Joint Research Centre (JRC)

European Commission

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

Borrelli P, Paustian K, Panagos P, Jones A, Schütt B, Lugato E

European Geosciences Union
General Assembly 2016
Vienna | Austria | 17–22 April 2016

Joint Research Centre

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

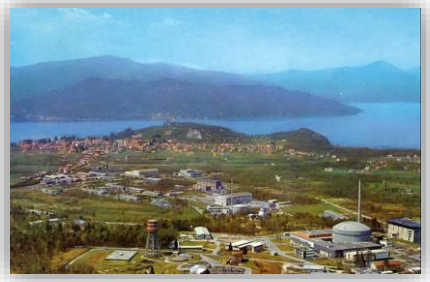
FLOODS-LANDSLIDES

SEALING

Policy background

In 2013, the European Commission requested to the JRC new soil erosion assessments

JRC:The European Commission's in-house science service



Water Erosion

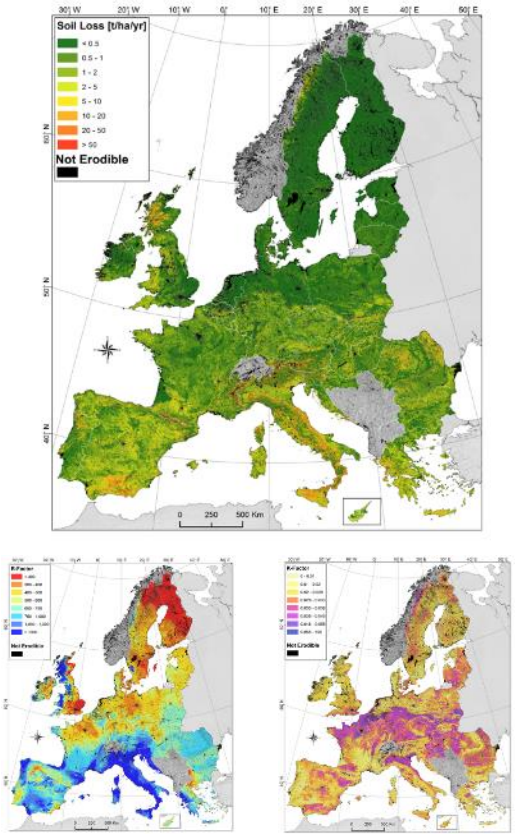
Wind Erosion

Forest Erosion

Brief overview of the JRC Soil Degradation Research Activity

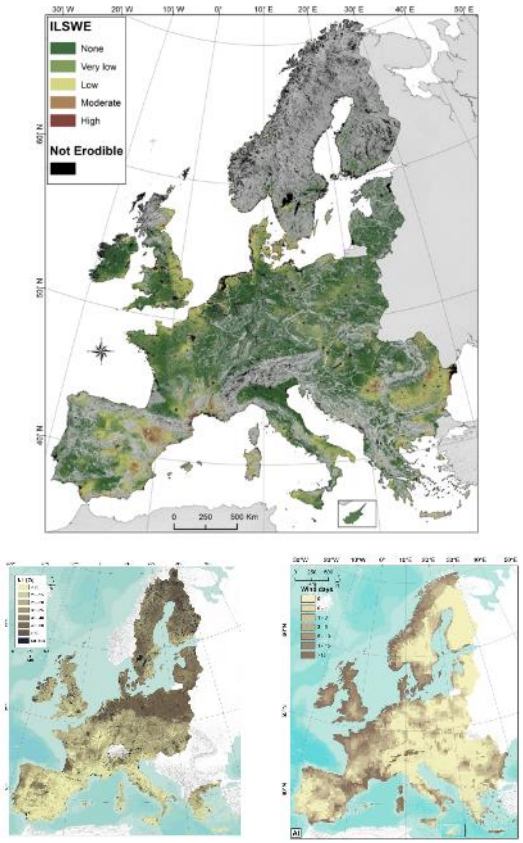
European Commission

Water Erosion



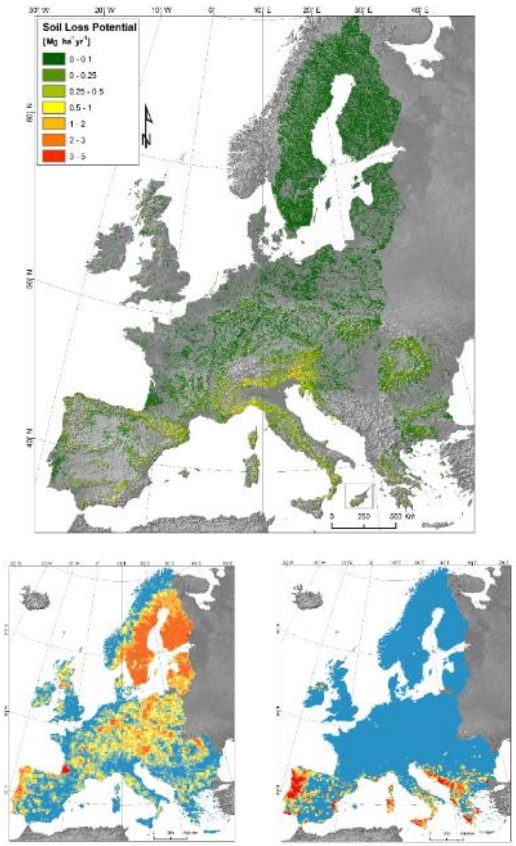
Panagos, Borrelli, Poesen et al. 2015. *Environmental Science & Policy, 54*

Wind Erosion



Borrelli et al. 2014. *Geoderma, 232*
Borrelli et al. 2014. *Land Degradation & Development*
Borrelli et al. 2015. *Sustainability, 7*

Forest Erosion

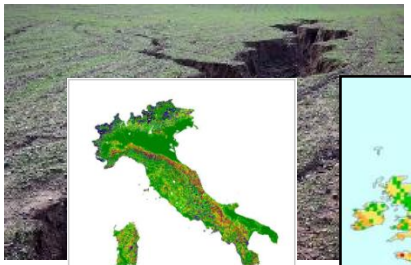


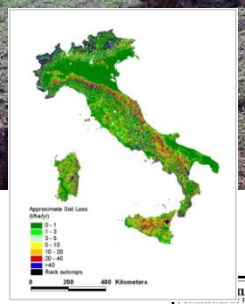
Borrelli et al. 2016. *Ecological Indicators*, 60
Borrelli et al. 2014. *Applied Geography*, 48
Borrelli et al. 2016. *Catena* (in press)

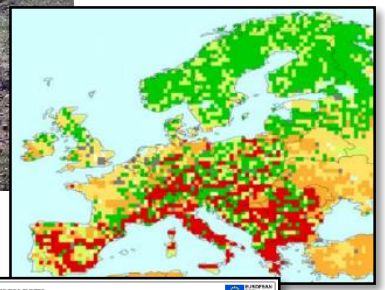
State of the art 2013

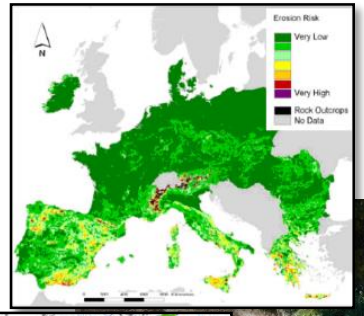
The recent report 'The implementation of the Soil Thematic Strategy and on-going activities' (Jones et al., 2012) stated that 20% of Europe's land surface is subject to erosion rates above 10 t ha^{-1} yr^{-1}

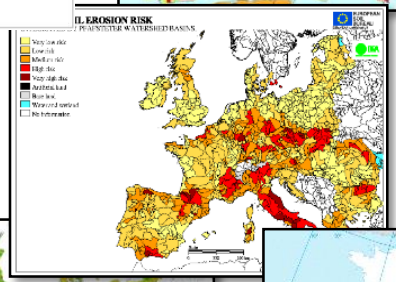
1990 → **2013**

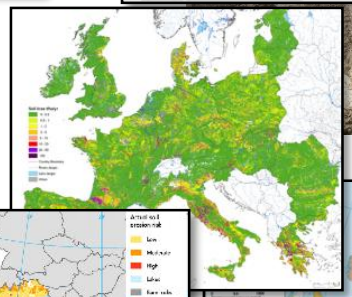


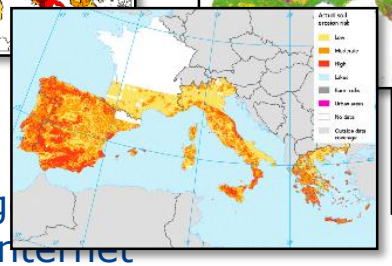


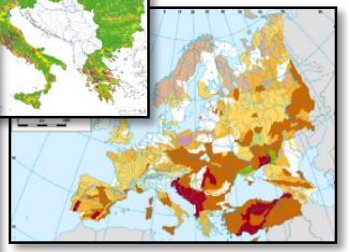












Limitations

- Spatial resolution
- Static land uses
- Crop systems
- Conservation practices (CAP)
- Remote sensing data

Water erosion modelling

European Commission

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...

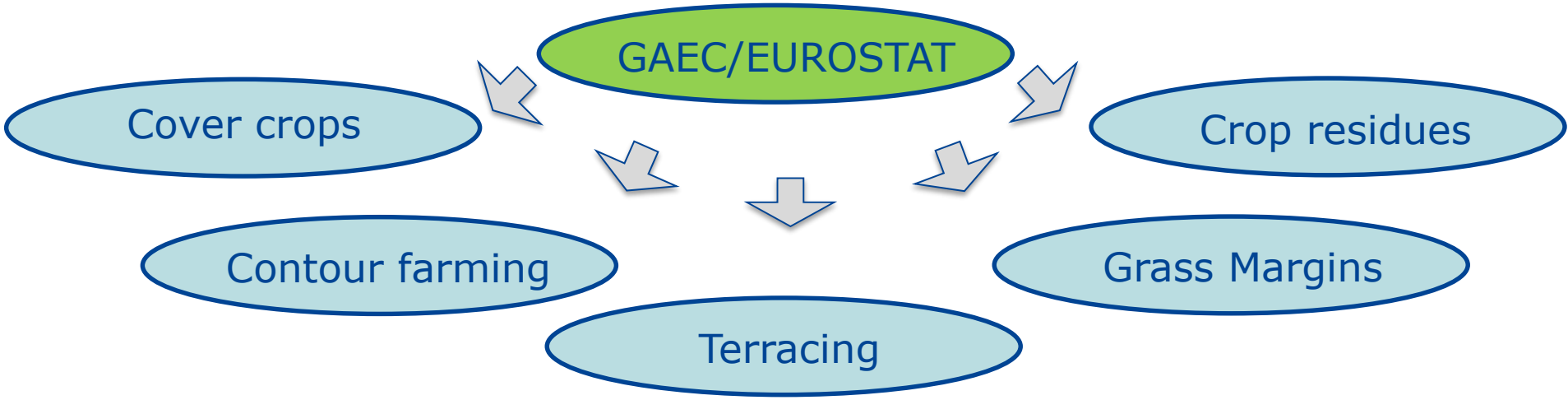
However, what is still largely unknown are the actual effects on processes affecting soils such as erosion and SOC change, which ultimately determine the efficacy and cost-effectiveness of the policy.

What is the effect of GAEC on soil erosion at EU level?

European Commission

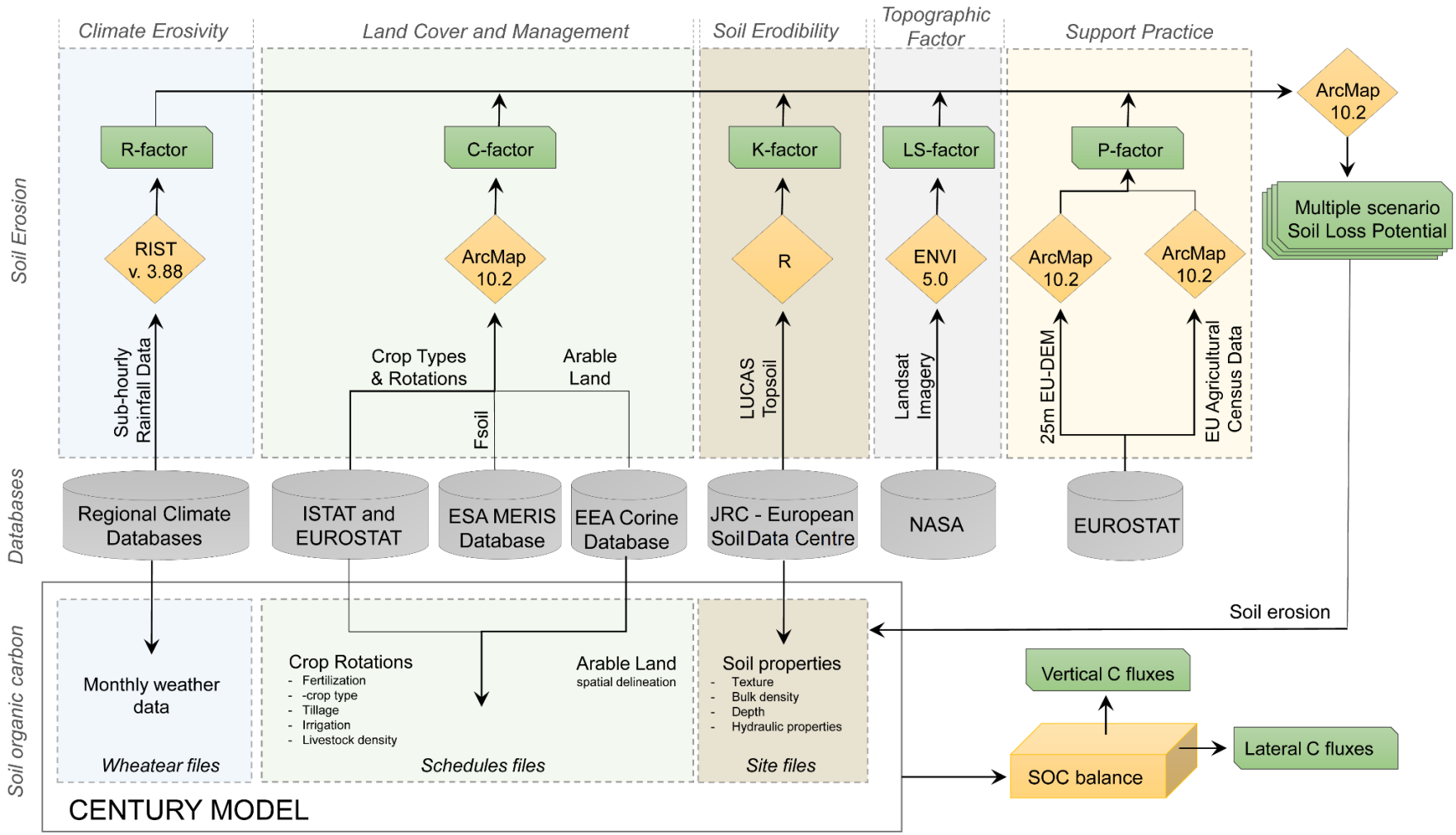
Good Agricultural and Environmental Conditions (GAEC)

Requirements and standards	
Soil and carbon stock	**GAEC 4:** Minimum soil cover
	GAEC 5: Minimum land management reflecting site specific conditions to limit erosion
	GAEC 6: Maintenance of soil organic matter level through appropriate practices including ban on burning arable stubbles, except for plant health reasons



Joint Research Centre

Pilot area: Italy



Lugato, Borrelli et al., 2016. *Global Change Biology*, 22
Lugato et al., 2014. *Global Change Biology*, 20

Borrelli et al., 2016. *Land Use Policy*, 50

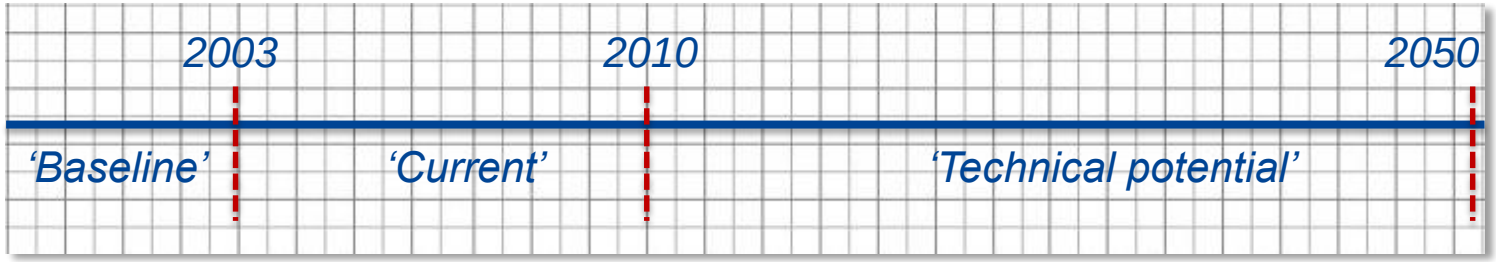
Pilot area: Potential Impact of GAEC Application

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

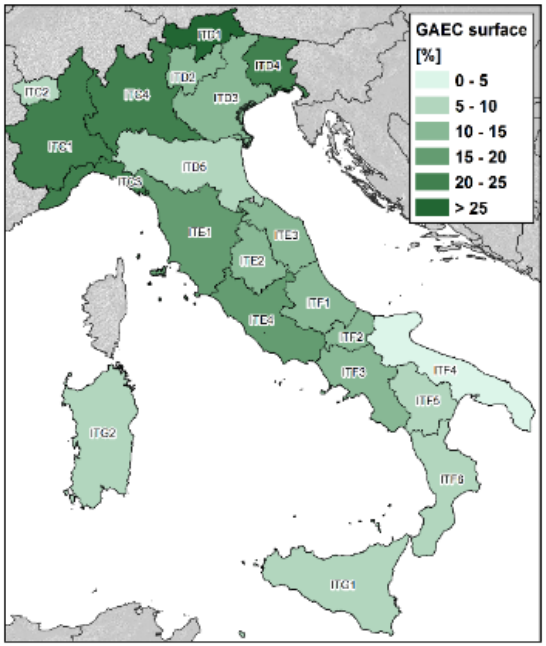
a) ‘Baseline’: In order to estimate the impact of GAEC implementation, a ‘baseline scenario’ underlying the absence of any specific policy on erosion prevention and carbon conservation was simulated; chronologically, it refers to the conditions before cross-compliance introduction (2003);

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;

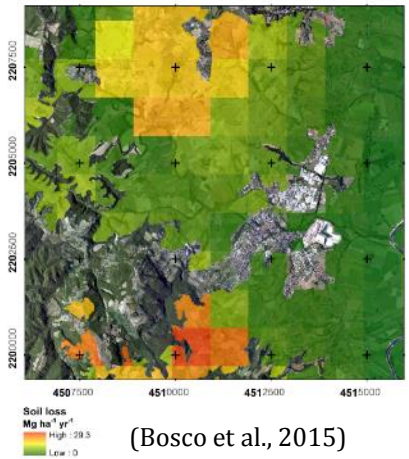
c) ‘Technical potential’: This scenario suggests the technical biophysical capacity of the arable land to sequester SOC, when GAEC standards are applied to the entire surface for a long-term period (2050).



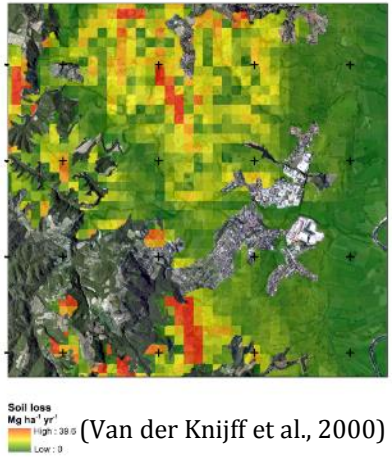
Pilot area: Potential Impact of GAEC Application – soil erosion



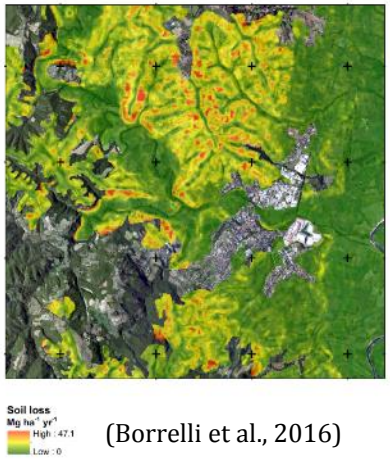
European Agricultural Census 2010 (NUTS-2 level) (Eurostat)



(Bosco et al., 2015)



(Van der Knijff et al., 2000)



(Borrelli et al., 2016)

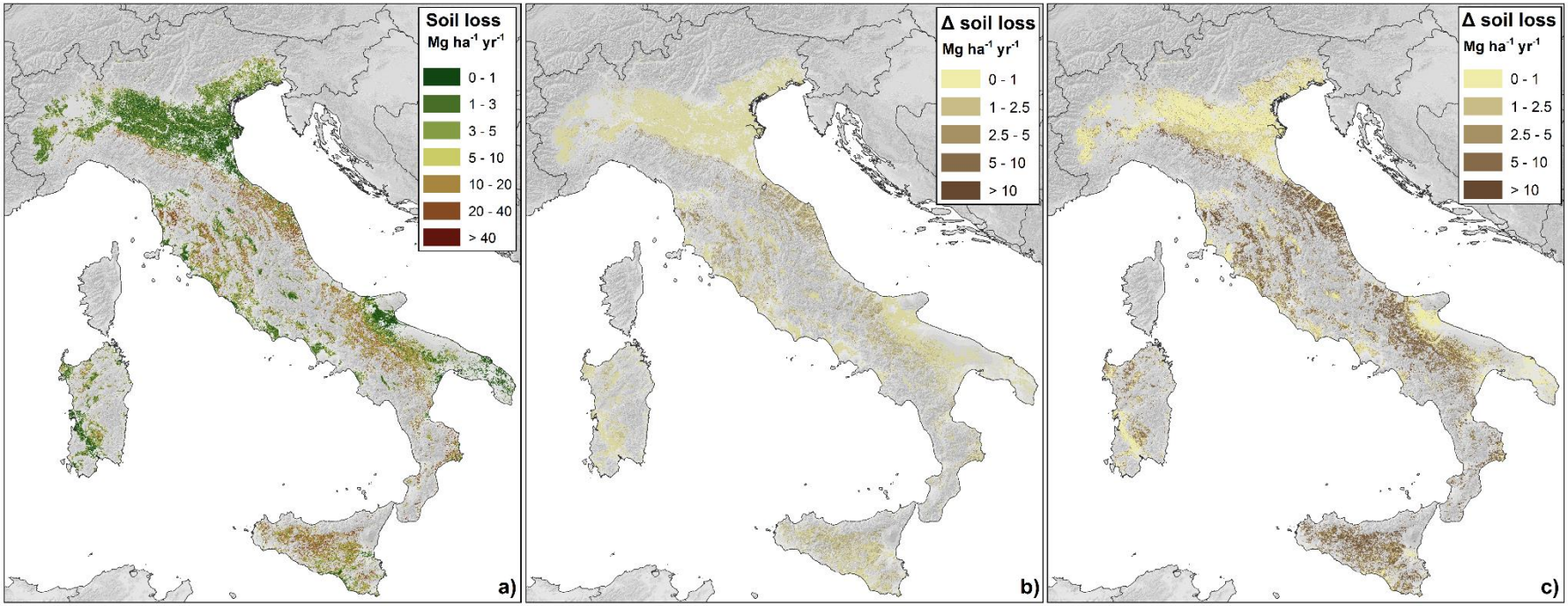
Borrelli et al. 2016. *Land Use Policy*, 50

Joint Research Centre

Pilot area: Potential Impact of GAEC Application – soil erosion

European Commission

‘baseline scenario’ ‘current scenario’ ‘technical potential’



Soil loss:

- 8.33 Mg ha^{-1} yr^{-1}
- 29.2 % > 10 Mg ha^{-1} yr^{-1}

Soil loss:

- 7.43 Mg ha^{-1} yr^{-1}
- 25 % > 10 Mg ha^{-1} yr^{-1}
- Decrease ca. 11%

Soil loss:

- 4.1 Mg ha^{-1} yr^{-1}
- 10.2 % > 10 Mg ha^{-1} yr^{-1}
- Decrease ca. 50%

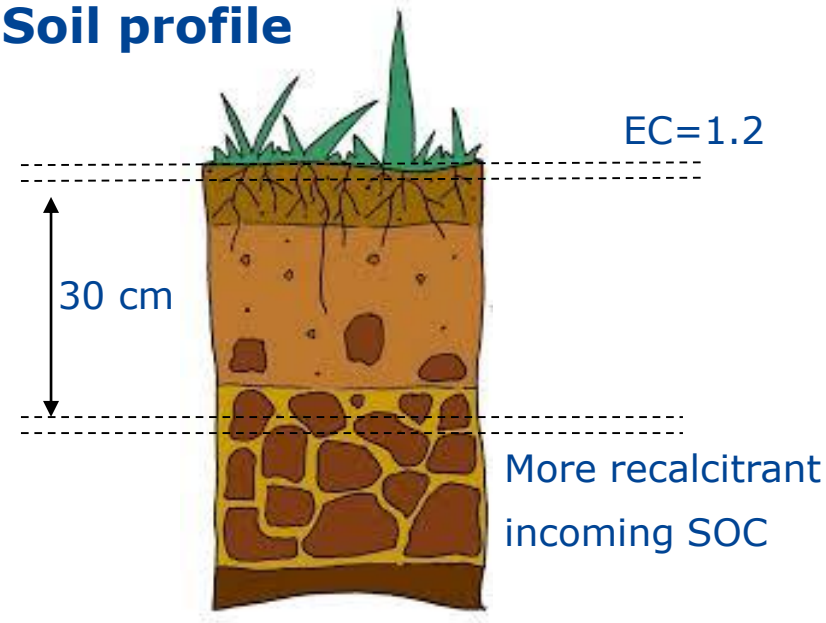
Borrelli et al. 2016. *Land Use Policy*, 50

Joint Research Centre

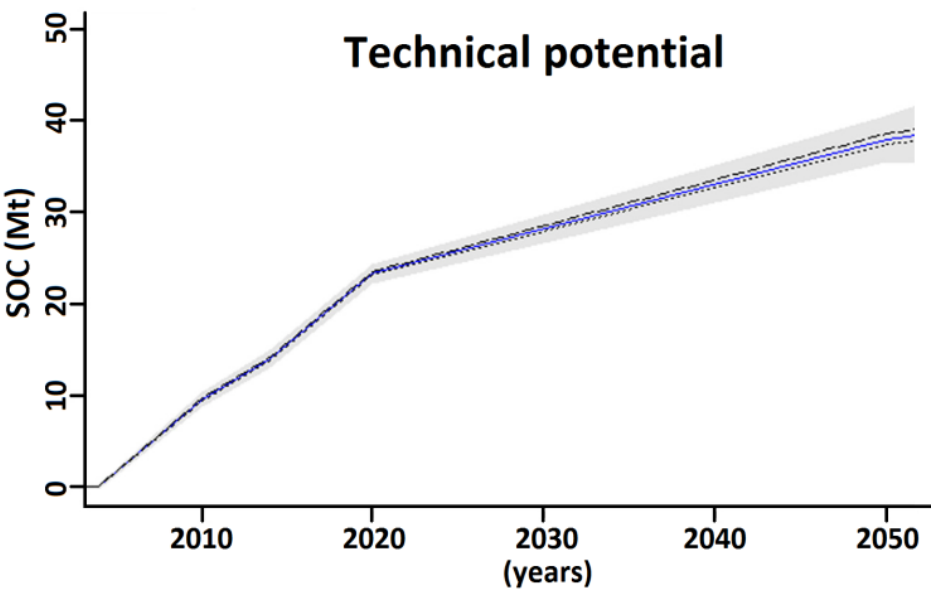
Coupling CENTURY with erosion: Soil organic carbon

European Commission

Soil profile



All the arable land 'technical potential'[by 2050]



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

Joint Research Centre

What happens at the European level?

European Commission

Agricultural land (soil loss)

Country		2000	2010	Effect
AT	Austria	4.7	4.0	-15.6
BE	Belgium	2.7	2.1	-23.8
BG	Bulgaria	[illegible]	[illegible]	[illegible]
CY	Cyprus	2.7	1.9	-31.8
CZ	Czech Republic	3.4	2.5	-26.9
DE	Germany	[illegible]	[illegible]	[illegible]
DK	Denmark	0.7	0.6	-9.7
EE	Estonia	0.9	0.7	-19.2
EL	Greece	3.6	2.8	-22.5
ES	Spain	5.5	4.3	-22.8
FI	Finland	0.7	0.5	-28.7
FR	France	2.8	2.0	-28.4
HR	Croatia	1.8	1.7	-4.8
HU	Hungary	2.3	2.1	-9.9
IE	Ireland	[illegible]	[illegible]	-13.2
LT	Lithuania	1.0	5.0	7.5
LU	Luxembourg	6.3	4.6	-27.1
LV	Latvia	1.1	1.0	-7.9
MT	Malta	17.5	15.9	-9.0
NL	Netherlands	0.7	0.5	-19.3
PL	Poland	1.8	1.6	-10.0
PT	Portugal	3.3	2.9	-11.2
RO	Romania	3.8	3.4	-9.7
SE	Sweden	1.3	1.1	-13.4
SI	Slovenia	5.4	4.6	-14.6
SK	Slovakia	4.1	3.5	-12.8
UK	United Kingdom	1.1	1.0	-8.8

"…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%"

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

Panagos , Borrelli , Robinson , 2015. *Nature,* 526
Panagos, Borrelli et al., 2016. *Environ. Science & Policy, 54*

Joint Research Centre

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

JRC-ISPRA

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

Joint Research Centre