

Forest Tracker - From Data to Action: Forest Monitoring for Environmental Policy in Romania

SDGs-EYES service - Monitoring Sustainable Development Goal 15 - Using Earth observation (EO) data to monitor forest cover in the Olt River Basin in Romania

15 LIFE ON LAND



Forest Cover Change
(Eurostat code:
15_10)

KEY MESSAGES

Forests are essential for biodiversity, climate stability, and rural economies.

However, they are under increasing threat from both anthropogenic pressures and climate change impacts, including drought, fire, and erosion.

Earth observation (EO) supports actionable forest monitoring.

SDGs-EYES Forest Tracker service provides spatially detailed information on forest cover change and degradation dynamics using satellite data and validated field information, enabling policymakers to monitor forest loss and degradation over time.

Enabling SDG and EU environmental monitoring.

The SDGs-EYES service is aligned with SDG 15 (Life on Land) and relevant EU directives, supporting evidence-based forest conservation policies, restoration efforts, and sustainable land-use planning.



Scene Setting

Soil Forests host over 80% of terrestrial biodiversity and provide essential services including carbon sequestration, climate regulation, soil protection, water retention, and livelihoods for millions of people. However, forest cover continues to decline in Europe and globally - due to urbanization, agricultural expansion, unsustainable logging, and increasing frequency of natural disturbances like drought and fire. Climate change further intensifies forest vulnerability by amplifying stress factors such as extreme weather events, pest outbreaks, and wildfire risk. Together, human-induced degradation and climate-driven disturbances create a cascading effect that undermines forest health

and resilience. In Romania, where the [Forest Tracker service](#) has been developed as part of the [SDGs-EYES](#) project, forest loss and degradation are particularly concerning, especially in the Olt River Basin. The area includes significant natural forest coverage but also suffers from illegal logging, land use change, and poor enforcement of environmental regulations. Monitoring and responding to these changes requires robust, up-to-date, spatially disaggregated data on forest conditions and dynamics. Traditional monitoring systems are often slow or fragmented. The Forest Tracker service addresses this by integrating EO data and ground observations to deliver timely, high-resolution insights into forest evolution.

Forest Tracker: A New Tool for Monitoring Forest Coverage and Changes

The Forest Tracker is a fully automated EO-based system that provides high-resolution maps of forest cover changes and disturbances across time. The service was piloted in the Olt River Basin in Romania and [supports national and EU-level policy reporting on forest conservation and land degradation](#).

The service delivers [maps of forest loss, degradation, and regeneration](#) based on annual time series of Sentinel-2 satellite imagery. By analysing vegetation indices (e.g., NDVI) and temporal trends in spectral reflectance, the system can detect not only complete forest clearing but also subtler forms of degradation due to thinning, disease, or fire.

Co-designed with forestry and environmental agencies, the tool is tailored to reflect [national forest definitions and regulatory needs](#). It provides yearly classifications of stable forest, deforested, degraded, or regenerated areas, allowing authorities to track spatial and temporal patterns in forest change. By focusing on a spatially explicit, high-frequency approach, the service enhances situational awareness and provides early warnings for intervention. Outputs are designed to support planning, policy enforcement, and restoration efforts and are aligned with EU and international standards for land monitoring and ecosystem reporting.

Main Features of the Service

The Forest Tracker is designed to deliver consistent, scalable, and user-oriented forest change information. Using Sentinel-2 Level 2A data, the service applies temporal segmentation techniques to identify abrupt or progressive changes in vegetation cover. The analysis distinguishes between forest loss (complete removal of canopy cover), degradation (partial loss or structural damage), and regeneration (new forest growth or restoration efforts).

Key processing steps include:

- Pre-processing of EO imagery (cloud masking, geometric correction, reflectance normalization).
- Derivation of vegetation indices (e.g., NDVI, NBR) and temporal metrics.
- Application of threshold-based classification and change detection algorithms.
- Post-processing and generation of raster and vector layers for mapping forest condition categories.

The outputs are provided through a web-based dashboard that allows users to visualize forest change per year, zoom into specific areas, and extract statistics at municipal or county level. Data can be downloaded as georeferenced rasters (e.g. GeoTIFF) for integration into GIS platforms and as stand-alone images (e.g. PNG) for policy reports. The system architecture is modular and cloud-based, enabling scalability to other regions and transferability to different national contexts.

The Technical Side of the Service

The Forest Tracker workflow (Fig. 1) combines multiple inputs: Sentinel-2 L2A imagery, GEDI LiDAR data, DEM, Copernicus Forest Type, land use maps, and SUMAL logging points. The main steps are:

1. Pre-processing: Cloud masking, composite creation, harmonisation of ancillary datasets.
2. Change Detection: Multi-temporal Sentinel-2 analysis to identify canopy disturbances based on Advanced Vegetation Index.
3. Computation of Indicators:
 - a. Forest change maps
 - b. Forest disturbance maps
 - c. Share of forest cover over total land area.

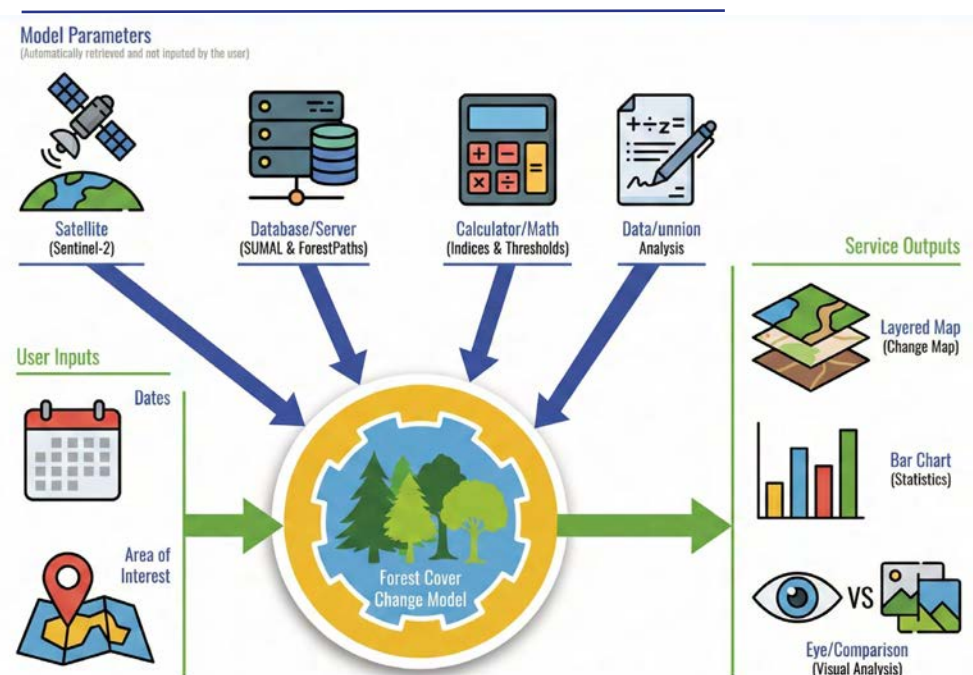


Figure 1. Forest Tracker Model Process.



What Does This Mean for Policy?

The Forest Tracker provides authorities with actionable data for forest protection, restoration, and sustainable land-use planning. For policymakers at regional, national, and EU level, the service supports environmental objectives across several dimensions:

- **Biodiversity Conservation:** It contributes to monitoring progress under the EU Biodiversity Strategy for 2030, which aims to protect and restore forests and reduce degradation by 2030.
- **Climate Mitigation and Adaptation:** Forests are vital carbon sinks. The service provides data for assessing forest-based climate strategies, aligning with the EU Climate Law and LULUCF Regulation.
- **Land Degradation Neutrality:** The service helps track degradation and regeneration patterns in support of SDG 15.3 and the UNCCD Land Degradation Neutrality framework.
- **Illegal Logging and Land Use Compliance:** By providing annual maps of forest disturbance, the service enhances transparency and enforcement, supporting national efforts against illegal logging.

Importantly, the service bridges the gap between remote sensing technology and policy needs by delivering outputs in formats compatible with national statistical and reporting systems. This improves data accessibility and usability by ministries, environmental agencies, and conservation actors.

From Barriers to Action: Enabling EO-Based SDG Reporting

Data Fragmentation

The Challenge: Forest-related data are often scattered across multiple agencies and managed in silos, leading to inconsistent and incompatible datasets. Different institutions (forestry departments, environmental agencies, research bodies, etc.) may each maintain their own records – from inventory statistics to satellite imagery – in varying formats and scales. This lack of harmonisation makes it difficult to assemble a **comprehensive picture** of forest conditions. Important information can fall through the cracks or take too long to compile, undermining timely decision-making. In short, fragmented data creates blind spots and inefficiencies in forest monitoring and policy enforcement.

Strategic Response: The **Forest Tracker** tackles fragmentation by integrating multi-year Earth observation data and ground observations into a single, streamlined workflow. Instead of disparate data sources, the service delivers one **annual, validated forest condition map** that all stakeholders can reference.

This unified approach ensures that everyone – from national policymakers to local forest managers – is working from the same up-to-date information. By harmonising data (e.g. using common formats and definitions for “forest” and disturbance), the service makes it easier to compare changes over time and across regions. Beyond the tool itself, a key recommendation is to promote open data standards and inter-agency data sharing frameworks. Encouraging agencies to adopt **common platforms or cloud-based repositories** for forest data will further break down silos. In essence, the service demonstrates how a centralized data approach can overcome fragmentation, and policymakers should build on this by investing in unified data infrastructures for forest monitoring.

Institutional Inertia

The Challenge: Many forestry agencies rely on long-established monitoring practices (e.g. infrequent field inventories or paper-based reporting) and can be slow to embrace new methods. There may be concern that introducing satellite-based monitoring will disrupt existing workflows or undermine the continuity of historical data series. As a result, forest loss is often addressed **reactively** – for instance, responding to illegal logging after the fact – rather than proactively. This institutional inertia, observed in Romania and across Europe, means innovative tools can remain underutilized even when they offer earlier warning and better coverage.

Strategic Response: The Forest Tracker service was **co-designed with Romanian authorities** (forestry departments, environmental agencies and statisticians) to ensure it complements rather than replaces traditional systems. By aligning with national forest definitions and reporting requirements, the EO-based approach slots into existing workflows seamlessly. A **phased adoption** is encouraged: side-by-side comparisons of satellite-derived results with conventional inventory data have been used to validate the new method and build trust. This gradual integration helps maintain long-term time series integrity while showcasing the added value of early detection (e.g. identifying hotspots of logging or effects of disease/insects disturbances). More broadly, instituting **joint working groups and training within agencies** can help overcome internal resistance – allowing staff to gain familiarity with EO tools and see them as enhancements to their work. Policymakers should also mandate or formally endorse the use of Earth observation outputs in forest monitoring and enforcement, which creates top-down momentum for change and a shift toward proactive management.

Insufficient Monitoring Frequency

The Challenge: Traditional forest inventory campaigns and reporting cycles are often too infrequent to capture rapid environmental changes. In many countries, comprehensive field inventories or surveys occur only once every few years (or even every decade), meaning that fast-paced changes – illegal logging spurts, wildfire damage, pest outbreaks, or storm losses – may go undetected until long after the fact. This low frequency of monitoring creates a **lag** in awareness: by the time problems are recognized in official reports, significant forest loss or degradation could have already occurred. In an era of climate change and intensive land use, forests can transform quickly, and infrequent monitoring struggles to track gradual declines in forest health as well. The result is that interventions often come late, and opportunities for early action (such as preventing an emerging pest infestation or halting unauthorized clearing) are missed.

Strategic Response: The **Forest Tracker** addresses this gap by providing **yearly updates** on forest conditions using up-to-date satellite data. Instead of waiting 5+ years for the next inventory, authorities receive **annual maps** that highlight where forest cover has been lost, degraded, or regained. This higher temporal frequency means both sudden changes (e.g. a large clear-cut or fire scar that appeared since last year) and subtle trends (e.g. a slow decline in canopy density due to drought or disease) are captured in near real-time. With yearly (or potentially more frequent) EO-driven assessments, policymakers and forest managers can respond much more proactively.

For example, if a hotspot of deforestation is detected in the latest annual map, enforcement actions or community engagements can be launched immediately rather than years later. Over the longer term, institutionalising such regular monitoring in policy frameworks is crucial. Governments are encouraged to **complement infrequent field inventories with continuous satellite-based monitoring** as a matter of standard practice.

By doing so, the **time gap** between forest change and policy response shrinks, enabling quicker interventions like protective measures or restoration efforts well before a small issue grows into a crisis.



Policy Inertia

The Challenge: Forest loss and degradation are too often addressed in a **reactive** manner rather than a proactive one. Policy measures frequently come after significant damage has been recorded or when crises (like massive illegal logging or destructive wildfires) draw public attention. This policy inertia stems from various factors – bureaucratic delays, competing economic interests, or simply a lack of timely evidence to trigger action – but its effect is clear: interventions lag behind the problem. Instead of implementing preventative strategies and safeguarding forests in advance, authorities may find themselves **playing catch-up**. This reactive approach not only allows avoidable damage to occur, but it can also lead to higher costs in restoration and lost ecosystem services, which might have been prevented with earlier action. In sum, slow policy response and hesitation to adjust course leave forests vulnerable to ongoing threats.

Strategic Response: The Forest Tracker service helps break policy inertia by functioning as an **early warning** system and decision-support tool. By flagging emerging issues through early detection – for instance, pinpointing a spike in tree cover loss in a particular area within the last year – the service empowers policymakers to shift from reaction to **prevention**. The spatially detailed maps enable targeted action: officials can identify exactly where interventions are needed (be it stepping up enforcement in an illegal logging hotspot, or allocating resources to combat a beetle outbreak in a specific forest). This level of timely, location-specific information supports more agile and forward-looking governance, allowing conservation and management measures to be deployed before problems escalate.

Moreover, using such data-driven insights can be built into the policy process itself. **Policymakers should formally incorporate EO outputs into forest management plans and emergency response protocols**, so that a signal of forest disturbance automatically prompts scrutiny and action. By mandating the use of up-to-date monitoring information (for example, requiring annual forest condition reports based on the latest satellite data), governments create a culture of proactive forest stewardship. In practice, this means not only reacting to forest loss after the fact, but actively working to prevent it – guided by continuous monitoring, early intervention in threatened areas, and strategic planning for restoration where needed. This shift – from inertia to initiative – is crucial for halting deforestation and achieving long-term sustainability goals in the forestry sector.

Experimental Results and Operational Validation

The Forest Cover Change (FCC) products for the Romanian pilot area successfully detected both large-scale events such as windthrow and clear-cuts, as well as small-scale selective harvests. Disturbance and change maps were generated at 20m resolution, capturing patterns often missed by coarser datasets.

Validation of the results relied on cross-comparison with the [ForestPaths – European Forest Disturbance Atlas](#) (Senf et al.) and the SUMAL 2.0 – Inspectorul Pădurii system, which reports legally approved harvesting activities in Romania. Spatial overlays showed high correspondence between FCC-detected disturbance patches and atlas-mapped events, especially for recent years (2019–2023). Agreement was strongest for large clear-cuts and windthrow areas, with more than 80% overlap in key hotspots. SUMAL data confirmed many of the detected patches as legal harvests, supporting the accuracy of disturbance localisation.

Cross-checked with ForestPaths - European Forest Disturbance Atlas

Ground Data Validation from SUMAL system, which reports the legal approved harvesting



Figure 2. Cross-validation of FCC outputs with the ForestPaths European Forest Disturbance Atlas (top left) and SUMAL 2.0 legal harvesting records (top right). Bottom left: observed changes from FCC outputs; bottom right: density of declared harvests from SUMAL.

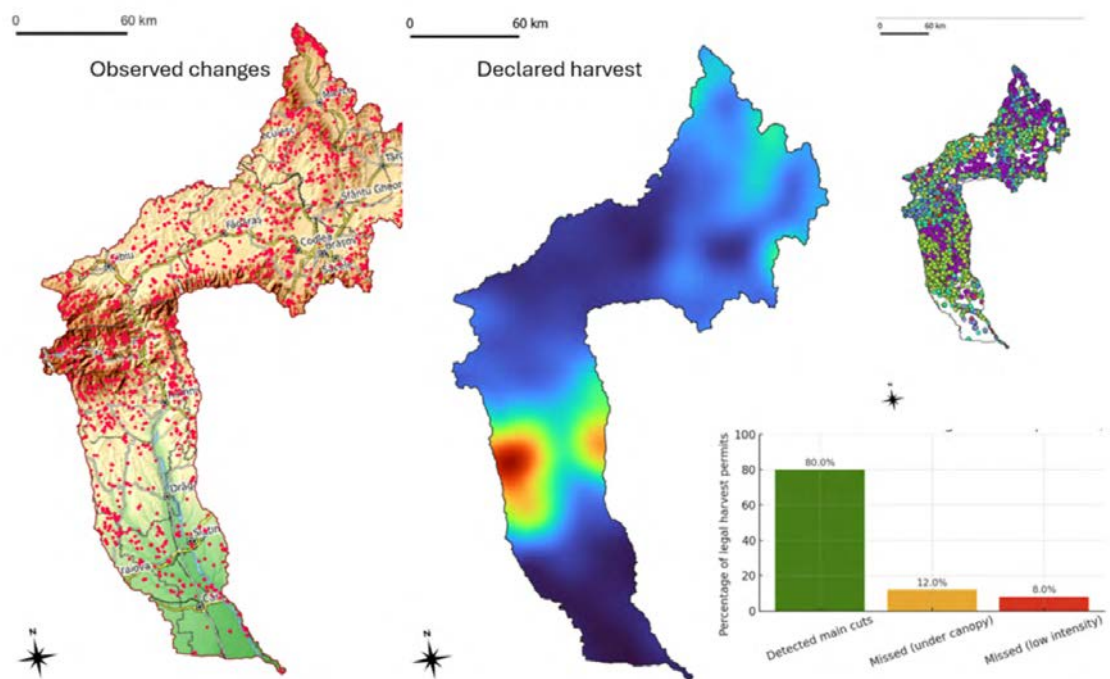


Figure 3. Comparison between FCC detections and legal harvest permits, showing the percentage of events detected (main cuts) and missed due to under-canopy or low-intensity harvests.

The computed share of forest cover values were within $\pm 5\%$ of national statistics, but offered sub-national detail for county-level monitoring. This granularity is particularly valuable for targeted conservation planning and compliance checks. The map of product agreement highlighted areas of strong alignment between FCC outputs and reference datasets, as well as zones of discrepancy - often in transitional areas such as shelterwood cuts and forest edges, where short-term canopy openings may or may not meet disturbance thresholds.

A quantitative comparison between FCC detections and SUMAL legal harvest permits showed that **approximately 80% of reported main cuts were successfully identified by the FCC algorithm**. The remaining 20% were missed, primarily due to under-canopy operations (around 12%) and low-intensity harvests (around 8%) that do not produce a sufficiently strong canopy signal to be detected with Sentinel-2 imagery. These results confirm the robustness of the FCC approach for open-canopy and large-scale disturbances, while indicating the need for supplementary techniques - such as radar-based time series or higher-resolution optical data - to capture sub-canopy and subtle changes.

Overall, the validation-driven FCC workflow proved computationally efficient, transparent, and well-suited for integration into operational EU and UN reporting frameworks. Its ability to combine multi-source EO data, in-situ records, and independent disturbance datasets enables reliable, high-resolution monitoring of forest dynamics.

The tool was reviewed in co-design workshops with stakeholders from the National Institute for Research and Development in Forestry (INCDS), Ministry of Environment, and local forest management units. Feedback resulted in refinements in the classification thresholds and visual interface. The service is now considered ready for broader national deployment.

Forward Looking

Building on the success of the Olt River Basin pilot, the SDGs-EYES Forest Tracker service aims to become a reference tool for forest condition monitoring in Romania and beyond. Expansion plans include:

- Geographic scaling to other Romanian counties and Balkan regions facing similar forest pressures.
- Improved resolution and temporal granularity, exploring bi-annual or seasonal updates to capture short-term dynamics.
- Integration with biodiversity datasets to assess habitat fragmentation and connectivity.
- Operational linkage with enforcement systems, such as alerting mechanisms for unauthorized logging.

Looking ahead, outputs from the Forest Tracker service are being progressively aligned with key policy frameworks, including the EU Forest Strategy indicators, the Nature Restoration Law, and Eurostat pathways for SDG 15 reporting. The service is designed to be adaptable for integration into Romania's national environmental monitoring infrastructure, and can also support local authorities in meeting their forest policy and reporting obligations. While uptake through Copernicus platforms and EU-supported forest governance networks offers a pathway to broader dissemination, the service remains equally suited for direct adoption by public agencies and stakeholders at regional and national levels.

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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

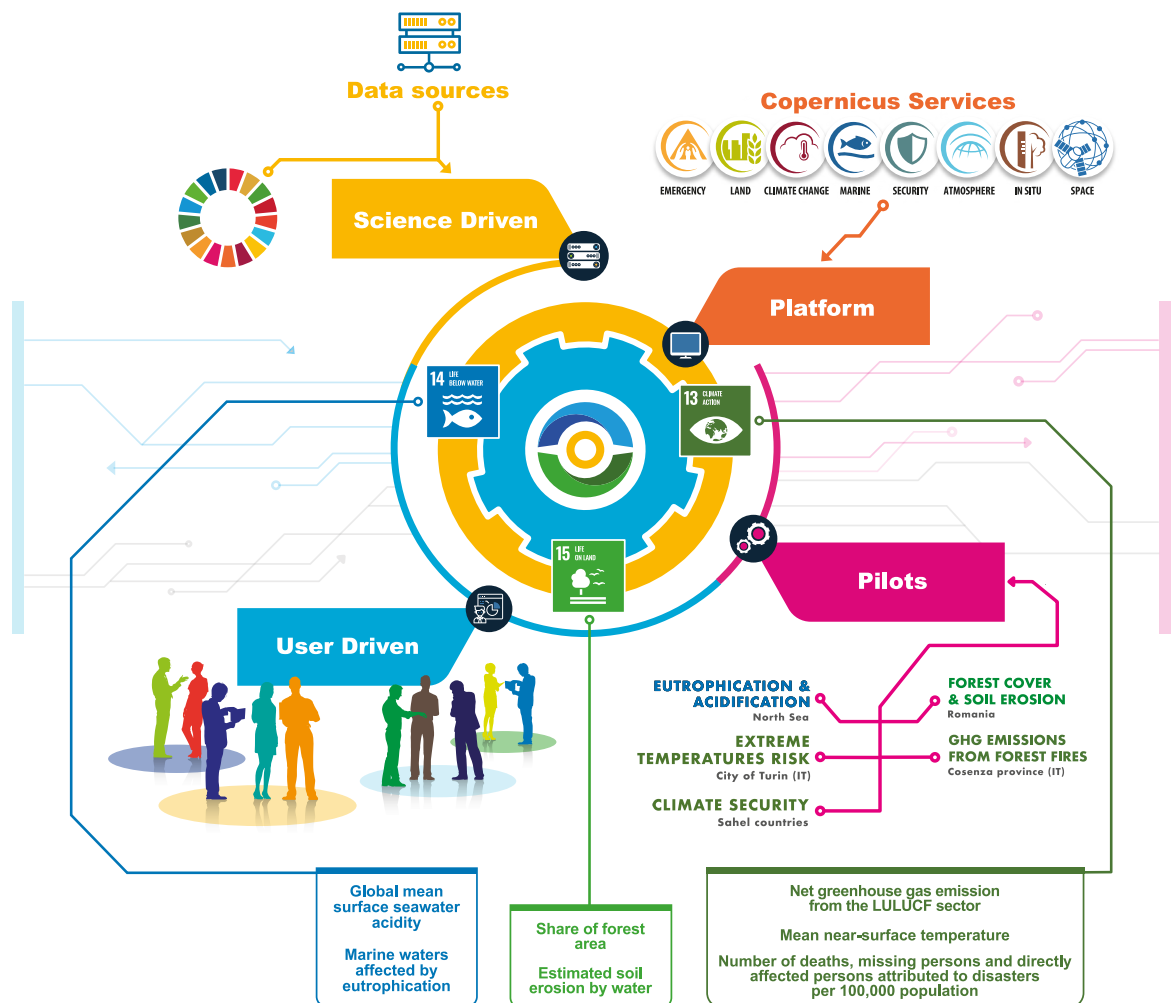
SDGs-EYES develops a scientific and technological framework to build robust and accurate indicators. It aggregates and processes data from Copernicus’s six core services - along with space-based and in situ sources - to make Earth observation information more accessible and actionable.

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.



SDGs EYES

Find Out More

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