

Establishing an environmental sustainability threshold on soil erosion

Concept of environmental sustainability thresholds

Human activities continue to put pressure on the world's natural resources and ecosystems. Many of these natural systems can withstand this pressure only up to a certain threshold – a so-called tipping point – beyond which serious negative and possibly irreversible consequences occur. As the exact thresholds are often unknown, prudence requires identifying danger zones before the threshold is reached, or safety zones in which humanity can safely operate. It is therefore important to find out where environmental thresholds exist, what values they have and to measure the distance to this threshold. This should help to alert policy makers in due time before a danger zone is reached and enable them to respond effectively to avoid unsustainable consequences. One objective of the [study](#) to which this factsheet is linked was to propose indicators for environmental thresholds relevant in the EU policy-making context.

Relevance of the topic

Soil erosion rates in Europe have increased in the last 30 years due mainly to intensification of agriculture, the development of tourism in sensitive areas and urban development. Soil erosion can be directly caused by natural drivers such as droughts and heavy rainfall, which could be exacerbated by climate change. Human activities also play a critical role in the deterioration of soils.

By contributing to the removal of soil material and the deterioration of the soil system, soil erosion directly affects the quality of the soil, its agricultural productivity and the biological diversity that is stored or lives in soil. Soil erosion also affects water quantity (loss of water holding capacity of soils) and water quality (turbidity through increased sediments in water). As soil is only created at a very slow pace, it should be considered essentially as a non-renewable resource. Substantial damage to soils can be irreversible.

In the literature, threshold levels of erosion are defined as “tolerable” rates of soil erosion in comparison with estimated natural rates of soil formation. The concept of a “tolerable” rate of soil erosion includes an aspect of human judgment in addition to scientific evidence for natural rates of soil formation. Based on reported values of soil formation rates, a European upper limit can be set at approximately 1 ton per ha per year¹. Actual soil erosion rates in Europe exceed this level in tilled, arable land on average by 3 to 40 times (approx. 3-40 t/ha/yr), with substantial variation in space and time.

The Common Agricultural Policy is crucial to tackling the problem of soil erosion in the EU as it can influence the intensification of European agriculture and help to promote soil protection measures in rural development policy or through the cross compliance mechanism. The current proposal for a Soil Framework Directive does not set threshold values for soil erosion and leaves the definition of risk reduction targets to the discretion of Member States.

¹ This threshold is an average valid only for mineral soils (less than 20% organic carbon) and not everywhere, as it is strictly linked to the type of soil.

Readily available and potential future threshold indicators

In principle, all types of soil erosion (by water, wind and tillage) should be considered when defining indicators showing the current distance of erosion rates from the erosion threshold value (on average, one ton per ha per year for mineral soils). However, in comparison with indicators of wind or tillage erosion, an indicator targeted at erosion by water, i.e. “estimated soil loss by rill, inter-rill, and sheet erosion vs. tolerable soil erosion rate” would both be more feasible due to the availability of comparable modelled estimates at EU level and most representative of the main erosion threat across the EU. However, it has to be underlined that an indicator based on erosion by water only is a temporary approach. Indeed, more information on the role of tillage erosion could significantly help policy makers at better targeting the most damaging soil management practices causing soil erosion through tillage, crop harvest and land levelling and bringing it above tolerable levels.

Advantages and disadvantages of suggested threshold indicators for soil erosion

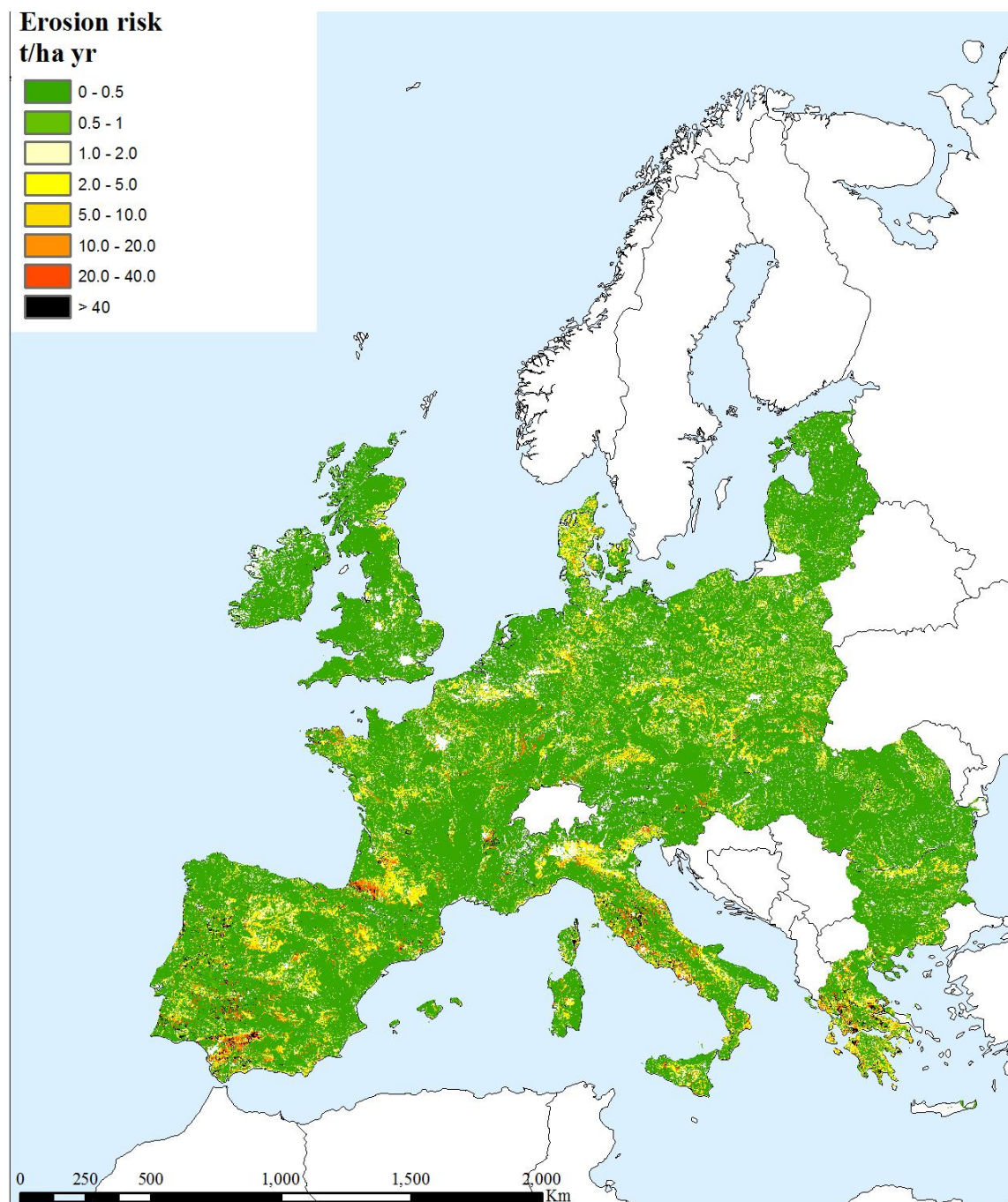
Estimated soil loss by water erosion vs. Tolerable soil erosion rate

Advantages	<p>Huber et al., 2008 (ENVASSO):</p> <ul style="list-style-type: none"> • Estimates of soil loss can be obtained from erosion models that already exist, for example: PESERA (Kirkby et al. 2004); USLE (Wischmeier and Smith, 1978); RUSLE (Renard et al., 1997); Morgan et al. (1984) and Morgan (2001). • These estimates exist for many European countries. • PESERA can offer quantitative information (at a 1km resolution). <p>A generally accepted benchmark for tolerable rate of erosion is 1 t/ha/y</p>
Disadvantages	<p>Huber et al., 2008 (ENVASSO):</p> <ul style="list-style-type: none"> • Modelling errors contribute to uncertainty of estimated values. • Very few sites exist in Europe where water erosion has been measured systematically enough to provide sufficient data for model calibration and validation. • Rill, inter-rill, and sheet erosion are difficult to estimate because of the complexity of erosion processes involved and a lack of sufficiently accurate data. • Gully erosion is not estimated – there is no reliable method or model for estimating soil erosion by gully erosion. <p>Difficult to establish tolerable rate of erosion due to localised differences and realistically due to socio-economic pressure. A regionally or locally based set of tolerable rates of erosion across the EU is not available.</p>

Exemplary illustration

The Pan European Soil Erosion Risk Assessment (PESERA)² map (Figure 1) illustrates modelled estimates of soil erosion by water in t/ha/y at a 1km x 1km resolution for the year 2003. Other forms of soil erosion, e.g. caused by wind, tillage, land-levelling and landslides are not included. The PESERA model is able to identify major differences between regions and to highlight areas particularly at risk.

² The PESERA model does not cover Cyprus, Finland, Malta and Sweden.



The yellow, orange, red and black areas on the map show where erosion rates by water have already crossed the one ton per ha per year erosion threshold. The map clearly shows that Mediterranean regions are particularly exposed to soil erosion and have in many areas already reached unsustainable levels of erosion.

Data availability in the EU

Modelling is currently the best option to generate comparable information on soil loss throughout Europe. Regarding water erosion data, to date, PESERA provides the only Europe-wide estimates that are based on a harmonised approach and standard data sets. Improvements of this model can be made for example by using better climate data, however the PESERA map has since not been updated.

Quantitative measurements of actual erosion rates and soil formation rates are used to calibrate models. Some Member States have established soil monitoring networks, but their methodologies and coverage vary considerably. National and regional networks are much denser in northern and eastern

parts of Europe than in southern Europe. To remediate this situation, a network of benchmark erosion monitoring sites across the EU needs to be established. Approximately ten sites per Member State would be needed to obtain the necessary monitoring and data gathering. The existing sites (approx. 50-60) in the EU have no standardised approach, nor have they operated over the same timescale.

The establishment of the proposed water erosion threshold indicator would require erosion risk estimates modelled at five years interval, using updated climatic and land cover data and calibrated with harmonised measurement data generated by a soil monitoring network.

Data availability to measure and monitor the threshold of soil erosion by water in the EU

Estimated soil loss by rill, inter-rill, and sheet erosion vs. Tolerable soil erosion rate

Unit of measurement	t/ha/y
Most suitable level of measurement	Various spatial scales needed, also site-specific – municipality level, minimum 1km x 1km
Current availability of data at the most suitable level in the EU, best practice example (with data source and update frequency)	No harmonised and systematic measurements across the EU. Best practice: Pan European <u>estimated</u> soil erosion risk (PESERA) at 1km x 1km resolution for 2003. Data sources: European Soil Database, CORINE land cover, climate data from the MARS Project and a Digital Elevation Model
Current availability of data at the national level in the EU, data source and update frequency	Non-harmonised national estimates of soil erosion available (mainly via USLE and RUSLE) e.g. for Austria, Belgium, Bulgaria, France, Germany, Hungary, Italy and Spain.

Conclusion

While a threshold level is available (1 t/yr/ha), measuring distance to this threshold is not established in a way that allows policy makers to react in time. Some Member States have established soil monitoring networks, for which methodology and coverage vary considerably. The present geographical coverage is very heterogeneous between and within countries. The establishment of the proposed water erosion threshold indicator would inform decision makers and practitioners at the various appropriate governance levels of the need to take action based on risk estimates. It would also enable a better identification and targeting of key land management practices that have proved to reduce the risk of soil erosion by water. In the medium term, it will be necessary to complement estimates of soil erosion by water with estimates for wind and tillage erosion.

Further reading:

- Ecologic Institute and SERI. 2010. Establishing an environmental sustainability threshold on water quality, Fact Sheet, October 2010.
- Ecologic Institute and SERI. 2010. Establishing an environmental sustainability threshold on water quantity, Fact Sheet, October 2010.
- Ecologic Institute and SERI. 2010. Establishing an environmental sustainability threshold on nonrenewable resource use, Fact Sheet, October 2010.
- Huber, S., Prokop, G., Arrouays, D. Et al. (Eds.). 2008. Environmental Assessment of Soil for Monitoring: Volume I Indicators & Criteria. Office for the Official Publications of the European Communities, Luxembourg.
- Kirkby, M.J., Jones, R.J.A., Irvine, B. et al. 2004. Pan-European Soil Erosion Risk Assessment: The PESERA Map, Version 1 October 2003. Explanation of Special Publication Ispra 2004 No.73 (S.P.I.04.73). European Soil Bureau Research Report No.16. Office for Official Publications of the European Communities, Luxembourg.
- Verheijen, F., Jones, R., Rickson, R., Smith, C. 2009. Tolerable versus actual soil erosion rates in Europe. Earth-Science Reviews 94(1-4), 23-38.