Integrating soil erosion into land degradation monitoring: Insights from the SDGs-EYES project

Melissa Latella (melissa.latella@cmcc.it)

Soil and Water Systems (SOWAS) division,
Euro-Mediterranean Center on Climate Change (CMCC Foundation)

cmcc
Centro Euro-Mediterraneo
sui Cambiamenti Climatici

SDGs EYES

The SDGs-EYES project

PROJECT KEY INFORMATION

Project number: **101082311**

Duration: **36 Months** (Starting date: 1 January 2023)

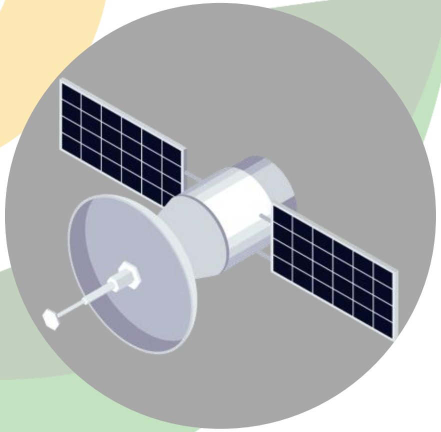
EU contribution: **HORIZON-RIA**

Consortium: **10 organisations from 6 countries**

Coordinator: **Fondazione CMCC**

Sustainable Development Goals- Enhanced monitoring through the family of Copernicus Services.

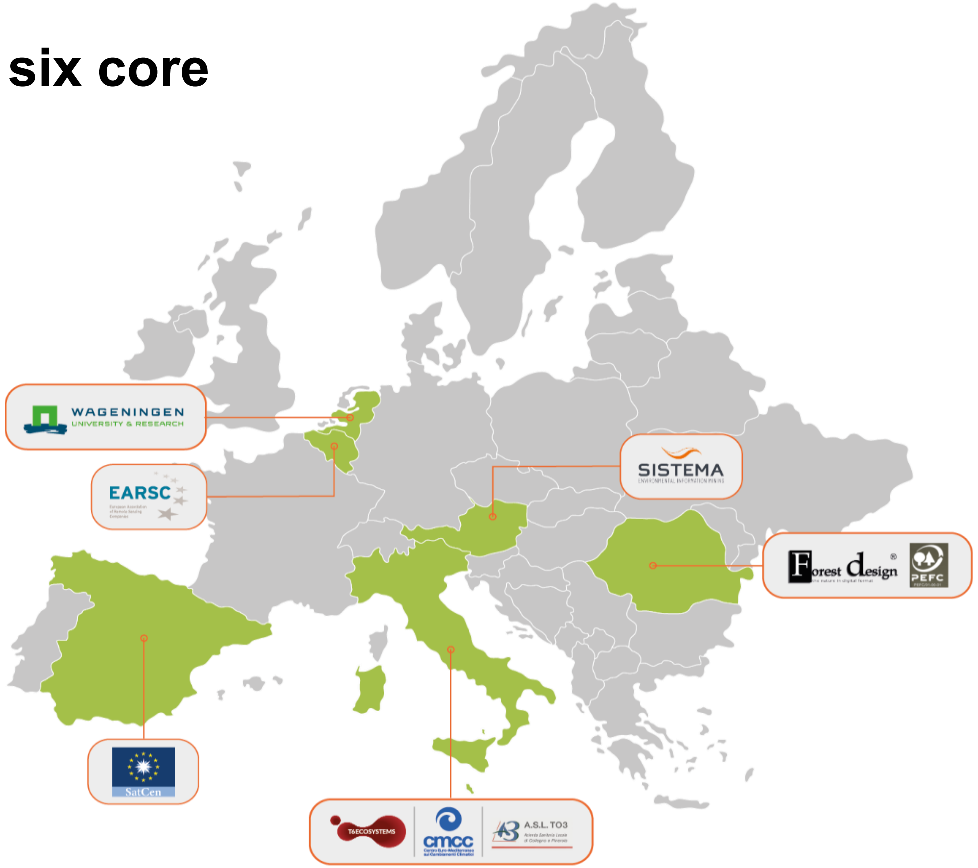
SDGs-EYES exploits and combines data from **Copernicus's six core services** to develop more accurate **SDGs indicators.**



Facilitate access and increase usability of Earth Observation information

Improve reliability, robustness and accuracy of SDGs indicators

Advance stakeholder capacity in the context of UN SDGs indicators



The SDGs-EYES project

Pilot-driven approach for demonstration, evaluation and assessment and an **agile development** of the SDGs-EYES Copernicus-based Service, closely **engaging stakeholders.**

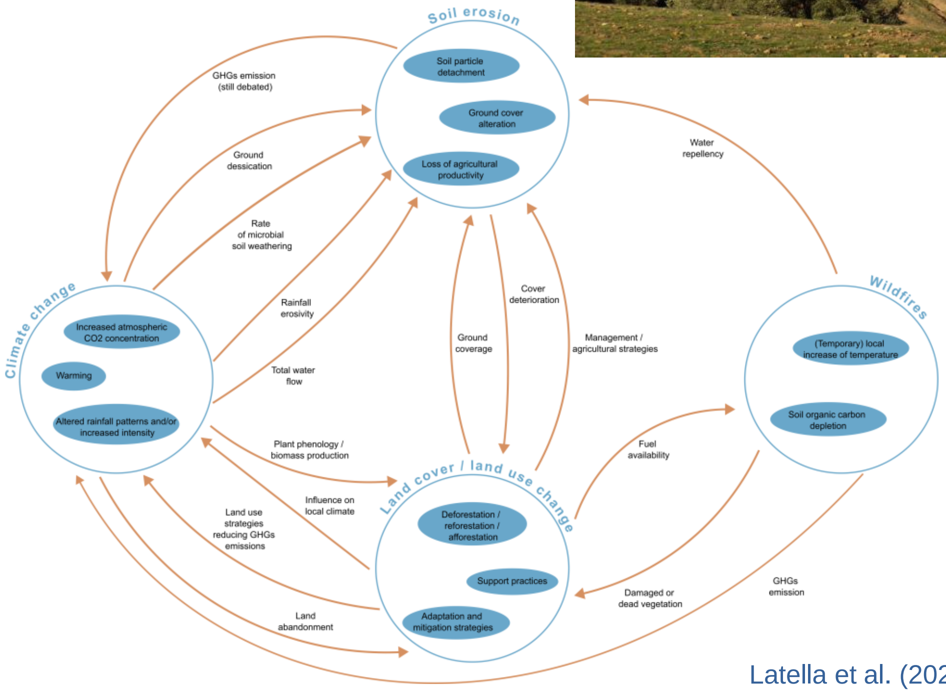
Why soil erosion?

62% of the European Union is affected by one or more **soil degradation** processes, among which **soil erosion by water.**

Anthropogenic activities lead to unbalanced rates of **soil loss** [e.g., 25% of EU, Panagos et al., 2015].

Soil erosion induces **on-site and off-site effects**, it overlaps with other degradation processes and **interacts with vegetation dynamics and climate change.**

Soil erosion in a forested slope (upper left), in a bare land (upper right) and in grasslands with sparse shrubs (lower row).



Latella et al. (2024)

Why soil erosion?

High costs for the EU (Panagos et al., 2018, Panagos et al., 2024)

- €1.25 billion/year agricultural productivity loss
- €155 million/year in GDP loss
- € 5 to 8 billion/year for sediment accumulation in large reservoirs
- €50 billion/year for loss of soil ecosystem services

Policy interest

- Preventing erosion is one of the 8 objectives (#5) of the *EU Mission: A Soil Deal for Europe*
- *S*oil erosion is one of the "soil descriptors" within the *Soil Monitoring Law* (Annex I)
- Soil erosion is one of the 28 agri-environmental indicator into the *Common Agricultural Policy*
- ***UN Indicator 15.3.1 - Proportion of land that is degraded over total land area*** assessed by using the corresponding ***EUROSTAT indicator: 15_50 - Estimated soil erosion by water*****.**

Indicator 15_50 Estimated soil erosion by water

Goal 1

Improve current assessments of the indicator through **a replicable and scalable workflow** based on data integration (EO products and other types) and artificial intelligence.

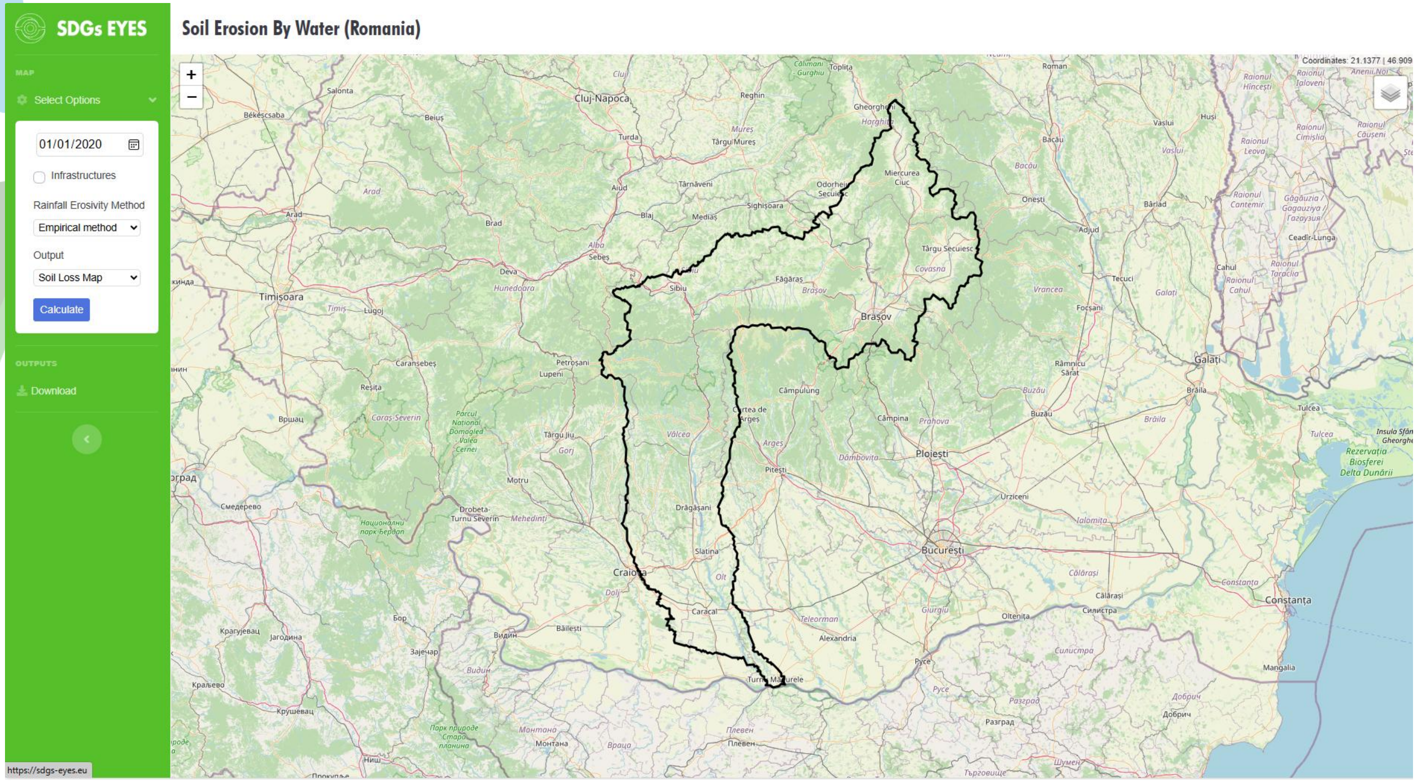
Feature	Score	Value	Potential improvements
Frequency of dissemination	n.a.	A-periodic	Quarterly
Timeliness	Low	> T + 2 years	Approx. 1 week
Reference area	High	All EU MS (+ UK)	All EU MS
Comparability – geographical	High	All EU MS	All EU MS
Coverage – Time	n.a.	Data points are 2000, 2010, 2016	Jan 2017 – present
Comparability – over time	Medium	3 data points	Time series
Unit of measurement	km^2 and % of the non-artificial erodible area		
Custodian agency	Eurostat		
Provider/Source	Data provider: European Commission – Joint Research Centre (JRC)		

Continuity is crucial for long-term monitoring and tracking change

Indicator 15_50 Estimated soil erosion by water

Goal 2

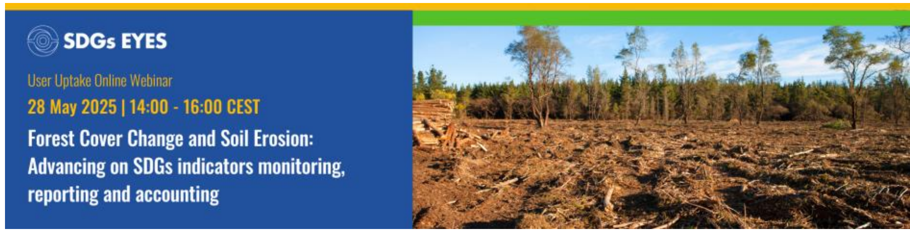
Provide a **<u>web-interface/programming environment for users</u>** to compute and visualize the indicator and its influencing factors.

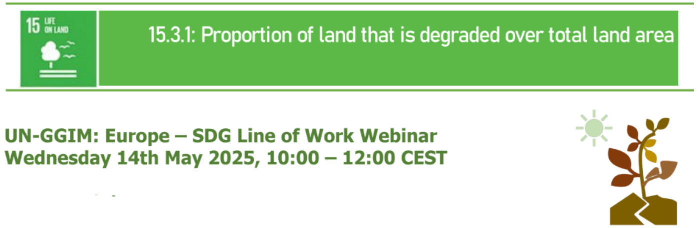


Stakeholder engagement

Stakeholders:
National and international authorities
Sectors: research, insurance, land planning and management, agriculture, transport.

→ **co-design approach!**





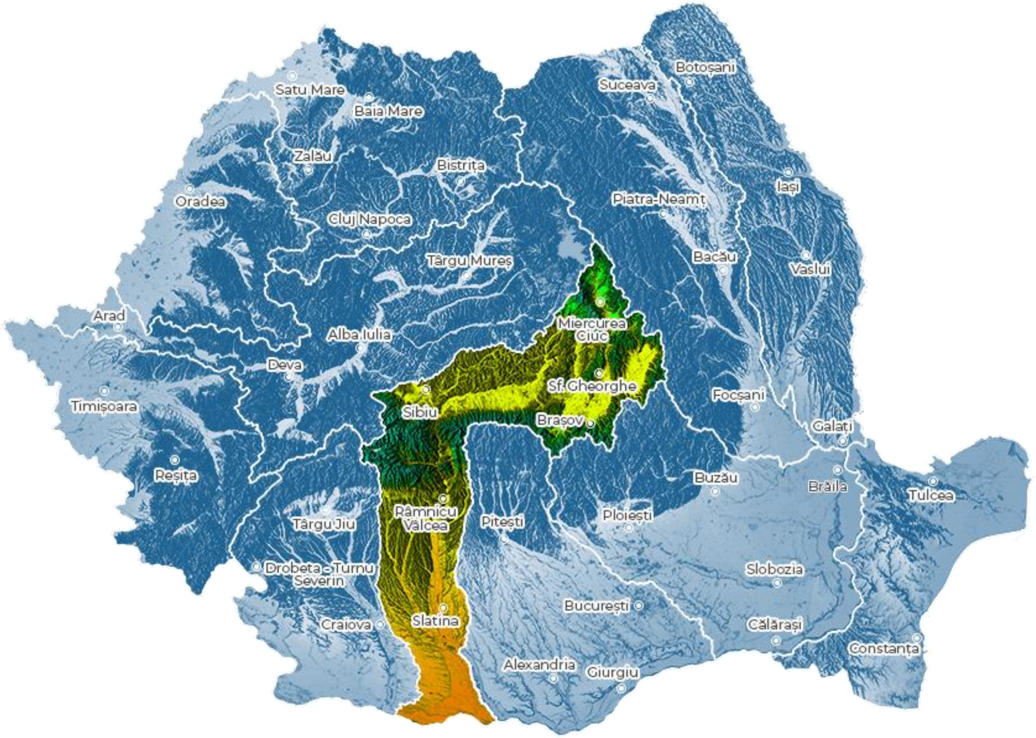
2023
Initial questionnaire

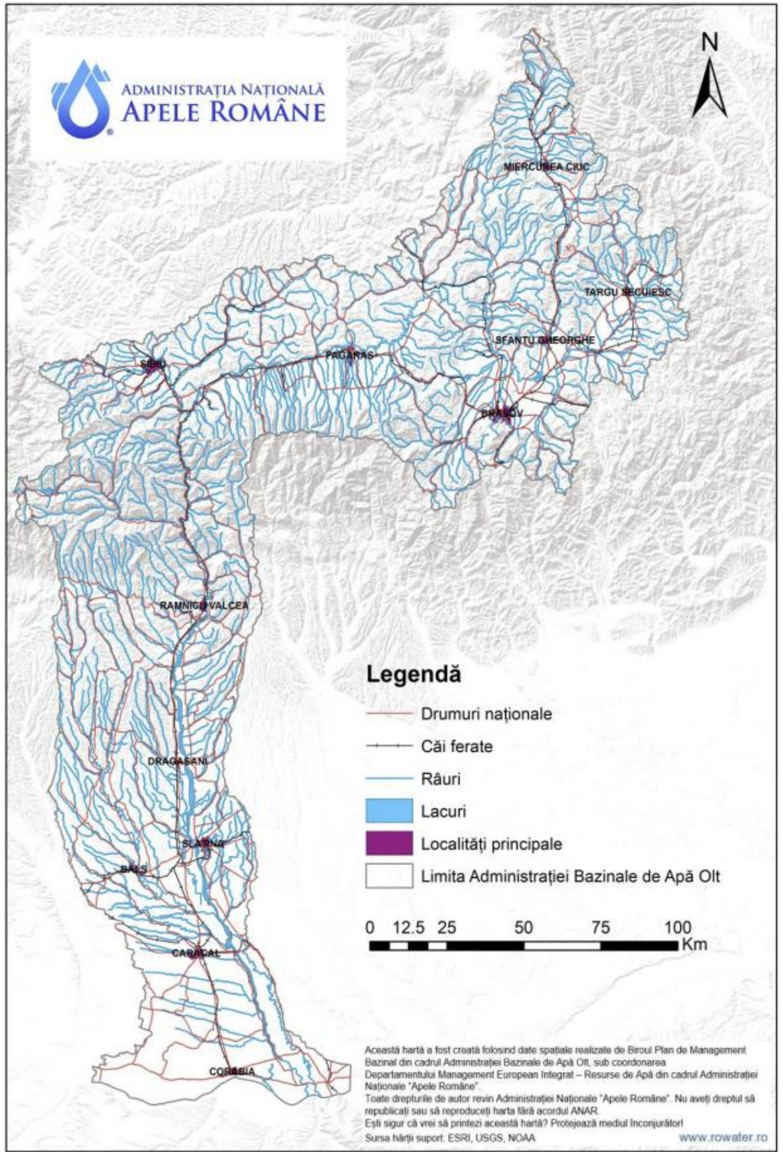
2024 (15-16 May)
First workshop in Brasov, Romania

2025 (14 May)
UN-GGIM: Europe Webinar

2025 (28 May)
User uptake webinar

Pilot 4B: Soil erosion by water





Olt river basin in Romania
River length: 615 km
Catchment area: 24,000 km2

Leader: CMCC
Partners: ForDes, Sistema, PEFC Romania

Methodology

Revised Universal Soil Loss Equation (RUSLE)

Potential long term average annual soil loss *A* (tons·ha^{-1}·yr^{-1})

Driving force   *Land response*

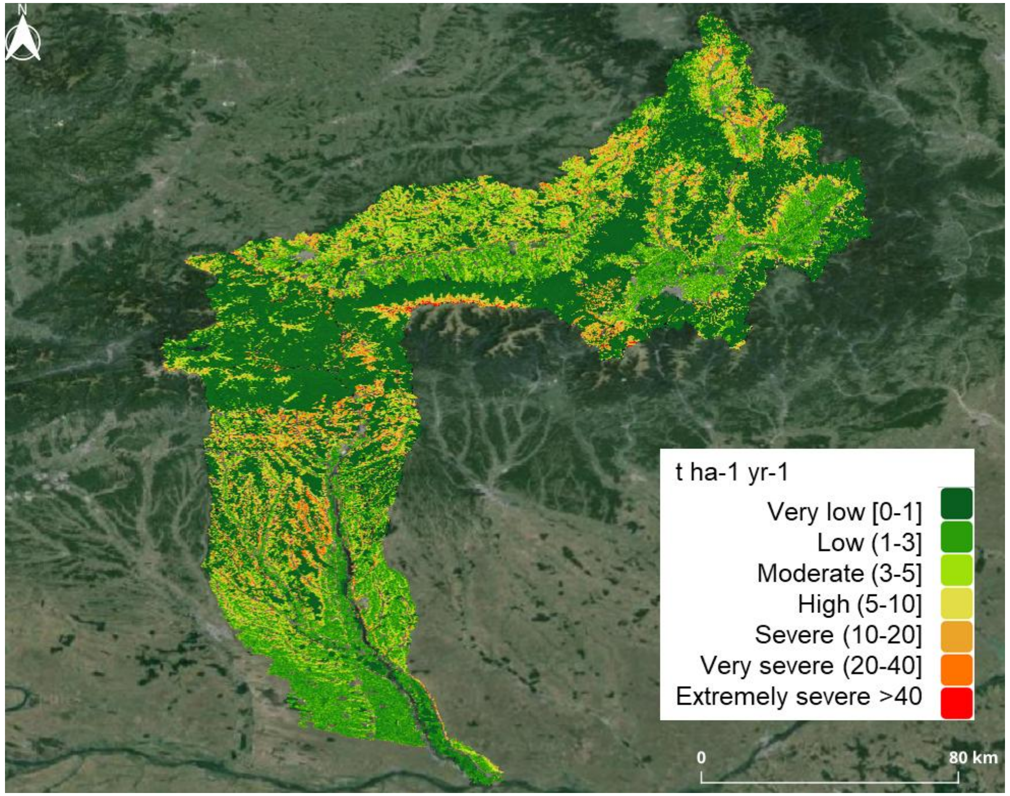
$$A = R \cdot LS \cdot K \cdot C \cdot P$$

- R: Rainfall erosivity
- LS: Slope length and steepness
- K: Soil erodibility
- C: Land cover and management
- P: Support practices

Renard et al. (1997)

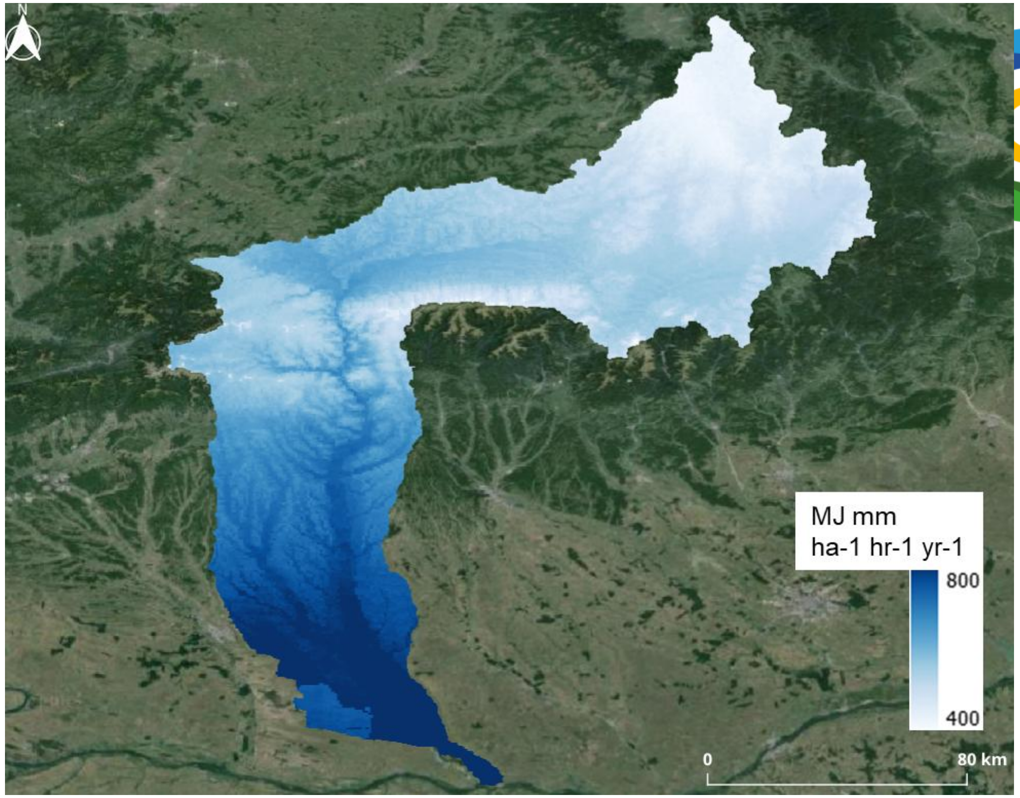
Gaps highlighted through literature review and **stakeholders' feedback.**

Example from ESDAC-JRC.



Rainfall erosivity (R-factor)

Clipping from the GloREDa dataset.



Computation:

- Rigorous formulation (Renard et al., 1997):

R is the average annual rainfall erosivity (MJ mm ha^{-1} h^{-1} yr^{-1}):

$$R = \frac{\sum_{j=1}^{n} \sum_{k=1}^{m_j} (EI_{30})_k}{n}$$

where n is the number of years recorded, m_j is the number of erosive events during a given year j and k is the index of a single event with its corresponding erosivity EI_{30}.

Challenges:

- It requires sub-hourly (15') precipitation measurements.
- SHs ask for: spatially explicit but gridded data are hourly or coarser.

Solution:

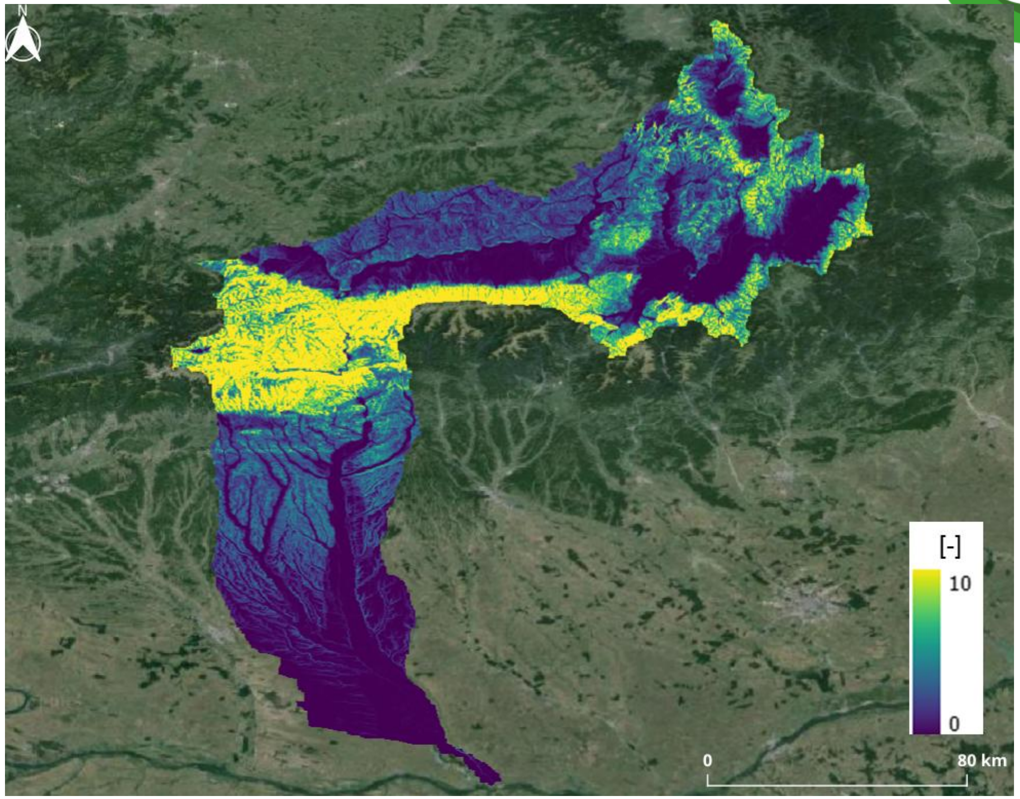
- Data-driven neural network approach to disaggregate gridded data from hourly to sub-hourly.

Slope length and steepness (LS-factor)

Computation:
DEM analysis in different steps.
Various literature methods for each steps available.

Challenges:
- No open-source code for the entire workflow available.
- SHs ask for improved spatial resolution, and inclusion of territorial features (transport infrastructures).

Output from SDGs-EYES



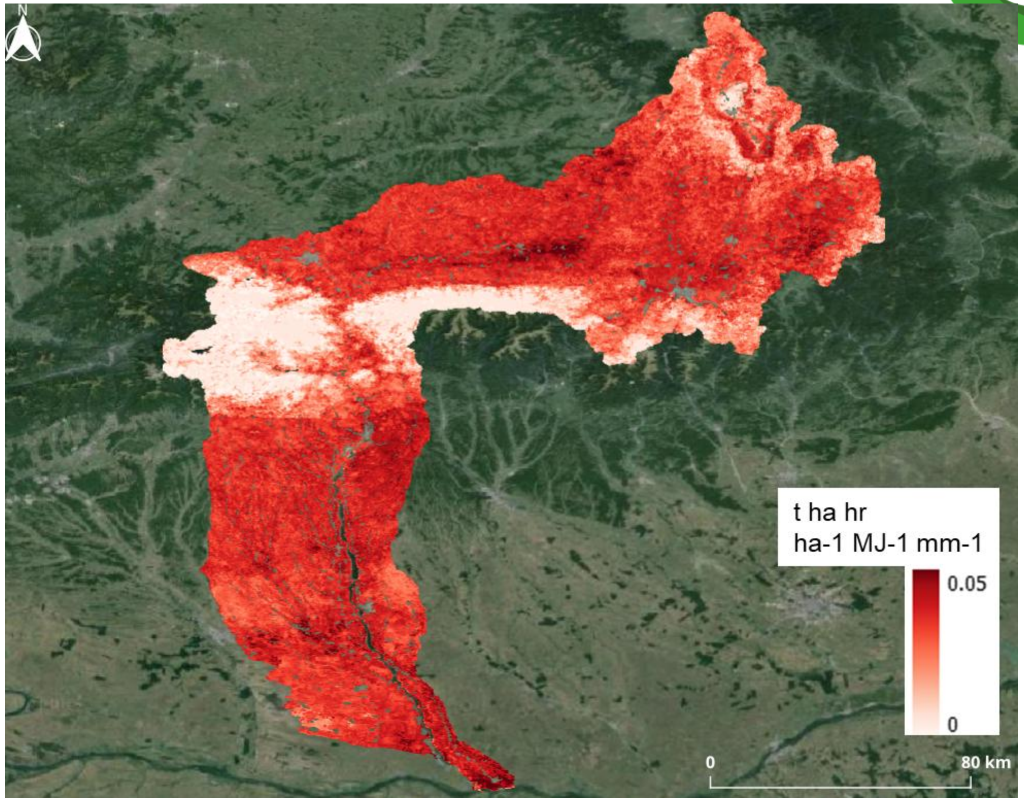
Solution:
State-of-the-art open-access algorithm with an innovative module for infrastructures.
From 25 to 10 m resolution.

Soil erodibility (K-factor)

Computation:
Empirical rules applied to textural and chemical soil features.

Challenges:
- No open-source code for the entire workflow available.
- SHs ask for improved spatial resolution, and inclusion of soil dynamics (e.g., altered post-wildfire hydro-repellency).

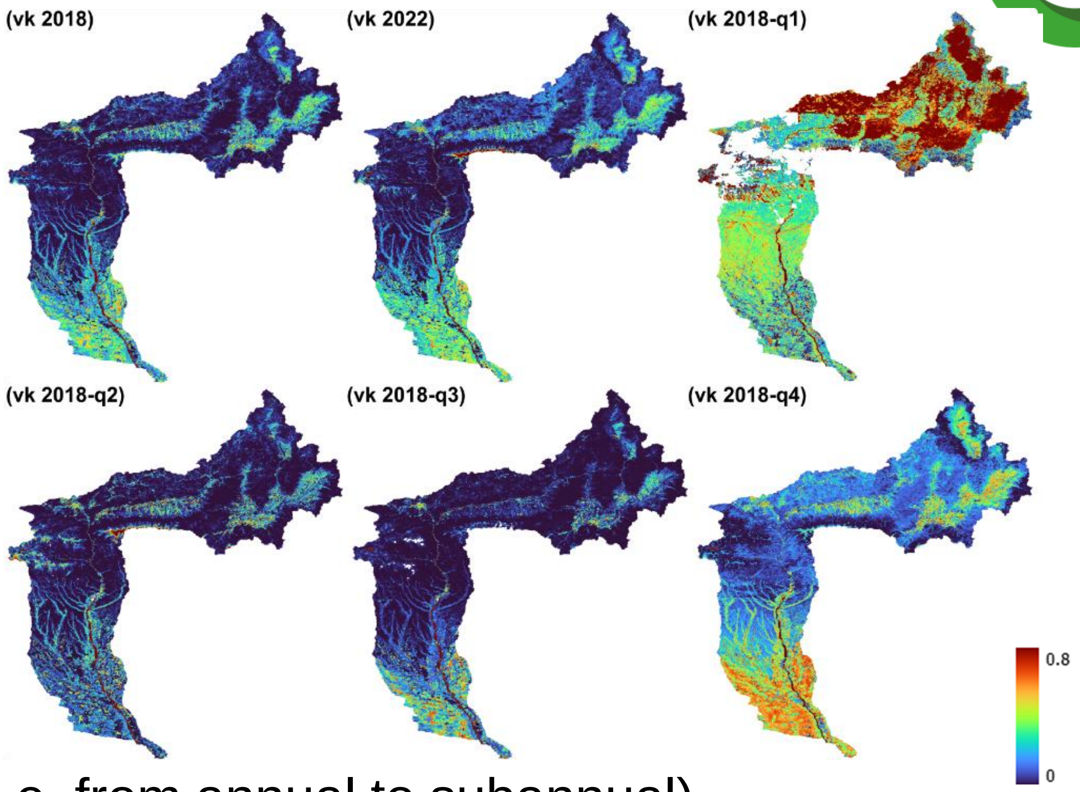
Output from SDGs-EYES



Solution:
v1. Open-access empirical algorithm. From 500 to 250 m resolution.
v2. (planned) Feedback from «forest cover» indicator or reference to wildfire datasets for post-wildfire response and forest dynamics.

Land cover and management (C-factor)

Output from SDGs-EYES for different time ranges



Computation:

Several methods, some of which relating C to NDVI or other spectral indexes.

Latella et al., CATENA (under review)

Challenges:

- High uncertainty in the regression.
- Every spectral index has limitations.
- Massive data is available but data-driven methods are
- still under-developed.
- SHs ask for improved spatial resolution, and the inclusion of land use and phenological dynamics (i.e. from annual to subannual).

Solution:

Neural network to determine C based on spectral properties. From 100 to 10 m spatial resolution.

Support practices (P-factor)

Computation:
Often equal to 1 in applications because of data scarcity
Or set arbitrarily

Solution:
Obsolete when LS and C are improved.

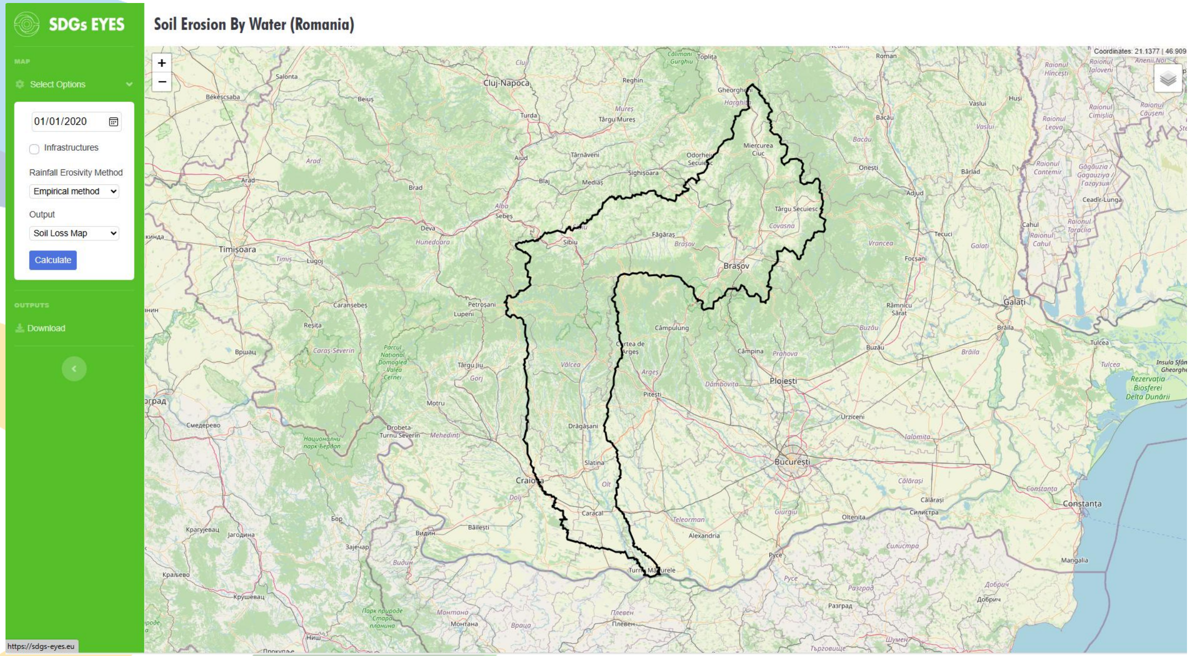
Terraces

Grass margins

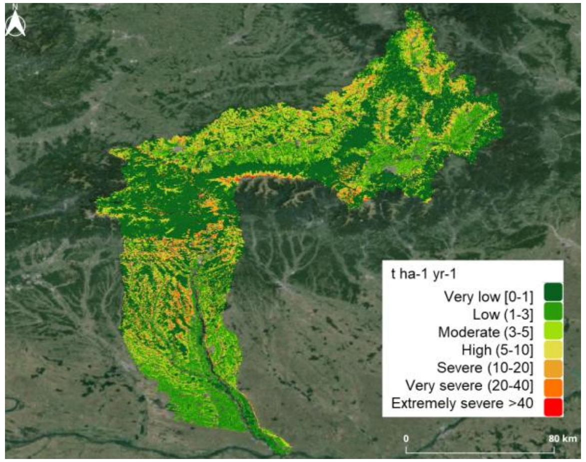
Stone walls

Contour farming

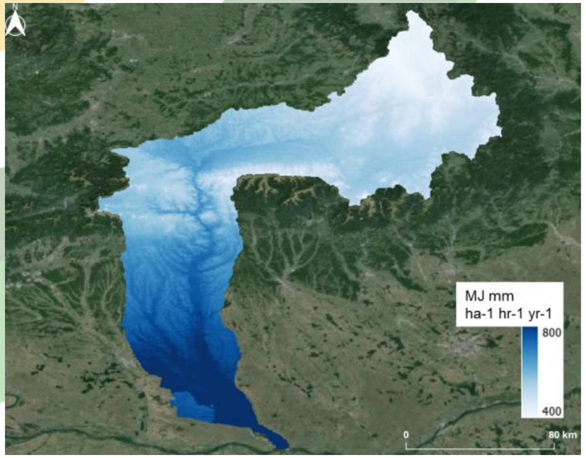
User interface



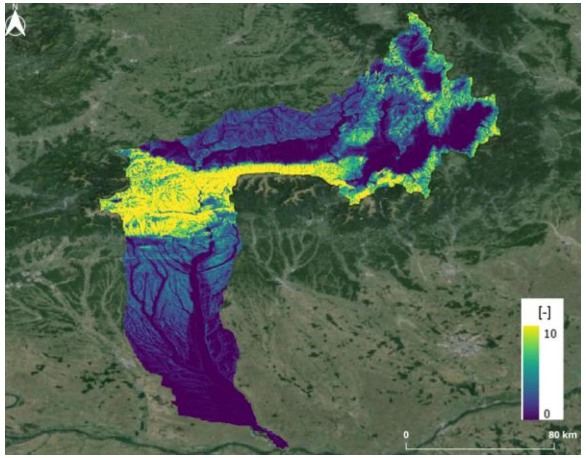
Soil Loss v1.0 (ESDAC JRC)



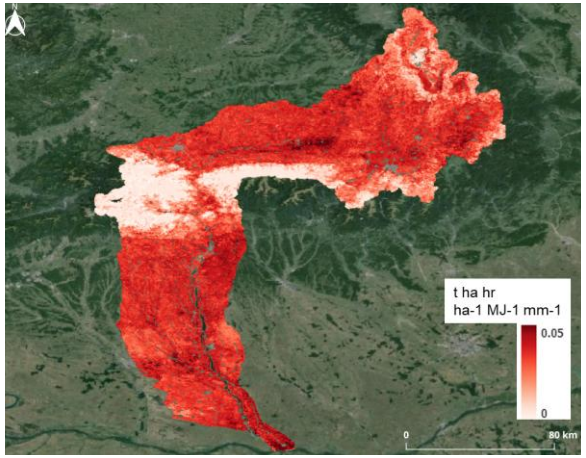
R-factor v1a



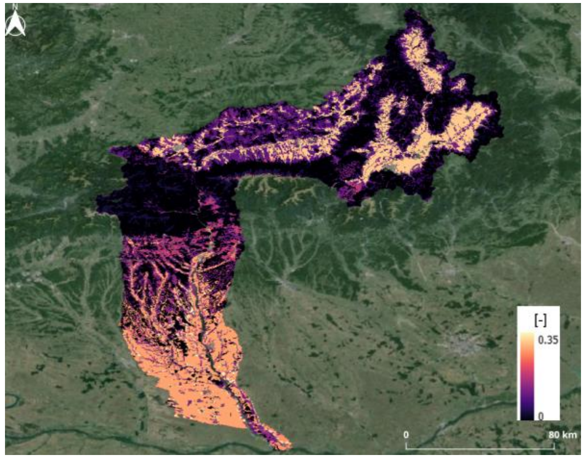
LS-factor v1



K-factor v1



C-factor v1.0 (ESDAC-JRC)



Input data

Factor	Type of data	Used dataset
R	Precipitation time series from meteostations	Provided by MeteoRomania
	Gridded precipitation	ERA5-Land
K	Gridded soil properties	SoilGrids
LS	Digital elevation model	EDTM30, next version: EEA-10
	Shapefiles of infrastructures	From Romanian Geoportal
	Land cover	CLC18
C	In-situ land cover information	LUCAS (2018-2022)
	Phenological information	Start, end, max of season by CLMS
	Spectral images	Sentinel-2

Data needed for training and validation only

Replicability and scalability

Factor	Type of data	Used dataset	Replicability	Scalability (data)	Scalability (resources)
R	Precipitation time series from meteostations	Provided by MeteoRomania	The algorithm has proven to be generalizable	To be retrieved if fine-tuning	• ERA5Land storage • Computationally demanding → parallelization?
	Gridded precipitation	ERA5-Land		Global coverage	
K	Gridded soil properties	SoilGrids	Yes	Global coverage	Yes
LS	Digital elevation model	EDTM30, next version: EEA-10	Yes	EDTM30 has global coverage	• Computationally demanding and spatially-dependent at the river basin scale
	Shapefiles of infrastructures	From Romanian Geoportal		Other datasets with global coverage (e.g., OSM)	
	Land cover	CLC18		Other land cover available with global coverage (e.g. DynamicWorld)	
C	In-situ land cover information	LUCAS (2018-2022)	Training and validation across Europe → new training for other areas	To be retrieved	• S2 storage; • Computationally demanding → parallelization?
	Phenological information	Start, end, max of season by CLMS		European coverage	
	Spectral images	Sentinel-2		Global coverage	

Visit the website:
https://sdgs-eyes.eu/

Follow us:
X (twitter)
LinkedIn

SDGs EYES

The SDGs-EYES project is funded by the European Union

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.”