SOIL CONSERVATION IN EUROPE: WISH OR REALITY?

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ABSTRACT

Nearly all of Europe is affected by soil erosion. A major policy response is required to reverse the impacts of erosion in degraded areas, particularly in light of the current climate change and water crisis. Soil loss occurs not because of any lack of knowledge on how to protect soils, but a lack in policy governance. The average rate of soil loss by sheet and rill erosion in Europe is 2·46 Mg ha⁻¹ yr⁻¹. To mitigate the impacts of soil erosion, the European Union’s Common Agricultural Policy has introduced conservation measures which reduce soil loss by water erosion by 20% in arable lands. Further economic and political action should rebrand the value of soil as part of ecosystem services, increase the income of rural land owners, involve young farmers and organize regional services for licensing land use changes. In a changing World of 9 billion people with the challenge of climate change, water scarcity and depletion of soil fertility, the agriculture economy should evolve taking into account environmental and ecological aspects. © 2016 The Authors Journal of Land Degradation & Development Published by John Wiley & Sons Ltd.

KEY WORDS: soil loss; soil erosion; CAP; soil protection; land degradation

BALANCING CULTIVATION AND CONSERVATION: A STRUGGLE AS OLD AS CAIN AND ABLE

Europe is considered to be a continent with limited mineral resources. However, one of the most valuable resources mankind has ever had, and ever will have, is soil (Reeves, 1997). Even though more than 95% of the food and feed produced for humans and animals on Earth depends on soils, soil is still an undervalued resource. It will only be possible to produce enough food for a projected global population of 9 billion by 2050 if we use all soil and land resources in a sustainable way (Fischer et al., 2011; Decock et al., 2015).

As soil degradation is very often an unseen and unmeasured process, political and public awareness of this threat is low.

Soil erosion by water is the most widespread form of soil degradation worldwide (Oldeman et al., 1991). Depending on site characteristics, it can take up to 200 years to form just 1 cm of soil (Verheijen et al., 2009), while it can be eroded in only a few minutes by an even moderate storm. Soil degradation is only identified as a societal problem when personal or financial disasters ensue, very often accompanied by the misconception that the primary cause is the triggering storm/climate change event rather than the degraded status of soils.

Knowledge about soil erosion and the struggle to find a balance between cultivation and conservation is as old as Cain and Able. In his book The Antiquities of the Jews, Josephus (AD 50) describes the struggle between Cain and Able, where Able opposed the ploughing of the soil by the followers of Cain because deforestation was disturbing the hydrological balance. Why do we still engage in the same struggle as Cain and Able? We need a dedicated soil and water management policy to develop the economy and maintain these natural resources for society as a whole.

The main reason for soil loss is not the lack of knowledge on how to protect soils, but a lack in governance into policy as a priority. The main factors behind soil erosion are geomorphological risks (heterogeneous surfaces, steep slopes) combined with climatic risk (rainfall erosivity, increased number of dry days combined with strong thunderstorms) and human interventions (e.g. land use change, agricultural intensification). Because geomorphology is a given factor and climate trends (expected increase of rainfall erosivity in north-west Europe) seem impossible to change, the opportunity and the challenge are to mitigate human intervention so as to halt soil erosion and improve soil quality. The increased rain erosivity can be compensated by protecting the soil by any kind of vegetation. Plants diversity has positive effects on soil erosion resistance (Berends et al., 2015). Plants are adapted to even the most intense rainfall that they intercept and allow to infiltrate via their root system by changing the topsoil structure. Farmers do the same by applying reduced tillage, plant residues and cover crops to enhance fertility and control runoff (Fageria et al., 2005; Triplett & Dick, 2008). The active participation of farmers is a key point to enhance soil quality and improve future environmental conditions (Bouma, 2016).

Advanced modelling techniques on soil erodibility and rainfall erosivity deliver indicators on the state of soil degradation and its trends, and scenarios in relation to climate change, land use change and future policy implementation.

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Thanks to open access data policies and progress in modeling techniques, soil loss can be predicted at 100-m resolution, which helps advance current knowledge about soil erosion hotspots and areas that would benefit from intervention. Climate change scenarios for Europe predict increased numbers of storms during summer months that lead to floods and erosion (Beniston et al., 2007). High-resolution land-degradation maps help implement good governance by identifying hotspots where, and periods during which, soil is at high risk of erosion.

SOIL LOSS BY WATER VS. SOIL CONSERVATION POLICY—THE EUROPEAN PARADIGM

The new soil erosion maps provided by the Joint Research Centre (JRC, Figure 1) suggest that areas could be defined according to their potential productivity and their resilience to climate change. The soils in the loess belt that runs from Belgium to Poland and further into the Ukraine are an important agricultural resource as they have a large plant-available water-holding capacity and they are usually fertile (Vanwalleghem et al., 2007), provided they have not been degraded by soil erosion. A sustainable strategy should safeguard the most fertile soils and even help restore their fertility (Keessstra et al., 2012; Mol & Keesstra, 2012; Brevik et al., 2015).

In the European Union, more than 5 Mg ha\(^{-1}\) yr\(^{-1}\) of soil is lost from 12.7% of arable lands. Those 140×10^3 km\(^2\) (more than the surface of Greece) of potentially eroded areas could jeopardize more than 12 billion Euros of arable production annually. Those unsustainable soil loss rates emphasize the need to ‘save our soils’ (Banwart, 2011). In Europe the mean soil loss rate by sheet and rill erosion (2-46 Mg ha\(^{-1}\) yr\(^{-1}\)) exceeds by 1-6 the average soil formation rates (Panagos et al., 2015a). Around 970 million tonnes (around 600 million m\(^3\)) of soil are potentially lost each year because of water erosion. On top of that, additional soil losses occur because of (ephemeral) gully erosion (Poesen et al., 2003). Furthermore, average soil loss values and status descriptions can be very misleading, because very small changes can sometimes transform a stable productive soil into an unstable degraded one, and a very productive agricultural region into an economically unsustainable one.

Besides modelling soil loss spatially, the new modelling approach developed by the JRC has a temporal dimension that can help identify risky seasons. Rainfall erosivity is strongest during the summer period, with 53% of erosive events occurring over four months (June-September) (Panagos et al., 2016). This has had a significant negative impact on the cultivation of maize (one of the most soil-erosion sensitive crops) during summer in Northern Italy, which is the area in Europe most prone to soil erosion by water (Figure 2). In addition, future climate scenarios applied in combination with recently published rain erosivity and soil erodibility maps predict an average increase in rainfall erosivity of between 10-20% by the year 2050, with the most sensitive regions to be found in north-western Europe and the Alps.

Policy interventions are needed to mitigate the on-site and off-site impacts of soil erosion and to implement soil conservation strategies in erosion-prone regions. During the last decade of the 20th Century, much of the increase in soil erosion could be attributed to the intensification of agriculture in the 1980’s. In 2003, the European Union’s Common Agricultural Policy (CAP) established the Good Agricultural Environmental Conditions (GAEC) requirement

![Figure 1. Modelling soil loss by water erosion in Europe (Reference year: 2010).](image1)

![Figure 2. Soil erosion by water in a maize field in Northern Italy in June 2015.](image2)
to reduce soil erosion rates and to maintain soil organic matter. This policy intervention calls for e.g. the maintenance of stone (terrace) walls, the further application of grass margins (buffer strips) and the implementation of contour farming on slopes steeper than 10%. In the context of the CAP, conservation tillage is the most widely applied conservation practice while the use of winter cover crops and plant residues is limited because of a lack of guidance (and awareness) about their contribution to soil loss. In the Netherlands, as well as in other European countries, such measures were found to be effective in preventing flooding triggered by land consolidation and the expansion of maize cropping (Spaan et al., 2010). In fact, there is a very long history (tracing back to AD 800 in the Netherlands) of managing farming and peat exploitation at the individual, community and regional level to prevent erosion and flooding on sandy and clay soils (Van de Veen, 1996).

The application of the Good Agricultural Environmental Conditions (reduced tillage, winter cover crops, plant residues, stone walls, grass margins and contouring) has reduced soil loss from European arable lands by ca. 20% in the past decade (Panagos et al., 2015b). The improved modelling results allow for effective policy interventions in areas of high erosion risk (i.e. steep slopes and high rainfall erosivity). For example, the mandatory application of contour farming on all arable lands exceeding a 5% slope could result in further reducing soil loss by an average of 6% from European arable lands. However, separate interventions for soil loss reduction are inadequate to prevent erosion and flooding if there is no overall strategy as some important spots in the landscape are excluded. These are the runoff generation along the tractor-turning zones within parcels and wheel tracks for example. Land management and land use change is crucial in soil conservation. Conventional land management practices such as ploughing and use of herbicides may accelerate soil erosion especially in slopes with angles over 5% (Cerdà et al., 2009). In Eastern Spain, the land use change from rainfed olive plantations (or scrublands) in terraces to new citrus and orange orchards with massive use of herbicides, drip irrigation, ploughing and heavy machinery has damaged soils and triggered land degradation processes (Figure 3).

In the drive towards the greening of the new CAP (2014–2020), measures such as ecological focus areas and the protection of permanent pastures, together with the further application of crop residues, may result in further protecting land resources. Those management practices will further be endorsed by other EU policies such as the climate change (Lugato et al., 2014) and initiatives such as the 4 per 1000 (Lal, 2016). The CAP requirement to link Good Agricultural and Environmental Conditions (GAEC) to payments can further be adapted based on Member States requirements considering local conditions. Farmers should also be engaged in a bottom-up approach providing feedback to researchers and policy makers about the impact of management practices on soil erosion rates.

HOW TO ASSESS THE INTEGRATED VALUE OF SOIL?

A potentially erosion-prone land (Figure 2) could be thought of as land receiving more than 1500 mm of rainfall per year. That asset could be expected to contribute to the economy as a value of an agricultural product (e.g. maize, sugar beet) that the land might have produced without erosion. Under current European policy, the economic loss because of soil erosion is not entirely a private cost, because agricultural income is mainly made up of subsidies. One way for the community to recover this loss is to rebrand the land as beautiful countryside with clean watersheds. As a result the area could attract investments from the urban population who would pay for high-quality products, holidays and clean water. Now what happens to this eroded maize field (Figure 2) is that the soil surface temperatures rise to 40 to 60 °C in the summer, compared to 20–25 °C in a forest soil. In a worst-case scenario, no water would infiltrate into the sealed and

The European implementation of the CAP is an example of good practice in preventing soil erosion in an acceptable way. China has also implemented the Grain for Green Project during last decade to reduce soil erosion and increase forest coverage by removing lands on steep slopes from agricultural production (Wang et al., 2016). Global policy forums such as the United Nations’ Sustainable Development Goals (Griggs et al., 2013; Keesstra et al., 2016) and Land Degradation Neutral World (Chasek et al., 2015) are ideal platforms for raising awareness and proposing actions to address the global soil degradation problem (Montanarella & Alva, 2015). Research and new modelling paradigms may promote resilience to soil degradation factors. Research has shown that this is not simply a bookkeeping exercise. Soil is a growing medium which, unless properly managed, can be irreversibly lost, changed, degraded, and sorted into different fractions that have a lower resource value, leading to land abandonment and desertification. Gathering input data, involving farmers, translating experimental research into models, and modelling policy interventions are some of the actions that could be taken to improve future soil loss predictions.
crusted soil and would instead become runoff. The groundwater levels would then fall and spring discharges would decrease, causing downslope impacts. The light colour of the maize reflects heat back into the atmosphere, which further adds to climate warming. This has a negative impact on both hydrology and the local economy, because the land is no longer productive. A similar example of erosion-prone field is shown in silt loam soil of a sugar beet field in Central Belgium (Figure 4).

Political and economic action is required to solve the erosion problem. A simple governance hurdle concerns how we name and value the land and what we call it and this can be changed by cultural adaptation. As a first step, land should not be defined as ‘farm land’, because farming is only a very small part of what it is used for, and there needs to be greater awareness of the fact that a farmer can own land but not the right to degrade it. Second, it would be beneficial to raise the income of rural land owners and farmers by aiming at clean watersheds and beautiful countryside areas (ecosystem services areas) through the prevention of soil erosion (Robinson et al., 2012; Dominati et al., 2014). Sustainable agriculture is in the heart of Sustainable Development Goals (SDGs), and policy makers should reinvent the agricultural economy taking into account environmental and ecological aspects (UNEP, 2016). In 15–20 years, farmers will be paid not only for their products but also for providing ecosystem services and safeguarding natural assets such as soil. Preventing soil erosion by management is a simple and cheap solution to the societal water problems. Third, soil conservation can be proposed as a business model especially to young farmers. For instance, reducing production costs can be an important factor to increase income contrary to the traditional tendency to maximize production (Bouma, 2016). Moreover, scientists and policy makers should also consider the farmers feedback on the application of management practices. Fourth, a pan-European soil and water conservation service (e.g. Secretary) that collaborates with regional services for disaster prevention and sustainability is needed. The European Union currently supports United Nations (UN) disaster prevention measures, but as soil erosion is generally and globally not seen as a disaster, it would be more effective to identify and include soil erosion actions in national and European land management plans. Regional services could organize licensing schemes for the change of land use, and control the implications for disaster prevention. The produced soil loss maps could provide them the tools they need to come up with solutions for different scenarios of environmental change. The above-mentioned recommendations are in line with the policy guidelines both at local scale (increase income, improve food security, sustain natural resources) and at global scale (safeguard ecosystem services) highlighted by the World Overview of Conservation Approaches and Technologies (WOCAT) (WOCAT, 2007).

CONCLUSIONS

The prior to 2003 situation in soil conservation in Europe is much different than the current one. An agricultural model with focus on agriculture intensification, maximizing productivity and profit (prior to 2003) is now replaced with a more environmental friendly agricultural management practices. The main contribution was the Good Agricultural and Environmental Conditions (GAEC) introduced by CAP and the engagement of farmers to protect their land. The 2003 reform in Common Agricultural Policy (CAP) had positive effects in reducing soil degradation in European Union. In the same direction, the subsidies to farmers should be distributed taking also into account soil conservation and farmer involvement in protecting soils while means to achieve them should also proposed. Further application of soil conservation practices in soil prone areas in combination with a new business model for farmers to reduce costs, re-brand their soils, reinforcement of ecosystem services and licensing land use changes are some of the proposed actions. This will not remain a wish list in literature, but it will take place as part of the new agricultural economy involving policy makers, researchers and farmers.

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