F. Land and soil
Chapter III – Environmental state and trends

Nikolai Dronin
Moscow State University
5 May 2021

Goals of presentation:

- 1. Critical review of quality of data:
  - cropland abandonment
  - soil erosion
  - soil organic content
- 2. Leveling of West (WE, NE,CE, SE) and EAST (EE and CA) representation in the assessment report

Structure:

- Policy initiatives
- Indicators
- State of art
- Implementation:
  - West
  - East

1.1. Cropland abandonment: Policy initiatives

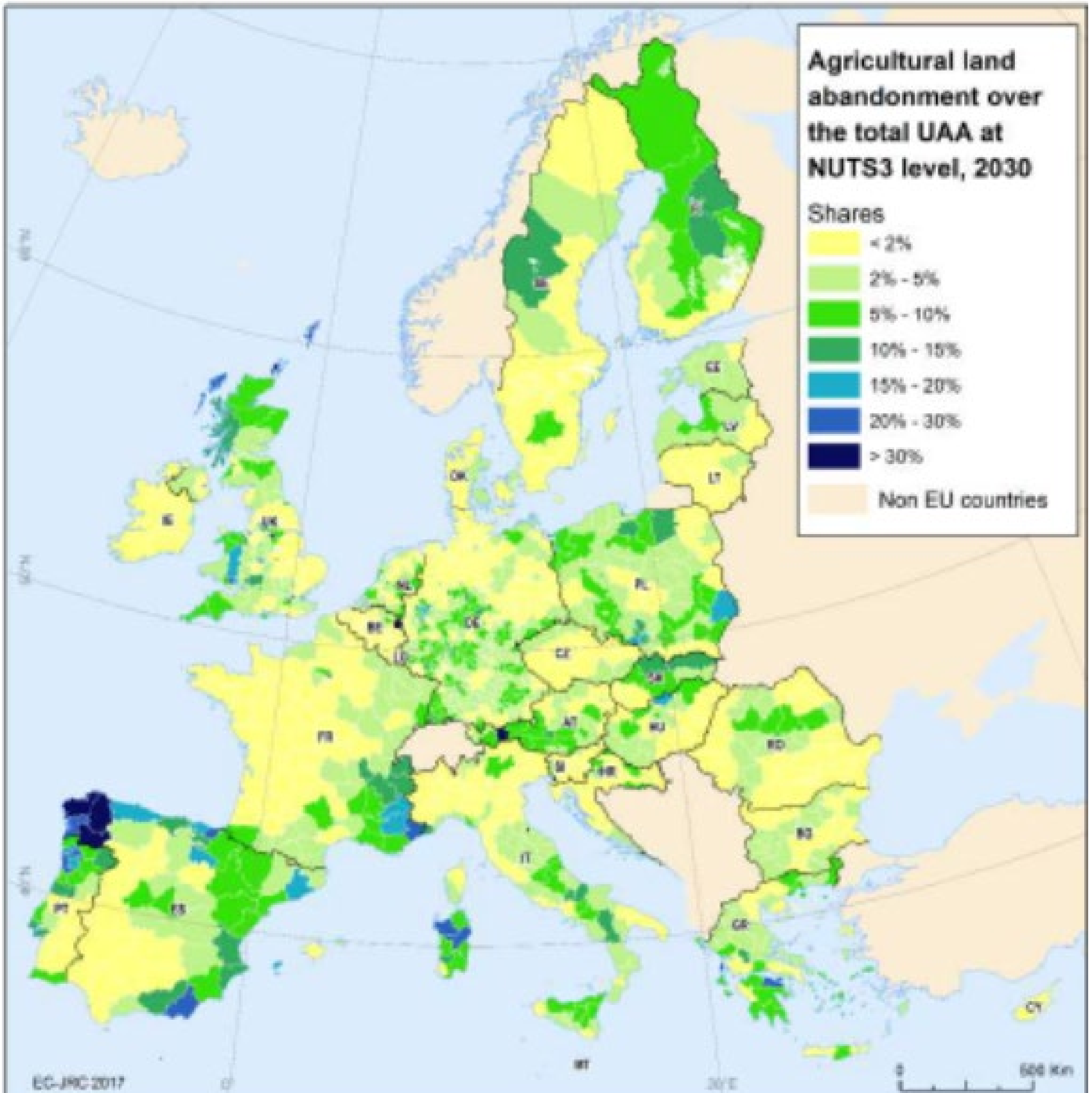
- Agricultural land abandonment is “the largest land-use change process in the Europe” (Castillo et al. 2020).
- Shifting EU consumers’ to more locally produced and sustainable food has a major implication on the EU policy to keep farming in marginal environment.
- In East concept of food security as self-sufficiency determines strong intention to bring most abandoned lands back into cultivation.

Indicators

Biophysical land suitability	Farm structure and agricultural viability	Population and regional context
Length of growing period	Age of farmers	Low population density
Soil Organic matter	Farmer qualification	Remote areas
Soil texture	Farm size	
Root depth	Rent paid	
Soil pH	Rented UAA	
Salinity and sodic	Farm income	
Precipitation	Farm investment	
Soil drainage	Farm scheme (subsidies)	
Slope		

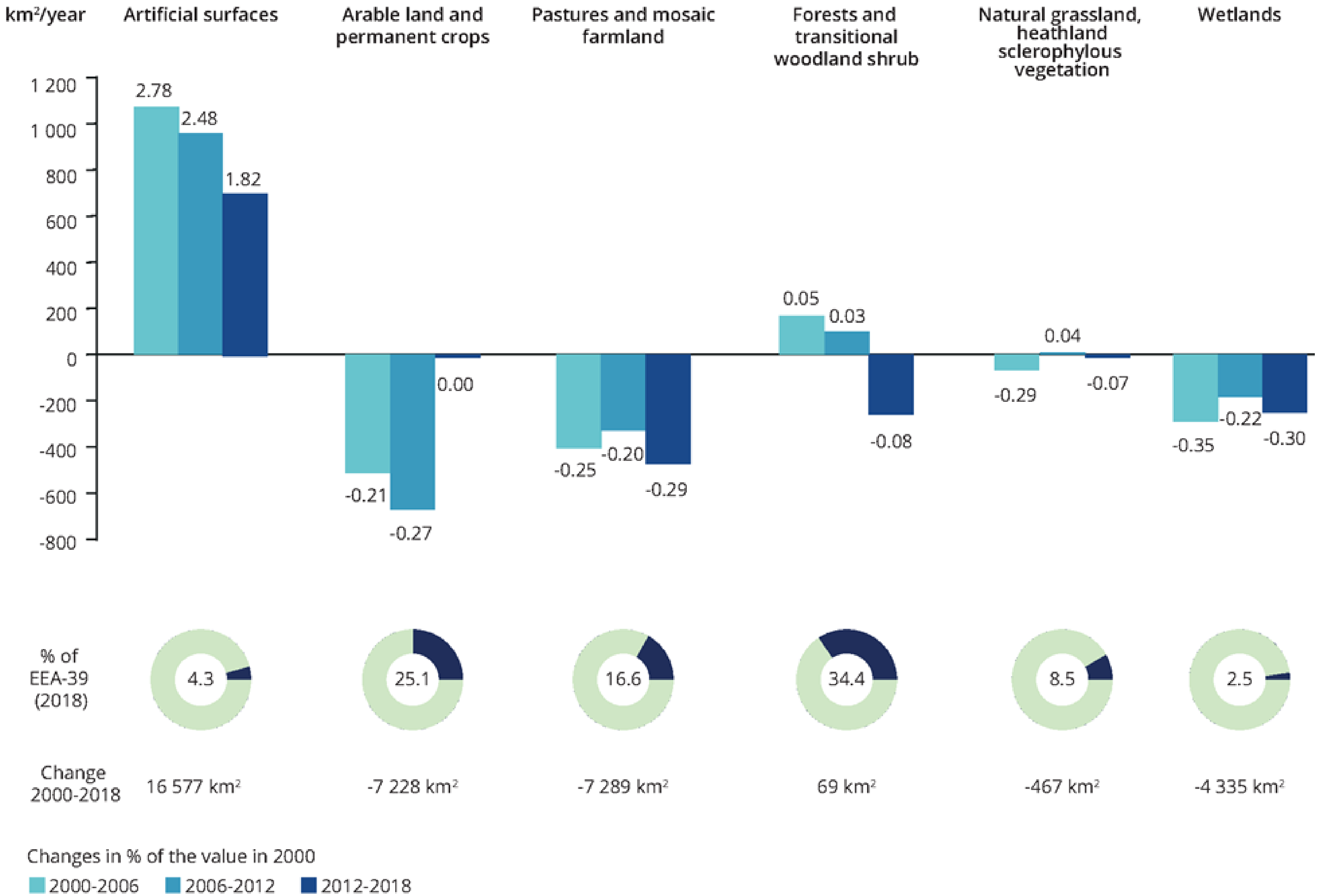
The primary reason of agricultural land abandonment is the increasing intensification of agriculture in the most productive lands and the simultaneous reduction of the agriculture land necessary to feed the European population (Novara et al. 2017). But it is not detectable!

State of art



Spain and Poland are the most vulnerable for land abandonment

Change in six major land cover types in the EEA-39 during the period 2000-2018: “smooth development”



Projection for EU LUC: “smooth development” will continue

- According to projections of land use change for the year 2050 based on the pan-European Land Use Modelling Platform (LUMP) (Lavalle et al., 2013):

  croplands will decrease by 1.2%,

  permanent crops by 0.2%

  pastures by 0.6%

  semi-natural areas by 1%

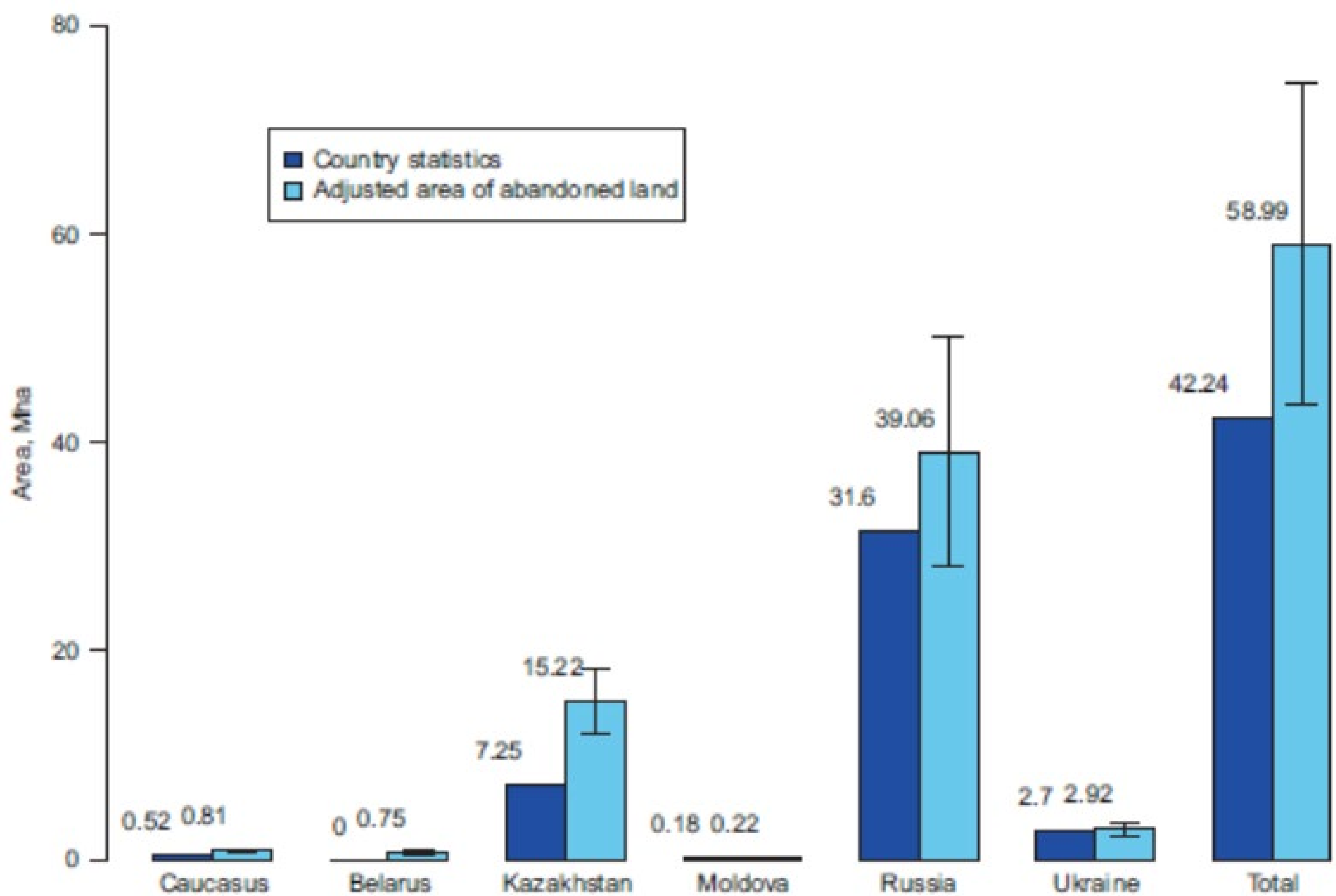
  Urban areas will increase by 0.7%

  forest areas by 2.2%.

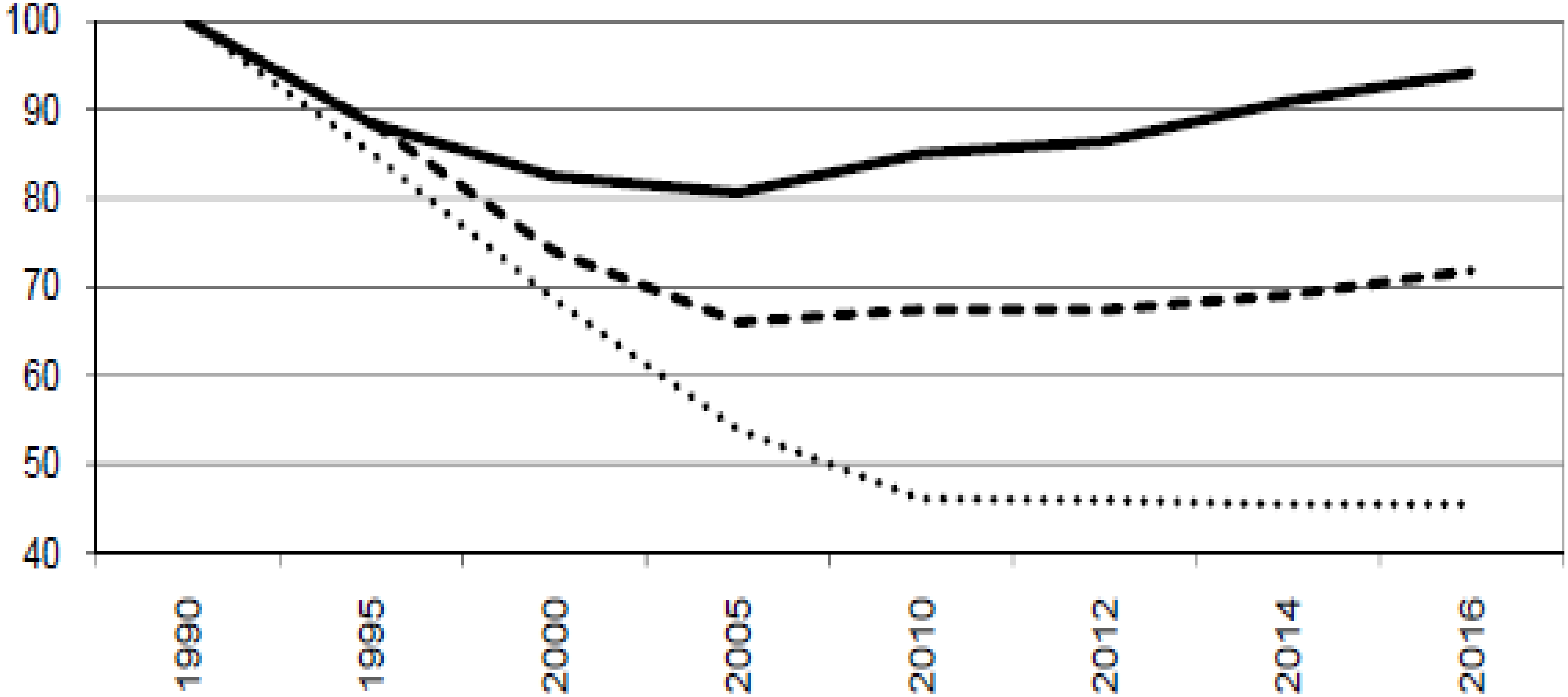
The JRC (2018) projects agricultural land abandonment in the EU-28 might reach 4.2 million ha by 2030 in cumulative terms (Castillo et al. 2018) or 2.9% of the current EU-27 UAA.

The highest rate of farmland abandonment at 7% (about 10 million ha) is projected with removal CAP subsidies and increasing competition for land (Lasanta et al. 2016).

Area estimates for abandoned land in Eastern Europe and Kazakhstan (Lesiv et al. 2017)



Dynamic of cropland abandonment in Russian regions, 1990 - 2017



Dynamics of sown areas in the south of European Russia (solid line), Middle Volga and south Urals (dashed line) and non-black-soil zone of European Russia (dotted line) , % to 1990 (Nevedova 2019).

1.2. Land degradation: Policy initiatives

- The European Parliament: land erosion is "probably the most significant environmental problem in Europe".
- The target throughout the EU-28 is to reduce areas with erosion rates beyond the threshold of 10 t ha^{-1} $year^{-1}$ at least by 25% by 2020 (GEO-6).

Indicators

- Rill and sheet erosion is the most documented soil erosion type in the scientific and technical literature in Europe. Gully erosion, tillage erosion, wind erosion, soil compaction, landslides have been understudied. For most of them no Europe-wide assessment is not possible to conduct due to a lack of systematic approaches and data.

Thresholds

- The limit should be equal rate of rock weathering – 1 t ha^{-1} yr^{-1} within a time span of 50–100 years;
- USDA "soil loss tolerance" (T-factor) "the maximum rate of soil loss that can occur while still permitting crop productivity to be sustained economically" – 2-10 t ha^{-1} yr^{-1} depending on soil type;
- OECD: >11 t ha^{-1} yr^{-1} as a threshold to define the areas affected by severe erosion;
- 12 t ha^{-1} yr^{-1} corresponds to the order of erosion of 1 mm yr^{-1} is regarded as still tolerable for maintaining crop productivity.

State of art

- The classical Universal Soil Loss Equation (USLE) model with two modifications such as RUSLE and PESERA has been applied for the Pan-Europe:

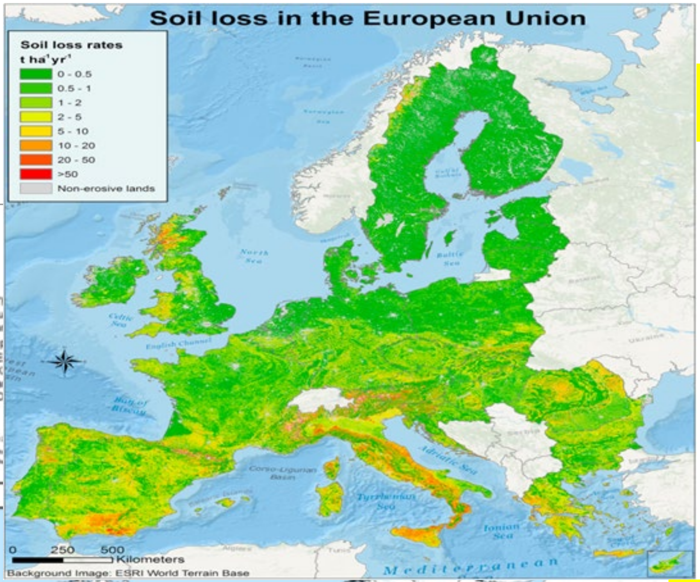
  A=R x K x LS x C x P;

  where A- estimated soil loss in tons per ha per year; R - rainfall factor; K - soil erodibility factor; LS - topographic factor; C - cover and management factor; P - conservation soil factor.

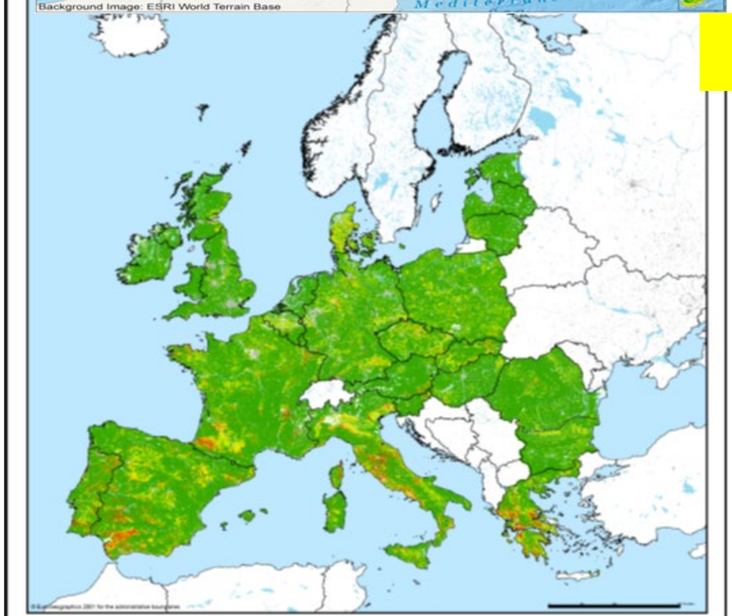
Limitations of USLE models

- “It is better not to take decisions at 100 m resolution where it is recommended to use local measurements” (Panagos et al. 2015).
- “There are no ‘scaling rules’ in erosion research” (Noordwijk et al. 1998)
- Strong bias in representation of different land use classes in field measurement of soil erosion.
- Poor availability national data on soil erosion rates to calibrate the models
- Verification of the models by remote sensing are rare

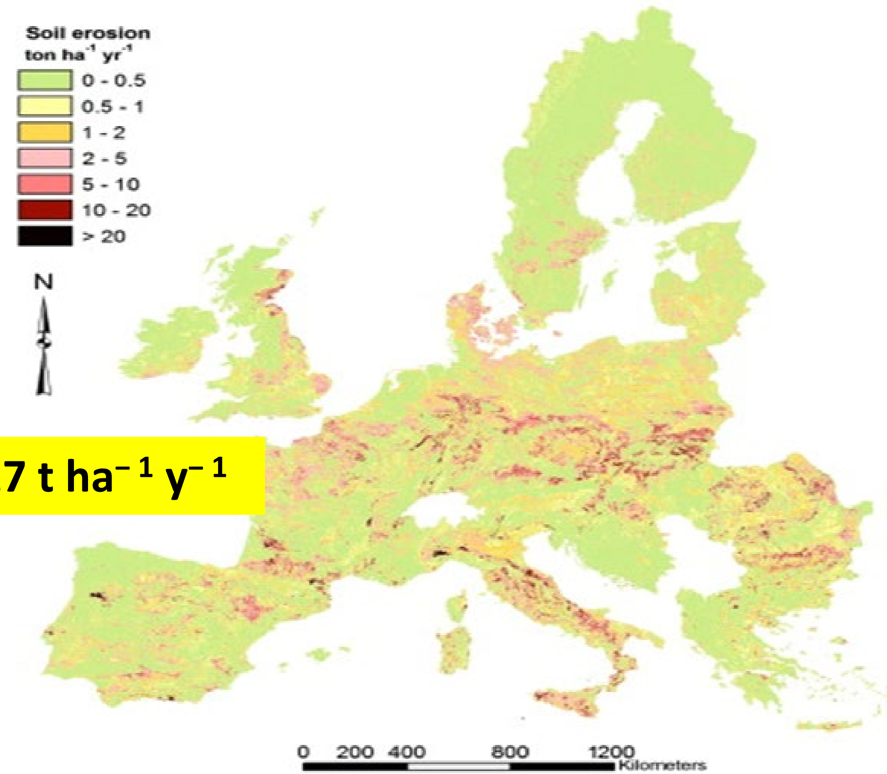
Water erosion the Europe



RUSLE: 2.46 t ha^{-1} y^{-1}



PESERA: 1.17 t ha^{-1} y^{-1}



Map of Soil Erosion by Cerdan et al. (2010) compiled on field measurements at 81 sites in 19 countries, covering 2741 plot-years: 1.23 t ha^{-1} y^{-1}

PESERA projection

- For intermediate system of farming, moderate current yield (4 t $ha^{-1}yr^{-1}$), average agro-technical trend (0.04 t ha^{-1} yr^{-1}), and moderate erosion rate (5 t ha^{-1} yr^{-1}such in France and Italy) linear extrapolation simulates rather insignificant rate of crop loss: 0.8% in 2035, 1.0 in 2050, and 1.5% in 2100.
- “the hypothesis that erosion poses a serious threat to Europe’s agricultural production is not likely to be correct under current land use and current erosion rates” (Bakker et al. 2007).

RUSLE projection

- The Thematic Strategy on Soil calculating annual cost of erosion for EU-27 ranges EUR 0.7-1.4 billion (JRC 2009). As of results of market equilibrium the annual cost of soil erosion is to be reduced from €1,257 million up to €295.7 million or from 0.43 to 0.12% of agriculture contribution to EU GDP. The principal conclusion of the study is “that soil erosion by water is not a threat to food security in the EU” but imposes high costs on the agricultural sector of several countries, most affected by soil erosion (Paganos et al.2018).

Water erosion the Eastern Europe (RUSLE model)

- For 1980 the model shows that 436.2 million t of soil was removed from agricultural area totaled 92.6 million ha. It gives the average rate of erosion about 4.7t $ha^{-1}yr^{-1}$. For 2012–2014 corresponding figures are 244.7 million tons, 61.2 million ha and 4.0t ha^{-1} yr^{-1}. Thus the average rate of erosion reduced by 15% in the last 30 years.
- Two major factors are responsible for these dynamics: dramatic arable land abandonment after 1991 (21 million ha) and warming in winter period (Litvin et al. 2017).

Wind erosion in Central Asia

- In Europe: A recent quantitative estimate of wind erosion (Borrelli et al., 2017) shows that around 7% of the EU arable lands have rates higher than 2 t ha^{-1} yr^{-1}.
- In Central Asia: The average rate of wind erosion on bareland reaches up to 100 t ha^{-1} yr^{-1}. Shrub and sparse vegetation lands have rates at 68 and 24 t ha^{-1} yr^{-1}.
- ***For cultivated lands rate of erosion are much lower: for pastureland – 8.7, irrigated cropland – 5, and rainfed cropland – about 4 t ha^{-1} yr^{-1}.***
- Forestland has rate of wind erosion at 0.3 t ha^{-1} yr^{-1}.
- The study also notes that wind erosion in CA is in increase in 2000-2019 although there was a slightly negative trend in previous decades (Wang et al. 2020).

1.3. Carbon stock in soil: Policy initiatives

- The EC Thematic Strategy for Soil Protection (EC 2006) postulated that the decline in soil organic matter (SOM) is one of the eight soil threats in the Europe;
- The EC's Roadmap for a resource-efficient Europe (EC 2011) included the goal to maintain and increase SOC levels by 2020;
- The Paris climate forum (2015): a voluntary action plan '4 per 1000 Soils' to boost carbon storage in agricultural soils by 0.4% each year to help mitigate climate change and increase food security everywhere.

Indicators

- Win-win situation or a dilemma: to reserve more OC in soils can suppress microbial activity thus reducing the positive effect of OC accumulation for crops;
- The Environmental Assessment of Soil for monitoring (ENVASSO) project: to use 3 different indicators
- - topsoil organic carbon content (%)- related only to productivity function of SOC
- and – soil organic carbon stocks (t ha^{-1}) and peat stocks (Mt)- to climate change mitigation

Thresholds

- The European Commission's Roadmap for a resource-efficient Europe (2011): SOC levels should not decrease overall and should increase for soils currently with less than 2% SOC by 2020. This concept of universal 2% critical level can be attractive for policy-makers due to its simplicity.
- Many studies did not reveal a significant additional yield of cereal crops due to larger organic inputs. It is suggested that the proportions of "fresh SOC" may be more important than the total pool of organic carbon.
- The ENVASSO project: 3 indicators - the total organic carbon, total organic nitrogen content, and C:N ratio (optimized at around 20).

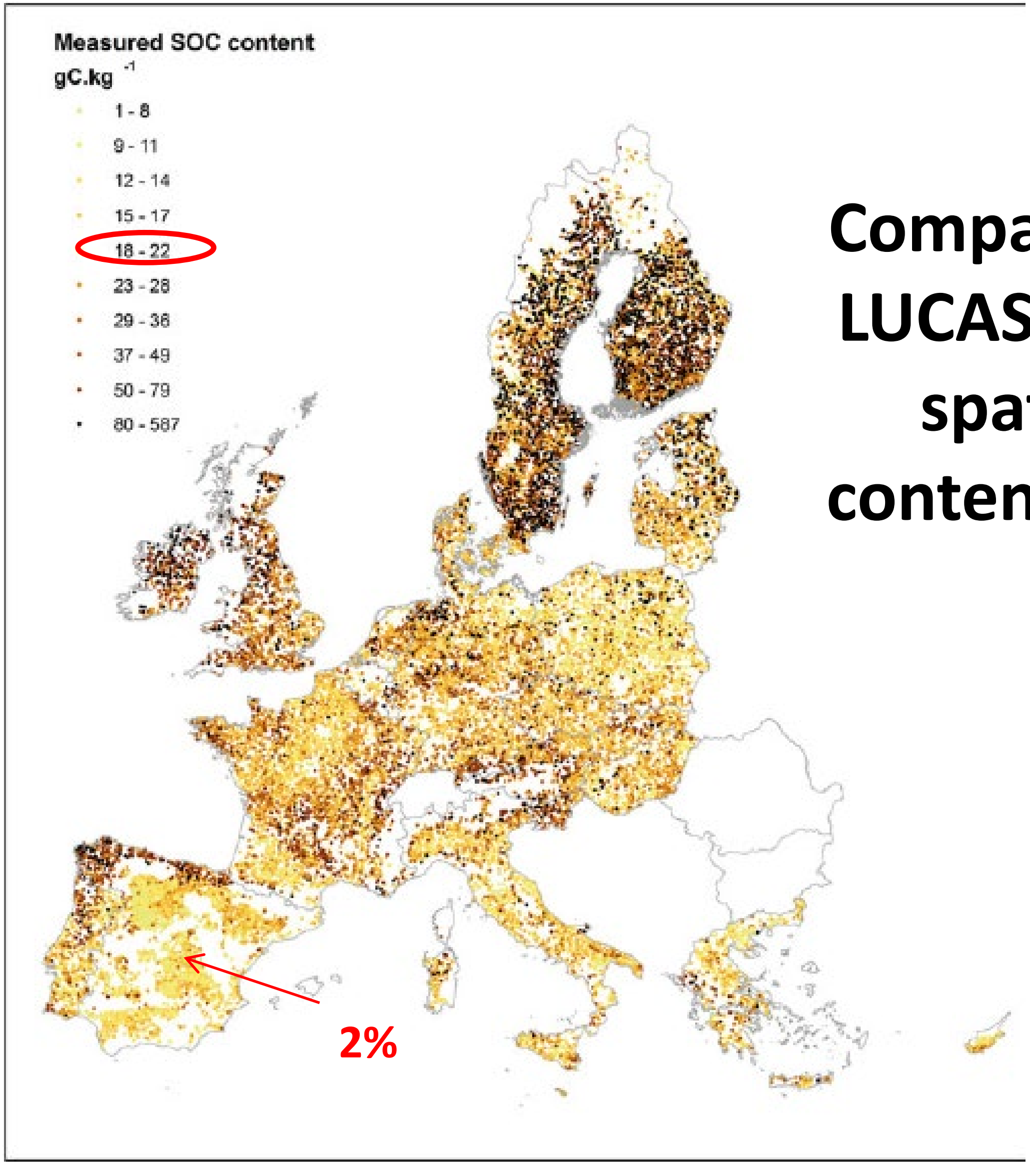
State of art

- In 2005, the map of Organic Carbon in Topsoils in Europe (OCTOP) at a 1km resolution was constructed on the base of a refined pedo-transfer rule and set of datasets.
- The results expressed as classes of OC were validated on measured values of SOC from above 12,000 sites the England/Wales and Italy.
- Compared with results of PESERA project: in Spain and France areas with low SOC content (<2%) corresponded with the most affected territories by land erosion (>5 t ha^{-1} yr^{-1}).

Land Use/Cover Area frame statistical Survey (LUCAS) project (2009)

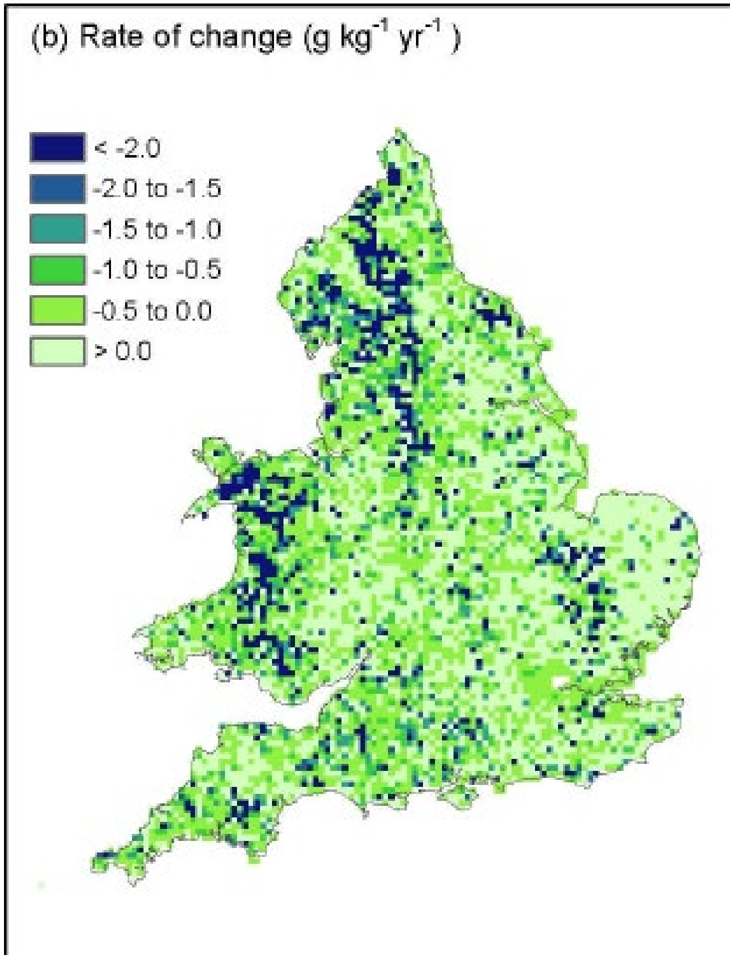
- The first comprehensive soil sampling operation throughout EU. In spring and summer 2009, in 25 EU Member States approximately 22,000 soil samples were taken using a standardized protocol. These samples were sent to a special laboratory.

Soil carbon content in Europe (LUCAS project)



Comparison of the OCTOP and LUCAS dataset shows a similar spatial distribution of OC content with few reservations

England and Wales: SOC dynamic between 1978 and 2003 (Bellamy et al. 2005)

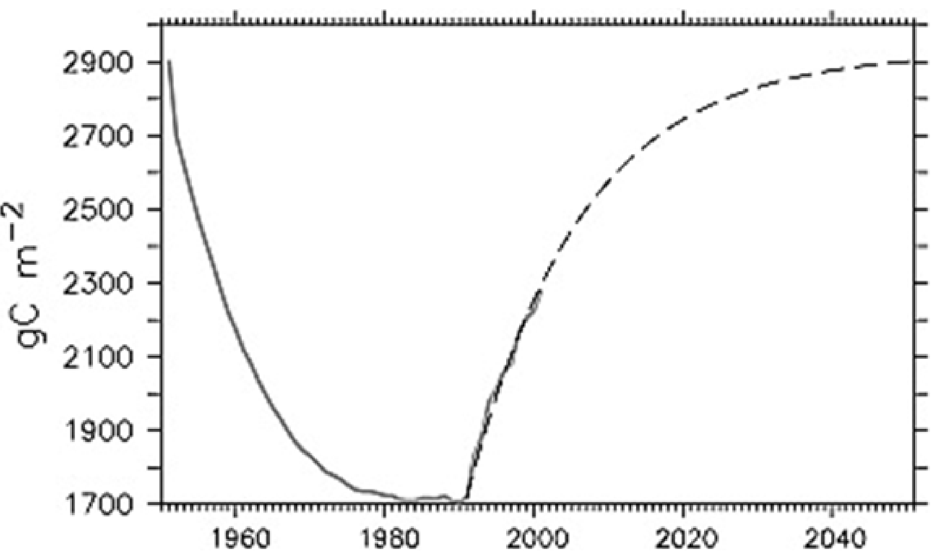


- The National Soil Inventory (NSI) comprises of measurements of SOC (5x5 km) at 6,000 sites between 1978 and 2003. The resampling shows carbon loss:
- -0.6% per year for soils with SOC> 5%
- -2% per year in soils with SOC> 10%
- + 0.01-0.03% in soils with SOC <2%.
- As significant carbon losses was observed in very different landscapes and all forms of land use a link to climate change is suggested.

Eastern Europe and Central Asia

- Abandonment of cropland leads to partial restoration of carbon pool in the undisturbed natural soils. The correction coefficients for abandoned were taken equal to 0.50 for the litter horizons and to 0.87 for the 1m soil layer (Schepaschenko et al. 2013). The correction coefficients are different for different of natural zones and ecoregions

Ukraine, Belarus and the European Russia: SOC dynamic between 1990 and 2000



SOC dynamic (in gC m^{-2}) as calculated by the ORCHIDEE-STICS model for a steppe primary land which experienced cultivation from 1950 to 1990 and an abrupt abandonment in 1991 and extrapolation by using a simple logistic curve for the time period 2000–2050.

- Due to "colossal land abandonment", the croplands switched from being a small source of atmospheric CO_2, releasing approximately 10 g carbon m^{-2} yr^{-1}, to a significant sink of atmospheric CO_2 up to 47 g C m^{-2} yr^{-1}. Net cumulated gain reaches 64 Tg C for 1990–2000. The C sink of the abandoned land is recognized as "certainly significant" and higher than that in the forests: 47 g C m^{-2} yr^{-1} against 31 g C m^{-2} yr^{-1} (Vuichard et al. 2008).

Permafrost zone and C sequestration

- Nearly 75 % of the territory of Russia lies in the permafrost zone with soils enriched in the SOM in the form of surface litter and peat. These substances are susceptible to decomposition upon rapid climate warming.
- “In spite of numerous publications following this notion, surprisingly little data is available to prove it” (Stolbovoy and Ivanov 2014).

Summaries:

- **1. Land abandonment is not principal issue in the Pan-Europe;**
- **2. Land erosion has limited impact on agricultural production and can be further limited due to spreading of conservation methods in agriculture in the Pan-Europe;**
- **3. There are some evidences about positive trend in C sequestration in soils due to climate change and cropland abandonment in the Pan-Europe;**
- **4. However, most measurable indicators used in assessments play only conceptual role to raise awareness among policy makers for land and soil degradation.**

Thank you for your attention!