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Abstract (150 words)

This paper analyses soils-related policies in Europe and in selected member states and regions. Our approach breaks down policy packages at European, national and regional levels into strategic objectives, operational objectives, policy measures and expected impacts, and assesses the relationships between these elements and soil stakes. Four major policy packages, both at EU and national level (CAP-I, RDP, Environment, national initiatives) were analysed. A numerical scale was developed to quantify the level of "embeddedness" of soil stakes in these policy packages. We found that countries better embed soil stakes into their policies when they also put more efforts on environmental innovation. In turn, countries with high embeddedness level, with high trust in European institutions and that make more efforts towards renewable energy, tend to propose a wider variety of management practices to farmers for dealing with soil stakes.

Keywords: soil stakes, sustainable soil management, policy framework, Europe

1- Introduction

Agricultural soils in Europe are facing many threats, such as wind and water erosion, decline of organic matter content, local and diffuse contamination, sealing, compaction, decline in biodiversity, salinization, floods and landslides (Jones *et al.*, 2012). These threats have gradually developed from an increasing pressure on natural resources (including soil), that are due to agricultural and industrial activities, urbanization and possibly climate change. To the best of our knowledge, there is no precise assessment on how the existing policies have affected, and will further impact, the pressure on agricultural soils in Europe. Such assessment would require knowledge on (i) how policy frameworks are implemented in the respective Member States (MS), (ii) how farmers' soil management responds to policy measures, and (iii) what impact these responses have on the state of soils in short and longer term. This paper aims to fil the existing gap in point (i) and documents how soils are currently integrated into policies, using results from a survey conducted by the EU funded research project Catch-C[1].

The extreme differentiation of policy implementation among MS and regions adds to the assessment difficulties. Consequently, soil quality has been taken for granted in most policy assessments performed so far. Among notable exceptions, Louwagie *et al.* (2011) assessed the capacity of (then) existing and "future" EU policies to address soil degradation. They concluded that, so far, not all relevant policy measures are implemented throughout the EU-27. Kutter *et al.* (2011) provided an extensive overview on how soil-relevant policies are being implemented, including the agricultural practices involved, in several EU regions, based on an on-line stakeholders survey. According to their results, soil quality is often mentioned among the main targets of the policies they have analysed, but the potential of these policies to address all soil degradation processes at EU level is hampered by the lack of adequate monitoring. However,

[1] http://www.catch-c.eu/

despite its size, their extensive database was not – in their view - suitable to analyse policies in individual MSs. More recently, Glæsner *et al.* (2014) performed a cross-policy analysis to identify gaps and overlaps in the existing (up to 2013) EU legislation concerning soil protection. They show that, for several major soil threats, MSs failed to include sufficient mitigation measures in their current national legislations.

Even if limited in number, the existing analyses of policy instruments in Europe (the most recent is Frelih-Larsen, et al., 2016) all conclude that soil functions are often only implicitly addressed in EU regulation or national initiative, and that the overall benefit for soil protection depends strongly on how issues are integrated in the various policy instruments and on how they are coordinated. It is precisely this aspect - how exactly are soils issues integrated in policies - that we set out to assess in this study: we have built our approach on the works by Louwagie *et al.* (2011) and Kutter, *et al.* (2011). In expanding their approach, we actualised the set of policy packages by including the last CAP reform. Next, we performed a cross-cutting analysis of policy measures and the soil management practices (MPs) they foster or discourage in relation to the different soil stakes, and we did so for regional, national and European levels. We introduce the new concept of 'embeddedness of soil stakes' in the policy frameworks, and we explain different levels of embeddedness found in the respective MSs by a set of indicators that reflect both the assets and the institutional constraints that characterise each MS.

The remainder of this paper is organised as follows. Section 2 depicts the method we applied to link soil stakes, policy packages, types of instruments, and involved management practices. Section 3 discusses the outcomes of our assessments. In Section 4, we use these outcomes to propose new pathways towards more sustainable soil management.

2- Methods and definitions

2.1 Soil stakes

There are many stakes related to soil management, from soil biodiversity to global climate change, and those stakes are affected by farmers and a large range of other actors, including civil society, land planners and policy makers at various levels. Soils supply private (farmer income) and public (ecosystem services, ES) goods and services, and the two are often hard to separate. A certain management practice can improve soil quality to the benefit of both types of purposes, or may foster one purpose but jeopardize others. Examples of these trade-offs are numerous, especially regarding the long-term impacts of practices. For instance, the use of farmyard manure in the continental climate zone does improve soil biological and physical quality and contributes to soil carbon stocks (Bhogal *et al.*, 2011), but reduces nitrogen (N) use efficiency and crop yield, as compared to mineral fertilisers at the same N input rate[2] Similarly, reduced tillage for soil conservation reduces fuel use but boosts herbicide use in many MSs, jeopardizing biodiversity (Moreby and Southway, 1999; Marshall, 2001).

Soil quality, as the foundation of agricultural production, is generally considered as a private good that is capitalized into rental (Kilian, *et al.,* 2008) or sale prices (Feichtinger and Salhofer, 2013). The public goods and services from soils have local as well as more global dimensions. The prevention of landslides, siltation and flooding, or the preservation of soil biodiversity may have a local character. Services with wider outreach are the sequestration or retention of carbon in soils, the regulation of water systems and water quality, and the sustenance of biodiversity at large.

[2] Many other examples can be found here : http://knowsoil.catch-c.eu/KnowSoil/?dojo.locale=en#

98 In this paper, we consider all ES affected by soil management as part of soil stakes. We refer to
99 'soil stakes' as public and/or private interests affected by the management of agricultural soils.
100 These include in the first place the protection and improvement of the soil itself, notably the
101 integrity and quality of soils for use in agriculture and in the provision of other ES. These "soil
102 quality stakes" relate to the status of the soil itself. Among these we distinguish the retention of
103 topsoil by protection against erosion by water (1) and wind (2), the protection of soil structure
104 against compaction (3), and the conservation and enhancement of soil organic carbon (SOC)
105 (4) and soil biodiversity (5). Besides their obvious importance to farming, these stakes also
106 relate to the above public goods and services. Beyond the soil quality stakes, we distinguish a
107 second set of stakes that include the provision of landscape-based ES such as water quality (6),
108 air quality (7), and (above-ground) biodiversity (8). These are evidently public stakes, have far
109 wider than just local outreach, and are largely determined by soil management practices,
110 irrespective of their impact on soil quality. For example, excessive fertiliser or herbicide use
111 pollutes water bodies, and monoculture cropping diminishes the potential to sustain
112 biodiversity, even if they would leave the soil unaltered. We refer to these stakes as "other
113 environmental stakes affected by soil management" (hereafter in short "other stakes"). We did
114 not cover the threats of soil acidification (mentioned by only few MSs), or industrial
115 contamination (no direct link with agriculture).
116
117 *2.2 Policies affecting soil management*
118 The appropriate level of policy design for the protection of soils, as that for other environmental
119 goods, is fiercely debated in the literature. Millimet (2013) provides a recent review of the
120 advantages and drawbacks of centralised versus decentralised levels of policy design for
121 environmental protection in general, which applies also to soil protection. Beyond achieving a
122 sufficient level of protection, criteria for or against centralisation are the existence of
123 spillovers[3], the heterogeneity between regions[4], and the ability of local governments to respond
124 better or not - than the central government - to community preferences.
125
126 According to the Subsidiarity Principle[5], the EU countries and regions have the freedom to
127 implement policies to protect soils according to the needs and specific geo-climatic and farming
128 conditions in their territories. This has resulted in an incredibly complex set of strategies overall
129 Europe for soil protection. Kutter *et al.* (2011) counted 410 different soil conservation measures
130 in the European Member States in 2008. A few years later, Frelih-Larsen, *et al.* (2016) have
131 identified 35 EU level policies and 671 instruments across the 28 EU Member States that can
132 deal with soil stakes. The spatial extent of these measures, however, is rather low: for example,
133 out of all areas under agri-environmental measures (AEM) in 2008, only 8 % benefited from
134 actions to conserve soils.
135
136 Acknowledging the importance of soils as a major asset for agricultural production and other
137 ES, including mitigation of climate change, the European Commission launched a consultation
138 towards a Soil Framework Directive in 2006. The objective of this consultation was to simplify
139 the way soil stakes were considered in policies and to initiate a comprehensive legislation on
140 soil protection. The Directive was withdrawn in May 2014[6], mostly because of the difficulties
141 such a Directive would induce for industrially polluted soils and with several MS grounding

[3] Spillovers occur when the level of environmental (soil) protection chosen by a region affects the benefits of other regions. The most common examples are transboundary water protection, climate change mitigation or research effort benefitting more regions than those where research is done, but spillovers can also derive from changes in competitive assets when some regions choose low protection levels to attract polluting enterprises or to decrease production costs.
[4] When the regions are highly heterogeneous, a centralised uniform policy is inefficient.
[5] The Subsidiarity Principle dictates that EU action is only allowed in situations where policy objectives cannot be sufficiently achieved through MS actions (Revesz, 1997).
[6] OJ C 163, 28.5.2014

142 their opposition on the Subsidiarity Principle. Meanwhile, the Soil Thematic Strategy[7] was
143 introduced to integrate soil stakes into all relevant policies when renewed, to raise awareness
144 about the importance of soil stakes, and to encourage soil research. This Strategy has put much
145 emphasis on agricultural soils, notably with the renewal of the Common Agricultural Policy
146 (CAP). In 2015 - the International Year of Soils - discussions intensified with the aim of better
147 protecting soils and using them in a more sustainable way.
148
149 So far, most policies do not focus on soil quality stakes, but rather on the ES supplied by
150 agricultural soils. These ES are promoted by thematic policies (regarding water, air and
151 biodiversity protection), but also through the 'Greening' of the CAP and - albeit on relatively
152 small surfaces - through measures in the Rural Development Programs (RDPs) for sustainable
153 management of natural resources (including the agri-environment-climate measures - AEC).
154 Agricultural soil protection is at the interface of these main policy packages, and a handful of
155 additional - national or regional - initiatives targeting soil protection directly or indirectly. For
156 example, legislation to mitigate urban sprawl protects agricultural soils from sealing in some
157 MSs. In this study, we have clustered the various policies into four 'policy packages': (1)
158 agricultural policies (CAP pillar I), (2) rural development policies (CAP pillar II), (3)
159 environmental policies, and (4) additional specific national policies. The environmental policies
160 comprise the Nitrates and Water Directives, the Habitats, Waste, Sewage Sludge, Plant
161 Protection Products, and National Emissions Ceiling Directives, plus the Environmental Impact
162 Assessment Directive, Resource Efficiency Roadmap, European Innovation Partnership, and
163 developments under the Kyoto Protocol. For package (4), we scrutinised a handful of national
164 legislations and documents, such as national soil protection acts.
165
166 *2.3 Screening of policy documents: Number of practices, Embeddedness of soil stakes, and*
167 *Types of instruments*
168 Our analysis builds on the Logic Model (Rogers, 2008) used by managers to evaluate policies[8].
169 For each of the four policy packages (Section 2.2), we studied available documents to assess
170 the precise formulation of strategic and operational objectives, the rationale behind the
171 proposed measures and, if mentioned, their expected impacts. National laws can be stricter than
172 EU legislation. The operational objectives are formulated at the national or regional level,
173 depending on the governance structure of each Member State. Measures are designed,
174 implemented, enforced (or not) and monitored at the national, regional or even very local level.
175 Thus for the same objective of soil protection, the sets of measures can be very different
176 between regions. This inventory provides, for each MS or region, a picture of management
177 practices that are promoted or restricted by each policy package to operationalise its objectives
178 for each soil stake. These MPs may include options for crop rotation, tillage, the use of catch
179 and cover crops and green manures, the use of manures and fertilisers, crop residue management
180 and water management. We counted the number of MPs related to each soil stake, and
181 investigated how this variable (N_{MP}) is related to 'country-level indicators' (see Section 2.4).
182
183 From the EU policy objectives to implementation, the soil stakes pass through several levels
184 from supra-national to subnational policies, and these policies can grant them different degrees
185 of priority. We describe these paths by the concept of '*embeddedness'* in the successive stages
186 of policy design, building on the growing body of literature on the embedding of ES in policies
187 (Helming, 2013). The embeddedness expresses to what extent a given soil stake is integrated

[7] COM(2006)231: COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Thematic Strategy for Soil Protection. SEC(2006)620, SEC(2006)1165, Brussels.

[8] The Logic Model builds on program theory to describe complex reality as a relatively simple causal representation of how the intervention (policy) works.

into the policy implementation process. To quantify this concept, we introduce the following scale:

- **Level 0**: no soil or soil stakes are mentioned in the specific policy.
- **Level 1**: soil or soil stakes are mentioned but not targeted at all.
- **Level 2**: soil or soil stakes are mentioned somewhere in the process of policy design, but never prominent. Level2 policies do target soil (or soil stakes) among all natural resources to be protected but clearly the focus of the policy is not on soils.
- **Level 3**: soil or soil stakes are mentioned in the policy objectives, but some elements are missing. Most often, the measures are not explicitly targeted towards soils (or soil stakes); or the elements that are present are only weakly related to soil or soil stakes. A typical example of such policy would be a regional policy aiming at restoring the quality of natural resources, among which soils, and promoting the restoration of natural grassland "because they are good for soils too".
- **Level 4**: soil or soil stakes are mentioned in the policy objective, as an outcome of a knowledge-based diagnosis (sometimes spatially differentiated), these stakes are explicitly mentioned in the measures, but their expected impacts are not expressed clearly.
- **Level 5**: soil and soil stakes are fully embedded in the policy process. The policy explicitly refers to soil or soil stakes in its objectives, includes clearly targeted measures towards soil or soil stakes, and is associated with a clear assessment of direct and indirect expected impacts of these measures on soil stakes. We did not take into account *ex-post* monitoring - of compliance or impacts - as a criterion for embeddedness).

Using the above scale, we expressed for each policy package the embeddedness of soil stakes at the national level for five MSs (Austria, France, Italy, the Netherlands, Poland), and additionally for regions in Germany (Lower Saxony, Thuringia), Spain (Andalusia), and Belgium (Flanders). Subsequently, we investigated how the embeddedness of soil stakes (E) is related to 'country-level indicators' (Section 2.4).

Besides the policy implementation process, we also analysed the type of instruments that each policy uses to influence soil management by farmers. Following the Baumol and Oates (1975) classification for environmental protection policies, we distinguish mandatory, incentives-based, or voluntary (based on awareness raising) instruments. This inventory yielded as quantified variables (a) the number of different instrument combinations[9] used per soil stake, and (b) the proportion of MPs promoted or restricted by mandatory or incentive-based instruments, respectively. We also studied the extent to which policy packages are interlinked, and quantified this aspect as (c) the proportion of MPs that appear in one policy package only. The above indicators (a, b, c) were used to explain variation – across MS and regions – in the response variables N_{MP} and E.

The screening of documents, and compilation of the above set of variables from these documents, was complemented by qualitative information on the views of regional and national policy makers in several countries on dealing with soil stakes in policies. We have conducted semi-structured interviews with 4-6 key policy makers per country. The aim of these interviews was to collect an overall description of the logics behind soil protection strategies and MPs at local/national level and identify relevant institutional aspects. The semi-structured interviews included three main groups of questions:

[9] The 7 combinations are (M for mandatory, I for incentive based and V for voluntary): M; I; V; MI; MV; IV and MIV.

1) how important are environmental stakes among all stakes in the region? Among environmental skates how important is soil? Which soil functions are the most prominent in the area?
2) Which are the strategic objectives in the area regarding soil protection (overall or in detail)? Which policy instruments are implemented for this purpose? How are soil stakes considered in these policy instruments? How are measures combined to reach the objectives?
3) On which features should we rely on if we want to enhance soil functions (or soil protection, depending on the local focus) in the area?

2.4 Explaining embeddedness and number of practices with the help of 'country-level indicators'

We aimed to explain the embeddedness of soil stakes *(E)*, as well as the number of MPs promoted or restricted by a country's policies *(N_{MP})*, with the help of country-level indicators that characterize the economies of our MSs and regions. We used an Ordered Logit model (Allison, 2012) to explain *E*, and an Ordinary Least Square (OLS) regression to explain N_{MP}. The indicators needed for both these analyses were selected from Eurostat. These were: the indicator A of farm income, the proportion of agricultural land that is owned by farmers, the percentage of arable land on total agricultural land, the eco-innovation index, the share of renewable energy in total energy consumption, and the citizens' confidence in EU institutions. These Eurostat indicators were identified by Principal Component Analysis to be the set that, from over 200 candidate indicators, best explained variation in *E* and N_{MP} between our MSs. They are shortly introduced below.

The importance of agriculture in the economy is expressed by the indicator A of farm income, which is the real net value added at factor cost of agricultural activity per unit of labour. Theesfeld *et al. (*2010) use the importance of agricultural area and of the agricultural sector employment as indicators for the bargaining power of farmers' associations. Instead, we used the share of arable land on total agricultural area, which is closer to soil stakes, and indicatorA of farm income[10], which is more recent than the employment ratio used in Theesfeld *et al.* (2010), and better reflects the economic importance of the agricultural sector where farms create employment not only in agriculture but also in the agri-food industry. Land ownership was included because we assume, following Bromley and Hodge (1990), that property rights have the potential to influence policy design. The next two indicators are more related to outcomes of national (non-soil oriented) policies. The eco-innovation index measures to what extent a country invests in environment-oriented innovation. The share of renewable energy in total energy consumption expresses the efforts a country makes towards mitigating CO2 emissions. As many of the practices for sustainable soil management are innovations too, a country's general policy towards environmental innovation may affect the embedding of soil stakes into policies.

Finally, perceptions of trust, fairness, and reciprocity are important for the effectiveness and efficiency of the policy regimes (Fehr and Gächter 2000; Ostrom 2010). To reflex these concepts, we included the citizens' confidence in EU institutions as 'trust indicator'. It expresses the share of positive opinions (people who declare that they tend to trust) about EU institutions. The indicator is based on the Eurobarometer, a survey conducted twice a year since 1973 to monitor public opinion in EU Member States.

[10] Descirption and use of Indicator A of farm income : http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_output,_price_indices_and_income#Income:_Indicator_A

The above set of Eurostat indicators was complemented with the three variables (derived from our own screening of documents) that depict how a MS or region combines the various types of policy instruments[11]. With the set of country-level indicators thus composed, we then investigated for all indicators to what extent they can explain the observed variation in the response variables E and N_{MP}.

3. Results

3.1 Variety of strategies across Europe to deal with soil stakes

Austria and Germany appear to have designed a comprehensive strategy towards soil stakes, albeit with different frameworks: Germany underpins its policies by national legislation, and builds on it to include soils in EU-driven policy packages; Austria has provincial laws about soil stakes with different levels of soil protection effort. In the Netherlands, the National Soil Act has a limited impact on agricultural soil management, apart from its connection with extensive legislation to control nutrient emissions.

Flanders in Belgium addresses soil stakes with EU driven (CAP) and regional policies. Italy, Spain and -to a lesser extent- Poland use the EU strategy to design some site-specific policies to deal with local soil issues. In France, despite a large bundle of general frameworks, we found only few measures that clearly target soil stakes in agriculture.

All surveyed countries include water quality, biodiversity and soil erosion by water in the environmental stakes handled by their policies. They also consider other soil stakes, but to different extents and they address these stakes with a large variety of MPs (Table 1) and combinations of instruments (Table 2).

Table 1: number of soil management practices (MPs) promoted or discouraged by policies in Member States or regions studied, for respective soil stakes (shaded cells indicate that the stake is not addressed by policies)

The MPs are promoted or restricted by different types of instruments (Table 2) with some overlap in most cases between types: similar MPs can be the subject of mandatory as well as incentives-based instruments, or can be included in awareness raising programs. A typical case would be a ban on soil tillage in highly erodible areas, while no-till or minimum tillage is only promoted by incentives in less erodible zones, or included in long-life learning programs in the entire country. Another frequent example is the obligation of using a 'basic level' MP as standard, with the voluntary option to apply a more stringent design of the same MP (reducing fertiliser input, for example).

Table 2: Number of instruments used to address soil stakes in policy packages in the Member States and regions studied (M: Mandatory instruments; I: incentives; V: voluntary instruments)

Table 2 shows no clear pattern in how countries and regions mix the three types of instruments, which confirms findings by Louwagie *et al.* (2011). Nevertheless, contrasts between countries exist and are related to country-level indicators as shown below.

3.2 Embeddedness of soil stakes

[11] See section 2.3 : these variable include: the number of different instrument combinations used per soil stake, the proportion of MPs promoted or restricted by mandatory or incentive-based instruments, respectively, and the proportion of MPs that appear in one policy package only.

We first analyse how soil stakes are embedded in the four policy packages studied[12]. Not only do countries have various strategies regarding soil stakes, they also incorporate them to varying levels into their policy packages (Table 3). Soil stakes are seldom fully embedded in the policies. Instead, embeddedness is commonly poor (level3) with no explicit connection between soil stakes mentioned in the policy objectives and the measures implemented to deal with these stakes in the field. Overall, the rural development policy package, which was recently renewed, shows somewhat higher embeddedness levels for soil stakes than the environmental policy package. The latter was not explicitly designed to include soils, and is older than the latest rural development programme.

Table 3: embeddedness of soil stakes into policy packages per country

Overlaps and cross-referencing exist between policy packages (see quantification of interlinkages, Section 2.3). For instance, the design of agri-environmental schemes under the rural development package has to start – as a baseline - from the MPs that are mandatory under the environmental package. Some countries do explain such connections in their policy documents, others just don't. Proper cross-referencing can reinforce policies' effectiveness by mitigating potential conflicts between policies (Nilsson *et al.*, 2012). Thus, building on Table 3, we assessed for each soil stake whether the respective policy packages refer to the other packages (for example: Does an environmental package explicitly mention RDP measures targeting soil stakes?). Instead of simply averaging the different embeddedness levels over the policy packages that deal with a given soil stake, we adjusted the overall mean depending on the level of cross-referencing to other policy packages (Table 4). Most countries consider a large range of soil stakes in their policies, but some incorporate them strongly into policies, with a good consistency across the different policy packages. Other MS or regions mention soil only in the strategic objectives but not elsewhere in the policy process.

Table 4: Embeddedness of soil stakes in policy packages in the Member States and regions studied

In addition, there are some regional differences in how soil stakes are embedded in policies. In Austria, the national law is a heterogeneous field established by contract in the competence of the provinces. The provinces Burgenland, Lower Austria, Upper Austria, Salzburg and Styria established five different laws for soil protection which set a framework for a sustainable use of soil. Neither the federal government nor the provinces have an overall competence in the field of soil protection. As a consequence, some Provinces commit more efforts to maintain or restore soils than others.

In Belgium, environmental and agricultural legislation is mainly a regional competence. Although environmental stakes with clear European targets (e.g., biodiversity, air and water quality) are higher on the political agenda than soil conservation, Flanders has a clear policy on soil contamination and soil erosion by water, which is regulated by a Soil Decree and the requirements for GAECs.

In France, the national level prevails even if, for the next programming period, the design of RDPs is largely by regional authorities. Knowledge gathering and dissemination is at national level, and so is the design of soil protection strategies and measures. Regional authorities mostly choose among measures designed at national level. The argument for this centralised approach is reducing costs of knowledge acquisition, coordination of efforts among regions, and the harmonisation of soil maps.

[12] These packages are: (1) agricultural policies (CAP pillar I), (2) rural development policies (CAP pillar II), (3) environmental policies, and (4) additional specific national policies.

Germany benefits from a Federal Soil Protection Act (BBodSchG) for the protection of soil from harmful alterations and the prevention of negative effects (disturbance of soil functions). Overall, the embeddedness of soil stakes into policy packages is high in Germany for rural development, environmental and national policy packages, with a good connection between these packages, and somewhat lower for the agricultural policy package.

In Italy, the European level has a strong influence on soil strategy design (as in France and Spain). There is substantial attention for soil erosion, nitrate leaching, pesticides leaching and run-off. The aim to mitigate SOC decline and erosion, and to enhance biodiversity and water quality is included in several policy packages with good coordination between them. MPs are mostly stimulated by Agri-Environment Schemes, specific agricultural support and the Nitrates Directive.

In the Netherlands, the Soil Protection Act was the first national initiative in Europe towards dealing with soil stakes. However, this Act is implemented into only a limited number of mandatory requirements relevant to farming. Similarly, most of the environmental stakes considered are EU driven, and soil quality stakes seem to receive only low priority, after water quality, biodiversity, and climate change. Apart from restrictions and obligations for farmers in the southern Loess district, there is no clear policy towards sustainable soil management. Soil management is rather addressed indirectly via policy measures designed for other stakes, such as water quality.

The major threats to soils in Poland are soil erosion, low organic matter, soil sealing and acidification. As in many countries, Poland mixes mandatory instruments with incentives to promote sets of management practices linked with sustainable soil management. However, soil stakes still show a relatively low embeddedness into these policy packages.

In line with Mediterranean soil stakes, Andalusia focuses strongly on loss of organic matter (in relation with productivity) and soil erosion threats. Environmental issues are dealt with in an interrelated manner, water quality issues (eutrophication, pollution, water availability and siltation) come immediately after erosion, and then the focus is on biodiversity, droughts and desertification, and the control of wildfires. There are different regional situations. For example, soil erosion is one of the main issues concerning to the Andalusian government. Soil stakes are very clearly embedded into CAP and rural policy packages, which ground on a combination of very precise mandatory measures. Measures are designed by consultation between the national level (Ministry of Agriculture), the autonomous communities and local stakeholders.

Apart from Austria and Germany, most countries seem to protect soils only where there is imminent danger or nuisance, and very few have a general effective protection against the loss of productive land (*e.g.* sealing, or land take by urban sprawl), or against the gradual decline of its quality (*e.g.* organic matter, compaction, soil biodiversity, soil pathogens). Moreover, we found very few examples of measures that are directly targeted to local soil stakes. Despite the policy implementation in the regions grounding on regional diagnosis, measures often lack protection ambition for easier adoption by farmers, and also lack spatial tailoring to specific areas or threats.

3.3 Relating embeddedness to country properties

The ordered logistic regression showed that embeddedness of soil stakes is significantly and positively related to the eco-innovation index and to the proportion of agricultural land owned by farmers (Table 5). Countries putting much effort on environmental innovation and where the farmers own higher shares of land appear to better incorporate soil stakes in their policies. A significant positive relationship was also found with the number of instrument type combinations used. The greater variety in instruments combinations used by a country, the higher the embeddedness of soil stakes. The influence of famers' bargaining power on the embeddedness appeared to be low from this analysis: none of the two indicators we used to reflect this bargaining power showed a significant relation to embeddedness. Finally, we also found that the embeddedness did not differ significantly between the respective soil stakes (Table 5, lower section).

Table 5. Ordered Logit estimates of embeddedness (E) of soil stakes in policies (lower section is related to the qualitative explanatory variable "type of stake")

3.4 Relating number of management practices (N_{MP}) to country properties

The regression analysis (Table 6) showed that the number of MPs promoted or restricted by a country's policies is positively related to the embeddedness of soil stakes in these policies, to national (or regional) efforts towards renewable energy, and to the level of trust in EU institutions. In contrast, indA of farm income (proxy for the bargaining power of farmers) shows a negative relation with the number of practices addressing soil stakes: countries with high farm income propose fewer practices to address soil stakes; Austria and Italy are exceptions, where this negative effect appears to be overruled by the positive effects of the other indicators.

We found no significant dependence of the number of MPs on the types of instruments employed by a country. Similarly, the extent to which different types of instruments - to promote or restrict MPs - are combined showed no relation with the number of MPs proposed.

Austria, Germany, Italy and Poland promote a large set of MPs to preserve SOC. It is for this stake that we observed the largest variability across countries in the number of MPs proposed. Policy packages dealing with erosion or compaction tend to propose fewer MPs to farmers than those targeting SOC preservation (negative values in lower half of Table 6, first col.).

Table 6: Results from the OLS for the number of soil management practices promoted or restricted by the policy packages for soil stakes

4. Discussion: Pathways to more ambitious sustainable soil management

Evidence of soil threats on large areas in Europe has not, so far, triggered efficient mainstreaming of soil stakes into policy packages in each country/region studied. Despite efforts under the European Soil Thematic Strategy towards a better integration of soil stakes into policies, all policy assessments over the past five years have found overly complex patterns of objectives, measures and instruments across Europe. This resulted in most cases in contradictions in the implementation of the various policy packages and losses of efficiency.

Our analysis confirms that assessment. Despite that most[13] existing soil stakes are now considered at the European level, they are not necessarily addressed at the national or regional levels. Moreover, the embeddedness of soil stakes in policy packages at national and regional levels appears rather low in many countries and is still far from homogenous between countries.

All centralised EU policy packages do already recognise that local tailoring is needed. This holds for CAP-I (design of GAECs measures), and for RDP and the Framework Directives (all measures), but this intention does not seem to work well for soil stakes, in spite of the Soil Thematic Strategy. One could have expected MSs to rely on the Subsidiarity Principle for protecting soils adequately, based on well diagnosed local stakes, and to have appropriately embedded these stakes and their policies in the EU driven packages. In practice, not only are soil stakes still poorly embedded in policy packages, we also found only few measures targeting specific local stakes. Finally, even where local measures are based on local diagnosis, we found little documentation on *ex-ante* impact assessment of such measures on the targeted soil stakes. The existing institutional framework appears currently under-utilised.

Based on our analysis, we identified three main flaws characterizing the generally poor state of integration of soil stakes in policies:

- The local tailoring of EU-driven policies is not easy for soils. The multilevel governance framework and the large amount of steps in the procedures renders easier for a local policy maker to pick up a set of measures in the lists established at the EU level than to fight for approval of more innovative or locally adapted measures. However, if such 'standard' measures do not properly address priority issues as seen by the stakeholders themselves, they will be reluctant to introduce them.
- Despite efficient measures in places of small spatial extent where soil threats are evident, the gradual decline of soils or the loss of productive land over much larger areas are rarely included in policy documents (at any level). Among the reasons for this relative absence we collected during interviews are the low awareness of some stakeholders, the potentially high cost of measures to deal with losses, and the absence of appropriate indicators to measure it.
- There is an evident lack of locally differentiated knowledge on the long term consequences of soil management practices on soil stakes. As a result, expected impacts of measures on soil stakes are not generally formulated, nor are the impacts monitored once the measures are in place.

The embeddedness of soil stakes into policy packages - from the very local to the European level, and including implementation and impact analysis - can be improved by several elements.

A. Allow for local stakes in centralised policy frames

A key point for the withdrawal of the Soil Directive was the potential lack of freedom to design and implement soils policies as suited to the needs and specific geo-climatic and farming conditions in their territories. Moreover, the policy makers we met often consider that the top-down design of current EU driven policies does not leave them this freedom. They could address local stakes by local measures, but stand-alone local policies can be inefficient for two main reasons: (i) policy makers tend to invest less in environmental issues when costs cannot be shared with other regions, and (ii) other regions can complain of unfair competition inside the European Union if funds are allocated to one region only.

[13] Salinization, acidification or sealing by urban sprawl are still poorly addressed.

The local tailoring of current policies does not work properly for soil stakes. A typical example of local stakes that would gain from being included in EU frameworks is the protection of specific landscapes that mix ES in a different way than usually done in the rest of Europe, like the Mediterranean wooded pasturelands known in Spain as "dehesas". These agro-silvopastoral systems combine livestock grazing, wood production, cropping and recreation. They provide rural livelihoods, a rich habitat for biodiversity, and add socio-economic values to the region, but do not currently benefit from policies integrated with the EU framework. Another example is the threat of soil acidification in Poland, which could be addressed more effectively if linked to EU policies.

Permitting local tailoring of measures to address local stakes in centralised policy frames offers several advantages: the measures are closer to local preferences; they better match with people willingness to pay for the environmental services that local measures supply; they can foster innovation and help find solutions to local problems. By addressing local issues, they can improve policy makers' awareness on the many services soils can supply, even if they believe that their soils do differ from all other soils in Europe. The relationship we have found between soil stakes embeddedness and eco-innovation index pleads in the same direction. Of course, the centralised frameworks in which these local stakes and measures are included should then serve as a safeguard: including local stakes should not favour short term regional outcomes at the expense of long term EU soil strategy, and these local stakes should be documented by proper local knowledge collection to assess locally expected impact.

B. Pay attention to interactions between policies and possible competition between regions at the expense of sustainable soil management and adjust policy frameworks accordingly

Allowing for local stakes in EU driven policy frames amounts to design placed-based policies and placed-based policies can be distortionary by driving public funds to less efficient places, or by letting MSs focus on local stakes at the expense of EU wide stakes. If some MS ignore EU-wide stakes like protection against erosion or the loss of productive land, that can lead to a "race to the bottom" (Cumberland 1981) too, where local resources are sacrificed for short term outcomes, in a context of competition among regions. Although policy makers mostly consider this of little relevance to soils stakes, we argue that the abandonment of the proposal for a GAEC "protection of wetlands and carbon rich soils" is an evident case where the EU level should have been legitimate to play its regulating role, but appeared not to do so due to reasons beyond soil stakes. Clearly, the amount of carbon lost from such soils when ploughed will require an untold amount of time and expense to be restored, and require more efforts to all MSs than if a centralised compensation scheme had be put in place.

Moreover, while policies are usually coherent at the level of their objectives, their implementation often introduces modifications, as stated by Nilsson *et al.* (2012), resulting in unintended outcomes. We have also found this for several regions, where soil stakes appeared well integrated at the objective level but not in the measures implemented. In sections 3.3 and 3.4, we have listed some country features that are positively associated with better embedding of soil stakes, and with the number of practices promoted or discouraged.

C. Encourage local knowledge collection and sharing

Effects of soil management practices as analysed in the Catch-C project were found to be highly variable, depending on local conditions (Spiegel, *et al.*, 2014). Local knowledge of effects that

a practice will generate should be better utilized in policies, ensuring a focus on locally best suited practices. Overall our sample of countries and regions, we found that the efforts of countries towards renewable energy are correlated to the embeddedness of soil stakes. Our survey highlights that at the regional level, synergies are not yet sought between the different practices promoted by the different policy packages.

Local knowledge can be collected by local institutions or advisors organised in independent networks in a collaborative fashion with farmers. National policies can promote such networks for independent knowledge sharing. Here too, a centralised policy frame has the potential to help sharing knowledge, sound science and costs, plus create the necessary coordination for building a set of validated indicators that, in turn, will ensure proper assessment of the impact of policies on soils.

Conclusion

We analysed how the embeddedness of soil stakes into policy packages is linked to institutional factors, to country assets and to the mixing of mandatory, incentive based and voluntary instruments by the respective countries. We complemented the analysis by interviews with stakeholders at EU, national and regional levels.

The integration of soil stakes into existing policy packages when renewed is part of the Soil Thematic Strategy. Analysing nine countries and regions, we found that this integration is not efficiently performed in all of them. Countries which integrate soil stakes into their policies are the ones that also put more efforts on environmental innovation. In turn, countries with high embeddedness level, countries with high trust in European institutions and countries that make more efforts towards renewable energy, tend to propose a larger numbers of management practices to farmers for dealing with soil stakes. Farmer's bargaining power, in contrast, tends to reduce the number of MPs implemented to address soil stakes.

We conclude that the current policy framework is insufficiently utilised for protection against decline of soil quality and of the services that soils can supply. A coherent policy framework, with clear and shared objectives and precise reporting of outcomes, seems essential to establish a comprehensive strategy for sustainable soil management in agriculture. First steps towards such a framework include allowing local stakes into centralised policy frames with a special attention to interactions between policies and fair competition rules between regions (not to incite them to deplete resources), and encourage knowledge collection and sharing. Concrete applications mix measuring impacts of policy measures on soil and soil stakes, include gradual decline of soil in the considered stakes and favour coordination between MSs to reach European public goals.

There are many features that argue for a European level to this framework. These include (i) the obvious under-provision of soil ES at regional and national levels, (ii) the existence of spillovers for many soil stakes, (iii) competition between regions at the expense of resource depletion and associated services, (iv) the need for a redistribution mechanism between Member States that allows to implement measures in those places that are best suited to contribute to global (or EU wide) public goals, given. Such a policy framework has the potential to enhance sustainable soil management, preserving soil and its functions (e.g. mitigation of

climate change by carbon retention and sequestration; and regulation of the water cycle) and also safeguarding other public goods and services affected by soil management such as biodiversity, and water and air quality.

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701
702 **Tables**
703

	Soil quality stakes					Other environmental stakes affected by soil management		
Country/region	Water erosion	Wind erosion	Soil compaction	SOC decline	Soil biodiversity decline	Water quality	Air quality	biodiversity (general)
Austria	17	17	17	17	17	21	10	15
Flanders	8		1	9		12	6	6
France	13		4	5	2	18		16
Lower Saxony	9	9	5	15	2	15	4	3
Thuringia	7	7	5	15	1	16		3
Italy	9	15	9	23	23	13	15	18
Netherlands	6	1	1	3	9	15	4	6
Poland	4		10	11	1	9		2
Andalusia	10			9		9		7

704 *Table 1: number of soil management practices (MPs) promoted or discouraged by policies in Member States or*
705 *regions studied, for respective soil stakes (shaded cells indicate that the stake is not addressed by policies)*
706

	Soil quality stakes					Other environmental stakes affected by soil management		
Level of analysis	Water erosion	Wind erosion	Soil compaction	SOC decline	Soil biodiversity	Water quality	Air quality	biodiversity (general)

													decline											
Instruments	M	I	V	M	I	V	M	I	V	M	I	V	M	I	V	M	I	V	M	I	V	M	I	V
Austria	5	14	0	5	14	0	5	14	0	5	14	0	5	14	0	7	14	0	5	14	0	5	14	0
Flanders	8	6	0				0	1	0	6	5	3				10	3	9	4	2	0	5	3	1
France	13	8	3				3	0	2	2	0	4	2	1	1	17	4	2				1	11	7
Lower Saxony	4	7	7	4	7	7	0	1	4	2	1	13	0	1	1	14	5	0	0	4	0	1	3	0
Thuringia	4	2	7	4	2	7	0	1	4	2	1	13	0	0	1	14	2	0				1	3	0
Italy	9	0	0	2	15	0	9	0	0	15	17	0	9	18	0	13	11	0	0	15	0	8	14	0
Netherlands	6	0	0	1	0	0	1	0	0	3	0	0	9	0	0	15	8	9	4	0	0	6	0	0
Poland	1	3	0				2	9	0	3	10	0	1	0	0	6	3	0				2	0	0
Andalusia	10	5	0							2	7	0	8	7	0	1	9	0				0	7	0

Table 2: Number of instruments used to address soil stakes in policy packages in the Member States and regions studied (M: Mandatory instruments; I: incentives; V: voluntary instruments)

Policy package	Agricultural policies	Rural development policies	Environmental policies	National initiatives
Austria	4	4	4	4
Belgium (Flanders)	4	4	2	4
France	2	3	2	2
Germany	3	5	4	5
Italy	3	3	3	2
Netherlands	3	2	3	2
Poland	3	3	2	2
Spain	3	4	3	3

Table 3: Embeddedness of soil stakes into policy packages per country

		Soil quality stakes					Other stakes		
Level of analysis	Country	Water erosion	Wind erosion	Soil compaction	SOC decline	Soil biodiversity decline	Water quality	Air quality	biodiversity (general)
Austria	Austria	4	4	4	4	4	4	4	4
Flanders	Belgium	4		2	4		4	1	2
France	France	3		2	2	2	3		3
Lower Saxony	Germany	4	4	4	4	2	3	2	3
Thuringia	Germany	5	5	4	4	2	3		3
Italy	Italy	4	3	4	3	3	3	2	3
Netherlands	Netherlands	3	0	1	1	3	4	2	2
Poland	Poland	3		3	4	0	3		1
Andalusia	Spain	4			4	4	3		3

Table 4: Embeddedness of soil stakes in policy packages in the Member States and regions studied

Number of obs	62	Pseudo R2	0.3373
LR chi2(14)	64.42	Log likelihood	-63.288958
Prob > chi2	0.0000		

description	Coeff.	Std. Err.	P>|z|	significant
Eco-innovation index	**0.067**	**0.017**	**0.000**	**
Share of renewable energy in total energy consumption	0.071	0.063	0.262	-
Proportion of agricultural land that is owned by farmers	**0.128**	**0.034**	**0.000**	**
Number of different combinations of instruments used	**1.402**	**0.348**	**0.000**	**
Level of citizens confidence in EU institutions	-0.934	0.057	0.101	-
Percent of arable land on the total UAA	-0.034	0.041	0.417	-
Indicator A of farm income	0.024	0.016	0.141	-

Stakes considered are treated as qualitative variables, against SOC decline

water erosion	1.987	1.026	0.053	-
wind erosion	-0.377	1.288	0.770	-
Soil compaction	0.520	1.049	0.620	-
soil biodiversity	-0.939	1.032	0.363	-
water quality	-0.041	1.006	0.967	-
air quality	-1.310	1.135	0.249	-
biodiversity	-0.776	0.933	0.406	-

Table 5: Ordered Logit estimates of embeddedness (E) of soil stakes in policies (lower section is related to the qualitative explanatory variable "type of stake")

Number of obs	62	R-squared	0.7064
F(18, 43)	6.23	Root MSE	3.7982
Prob > F	0.0000		

description	Coeff.	Std. Err.	P>|z|	significant
embeddedness	**1,806**	**0,647**	**0,008**	**
Percent of arable land on the total UAA	0,094	0,082	0,255	-
Share of renewable energy in total energy consumption	**0,394**	**0,139**	**0,007**	**
Indicator A of farm income	**-0,107**	**0,028**	**0,001**	**
Level of citizens confidence in EU institutions	**0,305**	**0,113**	**0,010**	*
Proportion of practices promoted or restricted by mandatory instruments	0,018	0,029	0,950	-
Proportion of practices promoted or restricted using incentives	0,032	0,026	0,230	-
Proportion of practices promoted or restricted by one policy package only	-0,024	0,025	0,345	-
Stakes considered are treated as qualitative variables, against SOC decline				
water erosion	**-4,447**	**2,020**	**0,033**	*
wind erosion	-4,440	2,334	0,063	-
compaction	**-4,886**	**1,906**	**0,014**	*
soil biodiversity	-2,440	1,963	0,22	-
water quality	1,754	1,978	0,38	-
air quality	-4,237	2,345	0,077	-
biodiversity	-2,832	1,933	0,15	-
constant	-5,416	10,104		

Table 6: Results from the OLS for the number of soil management practices promoted or restricted by the policy packages for soil stakes

An assessment of policies affecting Sustainable Soil Management in Europe and selected member states

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