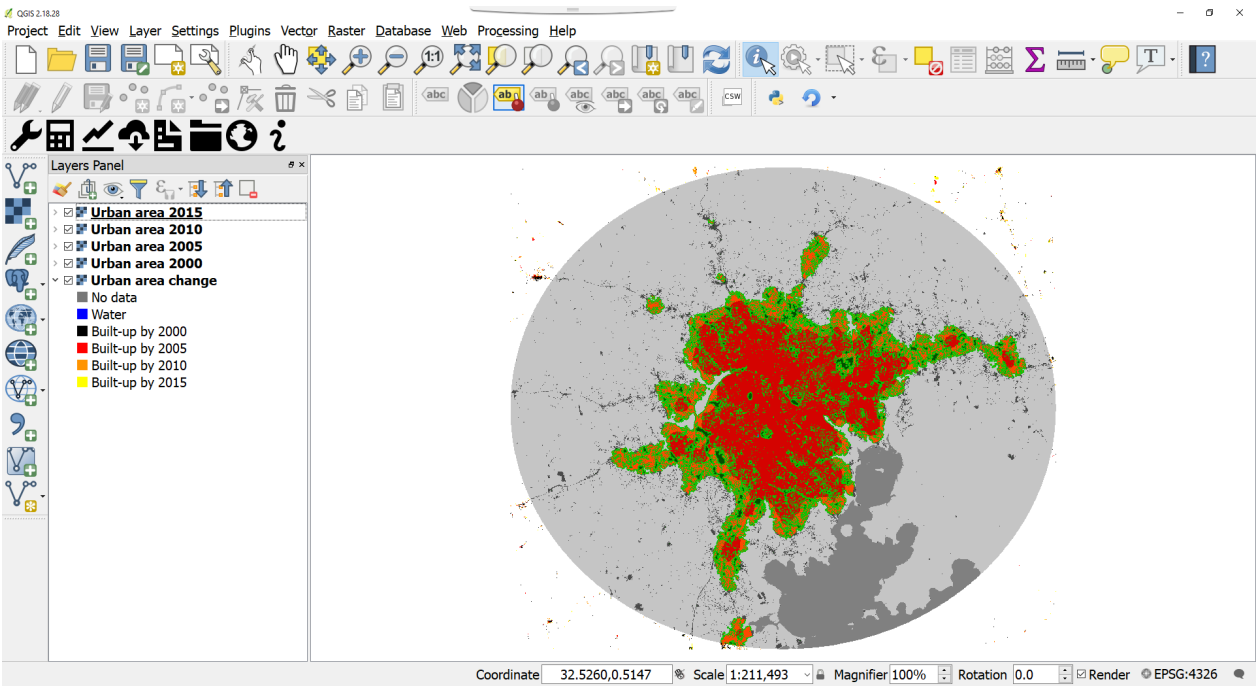
8. View results: A window will appear when the processing is complete. Select **OK**.



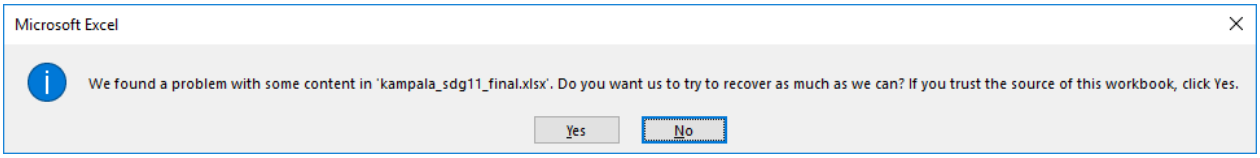
After clicking OK, the four annual urban extent maps with their corresponding zoning will load into the QGIS project.

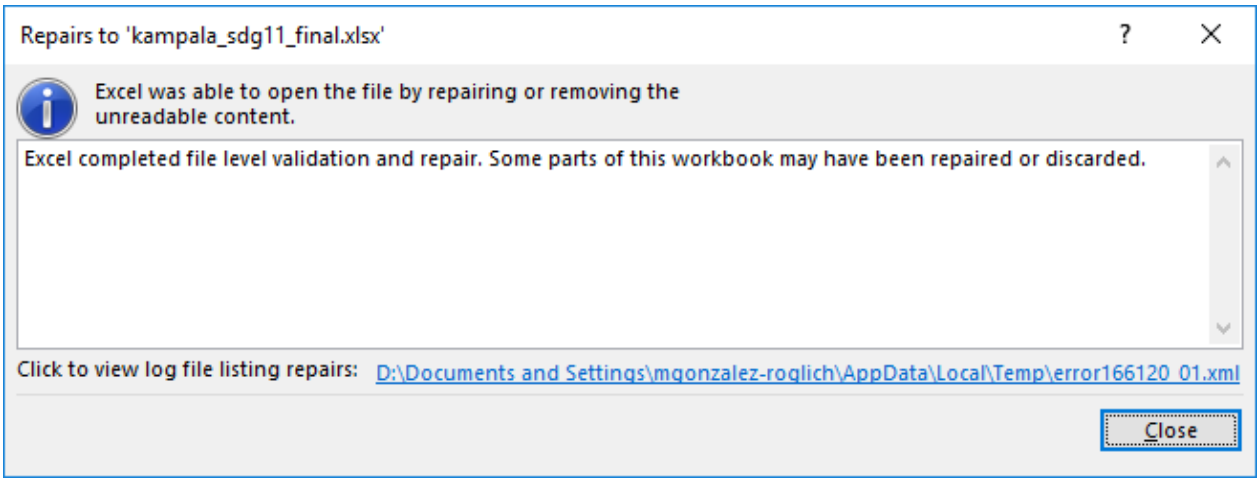
Note

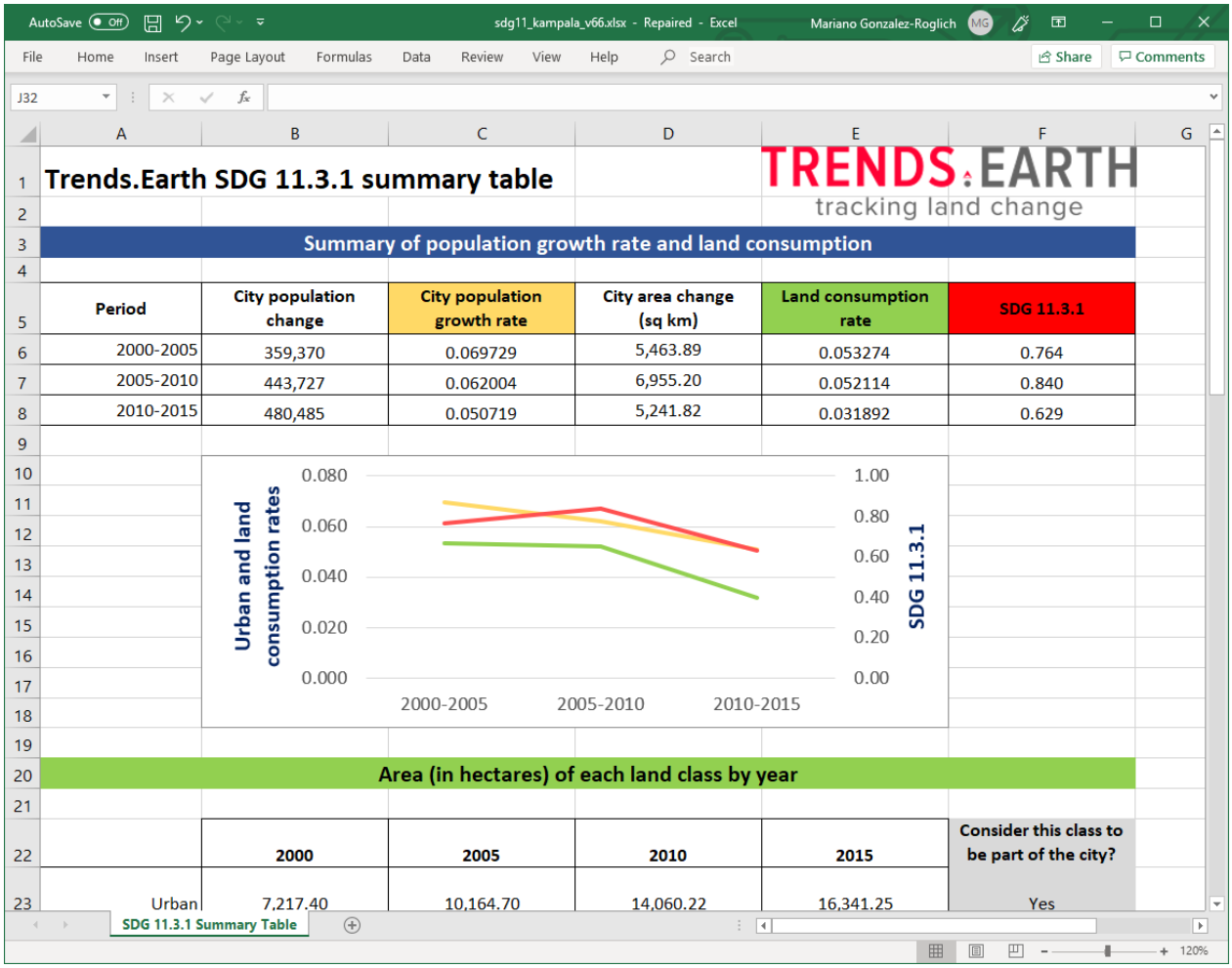
If you selected the buffer option for running the analysis, you may notice that the results do not seem to display a perfectly circular shape. We use planar coordinates to measure distance when computing the buffer, while displaying the results in geographic coordinates. This will cause an apparent distortion the further away your area is from the equator, but there is nothing to worry, the results are correct.



9. To explore the summary table, navigate to the folder in your computer where you saved the excel file and double click on it to open. If an error window appears, select the **Yes** and the summary will proceed to open.







10. In this table you'll find the area of the different city land cover classes (urban, suburban, fringe open space, capture open space and water) and the rural areas. You'll also find the population for each of the years analyzed (2000, 2005, 2010, and 2015) and the final SDG 11.3.1.

Note

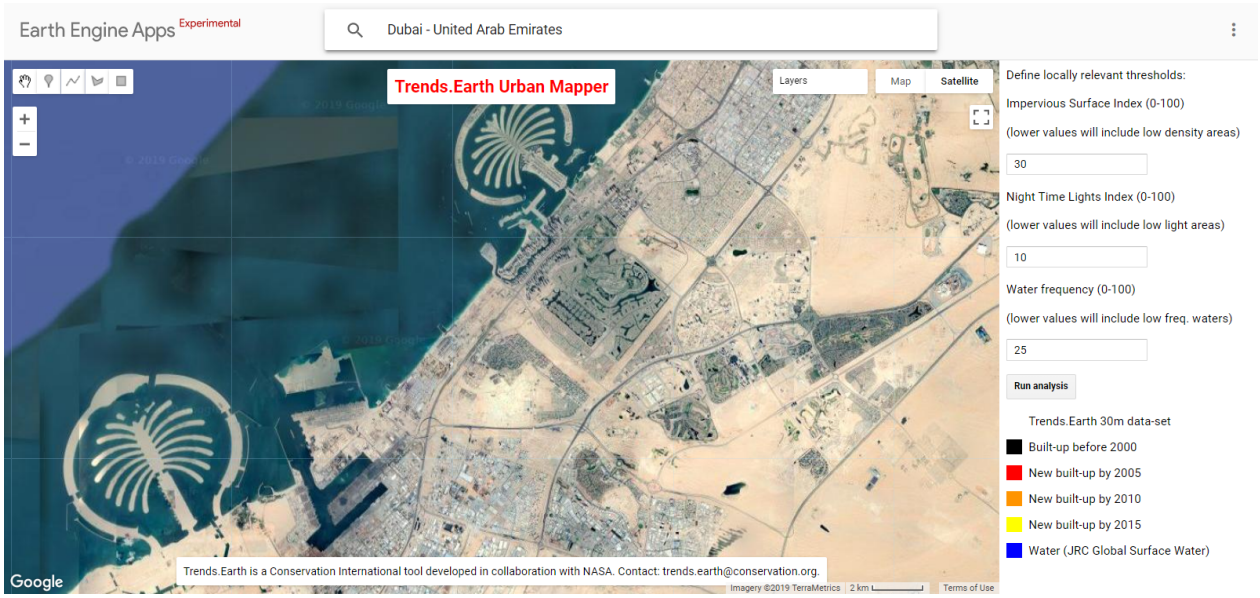
In order to improve the Impervious Surface Index and the guidance we provide to users, it would be very useful for us to learn the parameters you selected for your city, and your assessment on how the tool performed by filling this online form it will not take you more than 30 seconds to fill, and it will help us improve the tool. Thanks!

Extra: Water frequency parameter

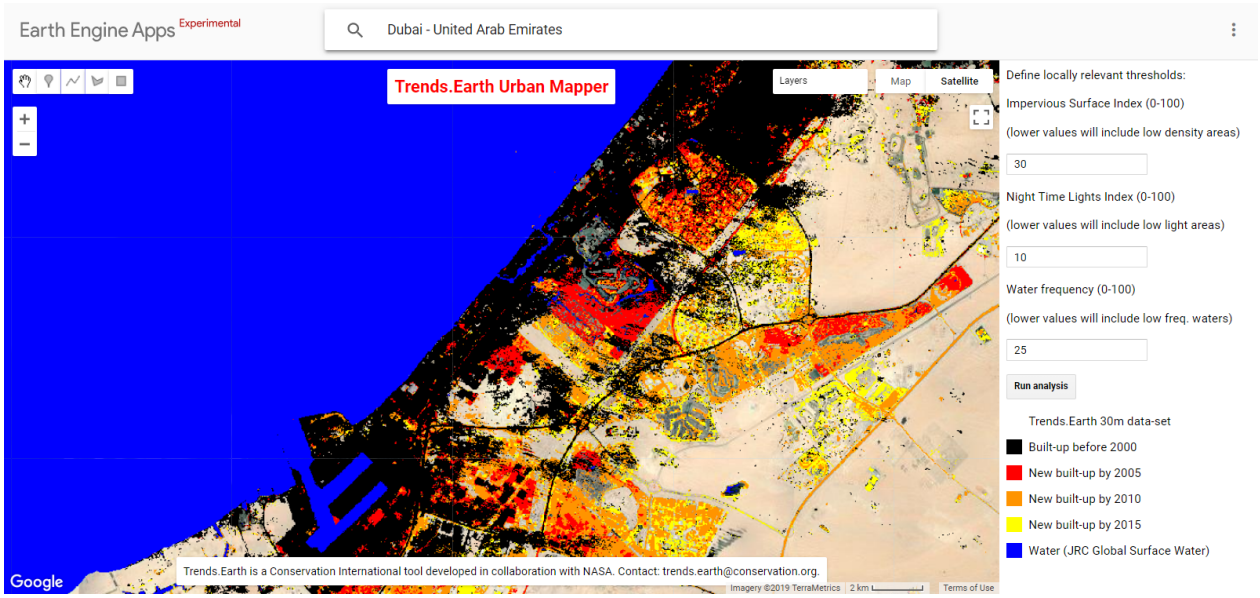
On this tutorial we did not explore the effect of the third parameter the Urban Mapper page. allow us to change, Water Frequency. This parameter will remain unchanged for most cities, but for those places in which capturing water dynamics is important for understanding how a city is changing, it will be very useful.

The water Frequency parameter should be interpreted as follows: A pixel needs to be covered by water for at least X percent of the time for it to be considered water, otherwise it will be considered land". This means that the higher the value, the less water the map will show and the more land (i.e. built up if that is the case).

To explore one of such cases, navigate to the Urban Mapper page and let's go to **Dubai**.



One of the main feature we'll notice is a set of islands. However, when we click **Run Analysis**, the dataset seems to miss them



If we change the Water Frequency parameter from 25 to 80, we can start seeing the recently built-up areas in the water (ISI = 30, NTL = 10, WFR = 80). But we are still missing some portions.



12. In this case, it seems like portions of these newly constructed islands don't have much lights on them. So if we set the NTL threshold to a lower value (e.g. 5) we will capture them.



Forest and Carbon Change Tool

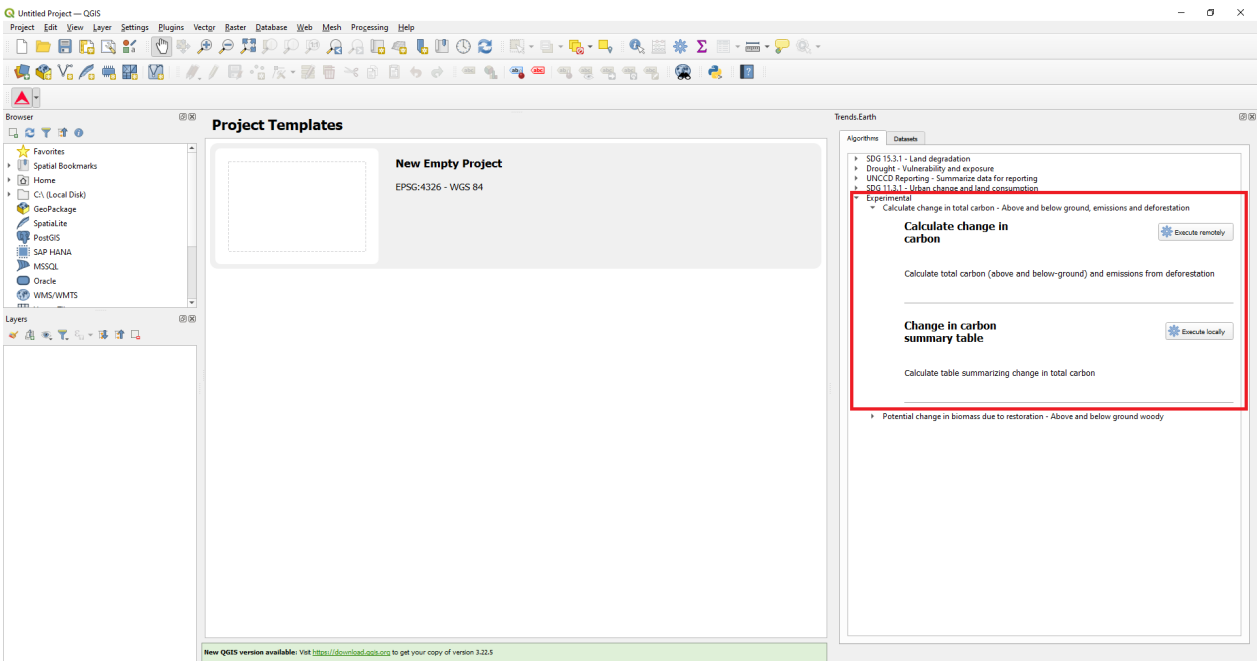
- **Objective**: Learn how to compute forest cover, forest loss, above and below ground biomass and emissions from deforestation in raster format and tabular outputs with areas estimated.
- **Estimated time of completion**: 20 minutes
- **Internet access**: Required

Note

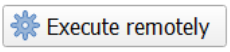
Refer to the Carbon emissions from deforestation **for background information on the datasets and** methodology used for this tutorial.

Calculate change in carbon

1. In the **Algorithms** tab in Trends.Earth plugin in QGIS, under the **Experimental** menu, select **Calculate change in total carbon - Above and below ground emissions, and deforestation** menu.



2. Select the **Calculate change in carbon** menu by selecting **Execute locally**.



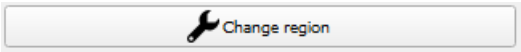
3. A window will appear where you can select the paramaters for the carbon analysis. Select the initial and target years for monitoring tree cover loss, carbon emissions from deforestation. Define the percent tree cover considered forest for your area of interest.

Note

The definition of canopy cover should be changed to accommodate the specific area of interest.

The dataset maps global tree cover based on percent canopy cover in the year 2000. Many studies cite 25% - 30% threshold to define forest, however this definition can change for arid regions. For more information, please see the publication”

4. Select **Change region** to define the area of interest.



Note

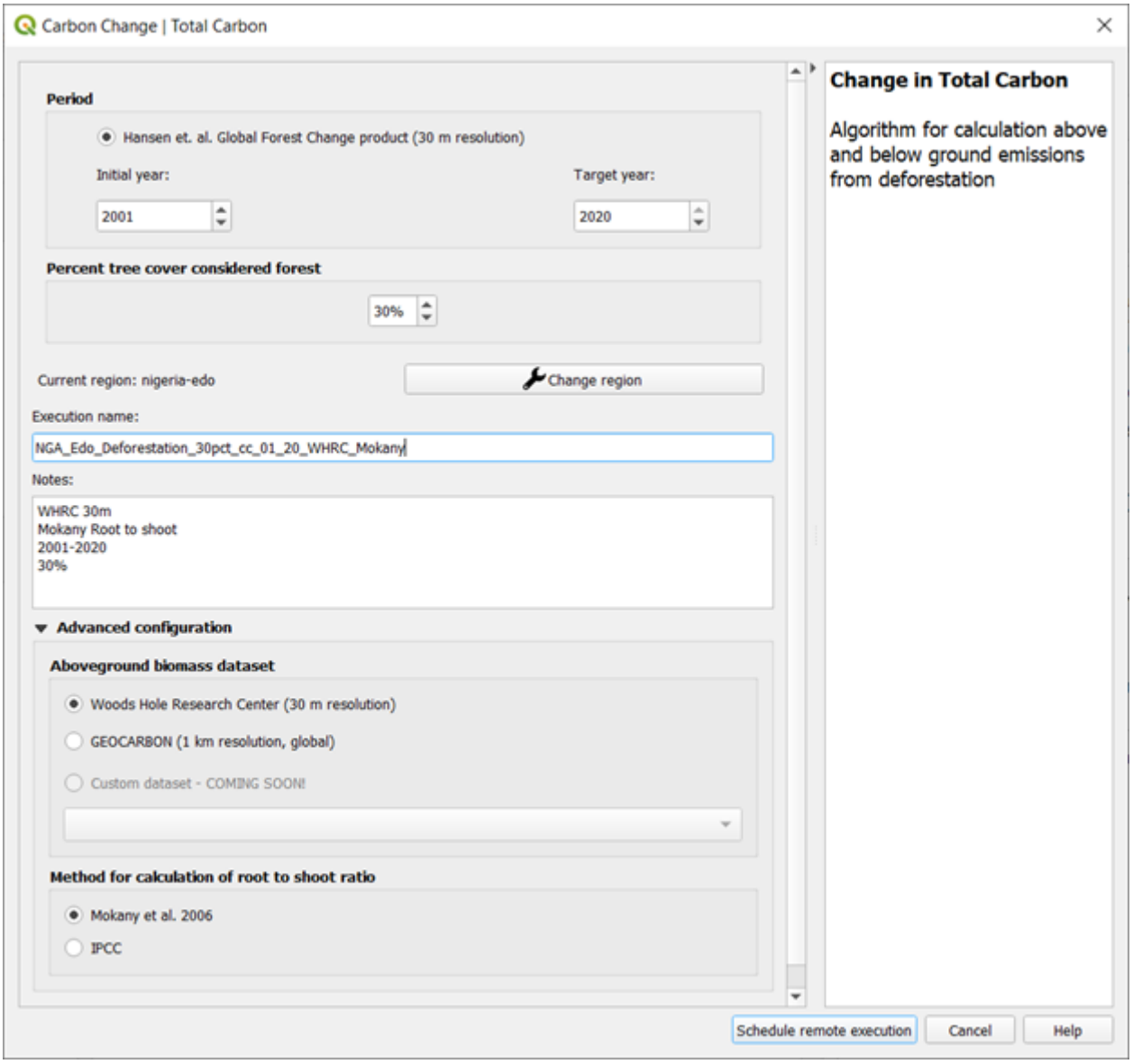
The geoBoundaries Administrative Boundaries provided in Trends.Earth are under the CC BY 4.0 license. The boundaries and names used, and the designations used, in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

- Use your own area file: If you want to use your own area of analysis, make sure the **Area from file** option is highlighted. Then click **Browse** and navigate to the folder in your computer where you have the file stored.

5. Add a descriptive name and notes for the analysis

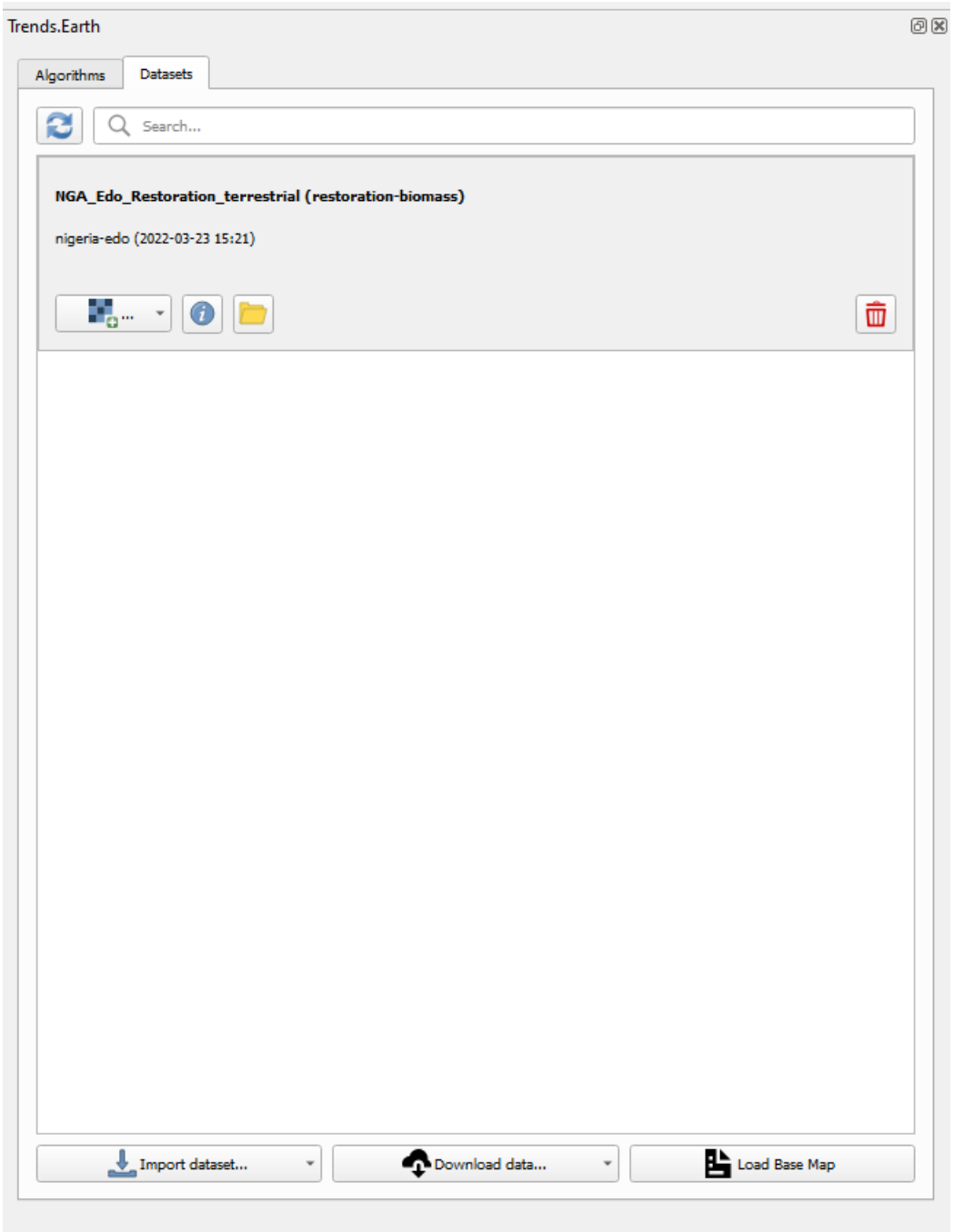
   Select the **Advanced configuration** menu to select the biomass dataset, and method for calculating the root to shoot ratio (below ground biomass) Select **Schedule remote exectution**



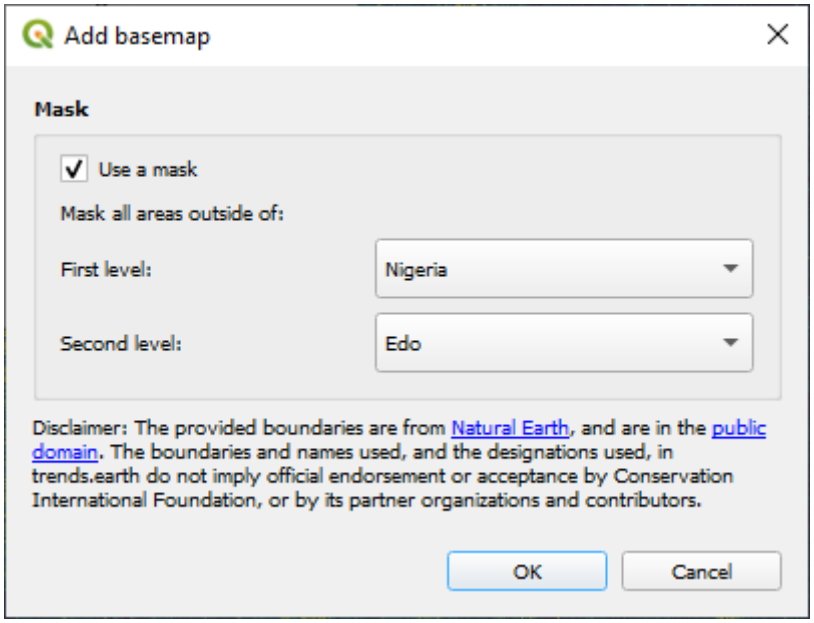
6. A light blue bar will temporarily show, indicating that the task was successfully submitted. The analysis will be run in Google servers and could take between 5 and 15 minutes depending on the size of the study area (larger areas tend to take longer).

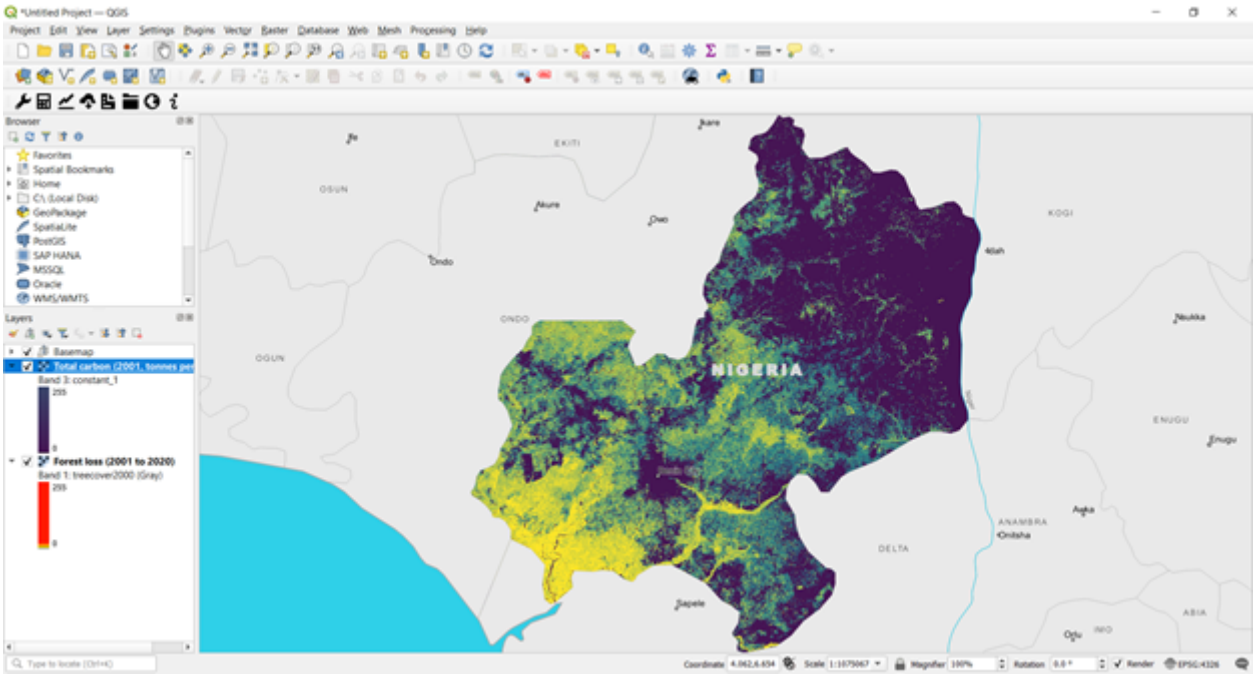
Change in carbon summary table

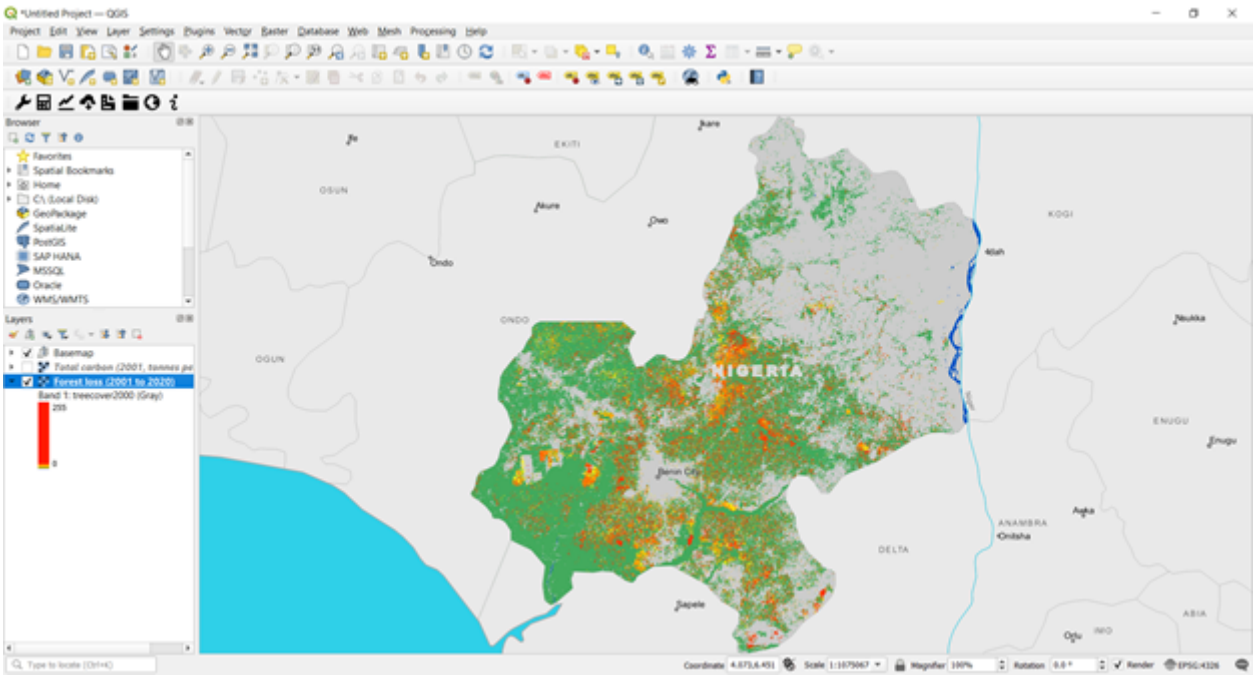
1. Go the the **Datasets** tab to **Add default layers from this dataset to map**.



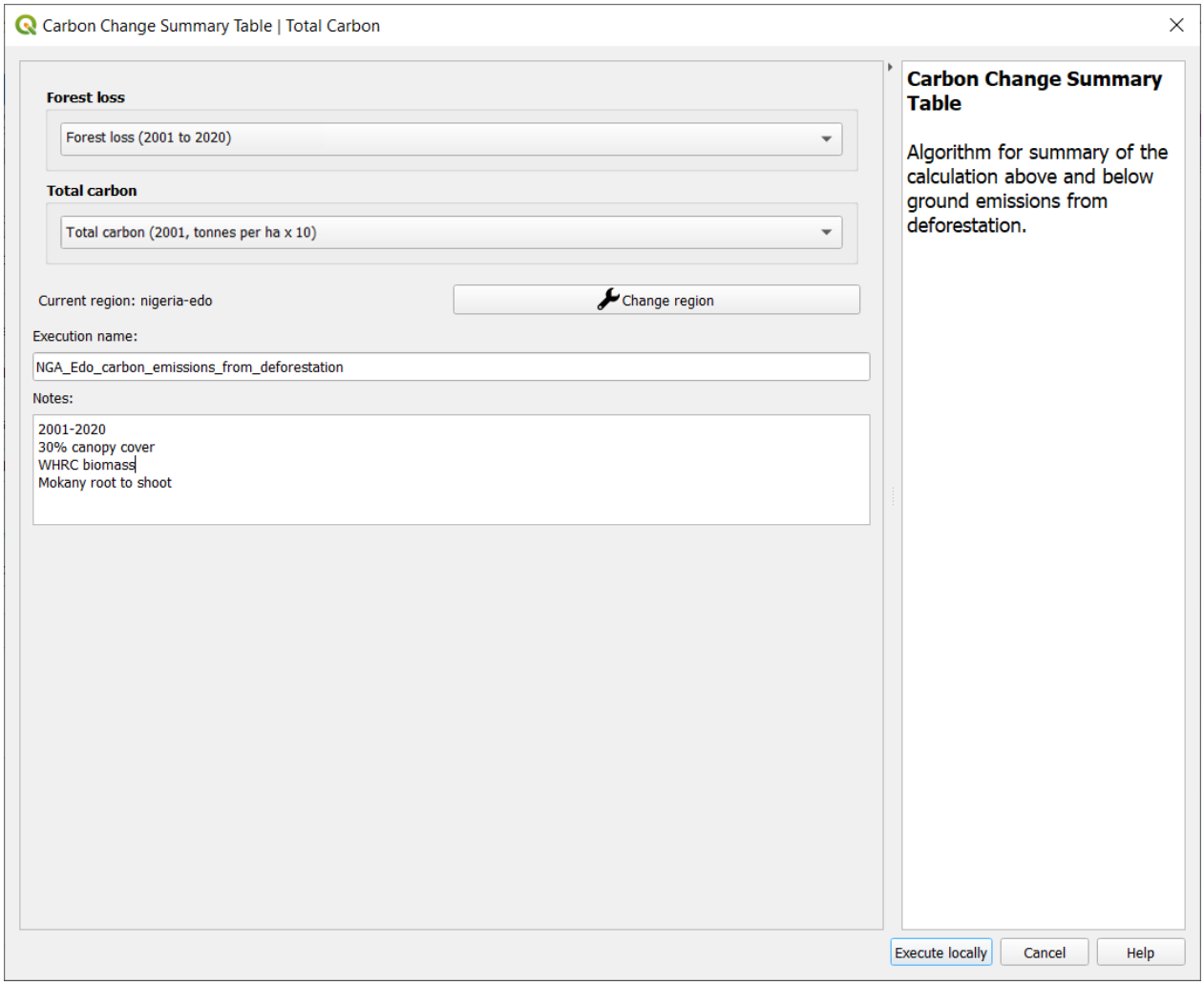
2. In order to view the defined area of interest with reference data, select the **Load Base Map** in the **Datasets** tab.


Add basemap
Mask
Use a mask
Mask all areas outside of:
First level:
Nigeria
Second level:
Edo
Disclaimer: The provided boundaries are from Natural Earth, and are in the public domain. The boundaries and names used, and the designations used, in trends.earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.
OK
Cancel


NIGERIA

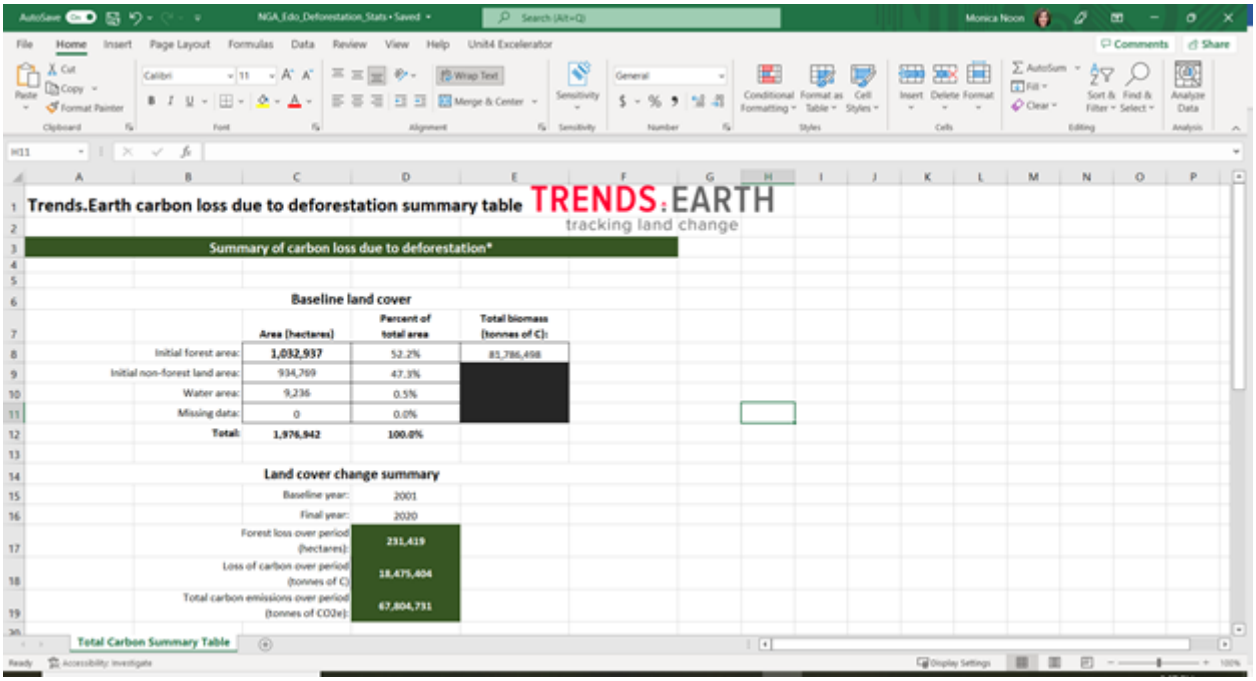


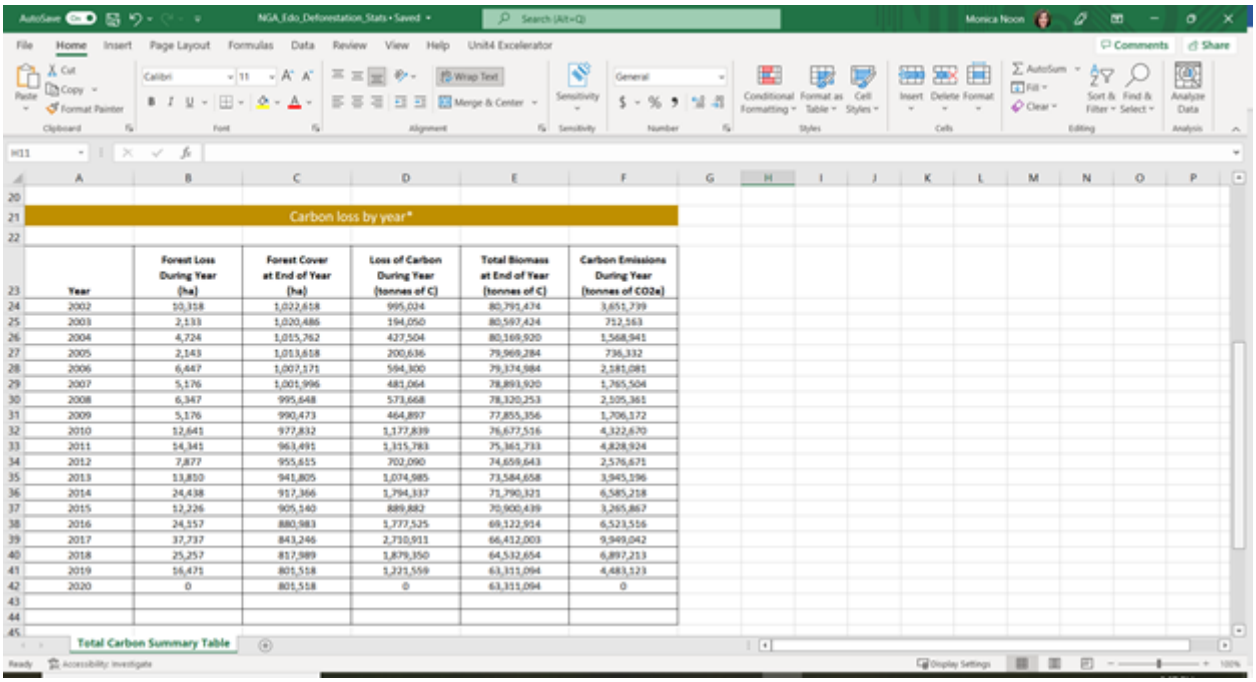
3. In the **Calculate change in total carbon - Above and below ground emissions, and deforestation** menu under **Change in carbon summary table**, select the **Execute locally** button.



4. **The layers will pre-populate in the data layer drop-down lists. Confirm the region is the same area of interest, provide descriptive names and notes and select Execute locally.**

   A spreadsheet comparing the final outputs is saved in your **trends_earth_data*** folder under your user account on your computer (e.g., C:Usersmnoontrends_earth_data).





Potential Carbon Sequestration under Restoration

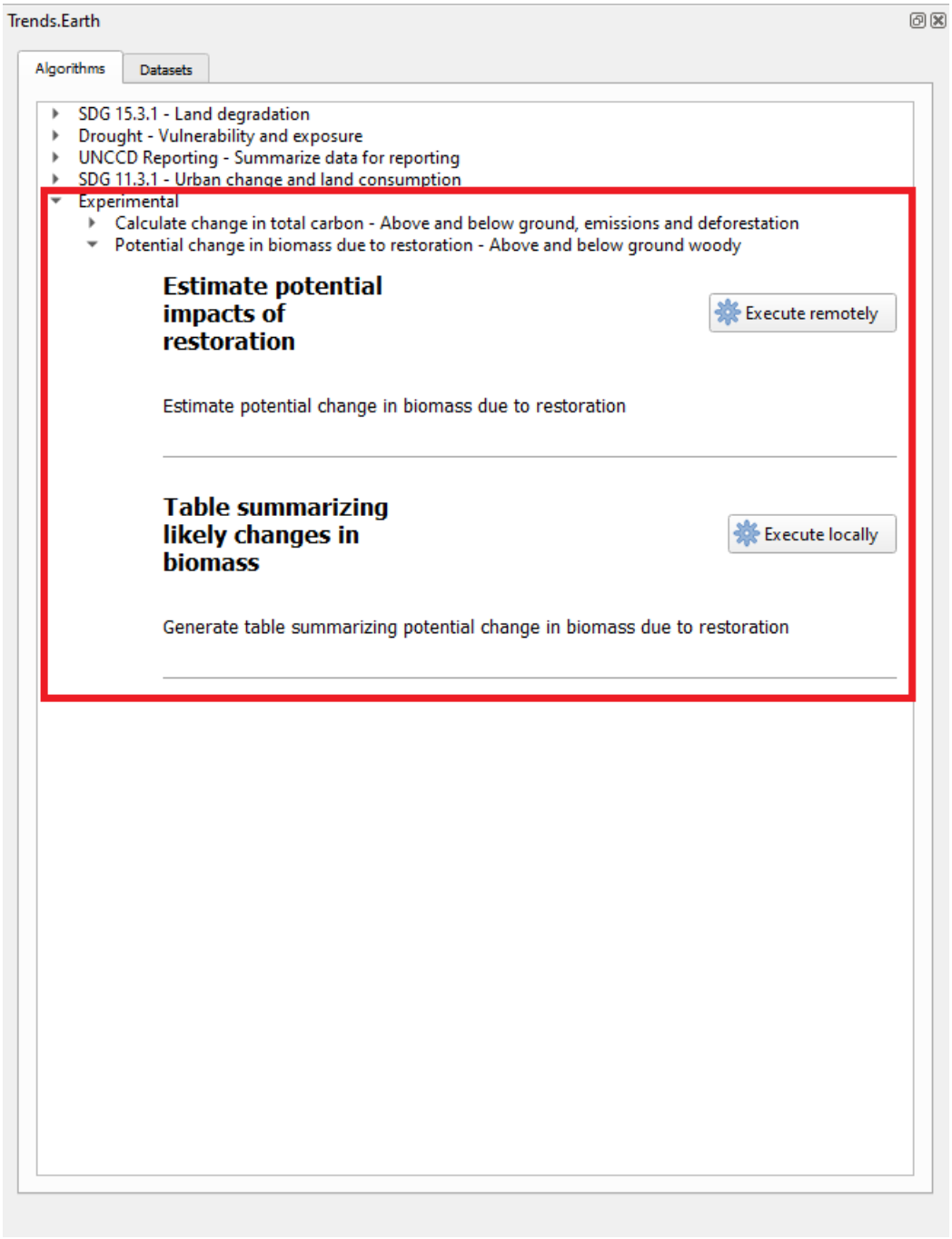
- **Objective**: Learn how to compute carbon sequestration under different forest restoration activities.
- **Estimated time of completion**: 20 minutes
- **Internet access**: Required

Note

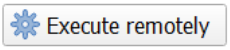
Refer to the Potential carbon sequestration from restoration **for background information on the datasets and**
methodology used for this tutorial.

Estimate potential impacts of restoration

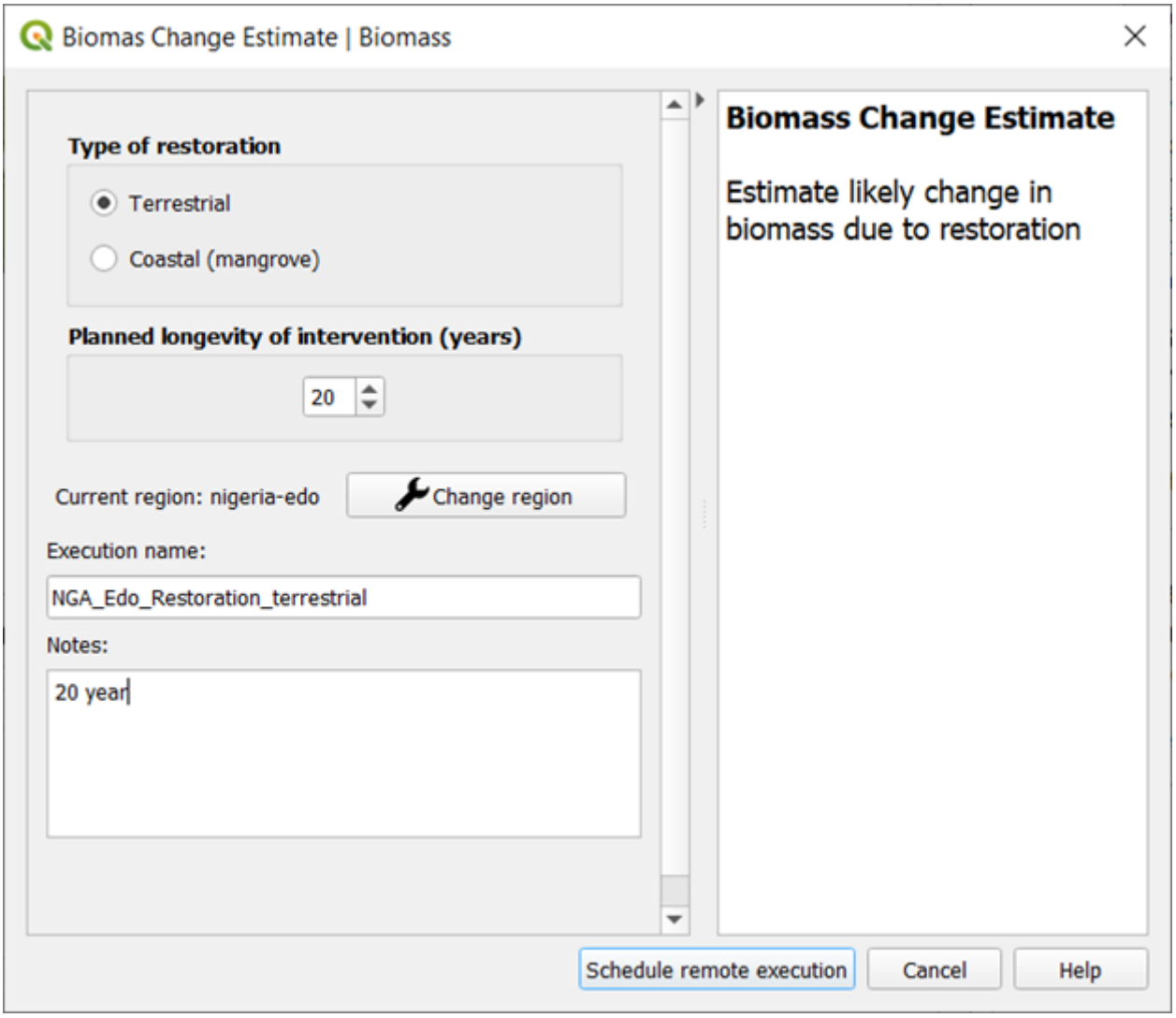
1. In the **Algorithms** tab in Trends.Earth plugin in QGIS, under the **Experimental** menu, select **Potential change in biomass due to restoration - Above and below ground woody** menu.



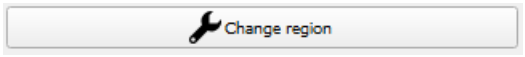
2. Select the **Estimate potential impacts of restoration** menu by selecting **Execute locally**.



3. A window will appear where you can select the paramaters for the restoration analysis. Select the type of restoration: terrestrial or coastal (mangrove). Define the length of the intervention in year.



4. Select **Change region** to define the area of interest.



Note

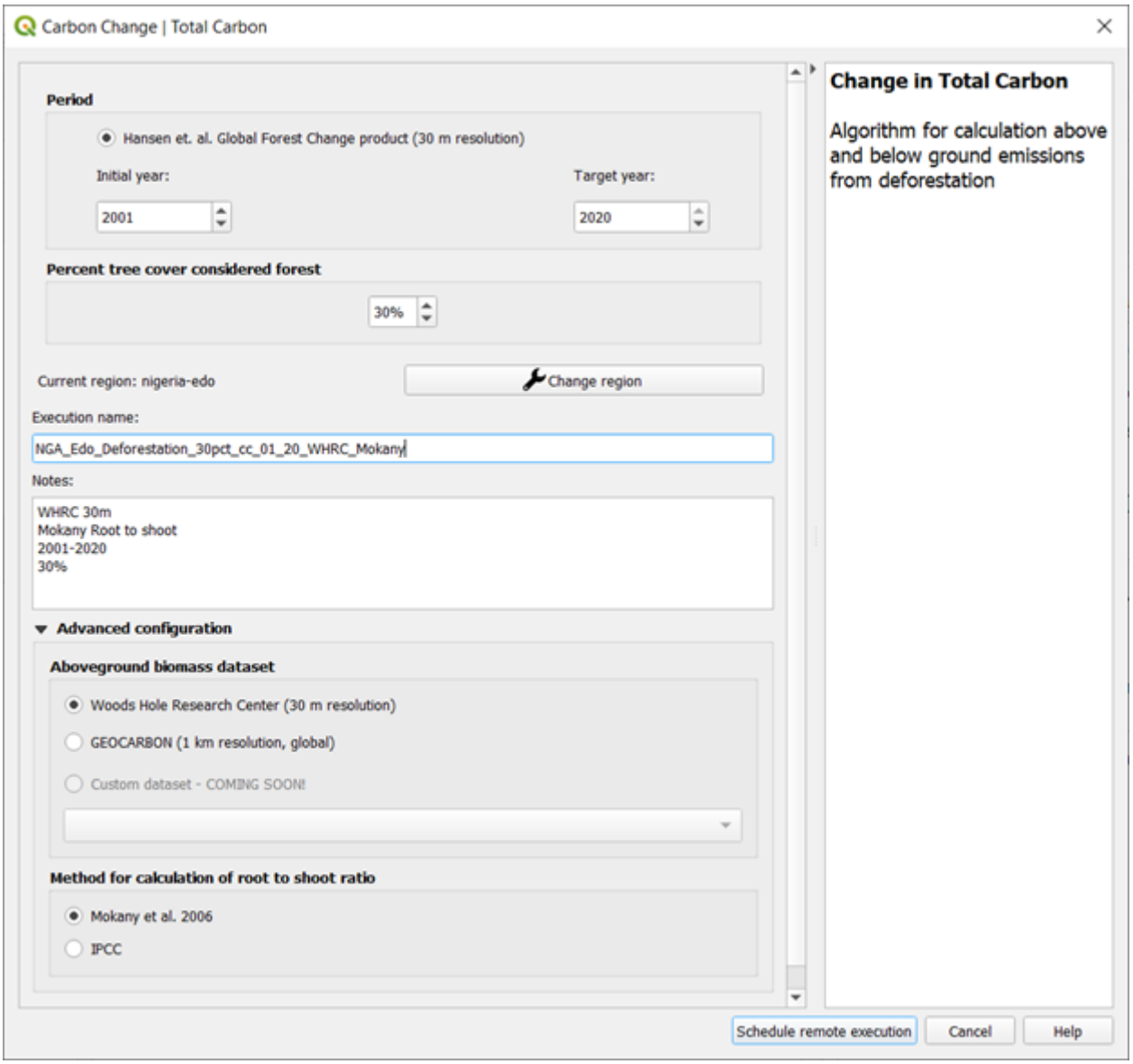
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If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

- Use your own area file: If you want to use your own area of analysis, make sure the **Area from file** option is highlighted. Then click **Browse** and navigate to the folder in your computer where you have the file stored.

5. Add a descriptive name and notes for the analysis

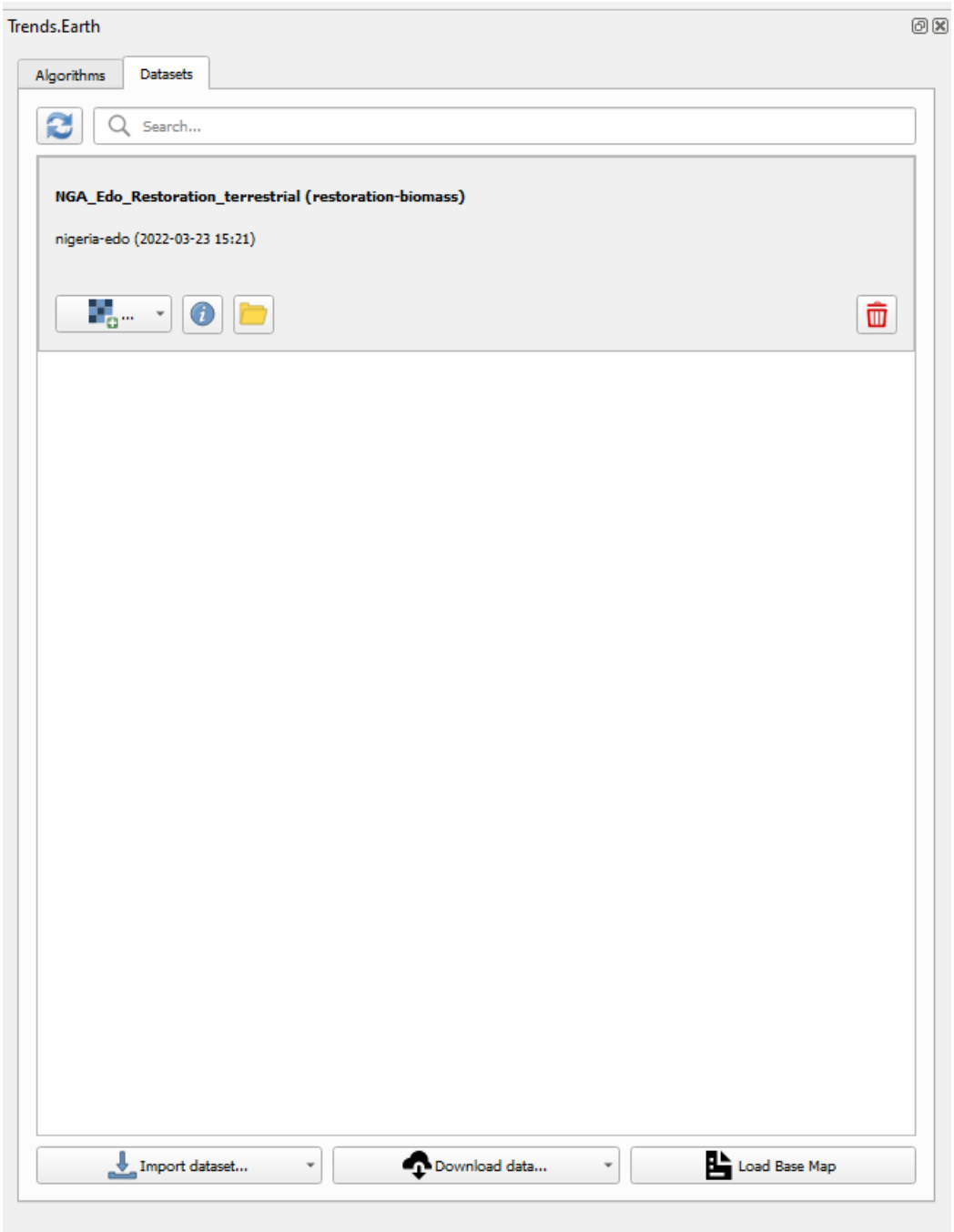
Select **Schedule remote exectution**



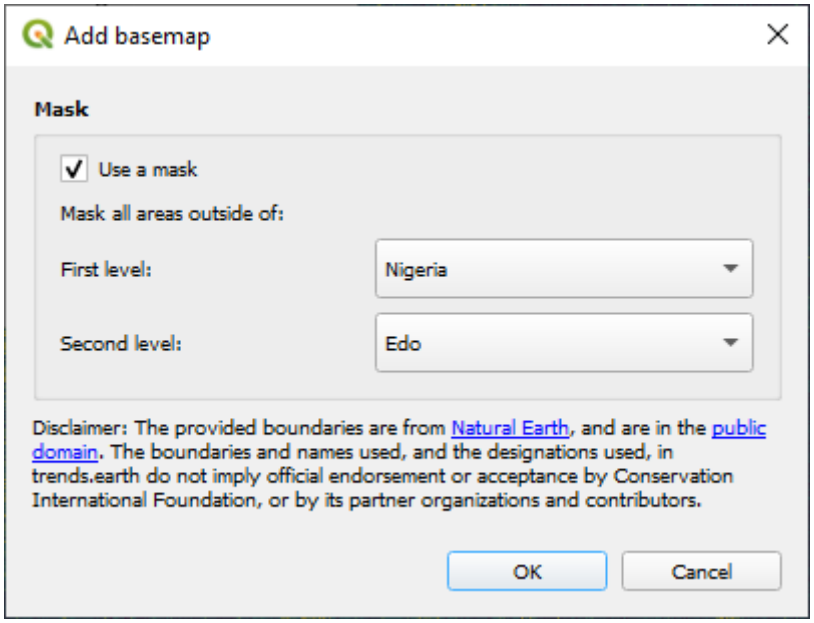
6. A light blue bar will temporarily show, indicating that the task was successfully submitted. The analysis will be run in Google servers and could take between 5 and 15 minutes depending on the size of the study area (larger areas tend to take longer).

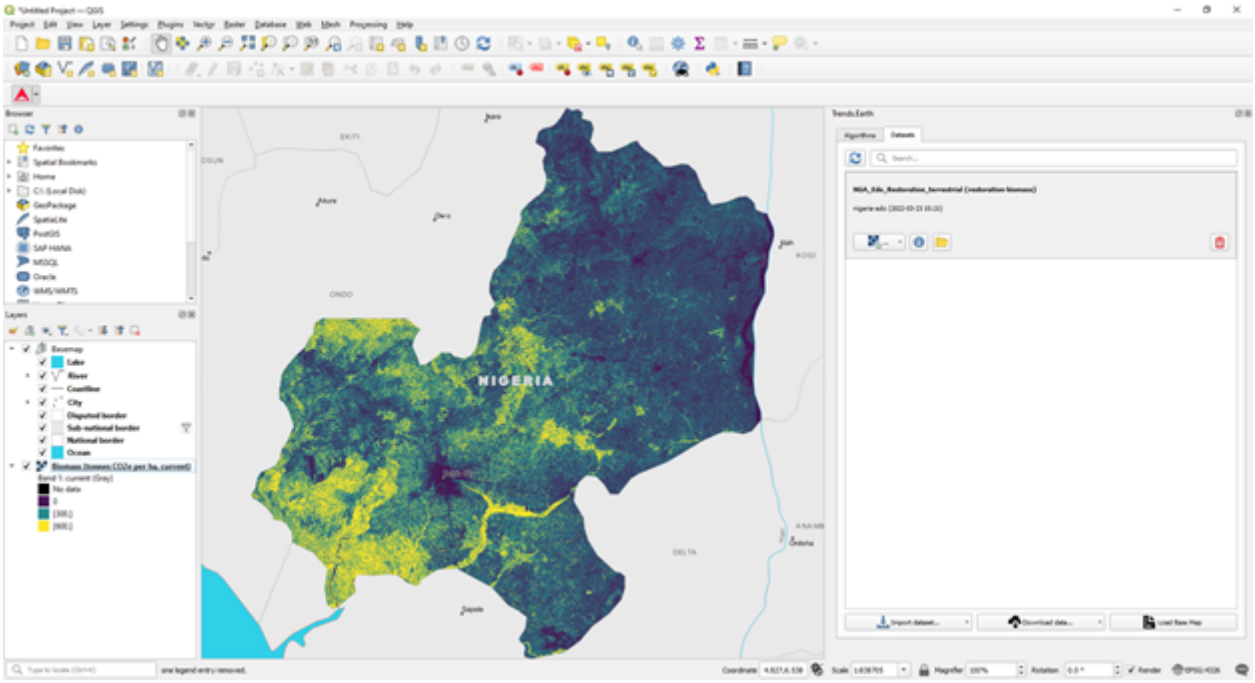
Table summarizing likely changes in biomass

1. Go the the **Datasets** tab to **Add default layers from this dataset to map**.

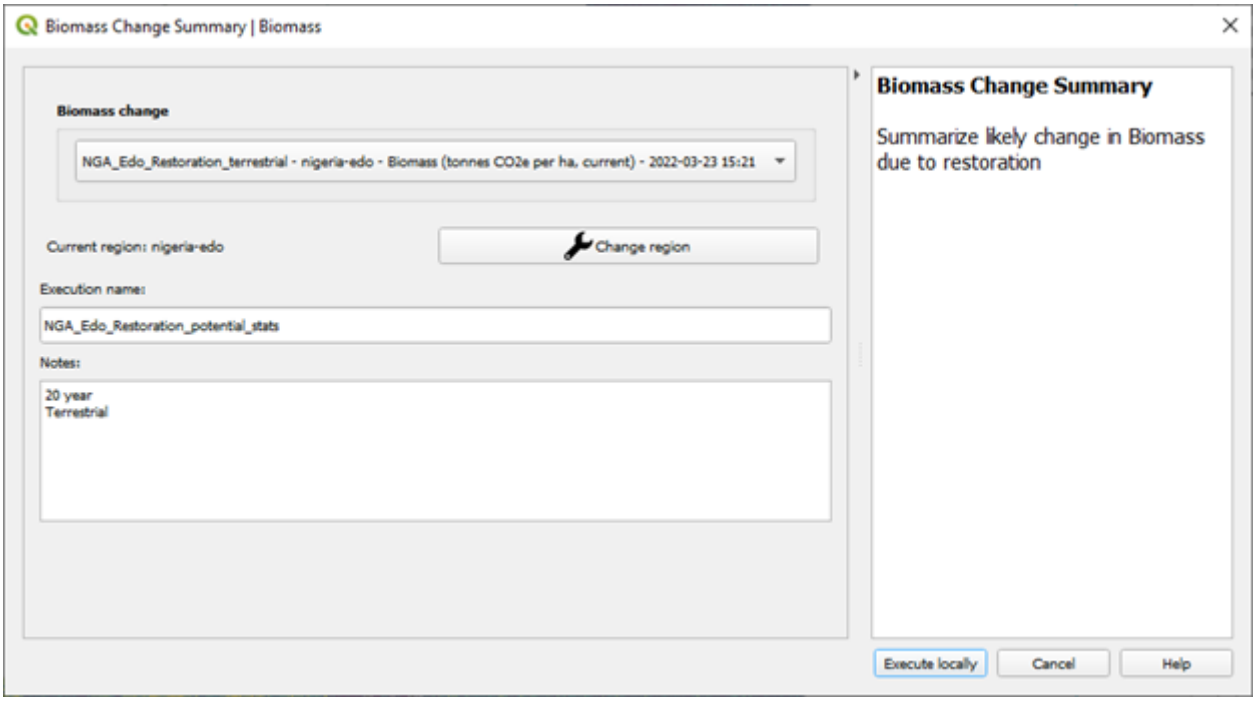


2. In order to view the defined area of interest with reference data, select the **Load Base Map** in the **Datasets** tab.



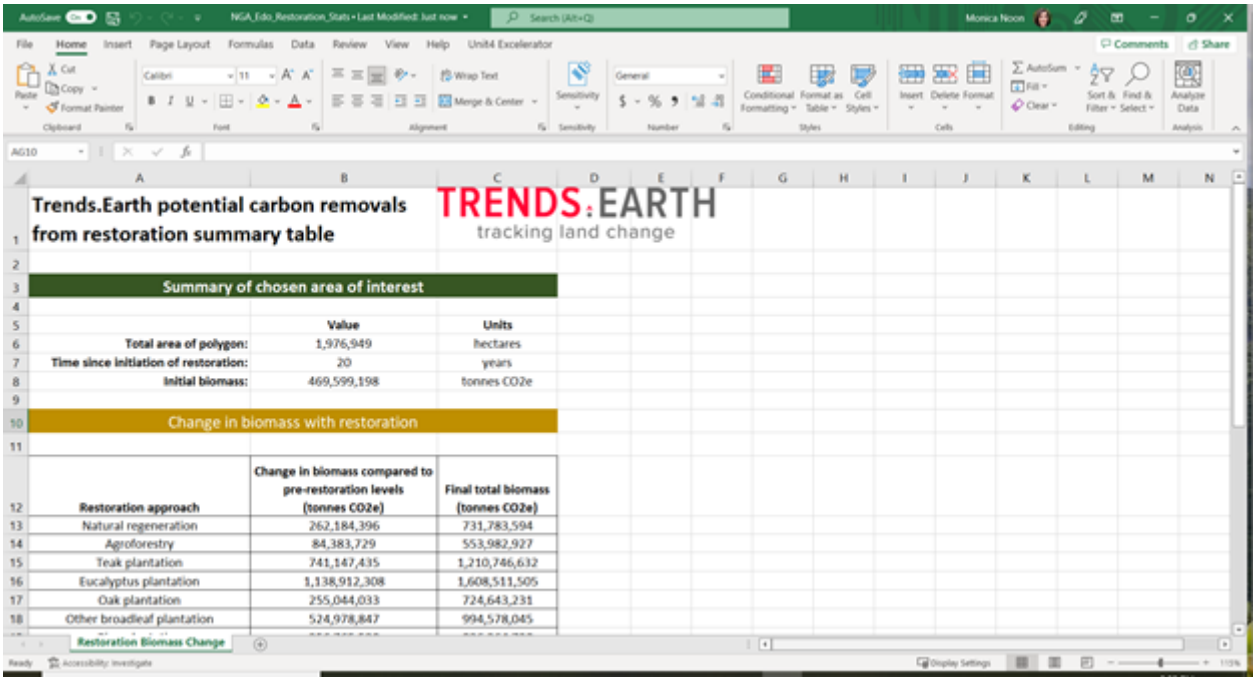


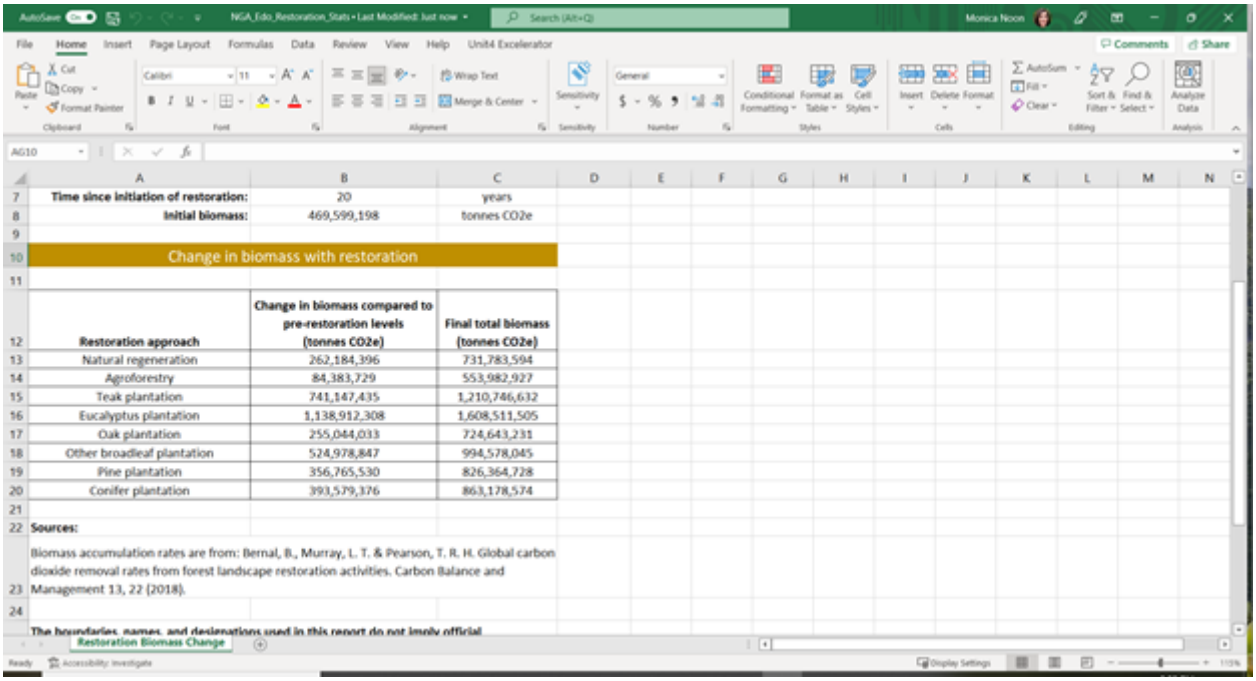
3. Go back to the **Algorithms** tab in Trends.Earth plugin in QGIS, under the **Experimental** menu, select **Potential change in biomass due to restoration - Above and below ground woody** menu and select the **Execute locally** button under **Table summarizing likely changes in biomass**.



4. **The layers will pre-populate in the data layer drop-down lists. Confirm the region is the same area of interest, provide descriptive names and notes and select Execute locally.**

   A spreadsheet comparing the final outputs is saved in your **trends_earth_data*** folder under your user account on your computer (e.g., C:Usersmnoontrends_earth_data).



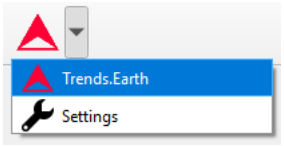


	A	B	C
7	**Time since initiation of restoration:**	20	years
8	**Initial biomass:**	469,599,198	tonnes CO2e
9			
10	Change in biomass with restoration		
11			
12	**Restoration approach**	**Change in biomass compared to pre-restoration levels (tonnes CO2e)**	**Final total biomass (tonnes CO2e)**
13	Natural regeneration	262,184,396	731,783,594
14	Agroforestry	84,383,729	553,982,927
15	Teak plantation	741,147,435	1,210,746,632
16	Eucalyptus plantation	1,138,912,308	1,608,511,505
17	Oak plantation	255,044,033	724,643,231
18	Other broadleaf plantation	524,978,847	994,578,045
19	Pine plantation	356,765,530	826,364,728
20	Conifer plantation	393,579,376	863,178,574
21			
22	**Sources:**		
23	Biomass accumulation rates are from: Bernal, B., Murray, L. T. & Pearson, T. R. H. Global carbon dioxide removal rates from forest landscape restoration activities. Carbon Balance and Management 13, 22 (2018).		
24			

Dataset Metadata

- **Objective**: Learn how to edit and view dataset metadata.
- **Estimated time of completion**: 15 minutes
- **Internet access**: Not needed

1. Click on the Trends.Earth toolbar within QGIS, and click on the Trends.Earth icon.

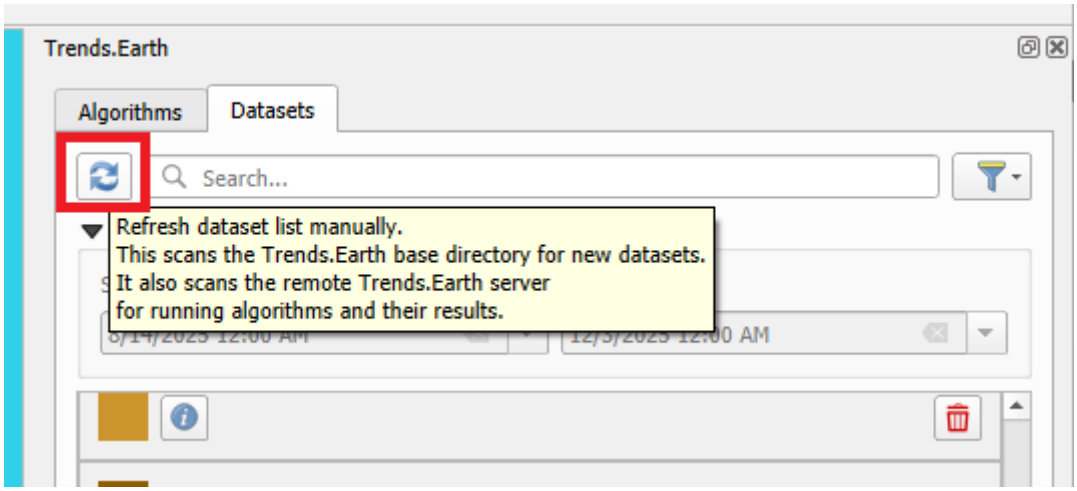


2. The **Trends.Earth** menu will open. In the **Dataset** window, where existing tasks are listed in the menu if the **Download remotely-generated datasets automatically** is checked in settings.

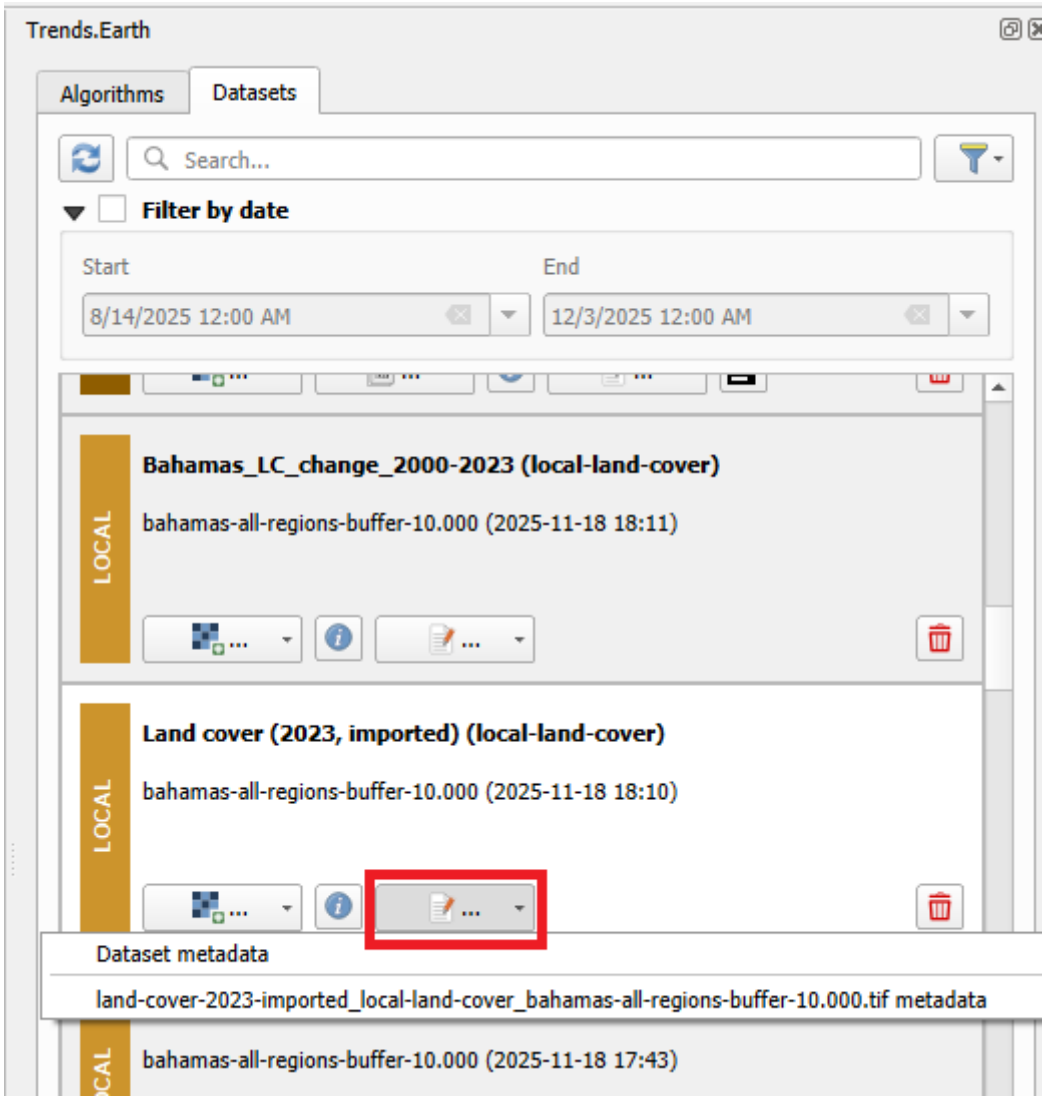
Note

Refer to the Settings section of this manual to learn more about **Advanced settings**

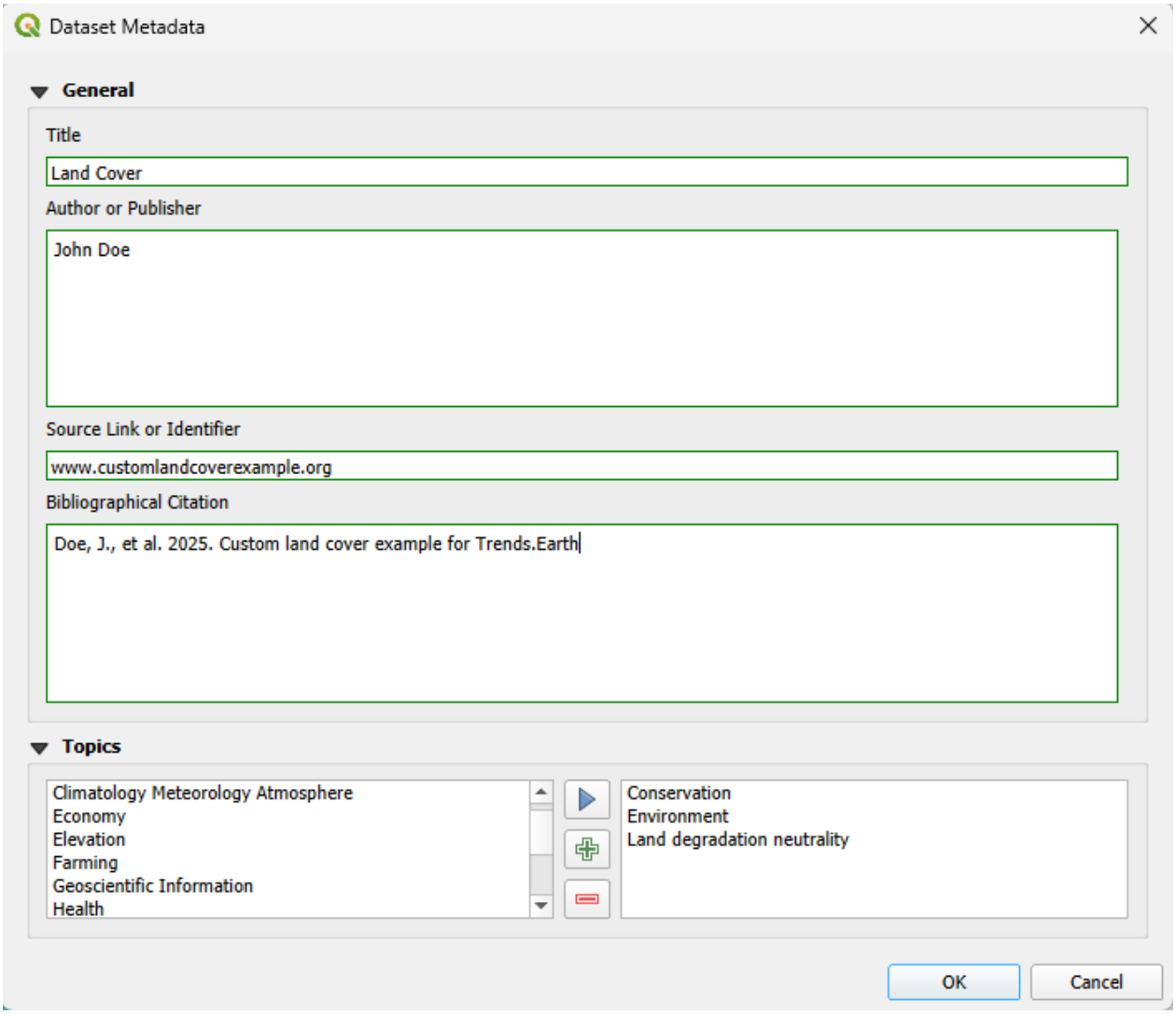
- Select the Refresh button if no datasets appear in the menu.



3. Press the Edit metadata button to open a drop-down menu with available options



4. The drop-down menu allows to select any raster from the list of all available rasters of the dataset to edit or view its metadata. Once raster is selected a metadata editor dialog will show up.

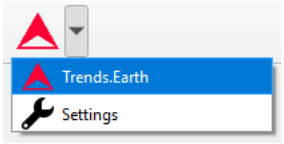


5. Fill in the necessary information or edit existing data in the dialog fields and press OK button to save your changes. Metadata will be saved in the QGIS QMD format, in a separate file for each raster in the dataset folder.

False positive/negative layers

- **Objective**: Learn how to create false positive/negative vector datasets.
- **Estimated time of completion**: 40 minutes
- **Internet access**: Not needed

1. Click on the Trends.Earth toolbar within QGIS, and click on the Trends.Earth icon.

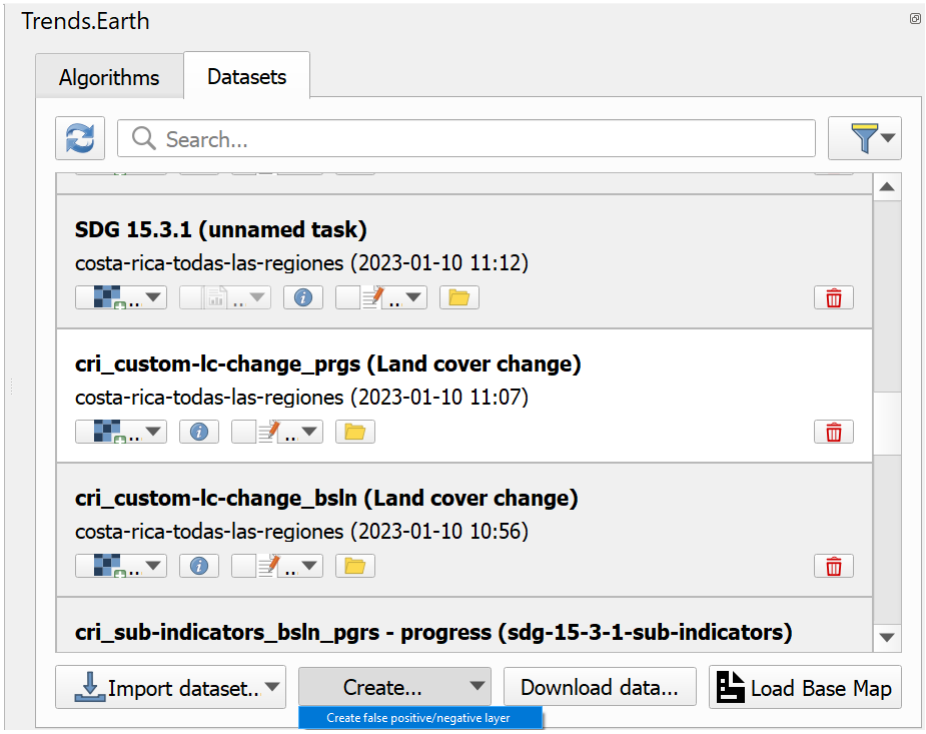


2. The **Trends.Earth** menu will open. In the **Dataset** window, where existing tasks are listed in the menu if the **Download remotely-generated datasets automatically** is checked in settings.

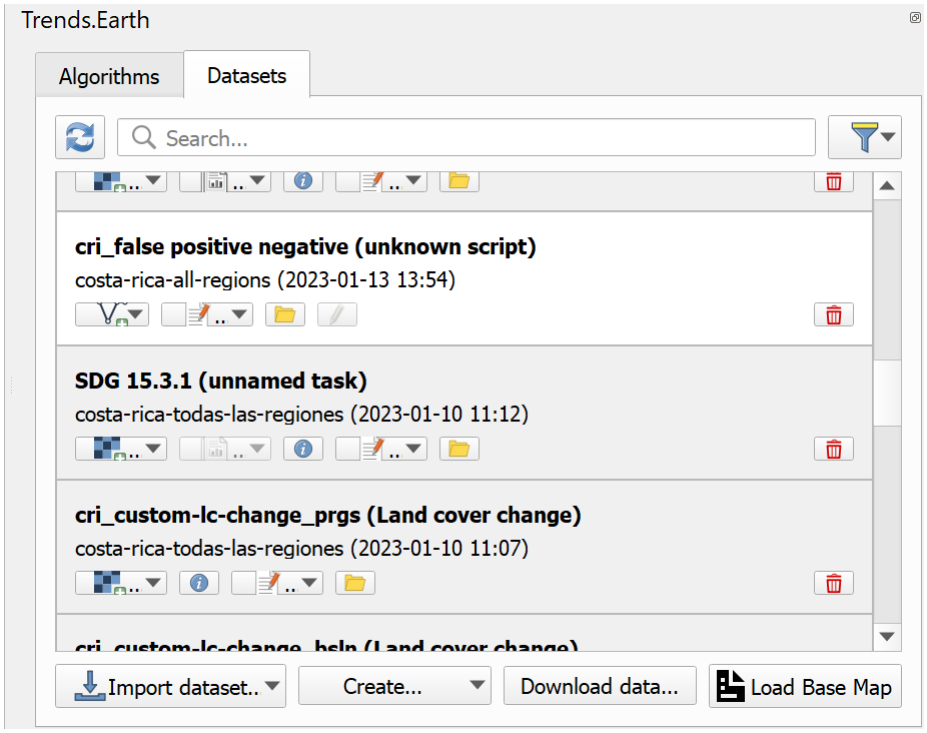
> **Note**
>
> Refer to the Settings section of this manual to learn more about **Advanced settings**

- Select the Refresh button if no datasets appear in the menu.

3. Press the **Create** button at the bottom of the **Trends.Earth** menu and then select **False positive/negative layer**

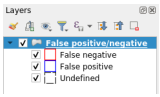


4. A new dataset called “False positive/negative” will be added to the **Dataset** window.



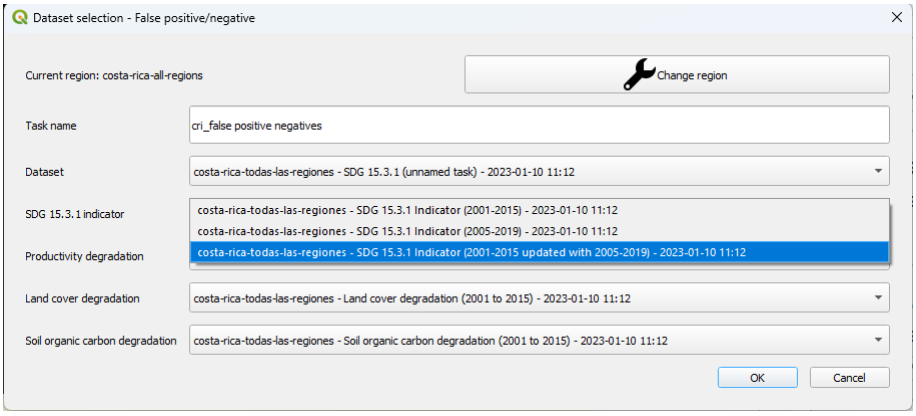
5. To add the vector dataset to QGIS map canvas for viewing use **Add to canvas** button

- Layer will be added with the predefined styling as shown below



6. To define areas in the dataset it is necessary to add it to QGIS map canvas using **Edit layer** button

7. If this is the first time a false positive/negative layer is added to QGIS canvas a dialog asking for indicator layers will be shown

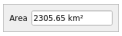


In this dialog it is necessary to correctly select corresponding indicator layers which will be used to calculate charts - **special attention when selecting the layer for SDG 15.3.1 indicator, make sure to select the SDG 15.3.1 Indicator that has been updated with the respective progress period**. This is a one-time action, choice made in this dialog will be preserved and used in all subsequent edits of this specific vector dataset.

8. Once the dataset added to the canvas in editing mode, polygons can be created using either **Polygon** tool or **Buffer** tool which can be found on the **Trends.Earth** toolbar.



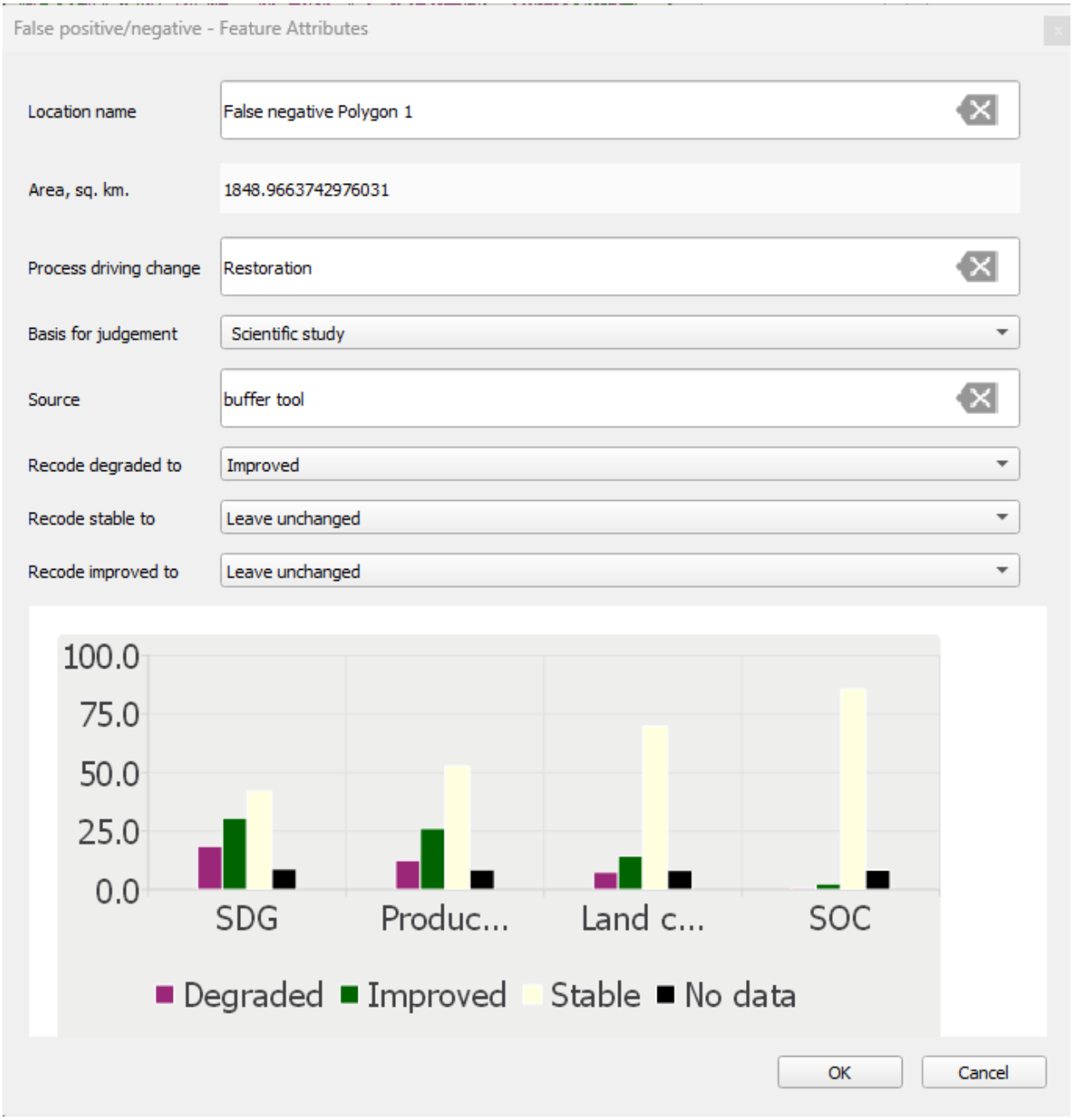
9. The **Polygon** tool used to digitize polygons manually, using the same point-and-click approach as native QGIS digitizing tools do. When **Polygon** tool is selected and digitizing started in the top-right corner of the QGIS map canvas a widget showing area of the polygon will be displayed.



10. The **Buffer** tool used to digitize polygons by selecting a center point and defining a radius or area of the circle around that center point. Once **Buffer** tools is selected and center point defined with the mouse click in the top-right corner of the QGIS map canvas a widget showing circle radius will be shown. Enter desired radius and press **Enter** key to create circle. Alternatively it is possible to draw circle manually by moving mouse cursor, in this case current radius will be displayed in the same widget.



11. When digitizing of the polygon is finished a custom attribute form will be shown.



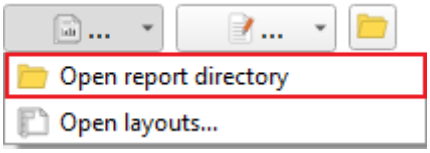
In addition to various attributes this form also contains indicators chart calculated based on the rasters selected in the step 7.

Dataset Reports

- **Objective**: Learn how to generate and view reports from one or more datasets.
- **Estimated time of completion**: 10 minutes
- **Internet access**: Not Required

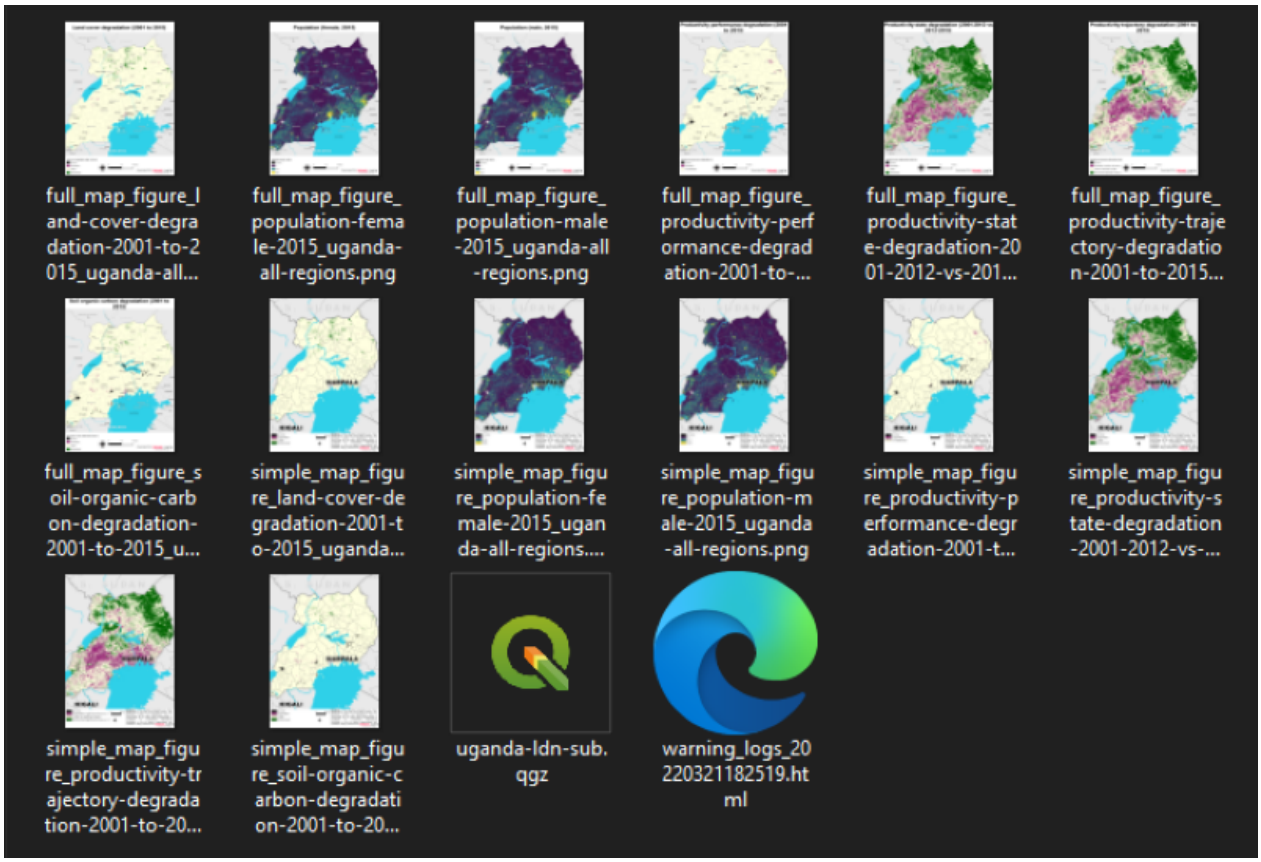
View Dataset Output Reports

1. Select the **Open report directory** sub-menu in a dataset item's report button.



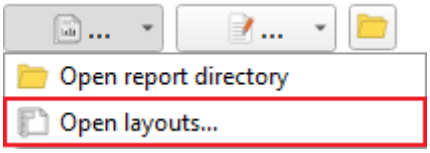
2. This action will open the directory containing the output reports for the selected dataset. Depending on the report configuration for the given algorithm, the directory will contain PDF and/or image files showing the default thematic layers for the selected dataset.

   The example below is from the sub-indicators for SDG 15.3.1 algorithm with the AOI set to Uganda.

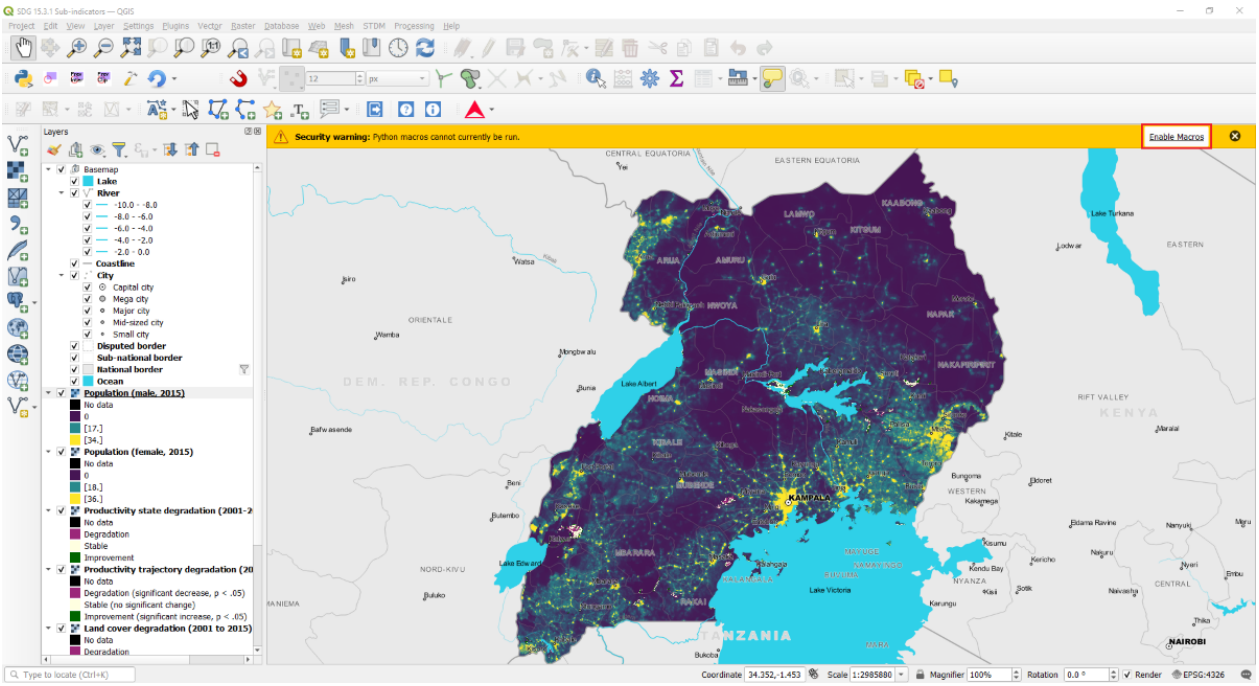


Open Report Layouts

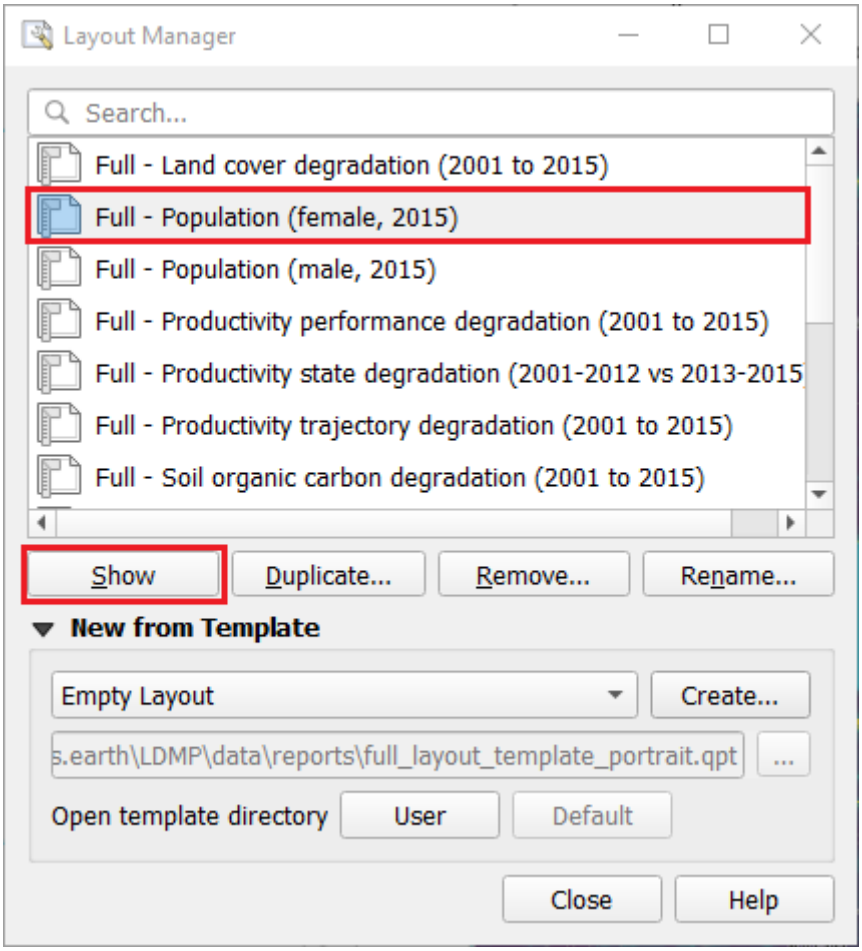
1. Select the **Open layouts…** sub-menu in a dataset item's report button.



2. This action will open the QGIS project containing the job's layers and layouts in a separate application instance.
3. By default, on opening the project, a warning message will appear indicating Python macros cannot be run. This is a security features that prevents users from running macros for QGIS projects from unknown or untrusted sources. However, in this case, the project is locally generated hence it is safe to run macros by clicking on the **Enable Macros** button in the message bar (top-right corner).



4. On the Layout Manager dialog, select a layout name in the list then click on **Show** to edit the layout.



Note

- If the **Reports** button ( ) is disabled, it means the report generation task is still running and will automatically be enabled once the process is complete.
- If the **Reports** button is not visible, then it means there is no report configuration defined for datasets resulting from the given algorithm.

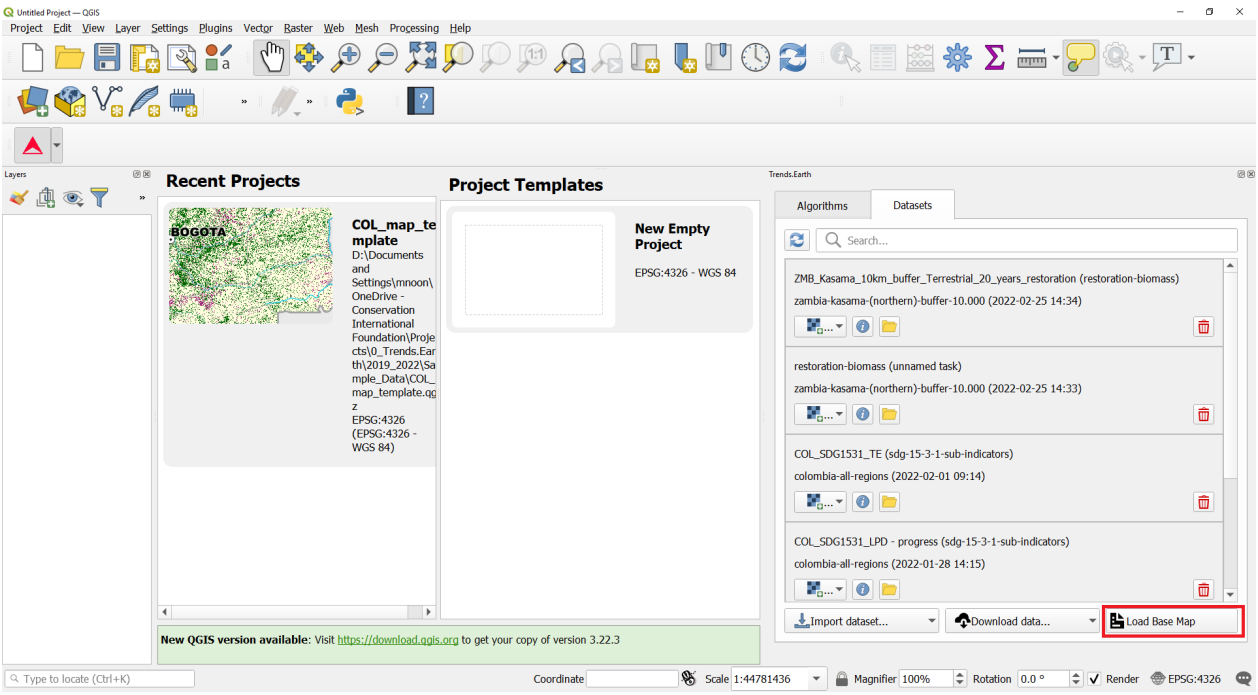
Note

To allow macros to be executed automatically, go to **Settings > Options** then, under the **General** category, scroll to the bottom to the **Enable Macros** setting. Select **Always**, though this option is not recommended especially if you interact with qgs or qgz projects from external sources.

Adding a basemap

Basemaps are very useful as a reference for identifying specific locations in maps. When downloaded, Trends.Earth results are displayed on an empty QGIS project, which could limit the user ability for identifying know places in the landscape. To facilitate this process, you can use the **Add Basemap** tool which will load country and state boundaries, roads, rivers, cities, coastlines and water bodies with labels to the QGIS project.

1. To load the tool click on the **Datasets** tab and select **Load Base Map** in the bottom right of the window.

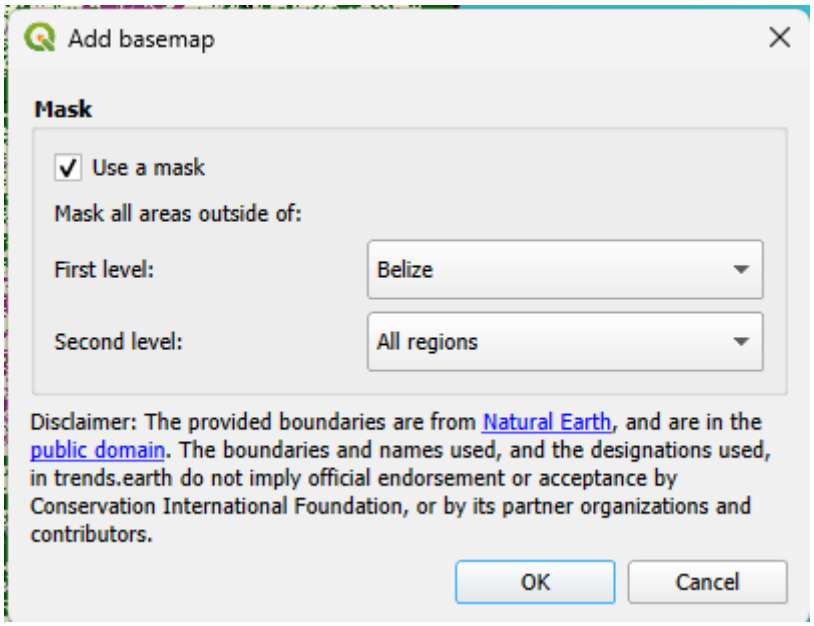


2. On the **Add basemap** window you can do one of two things:

   - **Use a mask option selected** will create a mask blocking all the information outside of the selected area. In this example, all the information outside of Uganda will not be displayed on

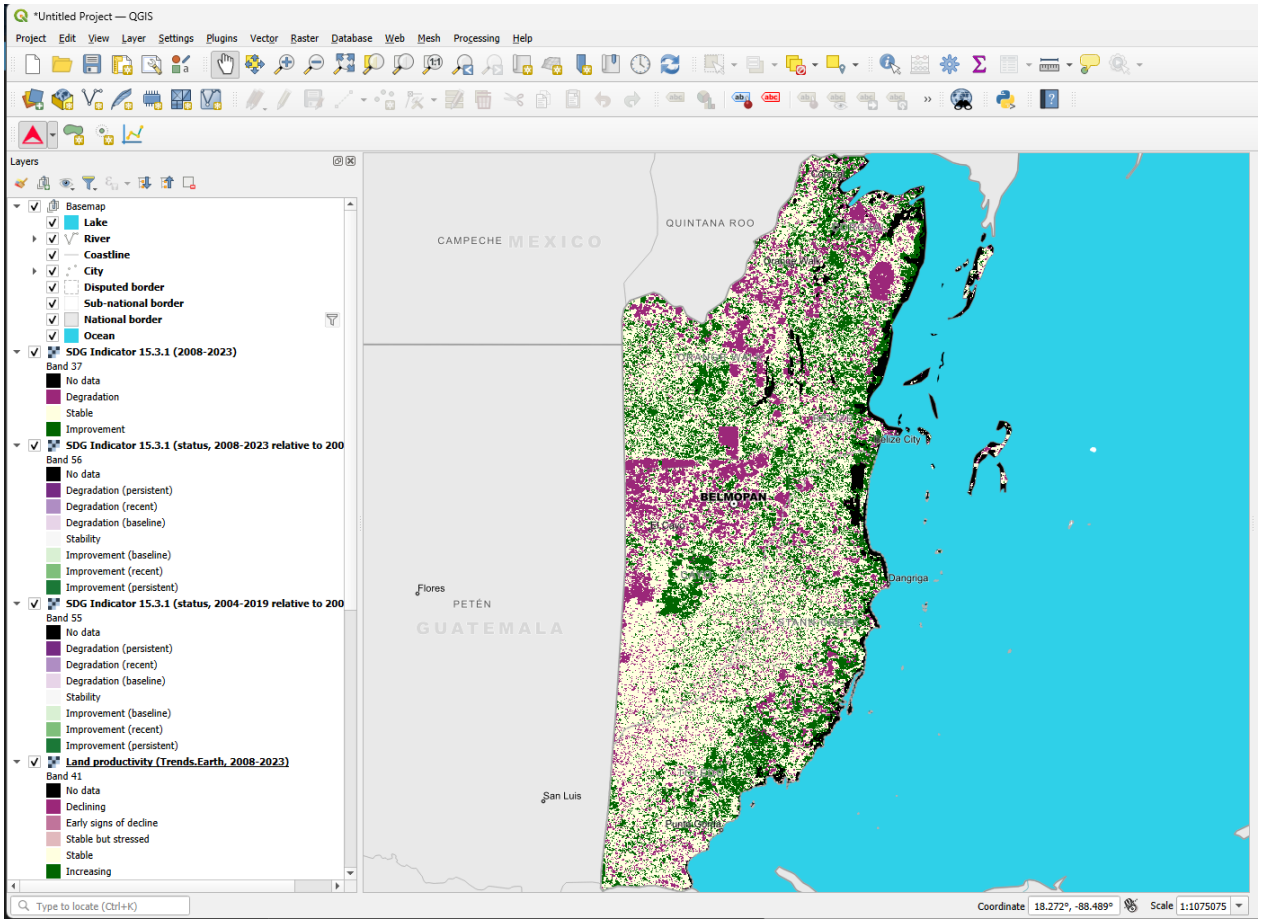
the map. This option is useful when displaying the sub-indicators downloaded from Trends.Earth, since the data download is not clipped to administrative boundaries (a bounding box is used instead). You can use first and second level administrative boundaries.

- **Use a mask option not selected** will load all the reference information, but no mask will be applied.



3. Once the basemap is loaded, you will notice the information added to the map and to the Layer panel. The basemap has information for:

   - Lake
   - River
   - Coastline
   - City
   - Disputed border
   - Subnational border
   - National border
   - Ocean



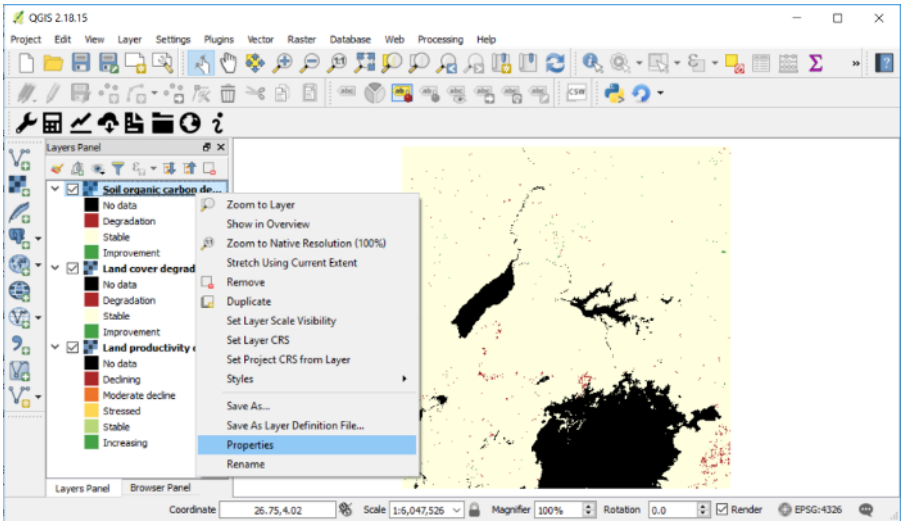
Computing Pyramids

When the raster file is too big, due to a large study area, high spatial resolution, or a large number of bands in the file, the data could take several seconds to display. If you change the zoom or turn layers on an off frequently, this could make the work a bit frustrating. An option to overcome this is to compute **Pyramids** to the file. This process will take from **minutes to hours** to run depending on the size of the area, so make sure to have enough time for it to process. To compute pyramids you have to:

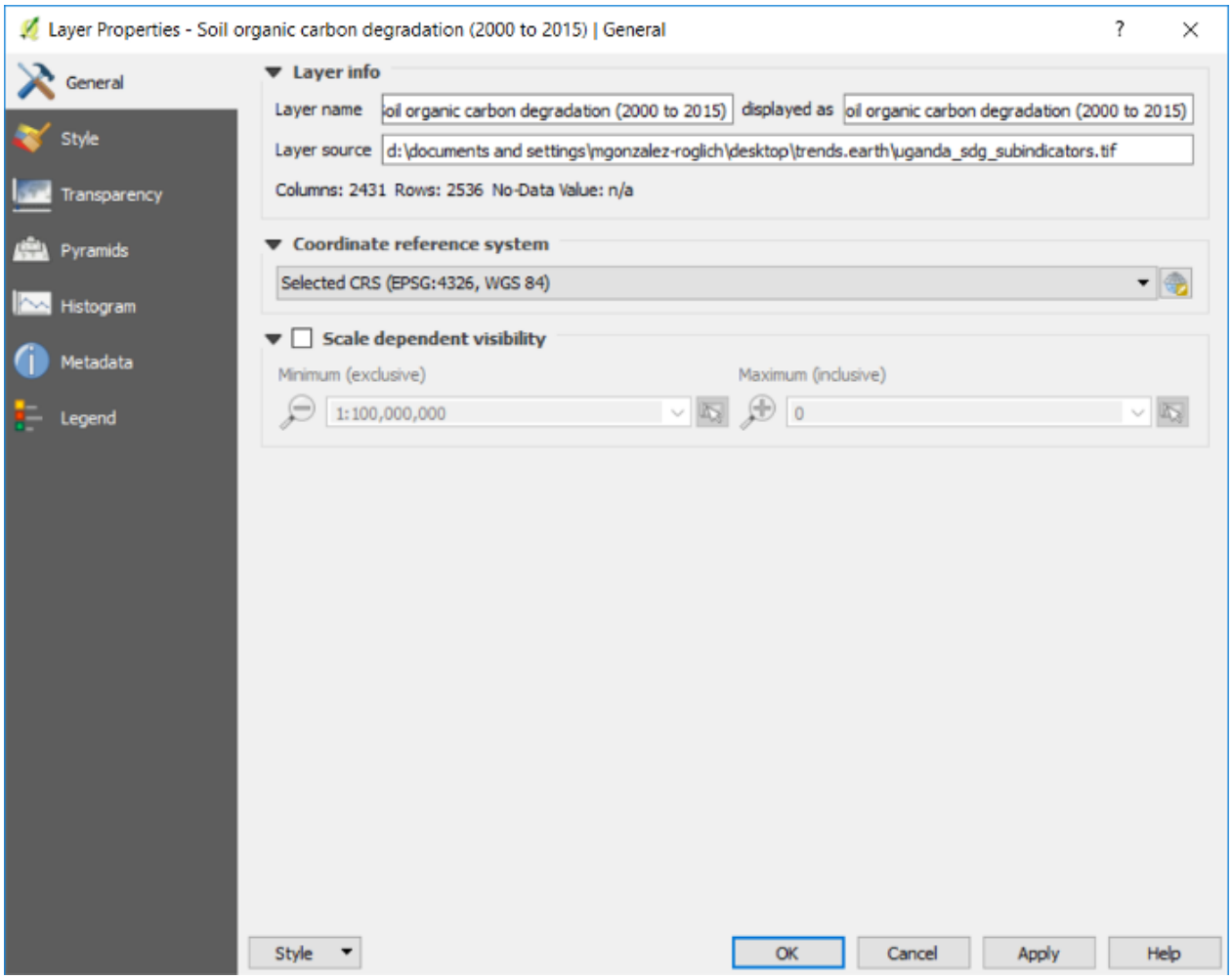
1. Navigate with your cursor to the layer you want to compute pyramids for and right click over it. A menu will open. Navigate to **Properties** and click on it.

Note

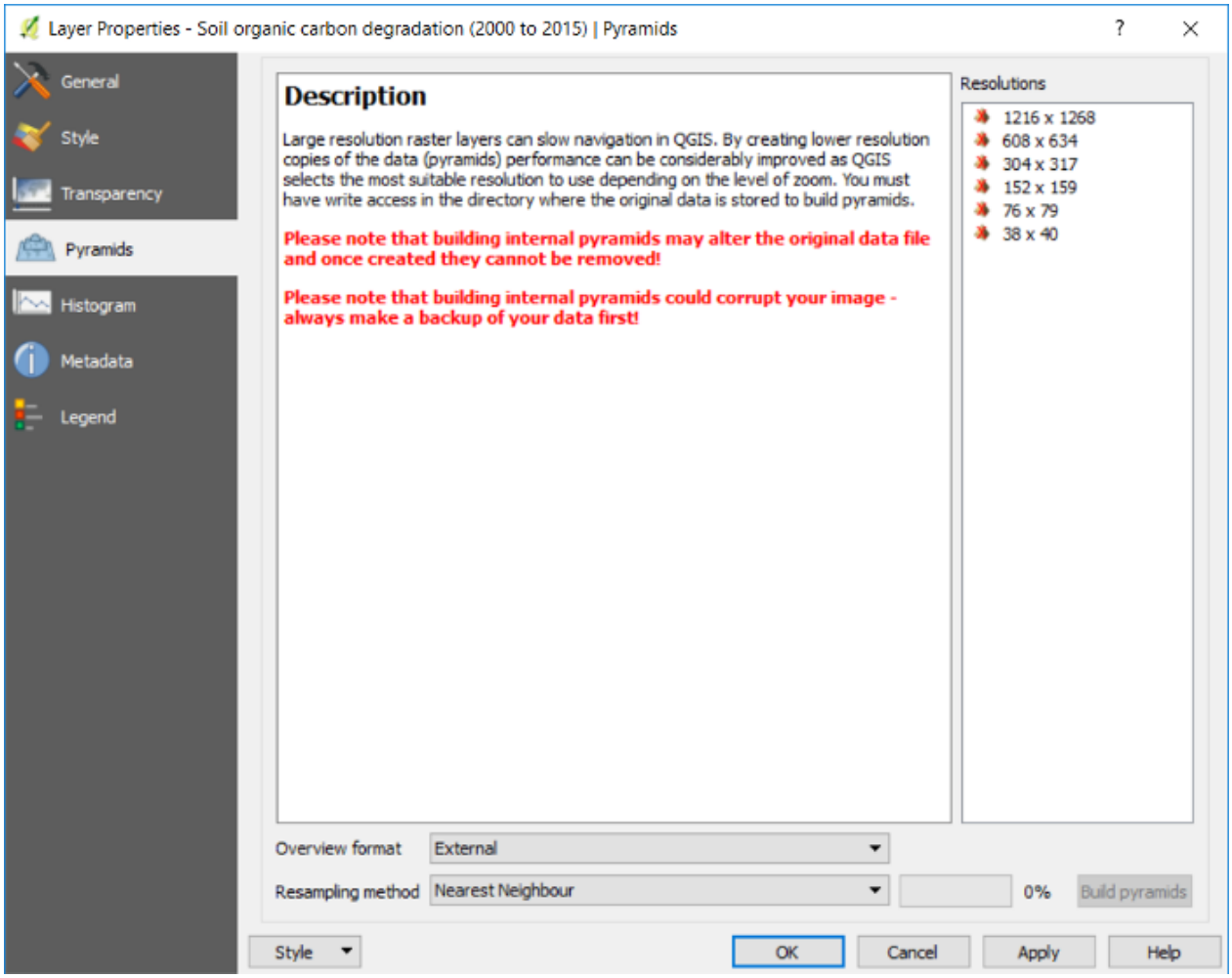
When using the **Calculate all three sub-indicators in one step** option (described in the tutorial Land Degradation), all the bands are stored in a single TIF file, so even though you see three layers loaded in the QGIS window, they all refer to the same file. This means that the pyramids need to be computed only once for the three sub-indicators.



2. The Layer Properties menu will open. From the options on the left, navigate to **Pyramids** and click on it.



3. Once on the **Pyramids** tab you will see a description about they are.

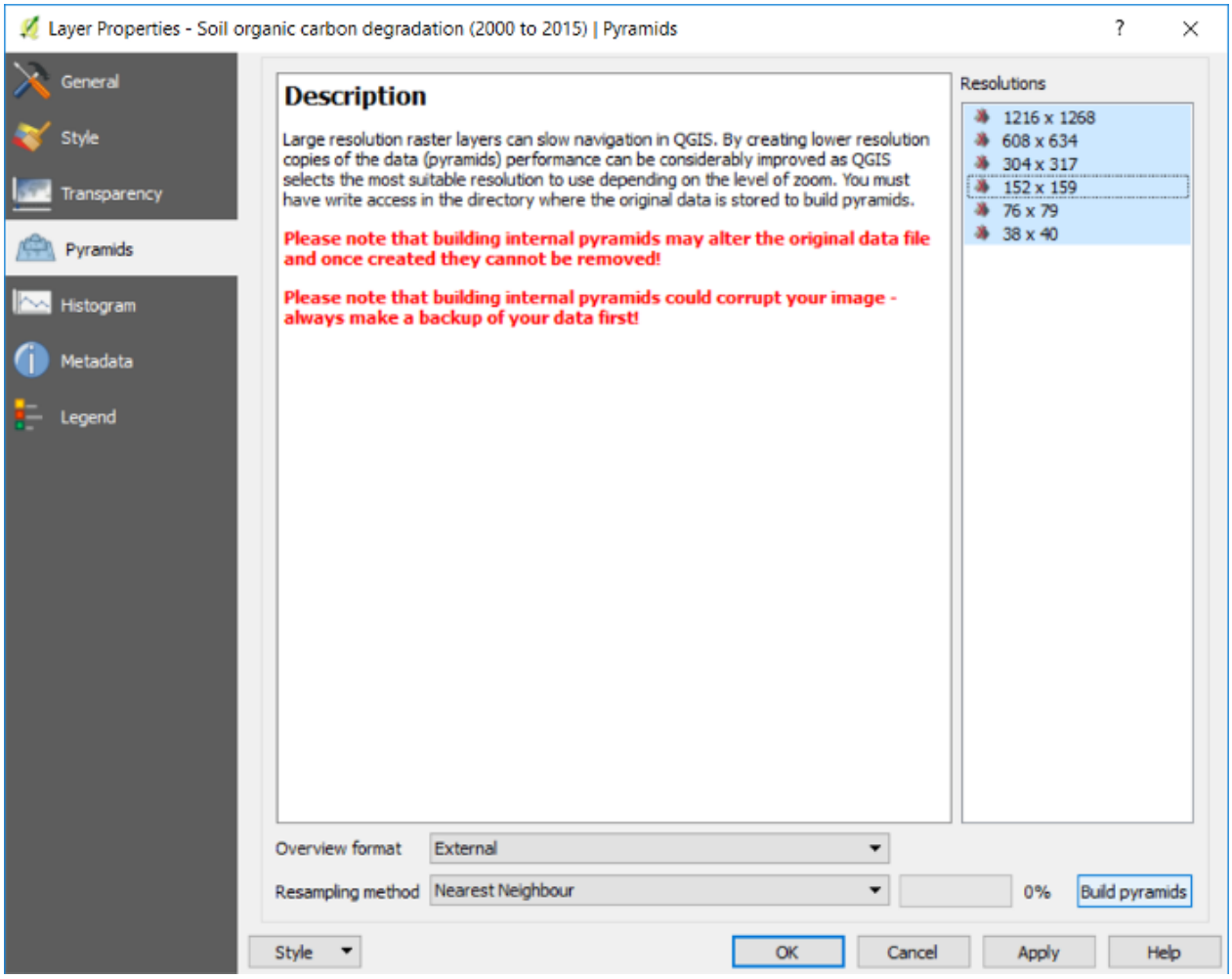


4. To the right of the window you will see the **Resolutions** options. Selecting all of them will make displaying in QGIS the fastest, but this could take hours to compute depending on the file size and processing capabilities of the computer you are using. For the Uganda example, we can select them all, but if using a larger area or higher spatial resolution than the default 250m, we recommend you select alternating resolutions options (i.e. one resolution selected and one not selected, and so on). Resolutions are selected by clicking on them. When selected, they will turn blue.

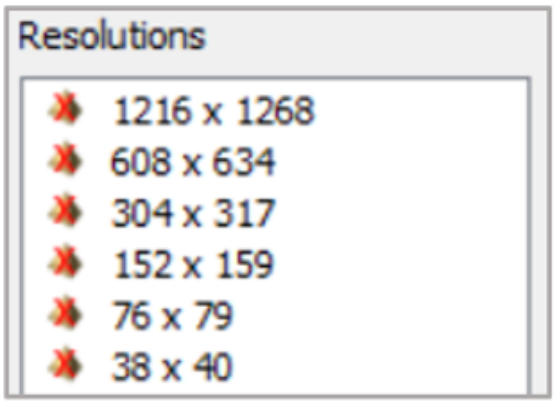
   Make sure that the settings at the bottom are set to:

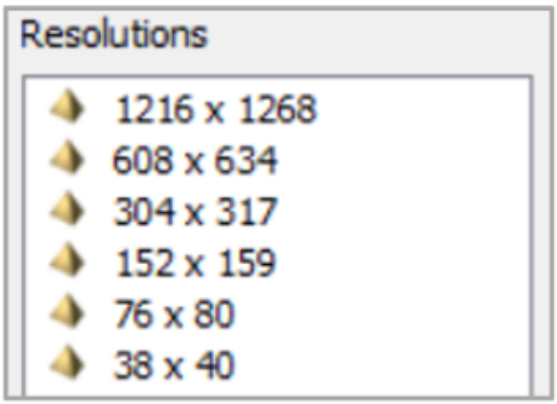
   - **Overview format**: External
   - **Resampling method**: Nearest Neighbour

5. Then click on the **Build pyramids** button. The progress bar next to it will show which percentage of the task has been completed.



6. When pyramids have been built you will notice that the icons next to the resolutions will have changed from **red crosses** to **yellow pyramids**.





7. Click **OK** to go back to the QGIS main interface.

Frequently asked questions

This page lists some Frequently Asked Questions (FAQs) for the ▲TRENDS.EARTH tool.

General Questions

Is there a user group I can share experiences with and learn from?

Yes, we recently created a Google group for Trends.Earth users so please join and participate! We aim for this group to be a forum for users to post questions about the tool, methods, and datasets in support of Sustainable Development Goals monitoring. The TRENDS.EARTH team will monitor the group and answer questions as needed, but we'll get the most out of this community if users support each other by answering questions based on their unique background and experiences. The group will also be used for announcements on tool updates and capacity building efforts.

How can I provide feedback on the tool?

There are three ways to give feedback, emailing the project team, visiting the project site and messaging through the anonymous form or rate the toolbox in the plugins menu of QGIS. The project technical team can address questions through trends.earth@conservation.org. Users can rate the toolbox by opening Plugins in QGIS and selecting Manage and Install Plugins. Select All in the side bar and navigate to trends.earth plugin. Click on trends.earth and rate the toolbox by selecting the number of stars you would like to give the plugin, 5 stars being highly satisfied.

Why is my job stuck in "Pending" status?

When you submit an analysis job, Trends.Earth places it in a queue that processes requests in the order they were received. To ensure fair access to computing resources for all users, each account is limited to running a small number of jobs at the same time (typically three). If you already have several jobs running, any new jobs you submit will remain in "Pending" status until one of your active jobs finishes. Once a slot becomes available, your oldest pending job will automatically start processing. You don't need to take any action - once your earlier jobs complete, your queued jobs will begin shortly afterward.

Installation of Trends.Earth

What version of Quantum GIS (QGIS) do I need for the toolbox?

To download QGIS, please go to the QGIS Downloads page. As of January, 2025, please use version 3.40 Long Term Release or higher version for the trends.earth plugin.

How do I install the plugin?

Open QGIS, navigate to Plugins on the menu bar, and select Manage and install plugins. On the side menu, select All to view the plugins available in QGIS. Search for trends.earth and select Install plugin at the bottom of the window.

How do I upgrade the plugin?

If you have already installed the plugin, navigate to Plugins on the menu bar, and select Manage and install plugins. On the side menu, select Installed to view the plugins that you have installed in your computer. At the bottom of the window, select Upgrade all to upgrade the toolbox to the latest version.

I get a Python error after upgrading the plugin. What should I do?

If you see a Python error (such as `AttributeError` or `ModuleNotFoundError`) immediately after upgrading the plugin within QGIS, this is caused by Python's module cache retaining old versions of the plugin's libraries. Simply restart QGIS and the plugin should load correctly. This issue typically only occurs when upgrading from older versions of the plugin; newer versions include a fix that clears the module cache automatically during upgrades.

How do I uninstall the plugin?

If you would like to uninstall the plugin, normally you can do so with the QGIS plugins manager. To access the tool, choose "Plugins" and then "Manage and Install Plugins…" from the QGIS menu bar. From the plugin manager screen, select "Installed" from the menu on the left-hand side. Then click on "Trends.Earth" in the list of plugins, and on "Uninstall Plugin" to uninstall it.

If you encounter an error uninstalling the plugin, it is also possible to remove it manually. To manually remove the plugin:

1. Open QGIS
2. Navigate to where the plugin is installed by selecting "Open Active Profile Folder" from the menu under "Settings" - "User Profiles" on the menu bar.
3. Quit QGIS. You may not be able to uninstall the plugin if QGIS is not closed.
4. In the file browser window that opened, double click on "python", and then double click on "plugins". Delete the LDMP folder within that directory.
5. Restart QGIS.

OR

Navigate to the AppData folder under user account and find the plugins info under the directory. For example: C:DocumentsuserAppDataRoamingQGISQGIS3profilesdefaultpythonplugins

Datasets

> **Note**
>
> Refer to the Input Data Used in Trends.Earth section for more information on data sources used in Trends.Earth.

When will you update datasets for the current year?

Trends.Earth uses publicly available data, as such the most up to date datasets will be added to the toolbox as soon as the original data providers make them public. If you notice any update that we missed, please do let us know.

Is there an option to download the original data?

Users can download the original data using the Download option within the toolbox.

Will the toolbox support higher resolution datasets?

The toolbox supports AVHRR (8km) and MODIS (250m) data for primary productivity analysis, and ESA LCC CCI (300m) for land cover change analysis.

In partnership with Apacheta and *Auspatious <http://auspatious.com/>* and funding from the Global Environmental Facility (GEF), our team is currently developing datasets for land productivity dynamics and land cover at 30 meter scale that will cover the Small Islands Developing States (SIDS)

Can the toolbox support analysis with national-level datasets?

Trends.Earth does have the capacity to import, load and process national-level datasets representing soil organic carbon, land cover and land productivity dynamics, allowing users to take advantage of existing datasets that might be of higher spatial resolution at a national-level than the global datasets that are the defaults in the tool. Please note that working with national-level datasets relies on the local processing capacity of user's computer, so the time to run analysis using custom datasets will depend on the especifications of user's machine.

Methods

Note

Refer to the Land degradation and SDG 15.3.1 section for more background on analyses available in Trends.Earth.

Productivity

How does the result provided by state differs from trajectory?

The trajectory analysis uses linear regressions and non-parametric tests to identify long term significant trends in primary productivity. This method however, is not able to capture more recent changes in primary productivity, which could be signals of short term processes of improvement or degradation. By comparing a long term mean to the most recent period, state is able to capture such recent changes.

Land cover

Currently, the land cover aggregation is done following the UNCCD guidelines, but that classification does not take into account country level characteristics. Could it be possible to allow the user to define the aggregation criteria?

Users are able to make these changes using the advanced settings in the land cover GUI so that appropriate aggregations occur depending on the context of your country.

How can we isolate woody plant encroachment within the toolbox?

This can be altered using the land cover change matrix in the toolbox. For every transition, the user can mark the change as stable, improvement or degraded. The transition from grassland/rangeland to shrubland may indicate woody encroachment and this transition can be marked as an indicator of degradation.

Carbon stocks

Why use soil organic carbon (SOC) instead of above and below-ground carbon to measure carbon stocks?

The original proposed indicator is Carbon Stocks, which would include above and below ground biomass. However, given the lack of consistently generated and comparable dataset to assess carbon stocks in woody plants (including shrubs), grasses, croplands, and other land cover types both above and below ground, the Good Practice Guidance published by the UNCCD recommends for the time being to use SOC as a proxy.

Is it possible to measure identify processes of degradation linked to salinization using this tool?

Not directly. If salinization caused a reduction in primary productivity, that decrease would be identified by the productivity indicators, but the users would have to use their local knowledge to assign the causes.

Land degradation outputs

How were the layers combined to define the final land degradation layer?

Performance, state, and trajectory (the three metrics of change in productivity) are combined following a modified version of the good practice guidance developed by the UNCCD (in section SDG Indicator 15.3.1 of this manual a table is presented). Productivity, soil carbon, and land cover chance (the three sub-indicators of SDG 15.3.1) are combined using a “one out, all out” principle. In other words: if there is a decline in any of the three indicators at a particular pixel, then that pixel is mapped as being “degraded”.

Why do I see areas the data says are improving or degrading when I know they are not?

The final output should be interpreted as showing areas potentially degraded. The indicator of land degradation is based on changes in productivity, land cover and soil organic carbon. Several factor could lead to the identification of patterns of degradation which do not seem to correlate to what is happening on the ground, the date of analysis being a very important one. If the climatic conditions at the beginning of the analysis were particularly wet, for example, trends from that moment on could show significant decreases in primary productivity, and degradation. The user can use Trends.Earth to address some of this issues correcting by the effect of climate. The resolution of the data could potentially be another limitation. Trends.Earth by default uses global datasets which will not be the most relevant at all scales and geographies. A functionality to use local data will be added shortly.

All of the sub-indicators are measuring vegetation: how does this contribute to understanding and identifying land degradation?

Vegetation is a key component of most ecosystems, and serve as a good proxy for their overall functioning and health. The three sub-indicators used for SDG 15.3.1 measure different aspects of land cover, which do relate to vegetation. Primary productivity directly measures the change in amount of biomass present in one area, but it does not inform us if that change is positive or not (not all increases in plant biomass should be interpreted as improvement). Land cover fills that gap by interpreting the landscape from a thematic perspective looking at what was there before and what is there now. It does include vegetation, but also bare land, urban and water. Finally, the soil organic carbon indicator uses the land cover map to inform the changes in soil organic carbon over time. This method is not ideal, but given the current state of global soil science and surveying, there is consensus that it this point in time and globally, this is the best approach.

Future plans

When will there be an offline version of the toolbox?

The toolbox is available as both as an offline and online version. The online version allows users to access current datasets more easily, while also allowing users to leverage Google Earth Engine to provide computing in the cloud. The offline version allows users to access data and perform analyses where internet connectivity may be limited, but it does have the disadvantage of requiring users to have enough local computing capacity to run analyses locally.

Will you create a trends.earth toolbox for ESRI users?

The toolbox is available as a plugin to QGIS, an open source software package. This allows users around the world free access to the toolbox. There are no plans to build a toolbox within ArcGIS or ArcPro.

Datasets (input and output)

Input Data Used in Trends.Earth

▲TRENDS.EARTH draws on a number of data sources. The data sets listed below are owned/made available by the following organizations and individuals under separate terms as indicated in their respective metadata.

NDVI

Sensor/Dataset	Temporal	Spatial	Extent	License
AVHRR/GIMMS	1982-2015	8 km	Global	Public Domain
MOD13Q1-coll6.1	2001-2024	250 m	Global	Public Domain

Soil Moisture

Sensor/Dataset	Temporal	Spatial	Extent	License
MERRA 2	1980-2019	0.5° x 0.625°	Global	Public Domain
ERA I	1979-2016	0.75° x 0.75°	Global	Public Domain

Precipitation and Drought

Sensor/Dataset	Temporal	Spatial	Extent	License
GPCP v2.3 1 month	1979-2019	2.5° x 2.5°	Global	Public Domain
GPCC V6	1891-2019	1° x 1°	Global	Public Domain
CHIRPS	1981-2024	5 km	50N-50S	Public Domain
PERSIANN-CDR	1983-2024	25 km	60N-60S	Public Domain

Datasets (input and output)

Evapotranspiration

Sensor/Dataset	Temporal	Spatial	Extent	License
MOD16A2GF	2000-2024	500 m	Global	Public Domain

Land cover

Sensor/Dataset	Temporal	Spatial	Extent	License
ESA CCI Land Cover	1992-2022	300 m	Global	CC BY 4.0

Soil carbon

Sensor/Dataset	Temporal	Spatial	Extent	License
Soil Grids (ISRIC)	Present	250 m	Global	CC by-SA 4.0

Agroecological Zones

Sensor/Dataset	Temporal	Spatial	Extent	License
FAO - IIASA Global Agroecological Zones (GAEZ)	2000	8 km	Global	Public Domain

Administrative Boundaries

Sensor/Dataset	Temporal	Spatial	Extent	License
geoBoundaries Administrative Boundaries	Present	10/50 m	Global	CC BY 4.0

Note

The geoBoundaries Administrative Boundaries provided in Trends.Earth are under the CC BY 4.0 license. The boundaries and names used, and the designations used, in Trends.Earth do not imply official endorsement or acceptance by Conservation International Foundation, or by its partner organizations and contributors.

If using Trends.Earth for official purposes, it is recommended that users choose an official boundary provided by the designated office of their country.

Population

Sensor/Dataset	Temporal	Spatial	Extent	License
WorldPop 100m Global Population grid	2000-2020	100 m	Global	CC BY 4.0

Note

The WorldPop dataset included in Trends.Earth was produced by the UNCCD from publicly available data layers from the WorldPop project. This dataset is a combination of the national-level age and sex-disaggregated grids produced by the WorldPop project at 100m resolution. In support of UNCCD National Reporting on Strategic Objectives 2 and 3, UNCCD funded the development of a set of global mosaics, disaggregated by sex, giving population counts per pixel. These layers are used within Trends.Earth to tabulate population exposure to drought and degradation, disaggregated by sex.

These data are also available in a publicly-accessible S3 bucket (trends.earth-shared, in the us-east-1 region), as tiled 32-bit floating point GeoTiffs at 100m, 300m, and 1200m resolution, at the following locations on s3:

- s3://trends.earth-shared/worldpop/100m
- s3://trends.earth-shared/worldpop/300m
- s3://trends.earth-shared/worldpop/1200m

Output datasets from Trends.Earth

The spatial data produced by TRENDS.EARTH is in GeoTiff format. This is a widely supported format, so these datasets can be used within QGIS as well as within any other GIS software.

If you wish to use TRENDS.EARTH data outside of the tool itself, you will need to know how the data is coded. The tables below provide guidance on what the exact layers are that are produced by each analysis in TRENDS.EARTH.

To see which of the below layers is contained within a TRENDS.EARTH output file, use the load data tool. When you choose a file with that tool, it will show you a list of the layers within that file, as well as the band number for each layer.

Land degradation (SDG 15.3.1)

SDG 15.3.1 Indicator

Value	Meaning
-32768	No data
-1	Degradation
0	No change
1	Improvement

SDG 15.3.1 Indicator (status)

Value	Meaning
-32768	No data
1	Degradation (persistent)
2	Degradation (recent)
3	Degradation (baseline)
4	Stability
5	Improvement (baseline)
6	Improvement (recent)
7	Improvement (persistent)

Productivity

Productivity trajectory (trend)

Value	Meaning
-32768	No data
Any other value	Linear trend of annually integrated NDVI, scaled by 10,000

Productivity trajectory (significance)

Value	Meaning
-32768	No data
-3	Significant decline (p > .99)
-2	Significant decline (p > .95)
-1	Significant decline (p > .90)
0	No significant change
1	Significant increase (p > .90)
2	Significant increase (p > .95)
3	Significant increase (p > .99)

Productivity performance (degradation)

Value	Meaning
-32768	No data

Value	Meaning
-1	Degradation
0	No change

Productivity performance (ratio)

Value	Meaning
-32768	No data
0	Ratio of mean NDVI and maximum productivity. See background on performance.

Productivity performance (units)

Value	Meaning
-32768	No data
Any other value	ID number of unit used to calculate performance. See background on performance.

Productivity state (degradation)

Value	Meaning
-32768	No data
Any other value	Change in productivity state classes between baseline and target period, calculated as the rank in the target period minus the rank in the baseline period. Positive values indicate improvement, negative values indicate decline.

Productivity state classes

Value	Meaning
-32768	No data
Any other value	Percentile class for productivity state. See background on productivity state.

Productivity state NDVI mean

Value	Meaning
-32768	No data
Any other value	Mean annually integrated NDVI for the baseline period chosen for productivity state, scaled by 10,000. See background on productivity state.

SDG 15.3.1 productivity indicator

Value	Meaning
-32768	No data
1	Declining
2	Early signs of decline
3	Stable but stressed
4	Stable
5	Increasing

Land Productivity Dynamics - (Trends.Earth, JRC, and FAO-WOCAT)

Value	Meaning
-32768	No data
1	Declining
2	Moderate decline
3	Stressed
4	Stable
5	Increasing

Land cover

Land cover (degradation)

Value	Meaning
-32768	No data
-1	Degradation
0	No change
1	Improvement

Land cover (7 class)

Value	Meaning
-32768	No data
1	Tree-covered
2	Grasslands
3	Cropland
4	Wetland
5	Artificial
6	Other land
7	Water body

Land cover (ESA classes)

Value	Meaning
-32768	No data
10	Cropland, rainfed
11	Herbaceous cover
12	Tree or shrub cover
20	Cropland, irrigated or post■flooding
30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)
50	Tree cover, broadleaved, evergreen, closed to open (>15%)
60	Tree cover, broadleaved, deciduous, closed to open (>15%)
61	Tree cover, broadleaved, deciduous, closed (>40%)
62	Tree cover, broadleaved, deciduous, open (15■40%)
70	Tree cover, needleleaved, evergreen, closed to open (>15%)
71	Tree cover, needleleaved, evergreen, closed (>40%)
72	Tree cover, needleleaved, evergreen, open (15■40%)
80	Tree cover, needleleaved, deciduous, closed to open (>15%)
81	Tree cover, needleleaved, deciduous, closed (>40%)
82	Tree cover, needleleaved, deciduous, open (15■40%)
90	Tree cover, mixed leaf type (broadleaved and needleleaved)
100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)
110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)
120	Shrubland
121	Evergreen shrubland

Value	Meaning
122	Deciduous shrubland
130	Grassland
140	Lichens and mosses
150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)
151	Sparse tree (<15%)
152	Sparse shrub (<15%)
153	Sparse herbaceous cover (<15%)
160	Tree cover, flooded, fresh or brakish water
170	Tree cover, flooded, saline water
180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water
190	Urban areas
200	Bare areas
201	Consolidated bare areas
202	Unconsolidated bare areas
210	Water bodies
220	Permanent snow and ice

Land cover (transitions)

Value	Meaning
-32768	No data
1	Tree-covered - Tree-covered (no change)
2	Grassland - Grassland (no change)
3	Cropland - Cropland (no change)
4	Wetland - Wetland (no change)
5	Artificial - Artificial (no change)
6	Other land - Other land (no change)
7	Water body - Water body (no change)
12	Forest - Grassland
13	Forest - Cropland
14	Forest - Wetland
15	Forest - Artificial
16	Forest - Other land
17	Forest - Water body
21	Grassland - Forest

Value	Meaning
23	Grassland - Cropland
24	Grassland - Wetland
25	Grassland - Artificial
26	Grassland - Other land
27	Grassland - Water body
31	Cropland - Forest
32	Cropland - Grassland
34	Cropland - Wetland
35	Cropland - Artificial
36	Cropland - Other land
37	Cropland - Water body
41	Wetland - Forest
42	Wetland - Grassland
43	Wetland - Cropland
45	Wetland - Artificial
46	Wetland - Other land
47	Wetland - Water body
51	Artificial - Forest
52	Artificial - Grassland
53	Artificial - Cropland
54	Artificial - Wetland
56	Artificial - Other land
57	Artificial - Water body
61	Other land - Forest
62	Other land - Grassland
63	Other land - Cropland
64	Other land - Wetland
65	Other land - Artificial
67	Other land - Water body
71	Water body - Forest
72	Water body - Grassland
73	Water body - Cropland
74	Water body - Wetland
75	Water body - Artificial
76	Water body - Other land

Soil organic carbon

Soil organic carbon (degradation)

Value	Meaning
-32768	No data
Any other value	Percentage change in soil organic carbon content (0 - 30 cm depth) from baseline to target year. Positive values indicate increase, negative values indicate decrease.

Soil organic carbon

Value	Meaning
-32768	No data
Any other value	Soil organic carbon content (0 - 30 cm depth) in metric tons per hectare

Drought hazard, vulnerability, and exposure

Standardized Precipitation Index (SPI)

Value	Meaning
-32768	Meaning
Any other value	Standardized precipitation index, scaled * 1000

Population at maximum drought

As an indicator of population exposure to drought, Trends.Earth's drought tools produce a layer assessing total population (or male or female population, depending on the selections made by the user) at time of maximum drought. For the purpose of these analyses, drought is defined as an SPI less than -1.0 (a lag 12 SPI is the default used in the tool).

Value	Meaning
-32768	Meaning
Any negative value	A negative value indicates a pixel **was** exposed to drought (defined as SPI < -1) during a particular (typically four- year) period. The pixel value indicates the population of the pixel at the time of maximum drought.
Any positive value	A positive value indicates a pixel **was not** exposed to drought during a particular (typically four-year) period. The pixel value indicates the maximum population of the pixel during the period.

Sustainable urbanization (SDG 11.3.1)

Urban

Value	Meaning
-32768	No data
1	Urban
2	Suburban
3	Built-up rural
4	Open space (fringe)
5	Open space (captured)
6	Open space (rural)
7	Open space (fringe water)
8	Open space (captured water)
9	Open space (rural water)

Urban series

Value	Meaning
-32768	No data
-1	Water
1	Built up by 2000
2	Built up by 2005
3	Built up by 2010
4	Built up by 2015

Population

Population density

Value	Meaning
-32768	No data
Any other value	Population density in persons per sq km

Population (total, male, or female)

This output draws on data from the WorldPop project. Depending on the tool used in Trends.Earth, population outputs can be: total population (male and female), total male population, or total female population. The pixels values in each all are coded the same way, and refer to actual population counts per grid cell.

Value	Meaning
-32768	No data
Any other value	Population density in persons per sq km

Designing Reports

Reports are, in simplest terms, created by populating a report template with textual and/or spatial data from one or more jobs. It is important to note that reports are generated at the layer/band level hence the number of reports from a single job will correspond to the number of **default** bands for the given job.

Designing reports is a two-step process that involves:

1. Designing templates using the QGIS layout framework;
2. Specifying the configuration parameters in a report configuration file.

Prerequisites

Before embarking on designing new or customizing existing reports, it is recommended to familiarize with the following topics:

- QGIS Expression Framework
- QGIS Layout Framework
- JSON Data Format

Layout Expression Variables

A report is made up of static content (such as logos, disclaimer text etc.) that does not change from one report to another. It may also include dynamic content (such as maps or attribute information) that is generated at runtime during the execution process.

The Trends.Earth toolbox provides a number of layout expression variables that can be used to insert dynamic content in a layout. Some of these are available at design time while others are only available at runtime. The table below provides a summary of the available variables.

Job Variables

These are characterized by a *te_job_* prefix and only available at runtime.

Variable Name	Description	Data Type
te_job_id	Unique identified corresponding to the job's UUID	String
te_job_input_params	JSON representation of a job's input parameters	String
te_job_paths	Local path to the job's dataset(s)	String

Variable Name	Description	Data Type
te_job_alg_name	Job's algorithm name	String
te_job_creation_date	Creation date/time of a job	String in %Y-%m-%d %H:%M format
te_job_status	Completion status of a job e.g. DOWNLOADED, GENERATED_LOCALLY etc.	String
te_job_name	Name of the job as inputted by the user.	String
te_job_comments	Comments to a job as provided by the user	String

Layer Variables

These are characterized by a *te_current_layer_* prefix and only available at runtime.

Variable Name	Description	Data Type
te_current_layer_name	Name of the layer in the current execution context	String

Report Settings Variables

These are characterized by a *te_report_* prefix and are available at both design time and runtime. Refer to the Reports section for a detailed description of the report settings and corresponding variable names.

Template Types

There are two main report template types:

Full Template

This is designed to contain - or provide an allowance to include - more information such as author name. The default template is set on an A4 page and includes a layout title, map, legend, scale bar, north arrow, disclaimer text. and logo.

Simple Template

This is designed to be a lighter version of the template with the default one set on an 83mm by 59mm page size (in landscape mode) or vice versa in portrait mode and contains a map, legend, north arrow, scale bar, disclaimer text and logo.

Note

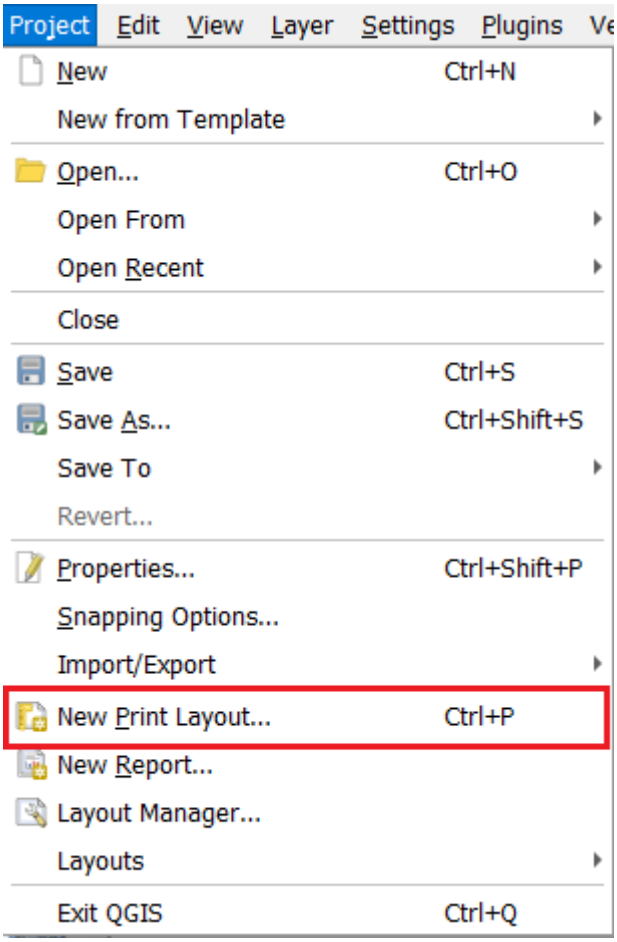
For each template type, you will need to provide both the portrait and landscape versions as the toolbox will select one of these depending on the dimensions of the map layer being rendered.

Designing Report Templates

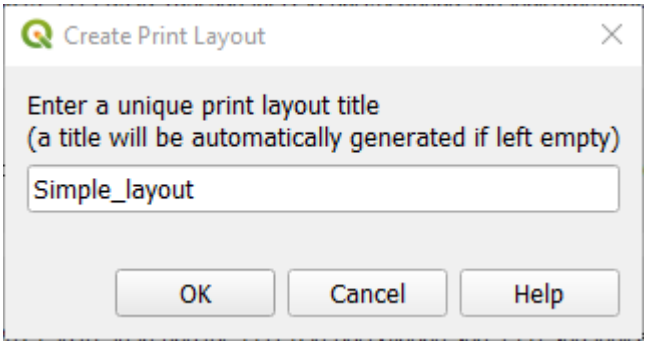
You can create templates either by:

Creating A New One

1. Navigate to **Project > New Print Layout…**.



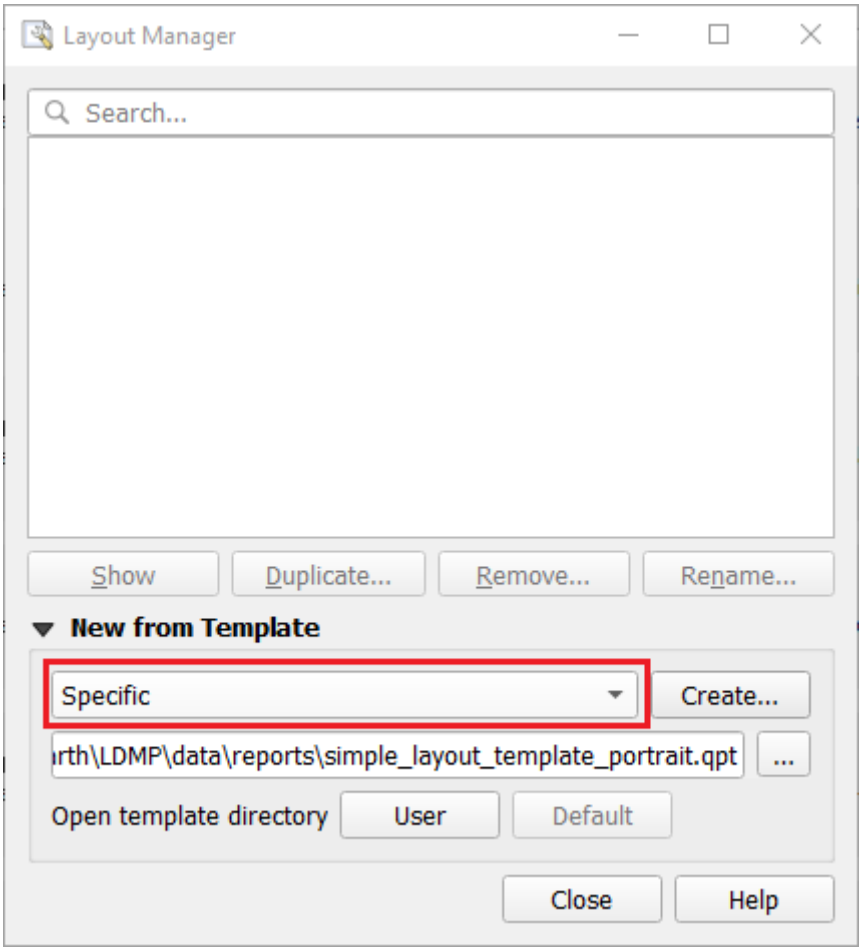
2. Specify a user-friendly name for the layout.



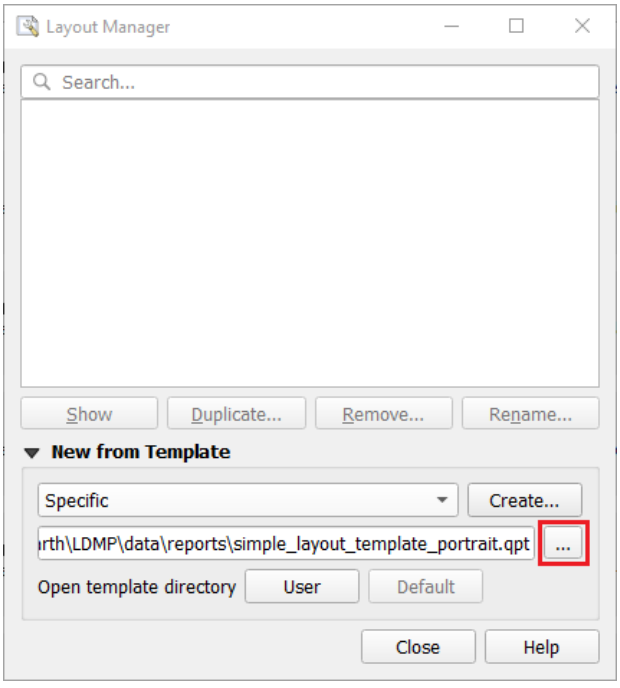
Modifying an Existing One

1. Navigate to **Project > Layout Manager…**.

2. Select **Specific** in the drop-down menu under **New from Template** section.

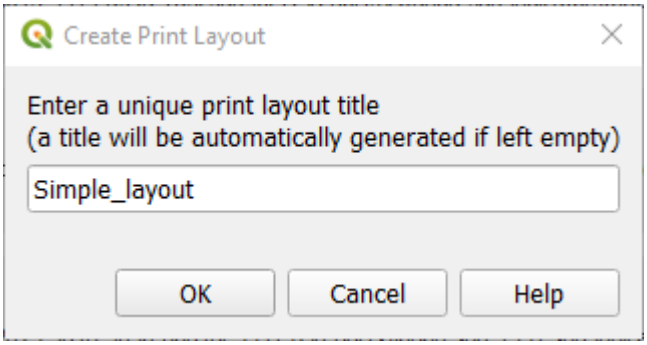


3. Click on the browse button (with three dots) to select an existing qpt template. The default templates can be found in *[base_data_directory]/reports/templates*.



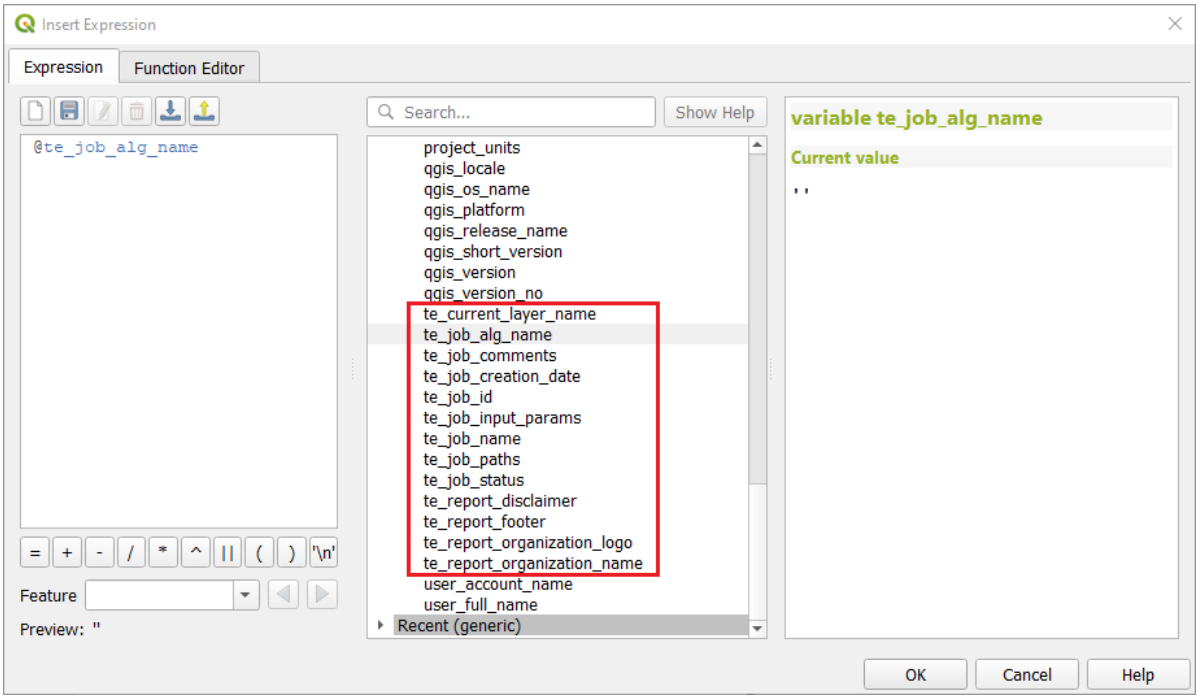
4. Click on **Create…** button.

5. Specify a user-friendly name for the template.

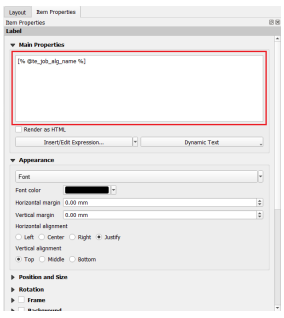


Adding Layout Items

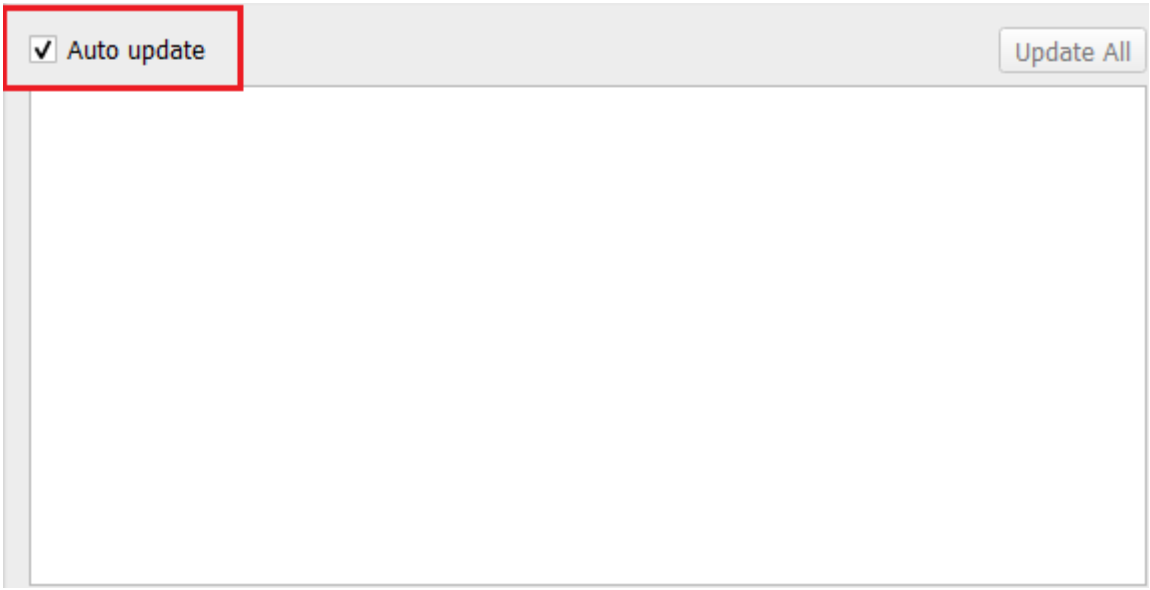
- You can add items to the template in a similar fashion as defined in the QGIS manual. Trends.Earth expression variables are available in the **Expression Builder** dialog and can be inserted in label items as any other QGIS variable.



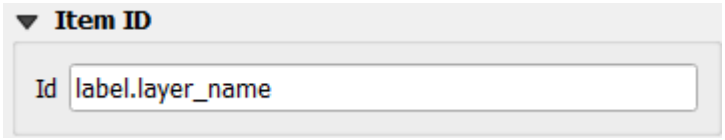
- For instance, to insert a job's algorithm name in a label item, you can use the following expression: `[% @te_job_alg_name %]`.



- For a map item, do not add any layers or specify a map theme as the layers and their ordering will be automatically set during the report generation process.
- When using a legend item, ensure the **Auto update** option is selected. The toolbox will determine which legend items to show/hide depending on the rendering context.



- For map items rendering a job's layers or label items that use the toolbox's expression variables, please ensure that you define their corresponding item IDs so that they can be flagged for updating during the report generation process. A preferred naming convention - for the item ID - is *[item_type.context_name]* e.g. `label.layer_name`, `label.job_alg_name`, `map.main`. We will see how these item IDs are used in the item_scope_mapping section.



Configuring Report Parameters

The next step is to define which templates will be used for which algorithms. This is done through a report configuration file -*templates.json*- that is created in *[base_data_directory]/reports/templates* on loading the toolbox for the first time.

templates.json is a list of report configuration objects where each configuration object corresponds to one or more scopes. A scope, in this case, refers to an algorithm. A configuration is made up of two parts:

- **template_info** - Contains information about the QGIS report templates associated with one or more algorithm scopes.
- **output_options** - Output options for exporting a report.

See sample below:

```
{
  "template_info":{
     "id":"70ca4be7-839e-4248-be14-34ba8665ed98",
     "name":"Land Productivity",
     "description":"Overview of land productivity indicator.",
     "simple_portrait_path":"simple_layout_template_portrait.qpt",
     "simple_landscape_path":"simple_layout_template_landscape.qpt",
```

```
      "full_portrait_path":"full_layout_template_portrait.qpt",
      "full_landscape_path":"full_layout_template_landscape.qpt",
      "item_scopes":[
         {
            "name":"productivity",
            "type_id_mapping":{
               "map":["map.main"],
               "label":["label.layer_title"]
            }
         }
      ]
   },
   "output_options":{
      "template_type": "ALL",
      "formats": [
         {
            "format_type": "PDF"
         },
         {
            "format_type": "IMAGE",
            "params": {
               "image_type": "png"
            }
         }
      ]
   }
}
```

template_info

Contains information about the QGIS report templates associated with one or more algorithm scopes.

Property Name	Description	Required
id	A unique UUID identifier in string format	Yes
name	A friendly name of the template configuration	No
description	A brief description of the template configuration	No
simple_portrait_path	Name of the template file for a simple portrait layout	Yes
simple_landscape_path	Name of the template file for a simple landscape layout	Yes
full_portrait_path	Name of the template file for a full portrait layout	Yes
full_landscape_path	Name of the template file for a full landscape layout	Yes
item_scopes	A list of item scope objects. It should contain at least one scope definition. See item_scope_mapping for more information.	Yes

Note

The paths defined above are basically file names which are relative to the location of the *templates.json* configuration file.

output_options

Options for exporting an output report.

Property Name	Description	Required
formats	A list of format objects specifying the output format of the report. You can have a report produced in multiple types such as PDF and PNG. At least one output format needs to be defined. See output_format for configuration options for an output format object.	Yes
template_type	Report template type in string format. Supported options include: **SIMPLE**, **FULL** or **ALL**. Please note that these should be in uppercase as provided above.	Yes

item_scope_mapping

Provides a mechanism for grouping layout items based on a scope (i.e. algorithm).

Property Name	Description	Required
name	Name of the algorithm that will be matched to this configuration e.g. *productivity*, *sdg-15-3-1-sub-indicators* etc. Refers to the algorithm names defined in *scripts.json* in the toolbox's data folder.	Yes
type_id_mapping	A dictionary containing an enumeration of the layout item type and corresponding list of item IDs defined in the template. Supported layout item types include: **map**, **label**, **picture** `"type_id_mapping":{ "map":["map.main"], "label":["label.layer_title"] }` See Adding Layout Items on how to specify item IDs.	Yes

output_format

Format information for the report output.

Property Name	Description	Required
format_type	An enumeration of the file output type. Supported enumeration options include: **PDF** and **IMAGE**. Please note that these should be in uppercase as provided above.	Yes
params	Depending on the specified output type, this property contains additional information regarding the format. For instance, if the IMAGE is specified as the output format, then this property can be used to specify the IMAGE type. Does nothing for PDF type and defaults to PNG for an IMAGE type.	No

Resetting to Default Templates and Configuration

To revert back to the default templates and report configuration file that ship with the toolbox, perform the following steps:

1. Close QGIS then back-up the *templates* folder in *[base_data_directory]/reports/templates*.
2. Proceed to delete the *templates* folder then restart QGIS.

Downloads

This page lists data packages containing national-level datasets (produced by Trends.Earth), following accepted best practices for calculating the UNCCD Indicators for land degradation and drought vulnerability and exposure.

These zipfiles are designed to be imported directly into Trends.Earth, and may be useful to countries reporting to the UNCCD on Strategic Objectives 1, 2, and 3 (including SDG Indicator 15.3.1). Global datasets are also available as Cloud-optimized GeoTIFFs (COGs) and as Google Earth Engine assets. See the Trends.Earth SDG Indicator 15.3.1 Datasets page on Zenodo for more details on these datasets.

The methods used to produce the estimates of land degradation in these files are consistent with Version 2.0 of the Good Practice Guidance for SDG Indicator 15.3.1. Calculations of land condition are consistent with the addendum to that guidance. Calculations of drought vulnerability and exposure are consistent with the Good Practice Guidance for National Reporting on UNCCD Strategic Objective 3.

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The below packages use data from geoBoundaries to define country borders. These boundaries are made available by geoBoundaries under the CC BY 4.0 license.

SDG Indicator 15.3.1 (UNCCD Strategic Objectives 1 and 2)

The below datasets can be used to support assessing SDG Indicator 15.3.1, and include indicators of change in land productivity dynamics (LPD), land cover, and soil organic carbon. These datasets can be used to support reporting on UNCCD Strategic Objectives 1 and 2. Note that there are three different LPD datasets available (from the default Trends.Earth method, from FAO-WOCAT, and from JRC).

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
ABW	ABW (Trends.Earth LPD)	ABW (FAO-WOCAT LPD)	ABW (JRC LPD)
AFG	AFG (Trends.Earth LPD)	AFG (FAO-WOCAT LPD)	AFG (JRC LPD)
AGO	AGO (Trends.Earth LPD)	AGO (FAO-WOCAT LPD)	AGO (JRC LPD)
AIA	AIA (Trends.Earth LPD)	AIA (FAO-WOCAT LPD)	AIA (JRC LPD)
ALB	ALB (Trends.Earth LPD)	ALB (FAO-WOCAT LPD)	ALB (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
AND	AND (Trends.Earth LPD)	AND (FAO-WOCAT LPD)	AND (JRC LPD)
ARE	ARE (Trends.Earth LPD)	ARE (FAO-WOCAT LPD)	ARE (JRC LPD)
ARG	ARG (Trends.Earth LPD)	ARG (FAO-WOCAT LPD)	ARG (JRC LPD)
ARM	ARM (Trends.Earth LPD)	ARM (FAO-WOCAT LPD)	ARM (JRC LPD)
ASM	ASM (Trends.Earth LPD)	ASM (FAO-WOCAT LPD)	ASM (JRC LPD)
ATG	ATG (Trends.Earth LPD)	ATG (FAO-WOCAT LPD)	ATG (JRC LPD)
AUS	AUS (Trends.Earth LPD)	AUS (FAO-WOCAT LPD)	AUS (JRC LPD)
AUT	AUT (Trends.Earth LPD)	AUT (FAO-WOCAT LPD)	AUT (JRC LPD)
AZE	AZE (Trends.Earth LPD)	AZE (FAO-WOCAT LPD)	AZE (JRC LPD)
BDI	BDI (Trends.Earth LPD)	BDI (FAO-WOCAT LPD)	BDI (JRC LPD)
BEL	BEL (Trends.Earth LPD)	BEL (FAO-WOCAT LPD)	BEL (JRC LPD)
BEN	BEN (Trends.Earth LPD)	BEN (FAO-WOCAT LPD)	BEN (JRC LPD)
BES	BES (Trends.Earth LPD)	BES (FAO-WOCAT LPD)	BES (JRC LPD)
BFA	BFA (Trends.Earth LPD)	BFA (FAO-WOCAT LPD)	BFA (JRC LPD)
BGD	BGD (Trends.Earth LPD)	BGD (FAO-WOCAT LPD)	BGD (JRC LPD)
BGR	BGR (Trends.Earth LPD)	BGR (FAO-WOCAT LPD)	BGR (JRC LPD)
BHR	BHR (Trends.Earth LPD)	BHR (FAO-WOCAT LPD)	BHR (JRC LPD)
BHS	BHS (Trends.Earth LPD)	BHS (FAO-WOCAT LPD)	BHS (JRC LPD)
BIH	BIH (Trends.Earth LPD)	BIH (FAO-WOCAT LPD)	BIH (JRC LPD)
BLM	BLM (Trends.Earth LPD)	BLM (FAO-WOCAT LPD)	BLM (JRC LPD)
BLR	BLR (Trends.Earth LPD)	BLR (FAO-WOCAT LPD)	BLR (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
BLZ	BLZ (Trends.Earth LPD)	BLZ (FAO-WOCAT LPD)	BLZ (JRC LPD)
BMU	BMU (Trends.Earth LPD)	BMU (FAO-WOCAT LPD)	BMU (JRC LPD)
BOL	BOL (Trends.Earth LPD)	BOL (FAO-WOCAT LPD)	BOL (JRC LPD)
BRA	BRA (Trends.Earth LPD)	BRA (FAO-WOCAT LPD)	BRA (JRC LPD)
BRB	BRB (Trends.Earth LPD)	BRB (FAO-WOCAT LPD)	BRB (JRC LPD)
BRN	BRN (Trends.Earth LPD)	BRN (FAO-WOCAT LPD)	BRN (JRC LPD)
BTN	BTN (Trends.Earth LPD)	BTN (FAO-WOCAT LPD)	BTN (JRC LPD)
BWA	BWA (Trends.Earth LPD)	BWA (FAO-WOCAT LPD)	BWA (JRC LPD)
CAF	CAF (Trends.Earth LPD)	CAF (FAO-WOCAT LPD)	CAF (JRC LPD)
CAN	CAN (Trends.Earth LPD)	CAN (FAO-WOCAT LPD)	CAN (JRC LPD)
CHE	CHE (Trends.Earth LPD)	CHE (FAO-WOCAT LPD)	CHE (JRC LPD)
CHL	CHL (Trends.Earth LPD)	CHL (FAO-WOCAT LPD)	CHL (JRC LPD)
CHN	CHN (Trends.Earth LPD)	CHN (FAO-WOCAT LPD)	CHN (JRC LPD)
CIV	CIV (Trends.Earth LPD)	CIV (FAO-WOCAT LPD)	CIV (JRC LPD)
CMR	CMR (Trends.Earth LPD)	CMR (FAO-WOCAT LPD)	CMR (JRC LPD)
COD	COD (Trends.Earth LPD)	COD (FAO-WOCAT LPD)	COD (JRC LPD)
COG	COG (Trends.Earth LPD)	COG (FAO-WOCAT LPD)	COG (JRC LPD)
COK	COK (Trends.Earth LPD)	COK (FAO-WOCAT LPD)	COK (JRC LPD)
COL	COL (Trends.Earth LPD)	COL (FAO-WOCAT LPD)	COL (JRC LPD)
COM	COM (Trends.Earth LPD)	COM (FAO-WOCAT LPD)	COM (JRC LPD)
CPV	CPV (Trends.Earth LPD)	CPV (FAO-WOCAT LPD)	CPV (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
CRI	CRI (Trends.Earth LPD)	CRI (FAO-WOCAT LPD)	CRI (JRC LPD)
CUB	CUB (Trends.Earth LPD)	CUB (FAO-WOCAT LPD)	CUB (JRC LPD)
CUW	CUW (Trends.Earth LPD)	CUW (FAO-WOCAT LPD)	CUW (JRC LPD)
CYM	CYM (Trends.Earth LPD)	CYM (FAO-WOCAT LPD)	CYM (JRC LPD)
CYP	CYP (Trends.Earth LPD)	CYP (FAO-WOCAT LPD)	CYP (JRC LPD)
CZE	CZE (Trends.Earth LPD)	CZE (FAO-WOCAT LPD)	CZE (JRC LPD)
DEU	DEU (Trends.Earth LPD)	DEU (FAO-WOCAT LPD)	DEU (JRC LPD)
DJI	DJI (Trends.Earth LPD)	DJI (FAO-WOCAT LPD)	DJI (JRC LPD)
DMA	DMA (Trends.Earth LPD)	DMA (FAO-WOCAT LPD)	DMA (JRC LPD)
DNK	DNK (Trends.Earth LPD)	DNK (FAO-WOCAT LPD)	DNK (JRC LPD)
DOM	DOM (Trends.Earth LPD)	DOM (FAO-WOCAT LPD)	DOM (JRC LPD)
DZA	DZA (Trends.Earth LPD)	DZA (FAO-WOCAT LPD)	DZA (JRC LPD)
ECU	ECU (Trends.Earth LPD)	ECU (FAO-WOCAT LPD)	ECU (JRC LPD)
EGY	EGY (Trends.Earth LPD)	EGY (FAO-WOCAT LPD)	EGY (JRC LPD)
ERI	ERI (Trends.Earth LPD)	ERI (FAO-WOCAT LPD)	ERI (JRC LPD)
ESP	ESP (Trends.Earth LPD)	ESP (FAO-WOCAT LPD)	ESP (JRC LPD)
EST	EST (Trends.Earth LPD)	EST (FAO-WOCAT LPD)	EST (JRC LPD)
ETH	ETH (Trends.Earth LPD)	ETH (FAO-WOCAT LPD)	ETH (JRC LPD)
FIN	FIN (Trends.Earth LPD)	FIN (FAO-WOCAT LPD)	FIN (JRC LPD)
FJI	FJI (Trends.Earth LPD)	FJI (FAO-WOCAT LPD)	FJI (JRC LPD)
FLK	FLK (Trends.Earth LPD)	FLK (FAO-WOCAT LPD)	FLK (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
FRA	FRA (Trends.Earth LPD)	FRA (FAO-WOCAT LPD)	FRA (JRC LPD)
FRO	FRO (Trends.Earth LPD)	FRO (FAO-WOCAT LPD)	FRO (JRC LPD)
FSM	FSM (Trends.Earth LPD)	FSM (FAO-WOCAT LPD)	FSM (JRC LPD)
GAB	GAB (Trends.Earth LPD)	GAB (FAO-WOCAT LPD)	GAB (JRC LPD)
GBR	GBR (Trends.Earth LPD)	GBR (FAO-WOCAT LPD)	GBR (JRC LPD)
GEO	GEO (Trends.Earth LPD)	GEO (FAO-WOCAT LPD)	GEO (JRC LPD)
GGY	GGY (Trends.Earth LPD)	GGY (FAO-WOCAT LPD)	GGY (JRC LPD)
GHA	GHA (Trends.Earth LPD)	GHA (FAO-WOCAT LPD)	GHA (JRC LPD)
GIB	GIB (Trends.Earth LPD)	GIB (FAO-WOCAT LPD)	GIB (JRC LPD)
GIN	GIN (Trends.Earth LPD)	GIN (FAO-WOCAT LPD)	GIN (JRC LPD)
GLP	GLP (Trends.Earth LPD)	GLP (FAO-WOCAT LPD)	GLP (JRC LPD)
GMB	GMB (Trends.Earth LPD)	GMB (FAO-WOCAT LPD)	GMB (JRC LPD)
GNB	GNB (Trends.Earth LPD)	GNB (FAO-WOCAT LPD)	GNB (JRC LPD)
GNQ	GNQ (Trends.Earth LPD)	GNQ (FAO-WOCAT LPD)	GNQ (JRC LPD)
GRC	GRC (Trends.Earth LPD)	GRC (FAO-WOCAT LPD)	GRC (JRC LPD)
GRD	GRD (Trends.Earth LPD)	GRD (FAO-WOCAT LPD)	GRD (JRC LPD)
GRL	GRL (Trends.Earth LPD)	GRL (FAO-WOCAT LPD)	GRL (JRC LPD)
GTM	GTM (Trends.Earth LPD)	GTM (FAO-WOCAT LPD)	GTM (JRC LPD)
GUF	GUF (Trends.Earth LPD)	GUF (FAO-WOCAT LPD)	GUF (JRC LPD)
GUM	GUM (Trends.Earth LPD)	GUM (FAO-WOCAT LPD)	GUM (JRC LPD)
GUY	GUY (Trends.Earth LPD)	GUY (FAO-WOCAT LPD)	GUY (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
HND	HND (Trends.Earth LPD)	HND (FAO-WOCAT LPD)	HND (JRC LPD)
HRV	HRV (Trends.Earth LPD)	HRV (FAO-WOCAT LPD)	HRV (JRC LPD)
HTI	HTI (Trends.Earth LPD)	HTI (FAO-WOCAT LPD)	HTI (JRC LPD)
HUN	HUN (Trends.Earth LPD)	HUN (FAO-WOCAT LPD)	HUN (JRC LPD)
IDN	IDN (Trends.Earth LPD)	IDN (FAO-WOCAT LPD)	IDN (JRC LPD)
IMN	IMN (Trends.Earth LPD)	IMN (FAO-WOCAT LPD)	IMN (JRC LPD)
IND	IND (Trends.Earth LPD)	IND (FAO-WOCAT LPD)	IND (JRC LPD)
IRL	IRL (Trends.Earth LPD)	IRL (FAO-WOCAT LPD)	IRL (JRC LPD)
IRN	IRN (Trends.Earth LPD)	IRN (FAO-WOCAT LPD)	IRN (JRC LPD)
IRQ	IRQ (Trends.Earth LPD)	IRQ (FAO-WOCAT LPD)	IRQ (JRC LPD)
ISL	ISL (Trends.Earth LPD)	ISL (FAO-WOCAT LPD)	ISL (JRC LPD)
ISR	ISR (Trends.Earth LPD)	ISR (FAO-WOCAT LPD)	ISR (JRC LPD)
ITA	ITA (Trends.Earth LPD)	ITA (FAO-WOCAT LPD)	ITA (JRC LPD)
JAM	JAM (Trends.Earth LPD)	JAM (FAO-WOCAT LPD)	JAM (JRC LPD)
JOR	JOR (Trends.Earth LPD)	JOR (FAO-WOCAT LPD)	JOR (JRC LPD)
JPN	JPN (Trends.Earth LPD)	JPN (FAO-WOCAT LPD)	JPN (JRC LPD)
KAZ	KAZ (Trends.Earth LPD)	KAZ (FAO-WOCAT LPD)	KAZ (JRC LPD)
KEN	KEN (Trends.Earth LPD)	KEN (FAO-WOCAT LPD)	KEN (JRC LPD)
KGZ	KGZ (Trends.Earth LPD)	KGZ (FAO-WOCAT LPD)	KGZ (JRC LPD)
KHM	KHM (Trends.Earth LPD)	KHM (FAO-WOCAT LPD)	KHM (JRC LPD)
KIR	KIR (Trends.Earth LPD)	KIR (FAO-WOCAT LPD)	KIR (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
KNA	KNA (Trends.Earth LPD)	KNA (FAO-WOCAT LPD)	KNA (JRC LPD)
KOR	KOR (Trends.Earth LPD)	KOR (FAO-WOCAT LPD)	KOR (JRC LPD)
KWT	KWT (Trends.Earth LPD)	KWT (FAO-WOCAT LPD)	KWT (JRC LPD)
LAO	LAO (Trends.Earth LPD)	LAO (FAO-WOCAT LPD)	LAO (JRC LPD)
LBN	LBN (Trends.Earth LPD)	LBN (FAO-WOCAT LPD)	LBN (JRC LPD)
LBR	LBR (Trends.Earth LPD)	LBR (FAO-WOCAT LPD)	LBR (JRC LPD)
LBY	LBY (Trends.Earth LPD)	LBY (FAO-WOCAT LPD)	LBY (JRC LPD)
LCA	LCA (Trends.Earth LPD)	LCA (FAO-WOCAT LPD)	LCA (JRC LPD)
LIE	LIE (Trends.Earth LPD)	LIE (FAO-WOCAT LPD)	LIE (JRC LPD)
LKA	LKA (Trends.Earth LPD)	LKA (FAO-WOCAT LPD)	LKA (JRC LPD)
LSO	LSO (Trends.Earth LPD)	LSO (FAO-WOCAT LPD)	LSO (JRC LPD)
LTU	LTU (Trends.Earth LPD)	LTU (FAO-WOCAT LPD)	LTU (JRC LPD)
LUX	LUX (Trends.Earth LPD)	LUX (FAO-WOCAT LPD)	LUX (JRC LPD)
LVA	LVA (Trends.Earth LPD)	LVA (FAO-WOCAT LPD)	LVA (JRC LPD)
MAR	MAR (Trends.Earth LPD)	MAR (FAO-WOCAT LPD)	MAR (JRC LPD)
MCO	MCO (Trends.Earth LPD)	MCO (FAO-WOCAT LPD)	MCO (JRC LPD)
MDA	MDA (Trends.Earth LPD)	MDA (FAO-WOCAT LPD)	MDA (JRC LPD)
MDG	MDG (Trends.Earth LPD)	MDG (FAO-WOCAT LPD)	MDG (JRC LPD)
MDV	MDV (Trends.Earth LPD)	MDV (FAO-WOCAT LPD)	MDV (JRC LPD)
MEX	MEX (Trends.Earth LPD)	MEX (FAO-WOCAT LPD)	MEX (JRC LPD)
MHL	MHL (Trends.Earth LPD)	MHL (FAO-WOCAT LPD)	MHL (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
MKD	MKD (Trends.Earth LPD)	MKD (FAO-WOCAT LPD)	MKD (JRC LPD)
MLI	MLI (Trends.Earth LPD)	MLI (FAO-WOCAT LPD)	MLI (JRC LPD)
MLT	MLT (Trends.Earth LPD)	MLT (FAO-WOCAT LPD)	MLT (JRC LPD)
MMR	MMR (Trends.Earth LPD)	MMR (FAO-WOCAT LPD)	MMR (JRC LPD)
MNE	MNE (Trends.Earth LPD)	MNE (FAO-WOCAT LPD)	MNE (JRC LPD)
MNG	MNG (Trends.Earth LPD)	MNG (FAO-WOCAT LPD)	MNG (JRC LPD)
MNP	MNP (Trends.Earth LPD)	MNP (FAO-WOCAT LPD)	MNP (JRC LPD)
MOZ	MOZ (Trends.Earth LPD)	MOZ (FAO-WOCAT LPD)	MOZ (JRC LPD)
MRT	MRT (Trends.Earth LPD)	MRT (FAO-WOCAT LPD)	MRT (JRC LPD)
MSR	MSR (Trends.Earth LPD)	MSR (FAO-WOCAT LPD)	MSR (JRC LPD)
MTQ	MTQ (Trends.Earth LPD)	MTQ (FAO-WOCAT LPD)	MTQ (JRC LPD)
MUS	MUS (Trends.Earth LPD)	MUS (FAO-WOCAT LPD)	MUS (JRC LPD)
MWI	MWI (Trends.Earth LPD)	MWI (FAO-WOCAT LPD)	MWI (JRC LPD)
MYS	MYS (Trends.Earth LPD)	MYS (FAO-WOCAT LPD)	MYS (JRC LPD)
MYT	MYT (Trends.Earth LPD)	MYT (FAO-WOCAT LPD)	MYT (JRC LPD)
NAM	NAM (Trends.Earth LPD)	NAM (FAO-WOCAT LPD)	NAM (JRC LPD)
NCL	NCL (Trends.Earth LPD)	NCL (FAO-WOCAT LPD)	NCL (JRC LPD)
NER	NER (Trends.Earth LPD)	NER (FAO-WOCAT LPD)	NER (JRC LPD)
NGA	NGA (Trends.Earth LPD)	NGA (FAO-WOCAT LPD)	NGA (JRC LPD)
NIC	NIC (Trends.Earth LPD)	NIC (FAO-WOCAT LPD)	NIC (JRC LPD)
NIU	NIU (Trends.Earth LPD)	NIU (FAO-WOCAT LPD)	NIU (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
NLD	NLD (Trends.Earth LPD)	NLD (FAO-WOCAT LPD)	NLD (JRC LPD)
NOR	NOR (Trends.Earth LPD)	NOR (FAO-WOCAT LPD)	NOR (JRC LPD)
NPL	NPL (Trends.Earth LPD)	NPL (FAO-WOCAT LPD)	NPL (JRC LPD)
NRU	NRU (Trends.Earth LPD)	NRU (FAO-WOCAT LPD)	NRU (JRC LPD)
NZL	NZL (Trends.Earth LPD)	NZL (FAO-WOCAT LPD)	NZL (JRC LPD)
OMN	OMN (Trends.Earth LPD)	OMN (FAO-WOCAT LPD)	OMN (JRC LPD)
PAK	PAK (Trends.Earth LPD)	PAK (FAO-WOCAT LPD)	PAK (JRC LPD)
PAN	PAN (Trends.Earth LPD)	PAN (FAO-WOCAT LPD)	PAN (JRC LPD)
PCN	PCN (Trends.Earth LPD)	PCN (FAO-WOCAT LPD)	PCN (JRC LPD)
PER	PER (Trends.Earth LPD)	PER (FAO-WOCAT LPD)	PER (JRC LPD)
PHL	PHL (Trends.Earth LPD)	PHL (FAO-WOCAT LPD)	PHL (JRC LPD)
PLW	PLW (Trends.Earth LPD)	PLW (FAO-WOCAT LPD)	PLW (JRC LPD)
PNG	PNG (Trends.Earth LPD)	PNG (FAO-WOCAT LPD)	PNG (JRC LPD)
POL	POL (Trends.Earth LPD)	POL (FAO-WOCAT LPD)	POL (JRC LPD)
PRK	PRK (Trends.Earth LPD)	PRK (FAO-WOCAT LPD)	PRK (JRC LPD)
PRT	PRT (Trends.Earth LPD)	PRT (FAO-WOCAT LPD)	PRT (JRC LPD)
PRY	PRY (Trends.Earth LPD)	PRY (FAO-WOCAT LPD)	PRY (JRC LPD)
PSE	PSE (Trends.Earth LPD)	PSE (FAO-WOCAT LPD)	PSE (JRC LPD)
PYF	PYF (Trends.Earth LPD)	PYF (FAO-WOCAT LPD)	PYF (JRC LPD)
QAT	QAT (Trends.Earth LPD)	QAT (FAO-WOCAT LPD)	QAT (JRC LPD)
REU	REU (Trends.Earth LPD)	REU (FAO-WOCAT LPD)	REU (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
ROU	ROU (Trends.Earth LPD)	ROU (FAO-WOCAT LPD)	ROU (JRC LPD)
RUS	RUS (Trends.Earth LPD)	RUS (FAO-WOCAT LPD)	RUS (JRC LPD)
RWA	RWA (Trends.Earth LPD)	RWA (FAO-WOCAT LPD)	RWA (JRC LPD)
SAU	SAU (Trends.Earth LPD)	SAU (FAO-WOCAT LPD)	SAU (JRC LPD)
SDN	SDN (Trends.Earth LPD)	SDN (FAO-WOCAT LPD)	SDN (JRC LPD)
SEN	SEN (Trends.Earth LPD)	SEN (FAO-WOCAT LPD)	SEN (JRC LPD)
SGP	SGP (Trends.Earth LPD)	SGP (FAO-WOCAT LPD)	SGP (JRC LPD)
SHN	SHN (Trends.Earth LPD)	SHN (FAO-WOCAT LPD)	SHN (JRC LPD)
SLB	SLB (Trends.Earth LPD)	SLB (FAO-WOCAT LPD)	SLB (JRC LPD)
SLE	SLE (Trends.Earth LPD)	SLE (FAO-WOCAT LPD)	SLE (JRC LPD)
SLV	SLV (Trends.Earth LPD)	SLV (FAO-WOCAT LPD)	SLV (JRC LPD)
SMR	SMR (Trends.Earth LPD)	SMR (FAO-WOCAT LPD)	SMR (JRC LPD)
SOM	SOM (Trends.Earth LPD)	SOM (FAO-WOCAT LPD)	SOM (JRC LPD)
SRB	SRB (Trends.Earth LPD)	SRB (FAO-WOCAT LPD)	SRB (JRC LPD)
SSD	SSD (Trends.Earth LPD)	SSD (FAO-WOCAT LPD)	SSD (JRC LPD)
STP	STP (Trends.Earth LPD)	STP (FAO-WOCAT LPD)	STP (JRC LPD)
SUR	SUR (Trends.Earth LPD)	SUR (FAO-WOCAT LPD)	SUR (JRC LPD)
SVK	SVK (Trends.Earth LPD)	SVK (FAO-WOCAT LPD)	SVK (JRC LPD)
SVN	SVN (Trends.Earth LPD)	SVN (FAO-WOCAT LPD)	SVN (JRC LPD)
SWE	SWE (Trends.Earth LPD)	SWE (FAO-WOCAT LPD)	SWE (JRC LPD)
SWZ	SWZ (Trends.Earth LPD)	SWZ (FAO-WOCAT LPD)	SWZ (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
SYC	SYC (Trends.Earth LPD)	SYC (FAO-WOCAT LPD)	SYC (JRC LPD)
SYR	SYR (Trends.Earth LPD)	SYR (FAO-WOCAT LPD)	SYR (JRC LPD)
TCA	TCA (Trends.Earth LPD)	TCA (FAO-WOCAT LPD)	TCA (JRC LPD)
TCD	TCD (Trends.Earth LPD)	TCD (FAO-WOCAT LPD)	TCD (JRC LPD)
TGO	TGO (Trends.Earth LPD)	TGO (FAO-WOCAT LPD)	TGO (JRC LPD)
THA	THA (Trends.Earth LPD)	THA (FAO-WOCAT LPD)	THA (JRC LPD)
TJK	TJK (Trends.Earth LPD)	TJK (FAO-WOCAT LPD)	TJK (JRC LPD)
TKL	TKL (Trends.Earth LPD)	TKL (FAO-WOCAT LPD)	TKL (JRC LPD)
TKM	TKM (Trends.Earth LPD)	TKM (FAO-WOCAT LPD)	TKM (JRC LPD)
TLS	TLS (Trends.Earth LPD)	TLS (FAO-WOCAT LPD)	TLS (JRC LPD)
TON	TON (Trends.Earth LPD)	TON (FAO-WOCAT LPD)	TON (JRC LPD)
TTO	TTO (Trends.Earth LPD)	TTO (FAO-WOCAT LPD)	TTO (JRC LPD)
TUN	TUN (Trends.Earth LPD)	TUN (FAO-WOCAT LPD)	TUN (JRC LPD)
TUR	TUR (Trends.Earth LPD)	TUR (FAO-WOCAT LPD)	TUR (JRC LPD)
TUV	TUV (Trends.Earth LPD)	TUV (FAO-WOCAT LPD)	TUV (JRC LPD)
TWN	TWN (Trends.Earth LPD)	TWN (FAO-WOCAT LPD)	TWN (JRC LPD)
TZA	TZA (Trends.Earth LPD)	TZA (FAO-WOCAT LPD)	TZA (JRC LPD)
UGA	UGA (Trends.Earth LPD)	UGA (FAO-WOCAT LPD)	UGA (JRC LPD)
UKR	UKR (Trends.Earth LPD)	UKR (FAO-WOCAT LPD)	UKR (JRC LPD)
URY	URY (Trends.Earth LPD)	URY (FAO-WOCAT LPD)	URY (JRC LPD)
USA	USA (Trends.Earth LPD)	USA (FAO-WOCAT LPD)	USA (JRC LPD)

Country	SDG 15.3.1 using Trends.Earth LPD	SDG 15.3.1 using FAO-WOCAT LPD	SDG 15.3.1 using JRC LPD
UZB	UZB (Trends.Earth LPD)	UZB (FAO-WOCAT LPD)	UZB (JRC LPD)
VAT	VAT (Trends.Earth LPD)	VAT (FAO-WOCAT LPD)	VAT (JRC LPD)
VCT	VCT (Trends.Earth LPD)	VCT (FAO-WOCAT LPD)	VCT (JRC LPD)
VEN	VEN (Trends.Earth LPD)	VEN (FAO-WOCAT LPD)	VEN (JRC LPD)
VGB	VGB (Trends.Earth LPD)	VGB (FAO-WOCAT LPD)	VGB (JRC LPD)
VIR	VIR (Trends.Earth LPD)	VIR (FAO-WOCAT LPD)	VIR (JRC LPD)
VNM	VNM (Trends.Earth LPD)	VNM (FAO-WOCAT LPD)	VNM (JRC LPD)
VUT	VUT (Trends.Earth LPD)	VUT (FAO-WOCAT LPD)	VUT (JRC LPD)
WLF	WLF (Trends.Earth LPD)	WLF (FAO-WOCAT LPD)	WLF (JRC LPD)
WSM	WSM (Trends.Earth LPD)	WSM (FAO-WOCAT LPD)	WSM (JRC LPD)
XKX	XKX (Trends.Earth LPD)	XKX (FAO-WOCAT LPD)	XKX (JRC LPD)
YEM	YEM (Trends.Earth LPD)	YEM (FAO-WOCAT LPD)	YEM (JRC LPD)
ZAF	ZAF (Trends.Earth LPD)	ZAF (FAO-WOCAT LPD)	ZAF (JRC LPD)
ZMB	ZMB (Trends.Earth LPD)	ZMB (FAO-WOCAT LPD)	ZMB (JRC LPD)
ZWE	ZWE (Trends.Earth LPD)	ZWE (FAO-WOCAT LPD)	ZWE (JRC LPD)

Drought hazard, vulnerability and exposure (UNCCD Strategic Objective 3)

The below datasets can be used to support assessing drought hazard, vulnerability, and exposure, and for reporting on UNCCD Strategic Objective 3.

These data are processed in accordance with the Good Practice Guidance for National Reporting on UNCCD Strategic Objective 3. Two variations of the data are provided. Both are based on the Standardized Precipitation Index (SPI) for a 12-month accumulation period. One version uses the Global Multi-Index Drought (GMID) dataset from the UK-CEH, the other uses an SPI dataset derived by the Trends.Earth team from the CHIRPS precipitation dataset.

CHIRPS is a gridded precipitation dataset spanning 50°S-50°N, starting in 1981, that merges in-situ with satellite data to produce a timeseries grid.

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
ABW	ABW (UK-CEH)	ABW (CHIRPS)
AFG	AFG (UK-CEH)	AFG (CHIRPS)
AGO	AGO (UK-CEH)	AGO (CHIRPS)
AIA	AIA (UK-CEH)	AIA (CHIRPS)
ALB	ALB (UK-CEH)	ALB (CHIRPS)
AND	AND (UK-CEH)	AND (CHIRPS)
ARE	ARE (UK-CEH)	ARE (CHIRPS)
ARG	ARG (UK-CEH)	ARG (CHIRPS)
ARM	ARM (UK-CEH)	ARM (CHIRPS)
ASM	ASM (UK-CEH)	ASM (CHIRPS)
ATG	ATG (UK-CEH)	ATG (CHIRPS)
AUS	AUS (UK-CEH)	AUS (CHIRPS)
AUT	AUT (UK-CEH)	AUT (CHIRPS)
AZE	AZE (UK-CEH)	AZE (CHIRPS)
BDI	BDI (UK-CEH)	BDI (CHIRPS)
BEL	BEL (UK-CEH)	BEL (CHIRPS)
BEN	BEN (UK-CEH)	BEN (CHIRPS)
BES	BES (UK-CEH)	BES (CHIRPS)
BFA	BFA (UK-CEH)	BFA (CHIRPS)
BGD	BGD (UK-CEH)	BGD (CHIRPS)
BGR	BGR (UK-CEH)	BGR (CHIRPS)
BHR	BHR (UK-CEH)	BHR (CHIRPS)
BHS	BHS (UK-CEH)	BHS (CHIRPS)
BIH	BIH (UK-CEH)	BIH (CHIRPS)
BLM	BLM (UK-CEH)	BLM (CHIRPS)
BLR	BLR (UK-CEH)	BLR (CHIRPS)
BLZ	BLZ (UK-CEH)	BLZ (CHIRPS)
BMU	BMU (UK-CEH)	BMU (CHIRPS)
BOL	BOL (UK-CEH)	BOL (CHIRPS)
BRA	BRA (UK-CEH)	BRA (CHIRPS)
BRB	BRB (UK-CEH)	BRB (CHIRPS)
BRN	BRN (UK-CEH)	BRN (CHIRPS)
BTN	BTN (UK-CEH)	BTN (CHIRPS)
BWA	BWA (UK-CEH)	BWA (CHIRPS)
CAF	CAF (UK-CEH)	CAF (CHIRPS)

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
CAN	CAN (UK-CEH)	CAN (CHIRPS)
CHE	CHE (UK-CEH)	CHE (CHIRPS)
CHL	CHL (UK-CEH)	CHL (CHIRPS)
CHN	CHN (UK-CEH)	CHN (CHIRPS)
CIV	CIV (UK-CEH)	CIV (CHIRPS)
CMR	CMR (UK-CEH)	CMR (CHIRPS)
COD	COD (UK-CEH)	COD (CHIRPS)
COG	COG (UK-CEH)	COG (CHIRPS)
COK	COK (UK-CEH)	COK (CHIRPS)
COL	COL (UK-CEH)	COL (CHIRPS)
COM	COM (UK-CEH)	COM (CHIRPS)
CPV	CPV (UK-CEH)	CPV (CHIRPS)
CRI	CRI (UK-CEH)	CRI (CHIRPS)
CUB	CUB (UK-CEH)	CUB (CHIRPS)
CUW	CUW (UK-CEH)	CUW (CHIRPS)
CYM	CYM (UK-CEH)	CYM (CHIRPS)
CYP	CYP (UK-CEH)	CYP (CHIRPS)
CZE	CZE (UK-CEH)	CZE (CHIRPS)
DEU	DEU (UK-CEH)	DEU (CHIRPS)
DJI	DJI (UK-CEH)	DJI (CHIRPS)
DMA	DMA (UK-CEH)	DMA (CHIRPS)
DNK	DNK (UK-CEH)	DNK (CHIRPS)
DOM	DOM (UK-CEH)	DOM (CHIRPS)
DZA	DZA (UK-CEH)	DZA (CHIRPS)
ECU	ECU (UK-CEH)	ECU (CHIRPS)
EGY	EGY (UK-CEH)	EGY (CHIRPS)
ERI	ERI (UK-CEH)	ERI (CHIRPS)
ESP	ESP (UK-CEH)	ESP (CHIRPS)
EST	EST (UK-CEH)	EST (CHIRPS)
ETH	ETH (UK-CEH)	ETH (CHIRPS)
FIN	FIN (UK-CEH)	FIN (CHIRPS)
FJI	FJI (UK-CEH)	FJI (CHIRPS)
FLK	FLK (UK-CEH)	FLK (CHIRPS)
FRA	FRA (UK-CEH)	FRA (CHIRPS)
FRO	FRO (UK-CEH)	FRO (CHIRPS)

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
FSM	FSM (UK-CEH)	FSM (CHIRPS)
GAB	GAB (UK-CEH)	GAB (CHIRPS)
GBR	GBR (UK-CEH)	GBR (CHIRPS)
GEO	GEO (UK-CEH)	GEO (CHIRPS)
GGY	GGY (UK-CEH)	GGY (CHIRPS)
GHA	GHA (UK-CEH)	GHA (CHIRPS)
GIB	GIB (UK-CEH)	GIB (CHIRPS)
GIN	GIN (UK-CEH)	GIN (CHIRPS)
GLP	GLP (UK-CEH)	GLP (CHIRPS)
GMB	GMB (UK-CEH)	GMB (CHIRPS)
GNB	GNB (UK-CEH)	GNB (CHIRPS)
GNQ	GNQ (UK-CEH)	GNQ (CHIRPS)
GRC	GRC (UK-CEH)	GRC (CHIRPS)
GRD	GRD (UK-CEH)	GRD (CHIRPS)
GRL	GRL (UK-CEH)	GRL (CHIRPS)
GTM	GTM (UK-CEH)	GTM (CHIRPS)
GUF	GUF (UK-CEH)	GUF (CHIRPS)
GUM	GUM (UK-CEH)	GUM (CHIRPS)
GUY	GUY (UK-CEH)	GUY (CHIRPS)
HND	HND (UK-CEH)	HND (CHIRPS)
HRV	HRV (UK-CEH)	HRV (CHIRPS)
HTI	HTI (UK-CEH)	HTI (CHIRPS)
HUN	HUN (UK-CEH)	HUN (CHIRPS)
IDN	IDN (UK-CEH)	IDN (CHIRPS)
IMN	IMN (UK-CEH)	IMN (CHIRPS)
IND	IND (UK-CEH)	IND (CHIRPS)
IRL	IRL (UK-CEH)	IRL (CHIRPS)
IRN	IRN (UK-CEH)	IRN (CHIRPS)
IRQ	IRQ (UK-CEH)	IRQ (CHIRPS)
ISL	ISL (UK-CEH)	ISL (CHIRPS)
ISR	ISR (UK-CEH)	ISR (CHIRPS)
ITA	ITA (UK-CEH)	ITA (CHIRPS)
JAM	JAM (UK-CEH)	JAM (CHIRPS)
JOR	JOR (UK-CEH)	JOR (CHIRPS)
JPN	JPN (UK-CEH)	JPN (CHIRPS)

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
KAZ	KAZ (UK-CEH)	KAZ (CHIRPS)
KEN	KEN (UK-CEH)	KEN (CHIRPS)
KGZ	KGZ (UK-CEH)	KGZ (CHIRPS)
KHM	KHM (UK-CEH)	KHM (CHIRPS)
KIR	KIR (UK-CEH)	KIR (CHIRPS)
KNA	KNA (UK-CEH)	KNA (CHIRPS)
KOR	KOR (UK-CEH)	KOR (CHIRPS)
KWT	KWT (UK-CEH)	KWT (CHIRPS)
LAO	LAO (UK-CEH)	LAO (CHIRPS)
LBN	LBN (UK-CEH)	LBN (CHIRPS)
LBR	LBR (UK-CEH)	LBR (CHIRPS)
LBY	LBY (UK-CEH)	LBY (CHIRPS)
LCA	LCA (UK-CEH)	LCA (CHIRPS)
LIE	LIE (UK-CEH)	LIE (CHIRPS)
LKA	LKA (UK-CEH)	LKA (CHIRPS)
LSO	LSO (UK-CEH)	LSO (CHIRPS)
LTU	LTU (UK-CEH)	LTU (CHIRPS)
LUX	LUX (UK-CEH)	LUX (CHIRPS)
LVA	LVA (UK-CEH)	LVA (CHIRPS)
MAR	MAR (UK-CEH)	MAR (CHIRPS)
MCO	MCO (UK-CEH)	MCO (CHIRPS)
MDA	MDA (UK-CEH)	MDA (CHIRPS)
MDG	MDG (UK-CEH)	MDG (CHIRPS)
MDV	MDV (UK-CEH)	MDV (CHIRPS)
MEX	MEX (UK-CEH)	MEX (CHIRPS)
MHL	MHL (UK-CEH)	MHL (CHIRPS)
MKD	MKD (UK-CEH)	MKD (CHIRPS)
MLI	MLI (UK-CEH)	MLI (CHIRPS)
MLT	MLT (UK-CEH)	MLT (CHIRPS)
MMR	MMR (UK-CEH)	MMR (CHIRPS)
MNE	MNE (UK-CEH)	MNE (CHIRPS)
MNG	MNG (UK-CEH)	MNG (CHIRPS)
MNP	MNP (UK-CEH)	MNP (CHIRPS)
MOZ	MOZ (UK-CEH)	MOZ (CHIRPS)
MRT	MRT (UK-CEH)	MRT (CHIRPS)

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
MSR	MSR (UK-CEH)	MSR (CHIRPS)
MTQ	MTQ (UK-CEH)	MTQ (CHIRPS)
MUS	MUS (UK-CEH)	MUS (CHIRPS)
MWI	MWI (UK-CEH)	MWI (CHIRPS)
MYS	MYS (UK-CEH)	MYS (CHIRPS)
MYT	MYT (UK-CEH)	MYT (CHIRPS)
NAM	NAM (UK-CEH)	NAM (CHIRPS)
NCL	NCL (UK-CEH)	NCL (CHIRPS)
NER	NER (UK-CEH)	NER (CHIRPS)
NGA	NGA (UK-CEH)	NGA (CHIRPS)
NIC	NIC (UK-CEH)	NIC (CHIRPS)
NIU	NIU (UK-CEH)	NIU (CHIRPS)
NLD	NLD (UK-CEH)	NLD (CHIRPS)
NOR	NOR (UK-CEH)	NOR (CHIRPS)
NPL	NPL (UK-CEH)	NPL (CHIRPS)
NRU	NRU (UK-CEH)	NRU (CHIRPS)
NZL	NZL (UK-CEH)	NZL (CHIRPS)
OMN	OMN (UK-CEH)	OMN (CHIRPS)
PAK	PAK (UK-CEH)	PAK (CHIRPS)
PAN	PAN (UK-CEH)	PAN (CHIRPS)
PCN	PCN (UK-CEH)	PCN (CHIRPS)
PER	PER (UK-CEH)	PER (CHIRPS)
PHL	PHL (UK-CEH)	PHL (CHIRPS)
PLW	PLW (UK-CEH)	PLW (CHIRPS)
PNG	PNG (UK-CEH)	PNG (CHIRPS)
POL	POL (UK-CEH)	POL (CHIRPS)
PRK	PRK (UK-CEH)	PRK (CHIRPS)
PRT	PRT (UK-CEH)	PRT (CHIRPS)
PRY	PRY (UK-CEH)	PRY (CHIRPS)
PSE	PSE (UK-CEH)	PSE (CHIRPS)
PYF	PYF (UK-CEH)	PYF (CHIRPS)
QAT	QAT (UK-CEH)	QAT (CHIRPS)
REU	REU (UK-CEH)	REU (CHIRPS)
ROU	ROU (UK-CEH)	ROU (CHIRPS)
RUS	RUS (UK-CEH)	RUS (CHIRPS)

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
RWA	RWA (UK-CEH)	RWA (CHIRPS)
SAU	SAU (UK-CEH)	SAU (CHIRPS)
SDN	SDN (UK-CEH)	SDN (CHIRPS)
SEN	SEN (UK-CEH)	SEN (CHIRPS)
SGP	SGP (UK-CEH)	SGP (CHIRPS)
SHN	SHN (UK-CEH)	SHN (CHIRPS)
SLB	SLB (UK-CEH)	SLB (CHIRPS)
SLE	SLE (UK-CEH)	SLE (CHIRPS)
SLV	SLV (UK-CEH)	SLV (CHIRPS)
SMR	SMR (UK-CEH)	SMR (CHIRPS)
SOM	SOM (UK-CEH)	SOM (CHIRPS)
SRB	SRB (UK-CEH)	SRB (CHIRPS)
SSD	SSD (UK-CEH)	SSD (CHIRPS)
STP	STP (UK-CEH)	STP (CHIRPS)
SUR	SUR (UK-CEH)	SUR (CHIRPS)
SVK	SVK (UK-CEH)	SVK (CHIRPS)
SVN	SVN (UK-CEH)	SVN (CHIRPS)
SWE	SWE (UK-CEH)	SWE (CHIRPS)
SWZ	SWZ (UK-CEH)	SWZ (CHIRPS)
SYC	SYC (UK-CEH)	SYC (CHIRPS)
SYR	SYR (UK-CEH)	SYR (CHIRPS)
TCA	TCA (UK-CEH)	TCA (CHIRPS)
TCD	TCD (UK-CEH)	TCD (CHIRPS)
TGO	TGO (UK-CEH)	TGO (CHIRPS)
THA	THA (UK-CEH)	THA (CHIRPS)
TJK	TJK (UK-CEH)	TJK (CHIRPS)
TKL	TKL (UK-CEH)	TKL (CHIRPS)
TKM	TKM (UK-CEH)	TKM (CHIRPS)
TLS	TLS (UK-CEH)	TLS (CHIRPS)
TON	TON (UK-CEH)	TON (CHIRPS)
TTO	TTO (UK-CEH)	TTO (CHIRPS)
TUN	TUN (UK-CEH)	TUN (CHIRPS)
TUR	TUR (UK-CEH)	TUR (CHIRPS)
TUV	TUV (UK-CEH)	TUV (CHIRPS)
TWN	TWN (UK-CEH)	TWN (CHIRPS)

Country	Drought indicators (UK-CEH SPI)	Drought indicators (CHIRPS SPI)
TZA	TZA (UK-CEH)	TZA (CHIRPS)
UGA	UGA (UK-CEH)	UGA (CHIRPS)
UKR	UKR (UK-CEH)	UKR (CHIRPS)
URY	URY (UK-CEH)	URY (CHIRPS)
USA	USA (UK-CEH)	USA (CHIRPS)
UZB	UZB (UK-CEH)	UZB (CHIRPS)
VAT	VAT (UK-CEH)	VAT (CHIRPS)
VCT	VCT (UK-CEH)	VCT (CHIRPS)
VEN	VEN (UK-CEH)	VEN (CHIRPS)
VGB	VGB (UK-CEH)	VGB (CHIRPS)
VIR	VIR (UK-CEH)	VIR (CHIRPS)
VNM	VNM (UK-CEH)	VNM (CHIRPS)
VUT	VUT (UK-CEH)	VUT (CHIRPS)
WLF	WLF (UK-CEH)	WLF (CHIRPS)
WSM	WSM (UK-CEH)	WSM (CHIRPS)
XKX	XKX (UK-CEH)	XKX (CHIRPS)
YEM	YEM (UK-CEH)	YEM (CHIRPS)
ZAF	ZAF (UK-CEH)	ZAF (CHIRPS)
ZMB	ZMB (UK-CEH)	ZMB (CHIRPS)
ZWE	ZWE (UK-CEH)	ZWE (CHIRPS)

Advanced

Installing Numba for local calculations

Numba can speed up some local Trends.Earth calculations. It is not included by default with the Trends.Earth installer given limitations on packaging binaries for distribution via the standard QGIS repositories. To use it, install it in the Python environment used by QGIS. Close QGIS before installing packages, and restart it afterward.

Windows

Open the **OSGeo4W Shell** installed with your QGIS installation (use the shell for the same QGIS version you run Trends.Earth in). Run:

```
python -m pip install --user numba
```

If the shell reports that pip is unavailable, or the installation conflicts with packages supplied by QGIS, consult your QGIS distribution's package manager rather than replacing its bundled packages.

macOS

Open **Plugins > Python Console** in QGIS and run:

```
import sys
print(sys.executable)
```

Quit QGIS. If the printed path points to a Python executable, use that exact path in Terminal (substitute your own path for `/path/to/qgis/python3`):

```
"/path/to/qgis/python3" -m pip install --user numba
```

If the path points to the QGIS application instead of Python, use the Python interpreter provided by your QGIS installation. For example, with a Homebrew installation, use the Python from the same Homebrew environment as QGIS; with a standalone QGIS app, check the app bundle for its Python interpreter.

Linux

For QGIS installed from your distribution's package manager, install the matching Numba package from that same distribution. For example, on Debian/Ubuntu:

```
sudo apt install python3-numba
```

If QGIS instead uses a separate Python environment, activate that environment and install Numba there:

```
python -m pip install numba
```

To check the result on any platform, restart QGIS and run this in **Plugins > Python Console**:

```
import numba
print(numba.__version__)
```

If this raises `ModuleNotFoundError`, Numba was installed in a different Python environment. Check `sys.executable` and `sys.prefix` in the QGIS Python Console and select the Python environment associated with that QGIS installation before trying again.