The new Soil Erosion map of Europe: A Contribution to soil conservation

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Soil Biodiversity loss
Sealing
Decline of Soil Organic Matter
Salinization
Compaction
Contamination
Landslides
Erosion

Soil Threats

Soil degradation through erosion has been identified as major threat to European soils and agriculture.

European Commission requested new assessments to the Joint Research Centre.

- **Water Erosion**
- **Wind Erosion**
- **Forest Erosion**
Why we do soil erosion modelling?

- **Develop Indicators for EU Statistical services (DG ESTAT):** Aggregated data at different regional levels (per country, Region, province)

- **Policy support to DG AGRI:** Common Agricultural policy impact. Provide aggregated data for agricultural areas with soil loss rates $> 10 \text{ t ha}^{-1} \text{ yr}^{-1}$

- **Policy Support to DG ENV:** Monitor the state of soils (Aggregated data & maps of soil erosion)

- **European Environmental Agency (EEA):** State of the Environment report

- **EUROPE 2020:** Develop soil erosion indicator for Resource efficiency scoreboard

- **Development of Green Growth Indicators for the Organisation for Economic Co-operation and Development (OECD):**

- **Scientific Collaborations & “Open Data Access” through the European Soil Data Centre (ESDAC):**
  - Distribute data (soil erodibility, rainfall erosivity, support practices, Cover Management, Topography, etc.) to the scientific community and policy makers in EU-countries
  - **400 datasets of K-factor** (April 2014–Aug 2015); **200 datasets of R-factor** (Jan - Aug 2015), **150 datasets** in Erosion RUSLE2015 (Sept 2015).............
Soil Erosion EIONET Map (2009-2010)

Panagos et al. (2014), Soil Science & Plant Nutrition
RUSLE2015: New soil erosion model

\[ A = K \times R \times C \times LS \times P \]

Soil Erodibility (K-factor)

Soil Erodibility is an integrated annual value of the soil profile reaction to the process of soil detachment and transport by raindrops & surface flow.

- Combines the influence of **Texture**, **Organic carbon**, **soil structure**, **Permeability**, **coarse fragments** and **Stone cover**
- **20,000** Land use/cover survey (LUCAS) samples with measured data
- **Regression interpolation** using Terrain features, Lat/Long, vegetation covariates
- **Spatial Resolution**: 500m
- **Stone cover effect**: 15%; Important effect in Mediterranean
- **Verified** against 21 local, regional and national datasets from 13 countries

Rainfall erosivity and data collection

- **Rainfall erosivity** is the kinetic energy of rainfall (MJ mm ha$^{-1}$ h$^{-1}$ y$^{-1}$)
- Combines the influence of precipitation duration, magnitude and intensity
- **Participatory approach**: Environmental & Meteorological Services from all Member States (Mar 2013 – Jun 2014).
- **1,541 Precipitation stations** with detailed rainfall intensity (all countries)
- **Calibration requested**: 5 min, 10-min, 15 min, 60 min.
- **Temporal Resolution**: 30-Minutes
- **Time series**: 7 – 56 Years (Mean: 17.1yr; 75% of time series in 2000-2010)
- **Data**: 26,394 years of High Temporal resolution precipitation records
- **REDES**: Rainfall Erosivity Database on the European Scale

Rainfall Erosivity (R-factor)

- Resolution: 500m; **Robust Geostatistical** model
- Highest R-factor in Mediterranean & Alpine regions and lowest in Scandinavia
- R-factor **not dependent** only from precipitation

Panagos et al. (2015)
Differentiate between Arable lands & Non-Arable lands

Non arable: Forest – Shrub – sparse vegetation – Heterogeneous – Permanent crops - pastures/grasslands

Use of CORINE Land Cover classes

- Calibrate the C-factor from literature: 20 major published studies
- with Remote Sensing (RS) images from Copernicus Programme: Vegetation Density layer: RS every 10 days

Example: Pastures C-factor

- Range from literature: 0.05 – 0.15
- Each pixel gets a value in this range depending on its Vegetation Density (0-100%)
- Pastures (mean) C-factor in Ireland: 0.077
- Pastures (mean) C-factor in Cyprus: 0.125

Arable lands C-factor: Crop factor & management

**Crop factor:** C-factor (from experimental sites in the European Union) for 17 crops. e.g. wheat: 0.20, Rice: 0.15, Potatoes: 0.34, Maize: 0.38, .......... cotton seed: 0.5

Estimate the **C-factor per region** based on its crop composition

**Plus 3 management sub-factors** (using input official data from EUROSTAT): 

Topography (LS-factor)

- **25m DEM → resolution 25m LS-factor** (capture geomorphological features compared to 100m DEM)

- Desmet & Govers algorithm (1996)

- Fast process with SAGA software

- **50GB** of dataset available in European Soil Data Centre (ESDAC)

- No arbitrary limitations in slope length

- Slope cutoff: 50% (after literature review & experimental results in Switzerland)

*Panagos et al. (2015), Geosciences, MDPI*
Support Practices (P-factor)

Data input from:
- Good Agricultural Environmental Conditions (GAEC) plus
- LUCAS 270,000 earth observations

Support practices Impact:
- Contour farming (5%)
- Stone Walls (38%)
- Grass Buffers (57%)

P-factor in EU-28: 0.97
P-factor in arable: 0.95

Soil water erosion

- Average EU-28: \(2.46 \text{ t ha}^{-1} \text{yr}^{-1}\) (in the erosive prone areas: 91% of EU)
- Total Soil loss: 970 Mt annually
- Spatial resolution: 100m
- Reference year: 2010
- 24% of EU lands have rates >2 t/ha
- 11% of total area contributes to almost 70% of total Soil Loss

“Between 2000 and 2010, intervention measures through the CAP have reduced the rate of soil erosion by an average of 20% for arable lands”

Change on soil erosion potential 2000 - 2010

Agricultural land

"...between 2000 and 2010, intervention measures through the Common Agricultural Policy have reduced the rate of soil loss in the European Union by an average of 9.5% overall, and by 20% for arable lands”

"...the amount of soil lost to water erosion in Europe equates to an estimated economic loss of about US$20 billion per year”

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<th>Country</th>
<th>2000</th>
<th>2010</th>
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RUSLE2015 & Soil Loss Map: Concluding remarks

- **Trend**: Decrease of 9% (20% in arable lands) due to impact of Common Agriculture Policy (CAP) and soil protection measures: reduced tillage, plant residues, cover crop, contour farming, maintenance of stone walls, increase of Buffer strips.

- Very good correspondence with EIONET (7 out of 9 Member States): The European model is as robust as national ones.

- **High resolution** (100m) & **best available** input data in EU

- **Transparent way & easily parameterization**

- **Peer-reviewed following literature** (> 20 publications during the last 3 years)

- **Replicable & comparable** with national estimates

- **Participatory**: involvement of countries (R-factor, K-factor, Statistics - EUROSTAT)

- **Scenario analysis**:
  - Land cover change (Land Use Modelling Platform – LUMP 2050)
  - Management changes (Policies: CAP 2014-2020, Biofuels directive)
  - Climate Change (precipitation & intensity trends in 2050)

The following scenarios were simulated to assess the impact of GAEC application on soil erosion and SOC conservation:

a) ‘Baseline’: it refers to the conditions before cross-compliance introduction (2003)

b) ‘Current’: This scenario is based on the implementation of the compulsory GAEC standards.

c) ‘Technical potential’: GAEC standards are applied to the entire surface for a long-term period (2050).
Pilot area: Potential Impact of GAEC Application – soil erosion

‘baseline scenario’
Soil loss:
- $8.33 \text{ t ha}^{-1} \text{ yr}^{-1}$
- 29.2% > 10 t ha$^{-1}$ yr$^{-1}$

‘current scenario’
Soil loss:
- $7.43 \text{ t ha}^{-1} \text{ yr}^{-1}$
- 25% > 10 t ha$^{-1}$ yr$^{-1}$
- Decrease ca. 11%

‘technical potential’
Soil loss:
- $4.1 \text{ t ha}^{-1} \text{ yr}^{-1}$
- 10.2% > 10 t ha$^{-1}$ yr$^{-1}$
- Decrease ca. 50%

Borelli et al (2016) – Land Use Policy
Soil organic carbon
Current scenario

a) organic carbon lost by erosion in the **baseline** scenario;

b) avoided eroded C with **GAEC** application;

c) SOC stock (0-30 cm layer) in the **baseline** scenario;

d) SOC accumulation due to **GAEC** application.

*Borelli et al (2016) – Land Use Policy*
Soil erosion in forestland: Europe

Soil loss rates (30-year average)

- Undisturbed forest: \(0.09 \text{ Mg}^{-1} \text{ ha}^{-1} \text{ yr}^{-1}\)
- Logged forest: \(0.45 \text{ Mg}^{-1} \text{ ha}^{-1} \text{ yr}^{-1}\)

Undisturbed forest: \(0.37 \text{ Mg}^{-1} \text{ ha}^{-1} \text{ yr}^{-1}\)
Logged forest: \(3.0 \text{ Mg}^{-1} \text{ ha}^{-1} \text{ yr}^{-1}\)

Borrelli et al., 2016. Ecological Indicators 60, 1208–1220
The first quantitative assessment at European level.

Main Factors influencing wind erosion:

**Climate**: wind velocity & direction, Rainfall and evaporation

**Soil characteristics**: sand, silt, clay, CaCO3, organic matter, water-retention capacity and soil moisture

**Land use**: land use type, percent of vegetation cover and landscape roughness

**Model used**: RWEQ

**Average erosion is 0.6 t/ha/yr.**

*Borrelli et al (2014) - Journal of Land Degradation*

*Borrelli et al (2014) - Geoderma*

*Borelli et al (2015) – Sustainability*
Information in peer review publications:

Rainfall erosivity in Europe
Panos Panagos 1,2, Cristian Ballabio 1, Pasquale Borrelli 1, Katrin Meusburger 2, Andreas Klik 2, Svetlana Roussea 4, Melita Perfeć Tadić 6, Silvia Michaudides 6, Michaela Hrabálová 2, Preben Olsen 6, Juha Aalto 4, Mónika Lakatos 1, Anna Rymiszewicz 4, Alexandru Dumitrescu 1, Santiago Begeru 2, Christine Alewell 2

Soil Erosion in Europe: A high-resolution dataset based on LUCAS
Panos Panagos 1,2, Katrin Meusburger 2, Cristian Ballabio 1, Pasquale Borrelli 1, Christine Alewell 2

Assessment of the cover changes and the soil loss potential in European forestland: First approach to derive indicators to capture the ecological impacts on soil-related forest ecosystems

Estimating the soil erosion cover-management factor at the European scale

The new assessment of soil loss by water erosion in Europe

A New European Slope Length and Steepness Factor (LS-Factor) for Modeling Soil Erosion by Water
Panos Panagos 1,2, Pasquale Borrelli 1 and Katrin Meusburger 2

European Soil Data Centre:
http://esdac.jrc.ec.europa.eu/