The potential of European Union policies to address soil degradation in agriculture. Land Degrad Dev

Article *in* Land Degradation and Development · January 2011

Impact Factor: 3.09 · DOI: 10.1002/ldr.1028

4 authors, including:

Geertrui Louwagie
European Environment Agency
24 PUBLICATIONS **209** CITATIONS
SEE PROFILE

Stephan Hubertus Gay
Organisation for Economic Co-operation a…
29 PUBLICATIONS **123** CITATIONS
SEE PROFILE

Tomas Ratinger
Technology Centre of the Academy of Scien…
29 PUBLICATIONS **150** CITATIONS
SEE PROFILE

LAND DEGRADATION & DEVELOPMENT

Land Degrad. Develop. **22**: 5–17 (2011)

Published online 17 September 2010 in Wiley Online Library (wileyonlinelibrary.com) **DOI**: 10.1002/ldr.1028

THE POTENTIAL OF EUROPEAN UNION POLICIES TO ADDRESS SOIL DEGRADATION IN AGRICULTURE

G. LOUWAGIE*, S. H. GAY, F. SAMMETH AND T. RATINGER

European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Edificio EXPO, Calle Inca Garcilaso 3, 41092 Seville, Spain

Received 28 August 2009; Revised 9 June 2010; Accepted 11 June 2010

ABSTRACT

Six of the soil degradation processes recognised at European Union (EU) level are closely linked to agriculture. Soil degradation implies a need for protection, maintenance and improvement of soil quality. However, due to the public good characteristics of soil quality, the market does not sufficiently assure its provision. Thus, policy intervention is required to reach desired levels of soil quality through appropriate practices. This paper provides a comprehensive overview of EU policies that have scope for addressing soil degradation in agriculture. To this aim, EU legislation and legislative proposals along with related evaluations and research projects were analysed with the intervention logic approach.

To date, soil protection is not a specific objective of EU legislation but features in some policies as a secondary objective. Pursuing other environmental objectives contributes to some extent to soil quality, although not always effectively. The most important EU environmental directives for soil quality are the Nitrates Directive and the Water Framework Directive.

Under the Common Agricultural Policy, the compulsory requirement to keep land in good agricultural and environmental condition plays an important role in soil protection and conservation. Rural development policy, in particular agri-environment measures, offers Member States or regions options for encouraging farmers to achieve environmental quality beyond a predefined reference level.

Overall, the study indicates that the existing EU policies have the potential to address all recognised soil degradation processes across the EU. Nevertheless, they should be well targeted and require appropriate farm management in order to reach desired levels of soil quality.

KEY WORDS: Common Agricultural Policy; European agriculture; soil degradation processes; soil-friendly farming practices; soil-relevant EU policies; environmental public goods

INTRODUCTION

The Common Agricultural Policy (CAP) of the European Union (EU) is increasingly designed to meet a wide range of needs, including the maintenance of farm incomes and environment-friendly farming practices, enhancing food quality and promoting animal welfare. This calls for natural resources, including soils, to be managed in such a way such that their benefits are also available in the future.

Soil provides food, biomass and raw materials. It serves as a basis for human activities and landscape, and as an archive of heritage. It also plays a central role as a habitat, species and gene pool. It stores, filters and transforms many substances, including water, nutrients and carbon. Thanks to their carbon storage function, soils can play a considerable role in adapting to and mitigating climate change. Soil thus performs multiple functions for humans and ecosystems.

* Correspondence to: G. Louwagie, European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Edificio EXPO, Calle Inca Garcilaso 3, 41092 Seville, Spain.
E-mail: geertrui.louwagie@ec.europa.eu

Soil is also subject to a series of degradation processes. The Global Environment Outlook (UNEP, 2007) describes land degradation in the form of soil erosion, nutrient depletion, water scarcity, salinity and disruption of biological cycles as a fundamental and persistent problem. Six of the soil degradation processes recognised at EU level [COM(2006) 231] are closely linked to agriculture: erosion, organic carbon decline, soil biodiversity decline, compaction, contamination, and salinisation and sodification. Soil degradation processes are driven by the internal response properties of the soil and by external soil-forming factors such as climate, land use or soil management, thus referring to natural and anthropogenic processes. This distinction is particularly important because soil degradation processes may be accelerated or decelerated by human activities. In Europe, intensification of production in some regions and concurrent abandonment in others remain the major threats to the ecology of agro-ecosystems, impairing the state of soil, water and air and reducing biological diversity in agricultural landscapes (Stoate *et al.*, 2009).

These trends prevail, mainly because most environmental problems can be seen as problems of incomplete, inconsistent, or unenforced property rights regimes (Hanna *et al*., 1995). In the case of soil quality, land in the EU is mostly privately owned, and farmers, who at least have the temporary use rights to soil, suffer first from soil degradation. Depending on the time horizon of their use rights, they have a genuine interest in a good condition of their land, for example to maximise yields and thus income. However, degradation-induced yield losses have historically been masked by yield growth spurred by improvements in technology and increases in input use (Wiebe, 2003). Under such scenario and when considering soil as a production factor with private good characteristics, farmers may not have an incentive to adopt practices that reduce degradation. In addition, the longer-term benefits associated with highly functioning soils (e.g. carbon sequestration, long-term provision of food) have the two main characteristics of public goods (Cooper *et al*., 2009): their quantity of supply does not decrease with consumption (non-rivalry) and their access and consumption is general and free (non-exclusion) (e.g. Weimer and Vining, 2004). Thus, overall society needs for soil quality may differ from the quality level farmers provide. Specifically due to the public good character of soil quality, the market does not sufficiently assure its provision (market failure). Policy intervention is therefore required to reach satisfactory levels of this good in terms of quality and quantity through appropriate farming practices.

The scale of policy intervention will depend on the scale required to meet societal demand. Externalities of land use and management can be local, regional (e.g. off-site effects of erosion, landslides) or global, and can be either positive or negative. Global externalities refer in particular to the soil's potential as a carbon dioxide source (negative) or sink (positive), its support function to biodiversity, or also its function in the long-term provision of food (food security). Accordingly, policy intervention should be conceived at local, regional, national, supranational or global level.

Understanding soil processes and how humans can influence them is essential for policy design and evaluation. At the same time, well-intended but badly designed policies can lead farmers to take farm management decisions that reduce soil quality (e.g. Martínez-Casasnovas *et al*., 2010).

So far, EU policies have only to a limited extent been evaluated for their soil quality objectives. The evaluations were either restricted to particular policy measures (e.g. GFA Consulting Group, 2006; Alliance Environnement, 2007; Hudec *et al*., 2007) or were only considering one (or a few) soil degradation process(es) (e.g. Rodrigues *et al*., 2009). To assess the potential of EU policies to address soil degradation in agriculture, three pieces of information are essential. Which soil degradation processes are currently active in European agriculture? What farm action can be taken to protect, maintain or improve soil quality? Which policies encourage the adoption of such practices or systems? The project 'Sustainable agriculture and soil conservation (SoCo)' conducted a stock-taking on soil degradation processes, soil-friendly farming practices and systems and soil-relevant policies. Ten case studies and a series of regional workshops across the EU further clarified the link between these three elements; aspects of these are presented in this issue.

The objective of this paper is to highlight those EU policies that have scope for soil quality protection, maintenance or improvement in agriculture, and on which basis they do so. The results of a survey on national and regional implementation of some of these policies are presented in Kutter *et al*. (2011).

MATERIALS AND METHODS

Material

The first source of information was the original text of the EU law. Legislation and legislative proposals were assessed regarding their potential to address soil degradation processes. The selection was limited to legislation with at least an indirect link to farming and/or soil and other environmental objectives. In addition, secondary material, such as impact assessments, evaluations and research projects on these policies were reviewed.

Methods

Policy types and levels of environmental quality

In analysing whether a policy has scope for protecting, maintaining or improving soil quality, it is also important to assess to which degree the desired soil quality can be achieved. When targeting soil quality, the policy process defines soil quality levels (reference, target) in line with property rights regimes (Bromley, 1997; OECD, 2001). Parallel, in line with their influence on farmers' behaviour, policies can be classified as mandatory, voluntary incentive-based, and awareness-raising measures, derived from Baumol and Oates (1979).

Whereas targets relate to the economic criterion of an optimal allocation of resources, reference levels reflect the distribution of costs between farmers and society (Scheele, 1999). The reference level thus distinguishes between what is considered a minimum or mandatory requirement and what exceeds this level and should therefore be obtained contractually or on a voluntary basis. This level thus separates two types of policy measures: mandatory and voluntary incentive-based measures. Under mandatory measures (e.g. cross compliance rules) farmers have to respect the reference level of soil quality at their own expense. Farmers can choose to target a higher level of soil

quality (target) under voluntary incentive-based measures (e.g. agri-environment payments). The related payments compensate for income losses due to reduced productivity or extra costs incurred when implementing the contract. Awareness-raising measures also aim at promoting soil quality objectives, but their compliance is voluntary and the programmes attempt to raise the awareness of farmers. Technical assistance and extension to producers fit in the latter category.

Indicators are often used to characterise these levels of environmental quality in a measurable way. Such levels are usually site- and farm-specific and do not represent a unique point on the scale of environmental quality (OECD, 2001). They thus depend on natural conditions, farming types (arable, livestock, etc.), farming systems (conventional, organic, etc.), agricultural structures, or traditions and social perceptions. As a consequence, these quality levels are often poorly defined.

Intervention logic: a tool for policy analysis

SoCo adopted the intervention logic to perform the policy analysis. The intervention logic breaks a measure down into different steps, from society's needs over policy design (objectives) and implementation (including input in terms of costs and administration) to effects (outputs, results and impacts) (EC–DG BUDG, 2004). This, in turn, should allow assessing the relevance and effectiveness of a measure. Relevance is the extent to which the policy is responsive to the underlying needs. It is assessed by comparing the policy objectives with the scope of a policy for addressing soil degradation processes. Thus, policies that do not specifically target soil quality may nevertheless be relevant to soil protection, maintenance or improvement. Policies may indeed have side-effects that affect soil quality positively. On the other hand, effectiveness is the extent to which the observed policy effects match the policy objectives. Finally, efficiency depends on the amount of policy output per unit of input (i.e. financial and/or administrative resources).

The intervention logic thus helps to structure the elements of a policy, the identification of which is essential for policy analysis. Relevant elements of policies, provided that they are available, will be described following the sequence set out below. A policy cycle starts with defining the *needs* to be addressed through the policy. These needs are translated into policy *objectives* (by, e.g. a directive or regulation). There are three categories of objectives: general, specific and operational objectives (Figure 1).

General objectives represent those pointed out in the legislation [e.g. maintain land in good agricultural and environmental condition (GAEC)], while the specific objectives are those leading to the achievement of the general objectives (e.g. compliance with the GAEC standards set at EU level). Finally, the operational objectives

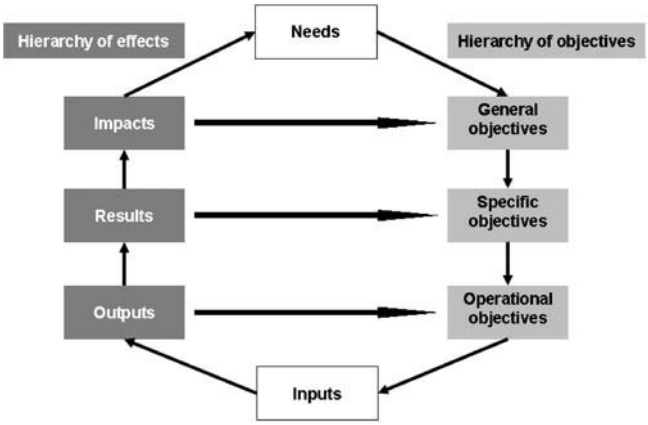

Figure 1. Simplified presentation of the intervention logic approach (source: Canenbley, 2009).

represent enforcement and monitoring mechanisms (e.g. inform farmers on GAEC standards, reduction of payments to non-compliant farmers). The analysis in this paper was done at EU level; information on objectives is therefore mostly limited to the general level.

Next, different objectives are transformed into appropriate *inputs*. These inputs are concrete procedures to achieve the objective, consisting of, for example control systems and the implementation of the policy. These inputs produce *effects* at different levels, in line with the distinct levels of objectives. The first measurable effects are *outputs*, for example number of farms inspected, number of farms complying or frequency of control. From these outputs, *results* on the rate of achieving the specific objectives are received, for example the rate of compliance with the GAEC requirement. Results, in turn, provoke *impacts*. Impact assessment allows us to measure the extent to which farmers meet the general objective(s), for example GAEC of the land. The final step, which closes the cycle, links the effects to the needs the policy should address.

These evaluation aspects (inputs, outputs, results and impacts) can only be assessed using appropriate qualitative and quantitative indicators and methods. In this sense, effectiveness and efficiency were hard to evaluate in the current study as data were often unavailable. The environmental impact of policies often depends on site-specific conditions and is not monitored (effectiveness), or information on the different costs associated with an intervention is not available (efficiency). The Commission's common monitoring and evaluation framework (CMEF) is a good example of these insufficiencies, as soil quality indicators are poorly represented here.

Soil is embedded in the landscape; soil quality is thus linked to and dependent on the quality of other environmental components. So, to review existing policies from a

soil quality perspective, one has to consider all stated objectives and, in addition, reflect on actual and expected effects of these policies on soil quality. Such assessments are scarce with the exception of research projects; these, however, often differ in their objectives or build on a few case studies from which it is difficult to draw general conclusions. Thus, SoCo had to draw mostly on its own expertise to define this potential for soil quality protection, maintenance or improvement.

Finally, policy measures can be either action- or result-oriented, meaning that either the farm technical requirements, or the required soil quality targets are prescribed. The latter leaves the farmer with the choice of selecting those actions that suit the farm context best, in order to reach the required soil quality level. In both cases, however, the adopted farming practices are expected to have a positive environmental, and in particular, a positive soil quality effect. Required farming practices can thus be a proxy indicator for a measure's potential to address soil degradation.

What follows describes the policy situation at the time of writing (2009).

RESULTS

Soil quality protection, maintenance or improvement is not a specific objective of any EU policy but it features in some policies as a secondary objective. Soils may furthermore benefit from targeting other environmental resources. A range of EU policies thus have the potential to address soil degradation processes. In the following, the existing EU policies with importance for soil quality protection, maintenance or improvement in agriculture are described, and their effects or expected effects on soil quality are discussed.

Environmental Policies

Since the European Commission adopted its first Environmental Action Programme in 1973, environmental protection has gradually obtained the status of being a precondition for sustainable economic development (McCormick, 1995). Creation of environmental policies has thus become a core part of EU policy making.

The most relevant EU environmental directives with respect to soil quality are the Nitrates Directive (91/676/EEC) and the Water Framework Directive (2000/60/EC), combined with the Groundwater Directives (80/68/EEC and 2006/118/EC). Others, such as the Sewage Sludge Directive (86/278/EEC), Regulation (EC) 1107/2009 concerning the placing of plant protection products on the market, and the Birds (79/409/EEC) and Habitats (92/43/EEC) Directives are expected to have beneficial effects on soil quality, but to a lesser extent owing to a more focussed set of objectives. In addition, the Thematic Strategy for Soil Protection [COM(2006) 231], which is in the development phase, sets the frame for a targeted EU policy for soil protection.

Targeting abiotic resources

The Nitrates Directive (91/676/EEC) is designed to protect the Community's waters against nitrates from agricultural sources. Member States must identify those waters (liable to be) affected by pollution. This requirement refers in particular to situations where nitrate concentrations exceed $50\,mg\,L^{-1}$. They also have to indicate nitrate vulnerable zones that drain into waters affected by pollution.

Member States must then establish codes of good agricultural practice (Annex II). The codes should cover provisions for, among others: the storage capacity for livestock manure, and application methods (e.g. rate, uniformity of spreading) and conditions (timing, soil state) for both chemical fertilisers and livestock manure. The codes may also include soil management measures, such as maintaining a minimum quantity of vegetation cover in rainy periods or fertiliser plans on a farm-by-farm basis.

Member States must also define and implement action programmes for vulnerable zones (Annex III). The limitations should be consistent with the codes of good agricultural practice and consider the characteristics of the vulnerable zone concerned. These characteristics refer to (a) soil conditions, soil type and slope, (b) climatic conditions (rainfall) and irrigation and (c) land use and agricultural practices (including crop rotation systems). Furthermore, the limitations should be based on a balance between the foreseeable nitrogen requirements of and supply to the crops.

The Nitrates Directive primarily targets water quality. However, it is expected to have positive effects on local and diffuse soil contamination, with side-effects on soil biodiversity. When fertiliser spreading is banned in the winter period (with prevailing wet or water-saturated soils), soil compaction and water erosion (due to their inter-relationship) might be positively affected. Whether limiting nitrogen fertiliser inputs has a positive or negative effect on soil organic carbon contents has so far proven to be inconclusive (Schils *et al*., 2008).

The Water Framework Directive (2000/60/EC) (WFD) aims to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts. Its goal is to establish a 'good status' for all waters by the year 2015. Agricultural activities, in particular the use of fertilisers and pesticides, are listed as a possible origin of pollution.

Member States have to assign all river basins within their territory to individual river basin districts. River basins covering the territory of more than one Member State are

assigned to an international river basin district. Member States must then characterise each river basin district (Article 5), review the impact of human activity on water and do an economic analysis of water use. They must also compile a register of areas requiring special protection. Member States also have to produce a management plan and programme of measures for each river basin district.

The Commission's Environment Directorate-General studied the soil protection aspects of this Directive (Hudec *et al*., 2007). Fifty-one (out of 61) national and international river basin district reports (WFD Article 5 reports), covering 121 river basin districts, or 99 per cent of the area of the EU-25, were reviewed regarding the extent to which soil degradation processes were identified as a negative factor for water quality. Erosion was identified as a negative factor for water quality (to differing extents) in 62 per cent of the reports (covering 20 Member States), although mostly only in a general way. Local and diffuse contamination were identified as negative factors for water quality in 73 per cent and 98 per cent of the reports, respectively. Pesticide application, nutrient (nitrates and phosphates) input, or atmospheric deposition were identified as the sources. Decline in organic matter was only in one case recognised as a negative factor for water quality. However, 21 per cent of the reports identified draining of peat soils, which can be reasonably expected to cause a decline in organic matter. Compaction was only mentioned in the Rhine River basin district report, where it was explicitly identified as increasing flood risks. Salinisation was not specifically identified as having negative consequences for water quality, whereas decline in soil biodiversity and landslides were not mentioned as soil degradation processes in any of the reports.

Overall, one can expect that soil degradation will be directly addressed through the management plans of river basin districts.

Linked to the WFD, the Groundwater Directive (80/68/EEC) (which will be repealed as of 21 December 2013) and new Groundwater Directive (2006/118/EC) prohibit or limit the discharge of dangerous substances into groundwater. Pesticides and fertilisers in particular can consist of toxic, persistent substances that can accumulate in organisms.

Given the link between soil and water quality, measures taken under directives primarily targeting water quality may contribute to reducing erosion (in particular the Water Framework Directive) and diffuse soil contamination. Soil biodiversity might be positively affected as a consequence. However, as with the Nitrates Directive, whether the encouragement of extensification under these Directives leads to reductions in soil organic carbon contents remains unclear (Schils *et al*., 2008).

The Sewage Sludge Directive (86/278/EEC) regulates the use of sewage sludge in agriculture. Sewage sludge contains large amounts of nutrients, and is therefore regarded as a good fertiliser for agriculture. However, substances in sludge can be harmful or even toxic to human beings and plants (e.g. pathogens contaminating crops).

The Directive sets limits on the concentrations of certain substances in sludge, regulates its treatment and bans its use in certain cases. Account must thus be taken of the nutrient needs of the plants without, however, impairing the quality of the soil and of surface and groundwater. The Directive furthermore specifies that it aims at establishing initial Community measures in connection with soil protection. It is likely to address the decline of organic matter, soil biodiversity and diffuse soil contamination.

The Regulation (EC) 1107/2009 concerns the placing of plant protection products on the market and has repealed the Plant Protection Products Directive (91/414/EEC). This Regulation is complemented with a Framework Directive on the Sustainable Use of Pesticides (Directive 2009/128/EC) setting rules for the use of pesticides in order to reduce risks to human health and the environment from their use.

Member States shall ensure that a plant protection product is not authorised unless its active substances are authorised. The application dossier (Article 8) should provide the information necessary for evaluating the foreseeable risks, whether immediate or delayed, which the substance may entail for humans and the environment.

Concerning the effects on soils, the application dossier should include a description of the fate and residue behaviour of plant protection products in the soil, such as rate and route of degradation, adsorption–desorption and mobility in different soil types, as well as extent and nature of the bound residues. It should also cover eco-toxicological studies on the active substance, including toxicity to earthworms and to other soil non-target macro-organisms. This Regulation thus tackles diffuse soil contamination at source. Positive effects on soil biodiversity can be expected.

Targeting biotic resources

The Birds Directive (79/409/EEC) aims at long-term conservation of wild bird species across the EU through protecting, managing and monitoring these species. Member States shall take measures to maintain or adjust the population of each species at/to a level in line with ecological, scientific and cultural requirements, while considering economic and recreational requirements. The most suitable territories for wild bird conservation are designated as Special Protection Areas (SPAs). Member States shall (strive to) avoid pollution or deterioration of habitats or any disturbances affecting birds in- and outside the protected areas.

The Habitats Directive (92/43/EEC) is intended to ensure biodiversity by establishing a 'favourable conservation status' for natural habitats and wild species, organised in a

coherent European ecological network known as Natura 2000. This network comprises Special Areas of Conservation (SACs) and the SPAs.

Member States designate the Natura 2000 sites in partnership with the Commission. The network comprised more than 25 000 sites, covering around 20 per cent of the total land area of the EU, or around 800 000 km^2 by the end of 2008 (EC, 2008); however, only a small fraction of this land is in agricultural use.

Protection and conservation of soils are not mentioned explicitly in either the Birds or Habitats Directive. However, soil protection can be considered an implicit precondition for the protection or recovery of habitats. Diffuse soil contamination and soil biodiversity are likely to benefit from the (extensive) farm practices required when implementing these Directives. Likewise, soil compaction and erosion might be reduced as a consequence of reduced stocking density for example. Furthermore, the network structure of the Natura 2000 sites (at least where interconnected) provides an additional bonus for biodiversity. Protecting sites such as forests and peatlands furthermore adds to the soil's carbon pool function.

EU Thematic Strategy for Soil Protection

The objective of the Thematic Strategy for Soil Protection [COM(2006) 231] is protection and sustainable use of soil. The proposed Soil Framework Directive [COM(2006) 232] would require Member States to preserve soil functions, to identify where degradation is already occurring and to set their own level of ambition and timetable to combat such degradation. Of the acknowledged soil degradation processes, erosion, organic matter decline, salinisation, compaction and landslides are relevant to agriculture. Member States would have to identify risk areas at the appropriate level using common criteria (like soil type, texture, density, hydraulic properties, topography, land cover, land use and climate) and methods (empirical (monitoring) or modelled evidence). Member States would have to establish risk reduction targets and adopt appropriate measures for reaching those targets. Risk acceptability, risk reduction targets and measures would vary in response to the severity of the degradation processes, local conditions and socio-economic considerations. Programmes could build on measures already implemented in national and Community contexts, such as cross compliance and rural development under the CAP. The proposal is still under discussion.

Common Agricultural Policy (CAP)

The EU's CAP comprises two main elements: market price support and direct income payments (Pillar 1), and incentive payments targeting rural development (Pillar 2). Under the Cardiff Process, environmental objectives have to be integrated into EU sectoral policies, including the CAP.

Cross compliance

Cross compliance, a horizontal tool for both pillars and compulsory since 2005 [Regulation (EC) 1782/2003 repealed by Council Regulation (EC) 73/2009], plays an important role in the protection, conservation and/or improvement of soils. Under cross compliance rules, farmers' receipt of the single farm payment and payments for eight rural development measures under Axis 2 [Rural Development Regulation (EC) 1698/2005] are conditional on their compliance with a set of standards. Farmers' failure to respect cross compliance conditions can result in deductions from, or complete cancellation of their direct payments. Cross compliance, a mandatory measure, also defines the reference level for voluntary agri-environment measures (AEMs) (see below).

The main purpose of cross compliance is to promote more sustainable agriculture. All direct payments are subject to 19 statutory management requirements (SMRs) in the field of environment, public, animal and plant health, and animal welfare, some of which have particular relevance to soil quality and have been discussed before (Table I). It appears that cross compliance is a means of enforcing compliance with pre-existing legislation in the agricultural sector and is therefore a tool to help meet the objectives of this body of legislation. SMRs gradually became applicable between January 2005 and January 2007. The new Member States applying the Single Area Payment Scheme (SAPS) have been granted a transitional derogation from the application of these requirements. Member States have some discretion when translating the SMRs into farm-level restrictions or guidelines to take their own environmental specificities into account.

The effectiveness of SMR enforcement with respect to addressing soil degradation depends on two main factors. The first is the degree to which a specific SMR is aimed at reducing soil degradation processes. This has been discussed above. Second, it depends on how the obligation set out in the SMR is translated into specific farm-level requirements, and how well farmers understand and apply these; this is, however, not the topic of this paper.

The extent of compliance with environmental SMRs was assessed in 2005 in selected European countries (France, Germany, Italy, the Netherlands, Poland, Spain, the United Kingdom) (Jongeneel *et al*., 2007). On average, the degree of compliance with the Birds and Habitats Directives, the protection of groundwater and compliance with the Sewage Sludge Directive was found to be high, with some minor exceptions. In contrast, the rate of compliance with the Nitrates Directive was not satisfactory in some Member States. For example in the UK, the second most common breach was excess amounts of manure used by intensive livestock farms in nitrate vulnerable zones. These results have to be interpreted cautiously, as they depend on expert

Table I. Statutory management requirements (SMRs) relevant to soil quality

Environment	
Birds Directive	Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (OJ EC L 103, 25 April 1979, p. 1) Art. 3(1) and (2)(b), 4(1), (2) and (4), 5(a), (b) and (d)
Groundwater Directive	Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances (OJ EC L 20, 26 January 1980, p. 43) Art. 4 and 5
Sewage Sludge Directive	Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (OJ EC L 181, 4 July 1986, p. 6) Art. 3
Nitrates Directive	Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (OJ EC L 375, 31 December 1991, p. 1) Art. 4 and 5
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ EC L 206, 22 July 1992, p. 7) Art. 6, 13(1)(a)
Public, animal and plant health	
Plant Protection Products Directive[a]	Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market (OJ L 230, 19 August 1991, p. 1) Art. 3

Source: Council Regulation (EC) 73/2009, Annex II.
[a]This Directive has been repealed by Regulation (EC) 1107/2009.

judgement and selective observations and are not based on a complete evaluation.

Cross compliance also refers to the requirement to maintain land in GAEC [Council Regulation (EC) 73/2009, Annex III] (Table II). Member States should use the above-mentioned common framework to specify the GAEC requirement at national or regional level. Member States can thus take account of the specific characteristics of the areas concerned, including soil and climatic conditions, existing farming systems and practices, and farm structures.

Table II. Common framework for defining standards for keeping land in good agricultural and environmental condition (GAEC)

Issue	Compulsory standards	Optional standards
Soil erosion: protect soil through appropriate measures	Minimising the area of bare soil Adequate land management reflecting site-specific conditions	Retain terraces
Soil organic matter: maintain soil organic matter levels through appropriate practices	Arable stubble management	Standards for crop rotation
Soil structure: maintain soil structure through appropriate measures		Appropriate machinery use
Proper level of maintenance: ensure a proper level of maintenance and avoid deterioration of habitats	Retention of landscape features, including (where appropriate) hedges, ponds, ditches, trees in line, in groups or isolated, and field margins Avoiding the encroachment of unwanted vegetation on agricultural land Retention of permanent pasture	Minimum livestock stocking rates or/and appropriate regimes Establishment or retention of habitats Prohibition on grubbing up olive trees Maintenance of olive groves and vineyards in good vegetative condition
Protection and management of water: protect water against pollution and run-off, and manage the use of water	Establishment of buffer strips along watercourses Compliance with authorisation procedures where use of water for irrigation is subject to such	

Source: Council Regulation (EC) 73/2009, Annex III.

In addition, Member States may add specific national standards and related measures. An evaluation of implementation at Member State level showed both positive and negative examples of how this flexibility has been used (Hudec *et al*., 2007). The specific conditions of Member States and regions are considered in most cases, but the evaluation emphasises that an even sharper focus would have been possible. The discretion available inevitably also results in a high diversity of farm technical measures. While the technical measures established in some countries might be insufficient and ineffective, they could well go beyond the intended scope and philosophy of the GAEC requirement in other Member States (Dimopoulos *et al*., 2006).

GAEC directly addresses soil protection and relates soil degradation to farming practices, both in terms of machinery use and land management (Table II). The standards relate to protection against soil erosion, maintenance of soil organic matter and structure, avoidance of the deterioration of habitats, and water management. Minimising the area of bare soil and retention of terraces directly contribute to the prevention of soil erosion, whereas crop residue management and crop rotation help to maintain organic matter in the soil. Compliance with management requirements that target habitat and water quality, such as the retention of landscape features, the establishment of buffer strips along watercourses or the avoidance of encroachment, may help to control water erosion and are likely to contribute to soil biodiversity. Retaining land as permanent pasture has the additional advantage of maintaining soil organic matter. Finally, appropriate use of irrigation water helps control salinisation and sodification. Effects of particular farming practices on soil degradation processes applied within distinctive Member States or regions are elaborated in Hudec *et al*. (2007). Cost estimates related to compliance with GAEC in selected Member States reflect the different requirements stemming from different implementations (Jongeneel *et al*., 2007). Data were scarce for all groups of GAEC standards [as outlined in Regulation (EC) 1782/2003] and reported costs varied considerably.

Member States also have to set up a farm advisory system (FAS) in order to increase farmers' awareness on cross compliance; farmers may however participate in the FAS voluntarily. Member States' implementation of the FAS mainly depends on the implementation level (national or regional) and on the financial resources available (national and Community funds, mostly drawn from the rural development budget) (Angileri, 2007). All Member States recognise one-to-one advice, sometimes combined with small group advice, both on the farm, as the core approach for the FAS (Angileri, 2009). Twenty-one per cent of farmers receiving direct payments are expected to use advisory services; whereas about double the number is expected in the Member States not implementing the rural development measure for advisory services (Angileri, 2009). A review of existing FASs for cross compliance environmental SMRs carried out in 13 Member States (Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Poland, Slovenia, Spain, Sweden, and the United Kingdom) highlights the particular challenge in the provision of farm advice to small farmers for countries with a large number of small farms (CIFAS project, s.a.).

Despite variations and difficulties, early signs about the overall effectiveness of cross compliance are positive. Evidence for both the known and expected outcomes of cross compliance indicates it is making, or likely to make, a significant contribution to ensuring compliance with obligations (Alliance Environnement, 2007). In general, cross compliance has increased farmers' awareness of soil degradation, as well as the environmental reasons for introducing standards to prevent it. On efficiency, it is clear that it resulted in internalising soil conservation efforts into farming; nevertheless, a detailed analysis of linked societal and individual benefits and costs would lighten the welfare implications.

Rural development

The Rural Development Regulation (EC) 1698/2005 provides funding for a wide range of measures that Member States or regions use to support the sustainable development of their rural areas. The Regulation provides the principle objectives and the common rules for their applications. However, Member States establish their Rural Development Programmes (RDPs) at national or regional level (NUTS 0-2). They thus select and specify measures most relevant to their needs, reflected in their respective National Strategy Plans, that have to follow the Community priorities for the programming period as outlined in the Strategic Guidelines (Decision 2006/144/EC).

RDPs are co-financed by the EU and the Member States. Following the objectives of the Rural Development Regulation, Member States or regions have to spread their rural development funding across four axes. Three axes are thematic: competitiveness, environment and the countryside, and quality of life and economic diversification. A minimum spending threshold to each axis applies: 10 per cent for Axes 1 and 3, and 25 per cent for Axis 2. The fourth axis, Leader, involves highly individual projects designed and executed by local partnerships to address specific local problems. This axis applies to and complements the three others. Minimum spending amounts to 5 per cent and 2·5 per cent, in the EU-15 and the new Member States, respectively.

Measures under all three thematic axes may address soil degradation on agricultural land when such a need has been identified. Measures that are potentially relevant to soil quality protection, conservation or improvement are listed in

Table III. Rural development measures potentially relevant to soil quality

Measure	Objective
Axis 1	
Vocational training and information actions (Art. 20 (a) (i) or Art. 21)	To promote diffusion of knowledge in respect to technological innovation and sustainable management of natural resources
Use of advisory services (Art. 20 (a) (iv) or Art. 24)	To help farmers meet costs arising from the use of advisory services for the improvement of the overall performance of their holding
Setting up of farm management, farm relief and farm advisory services (Art. 20 (a) (v) or Art. 25)	To cover costs arising from the setting up of farm management, farm relief and farm advisory services
Modernisation of agricultural holdings (Art. 20 (b) (i) or Art. 26)[a]	To improve the overall performance of the agricultural holding, while respecting the Community standards applicable to the investment concerned
Restoring agricultural production potential damaged by natural disasters and introducing appropriate preventative actions (Art. 20 (b) (vi))	
Axis 2	
Natural handicap payments in mountain areas and payments in other areas with handicaps (Art. 36 (a) (i–ii) or Art. 37)[b]	To support continued use of agricultural land (preventing abandonment of farming) and compensate for farmers' additional costs and income foregone related to the limitations for agricultural production (handicaps) in the area concerned
Natura 2000 payments and payments linked to Directive 2000/60/EC (Art. 36 (a) (iii) or Art. 38)	To help farmers address specific problems resulting from implementation of the Birds, Habitats and Water Framework Directives in agricultural areas through compensation for costs incurred and income foregone
Agri-environment measures (Art. 36 (a) (iv) or Art. 39)	To support provision of environmental services in agricultural areas
Support for non-productive investment (Art. 36 (a) (vi) or Art. 41)	To support non-remunerative investments in order to achieve agri-environmental objectives (including those in the framework of agri-environment measures) or to enhance the amenity value of Natura 2000 and high nature value areas
Afforestation of agricultural land (Art. 36 (b) (i) or Art. 43) and First establishment of agroforestry systems on agricultural land (Art. 36 (b) (ii) or Art. 44)	To stimulate diversification from agriculture toward forestry which has high ecological (and good long-term economic) potential

Source: Council Regulation 1698/2005.
[a]Alternatively called: investment support.
[b]Alternatively called: less favoured area (LFA) payments.

Table III. Some of them, rather than directly targeting soil quality, address important determinants of soil quality.

Axis 2 measures, which aim to improve the environment and the countryside through land management, are particularly relevant to address soil degradation processes. Member States are encouraged to focus on key actions of which some explicitly refer to soil, such as the protection of water and soil, or stress the role of soils in adapting to and mitigating climate change [Regulation (EC) 1698/2005, Preamble (31)]. The 'health check' revision of the CAP has reiterated some of and expanded upon these priorities. In addition, it tentatively specified types of farm operations (sorted according to main priorities), along with their potential effects [Regulation (EC) 74/2009, Annex II]. Relevant farm operations for soil quality under the priority 'climate change adaptation and mitigation' are among others: soil management practices (e.g. tillage methods, catch crops, crop rotation), land use change, and efficiency improvement of nitrogen fertiliser use. For the priority 'water management' similar farm operations are mentioned, which shows the clear interaction between these environmental priorities. Under the priority 'biodiversity' the document lists farming operations such as: no application of fertiliser and pesticides on high nature value agricultural land, integrated and organic production, setting up of management plans for Natura 2000, and construction/management of biotopes/habitats within and outside Natura 2000 sites. These farming operations have or may have beneficial effects on soil quality. However, soil is not listed as a priority and apart from the operation 'soil management practices', is not explicitly mentioned.

The listed measures under Axis 2 thus stimulate specific soil-friendly farming practices such as establishing buffers, or farming systems such as organic farming or conservation agriculture. In contrast, farmland abandonment can in the short-term result in increased erosion and reduction of soil

organic matter, in particular on sloping land that is left bare; however, these processes are not expected in the long run (Pointereau *et al*., 2008). Targeting less favoured area payments on areas suffering from natural handicaps like poor soil texture or steep slopes, and to extensive farming systems important for land management, reduces the above risk of land abandonment.

In most cases, it is impossible to conclude at the EU level to what extent the measures focus on, or are relevant to soil quality, since the required level of detailed information, in particular the link between farming practices and specific soil degradation processes, can only be obtained at the programme level or by means of case studies.

In a study commissioned by the Directorate-General Agriculture and Rural Development, 63 RDPs (2000–2006) in six Member States (Austria, France, Germany, Ireland, Italy, the United Kingdom) were screened for measures that have a potential effect on soil or biodiversity protection, or greenhouse gas (GHG) mitigation (GFA Consulting Group, 2006). Out of a total of more than 3000 reviewed measures, 246 measures were expected to have a medium potential impact on soil protection and 113 measures a high potential impact. The results clearly show that the core environmental focus of RDPs in these Member States is on above-ground biodiversity protection (habitat, species and genetic diversity). However, in Italy, the focus is on soil protection, followed by biodiversity protection and GHG mitigation.

Our analysis (JRC, 2009) of eight RDPs for 2007–2013 (Andalucía, Spain; Austria; Czech Republic; England, UK; Ireland; Poland; Sachsen, Germany; Sweden) indicated that agri-environment payments (Axis 2) are commonly used to target soil quality. Five AEMs include elements of soil quality in their objectives. Some schemes (Ireland, Poland) refer to soil and water protection in a general way; others address particular soil degradation processes, such as run-off and water erosion (Austria, England, Sachsen), or compaction and organic matter decline (England). The remaining three do not particularly refer to soil protection; the Czech and Andalusian cases nevertheless refer to related environmental objectives (e.g. landscape) or mention soil-friendly farming systems (e.g. conservation agriculture).

The mid-term evaluation reports of the 2000–2006 programming period [Regulation (EC) 1257/1999] proved that AEMs are beneficial for soil conservation (EC–DG AGRI, 2005). For example, direct drilling techniques in maize production (Austria), organic farming techniques (Umbria, Italy), hedge planting (Piemonte, Italy), green cover (Flanders, Belgium; Niedersachsen, Germany), arable set-aside (Niedersachsen, Germany), and conversion/reversion of arable to grassland (Niedersachsen, Germany) contributed to controlling water erosion. Alternatively, a combination of soil analysis and modelling was used to calculate the impact of AEMs on soil quality (tested farms in comparison to control farms using so-called good farming practice) (Piemonte, Italy). This showed considerable reductions of polluting substances in the soil for the main crops.

For the same programming period 2000–2006, Finn *et al*. (2007) estimated the environmental performance of AEMs in selected Member States and regions (Basse Normandie, France; Brandenburg, Germany; Emilia-Romagna, Italy; England (North East), the United Kingdom; Finland; Flanders, Belgium; Ireland; Veneto, Italy) (ITAES project). Experts evaluated five criteria of environmental performance pair-wise with objectives of the measures selected. Across the nine case studies, experts generally considered the measures on reducing soil erosion and chemical soil contamination to be well designed and administered, but weaker in terms of geographical targeting and uptake.

Overall, rural development policy offers options to the Member States or regions for encouraging farmers to go beyond the reference level of soil quality, that is the soil quality level that the farmer has to respect at his/her own expense. For example, agri-environment payments provide the Member States or regions with possibilities for encouraging farmers to go voluntarily beyond the reference level of soil quality, established through the requirements under SMRs, GAEC, and minimum requirements for fertilisers and plant protection products and other relevant mandatory requirements established by national legislation.

DISCUSSION AND CONCLUSIONS

Six of the soil degradation processes that are recognised at EU level are closely linked to agriculture: erosion, organic carbon decline, soil biodiversity decline, compaction, contamination, and salinisation and sodification.

This paper looked into the potential of existing and proposed EU policies to address these soil degradation processes. Due to a lack of suitable data, the analysis was mostly restricted to relevance of the policies scanned; effectiveness and efficiency were difficult to evaluate. Table IV synthesises what has been described above, that is which soil degradation problems are covered in the current objectives of existing and proposed EU policies, or are expected to be positively affected by implementing these policies (positive side-effects). This summary only includes the effects expected in the long term and thus neglects potential negative, but transitional short-term effects. The qualitative assessment assumes strong interrelationships between the different environmental compartments and is to a large degree based on expert judgement. Such judgement uses ‘common sense’ about how agricultural practices are linked to environmental changes. This approach is in line with that used in the design of most AEMs in the EU:

Table IV. Positively expected effects of EU policies on soil degradation processes

	Soil degradation processes					
	Water erosion	Organic carbon decline	Soil biodiversity decline	Compaction	Contamination	Salinisation/ sodification
Environmental policies						
Nitrates Directive	+		+	+	+	
Water Framework Directive	+		+		+	
Groundwater Directive			+		+	
Sewage Sludge Directive		+	+		+	
Plant Protection Products Directive[a]			+		+	
Birds Directive	+	+	+	+	+	
Habitats Directive	+	+	+	+	+	
(proposed) Soil Framework Directive[b]	+	+	+[c]	+	+	+
Common Agricultural Policy						
Cross compliance [Regulation (EC) 73/2009]						
Statutory management requirements	+	+	+	+	+	
GAEC[d] requirement	+	+	+	+		+
Rural Development Regulation [Regulation (EC) 1698/2005]						
LFA payments	+	+				
Agri-environment payments[e]	+	+	+	+	+	+

[a]This Directive has been repealed by Regulation (EC) 1107/2009. Similar effects are expected from the Directive on Biocidal Products (98/8/EC) and the Framework Directive on the Sustainable Use of Pesticides (Directive 2009/128/EC).
[b]In addition, the proposed Soil Framework Directive also explicitly addresses sealing and landslides.
[c]Positive effects on soil biodiversity are expected, even though the proposed Soil Framework Directive does not particularly target this soil degradation process.
[d]GAEC requirement: requirement to keep land in good agricultural and environmental condition.
[e]Agri-environment payments in general have the scope to address any potential soil degradation process. The actual effect of these payments depends on the national/regional implementation process.

empirical analysis showed that more than half of the management packages surveyed were based on 'common sense' impact models, rather than on documented evidence (Primdahl *et al*., 2010). Use of quantitative models would expectedly lead to higher effectiveness of policies. Nevertheless, even if quantitative impact models existed, their validity would depend on the context, as the results of such models cannot automatically be extrapolated to different contextual settings.

The range of existing policy measures has the potential to address all recognised soil degradation processes in EU agriculture, even though not all relevant policy measures are implemented throughout the EU-27. However, evaluation of effectiveness and efficiency of the policy measures with respect to soil quality has so far been limited. At present, reference and target levels of soil quality are often not clearly defined and thus not integrated into the objectives of relevant polices. Whether adequate levels of soil quality will be reached with the policy instruments provided will very much depend on policy implementation. Following the subsidiarity principle, Member States or regions implement policies according to the needs and specific geo-climatic and farming conditions identified within their territories. The policy objectives and/or farm management requirements should be sufficiently specified and adapted to local conditions, and subsequently adopted to reach sufficient levels of soil quality. Awareness-raising and advice considerably strengthen compliance with mandatory measures and the uptake of voluntary incentive-based measures.

Coordination between existing measures with a focus on soil protection is missing at the EU level and further limits both the effectiveness and efficiency of relevant policy measures. Nevertheless, initiatives at national and local level exist. Nine Member States have specific legislation on soil protection, albeit often addressing only one specific degradation process. One option to achieve an EU-wide coordination could be the adoption of the proposed Soil Framework Directive. Such coordination would allow dealing with soil degradation processes at all spatial levels (global, regional and local). As such, it would encourage alignment of regional approaches to soil conservation with supranational needs, including addressing transboundary effects of soil degradation. A coordinating policy could thus increase fairness among Member States, an important criterion for policy makers when evaluating policy options. However, where local or regional initiatives exist, the change in focus from a local or regional to a transnational perspective

could at the same time involve the risk of abandoning solutions adapted to local specificities. In the consultation accompanying the proposed Soil Framework Directive, 74·6 per cent and 87·8 per cent of the European citizens, and soil experts and organisations, respectively, favoured that a framework be developed at EU level and concrete measures established at national or local level [SEC(2006) 620].

The impact assessment of the Thematic Strategy on Soil Protection [SEC(2006) 620 and SEC(2006) 1165] gives an overview of expected costs and benefits if the proposed Directive were accepted. These are mainly linked to the identification of risk areas and contaminated sites, and the measures that Member States would have to take to address the needs identified. It is recognised that the costs of possible implementation measures would vary enormously depending on the (site-)specific approach and the actual measures taken. Nevertheless, it was estimated that the existing and expected benefits to society from measures against erosion and organic matter decline would amount to €8·6 billion per year for the EU-25, compared to a current annual expenditure of €1·7 billion on such measures through agri-environmental programmes, and additional net costs of €2·3 billion if the Directive were accepted.

Evaluating the effectiveness of policy measures on soil quality would be facilitated if a (quantified) framework for soil quality objectives existed. This would require a complex database that takes into account the wide variability of geo-climatic conditions and of farming types in the EU-27. The proposed Soil Framework Directive mirrors the absence of systematic monitoring and operational indicators for policy evaluation. The proposal suggests common criteria and factors (such as soil type, texture, hydraulic properties, land use, topography and climate) for a harmonised definition of soil degradation risk areas, but leaves the responsibility for selecting indicators to the Member States or regions. Also the definition of reference and target levels is shifted to the implementation level, which is appropriate, as it is impossible to set threshold levels centrally. Nevertheless, it should be emphasised that the proposed Soil Framework Directive strongly recommends collecting information and monitoring the state of soils. In this spirit, the ENVASSO consortium (Kibblewhite *et al*., 2008) has developed 'a system to harmonise existing, mostly national soil monitoring networks and databases, to form a European-wide reference that can assess current and future soil status and support the sustainable management of soil resources'.

Nevertheless, analysis at local and farm level appears necessary to clarify what drives successful adoption of proposed measures. The latter is especially relevant for understanding the adoption of whole farming systems, rather than a number of uncoordinated individual practices.

Overall, this paper presented the relevance of the legislative frame to address soil degradation processes in EU agriculture. This is a fundamental step in assessing policy effectiveness and efficiency, requiring analysis at local and farm level.

ACKNOWLEDGEMENTS

The project 'Sustainable agriculture and soil conservation' (SoCo) is a pilot project commissioned by the Directorate-General for Agriculture and Rural Development (DG AGRI), in response to the request of the European Parliament (administrative arrangement AGRI-2007-336 between DG AGRI and JRC). It was performed by the Joint Research Centre's Institute for Prospective Technological Studies (IPTS) and Institute for Environment and Sustainability (IES). The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

REFERENCES

Alliance Environnement. 2007. Evaluation of the application of cross compliance as foreseen under Regulation 1782/2003. Part II: Replies to evaluation questions. European Commission, Directorate-General for Agriculture and Rural Development. Available at: http://ec.europa.eu/agriculture/eval/reports/cross_compliance/part2.pdf; accessed July 2009.

Angileri V. 2007. Overview of the implementation of the Farm Advisory System in Member States. European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, Scientific and Technical Research series, EUR 23074 EN—2007.

Angileri V. 2009. FAS implementation in the EU. Setting-up, farm advisory bodies and rural development support. European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, Scientific and Technical Research series, JRC 49725—2009.

Baumol WJ, Oates WE. 1979. *Economics, Environmental Policy and the Quality of Life*. Englewood Cliffs: Prentice-Hall, NJ.

Bromley D. 1997. Environmental Benefits of Agriculture: Concepts. In OECD (ed.), Environmental Benefits from Agriculture: Issues and Policies. OECD Proceedings: Paris, 35–53.

Canenbley C. s.a. Evaluating the Common Agricultural Policy. Presentation, European Commission, Agriculture and Rural Development Directorate-General, AGRI G.4. Available at: http://www.rlg.nl/english/publications/downloads/canenbly.ppt; accessed July 2009.

CIFAS project. s.a. Cross compliance Indicators in the context of the Farm Advisory System (CIFAS). European Environmental Agency: Copenhagen K, Denmark. Available at: http://cifas.ew.eea.europa.eu/. accessed December 2008.

Cooper T, Hart K, Baldock D. 2009. *The Provision of Public Goods through Agriculture in the European Union, Report prepared for the Directorate-General Agriculture and Rural Development, Contract No. 30-CE-0233091/00-28*. Institute for European Environmental Policy: London.

Dimopoulos D, Fermantzis Y, Vlahos G, Farmer M. 2006. The responsiveness of cross compliance standards to environmental pressures, Cross Compliance Network Bulletin, Autumn 2006. Available at: http://www.ieep.eu/publications/pdfs/crosscompliance/Cross%20Compliance%20Network%20Bulletin%20Autumn%202006.pdf; accessed July 2009.

European Commission (EC). 2008. Environment fact sheet: Natura 2000. Available at: http://ec.europa.eu/environment/pubs/pdf/factsheets/natura2000_en.pdf; accessed December 2008.

European Commission (EC)—DG BUDG. 2004. Evaluating EU activities. A practical guide for the commission services. European Commission, Directorate-General for the Budget. Available at: http://ec.europa.eu/agriculture/eval/guide/eval_activities_en.pdf; accessed July 2009.

European Commission (EC) – DG AGRI. 2005. Agri-environment measures, overview on general principles, types of measures, and application. European Commission, Directorate-General for Agriculture and Rural Development, Unit G.4. Available at: http://ec.europa.eu/agriculture/publi/reports/agrienv/rep_en.pdf; accessed July 2009.

Finn JA, Bourke D, Kurz I, Dunne L. 2007. Estimating the environmental performance of agri-environmental schemes via use of expert consultations. ITAES WP5 Final Report. Available at: http://merlin.lusignan.inra.fr/ITAES/website/Publicdeliverables; accessed July 2009.

GFA Consulting Group. 2006. Germany, France, Italy, United Kingdom, Ireland, Austria—Analysis of the requirements for soil and biodiversity protection as well as for greenhouse gas mitigation within the rural development programmes. Final deliverable. European Commission, Agriculture and Rural Development Directorate-General. Available at: http://ec.europa.eu/agriculture/analysis/external/soil_biodiv/; accessed July 2009.

Hanna S, Folke C, Mäler K-G. 1995. Property rights and environmental resources. In Hanna S, Munasinghe M (Eds.) *Property Rights and the Environment: Social and Ecological Issues*. Beijer International Institute of Ecological Economics and the World Bank: Washington, DC; 15–29.

Hudec B, Kaufmann C, Landgrebe-Trinkunaite R, Naumann S. 2007. Evaluation of soil protection aspects in certain programmes of measures adopted by Member States. Cont. No. 07010401/2006/443994/ATA/B1. Final Report. European Commission, Environment Directorate-General: Brussels. Available at: http://ec.europa.eu/environment/soil/pdf/final_report.pdf; accessed July 2009.

Jongeneel R, Brouwer F, Farmer M, Müssner R, Roest KD, Poux C, Fox G, Meister A, Karaczun Z, Winsten J, Ortéga C. 2007. *Compliance With Mandatory Standards in Agriculture. A Comparative Approach of the EU vis-à-vis the United States, Canada and New Zealand*. LEI: Wageningen.

JRC (Joint Research Centre). 2009. Addressing soil degradation in EU agriculture: Relevant processes, practices and policies. Report on the project 'Sustainable Agriculture and Soil Conservation (SoCo)'. JRC Scientific and Technical Report, EUR 23767 EN. European Commission, Joint Research Centre: Seville (Spain) and Ispra (Italy).

Kibblewhite MG, Jones RJA, Baritz R, Huber S, Arrouays D, Micheli E, Stephens M. 2008. ENVASSO final report, Part I: Scientific and Technical Activities. ENVASSO Project coordinated by Cranfield University, UK, for Scientific Support to Policy, European Commission 6th Framework Research Programme.

Kutter T, Louwagie G, Schuler J, Zander P, Helming K, Hecker J-M. 2011. Policy measures for agricultural soil conservation in the European Union and its Member States: policy review and classification. *Land Degradation & Development* **22**: 18–31.

Martínez-Casasnovas JA, Concepción Ramos M, Cots-Folch R. 2010. Influence of the EU CAP on terrain morphology and vineyard cultivation in the Priorat region of NE Spain. *Land Use Policy* **27**: 11–21. 10.1016/j.landusepol.2008.01.009.

McCormick J. 1995. Environmental policy and the European Union. In Bartlett RV, Kurian PA, Malik M (Eds.) *International Organizations and Environmental Policy*. Greenwood Publishing Group: Westport, CT; 37–50.

OECD (Organisation for Economic Co-operation and Development). 2001. *Improving the Environmental Performance of Agriculture: Policy Options and Market Approaches*. OECD: Paris.

Pointereau P, Coulon F, Girard P, Lambotte M, Stuczynski T, Sanchez Ortega V, Del Rio A. 2008. Analysis of farmland abandonment and the extent and location of agricultural areas that are actually abandoned or are in risk to be abandoned. European Commission, Joint Research Centre, Institute for Environment and Sustainability, JRC Scientific and Technical Reports, EUR 23411EN—2008.

Primdahl J, Vesterager JP, Finn JA, Vlahos G, Kristensen L, Vejre H. 2010. Current use of impact models for agri-environment schemes and potential for improvements of policy design and assessment. *Journal of Environmental Management* **91**: 1245–1254.

Rodrigues SM, Pereira ME, Ferreira da Silva E, Hursthouse AS, Duarte AC. 2009. A review of regulatory decisions for environmental protection: Part I—Challenges in the implementation of national soil policies. *Environment International* **35**: 202–213. 10.1016/j.envint.2008.08.007.

Scheele M. 1999. Environmental Services Provided by Agriculture. The Setting of Environmental Targets and Reference Levels. Paper presented at the workshop on 'Non-Trade Concerns in a Multifunctional Agriculture', Gran (Norway), 9-11 March 1999. European Commission, Directorate-General for Agriculture, DG VI A1—Analysis and Overall Approach: Brussels.

Schils R, Kuikman P, Liski J, van Oijen M, Smith P, Webb J, Alm J, Somogyi Z, van den Akker J, Billett M, Emmett B, Evans C, Lindner M, Palosuo T, Bellamy P, Jandl R, Hiederer R. 2008. Review of existing information on the interrelations between soil and climate change, Final report prepared for DG Environment, Contract number 070307/2007/486157/SER/B1.

Stoate C, Báldi A, Beja P, Boatman ND, Herzon I, van Doorn A, de Snoo GR, Rakosy L, Ramwell C. 2009. Ecological impacts of early 21st century agricultural change in Europe—A review. *Journal of Environmental Management* **91**(1): 22–46. 10.1016/j.jenvman.2009.07.005.

UNEP (United Nations Environment Programme). 2007. *Global Environment Outlook (GEO-4): Environment for Development*. Progress Press Ltd: Valletta, Malta.

Weimer DL, Vining AR. 2004. *Policy Analysis: Concepts and Practice*. Pearson Prentice Hall: Upper Saddle River, NJ.

Wiebe K. 2003. Linking Land Quality, Agricultural Productivity, and Food Security. Agricultural Economic Report 823. United States Department of Agriculture, Economic Research Service: Washington, DC.