Policy Brief
November 2025

Strengthening Land Management with Earth Observation: Soil Erosion Insights from Romania's Olt Basin

SDGs-EYES service - Monitoring Sustainable Development Goal 15 – Using Earth Observation data to assess soil erosion in Romania's Olt River Basin

15 LIFE ON LAND

Area at risk of severe soil erosion by water (Eurostat code: 15_50)

KEY MESSAGES

Timely data for land degradation management.
Effective soil conservation depends on knowing when and where soil degradation occurs. Traditional assessments are infrequent and at a relatively coarse spatial resolution. The Soil Erosion by Water Assessment Tool changes this by delivering quarterly, 10 m-resolution maps of soil loss. This data allows policymakers and land managers to respond quickly to emerging erosion hotspots, transforming monitoring from a multi-year static snapshot into a dynamic, actionable process.

Integrated Earth Observation workflow for soil erosion.
The Soil Erosion by Water Assessment Tool merges satellite imagery, climate reanalysis, soil surveys, and high-resolution terrain data in an automated workflow. It enhances the Revised Universal Soil Loss Equation with machine-learning techniques, providing more accurate, locally relevant estimates of soil loss and its drivers. Fully aligned with Eurostat's 15_50 indicator "Area at risk of severe soil erosion by water", it generates official proxy data for SDG 15.3.1, ensuring consistency with national and EU reporting frameworks.

User-driven and scalable solution.
Developed through a co-design process with national agencies and stakeholders, the Soil Erosion by Water Assessment Tool features an intuitive web interface and an open-source, modular architecture. Users can access and explore data without technical expertise, and the workflow can be adapted to other regions by plugging in local datasets. This design promotes widespread adoption and integration into policy workflows, bridging the gap between research and practical land management.

SDGs EYES

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Scene Setting

Soil erosion by water undermines agricultural productivity, infrastructure, and ecosystems across Europe. In the European Union, roughly 62 % of land faces degradation, with water erosion affecting about a quarter of the territory. Unsustainable farming practices, deforestation, and improper land use exacerbate erosion, leading to on-site losses of fertile topsoil and off-site impacts like sedimentation in rivers and reservoirs. Such degradation costs the EU billions in lost yields and infrastructure damage each year. Romania's Olt River Basin illustrates these challenges vividly: heavy rainfall, steep terrain, and varied land uses create a patchwork of erosion rates, highlighting the need for high-resolution monitoring.

Recognizing soil's vital role, policymakers have enshrined land degradation neutrality in SDG 15.3. European strategies reinforce this: the EU Soil Strategy and the "Soil Deal" mission aim to curb erosion, while the forthcoming Soil Monitoring Law and the Common Agricultural Policy (CAP) require Member States to track soil health indicators, including erosion. The EU Soil Mission commits the EU to healthy soils by 2030, including reducing water-driven soil erosion to sustainable levels; this underpins the Soil Strategy, the forthcoming Soil Monitoring Law, and CAP rules, all of which require regular, comparable evidence. Despite these ambitions, monitoring remains scarce and outdated. Eurostat's indicator 15_50, although useful, is based on coarse data updated rarely and aperiodically. In the EU set, 15_50 tracks the area and mean soil loss above a severe-erosion threshold (e.g., >10 t/ha/yr) and is directly linked to SDG 15.3.1, but its infrequent updates limit timely action. The Olt Basin Soil Erosion by Water Assessment Tool produces 15_50-compatible outputs at 10 m resolution and quarterly frequency, turning decadal, coarse estimates into routine, policy-ready indicators. This gap leaves policymakers without the insights needed to intervene effectively or measure progress.

Earth Observation (EO) offers a solution. Satellites deliver timely, consistent data on rainfall, vegetation, land cover, and topography. Integrating these data with local measurements and models can reveal current erosion patterns and trends. The SDGs-EYES project harnesses this capability, piloting an EO-based Soil Erosion by Water Assessment Tool in the Olt Basin. This demonstration shows how technology can modernize soil monitoring, providing policymakers with the evidence they need to achieve land degradation neutrality and implement soil protection policies. By aligning with SDG 15.3.1 and EU indicator 15_50, the Soil Erosion by Water Assessment Tool enables timely targeting of conservation measures in erosion hotspots and supports credible national and EU reporting.

Confronting Land Degradation with Innovation: Advancing SDG 15, EU Soil Strategy, and Land Resilience

Main Features of the Soil Erosion by Water Assessment Tool

The Soil Erosion by Water Assessment Tool combines scientific rigor with operational usability. It implements the Revised Universal Soil Loss Equation (RUSLE) using up-to-date Earth Observation inputs. Rainfall erosivity (R) is derived from ERA5-Land data and refined via a neural network trained on rain-gauge measurements, capturing short, intense storms. In addition, alternative methods to compute rainfall erosivity are available to support offline ensemble analysis. Soil erodibility (K) draws on national surveys and European soil maps, while topography uses 30 m-resolution digital elevation models to calculate slope length and steepness (LS), optionally accounting for the impact of transport infrastructure. The land cover factor (C) is updated seasonally with Sentinel-2 imagery and vegetation indices, reflecting dynamic changes in crops and forests. The support practice factor (P) remains conservative, but the system can integrate local data on terraces or contour farming when available.

Beyond calculating erosion, the Soil Erosion by Water Assessment Tool produces user-friendly outputs. It generates quarterly soil loss maps at 10 m resolution, allowing comparisons across time and space. Detailed layers show the individual factors of the RUSLE model (R, K, LS, C), helping users understand what drives erosion in each location. A web-based interface enables users to visualize and download maps and extract statistics. Because the system is open source and modular, other regions can replicate the workflow by adding local datasets.

Crucially, the Soil Erosion by Water Assessment Tool was co-designed with end users. National environmental agencies, statisticians, and local stakeholders provided input on functionality, ensuring the interface meets operational needs. The Soil Erosion by Water Assessment Tool aligns with policy frameworks by automatically calculating Eurostat's 15_50 indicator, ready for official reports. Its design also supports integration with other SDGs-EYES pilots, like those measuring forest cover changes or climate hazards, allowing for holistic land management assessments.

The Technical Side of the Soil Erosion by Water Assessment Tool

The technical foundation of the Soil Erosion by Water Assessment Tool uses the Revised Universal Soil Loss Equation (RUSLE) model enhanced by modern data sources and methods (see Figure 1). RUSLE was developed based on decades of soil erosion experiments carried out by universities and agencies across the United States in the 20th century. The first version of the model (called USLE) was published in 1965, while the first RUSLE handbook was issued in 1978 and then updated in 1997. RUSLE is an empirical model that yields the potential soil loss due to the combined effect of raindrop impact and surface runoff with land features. In practice, it consists of a single equation that returns average soil loss as the multiplication of five factors: the rainfall erosivity (R), representing the erosive force; the soil erodibility (K), accounting for soil textural and chemical properties; the slope length and steepness (LS) describing morphological configuration of the inspected area; land cover and management (C), considering both land cover and use properties; and the support practice factor (P), which includes man-made territorial features against erosion, like terraces.

The straightforwardness of RUSLE makes it suitable for large-scale analysis. Its use has steadily increased in the latest decades, so that RUSLE has become the common framework adopted for regional to global assessments, as witnessed by soil loss by water maps produced for the EU by the Joint Research Center.

In this project, rinfall erosivity is computed through multiple methods, ranging from empirical formulations to a specifically trained neural network able to enhance the temporal resolution of ERA5-Land precipitation data and apply the rigorous method provided by the handbooks for this factor. Soil erodibility is derived from high-resolution soil maps, ensuring local textures and organic contents are represented. Slope length and steepness are calculated using a digital terrain model ensemble at 30 m spatial resolution and highly accurate datasets on transport infrastructures. Land cover and management are mapped based on Sentinel-2 imagery and NDVI-based indicators, producing seasonal, 10-m resolution datasets. The support practice factor is currently set to one, which means disregarded in a conservative manner, but next tool updates might be able to incorporate local data on terraces or conservation farming when available.

Processing occurs in a cloud environment through Jupyter notebooks and Python scripts. This ensures scalability and reproducibility: new data are automatically ingested, and each step of the workflow is documented. Users interact via a web interface that retrieves and visualizes data without requiring local computing power. The outputs include maps of all RUSLE factors and the resulting soil loss, available for download and integration with Geographic Information Systems (GIS). The open-source design encourages adaptation and improvement, allowing other regions to replicate or enhance the model with their own data.

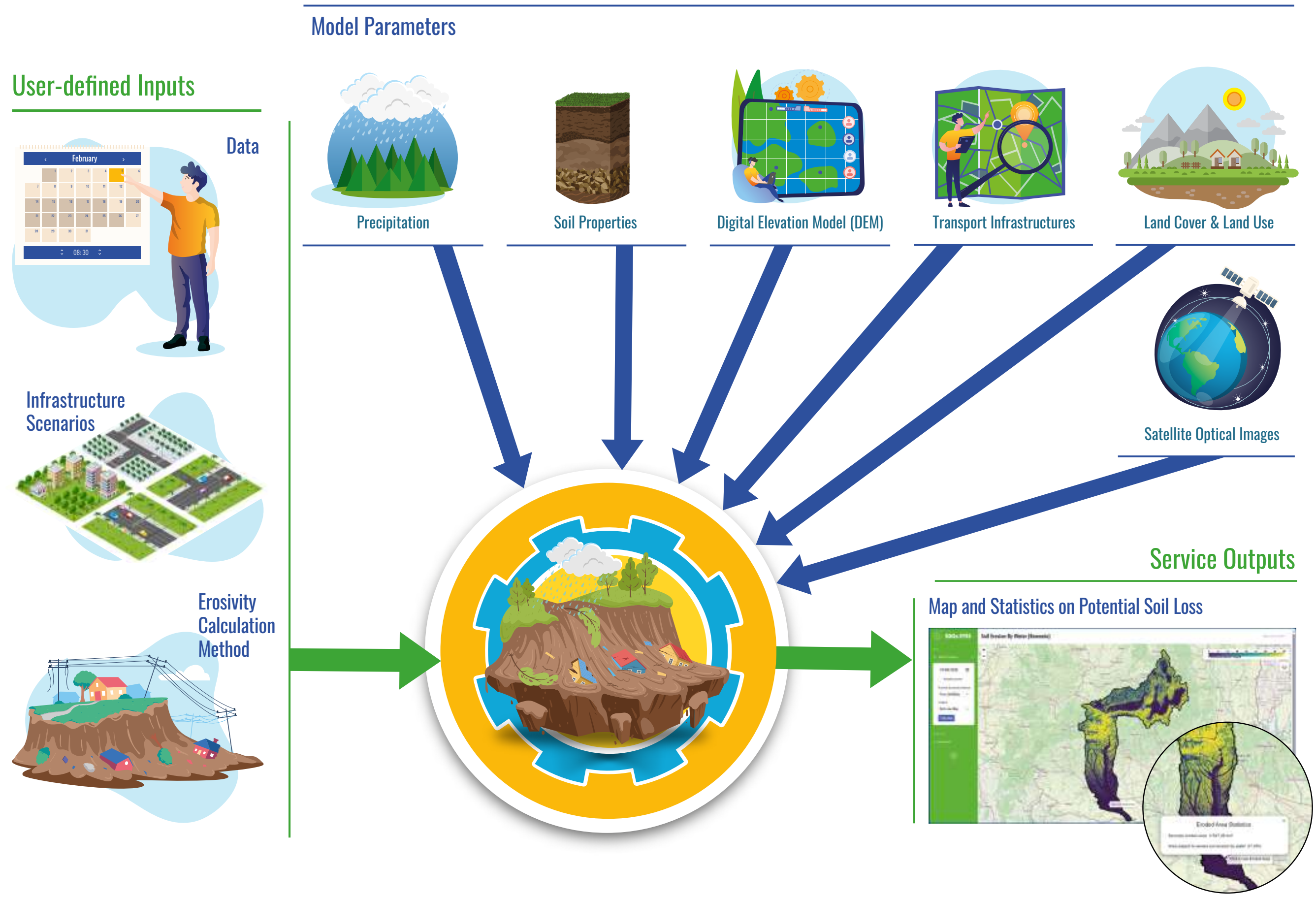


Figure 1. The Soil Erosion by Water Assessment Tool enables automated estimation of soil loss due to rainfall and modulated by land natural and man-made features. Upon user input of the date, the tool integrates diverse typologies of data to compute the factors contributing to overall erosion and then applies the Revised Universal Soil Loss Equation (RUSLE). The outputs generated are spatially explicit quarterly soil loss maps and the related RUSLE factors, and the overall amount of soil loss in the selected area.

What Does This Mean for Policy?

For policymakers, the Soil Erosion by Water Assessment Tool shifts the paradigm from sporadic, coarse monitoring to continuous, high-resolution assessment. National statistical offices can now calculate soil loss for SDG 15 reporting on an annual or quarterly basis, providing more accurate and timely indicators.

This enables better tracking of progress toward land degradation neutrality and more effective and easy operationable international reporting.

The Soil Erosion by Water Assessment Tool also informs targeted land management. By showing exactly where and why soil loss occurs, it helps agencies deploy conservation measures where they will be most effective. For example, it can reveal which sub-basins contribute most to sediment loads in reservoirs, guiding reforestation or terracing efforts. Agricultural advisors can use the data to tailor recommendations for farmers, promoting practices such as cover cropping or contour ploughing in high-risk areas. In addition, the Soil Erosion by Water Assessment Tool supports climate adaptation planning and disaster risk management by highlighting where erosion intersects with flooding or landslide hazards.

Integration with existing policies is seamless. The Soil Erosion by Water Assessment Tool's outputs align with the EU Soil Strategy, the proposed Soil Monitoring Law, and the Common Agricultural Policy. National authorities can cross-check the EO-derived data with traditional assessments, building confidence and ensuring continuity in reporting. Over time, this dual approach enables a gradual transition to EO-based indicators as the primary data source, enhancing accuracy without disrupting existing systems.

From Barriers to Action: Enabling EO-Based SDG Reporting

Data Fragmentation

The Challenge: Soil quality related data often reside in siloed databases maintained by different ministries, research institutes, or private operators, each with its own format, spatial resolution, and update cycle. This fragmentation hinders coordination, produces inconsistent baselines, and creates blind spots for national policy.

Strategic Response: Standardisation and interoperability are prioritised. The Soil Erosion by Water Assessment Tool integrates diverse data sources, formats, and resolutions. The Soil Erosion by Water Assessment Tool does not aim to harmonise all data sources - it enables meaningful aggregation. By combining heterogeneous datasets (topography, land cover, climate, soil) into a unified processing chain, it generates consistent, quarterly soil erosion outputs in open, standard formats. These outputs are policy-ready, though not centrally harmonised for reuse by third parties. Rather than investing time and resources into full interoperability, the approach leverages existing data to generate timely and actionable insights. For policymakers, this means shifting from siloed datasets to an aggregated evidence base that can directly inform SDG 15.3.1 reporting and EU soil strategies.

Institutional Inertia

The Challenge: Land planners and institutions generally do not have access to updated soil erosion assessments, but instead rely on local measurements, which are, however, rare and insufficient for characterisation, or on the dataset provided by JRC, which is, however, not updated and at too coarse a resolution for some local applications.

Strategic Response: Co-design is the pathway to trust. Soil Erosion by Water Assessment Tool has been developed in partnership with competent authorities. Trust begins with co-design. Soil Erosion by Water Assessment Tool engages users through shared events and targeted webinars. Interactions involved land planners and decision-makers, who confirmed the tool's relevance for seasonal land management. This user validation process shows that Earth Observation (EO)-based tools can be introduced flexibly, and still win institutional confidence - provided they are transparent, adaptable, and developed with user input.

Insufficient Monitoring Frequency

The Challenge: Conventional field inventories are usually based on an annual or multi-year average scale, even though the natural dynamics of vegetation (phenology) and land management practices (e.g., agricultural cycles) are sub-annual. This temporal mismatch makes it difficult for authorities to detect erosion risks in time to prevent degradation or deploy effective interventions.

Strategic Response: The Soil Erosion by Water Assessment Tool delivers quarterly assessments that better reflect the evolving, seasonal nature of soil erosion. By capturing changes in vegetation cover, rainfall patterns, and land use throughout the year, it allows for more precise identification of high-risk periods and locations. This sub-annual resolution was highlighted by stakeholders as essential for timely monitoring and strategic land planning. Regular, scheduled updates enable public authorities to transition from reactive to proactive soil conservation, strengthening territorial management and policy alignment with SDG 15.3.1.

Policy Inertia

The Challenge: Even when robust evidence exists, policy response can be slow due to bureaucratic delays, unclear triggers for action, or fragmented mandates between agencies. The risk is that data accumulate without translating into timely measures on the ground.

Strategic Response: The Soil Erosion by Water Assessment Tool is built for structured decision-making. It generates quarterly indicators that align with CAP implementation, national soil reporting, and territorial planning providing predictable, timely evidence to support regulatory cycles. Crucially, the tool is transferable and user-controlled: assessments can be performed where and when needed, without requiring users to gather or harmonise dispersed datasets. This self-service functionality empowers national and regional agencies to embed EO evidence directly into their workflows - transforming satellite data from background analysis into active policy instruments.

Experimental Results and Operational Validation

The Olt Basin pilot shows that EO-based soil erosion monitoring works in practice (see Figure 2). Rainfall erosivity maps show a gradient, leading to more intense erosivity from upstream to downstream. Soil erosibility is lower in the central sections of the basin, but in these areas, slope length and steepness are at their maximum. Land cover and management vary over time and across space. At the yearly averaged resolution, results show an expansion of areas susceptible to erosion due to the land cover and management in downstream croplands, and a net increase of susceptibility in some mountainous areas in the central section of the basin, likely due to deforestation. At the quarterly resolution, the entire basin suffers from increased susceptibility in winter, especially the upstream croplands, likely due to fallow; in spring, vulnerability reaches its minimum everywhere thanks to the plant growing season; in summer, some downstream croplands are associated with higher susceptibility, likely due to management and harvest, a trend that consolidates and exacerbates in fall.

Quarterly maps also reveal a mosaic of soil loss: high erosion on steep, deforested slopes and lower rates in flat, well-vegetated areas. The model captures temporal fluctuations, showing how erosion peaks in winter, when increased rainfall erosivity combines with higher land susceptibility, drops in spring and summer, and starts to increase again in fall. Trends indicate that erosion risk has increased slightly over the past decade, likely due to more intense rainfall and land-use changes, while targeted conservation efforts have reduced soil loss in specific areas.

Validation builds confidence in the model. Local experts confirmed that known erosion hotspots, such as the Făgăraș foothills, appear prominently in the maps. Throughout the pilot, user feedback prompted improvements-adding factor-specific layers, local language options, and simplified statistics, ensuring the tool meets operational needs.

At the time of the publication of this policy brief, one scientific paper documenting the methodology and results is in review, with others under preparation, providing further peer-reviewed validation.

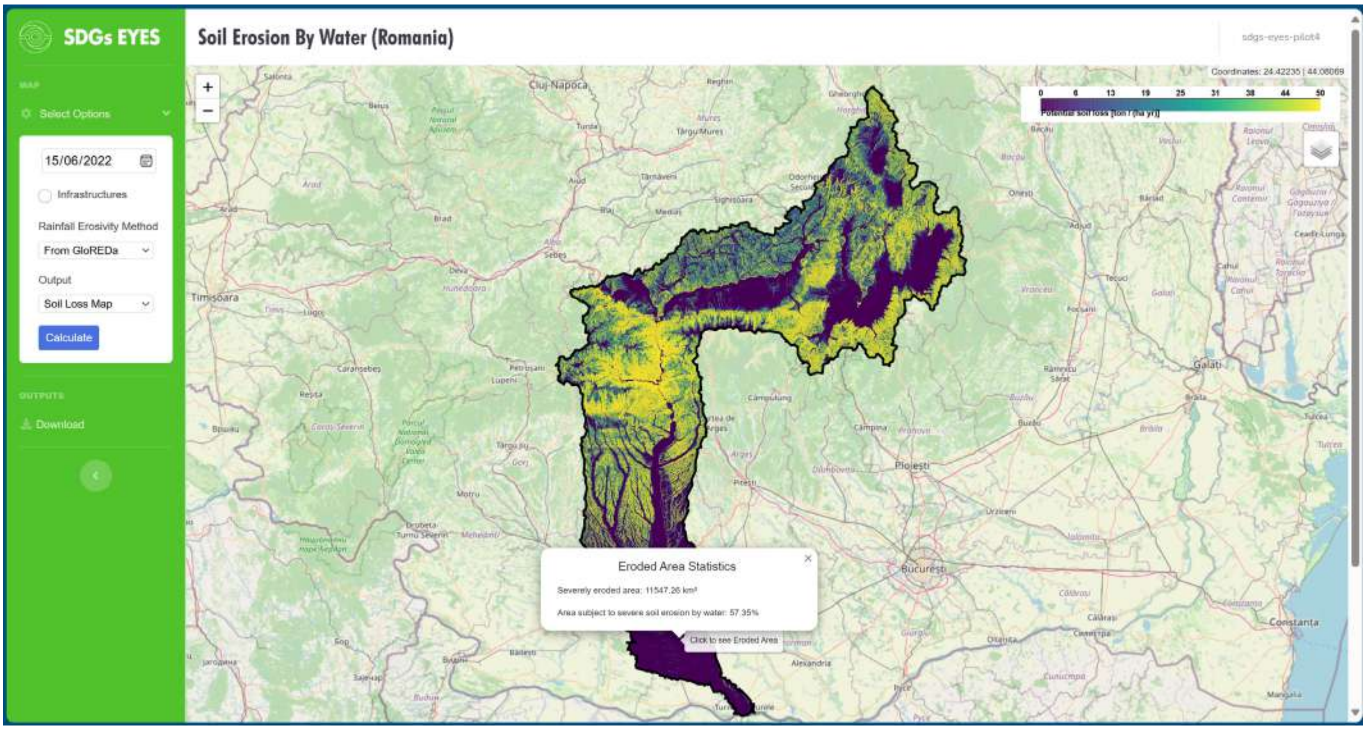


Figure 2. Example of the platform's dashboard capable of providing quarterly soil loss maps and statistics. The displayed data correspond to spring 2022.

Forward Looking

Looking ahead, the Soil Erosion by Water Assessment Tool aims to become a permanent, scalable tool for Europe and beyond. Immediate plans include continuing to update the methodologies and the data used, especially for rainfall erosivity and land cover factors, which are the two most dynamic factors influencing overall erosion, while rolling out the Soil Erosion by Water Assessment Tool nationwide in Romania, and collaborating with EU institutions to embed it within the EU Soil Observatory and Copernicus Land Monitoring. Beyond water erosion, the methodology could be adapted to monitor feedback with other land degradation processes, for instance linking the Soil Erosion by Water Assessment Tool with the tool to detect forest cover change developed in SDGs-EYES, thus further broadening the policy relevance of these services for land degradation monitoring. Continued user engagement and open-source collaboration will sustain and improve the Soil Erosion by Water Assessment Tool, ensuring it remains responsive to evolving needs. By the 2030 horizon, the goal is to make EO-based soil monitoring routine, supporting the EU and UN eff orts toward land degradation neutrality and sustainable development.

SDGs-EYES in short

SDGs-EYES aims to boost Europe's capacity to monitor the Sustainable Development Goals by harnessing the power of Copernicus Earth observation data. The project focuses on building a portfolio of decision-support tools to enhance the production and use of SDG indicators, with an emphasis on accessibility, reliability, and impact.

Enhancing Access and Usability of Earth observation Data

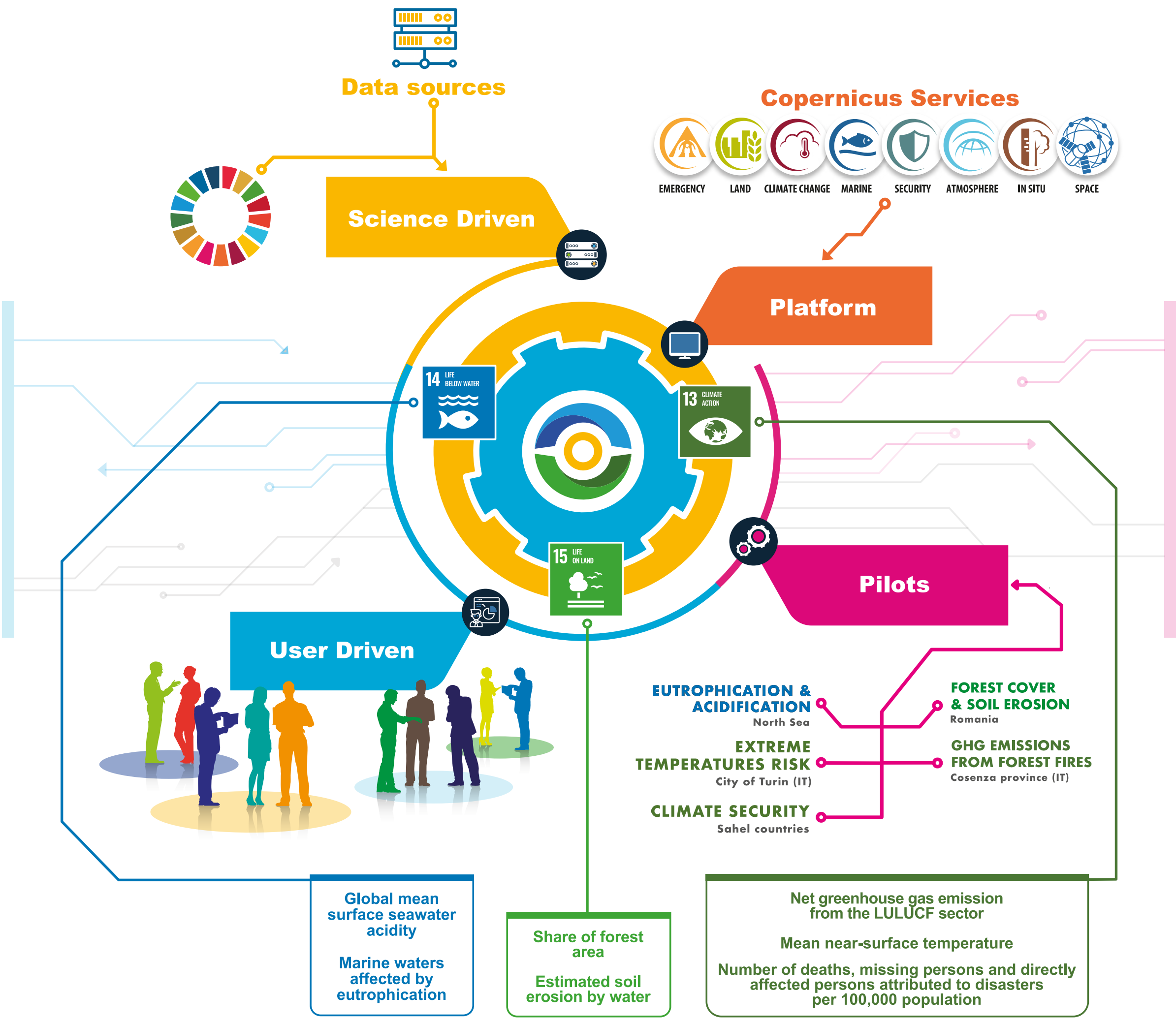
SDGs-EYES develops a scientific and technological framework to build robust and accurate indicators. It aggregates and processes data from Copernicus's six core services - along with space-based and in situ sources - to make Earth observation information more accessible and actionable.

Improving the Quality of SDG Indicators

The project demonstrates Copernicus-enhanced measurement for seven indicators across three SDGs goals (SDG 13 - Climate Action, SDG 14 - Life Below Water, SDG 15 - Life on Land). A cross-cutting indicator has been developed to assess the exposure of vulnerable communities to multiple and overlapping climate extremes.

Building Stakeholder Capacity for Societal Impact

SDGs-EYES delivers service-oriented data products that simplify the tracking and reporting of SDG indicators. These tools have been co-designed with users - including public authorities, researchers, and environmental agencies - to ensure usability and relevance in decision-making contexts.



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SDGs EYES

Find Out More

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PEFC – PEFC/48-01-01 – www.pefc.ro

Duration: 01/01/2023 - 31/12/2025

Acknowledgement

SDGs-EYES has received funding from the European Union's Horizon Europe Programme for research and innovation under project number 101082311.

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HADEA). Neither the European Union nor the granting authority can be held responsible for them.

Funded by the European Union