Coupling a high resolution soil erosion model with an agro-ecosystem model of SOC dynamics

An approach to assess the potential environmental effect of the new Common Agricultural Policy on soil degradation


http://esdac.jrc.ec.europa.eu/
Policy background

The EU thematic strategy for Soil Protection (COM 2006. 231) has identified eight main threats to soils:

- Erosion
- Contamination
- Organic Matter Loss
- Biodiversity Loss
- Compaction
- Salinisation
- Floods-Landslides
- Sealing
In 2013, the European Commission requested to the JRC new soil erosion assessments.
Brief overview of the JRC Soil Degradation Research Activity

Water Erosion

Wind Erosion

Forest Erosion

Panagos, Borrelli, Poesen et al. 2015. Environmental Science & Policy, 54

Borrelli et al. 2014. Geoderma, 232

Borrelli et al. 2014. Land Degradation & Development

Borrelli et al. 2015. Sustainability, 7

Borrelli et al. 2016. Ecological Indicators, 60

Borrelli et al. 2014. Applied Geography, 48

The recent report ‘The implementation of the Soil Thematic Strategy and on-going activities’ (Jones et al., 2012) stated that 20% of Europe’s land surface is subject to erosion rates above 10 t ha\(^{-1}\) yr\(^{-1}\)

**Limitations**
- Spatial resolution
- Static land uses
- Crop systems
- Conservation practices (CAP)
- Remote sensing data
Revised Universal Soil Loss Equation

The USLE was developed in the U.S. based on soil erosion data collected beginning in the 1930s by the USDA Natural Resources Conservation Service.

The RUSLE was developed from erosion plot and rainfall simulator experiments. It is composed of six factors to predict the long-term average annual soil loss (A). The equation includes the rainfall erosivity factor (R), the soil erodibility factor (K), the topographic factors (L and S) and the cropping management factors (C and P):

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

With the introduction of the cross-compliance mechanism, many efforts have been made in the EU to increase the sustainability of agricultural systems...

However, what is still largely unknown are the actual effects on processes affecting soils such as erosion and SOC change, which ultimately determine the efficacy and cost-effectiveness of the policy.
What is the effect of GAEC on soil erosion at EU level?

Good Agricultural and Environmental Conditions (GAEC)

Requirements and standards

<table>
<thead>
<tr>
<th>Soil and carbon stock</th>
<th>GAEC 4: Minimum soil cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GAEC 5: Minimum land management reflecting site specific conditions to limit erosion</td>
</tr>
<tr>
<td></td>
<td>GAEC 6: Maintenance of soil organic matter level through appropriate practices including ban on burning arable stubbles, except for plant health reasons</td>
</tr>
</tbody>
</table>

Cover crops

Contour farming

Crop residues

Grass Margins

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

a) ‘Baseline’: In order to estimate the impact of GAEC implementation, a ‘baseline scenario’ underlying the absence of any specific policy on erosion prevention and carbon conservation was simulated; chronologically, it refers to the conditions before cross-compliance introduction (2003);

b) ‘Current’: This scenario is based on the implementation of the compulsory GAEC standards. The data of the European Agricultural Census (year 2010) are employed to define the specific conservation practices and their application areas on the arable land;

c) ‘Technical potential’: This scenario suggests the technical biophysical capacity of the arable land to sequester SOC, when GAEC standards are applied to the entire surface for a long-term period (2050).
Pilot area: Potential Impact of GAEC Application – soil erosion

European Agricultural Census 2010 (NUTS-2 level) (Eurostat)

(Bosco et al., 2015)

(Van der Knijff et al., 2000)

(Borrelli et al., 2016)

Borrelli et al. 2016. Land Use Policy, 50
Pilot area: Potential Impact of GAEC Application – soil erosion

- **‘baseline scenario’**
  - Soil loss: 8.33 Mg ha\(^{-1}\) yr\(^{-1}\)
  - 29.2 % > 10 Mg ha\(^{-1}\) yr\(^{-1}\)

- **‘current scenario’**
  - Soil loss: 7.43 Mg ha\(^{-1}\) yr\(^{-1}\)
  - 25 % > 10 Mg ha\(^{-1}\) yr\(^{-1}\)
  - Decrease ca. 11%

- **‘technical potential’**
  - Soil loss: 4.1 Mg ha\(^{-1}\) yr\(^{-1}\)
  - 10.2 % > 10 Mg ha\(^{-1}\) yr\(^{-1}\)
  - Decrease ca. 50%

Borrelli et al. 2016. *Land Use Policy*, 50
Coupling CENTURY with erosion: Soil organic carbon

Soil profile

EC=1.2

30 cm

More recalcitrant incoming SOC

GAEC:
- crop residues during the winter period
- reduced straw exportation from 50 to 30%
- cover crops
- “Reduced erosion rates”

Borrelli et al. 2016. *Land Use Policy*, 50
Lugato, Borrelli et al., 2016. *Global Change Biology*, 22
What happens at the European level?

Agricultural land (soil loss)

“...between 2000 and 2010, intervention measures through the Common Agricultural Policy could have reduced the rate of soil loss in the arable lands of the European Union by an estimated 20%”

Panagos, Borrelli et al., 2016. Environ. Science & Policy, 54
CONCLUSIONS

• Tool to better and more comprehensively predict soil loss in Europe

• We can account for the effect of GAEC on erosion and SOC

• This can help the decision-makers in both ex-ante and ex-post policy evaluations

• The proposed modelling exercise is an useful starting point which we would like to improve strengthening scientific collaborations
THANK YOU FOR YOUR ATTENTION

Pasquale Borrelli – IES, LRM
Pasquale.borrelli@jrc.ec.europa.eu