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European Joint Programme

Towards climate-smart sustainable management of agricultural soils

Deliverable 2.5

Report on identified regional, national and European aspirations on soil services and soil functions

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ABSTRACT

This report contributes to the EJP SOIL roadmap for climate-smart sustainable agricultural soil management and research by identifying current policy targets and realizations and setting soil service aspirational goals by 2050 at the regional/national (Chapter 2) and European scale (Chapter 3). At both scales, the report is based on a desk study of current agricultural soil related policies, followed by a stakeholder consultation. Twenty countries/regions have contributed to the regional/national analyses and 347 different stakeholders have provided their views on soil policy.

The policy analysis demonstrates that large differences exist between the number of policy targets per soil challenge. In general, the soil challenge 'Maintaining/increasing soil organic carbon' can be considered as the most important soil challenge taking into account both the policies of the participating countries and of the EU level. This soil challenge not only has (one of) the largest share(s) of quantitative and qualitative targets, but also has a large share of the targets for which an indicator and monitoring is in progress or existing. At the EU level, 'Avoiding contamination' is also particularly high addressed in policy documents. In the participating countries, other very important soil challenges in policy are 'Enhance nutrient retention/use efficiency', 'Avoid soil erosion' and 'Avoid soil contamination'. These soil challenges comprise a large share of soil- and agricultural soil specific targets. However, despite the large number of policy targets, identified by the participating EJP SOIL countries, there is still a shared need for appropriate clear (quantified) policy targets with a specific time horizon, well-defined indicators and a monitoring systems. Similar results are found at the EU level. Policy targets addressing soil challenges are mostly not expressed in quantitative terms and indicators for monitoring policy targets with references to soil challenges were identified for less than half of the cases.

From the stakeholder consultations, it becomes clear that for all soil challenges there is still a way to go before future aspirational goals will be met. Generally, when averaging between all countries, the gap between current policy targets and realizations is for most soil challenges considered between large and halfway in reaching the current policy targets and for most soil challenges current policy targets are regarded almost- to- far from being futureproof.

In the prioritization of soil challenges, stakeholders at the regional/country and European level, clearly marked maintaining/increasing SOC as the most relevant soil challenge in the upcoming decades. The stakeholders explain the key role of maintaining/increasing soil organic carbon through the multiple interactions with other soil challenges and for climate change mitigation. At the EU level, the second highest ranked prioritization is soil sealing, due to its irreversible nature. This is, however, not reflected at the country level, potentially due to a misinterpretation of soil sealing as compaction by part of the stakeholders. At the country level, enhancing soil nutrient retention/use efficiency was ranked 2nd in the prioritization exercise.

Generally, there is an urgency for policy updates, because the current policy is considered unable to tackle the prominent soil challenges.

In the report, also the soil related management practices to achieve the aspirational goals have been identified, both in the policy analysis and in the stakeholder consultation. The most prominent differences between policy and stakeholders, is in the emphasis on the use of buffer strips and small

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landscape elements in policy, while measures in this category are less highly ranked by the stakeholders. On the other hand, conservation agriculture, agro-ecological farming, precision agriculture, incorporation of crop residues and controlled traffic farming are soil management techniques highly listed by the stakeholders, but less in policy.

Specific knowledge needs were emphasized for almost all soil challenges and for the land management categories at the regional/national and EU level. Apart from answers on specific questions on management options or instruments to achieve soil challenge aspirations, five themes of recommendations could be extracted from the country reports: (i) multi-stakeholder participation in a holistic perspective, (ii) appropriate policy targets, indicators and monitoring systems, (iii) (market-driven) economic incentives, (iv) knowledge and knowledge sharing and (v) innovative and data-driven soil management.

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1. Introduction

1.1 Aim of this report

The main objective of the European Joint Programme **EJP SOIL** (www.ejpsoil.org) is to enhance the contribution of agricultural soils to key societal challenges such as climate change adaptation and mitigation, sustainable agricultural production, ecosystem services provision, prevention and restoration of land and soil degradation and biodiversity maintenance.
The EJP SOIL consortium unites a unique group of 26 leading European research institutes and universities in 24 countries. National research efforts are pooled in order to make better use of Europe's research and development resources. EJP SOIL activities closely interact with stakeholders of different categories, including policy stakeholders, farmers and farmer organisations, research communities, NGOs and agro-industry.

One of the objectives of EJP SOIL is to develop and deploy a **roadmap** for climate-smart sustainable agricultural soil management research. This report contributes to this roadmap by **identifying current policy targets and realizations and setting soil service aspirational goals by 2050 at the regional/national (Chapter 2) and European scale (Chapter 3)**.

At both scales, first a desk study was carried out and this was followed by a stakeholder consultation.

In the report also soil management practices and instruments proposed in policy documents and by stakeholders were summarized as well as identified knowledge needs.

1.2 EJP SOIL glossary

Safeguarding a shared EJP SOIL language is important to ensure comparability between all stakeholders and regions. To enable this, a glossary and a soil concept framework was developed, linking management practices, soil challenges, soil functions and overarching EJP SOIL goals (Figure 1). The glossary used by EJP SOIL that is of importance for this report can be found in Annex I.

In this report, **soil challenges** are central and soil management practices listed in policy documents and mentioned by stakeholders as key to achieve soil challenge targets, are divided into the **land management categories** of the glossary.

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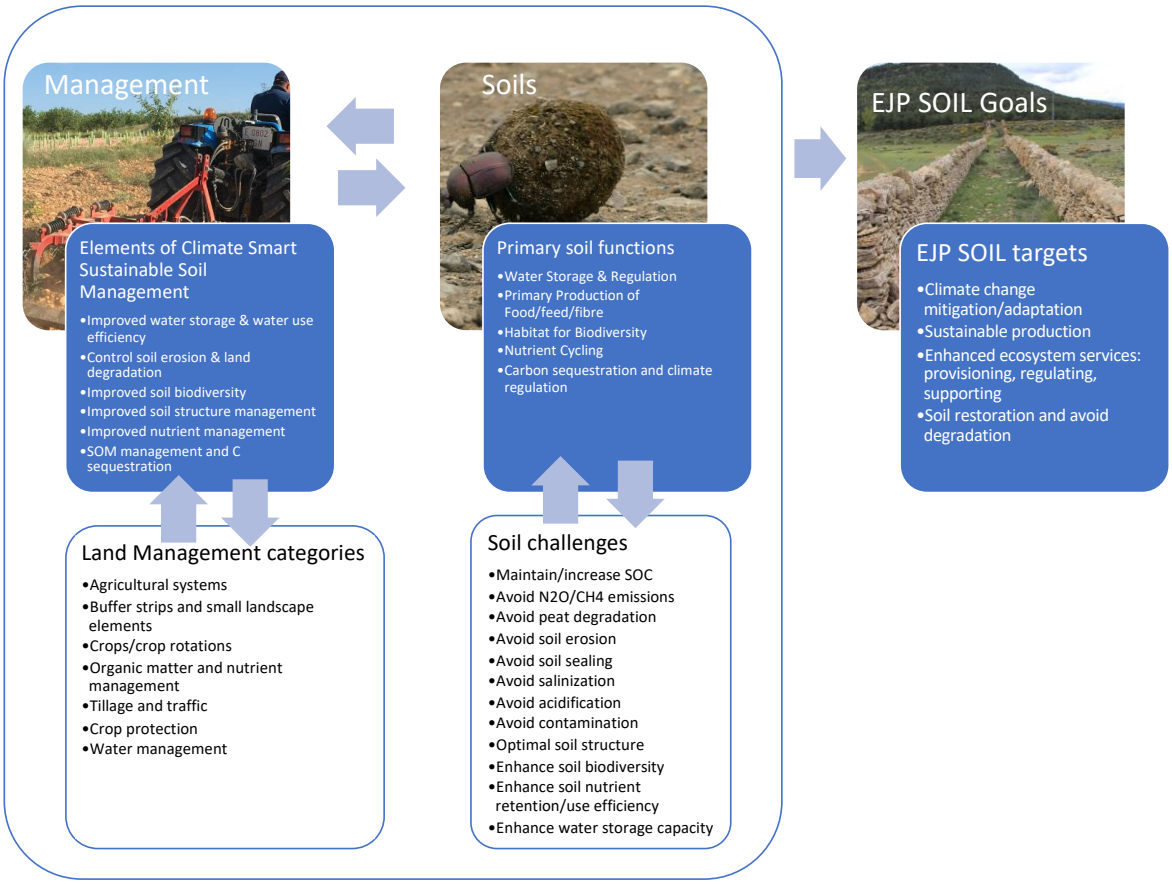

Figure 1: Soil Concept Framework: This linkages diagram illustrates how local land management choices can influence the elements defining climate smart sustainable soil management. Secondly, the diagram shows the interlinkage between the primary soil functions and soil challenges; and that the local soil conditions together impact and are impacted by the management choices made on a specific location. The knowledge on the interaction on climate smart sustainable soil management and the soil challenges/functions will enable to reach the EJP SOIL goals.

2. Current policy ambitions at the regional or country level

2.1 Approach

2.1.1 Participating countries

Chapter 2 of the report compiles the analyses of the participating countries on the current policy ambitions and the future aspirational goals at the country level, or in the case of Belgium at the regional level. In total 20 reports were completed (Austria, Belgium-Flanders, Belgium-Wallonia, Denmark, France, Germany, Ireland, Latvia, Lithuania, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, Turkey, United Kingdom). Since the report of Spain did not include results of the stakeholder interviews, 19 reports were used to analyse the stakeholders' input.

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In order to obtain insight in potential regional similarities, in some cases information was compiled per environmental zone according to Metzger et al. (2005) (Figure 2) or per regional cluster (Figure 3). Some regions are better represented than others. Central and Western Europe are represented by six and seven countries (regions in the case of Belgium), respectively, while Southern Europe is only represented by three (policy analysis) or two countries (stakeholder analysis) and Northern Europe by four countries.

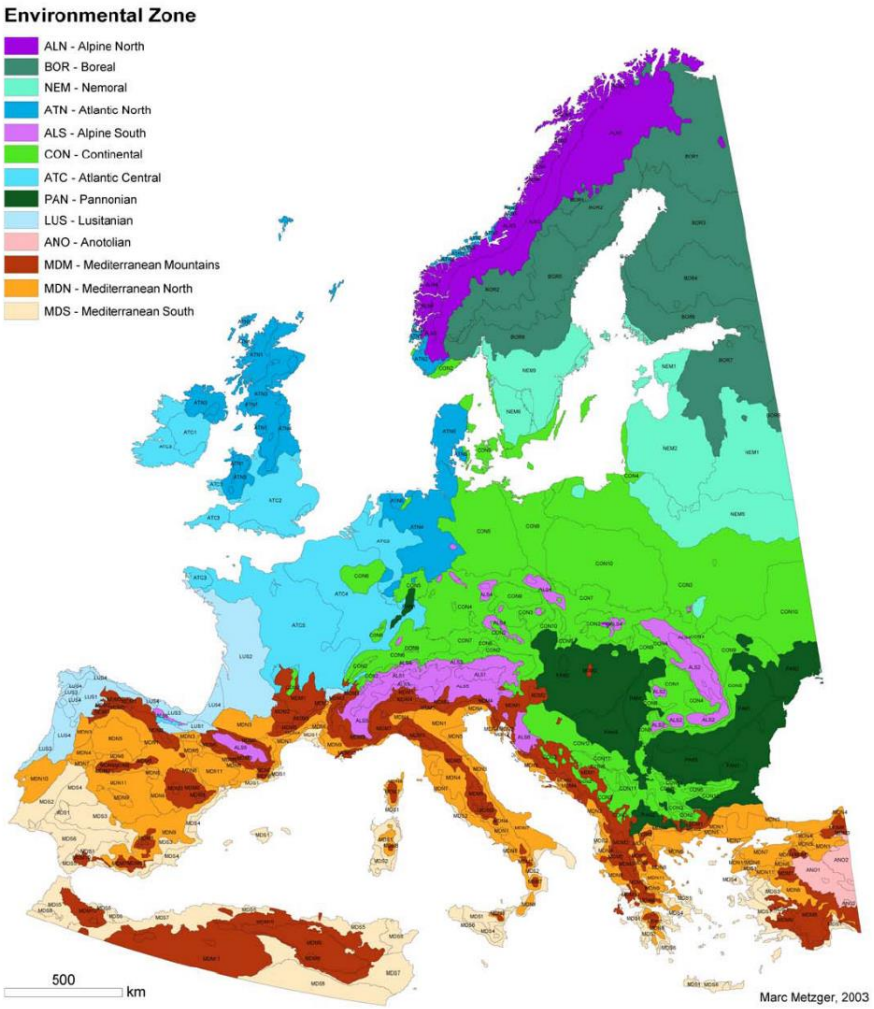

Figure 2: Metzger, M.J., Bunce, R.G.H., Jongman, R.H.G., Mücher, C.A. and Watkins, J.W. (2005). A climatic stratification of the environment of Europe. Global Ecology and Biogeography, 14, pp. 549–563.

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Figure 3: Map with the four regional clusters: Central, Western, Northern and Southern Europe

As the country representation in the regional clusters and environmental zones strongly varies between zones and regions, comparisons between regions and environmental zones should be interpreted with great care. In the report, whenever such comparisons are included, the reader is notified on the critical differences.

2.1.2 Stakeholder groups

The number of stakeholders that were involved in the country reports strongly varied and ranges from 2 to 56. In total, 347 individual (exclusive: gives no information on the different stakeholder groups) stakeholders were involved in the policy analyses across European countries (Figure 4). Since certain stakeholders are associated with multiple stakeholder groups, they are counted double in Table 1 where an overview of stakeholder categories is given; this results in a so called 'non-exclusive stakeholder number of 376. However, although a stakeholder could be positioned in more than one category, his/her input was only used once in further analysis and was thus not double-counted (Figure 5). Most of these stakeholders were members of research communities or are national policy stakeholders (both 22%). Stakeholders associated with farmers' organisations and advisors both represent 11%. Despite the stakeholder group 'Farmers and demonstration farms' did represent 15% of the total number of stakeholders, most participating countries did not include this group of

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stakeholders. Indeed, the majority of involved farmers and demonstration farms (11%) were in fact included in Latvia.

Table 1: Stakeholder representation (not-exclusive)

	National European soil partnership representatives	National policy stakeholders (local governance and policy implementing	Research communities	Research funders	Middle & Higher educational institutions	Farmer Schools	Farmers and demonstration farms	Advisors	Farmers' organisations	Agro-industry	Laboratories, National science testing, Verification centers etc.	Industry, Supply & Retail	NGOs and community-based organizations	**Total**	**% of total**
Austria	1	8	2	0	0	1	1	2	1	0	0	1	3	**20**	**5.3**
Belgium Flanders	1	14	6	0	0	0	0	4	6	0	0	0	0	**31**	**8.2**
Belgium Wallonia	0	4	3	0	0	0	0	7	3	0	1	0	2	**20**	**5.3**
Denmark	0	4	10	0	0	0	4	2	6	1	0	0	2	**29**	**7.7**
France	0	1	5	1	1	0	0	0	0	1	0	0	0	**9**	**2.4**
Germany	0	2	0	0	0	0	0	0	0	0	0	0	0	**2**	**0.5**
Ireland	0	2	2	0	0	0	0	0	1	2	0	0	0	**7**	**1.9**
Latvia	0	5	2	0	1	0	41	0	4	1	0	0	2	**56**	**14.9**
Lithuania	0	2	3	0	0	0	1	0	1	0	0	0	0	**7**	**1.9**
Norway	0	4	2	0	0	0	0	1	0	0	0	0	1	**8**	**2;1**
Poland	0	2	4	0	0	0	3	1	0	0	1	0	0	**11**	**2.9**
Portugal	0	1	3	0	6	0	0	0	6	0	1	1	1	**19**	**5.1**
Slovakia	1	2	2	0	2	0	0	0	1	0	1	0	0	**9**	**2.4**
Slovenia	10	7	18	1	3	0	2	12	1	0	0	1	1	**56**	**14.9**
Switzerland	0	19	8	0	0	0	3	7	6	0	5		0	**47**	**12.5**
Sweden	0	2	2	0	0	0	0	1	1	0	0	0	0	**6**	**1.6**
The Netherlands	1	4	4	0	1	0	0	1	3	5	1	0	0	**20**	**5.3**
Turkey	0	1	3	0	0	0	0	0	1	1	1	0	1	**8**	**2.1**
United Kingdom	0	1	5	0	0	1	0	3	0	0	0	0	1	**11**	**2.9**
Total	**14**	**84**	**84**	**2**	**14**	**2**	**55**	**41**	**41**	**11**	**11**	**3**	**14**	**376**	**100**
% of total	**3.7**	**22.3**	**22.3**	**0.5**	**3.7**	**0.5**	**14.6**	**10.9**	**10.9**	**2.9**	**2.9**	**0.8**	**3.7**	**100**	

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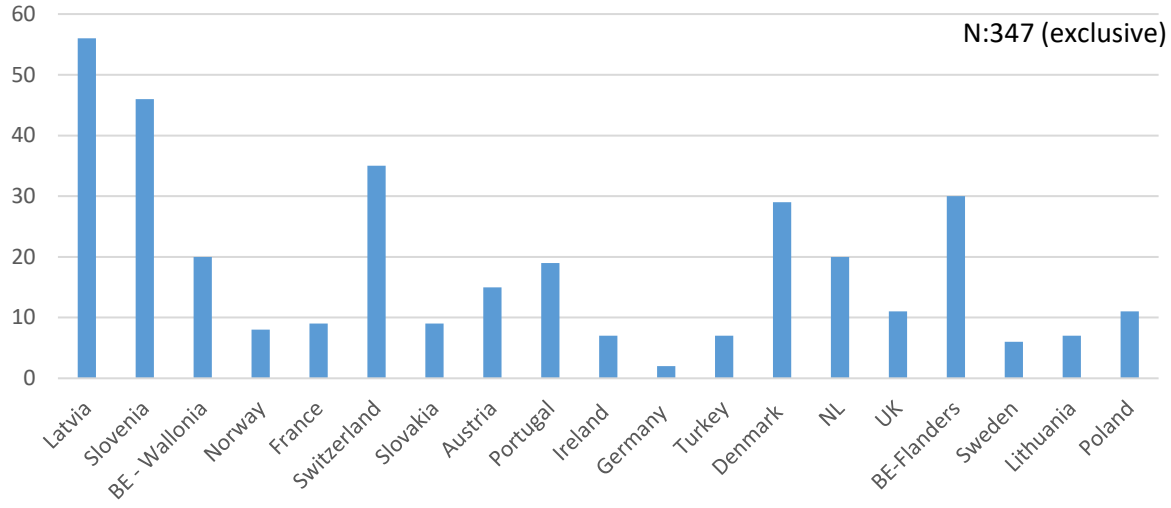

Figure 4: Total number of participants per country

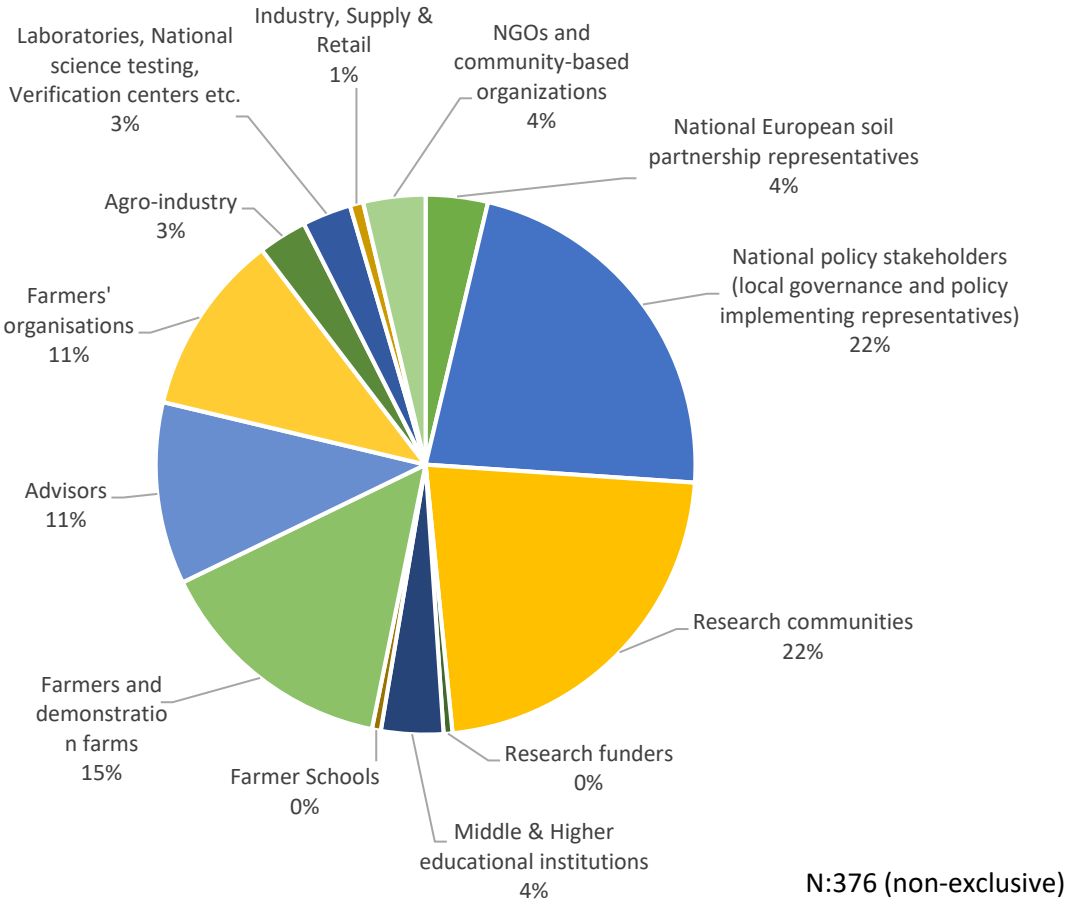

Figure 5: Relative share of the stakeholder groups represented in the report. This is a non-exclusive representation since some stakeholders were associated with multiple groups.

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The composition and representation of the stakeholder groups varies strongly between the countries (Table 1). For example, the stakeholders surveyed in Germany are only from the administration, whereas in other countries there is a mix of stakeholders. Moreover, in some reports, the total amount of stakeholders is small (Figure 4), for example also in Sweden only six stakeholders are surveyed. In countries with unbalanced composition of stakeholder groups and with little stakeholders surveyed, the results can be biased. Therefore care is needed in the interpretation of the results between countries. In the report, whenever such comparisons are included, the reader is notified.

2.1.3 Methodology

The study performed at the regional or country level consisted of two phases. The first phase (see 2.2 Policy analysis) was a desk study in which policy documents were analyzed to detect current policy ambitions and realizations. In the second phase (see 2.3 Stakeholder views), the opinion of key stakeholders was asked on how they perceive policy realizations and what aspirational goals for agricultural soils and soil management they would express towards 2050.

In order to foster a common approach and comparable results, detailed guidelines for both phase 1 and 2 were provided to the responsible persons in the participating countries and the approach was explained in a webinar on April 8, 2020. Furthermore, a template and guidelines for setting up the country/regional level questionnaire was provided (Annex II) as well a template with guidelines how to draft the country report.

Phase 1: Desk study on current policy ambitions and realizations (Policy analysis)

Phase 1 consisted of three steps (i) identification of relevant policy documents, (ii) analysis of the policy documents and (iii) validation by key contact persons.

In **step 1 'identification of relevant policy documents'**, three types of documents were considered that formulate targets for agricultural soils or mention management practices that impact agricultural soils. These documents are (i) policies that are national or regional transpositions of European legal acts and (ii) policies that are not linked with European policies but specific for the country or a region.

Regarding transpositions of EU legal acts, it was investigated if and how the following EU legal acts were transposed into national or regional legislation:

- Common Agricultural Policy (only the 'old' (2014-2020) CAP)
    - Greening measures (A-GM)
    - Cross-compliance – including good agricultural and environmental conditions (+ additional requirements) (A-CC)
    - Rural development – including agri-environmental schemes (A-RD)
- 2030 Climate and Energy Framework –-> national energy and climate plan (NECP)
- 2050 Long-term climate strategy - > national long-term strategies (NLS)
- EU Climate change adaptation strategy -> national adaptation strategies (NAS)

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- Nitrates Directive (91/676/EEG, December 12 1991) -> National and regional action programmes (ND)
- Water Framework Directive (2008/98/EC) (WFD)
- Groundwater Directive (GD)
- Floods Directive (FD)
- Areas of Natural or other specific constraint (ANC)
- Habitat Directive (92/43/EEG) (HD)
- Birds Directive 79/409/EEG (BD)
- Sewage Sludge Directive (86/278/EEG) (SSD)
- Sustainable Use of Pesticides Directives (2009/128/EC) (SUP)
- Environmental Impact Assessment (EIA) Directive (85/337/EEC amended by 97/11/EC and 2003/35/EC)
- Strategic Environmental Assessment (SEA) Directive (2001/42/EC).

For each of the documents found, a key person, mostly at policy departments, was identified that was closely involved with the development of the policy packages or has good knowledge on its content and how it was developed.

In **step 2**, the **gathered documents were analysed** and the following information was extracted:

- Policy targets on soils and whether these targets are specific for agricultural soils, specific for soils in general or non-soil specific (i.e.; non-exclusive to soils);
- Indicators used to monitor the targets;
- Current status of the indicators;
- Tools or methods used for monitoring and phase of development;
- Soil related management practices mentioned in policy packages to tackle specific soil challenges or other environmental stakes;
- Other policy instruments mentioned in the documents to reach the targets and phase of development.

The specific soil management practices are clustered in seven land management categories (see also Annex I EJP SOIL glossary): 1. Agricultural systems, 2. Organic matter/nutrient management, 3. Crops/rotations, 4. Tillage and traffic, 5. Buffer strips and small landscape elements, 6. Crop protection and 7. Water management.

In **step 3**, the key persons identified in step 1 were asked to validate the analysis of the policy documents they are familiar with. They were asked if the analysis was correct and complete and the policy analysis was adapted accordingly to feed into phase 2.

Phase 2: Stakeholders views on current realizations and future aspirational goals

The results of the phase 1 policy analysis formed the basis for asking for stakeholder views on current realizations of policy ambitions and future aspirational goals. Originally, workshops were foreseen to collect stakeholder views, but due to the first months of the 2020 COVID-19 pandemic, physical

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workshops were not possible and therefore, stakeholder views were collected by a questionnaire in all participating countries and, depending on the local situation, could be complemented by on-line group meetings and in-depth on-line interviews. On-line group meetings were for instance used to introduce the questionnaire and explain the purpose. The interview types that were used by the partner countries can be found in Table 2. In many countries the questionnaire was introduced and sent via e-mail. Stakeholders from some countries could choose to fill in the questionnaire individually or via an interview. Other countries organized interviews when extra information was required from the stakeholders after submission of the questionnaire or always interviewed the stakeholders. Due to the pandemic face to face interviews were scarce and most partner countries preferred an interview rather than a general webinar.

The number of stakeholders that have participated per country and the stakeholder groups were described in paragraph 2.1.2.

Table 2: Interview types used in the different countries

	Face-to-face	Phone or video interview	Webinar	Digital survey
Austria		x		
Belgium Flanders			x	x
Belgium Wallonia	x			x
Denmark		x		x
France				x
Germany				x
Ireland		x		x
Latvia		x		x
Lithuania		x		x
Norway		x		x
Poland		x		x
Portugal				x
Slovakia				x
Slovenia		x		x
Sweden		x		x
Switzerland				x
The Netherlands		x		x
Turkey		x		x
United Kingdom			x	x

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The questionnaire consisted of 4 main steps: (i) policy analysis validation, (ii) policy realization and defining aspirational goals, (iii) how to achieve aspirational goals and (iv) policy prioritization. The template of the questionnaire that was sent to the stakeholders is added in Annex II.

In **step 1**, the stakeholders were asked to validate the draft policy analysis compiled in phase 1.

In **step 2**, the stakeholders were asked to provide their expert opinion on the current realization of the policy ambitions and targets set in the policy analysis for each of the soil challenges. To identify the potential gap between the current realization of the policy ambitions and the policy targets that are currently set for each participating country, stakeholders in the countries evaluated their soil policy. For some policy targets, indicator values are available that track the current status of policy targets. When available, these indicator values were displayed in the survey along with the targets to aid the stakeholder scoring. In case no indicator value was available, the evaluation was solely based on expert knowledge and opinions.
A Likert scale was used for evaluating the realization of the current policy targets for the different soil challenges:

The gap between the policy target and realization is **very large**	The gap between the policy target and realization is **large**	The realization is **halfway** the policy target	The gap between the policy target and realization is **small**	The policy target is already **achieved**
1	2	3	4	5

The advantage of a Likert scale is that it allows the evaluation of policy realizations, even for policies without clearly defined indicators. Next, the stakeholders were also asked to write a short argumentation explaining their vote.

At the same time stakeholders were also asked to indicate whether the current policy ambition is sufficient in light of the societal challenges (climate change, land and soil degradation, loss of ecosystem services) that we face towards 2050..

A second Likert scale was used to answer the question, whether the current policy targets are futureproof with a horizon to 2050:

The policy ambition is **already** futureproof	The policy ambition is **almost** futureproof	The policy ambition is **far** from being futureproof	The policy ambition is **very far** from being futureproof
1	2	3	4

The frequency distribution of the answers per soil challenge was provided in the country reports. In the overall analysis across the countries (this report), the median results of these two questions is used

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to map the policy gaps (in case multiple inputs are provided for a single soil challenge, the average gap of the medians is calculated). The results are visualized with horizontal bar charts with two colours, i.e. the gap between current policy targets and current realization status in light red (Realization) and the gap between current policy targets and futureproof targets in dark red (Aspiration). The overall width of the red bar (light and dark colours), gives an impression of the total challenge to reach the futureproof policy aspirations , this is referred to as the total policy gap.

An overview of the different scales used is provided in Table 3. In the country reports a Likert scale was used, as described above. In the analysis, the actual size of the policy gap is rescaled between 0-4 and 0-3 respectively for the realizations and aspirations and in the figures the x-axis is scaled between 0-7.

Table 3 Different scales and their interlinkages used in the policy realization and aspiration analysis

Realization	*Likert scale (reports)*	*GAP width (number)*	*Scale used in the figures*	**Aspiration**	*Likert scale (reports)*	*GAP width (number)*	*Scale used in the figures*
Very large	1	4	0	Futureproof	1	0	4
Large	2	3	1	Almost	2	1	5
Halfway	3	2	2	Far	3	2	6
Small	4	1	3	Very Far	4	3	7
No Gap	5	0	4				

In **step 3**, the question how to achieve the aspirational goals set in step 2 was answered by the stakeholders. To identify the most appropriate soil related management practices to achieve the aspirational goals of each soil challenge, the stakeholders of the participating countries were asked to select three priority management practices for each soil challenge. From this, the proportional vote for every management practice was calculated per soil challenge. Stakeholders were also asked if, apart from management practices to tackle specific soil challenges, they could also think of other instruments that could be applied to address the soil challenges.

Similarly, with step 2 in phase 1, the specific soil management practices are clustered in seven land management categories (see also Annex I EJP SOIL glossary).

In **step 4**, the stakeholders were asked to prioritise the soil challenges in the dominant environmental zones defined by Metzger et al. (2005)[1]. To do this, the stakeholders in the participating countries

[1] Metzger, M.J., Bunce, R.G.H., Jongman, R.H.G., Mücher, C.A. and Watkins, J.W. (2005). A climatic stratification of the environment of Europe. *Global Ecology and Biogeography*, 14, pp. 549–563.

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prioritized the soil challenges, by attributing a total of 100 points between the various soil challenges in the dominant environmental zones, keeping the following question in mind:

"What do you expect will be the main soil challenges that are most relevant for the dominant environmental zones of your country in the upcoming decades?"

The different stakeholder votes were combined by calculating for every soil challenge the average and the standard deviation.

2.2 Policy analysis

In this chapter, an analysis is made of current policy ambitions and targets regarding different soil challenges in the participating partner countries. The soil targets mentioned in policy documents were analyzed based on their characteristics: soil challenge, target type (qualitative/quantitative), indicator status, monitoring status and their specificity for (agricultural) soils. In order to investigate potential specific characteristics of targets specific for agricultural soils and soils, the same analysis was performed as well for these targets. Finally, it was also analyzed if the relative importance of soil challenges was related to specific country clusters.

2.2.1 General overview of policy targets per soil challenge in participating European countries

The number of policy targets per soil challenge is an indicator for its current importance in European policy. At the same time, it can reveal which soil challenges could require more attention. In total 562 quantitative and qualitative targets were identified. A large share of the targets mentioned in policy documents are formulated for the soil challenges maintaining/increasing SOC, avoiding contamination and enhancing soil nutrient retention/use efficiency, followed by enhancing soil biodiversity, avoiding soil erosion, avoiding N_2O and CH_4 emission and optimal soil structure (Figure 6 and Figure 10). When considering the targets of each soil challenge, the major part are qualitative targets (Figure 6). Typical for these targets is their more general or sometimes even vague character. In general, there is a need for more specific (quantified) targets. When only considering quantitative targets, most attention in policy goes to the soil challenges avoiding N_2O and CH_4 emission, maintaining/increasing SOC and enhancing soil nutrient retention/use efficiency. In contrast only a limited number of targets are related to the soil challenge avoiding salinization. One reason for this is the limited number of partner countries (Austria, The Netherlands, Portugal) that actually defined targets for this soil challenge (Figure 10). This is also the case for the soil challenge avoiding acidification, for which only 7 partner countries defined targets.

The targets that were grouped in the category 'Extra' comprise soil challenges that aim at a.o. the more general preservation of soil functions (CH), land degradation in general (BE-FL), the reduction of NH_3 emissions (BE-WL). Due to its minimal share in the total number of policy targets, this will not be discussed further.

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An important note is that the term soil sealing was also interpreted as compaction in the national reports of some partner countries. This implies that the number of targets for the challenge soil sealing in this report is very likely an overestimation of the effective number of targets for soil sealing in the partner countries.

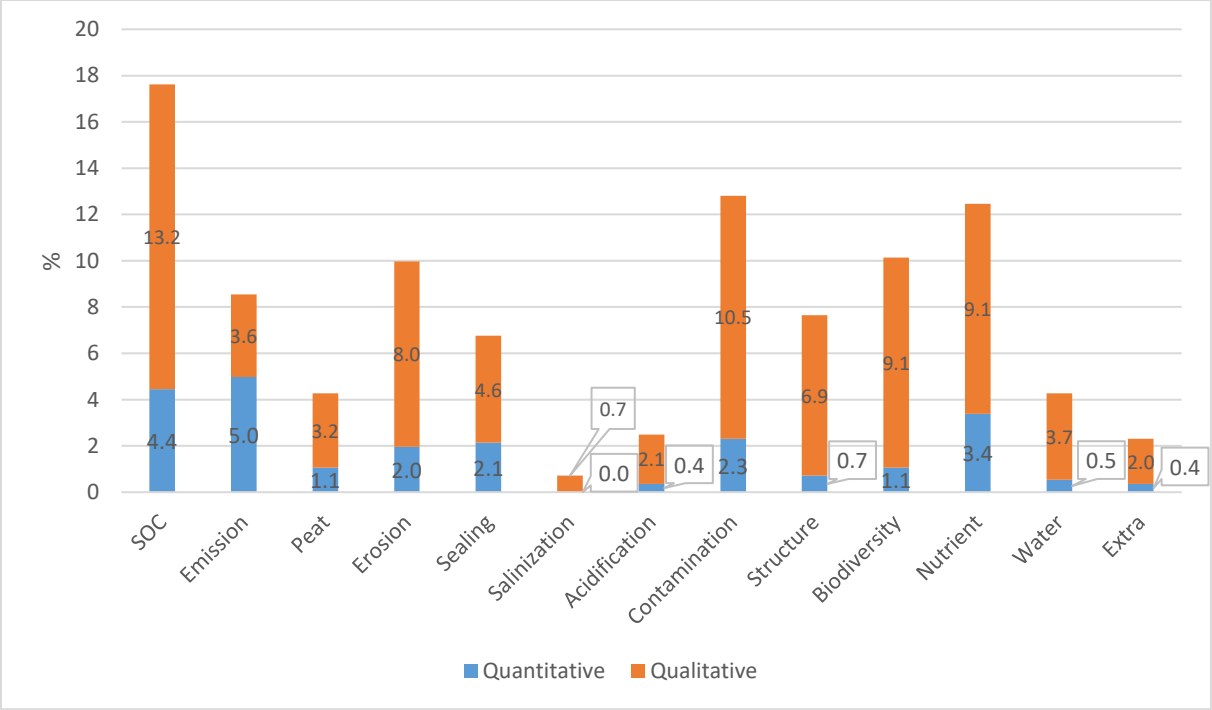

Figure 6: Share of targets (n=562) per soil challenge considered for all participating EJP SOIL countries independently of soil use. For every soil challenge the share of targets is also subdivided into quantitative targets (blue) and the qualitative targets (orange). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

Not all policy targets listed by the group of participating countries are specific for agricultural soils. Some targets mentioned in policy documents also comprise soils of other land uses or aim at soils in general ('soil' specific) or also involve other factors than soil ('Non-soil specific', e.g., LULUCF targets also comprising woody biomass). For some targets the specificity was not clear (Figure 7). Especially targets related to the soil challenges maintaining/increasing SOC, enhancing soil nutrient retention/use efficiency, avoiding soil erosion and optimal soil structure are characterized by a larger number and fraction of 'agricultural soil-specific' targets. For the soil challenges avoiding N_2O and CH_4 emission, avoiding contamination and enhancing soil biodiversity a large number and fraction of targets was non-soil specific. The majority of the policy targets related to the soil challenge soil sealing are soil specific. The soil challenges with the largest number of targets aiming at agricultural soils are maintaining/increasing SOC, avoiding soil erosion, enhancing soil nutrient retention/use efficiency and optimal soil structure.

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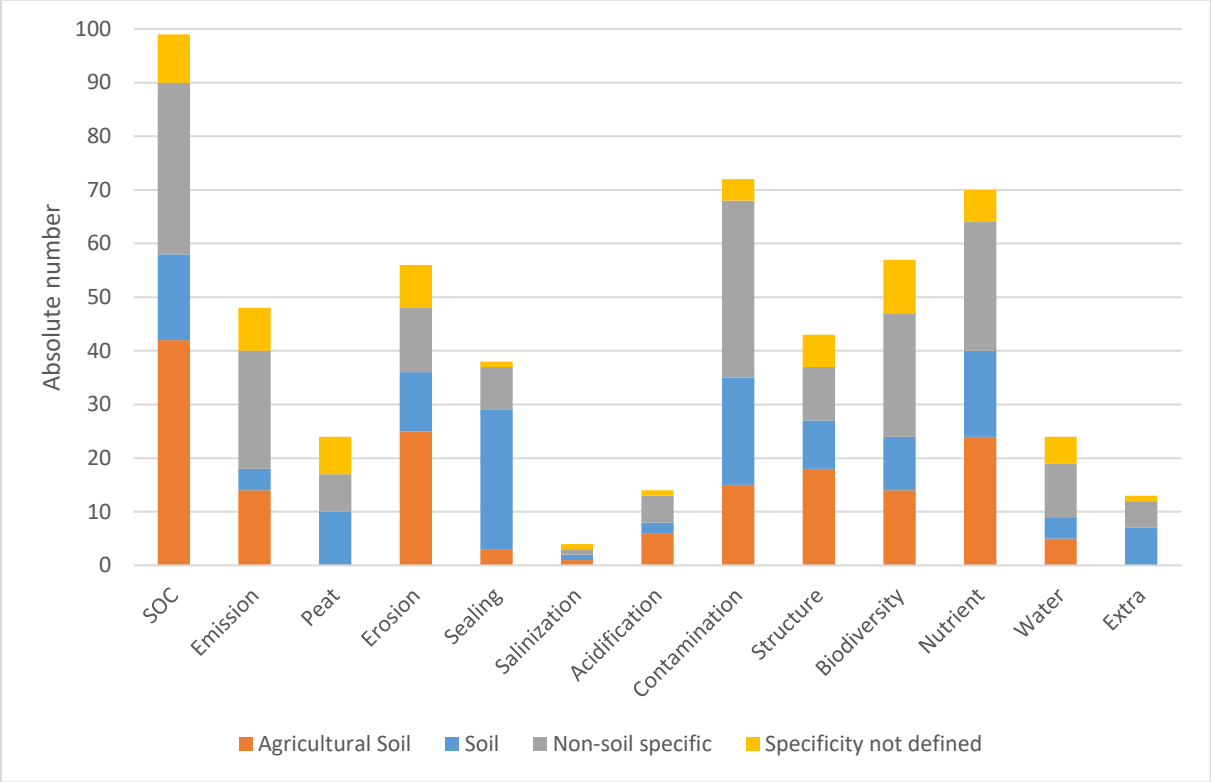

Figure 7: Number of quantitative and qualitative policy targets per soil challenge, considered for all participating EJP SOIL countries. Targets are grouped per specificity: agricultural soil (orange), soil (blue), non-soil specific (grey), specificity not defined (yellow). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

When only focusing on soil targets specific for soils or agricultural soils as defined by the group of participating EJP SOIL countries, the relative importance decreases particularly for the soil challenges avoiding N_2O and CH_4 emission, enhancing water storage capacity, avoiding peat degradation and enhancing soil biodiversity (Figure 8 and Figure 11). Maintaining/increasing SOC and enhancing nutrient retention/use efficiency remain the most important soil challenges, followed by avoiding soil erosion, avoiding contamination but also avoiding soil sealing, optimal soil structure and enhancing soil biodiversity despite the decrease for the latter. The soil challenges avoiding N_2O and CH_4 emission, maintaining/increasing SOC, avoiding soil sealing and avoid peat degradation are still characterized by the largest share of quantitative targets. With the focus on the soil or agricultural soil specific targets defined by the group of participating countries, the relative share of these quantitative targets slightly increased for the soil challenges optimal soil structure, avoiding soil erosion, maintaining/increasing SOC and avoid contamination. For optimal soil structure this, however, remains a marginal fraction. In addition, no major shift in the share from the participating countries was observed (Figure 11).

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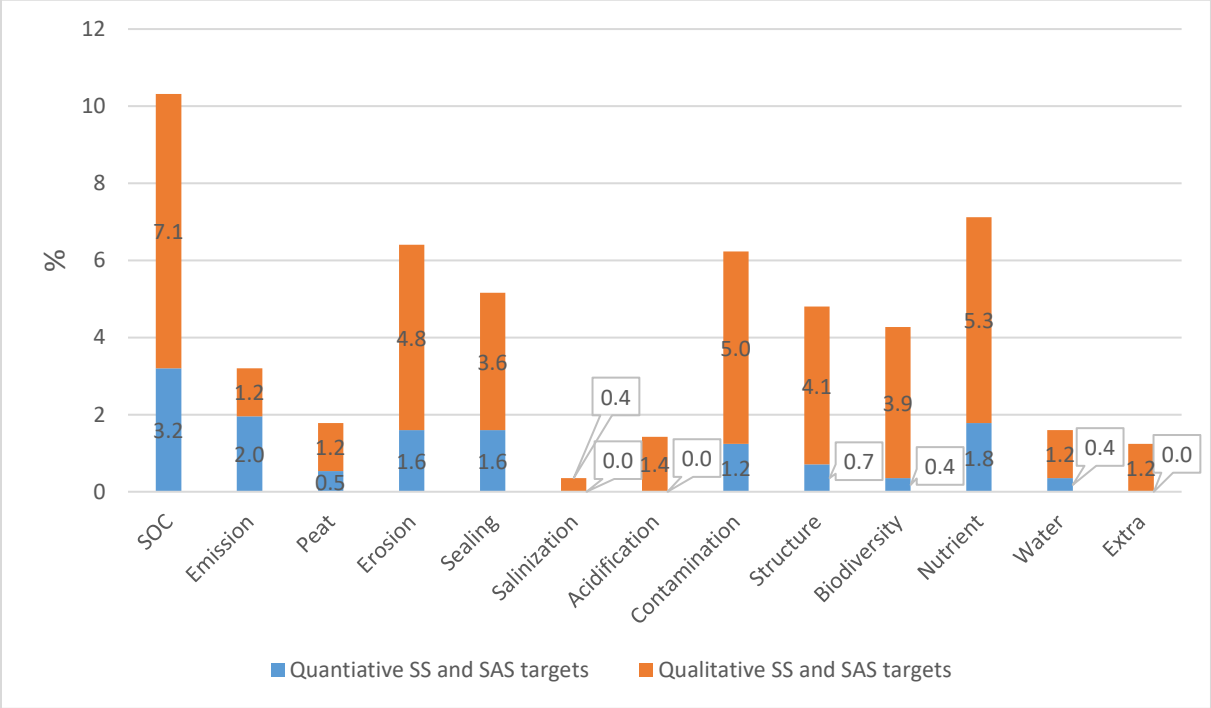

Figure 8: Share of 'agricultural soil-specific' (SAS) and 'soil-specific' (SS) targets (quantitative and qualitative, n=303) per soil challenge on total number of targets (n=562), considered for all participating EJP SOIL countries. The relative share of the quantitative targets is shown in blue, the relative share of qualitative targets is shown in orange. The total absolute number of soil targets differs per soil challenge: SOC (n=58), emission (n=18), peat (n=10), erosion (n=36), sealing (n=29), salinization (n=2), acidification (n=8), contamination (n=35), structure (n=27), biodiversity (n=24), nutrient (n= 40), water (n=9), extra (n=7). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

In order to achieve targets, countries need indicators and associated monitoring systems in order to follow-up compliance and developments. Despite their importance, for many targets (qualitative and quantitative) an indicator is not developed yet (Figure 9) in the group of participating countries. This can be related to the general or vague character of several targets but also to the large efforts and resources that would be required to measure the status of several targets mentioned in policy documents. Currently, only for four soil challenges indicators are developed for more than 60% of the related targets: avoiding N_2O and CH_4 emission, avoiding nutrient retention/use efficiency, maintaining/increasing SOC and avoiding acidification. The latter soil challenge is, however, characterized by a limited number of targets. These soil challenges in combination with avoiding soil erosion are also accompanied by the highest share (approximately 50%) of developed monitoring tools (Figure 9). However, many of these developed monitoring tools do not effectively comprise a highly developed and result-based monitoring network at large scale, but rather rely on manual inspections of the measures taken on the spot, annual inventories, databases (of e.g. permits, aid for physical investment (Be-WL)), and model based monitoring (e.g. water erosion (PI), erosion models (BE-FL))

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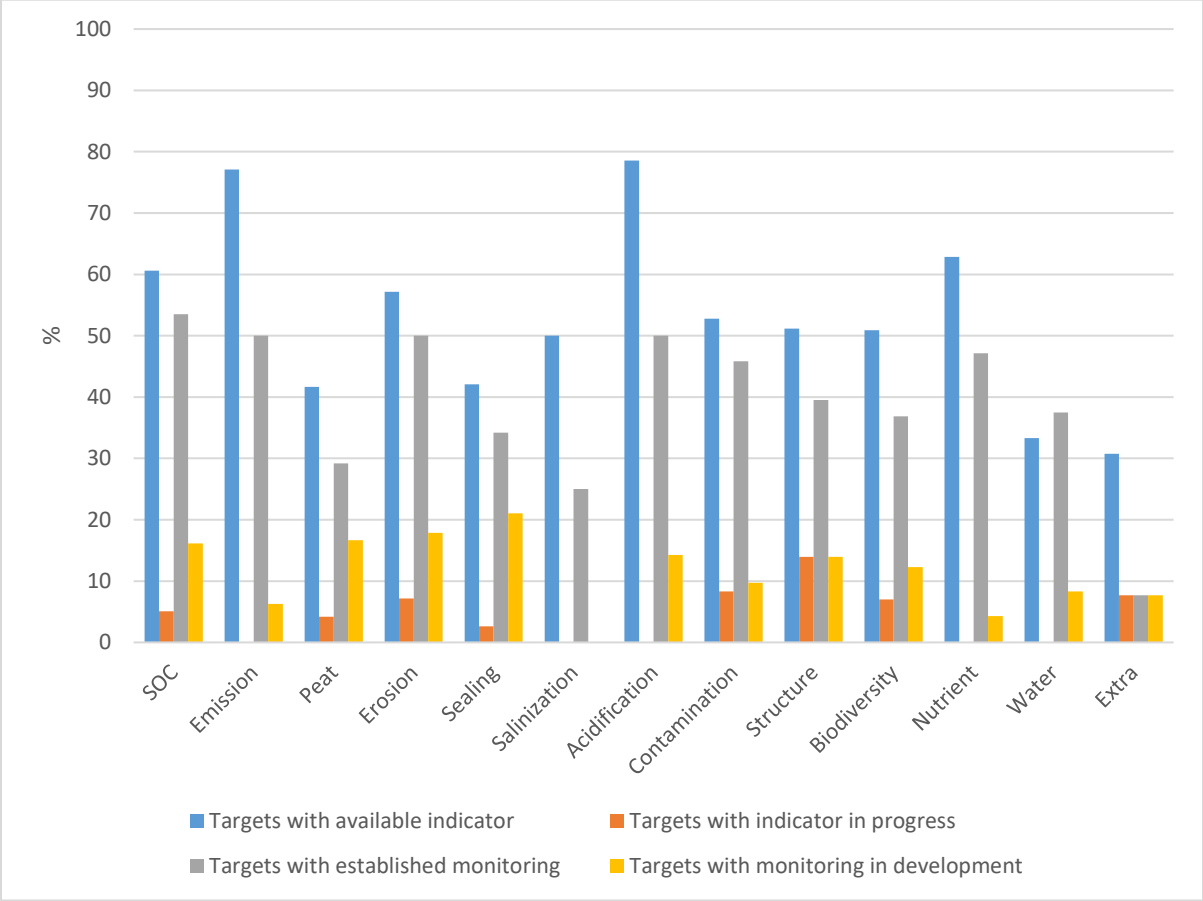

Figure 9: Share of policy targets (quantitative and qualitative), considered for all participating EJP SOIL countries independently of soil use) per soil challenge for which an indicator is available (blue) or an indicator is in progress (orange) and for which a monitoring tool is available (grey) or a monitoring tool is in development (yellow). The total absolute number of soil targets differs per soil challenge: SOC (n=99), emission (48), peat (n=24), erosion (n=56), sealing (n=38), salinization (n=4), acidification (n=14), contamination (n=72), structure (n=43), biodiversity (n=57), nutrient (n= 70), water (n=24), extra (n=13). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

When focusing on the soil and agricultural soil specific targets only for the soil challenge avoiding salinization, which has a marginal relative number of targets mentioned by the participating countries (Figure 6), the share of indicators strongly increased. A smaller increase in the relative number of targets for which an indicators is developed, was observed for the soil challenge enhancing soil nutrient retention/use efficiency, while avoiding soil sealing and other soil challenges (Extra) were characterized by a small decrease. Likewise, only small shifts were observed in the relative number of policy targets for which a monitoring tool exist or is in progress. An increase was observed for the soil challenges enhancing soil biodiversity, optimal soil structure, enhancing soil nutrient retention/use efficiency and enhancing water storage capacity, while small decreases were observed for avoiding N_2O and CH_4 emissions and avoiding soil sealing. Only for the soil challenge avoiding salinization a major increase is observed.

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In total 562 quantitative and qualitative targets were identified by the group of participating countries of which an large share (17.6%) were related to the soil challenge increasing/maintaining SOC, followed by avoiding contamination (12.9%) and enhancing soil nutrient retention/use efficiency (12.2%) (Table 4). Some of the targets were linked with more than one soil challenge. The soil challenges maintaining/increasing SOC and avoiding N_2O and CH_4 emission both represent the largest share of quantitative targets and the largest share of targets that clearly defined a timeframe during which the target should be achieved. However, also the soil challenge enhancing soil nutrient retention/use efficiency represents a large share of these quantitative targets. Maintaining/increasing SOC on its turn represents the largest share of qualitative targets, followed by avoiding contamination. The targets of the soil challenge maintaining/increasing SOC are also the targets that represent a large share of targets for which an indicator is available or in development, which is also the case for the soil challenges avoiding soil erosion and avoiding contamination. The soil challenges optimal soil structure and enhancing soil biodiversity only represent a large share of targets with indicator in progress while the soil challenge enhancing soil nutrient retention/use efficiency represent a relative large share of the targets with an available indicator. Considering the monitoring status, maintaining/increasing SOC also represents a large share of targets for which a monitoring tool is established, in progress or in development. The soil challenges avoiding soil erosion and avoiding contamination also have large shares in two of these monitoring status categories.

The largest share of the targets, defined by the group of participating countries, that were linked to a specific category (soil specific, agricultural soil specific, non-soil specific) is also dominated by the soil challenge maintaining/increasing SOC. This soil challenge has the largest number of agricultural soil specific targets, followed by the soil challenges avoiding soil erosion and enhancing soil nutrient retention/use efficiency (also see Figure 7). Soil specific targets were especially present within the group of targets belonging to the soil challenge avoiding soil sealing, followed by avoiding contamination, enhancing soil nutrient retention/use efficiency and maintaining/increasing SOC. However, the soil challenge maintaining/increasing SOC also represent a large share of the non-soil specific targets and targets for which the specificity was not defined. This is also the case for the soil challenges avoiding N_2O and CH_4 emission and enhancing soil biodiversity. The largest share of the targets of the soil challenge avoiding contamination are non-soil specific and these also represent the largest share within this category of targets.

When considering the shares of the soil challenges in each of the categories Indicator status and monitoring status, it is clear that in policy documents of the group of participating countries most attention is paid to the construction of tools to follow-up the achievement of the targets related to the soil challenges maintaining/increasing SOC, avoiding soil erosion and avoiding contamination.

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Table 4: Relative number (%) of policy targets normalized on total number of targets per analyzed category (considered for all participating EJP SOIL countries): Analyzed qualitative and quantitative targets (n=562), Quantitative target (n=131), Timeframe (n=101), Qualitative target (n=431), Indicator available (n=313), Indicator in progress (n=28), Monitoring established (n=247), Monitoring in progress (n=33), Monitoring initial development (n=36), Soil Specific (n=136), Agricultural Soil specific (n=167), Non-soil specific (n=192), Specificity not defined (n=67). Targets for which a specific timeframe was specified during which the target should be achieved were considered in the category Timeframe. Dark green marked cells contribute >15%, Light green cells contribute >10%, yellow marked cells contribute 5-10% and blue marked cells contribute <5%. The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

		Target information			Indicator status		monitoring status			Target specificity			
	Analyzed qualitative and quantitative targets	Quantitative target	Timeframe	Qualitative target	Indicator available	Indicator in progress	Monitoring established	Monitoring in progress	Monitoring initial development	Soil specific (SS)	Agriculutrual soil specific (SAS)	Non-soil specific (NS)	Specificity not defined
SOC	18	19	23	17	19	18	21	30	17	12	25	17	13
Emission	9	21	27	5	12	0	10	9	0	3	8	11	12
Peat	4	5	5	4	3	4	3	6	6	7	0	4	10
Erosion	10	8	3	10	10	14	11	6	22	8	15	6	12
Sealing	7	9	9	6	5	4	5	9	14	19	2	4	1
Salinization	1	0	0	1	1	0	0	0	0	1	1	1	1
Acidification	2	2	1	3	4	0	3	6	0	1	4	3	1
Contamination	13	10	9	14	12	21	13	12	8	15	9	17	6
Structure	8	3	2	9	7	21	7	3	14	7	11	5	9
Biodiversity	10	5	9	12	9	14	9	6	14	7	8	12	15
Nutrient	12	15	6	12	14	0	13	6	3	12	14	13	9
Water	4	2	3	5	3	0	4	6	0	3	3	5	7
Extra	2	2	4	3	1	4	0	0	3	5	0	3	1
SUM	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

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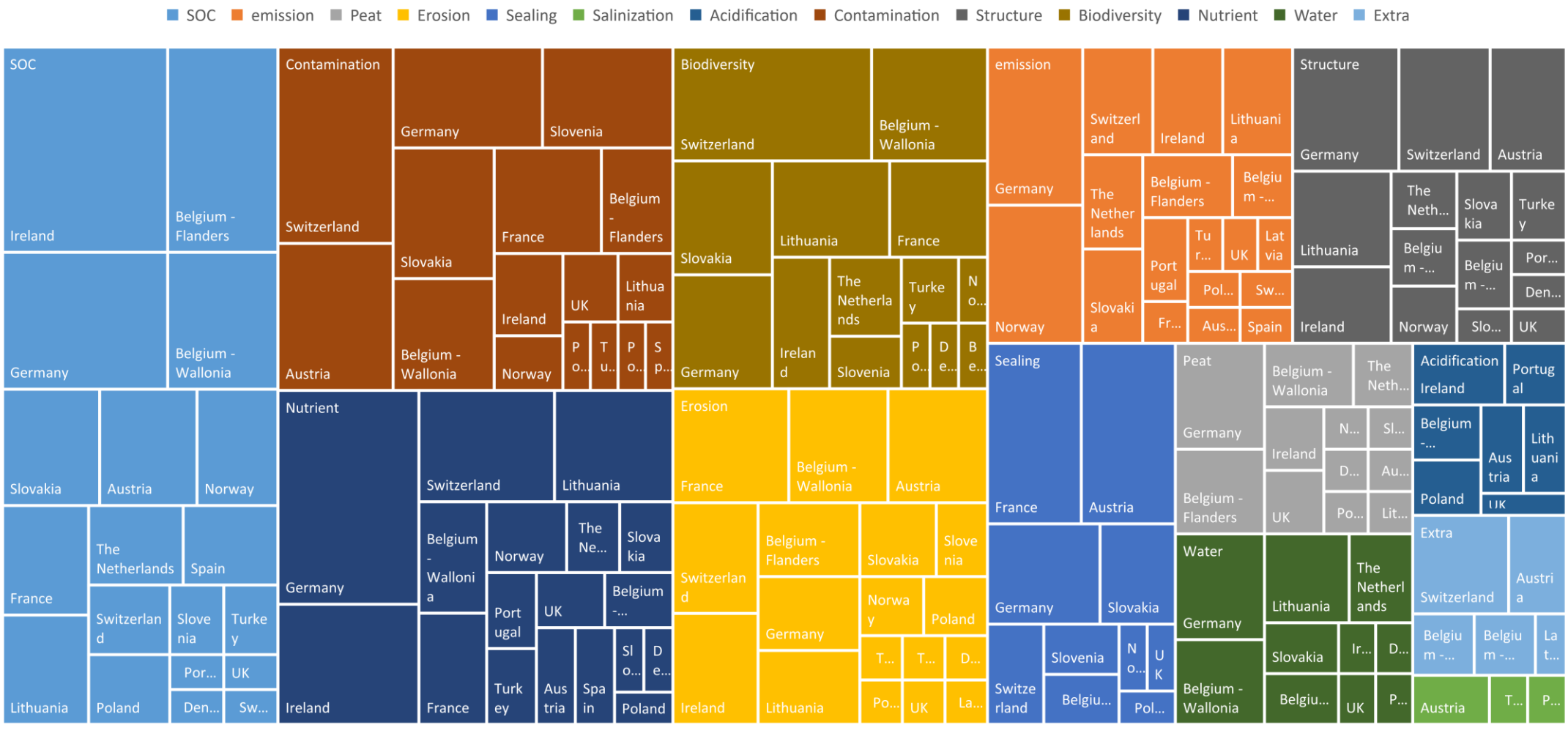

Figure 10: Share of qualitative and quantitative policy targets (n=562) per soil challenge and per EJP SOIL country in a hierarchy plot. The total number of soil targets differs per soil challenge: SOC (n=99), emission (48), peat (n=24), erosion (n=56), sealing (n=38), salinization (n=4), acidification (n=14), contamination (n=72), structure (n=43), biodiversity (n=57), nutrient (n= 70), water (n=24), extra (n=13). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

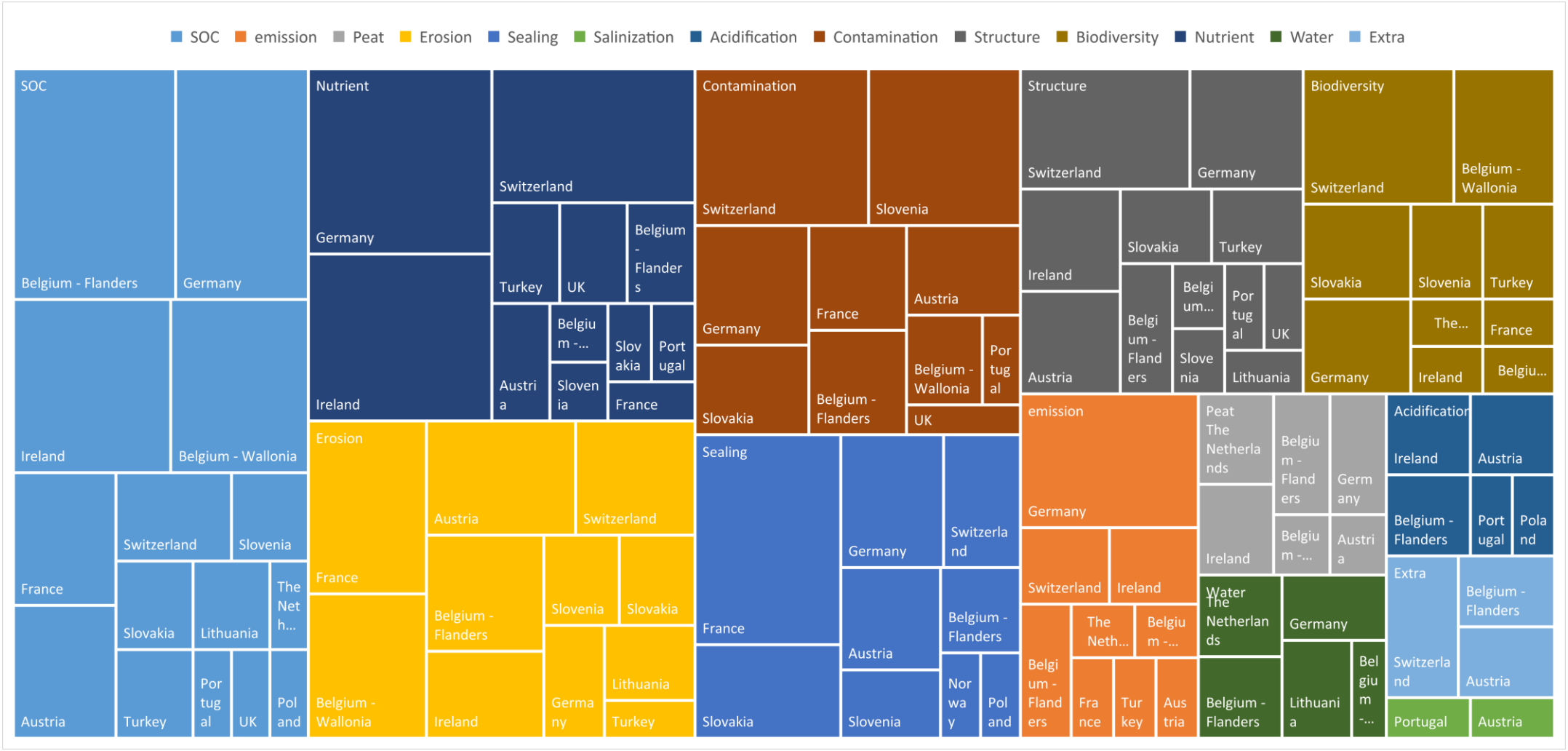

Figure 11: Share of qualitative and quantitative policy targets (agricultural soil specific and soil specific) per soil challenge and per EJP SOIL country in a hierarchy plot. The total absolute number of soil targets differs per soil challenge: SOC (n=58), emission (n=18), peat (n=10), erosion (n=36), sealing (n=29), salinization (n=2), acidification (n=8), contamination (n=35), structure (n=27), biodiversity (n=24), nutrient (n= 40), water (n=9), extra (n=7). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

2.2.2 Overview policy targets per country and regional country cluster

The relative contribution of each EJP SOIL country to the total number of policy targets is shown in Figure 12. This demonstrates the large differences between the participating countries. Figure 10 shows the large variation in the contribution to the total number of policy targets of each partner country per soil challenge. In addition, it demonstrates that the relative importance of a soil challenge may strongly vary between partner countries. However, this may also be impacted by the individual perception of the persons who contributed to the collection of the national/regional data that served as input for this report. It also indicates that the results presented from the policy target analysis need to be analyzed with certain prudence since specific soil challenges can be of higher interest for specific countries (e.g. salinization).

Since the number of policy targets may not only depend on the country but also on region-specific pedo-climatic and farming characteristics, the policy targets were also analyzed per regional country cluster (Figure 3). When comparing country clusters it is, however, important to keep in mind the relative contribution of each country cluster in this analysis: 30% of the analyzed reports resulted from a project partner in Western Europe, 30% from Central Europe while 25% from Northern Europe and 15 % from Southern Europe. This already indicates that an unequal distribution can be expected. In Figure 12 this is confirmed and it shows also that the underrepresentation of Northern and Southern Europe even becomes larger when looking at the number of targets compared to the number of reports. Within each country cluster the contribution of the different EJP SOIL countries strongly varies. Indeed, in Central and Western Europe a small number of partner countries represents more than 50% of the targets defined in that country cluster. A smaller number of countries may thus strongly impact the policy overview of a country cluster.

The relative importance of the different soil challenges in the policy of a country cluster can be related to the relative number of policy targets per soil challenge (Figure 13). The four most important soil challenges per country cluster cover at least 50% of the policy targets and these are (percentages are normalized per country cluster):

- Central Europe: Contamination (17.8%), SOC (13.0%), Nutrient (12.1%) and Biodiversity (10.5%)
- Northern Europe: Emission (17.1%), SOC (15.8%), Nutrient (14.5%), Erosion / Structure / Biodiversity (each 10.5%)
- Southern Europe: SOC (22.6%), Nutrient (19.4%), Emission (12.9), Contamination / Structure / Biodiversity (each 9.7%)
- Western Europe: SOC (23.1%), Erosion (11.5%), Nutrient (11.1%), Contamination (10.1%)

In all regional clusters SOC and Nutrient are soil challenges with many targets that are always comprised with the group of three most important soil challenges (Figure 13). For Western Europe and Southern Europe SOC is the most important soil challenge, while for Northern and Central Europe this is the second most important soil challenge. In Northern Europe Emission is the most important soil challenge, while in Central Europe especially Contamination is important. In Southern Europe the soil challenge Nutrient is the second most important soil challenge, while in all other country clusters this is the third most important challenge. The soil challenge Erosion is very important in Western Europe,

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where it is the second most important soil challenge. Only for Northern Europe the soil challenge Erosion also has a larger share of targets, where it is positioned as fourth most important challenge. In Southern Europe the soil challenge Emission is positioned as third most important soil challenged.

Thus, two general important soil challenges in each of the country clusters are SOC and Nutrient. While Contamination is especially important in Central Europe, Emission is especially very important in Northern Europe and Southern Europe. Erosion on its turn is especially important in Western Europe (and Northern Europe).

Figure 12: Relative number of qualitative and quantitative policy targets (n=562) identified by the EJP SOIL countries of different country clusters.

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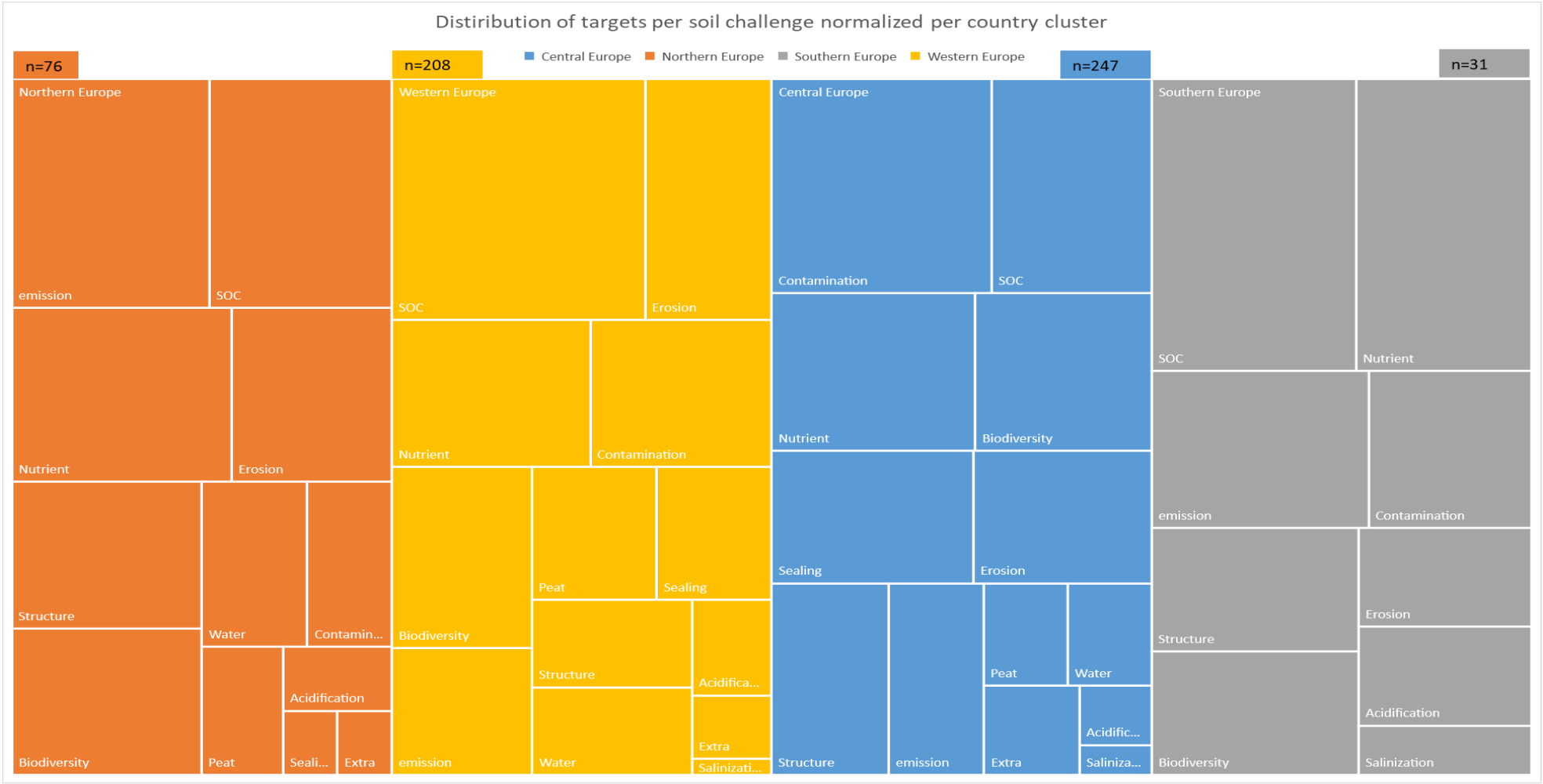

Figure 13: Share of policy targets (qualitative and quantitative) per country cluster and soil challenge, normalized per country cluster in a hierarchy plot. The total number of soil targets differs per country cluster: Southern Europe (n=31), Western Europe (n=208), Central Europe (n= 247), Northern Europe (n=76). The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water); Additional policy targets that not relate to the defined soil challenges (Extra)

2.2.3 Conclusions policy analysis

This policy analysis was focused on the policy targets as defined by the group of participating countries that were related to the soil challenges as defined within the EJP SOIL project. The analysis demonstrates that large differences exist between the number of policy targets per soil challenge. In general **the soil challenge 'Maintain/increase SOC' can be considered as the most important soil challenge** in the policy of the participating countries. This soil challenge not only has the largest share of quantitative and qualitative targets, but also has a large share of the targets for which an indicator and monitoring is in progress or exists. Other very **important soil challenges are 'Enhance nutrient retention/use efficiency', 'Avoid soil erosion' and 'Avoid soil contamination'**. These soil challenges also comprise the largest share of soil- and agricultural soil specific targets. The soil challenges maintaining/increasing SOC, avoiding contamination and avoiding soil erosion also represent the largest share of the targets for which an indicator and/or a monitoring tool exists/is available.

It is, however, important to take into account that the EJP SOIL countries had different relative contributions to the total number of policy targets for each of the soil challenges (Figure 12) and that **specific soil challenges may have been of higher interest for some partner countries**. The investigation of the relation between the soil challenges and four country cluster regions revealed some country clusters had a slightly different emphasis (Figure 13). In general, the soil challenges maintaining/increasing SOC and enhancing soil nutrient retention/use efficiency were of major importance for each of the country cluster regions. **For Southern and especially Northern Europe the soil challenge avoiding N_2O and CH_4 emission was important while in Central Europe avoiding contamination was of major importance. In Northern, but especially in Western Europe a lot of attention was paid to targets related to avoiding soil erosion.**

Despite a large number of policy targets could be identified by the participating EJP SOIL countries, there is still a shared need by these countries for appropriate policy targets, indicators and monitoring systems. Indeed, although several indicators and monitoring tools could be identified in this analysis (Figure 9) a result-based monitoring network or a **systematic soil monitoring** is not existing in most partner countries. However, it would support the development of adequate soil policies and evaluation of policy targets. Many partner countries report that policies are often vague and that there is a **lack of clear/quantified soil targets with time horizon** (P, UK, SK, NO, SI, BE-WL, CH, SLK, FR, DE, LV)**, indicators** (P, FR, UK, NO, NL, CH, VL, TR) and **monitoring** tools (P, SK , NO, CH, LV, FR). Furthermore, in some countries it was reported that **policy instruments/incentives** to reach targets are missing (LV, NO). In contrast, in Denmark it is stated that measures and instruments are available but that **policy ambition is lacking** or is low (BE-WL).

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2.3 Stakeholder views on current policy ambitions and future soil aspirational goals at the regional or country level

This section, based on stakeholder input, includes a compilation of the participating country reports on (i) the soil challenge prioritizations and (ii) policy realizations and aspirations

2.3.1 Prioritization

The results of the prioritization task is analysed at three spatial scales:

- The European level: average prioritization of the soil challenges for all participating countries and environmental zones jointly.
- Regional clusters: average prioritization of the soil challenges, subdivided in four regional clusters (1) Northern, (2) Central, (3) Western and (4) Southern Europe.
- Environmental zones: average prioritization of the soil challenge, subdivided in the environmental zones (EZ), with attention for the variability between the countries of an EZ.

European level

The relative score and ranking of the soil challenges in Europe, based on the soil challenge prioritization of the stakeholders in 18 participating countries[2] and including all environmental zones jointly is displayed in Figure 14.

[2] Switzerland is not included, because the data collection method was not compatible with the other countries.

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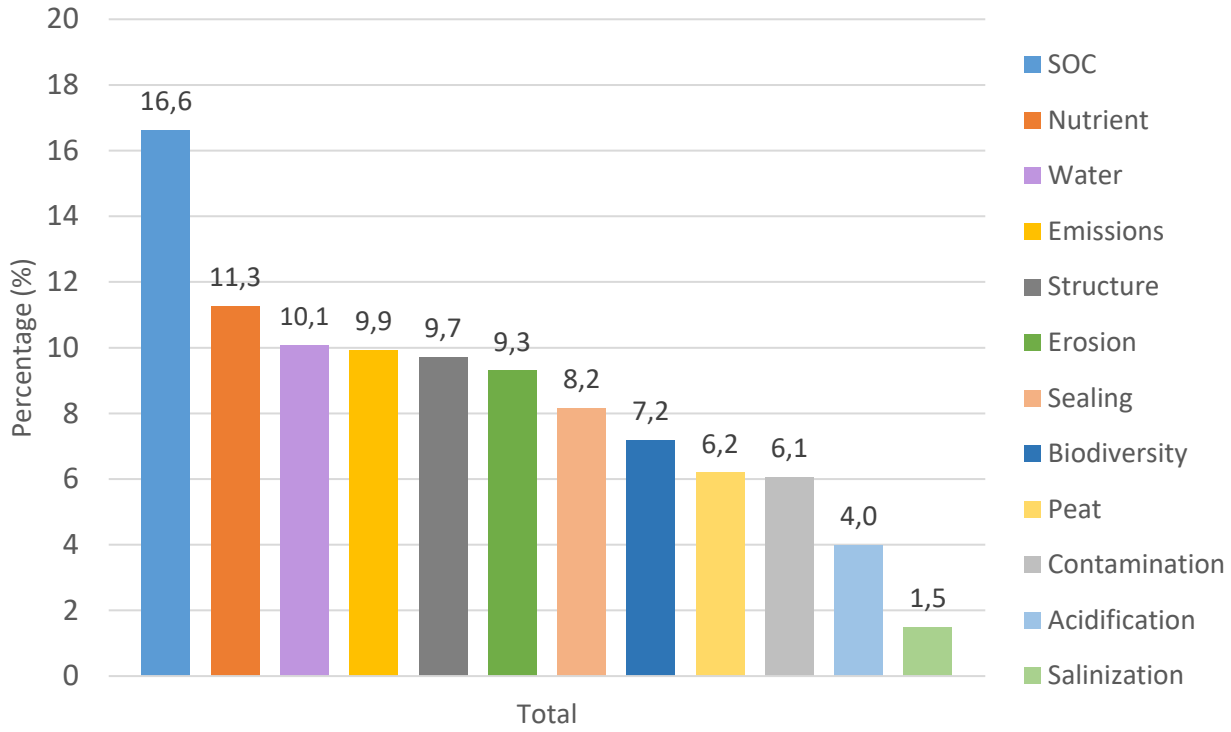

Figure 14: Relative score of the prioritizations of the soil challenges by stakeholders in Europe. The soil challenges are: Maintain/increase SOC (SOC); Avoiding N2O, CH4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water).

Ranking of the soil challenges prioritizations by stakeholders in Europe (top 10)

1. Maintain/increase SOC (16.6%)
2. Enhance soil nutrient retention/use efficiency (11.3%)
3. Enhance water storage capacity (10.1%)
4. Avoid N_2O and CH_4 emissions (9.9%)
5. Optimal soil structure (9.7%)
6. Avoid soil erosion (9.3%)
7. Avoid soil sealing (8.2%)
8. Enhance soil biodiversity (7.2%)
9. Peat degradation (6.2%)
10. Avoid contamination (6.1%)

The stakeholders prioritized maintaining/increasing SOC by far as the most relevant soil challenge in the upcoming decades, while avoiding acidification (4%) and salinization (1,5%) are low ranked priorities by the stakeholders. Note that soil sealing might not be understood the same way in every country or by every stakeholder.

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Variability between regional clusters

Important soil challenges per regional cluster with a prioritization score above 10% are (Figure 15):

- Northern Europe: maintaining/increasing SOC, enhancing soil nutrient retention/use efficiency, avoiding N_20/CH_4 emissions, optimal soil structure.
- Central Europe: maintaining/increasing SOC, soil sealing, soil erosion, enhancing water storage capacity.
- Western Europe: the scoring of the soil challenges is well distributed; high scores for maintaining/increasing SOC, avoiding N_20/CH_4 emissions, enhancing soil nutrient retention/use efficiency, enhancing water storage capacity, optimal soil structure and enhancing soil biodiversity.
- Southern Europe: maintaining/increasing SOC, soil erosion. In the composition of this region, only 4 country-environmental zones data inputs are included, therefore care is needed in the interpretation.

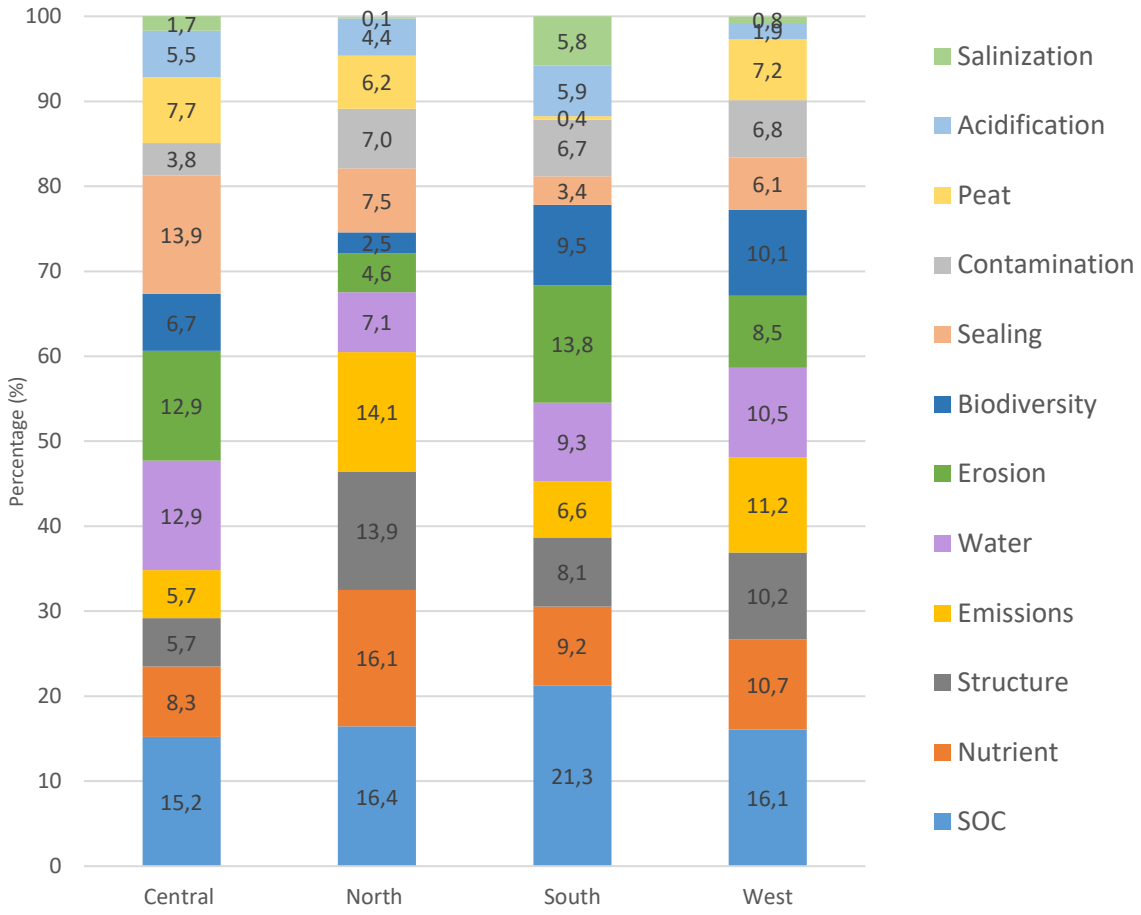

Figure 15: The relative scores of the prioritizations of the soil challenges by stakeholders clustered in 4 regional zones. North (N=8); Central (N=8); South (N=4); West (N=11); N = number of participating countries-EZ data inputs. The soil challenges are: Maintain/increase SOC (SOC); Avoiding N_2O, CH_4 emissions (Emission); Avoid peat degradation (Peat); Avoid soil erosion (Erosion); Avoid soil sealing (Sealing); Avoid salinization (Salinization); Avoid acidification (Acidification); Avoid contamination (Contamination); Optimal soil structure (Structure); Enhance soil biodiversity (Biodiversity); Enhance soil nutrient retention/use efficiency (Nutrient); Enhance water storage capacity (Water).

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When comparing the different regional zones of Europe, the following can be observed:

- **SOC is important in all zones**, but most important in Southern Europe.
- There is a **contrast between Northern Europe and the other zones**, in the sense that enhancing soil nutrient retention/use efficiency, optimal soil structure and avoiding N_2O and CH_4 emissions are most important in Northern Europe, and that soil erosion and enhancing soil biodiversity is a smaller issue in the North compared to the other zones.
- **Peat degradation is an issue in Northern, Central and Western Europe**, but even there scores are low.
- **Soil contamination is equally important in Northern, Southern and Western Europe**, while of lower importance in Central Europe.
- **Soil sealing is most important in central Europe**, followed by northern Europe, but soil sealing might not have been understood in the same way by different stakeholders.
- **Enhance soil biodiversity is important in Western and Southern Europe**, while regarded of lower importance in Northern Europe.
- **Salinization is more important in the south**, but also there the score is quite low (5.8%).

Variability within and between the environmental zones

The prioritization of the soil challenges could be potentially different between the environmental zones (Figure 2). Therefore, when there are several environmental zones within one country the participating countries were asked to do the prioritization separately per environmental zone. The diagram below shows the variability of the soil challenge prioritizations between the environmental zones (Figure 16). Below the graph, the number of countries included in the respective zones are indicated.

Note that, the data inputs for the environmental zones is limited to only one or two countries in nine of the twelve environmental zones. Those zones often have some high importance for one or few soil challenges, while in the zones in which more countries have scored, differences between soil challenges are less pronounced, because averaged out. Therefore, carefulness is needed when drawing conclusions from the prioritization in zones represented by few countries.

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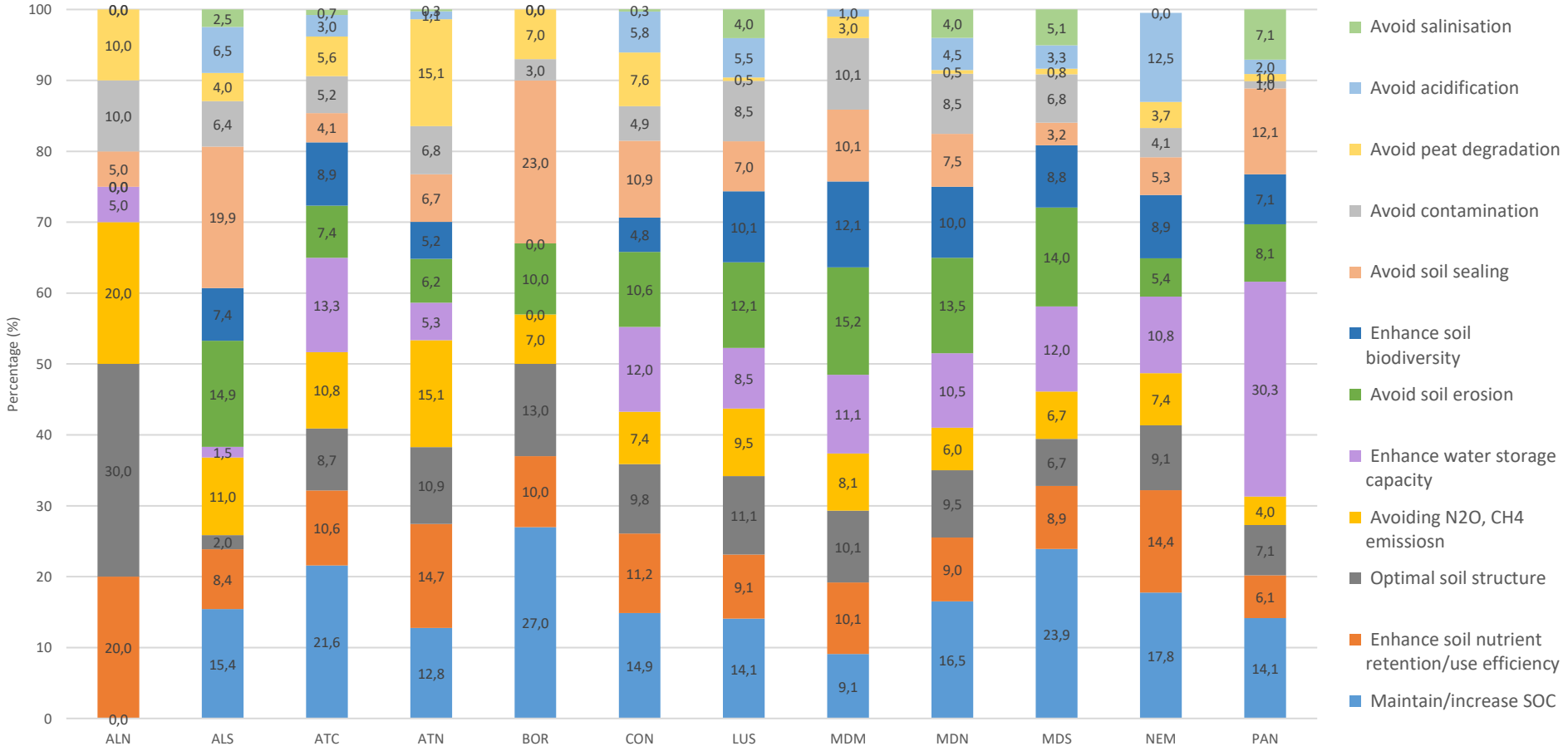

Figure 16: Comparison of the soil challenge prioritizations between the environmental zones (Figure 2). ALN (Alpine North, N=1); ALS (Alpine South, N=2); ATC (Atlantic Central, N= 7); ATN (Atlantic North, N= 5); BOR (Boreal, N=1); CON (Continental, N=5); LUS (Lusitanian, N=2); MDM (Mediterranean Mountains, N=1); MDN (Mediterranean North, N=2); MDS (Mediterranean South, N=2); NEM (Nemoral, N=2); PAN (Pannonic, N=1)

Based on the comparison shown in Figure 16, we observe the following trends for the soil challenge priorities:

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- **Maintaining/increasing SOC** has a high score in all zones, except for Alpine North (ALN) (0%) and scores are specifically high in the Boreal (BOR) (27%) and Mediterranean south (MDS) (24%) zones.
- **Enhancing soil nutrient retention/use efficiency** is particularly high ranked in ALN (20%) zone.
- **Optimal soil structure** is particularly important in ALN (30%) and particularly low ranked in Alpine south (ALS) (2%).
- **Avoiding N_2O and CH_4 emissions** is highly ranked in ALN (20%) and Atlantic North (ATN) (15%) zones, while lower ranked in Pannonian (PAN) (4%) zone.
- **Enhancing water storage capacity** is very important in the PAN zone (30%). In the Mediterranean zones (MDM, MDN, MDS), Atlantic Central (ATC), Nemoral (NEM) and Continental (CON) zones, the importance is 10-14%, while scores are very low in BOR (0%), ALS (1,5%) and ALN (5%).
- **Avoiding soil erosion** is not scored in ALN (0%) and low scored in NEM (5,4%), ATN (6,2%) and ATC (7,4%).
- **Enhancing soil biodiversity** is not ranked in ALN (0%) and BOR (0%) zones and low scored in ATN (5,2%) and CON (4,8%).
- **Avoiding soil sealing** is particularly high ranked in BOR (23%) and ALS (19,9%), while low ranked in ALN (5%), ATC (4,1%), and MDS (3,2%). We should be aware that soil sealing could have been interpreted differently by the stakeholders.
- **Avoiding contamination**, relatively high ranked in ALN (10%) and MDM (10%), while particularly little ranked in PAN (1%) and BOR (3%) zones.
- **Avoiding peat degradation**, relatively high ranked in ATN (15,1%), ALN (10%), BOR (7%) and CON (7,6%), while little or not ranked in the other zones.
- **Avoiding salinization and acidification** have a low scores in almost all zones. Yet avoiding acidification is particularly high in NEM (12,5) and avoiding salinization is particularly higher in more southern zones such as MDS (5,1%) and PAN (7,1%) zones.

Although some general trends could be observed, the results should be interpreted with care, since for many zones there are only one or two countries that completed the questionnaires.

Variability between the different countries of the environmental zones

For most environmental zones there are different countries included, it is therefore also possible to identify potential differences between the countries within each zone. In the diagram below the countries of each zone are shown separately (Figure 17).

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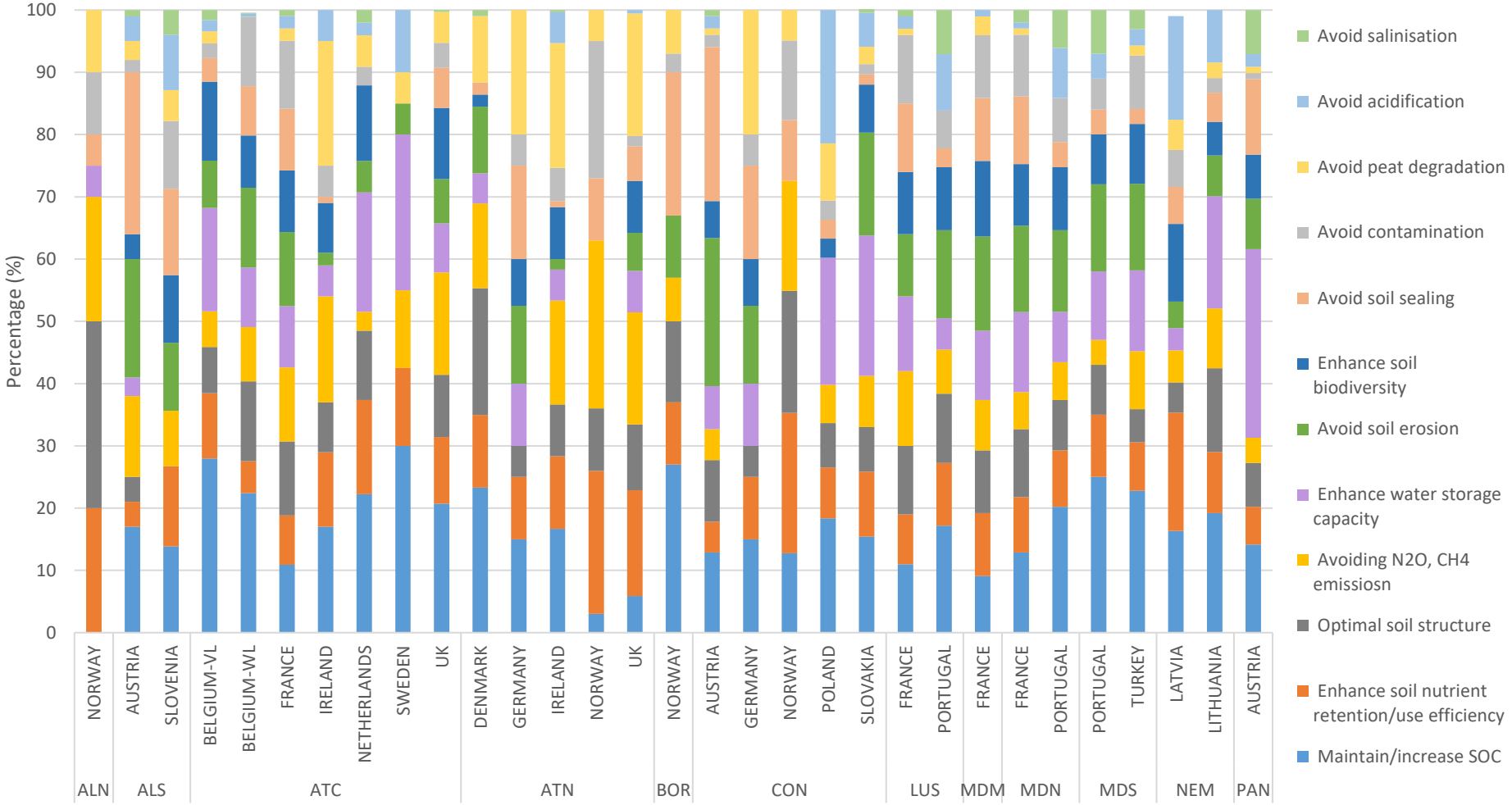

Figure 17 Variability of the soil challenge prioritizations between the countries of the environmental zones

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Based on the variability we observe the following trends for the soil challenges:

- **Alpine North (ALN)**: only Norway is included
- **Alpine South (ALS)**: soil sealing and soil erosion are more important in Austria, while enhancing soil nutrient retention/use efficiency and soil contamination are relatively higher ranked in Slovenia.
- **Atlantic Central (ATC)**: Looking to the **south-to-north gradient,** in Sweden, the Netherlands and Flanders SOC and enhancing water holding capacity are ranked higher than in the other regions. In France and Wallonia, soil erosion and soil contamination are more important than in the other zones. The prioritization in Ireland and UK are comparable, except for peat degradation which is particularly high in Ireland. Also avoiding N_2O/CH_4 emissions is relatively higher ranked in Ireland, particularly compared to the Netherlands.
- **Atlantic North (ATN):** Avoiding N_2O and CH_4 emissions, enhancing nutrient use efficiency and soil contamination are specifically high ranked in Norway, while SOC is almost no issue in that region.
- **Boreal (BOR)**: only Norway included; the priorities are different from other environmental zones in Norway, e.g., SOC is more important than in the other zones
- **Continental (CON)**: Norway and Poland have a clearly different rating. Norway has high rates for enhancing soil nutrient retention/use efficiency, optimal soil structure and avoiding N_2O/ CH_4 emissions. While, lacking any rate for soil erosion. Poland has a particularly high rate for avoiding acidification.
- **Lusitanian (LUS)**: relatively little variation. Soil sealing is higher ranked in France, while avoid acidification is higher ranked in Portugal.
- **Mediterranean Mountains (MDM)**: only France included.
- **Mediterranean North (MDN)**: relatively little variation. Soil sealing is higher ranked in France, while avoid acidification is higher ranked in Portugal.
- **Mediterranean South (MDS)**: includes Portugal and Turkey, but the differences are relatively small.
- **Nemoral (NEM)**: particularly high difference in enhance water storage capacity, high in Lithuania and small for Latvia.
- **Pannonic (PAN)**: only Austria included.

Overall, in some zones, differences between countries are fairly high, while in other zones (e.g., MDS) there are large similarities between the countries in the zone.

2.3.2 Policy ambitions and aspirational goals

The policy ambitions and aspiration are analyzed successively at the European level and at the country level.

European level

Generally, when averaging all countries, the gap between current policy targets and current realizations is for most soil challenges between large and halfway (Figure 18). For most soil challenges current policy targets are almost- to- far from being futureproof. This means that for all soil challenges there is still a way to go before future aspirational goals will be met.

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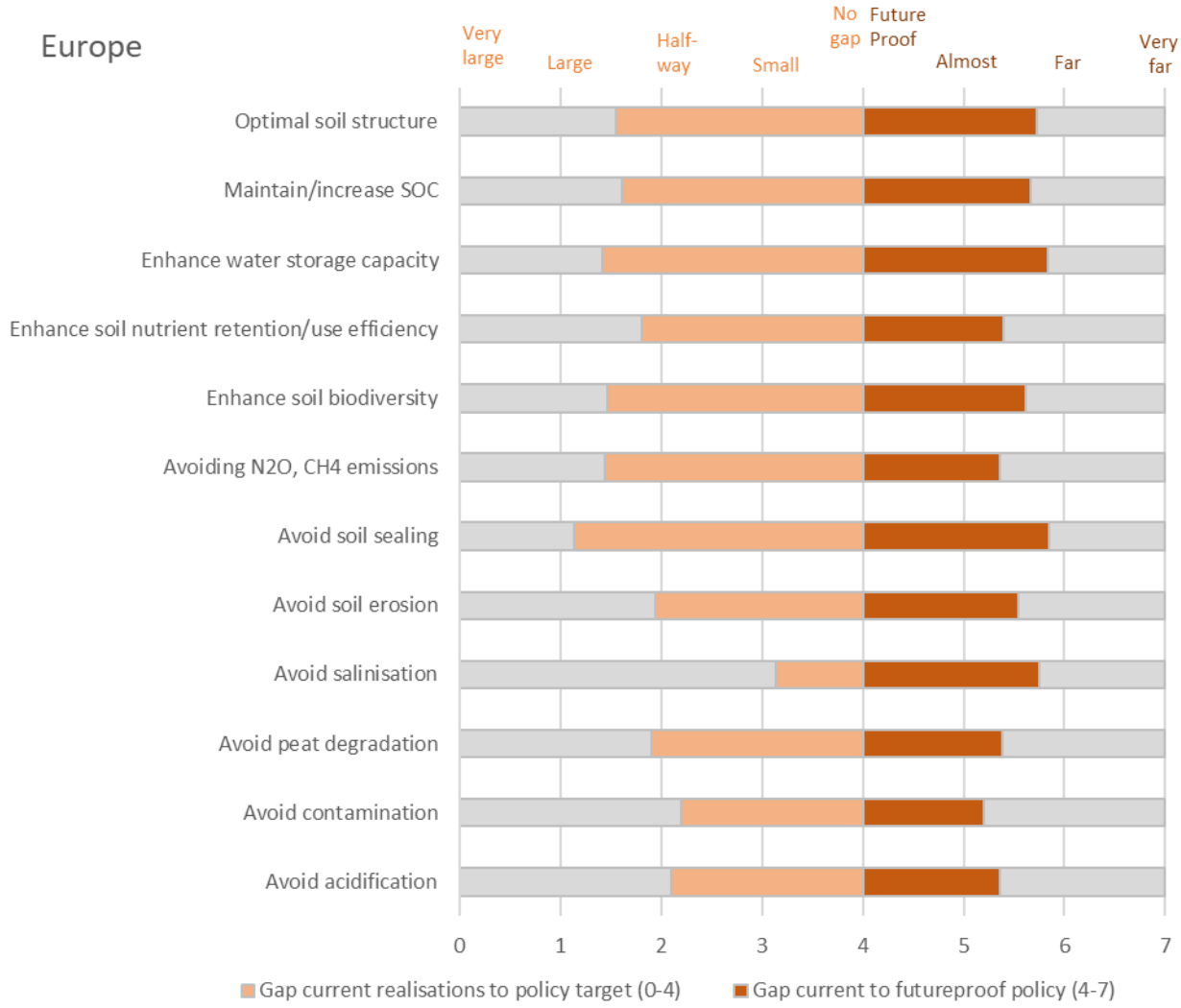

Figure 18 European average of realization and aspiration gap of the soil challenges (*based on the participating countries). The average realization gap is indicated in light red and the average aspiration gap is indicated in dark red. The size of the red bars together gives an indication of the remaining gap, a larger bar corresponds with a larger gap. Read further for country charts.*

The soil challenges that have the largest gap between realizations and current policy targets are in descending order of magnitude: avoiding soil sealing, enhancing water storage capacity, avoiding N_2O and CH_4 emissions, enhancing soil biodiversity, optimal soil structure and maintaining/increasing SOC. Current policy targets are least future proof for soil sealing, enhancing soil water capacity, avoiding salinization and optimal soil structure. That means that the gap between current realizations and futureproof targets is largest for avoiding soil sealing, enhancing water holding capacity, optimal soil structure and enhancing soil biodiversity. But also for maintaining/increasing SOC, enhancing nutrient use retention/efficiency, avoiding N_2O/CH_4 emissions current realizations are not even halfway the current targets yet and current targets are almost-to-far from futureproof, showing the big challenges ahead to deal with these soil challenges.

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For salinization the gap between realizations and current targets is small, while targets are far from futureproof. In many countries policy targets are missing, because salinization is not (perceived as) a challenge in all countries.

Country level

At the country level, the score of the country reports is used to visualize the realization and aspirational gap of the soil challenges. This allows a comparison between countries (Table 5), but we should notice that there are differences in stakeholder representation between countries both in composition and stakeholder size. These differences can be consulted in Table 1. The figure for maintaining/increasing SOC, the highest ranked priority by the stakeholders, is included in the report (Figure 19), figures for the other soil challenges are included in Annex III.

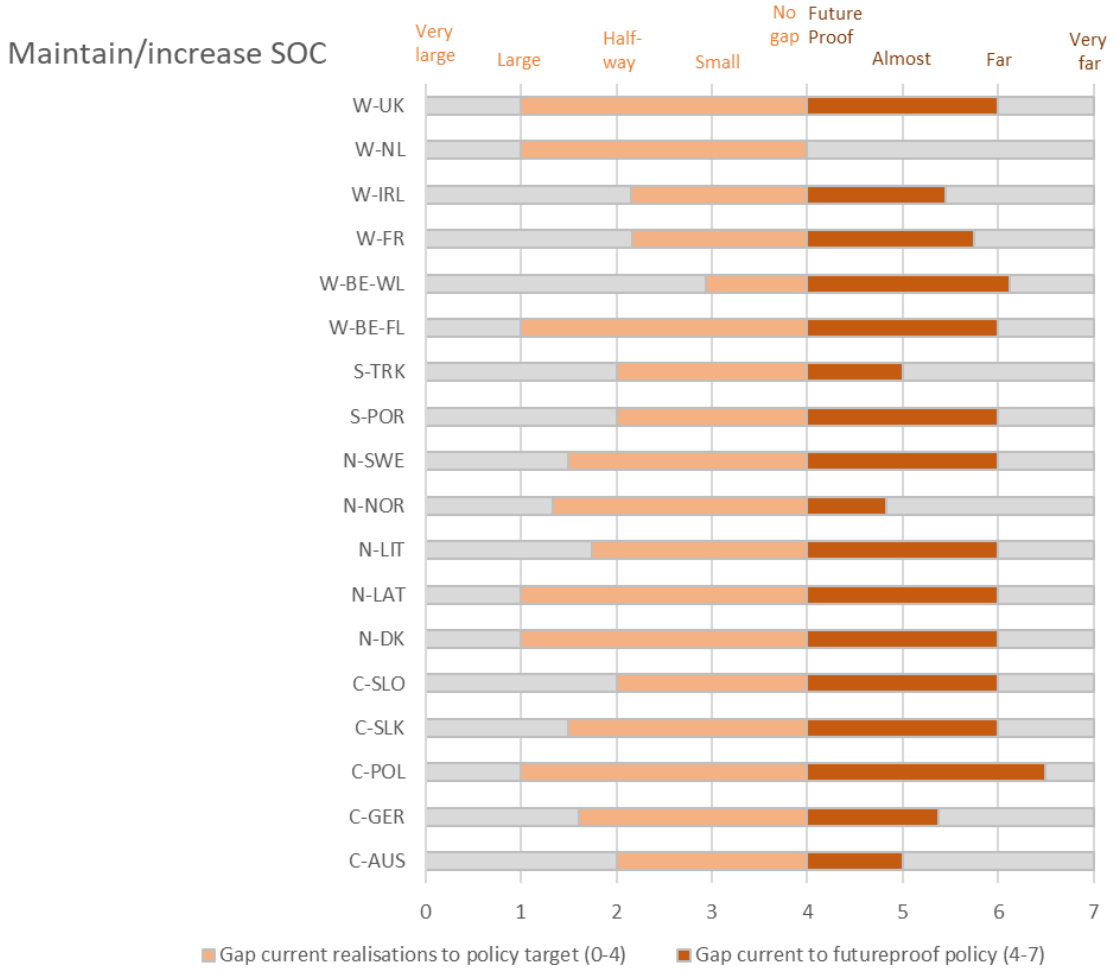

Figure 19 Country average of realization and aspiration policy gaps for maintaining/increasing SOC. The average realization gap is indicated in light red and the average aspiration gap is indicated in dark red. The size of the red bars together gives an indication of the remaining gap, a larger bar corresponds with a larger gap.

Table 5: Short description of realization and aspirational gaps for the different countries and for the successive soil challenges

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Soil challenges	Short description (see Annex III for all figures) of the stakeholder views on the soil challenges. *Note that differences in stakeholder representation are not taken into account.*	Annex
Maintaining/ increasing SOC	Overall, the stakeholders state that the upcoming policy challenges for SOC are still large. In most countries, stakeholders state that the policy targets are halfway or far from reached, while the current targets are mostly evaluated far from futureproof. The main exception is NL In NL the policy targets are considered futureproof, however the gap to the current policy targets are still considered large. In TRK, NOR and AUS, the futureproof policy gap is considered almost reached, but the realization gap is still regarded far to halfway reached. While, in BE-WL the realization gap is considered small, but the gap to a futureproof policy is considered large.	AIII.1
Enhance soil nutrient retention/use efficiency	Overall, the upcoming policy challenges for enhancing soil nutrient retention/use efficiency are considered large. In most countries the realization gap for the current policy targets is considered halfway to large and the policy is considered almost or far from futureproof. The stakeholders indicated that the largest challenges are in POL, DK and FR. While in SWE, NL and the UK the stakeholders indicated that the policy is close to futureproof.	AIII.2
Optimal soil structure	The upcoming policy challenges for optimal soil structure are considered large. Only in IRL, the gap between current realization and futureproof policy is considered small. For all countries (except IRL) the gap between realizations and current targets is considered halfway or larger. In 8 countries, policy is considered far to very far from being future proof, while for 7 countries the policy is regarded near to reaching almost futureproof policy. Stakeholders in DK, SK, UK and BE-FL have indicated big policy challenges to reach an optimal soil structure.	AIII.3
Avoid N_2O and CH_4 emissions	Again, the policy challenges are considered large, but there is more variation between the countries. In AUS, the remaining gap is considered smallest, stakeholders indicated that the policy is futureproof and the current policy is halfway to realization.	AIII.4

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	Stakeholders in FR indicated that the policy is close to realize the current policy targets, but these targets are still considered very far from being futureproof. In BE-FL, LAT, LIT, SLK, POL and BE-WL the stakeholders indicated that there is still a wide gap between target and realization and to a futureproof policy.	
Enhance water storage capacity	There is some variation between the countries. But the stakeholders from most countries indicate that there are still big challenges ahead. In POL, the challenge is considered particularly large. The realizations are very far from reaching the current policy and the current policy is considered very far from being futureproof. Stakeholders indicate that the remaining policy gap is smallest for the UK, TRK and DE, for these countries the realizations are considered to be halfway the current targets and the current policy is considered almost futureproof. Whereas for the other countries and BE-FL, SLK and LIT in particular the challenge is still considered large.	AIII.5
Avoid soil erosion	For most countries there remains a policy challenge in avoiding soil erosion, but for IRL and FR the current policy targets are considered almost reached and the policy is regarded almost futureproof. While, on the contrary for DK, SLK and UK the challenges are considered much larger.	AIII.6
Enhance soil biodiversity	Overall, the policy challenges are still considered large for most countries. The main exceptions is IRL. In IRL the current policy targets are considered almost reached and the policy is regarded close to futureproof. BE-WL and BE-FL are also considered to be on the way to reach the policy targets, but the policies need adjustments to be regarded futureproof. In TRK the policy is considered almost futureproof and regarded half realized. The stakeholders indicate the biggest challenges for the UK with a large gap in realizing the current policy targets and a policy that is considered far from futureproof. The UK is followed by SLK, LIT, LAT, DK, SLK, GER, POR and FR.	AIII.7
Avoid soil sealing	Overall the policy challenge for soil sealing are considered large. Particularly for AUS and BE-FL, the stakeholders indicate a very wide gap between realization and a policy that is considered very far and far from futureproof, respectively.	AIII.8

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	Stakeholders indicate that the remaining gap is smallest for NOR and TRK, they are considered halfway to reach realization and have a policy that is regarded almost futureproof. For NOR care is needed in the interpretation, since the reporting of soil sealing is part of an ongoing debate. In DE, the policy realization gap is considered large, but the policy is regarded very close to a futureproof policy.	
Avoid contamination	The stakeholders indicate that in many countries the policy gap is small, yet there is some variation between the countries. Particularly in NOR, IRL, AUS POL and UK the stakeholders indicate that the remaining gap is small. In POL, the policy targets are even considered realized, but the policy is still regarded far from futureproof. For FR, LAT, SLK, POR, TRK, LIT and SLO the challenges are still considered larger.	AIII.9
Peat degradation	Most countries have a policy that is considered almost futureproof, except for LIT, LAT, POL and AUS. Particularly for POL, the overall policy challenge is regarded large. The stakeholders in NOR and BE-WL indicate that the remaining gap is small, with a small gap to realization of the current policy targets and a policy that is almost futureproof.	AIII.10
Avoid acidification	Only few countries evaluated the policy on this soil challenge. There is some clear variation between the countries. The stakeholders in IRL, UK BE-FL and BE-WL indicated that the policy gap is small, whereas stakeholders in SLK, POL and LAT indicated that the gap is still large. For BE-FL, the policy is considered futureproof, but the realization is regarded halfway from reached. Whereas, for BE-WL, the policy target is considered realized, but the policy is regarded far from futureproof.	AIII.11
Avoid salinization	Only very few countries evaluated the policy on this soil challenge. For the UK the policy is considered very near to realization and regarded close to futureproof. For BE-WL and BE-FL, the policy target is considered realized, but the policy is regarded far from futureproof. The stakeholders indicated the largest remaining challenges for SLK, followed by TRK and POR.	AIII.12

2.3.3 Policy gaps and prioritization

In this section, a comparison is made between the prioritizations (2.3.1) of the soil challenges and the policy gaps of the soil challenges (2.3.2), as indicated by the stakeholders at the scale of Europe and the regional clusters respectively.

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Many of the top 6 soil challenge priorities, also face large policy challenges (Table 6). The total policy gap of these challenges are not even considered halfway in reaching a fully realised and futureproof policy. Of these soil challenges, soil nutrient retention/use efficiency and soil erosion, are regarded closest in reaching halfway the total policy gap.

Table 6: Policy gaps and prioritization in Europe. The prioritization is expressed as the relative importance (%) of the soil challenges. The realization gap of each soil challenge is expressed as the average gap to realizing current policy targets on a scale from 0 to 4. The aspiration gap is expressed as the average gap to futureproof policy per soil challenge on a scale from 0 to 3.

	Priority score*	Gap current targets –realisations**	Gap current targets-futureproof**	Total GAP (realisation gap + aspiration gap)**
	EU	EU	EU	EU
Maintain/increase SOC	16.6	2.39	1.67	4.1
Enhance soil nutrient retention/use efficiency	11.3	2.20	1.40	3.6
Enhance water storage capacity	10.1	2.59	1.84	4.4
Avoiding N2O, CH4 emissions	9.9	2.57	1.35	3.9
Optimal soil structure	9.7	2.45	1.72	4.2
Avoid soil erosion	9.3	2.06	1.54	3.6
Avoid soil sealing	8.2	2.87	1.85	4.7
Enhance soil biodiversity	7.2	2.53	1.62	4.1
Avoid peat degradation	6.2	2.09	1.39	3.5
Avoid contamination	6.1	1.81	1.20	3.0
Avoid acidification	4.0	1.90	1.36	3.3
Avoid salinisation	1.5	0.86	1.75	2.6

* Yellow marked cells have a value above the second quartile (Q2) of the priority scores; green marked cells have a value above the third quartile (Q3); ** Yellow marked cells have a value above the second quartile (Q2) of the gap widths; red marked cells have a value above the third quartile (Q3)

Within the different regional clusters, there is no one-to-one match between prioritization of soil challenges and policy evaluation. It is, however, remarkable that also at the level of the regional zones, policies are considered unable to close the gap for high priority soil challenges and still face a gap to reach a futureproof policy (Table 7). From these, only nutrient retention/use efficiency and soil erosion seem to perform better.

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Table 7 Policy gaps and prioritization at EU regional clusters. The prioritization is expressed as the relative importance (%) of the soil challenges. The realization gap of each soil challenge is expressed as the average gap to realizing current policy targets on a scale from 0 to 4. The aspiration gap is expressed as the average gap to futureproof policy per soil challenge on a scale from 0 to 3.

	Priority score*				Gap current targets –realisations**				Gap current targets-futureproof**				Total GAP (realisation gap + aspiration gap)**			
	C	N	S	W	C	N	S	W	C	N	S	W	C	N	S	W
SOC	15,2	16,4	21,3	16,1	2,4	2,7	2,0	2,3	1,8	1,8	1,5	1,6	4,2	4,5	3,5	3,8
Nutrient retention/use efficiency	8,3	16,1	9,2	10,7	2,3	2,2	2,0	2,1	1,8	1,4	1,0	1,2	4,2	3,6	3,0	3,3
Soil structure	5,7	13,9	8,1	10,2	2,4	2,6	2,5	2,3	1,6	1,8	1,0	2,0	4,0	4,5	3,5	4,3
N20/CH4 emissions	5,7	14,1	6,6	11,2	2,6	2,7	2,5	2,4	1,4	1,7	1,0	1,2	4,0	4,4	3,5	3,6
Water storage	12,9	7,1	9,3	10,5	3,1	2,5	2,0	2,3	1,8	1,9	1,0	2,0	4,9	4,4	3,0	4,3
Soil erosion	12,9	4,6	13,8	8,5	2,2	2,3	2,0	1,8	1,5	1,7	1,5	1,4	3,7	4,1	3,5	3,1
Soil biodiversity	6,7	2,5	9,5	10,1	2,9	2,9	2,5	2,0	2,0	1,6	1,0	1,7	4,9	4,5	3,5	3,6
Soil sealing	13,9	7,5	3,4	6,1	3,2	2,0	2,0	3,1	1,8	2,0	1,0	2,0	5,1	4,0	3,0	5,1
Contamination	3,8	7,0	6,7	6,8	1,5	1,9	2,3	1,9	1,7	1,3	1,0	0,8	3,2	3,3	3,3	2,7
Peat degradation	7,7	6,2	0,4	7,2	2,6	1,2	2,0	2,3	2,0	1,8	1,0	0,7	4,6	2,9	3,0	3,0
Acidification	5,5	4,4	5,9	1,9	2,7	2,2	2,0	1,1	2,0	1,5	1,0	1,0	4,7	3,7	3,0	2,0
Salinisation	1,7	0,1	5,8	0,8	1,0	4,0	2,0	0,0	2,0	0,0	1,0	2,2	3,0	4,0	3,0	2,2

* Yellow marked cells have a value above the second quartile (Q2); green marked cells have a value above the third quartile (Q3); ** Yellow marked cells have a value above the second quartile (Q2); red marked cells have a value above the third quartile (Q3)

2.4 Soil management

The most prominent differences between policy and stakeholders ranking of land management categories to tackle the soil challenges, is on the use of buffer strips/small landscape elements. Buffer strips comprised 13% of the management practices mentioned in policy documents, while they were only mentioned in 5% of the cases by the stakeholders. Agricultural systems were relatively mentioned more by the stakeholders (17%) than in policy documents (11%) (Figure 20).

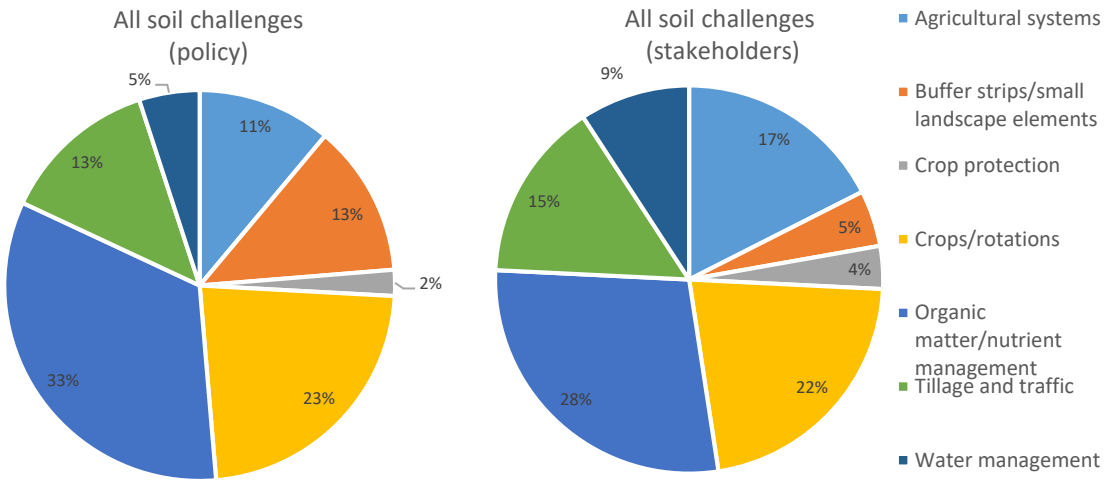

Figure 20 Relative share of land management categories mentioned in policy documents (left) and prioritized by stakeholders (right). Data are summarized across participating countries and soil challenges.

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In the paragraphs below we first focus on the more detailed results from the policy analysis and the stakeholder inputs separately, after which a comparison is made to identify the potential match and mismatches between policy and stakeholders.

2.4.1 Soil management – a policy perspective

The top five soil related management techniques listed in policy documents are part of the land management categories organic matter/nutrient management (reduced/more precise mineral fertiliser application, appropriate farmyard manure application and fertilizer plan/advice) and crops/rotations (cover/catch crops and more grassland) (Table 8).

Table 8: Overview of the 50% most mentioned soil related management practices in policy documents of the participating countries. The number of hits represents the number of soil policy documents that refer to this soil management technique, summed over all countries/regions. The share is the relative share (in %) of the number of policy documents that mention the practices in the total amount of documents listed (n=1856). The ranked cumulative share allows to identify the key soil related management techniques that represent a relative share of 50%. This method is used to identify a shortlist of the most important soil management techniques.

Soil related management techniques	Number of hits	Share (%)	Cumulative. share (%)
Reduced/more precise mineral fertiliser application (OM)	115	6.2	6.2
Appropriate farmyard manure application (OM)	104	5.6	11.8
Cover/catch crops (CR)	98	5.3	17.1
Fertilisation plan/advice (OM)	96	5.2	22.3
More grassland (CR)	85	4.6	26.8
Non-inversion/reduced tillage (TT)	84	4.5	31.4
Appropriate compost application (OM)	80	4.3	35.7
Grass buffer strips (BS)	77	4.1	39.8
Other buffer strips (BS)	69	3.7	43.5
Organic farming (AS)	68	3.7	47.2
Hedges (BS)	48	2.6	49.8
Better manure storage (OM)	44	2.4	52.2

(OM= organic matter/nutrient management; CR= crop/rotations; TT= tillage and traffic; AS= agricultural systems; BS = Buffer Strips/small landscape elements)

All soil related management techniques are displayed in a hierarchy plot (Figure 21). This plot provides a visual representation of both the most important land management categories and the specific soil related management techniques.

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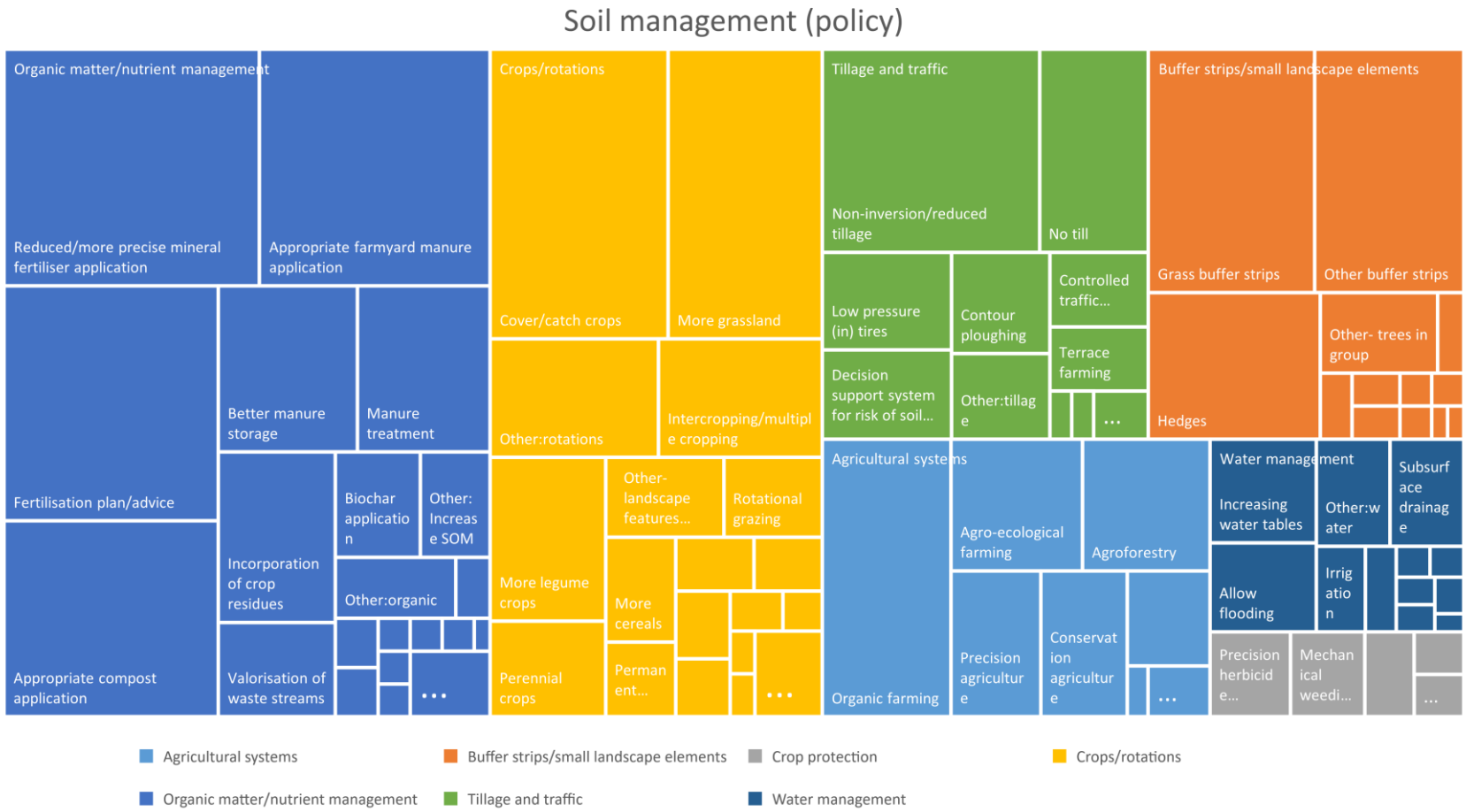

Figure 21: Share of land management categories and soil related management techniques belonging to these categories as mentioned in policy documents.

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In the country reports, the policy documents that mention soil related management practices were assigned to the soil challenges they were aiming for. For example, in BE-FL non-inversion tillage is recommended or even obligated in CAP cross-compliance to tackle the soil challenge soil erosion and cover crops are recommended or obligated in the manure action plan (Nitrates Directive) to prevent nitrate leaching and improve water quality (which was classified as 'other environmental stake'). The results for all countries are summarized in Table 9.

Table 9: Number of policy documents that mention the most important soil related management practices (Table 8) summed for all countries, but separated for the different soil challenges or other environmental stakes that the policy document was aiming for. In a final row the total number of (unique) policy documents are listed per soil challenge.

Soil management	Maintain/ increase SOC	Avoid N2O/CH4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid contamination	Avoid salinisation	Avoid acidification	Avoid soil sealing	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes	Weight
Reduced/more precise mineral fertiliser application	5	27	2	0	19	0	5	0	1	12	30	4	10	115
Appropriate farmyard manure application	14	19	0	5	18	0	5	0	6	8	16	9	4	104
Cover/catch crops	20	4	0	25	3	0	0	0	7	8	16	9	6	98
Fertilisation plan/advice	8	24	1	0	15	4	5	0	4	9	19	4	3	96
More grassland	17	8	3	9	5	1	2	1	6	6	9	11	7	85
Non-inversion/reduced tillage	7	2	0	22	3	0	0	6	14	11	6	10	3	84
Appropriate compost application	17	6	0	5	12	0	4	0	9	6	9	11	1	80
Grass buffer strips	6	3	1	29	6	0	0	2	2	13	1	6	8	77
Other buffer strips	4	2	1	17	6	0	0	2	0	19	2	6	10	69
Organic farming	11	4	2	2	5	0	0	2	8	10	9	4	11	68
Hedges	4	1	1	14	1	0	0	2	0	16	0	4	5	48
Better manure storage	2	16	0	0	9	0	0	0	0	2	8	2	5	44
Total sum of unique policy documents*	69	66	22	73	62	14	12	15	56	62	82	55	59	

Green if the number of policy documents that mention a soil management technique to tackle a specific soil challenge is above average (>6); Red if there is no link to this soil management technique in the policy documents for a specific soil challenge (=0). Weight: the number of policy documents per soil management technique summed over all soil challenges. A color scale from dark orange to white is used to illustrate the relative importance of the soil management practice.
(*) The total sum of unique policy documents is the sum of policy documents single-counted over all the soil management practices. Green: many unique policy documents that mention the soil management practices of Table 8 to tackle a specific soil challenge; red: little unique policy documents.

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Based on Table 9, the following observations can be made:

- The total sum of unique policy documents, mentioning soil management practices of Table 8 to address soil challenges is highest for enhance nutrient retention/use efficiency, followed by avoid soil erosion, maintain/increase SOC, avoid N_20/CH_4 emissions and enhance soil biodiversity and avoid soil contamination.
- Only few policy documents mention the practices of Table 8 to address salinization and acidification
- Avoid soil sealing shows links with tillage practices, which is not reasonable. Most probably the soil challenge is not well understood, due to confusion with soil structure.

Annex IV, contains the extended list of soil management techniques, presenting the key soil management techniques listed per soil challenge and the sum of policy documents for the different soil challenges.

2.4.2 Soil management – a stakeholder perspective

In the country reports, the stakeholders prioritized soil management techniques that are most relevant to address individual soil challenges. The results summed over all soil challenges are summarized in Table 10. The key soil-related management techniques can be grouped within four land management categories:

- Organic matter/nutrient management with a focus on **reduced or more precise mineral fertiliser application, fertilisation advice, manure and compost application and incorporation of crop residue;**
- Crops/rotations with a focus on **cover crops and more grassland;**
- Tillage and traffic with a focus on **reduced to no tillage and controlled traffic farming;**
- Agricultural systems with a focus on **agro-ecological farming, conservation agriculture. organic farming and precision agriculture.**

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Table 10: Overview of the 50% most mentioned soil related management practices listed by stakeholders of the participating countries. The number of hits represents the relative share attributed by stakeholders that refer to this soil management technique summed over all countries/regions. The share is the relative share (in %) of the total sum of attributed shares of the stakeholders (n=19600). The ranked cumulative share allows to identify the key soil related management techniques that represent a relative share of 50%. This method is used to identify a shortlist of the most important soil management techniques.

Soil related management techniques	Number of hits	Share (%)	Cumulative. share (%)
Cover/catch crops (CR)	1007	5.1	5.1
Fertilisation plan/ advice (OM)	982	5.0	10.1
Reduced more precise mineral fertiliser application (OM)	955	4.9	15.0
More grassland (CR)	934	4.8	19.8
Appropriate farmyard manure (OM)	757	3.9	23.7
No till (TT)	654	3.3	27.0
Agro-ecological farming (AS)	635	3.2	30.2
Appropriate compost application (OM)	611	3.1	33.3
Non-inversion/reduced tillage (TT)	600	3.1	36.4
Conservation agriculture (AS)	588	3.0	39.4
Organic farming (AS)	581	3.0	42.4
Precision agriculture (AS)	539	2.8	45.1
Controlled traffic farming (TT)	536	2.7	47.9
Incorporation of crop residue (OM)	520	2.7	50.5

(OM= organic matter/nutrient management; CR= crop/rotations; AS= agricultural systems; TT= tillage and traffic; WM= water management)

The land management category with the largest impact across all soil challenges is organic matter/nutrient management, followed by crop/rotations and agricultural systems. A hierarchy chart is used to visualize the relative share of the specific soil-related management techniques within these categories (Figure 22).

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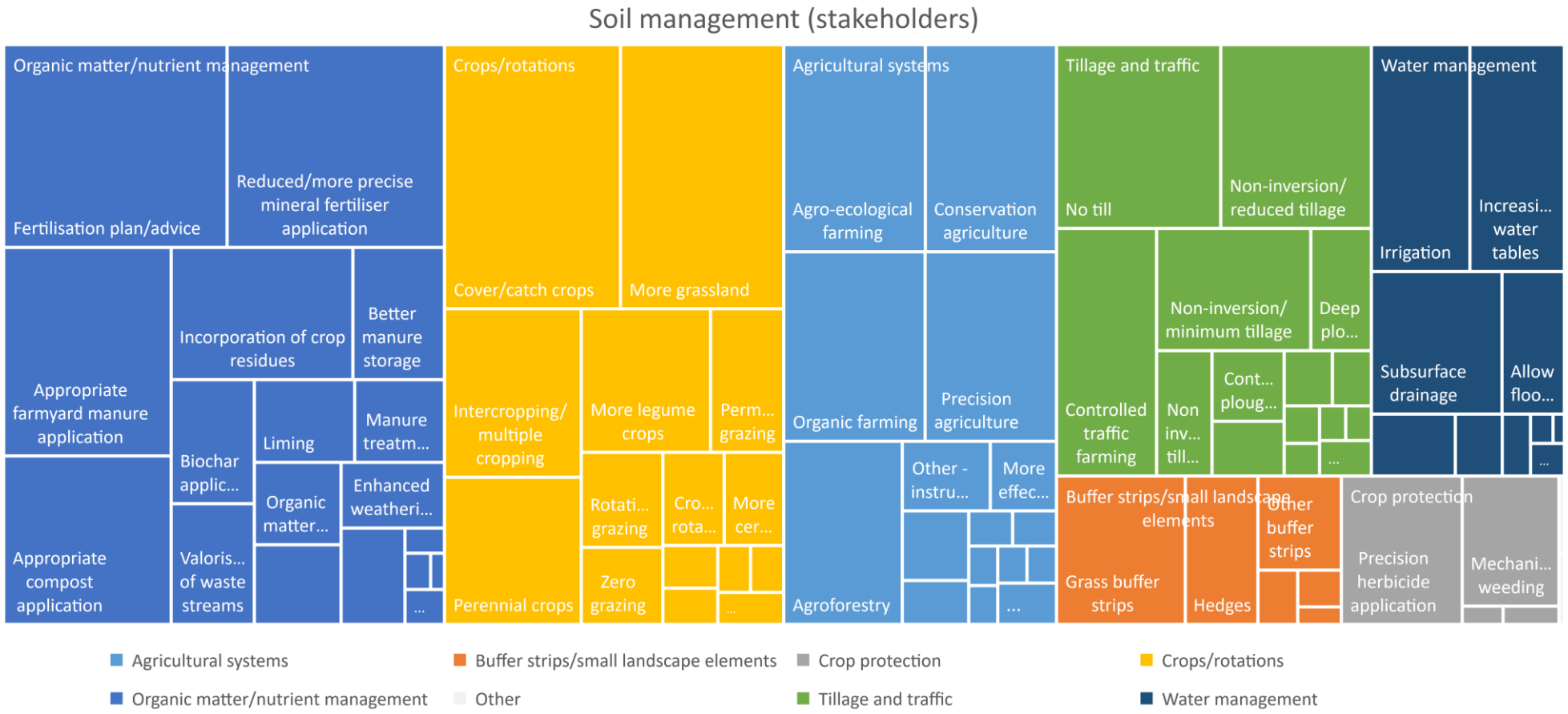

Figure 22: Share of land management categories and soil related management techniques belonging to these categories as prioritized by the stakeholders. Average share across all soil challenges and countries.

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Annex IV, contains the extended list of soil management techniques. This table shows the key soil management techniques listed per soil challenge and the summed stakeholder shares for the different soil challenges.

2.4.3 Soil management – stakeholders and policy comparison

In a comparison between the inputs from the policy perspective (2.4.1) and the stakeholder perspective (2.4.2) on soil management practices to address the several soil challenges, the following observations can be made (Table 11):

- Better manure storage, buffer strips and hedges are highly ranked in policy documents, but less highly ranked by stakeholders.
- Conservation agriculture, agro-ecological farming, precision agriculture, incorporation of crop residues and controlled traffic farming are soil management techniques listed by the stakeholders but not in policy.

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Table 11: Comparison of soil management techniques from a stakeholders and policy perspective. The comparison is focused on the highest ranked management techniques (as listed in Table 8 and Table 10) .

Land management category	Soil management technique	Policy	Stakeholders
Agricultural systems	Organic farming	X	X
Agricultural systems	Agro-ecological farming		X
Agricultural systems	Conservation agriculture		X
Agricultural systems	Precision agriculture		X
Buffer strips/small landscape elements	Grass buffer strips	X	
Buffer strips/small landscape elements	Other buffer strips	X	
Buffer strips/small landscape elements	Hedges	X	
Crops/rotations	Cover/catch crops	X	X
Crops/rotations	More grassland	X	X
Organic matter/nutrient management	Reduced/more precise mineral fertiliser application	X	X
Organic matter/nutrient management	Appropriate farmyard manure application	X	X
Organic matter/nutrient management	Fertilisation plan/advice	X	X
Organic matter/nutrient management	Appropriate compost application	X	X
Organic matter/nutrient management	Better manure storage	X	
Organic matter/nutrient management	Incorporation of crop residues		X
Tillage and traffic	Non-inversion/reduced tillage	X	X
Tillage and traffic	No till		X
Tillage and traffic	Controlled traffic farming		X

* Black: included in the 50% cumulative share by both stakeholders and policy; Orange: included by stakeholders but not by policy; Red: included by policy, but not by the stakeholders.

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The extended list of soil management techniques can be consulted in Annex IV. When consulting Annex IV, we can detect some agreement between the stakeholders and policy perspective, but there are also some differences. The following differences can be observed:

- Mechanical weeding, permanent grazing, liming, increasing organic inputs to reduce soil mining of key plant nutrients, valorization of waste streams, controlled traffic farming and irrigation are soil management techniques listed by the stakeholders, while less often mentioned in policy documents.
- While on the other hand: agroforestry, hedges, other buffer strips, group of trees, increasing SOM, decision support system for risk of soil compaction, low pressure in tires, wetland cultivation and other management techniques are listed in policy documents, but not often mentioned by the stakeholders.

2.5 Knowledge needs

In the evaluation of policy related to agricultural soils, many knowledge needs arose from the reports of the participating countries. In Table 12, an overview is provided of the common needs for the 4 main land management categories, perceived by the stakeholders. In Table 13, specific needs associated with a subset of soil challenges are listed.

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Table 12 Specific knowledge needs for the 4 main land management categories as perceived by the stakeholders

Land management categories	Highlights from this report (section 2.4)	Specific needs emphasized in the country reports (country abbreviations between brackets)
Agricultural systems	The relative share of management practices in the agricultural systems category is 17% for the stakeholders and only 11% in policy (Figure 20). In policy, organic farming is a high ranked soil management technique. From a stakeholders perspective, (future) soil management should, besides organic farming also focus on agro-ecological farming, conservation agriculture and precision farming.	There is a raising public and professional interest in **alternative agricultural systems** (regenerative agriculture, agroforestry, and permaculture), which could be addressed and answered by future research projects (CH). Clear definitions of agricultural systems are needed, but site-specific and farmer-specific variations must be possible (SK). Further, a lack of criteria to define agro-ecological farming is highlighted (FR). Agro-ecological approaches should be combined with **precision agriculture** (UK). Precision agriculture is mentioned by stakeholders, but not by policy document (yet) and could therefore deserve more attention in research (SK). Regarding precision farming, stakeholders in Austria did not agree amongst each other: some think it is part of the solution, others reject this (AU).
Tillage and traffic	The relative share of management practices in the tillage and traffic category: 15% by the stakeholders and (similarly) 13% in policy (Figure 20).	**Controlled traffic farming** is mentioned by stakeholders, but not by policy document (yet) and could therefore deserve more attention in research) (SK). Such improved farming traffic is needed to reduce disturbance and soil compaction, which in turn can have significant negative effects on many soil biological and physical properties (UK).

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	Both in policy and by the stakeholders non-inversion/reduced or minimum tillage is high ranked. In addition, the stakeholders also highly ranked no tillage and controlled traffic farming.	
Organic matter/nutrient management	The relative share of management practices in the organic matter/nutrient management category is high: 28% by the stakeholders and 33% in policy (Figure 20). The focus lies, in both, on reduced/more precise mineral fertiliser application, fertilisation advice, manure and compost application. In the stakeholder view, also the incorporation of crop residue is highly ranked, while policy puts the focus more on better manure storage.	Generally, there is a need for research on methods that **increase soil organic matter** content for different soil types and climatic conditions (TR). Techniques aiming to **reduce mineral fertilisers** (NH_4, P) can be disseminated for farmers such as the use of microbial fertilizers and organo-mineral fertilizer application. Also in France the need to design systems with alternative sources of nutrients is highlighted (FR). There is a need for knowledge on usage of sludge, **bio-residue, biochar-based fertilizers,** (NO), biological fertiliser (TR) and the production of **microbial fertiliser** (TR) and for **good fertilization plans/advice** (UK, SK).

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Crop rotations	The relative share of management practices in the crop rotation category is high: 22% by the stakeholders and 23% in policy (Figure 20). Both by the stakeholders and in policy the emphasis lies on cover/catch crops and more grassland.	There is a need for better understanding of the **impact of new crops** such as legumes, legume cover crops and natural fibres on N_2O emissions (BE-FL). Need for an in-depth review of non-livestock field crop systems with longer, more **diversified rotations**, associated staggered crops and the development of landscape elements (hedges, grassed strips, etc.) (BE-WL). There is a need to improve the mapping of sensitive grasslands, to provide this information to farmers and to adopt support policies for these grasslands. (BE-WL)

Table 13 Specific knowledge needs per soil challenge

Soil challenge	Highlights from this report (section 2.3)*	Specific needs emphasized in the country reports (country abbreviations between brackets)
Maintaining/increasing SOC	Prioritization rank: 1st (16.6%) Total gap (to a realized futureproof policy): 4.1 on a scale from 0 to 7.	Mapping of hotspots of high carbon stocks is needed (BE-FL). Methods needed to measure the effect of cover crops and biochar (NO). More research results needed to establish base lines on SOC measures (IE). The potential of soil to sequester carbon is unknown (PL).
Enhance nutrient retention/use efficiency	Prioritization rank: 2st (11.3%) Total gap (to a realized futureproof policy): 3.6 on a scale from 0 to 7.	What is the role of climate change on P and N leaching? (BE-FL) Having an overview of the nutrient balance is something that needs strengthening and could be included as a requirement in existing policies (NOR).

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Enhancing soil water storage capacity	Prioritization rank: 3th (10.1%) Total gap (to a realized futureproof policy): 4.4 on a scale from 0 to 7.	What is the link with other soil challenges? (BE-FL) How to increase water holding capacity and make soils more drought resistant? What are strategies for water retention in farmland. How can we minimize moisture loss and learn from arid countries (BE-FL)? How to formulate targets and monitor (BE-FL)? There is a need to develop new codes of practices and related research for better water storage (IE). The knowledge about water storage capacity when it comes to the root zone as such is rather incomplete. Therefore, both management decisions and setting of research priorities are made difficult by the lack of detailed knowledge (DK). In the Nemoral environmental zone, there is a particularly high difference in enhance water storage capacity, high in Lithuania and small for Latvia (section 2.3.1.). The high prioritization in Lithuania could be due to the emerging problem of dry conditions during the growing season, in 2016, 2017, 2018 and 2019. Such fluctuations in rainfall and unfavorable plant growth conditions during the most intensive stages of development could have triggered stakeholders to think about solving this emerging problem and highlights the emerging knowledge needs for this soil challenge.
N_2O/CH_4 emissions	Prioritization rank: 4th (9.9%)	What is the effect of the application of sludge, bio-residue, and biochar based fertilisers on N_2O emissions?

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	Total gap (to a realized futureproof policy): 3.9 on a scale from 0 to 7.	How to reduce mineral fertilizer use (BE-WL)? How to better manage storage of farmyard manure (BE-WL)? More accurate and evidence based methods for the N_2O emissions inventory are needed (BE-FL). What is the effect of technical and socio-economic developments on the reduction of fertilizer use (precision agriculture) and livestock (less meat consumption) (BE-WL)? What is the impact of legume cover crops on N_2O emissions and how can the N-supply from these crops be taken into account in fertilization advice? (BE-FL) There is a need to include agronomic measures that reduce N_2O emissions in the climate calculator that calculates the GHG balance at the farm scale (NOR).
Optimal soil structure	Prioritization rank: 5th (9.7%) Total gap (to a realized futureproof policy): 4.2 on a scale from 0 to 7.	How to monitor soil structure and formulate good policy targets. A policy is important in the light of upcoming climate change (BE-FL). Diagnosis and indicators should be provided to prevent soil compaction issues (FR).
Soil erosion	Prioritization rank: 6th (9.3%) Total gap (to a realized futureproof policy): 3.6 on a scale from 0 to 7.	There is insufficient knowledge about soil erosion and more scientific knowledge could lead to better requirements formulated in legislation (IE). How to improve farming practices to reduce soil erosion, including contour farming and contour agroforestry/hedges (BE-FL). How to achieve 100% soil cover to avoid erosion (BE-WL)?

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		What should be targets for soil erosion to reach land degradation neutrality (BE-FL)? What is the impact of wind erosion and how to prevent this (BE-FL)? Also in Poland it is stated that more attention is needed for wind erosion.
Soil biodiversity	Prioritization rank: 8th (7.2%) Total gap (to a realized futureproof policy): 4.1 on a scale from 0 to 7.	We still know very little on soil biodiversity (status, evolution, role) and how to enhance it to a desired level (BE-FL/WL, IE), moreover, should soil biodiversity be stimulated or specific functional groups? These insights are needed to develop proper legislation and targets (BE-FL). There are no good policy instruments at the moment to enhance biodiversity and stakeholders wonder what good policy instruments would be (BE-FL). There is a need for indicators, monitoring means and targets (FR). There is a need for long-term studies on the impact of pesticides (and pesticide cocktails) on biodiversity (BE-WL). Policies should define “biodiversity in soil” and emphasize on how to enhance it (TR).
Peat degradation	Prioritization rank: 9th (6.2%) Total gap (to a realized futureproof policy): 3.5 on a scale from 0 to 7.	There is a need for tools or information to demonstrate progress at the farm level and for baseline data on the SOM content for areas designated as peaty soils (IE). More knowledge on the peatland status is needed and instruments should be developed specifically devoted to organic soils (PL) Peat degradation is an issue in Northern, Central and Western Europe (section 2.3.1), but even there scores are surprisingly low in comparison with the other soil challenges. There is a need for more region specific knowledge to understand this scores.

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Soil contamination	Prioritization rank: 10th (6.1%) Total gap (to a realized futureproof policy): 3.0 on a scale from 0 to 7.	The use of sewage sludge should take into account emerging pollutants such as hormones and nanoparticles (e.g., plastics) (BE-WL). There is a need to study the cocktail effect of pesticides (BE-WL). There should be more attention to diffuse contamination (e.g., pesticides, heavy metals from manures, micro plastics, antibiotics) (BE-FL).
Soil salinization	Prioritization rank: 12th (1.5%) Total gap (to a realized futureproof policy): 2.6 on a scale from 0 to 7.	A monitoring system for soil salinization status should be created, quantified targets for salinity reduction in salt-affects soil should be defined and sit-specific practices to prevent salinization should be identified (PO)

* Prioritization rank: see section 2.3.1 – Figure 14; total gap: see section 2.3.3 Table 6

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2.6 Recommendations

Stakeholders were asked what instruments should be considered to achieve aspirational goals for the different soil challenges (see Step 3 – Table 7 of the questionnaire (Annex II)). Although they already had the chance to rank the most appropriate management options to tackle the soil challenges (see 2.4.2), when asking for instruments they also mentioned sometimes management measures or combinations. These instruments (including those management measures) are grouped into different clusters (Table 14). Per soil challenge the clusters are ranked with as first criteria the number of unique partner countries from which stakeholders suggested instruments and as second criteria the number of measures per cluster. In Annex V a detailed overview of all instruments per cluster is available. This annex also includes the additional category 'Other' to group additional measures or instruments that were not related to specific soil challenges, but to for example water quality.

Several interesting measures or instruments were suggested by the stakeholders. Two important instrument clusters for the soil challenge **maintain/increase SOC** were mentioned: first SOC monitoring, secondly establish a carbon market to reward farmers for their good practices to increase or maintain the SOC content of their soils. Several other instruments were related to practices that could increase SOC according to the stakeholders, such as reduce tillage, increase organic matter (OM) supply, compost/manure/biochar application, use of grassland and crop residue incorporation. To achieve a stronger reduction of **GHG emissions** many stakeholders stressed the importance of an improved manure storage and spreading by providing a better framework (e.g. economic incentives, regulatory instruments) for farmers. Next, also a reduced fertilizer use was an important suggestion, as well as improved crop residue management.
In order to improve **nutrient retention/use efficiency**, several countries suggested instruments to develop (improved) fertilizer plans, apply precision fertilization or improve the crop rotation to reduce nutrient losses. Nutrient management is also an important aspect of several instruments suggested for the soil challenge **contamination**. Indeed, both the management of alternative (organic) fertilizers and 'improve nutrient management' could be defined as important clusters for avoiding contamination. Only a small number of partner countries suggested instruments to avoid contamination by agricultural chemicals/pesticides, which were clustered as 'Improve use of plant protection products'. A reduction of the use of plant protection products and the stimulation of mechanical weed control are also clusters of instruments, suggested by several countries, that aim at stimulating **soil biodiversity**. However, for stimulation of the latter an improved education, stimulated organic fertilizer use/reduced mineral fertilizer use and organic farming may be even more important. Another soil challenge which may be affected by soil nutrient management is **acidification**. A majority of the instruments suggested for this soil challenge could be grouped into a cluster 'stimulate liming'.

For peat soils, stakeholders from several partner countries suggested instruments to 'improve protection' of these **peat soils** in varying ways (e.g. relocation of agricultural production or no more property development . However, not only instruments to protect but also to stimulate alternative management and to restore or rewet peat areas were suggested several times. The stimulation of water management initiatives, such as more pastures that can be flooded or the involvement of water companies to fund new initiatives in mineral soils are instruments that are suggested to enhance **water storage capacity**. Also water management, with focus on research for efficiency, is mentioned to avoid **salinization**, e.g. by development of an alternative to irrigation . Other suggestions to avoid salinization

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are related to the correct use of fertilizers. Via instruments that stimulate an improved land use planning, prohibit/limit land use change of agricultural soils, restrict soil sealing or transform existing soil sealing, stakeholders believe aspirational goals of avoiding **soil sealing** could be achieved.

Many factors impact an **optimal soil structure** and thus also a variety of instrument clusters could be defined for this soil challenge. Technological development of equipment is believed to play an important role in maintaining an optimal soil structure or avoiding soil structure degradation. Other instruments suggested to adapt the crop rotation and increase the SOC content of soils. However, according to several stakeholders there is also a need for improved education, demonstration and supporting tools related to soil structure. Stakeholders from two partner countries also suggested to give more responsibility to external contractors since they sometimes perform a majority of the field work.

Another soil challenge for which a large number of instruments was suggested is 'avoid **soil erosion**'. Most instruments were related to changes in the agricultural management system. Related to this are more specific clusters such as, reduced tillage, improved education, the importance of landscape elements and the increase of the SOC content. A detailed description of these instruments in provided in Annex V.

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Table 14: Overview of the instrument clusters that were defined based on instruments suggested by stakeholders from the partner countries to achieve aspirational goals. Per soil challenge the suggested instruments were grouped into clusters. These cluster were ranked per soil challenge based on 1) the number of unique partner countries from which stakeholders suggested instruments/measures and 2) the number of instruments/measures per cluster. If the rank of several clusters was identical, these clusters assigned a letter (a/b/c) as well to differentiate these clusters. More details can be found in Annex V.

		Soil challenges											
Rank		SOC	Emission	Peat	Erosion	Sealing	Salinization	Acidification	Contamination	Structure	Biodiversity	Nutrient	Water
1		establish SOC monitoring	Improve manure storage/ spreading	Improve Protection	Change agricultural management system	Improve land use planning	Research on efficient water management	Stimulate liming	Management of alternative (organic) fertilizers	Equipment: Technological development	Improve education	Develop fertilizer plans	Stimulate soil water management initiatives
2	a	establish C-market	Reduce fertilizer use	Alternative management	Reduce tillage	Prohibit/limit land use change of agricultural soil	Correct fertilizer use	Avoid ammonium fertilizer	Improve nutrient management	Adapt crop rotation	Stimulate organic fertilizer/ Reduce mineral fertilizer	Apply precision fertilisation	Increase SOC content
	b				Improve education								
3	a	Reduce tillage	Improve crop (residue) management	Rewet/restore peat areas	Adapt Crop rotation	Prohibit/restrict soil sealing		Stimulate organic fertilizers	Improve use of plant protection products	Increase SOC content	Stimulate organic farming	Improve crop rotation	Adapt crop rotation
	b	Increase OM supply			Landscape elements				Management of degraded soil		Reduce use of plant protection products and stimulate mechanical weed control		
	c										Improve crop rotation		
4	a	Compost/manure /biochar application	Improve education	Reduce use of peat	Maximize Soil cover	Transform existing soil sealing				Improve education	Reduce tillage	Increase SOC content	
	b		Reduce livestock								Adapt grassland management	Improve education	
5	a	Improve Education			Adapt tillage					Supporting tools		Stimulate improved organic fertilizer use	
	b	Organic farming/increase OM addition			Increase SOC content								
6	a	Use Grassland								Stimulate organic fertilizers			
	b									Mechanical loosening			
7		Crop residue incorporation								Responsibility for external contractors			
8		Establish concept of C-balance											

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Apart from specific questions on management options or instruments to achieve soil challenge aspirations, five themes of recommendations could be extracted from the country reports (Table 15), i.e. :

- Multi-stakeholder participation in a holistic perspective
- Appropriate policy targets, indicators and monitoring systems
- (Marker-driven) economic incentives
- Knowledge and knowledge sharing
- Innovative and data-driven soil management

Table 15: Five additional themes of recommendations extracted from the country reports

Multi-stakeholder participation in a holistic perspective
The country reports indicate the need to use a **participatory multi-stakeholder** approach, in order to use the knowledge of both the researcher and the farmer community to improve the applicability and effectiveness of practical solutions and to increase the acceptance by the target groups (e.g. practitioners). Most soil instruments involve the active participation of **multiple stakeholders** because synergy among scientists, farmers and policy makers is crucial to achieve targets (UK). Farmers work in a given socio-economic context. Decisions on farming practices are thus affected by many factors and actors. Therefore, the responsibilities of the **entire agro-food chain** (farmer, advisor, retail/processing industry, consumers, policy, research) to support farmers in sustainable soil management should be examined. Awareness raising should thus be targeted to the entire chain as well. In Ireland it is believed that a whole government and whole sector approach is needed, e.g. to tackle N_2O and NH_3 emissions. In Flanders (Belgium), it is suggested to **stimulate chains for beneficial crops** to deal with several soil challenges**.** For soil carbon increase think for instance of deep rooting crops, crops with large root systems and with a large amount of stable C residues, main crops that are early harvested to have well developed cover crop afterwards and multiple cropping. N_20 emissions could be avoided by stimulating crops which require low nutrient input (BE-FL). Also in France it is believed that storing carbon in the soil requires rethinking of the cropping system and that therefore, supply chains need to be supported that will make it possible to absorb new types of agricultural products (quantify targets, finance farmers) (FR). In several countries, stakeholders stressed the **interactions** between management practices and the need for better understanding about these interactions and potential **trade-offs** (NL, AU). A **holistic perspective and systems thinking** is needed (BE-FL, DK). In practice, soil challenges and measures are highly interrelated and also related to wider societal concerns, including protecting water bodies, biodiversity and reducing greenhouse gas emissions. Therefore, it is also important that measures and instruments are not assessed and adopted only in terms of their effect in relation to one particular issue, but that the broader context is taken into account (DK). Some examples provided: • Soil fungi and biodiversity in general are under pressure by traffic and tillage. But when studying minimum tillage also the influence of soil type (sand, clay,silt), of chemical pesticide use and different crops should be taken into account (AU);

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- Practices such as mechanical weed control can help to avoid contamination, but there might be conflicts with biodiversity and other soil targets (AU).

In most countries policies affecting soils and their management are scattered amongst many different laws and regulations (e.g., agricultural, environment, climate, nature, spatial planning) and an **integrated approach or soil policy framework** with holistic vision is missing (NL, BE-FL/WL, FR, UK, DE). This creates complexity and inconsistency. The advantage of country-specific soil frameworks would be that the process would raise awareness of different actors across sectors. In the Netherlands, efforts are currently made to align policy targets and instruments. In the UK, it is suggested to include soils in Environmental Land Management schemes.

At the same time, future policy objectives should also have a **targeted region or farm-specific approach**, rather than general regulation that expose all farmers to the same initiatives independent on the environmental status in their catchment or on their farm (DK, T). In the Netherlands some stakeholders require clear policy goals, while others advocate for the opportunity for famers to set their own goals in consultation with local and regional governmental organizations (enabling customization and focus areas). This is in line with the findings of the project 'LANDMARK', in which they concluded the impossibilities to fulfill all soil functions on one farm. Danish stakeholders find it important that farmers can choose from a menu of measures to meet policy targets, in a way that is suitable for their specific farm situation.

Appropriate policy targets, indicators and monitoring systems

There is a shared need by the participating countries for appropriate policy targets, indicators and monitoring systems. In most countries **systematic soil monitoring** is not existing, although it would support the development of adequate soil policies and evaluation of policy targets. These countries report that policies are often vague and that there is a **lack of clear/quantified soil targets with time horizon** (P, UK, SK, NO, SI, BE-WL, NL, CH, SLK, FR, DE, LV,)**, indicators** (P, FR, UK, NO, NL, CH, VL, TR) and **monitoring** tools (P, SK , NO, CH, LV, FR).

The current status of soil challenges and soil quality is often unknown (P, BE-FL, SK, CH, TR), so it is difficult to assess if targets have been met. To some degree, this can be explained by the **lack of easily accessible soil and soil management information**, i.e., the lack of appropriate indicators, monitoring systems and harmonized databases (CH). The fact that **targets are difficult to control/monitor at the farm level** is a barrier to develop adequate policies.

Soil is complex and difficult to monitor because of the spatial variability. **New monitoring programmes** and parameters can be established (eg. German MonVia monitoring biodiversity, innovative mapping by remote sensing, combining remote sensing with modelling) (DE, UK, BE-FL).

Some countries point out that a **representative soil monitoring system** should be established (P), in several countries such monitoring network is not existing (SK).

Regarding sustainable soil management practices, there is need of **evaluation/monitoring** of their implementation (P), most often results/implementation of measures subsidized in policies are not

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verified. Some stakeholders also point out that the current system focuses too much **on measures and not enough on reaching targets** (CH).

By the UK, it was stated that specific indicators of soil health (i.e. detailed soil chemical, physical and biological properties) should be included and better described in future policies. In 2019 a report has been published that describes the indicators that can be used in policy together with reference targets.

(Market-driven) economic incentives

There is already a lot of knowledge but for the implementation there should be more incentives at the farm level (IE), e.g. incentives for carbon sequestration (NO).

Financial compensation for providing soil ecosystem services or sustainable soil management is often mentioned as important policy instrument, but **accurate and cost-effective monitoring** at farm level is often lacking, which is a major barrier to implement such schemes.

In multiple country reports it is stressed that **financial stimulation/compensation** is crucial for sustainable soil management practices to be adopted (a.o. LV, NL). Sustainable soil management is often hindered by low prices due price setting at international markets and weak market position due to lack of collaboration between farmers and the fact that negative externalities (e.g., emissions to air, water and soil) are not integrated in the price, creating uneven playing field (NL). Because of the uneven playing field extra measures are needed and should be compensated adequately (DK).

Swiss stakeholders stress the importance of **market-driven economic incentives** to drive adoption of sustainable soil management practices. This is proven by the fact that 15% of all Swiss farms produce according to Bio-Suisse guidelines and 20% produce according to IP-Suisse guidelines. Financial support is regarded as important instrument to help farmers to sustainably manage their soils (ao LV, NL). A need for **payments for ecosystem services** (NL, BE-FL) was mentioned by several countries, with special attention for **payments for soil carbon sequestration** (BE-WL/FL, P, IRL, UK, FR). In Wallonia (Belgium), stakeholders were thinking of a carbon balance at farm level, in Portugal compensation for carbon stored in permanent pastures was suggested. In BE-FL it was stressed that that a certification/accounting method is needed that is cost-effective yet accurate. In France it was stressed that there is a lack of means to implement soil carbon accounting methodologies and to finance the implementation of C storage levers by farmers (FR).

The development of **business models** for sustainable management practices is considered as crucial in the development towards sustainable managed soils (NL). If it would be proven that practices increase yield, that would foster implementation (NL).

Other financial policy instruments to foster sustainable management practices include revisions of margins in supply chain (NL), performance related subsidies (NL, NO), fund for financial risks (NL), certification schemes (NL), developing business models (BE-FL). In Switzerland stakeholders think that there should be more direct payments for environmentally friendly practices (e.g. soil conservation management, no-till, “direktsaat”, compost application, or similar practices), and suggest to support effects instead of measures. Additionally, the stakeholders highlight the importance to facilitate dissemination of environmentally friendly practices (CH).

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Knowledge and knowledge sharing

Raising awareness, **access to knowledge** and **knowledge sharing** is important for adoption of sustainable management practices (NL, P, TR, FR). How can knowledge transfer be organized between science – policy – advisors – farmers. In this sense, **demonstration farms** and **peer-to-peer learning** in learning networks is regarded important to increase adoption (NL, P, AU). Technical-economic references of systems with sustainable soil management should be established to demonstrate that it is possible (or not) 1) to produce in an agro-ecological way and 2) to make a satisfactory income from it (FR).

Advisors play a crucial role (NL, AU, P). In the Netherlands it is suggested that farmers get vouchers to get advice on sustainable soil management. Moreover, all kinds of advisors that are in contact with the farmers should get training (e.g. salesman, contract workers) (NL). In BE-WL it was suggested that support services to farmers, more specifically for erosion, should be re-enforced.

In Poland there is a particular need to raise awareness on low N_2O emission practices.

In Ireland, it is stated that farmers should use results of soil testing more, for instance before liming. Now, farmers do have analysis results but these results and advices are underutilized (IRL).

In France there is a need for advice, transfer of knowledge and valorization in order to reach the target in reducing the use of plant protection products and glyphosate.

In Wallonia (Belgium), there is a need for better training and sensibilisation of farmers on soil structure. Likewise the awareness of the importance of a good soil structure must be increased in Norway.

In Ireland, the rewetting programme needs to be extended beyond a demonstration level and the knowledge needs to be available at a technical level (IE).

Innovative and data driven soil management

Data driven soil management and the use of decision support tools should be enhanced, as well as transparency and use of big data. It should be investigated how multiple data sources such as soil scans, tractor, UAV and satellite remote sensing data and weather data can be combined to better detect problems with soil quality so that targeted solutions could be implemented to improve soils and crop yield potential (BE-FL).

Innovative approaches, including the use of remote sensing and/or automated data sharing, should be considered to facilitate soil monitoring (UK, BE-FL).

In Turkey, GIS based and parcel level soil and land cover maps or inventories should be completed.

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2.7 Conclusions

The results of this part build on a policy scan performed by the EJP SOIL partner countries and a stakeholder consultation. The overall result is an inventory of the current policy target, the policy realizations and aspirational goals for the diverse soil challenges. The focus of the conclusions lies on the combined results of the countries and on results that are shared between the countries (Figure 23). We invite all readers to scan the full report for more detailed and region-specific or soil challenge specific outcomes. However, as mentioned, due to the variation in stakeholder and country representations in the regional clusters and environmental zones, comparisons between regions and environmental zones should be interpreted with great care.

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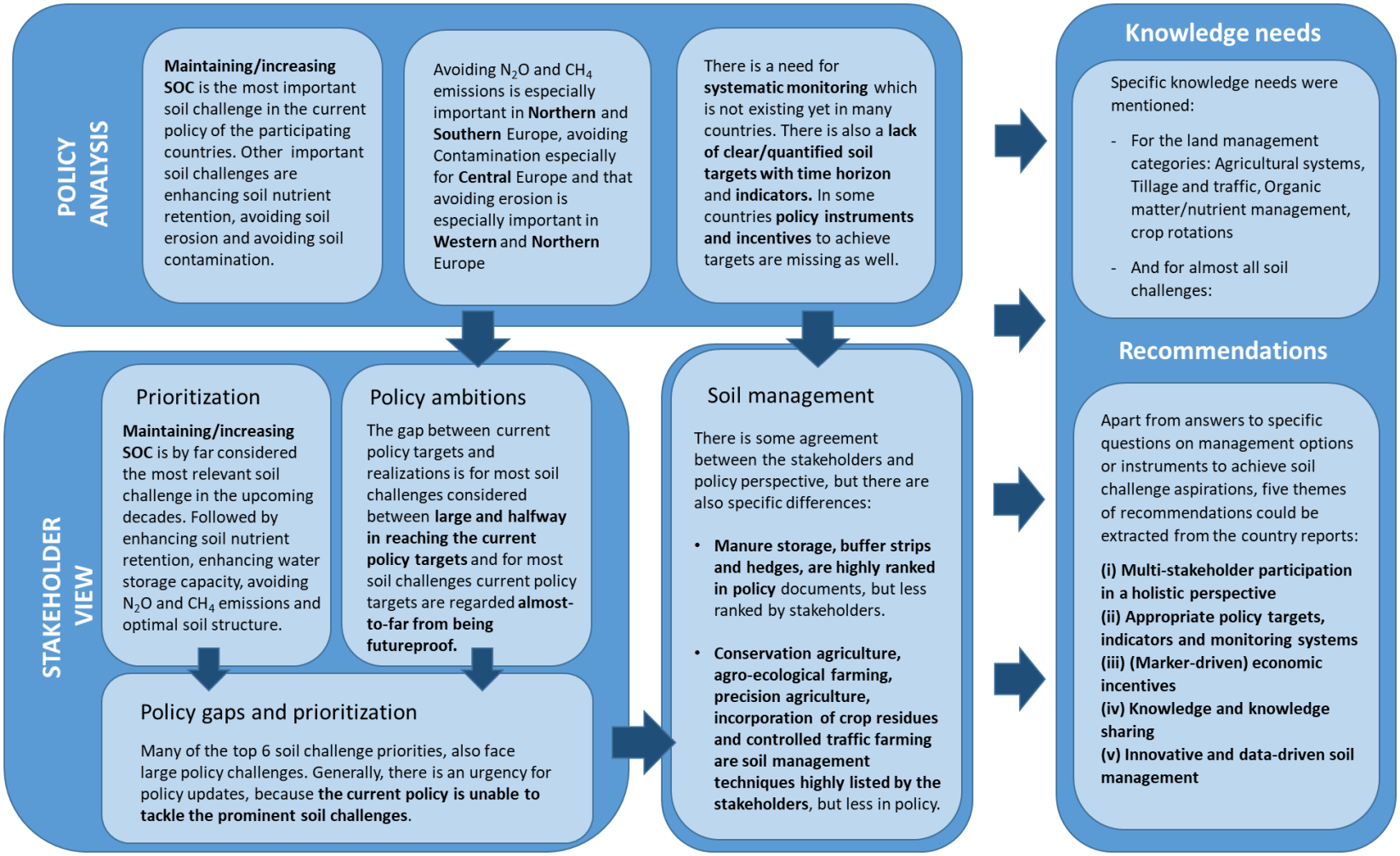

Figure 23: Key outcomes and linkages on current policy ambitions and future soil aspirational goals at country level.

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(i) Policy analysis

The analysis demonstrates that large differences exist between the number of policy targets per soil challenge. In general **the soil challenge 'Maintain/increase SOC' can be considered as the most important soil challenge** in the policy of the participating countries. This soil challenge not only has the largest share of quantitative and qualitative targets, but also has a large share of the targets for which an indicator and monitoring is in progress or exists. Other very **important soil challenges are 'Enhance nutrient retention/use efficiency', 'Avoid soil erosion' and 'Avoid soil contamination'**. These soil challenges also comprise the largest share of soil- and agricultural soil specific targets. The soil challenges SOC, Contamination and Erosion also represent the largest share of the targets for which an indicator and/or a monitoring tool exists/is available.

It is, however, important to take into account that the partner countries had different relative contributions to the total number of policy targets for each of the soil challenges (Figure 12) and that **specific soil challenges may have been of higher interest for some partner countries**. The investigation of the relation between the soil challenges and four country cluster regions revealed slightly different policy emphasis between the country clusters (Figure 13). In general, the soil challenges SOC and Nutrient were of major importance for each of the country cluster regions. **For Southern and especially Northern Europe the soil challenge Emission was important while in Central Europe Contamination was of major importance. In Northern, but especially in Western Europe a lot of attention was paid to targets related to the soil challenge Erosion.**

Despite a large number of policy targets could be identified by the partner countries, there is still a shared need by the partner countries for appropriate policy targets, indicators and monitoring systems. Indeed, although several indicators and monitoring tools could be identified in this analysis (Figure 9) a result-based monitoring network or a **systematic soil monitoring** is not existing in most partner countries. However, it would support the development of adequate soil policies and evaluation of policy targets. Many partner countries report that policies are often vague and that there is a **lack of clear/quantified soil targets with time horizon** (P, UK, SK, NO, SI, BE-WL, NL, CH, SLK, FR, DE, LV)**, indicators** (P, FR, UK, NO, NL, CH, VL, TR) and **monitoring** tools (P, SK , NO, CH, LV, F). Furthermore, in some countries it was reported that **policy instruments/incentives** to reach targets are missing (Latvia, NO). In contrast, in Denmark it is stated that measures and instruments are available but that **policy ambition is lacking** or is low (BE-WL).

(ii) Prioritization

The policy prioritization clearly marks that maintaining/increasing SOC is by far the most relevant soil challenge in the upcoming decades, while avoiding acidification (4%) and salinization (1.5%) are low ranked priorities. SOC is important in all regional zones, but most important in Southern Europe. There is a contrast between Northern Europe and the other zones, in the sense that enhancing soil nutrient retention/use efficiency, optimal soil structure and avoiding N2O and CH4 emissions are most important in Northern Europe, and that soil erosion and enhancing soil biodiversity is a smaller issue in the North compared to the other zones.

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(iii) Policy ambitions

Generally, when averaging all countries, the gap between current policy targets and realizations is for most soil challenges considered between large and halfway in reaching the current policy targets and for most soil challenges current policy targets are regarded almost- to- far from being futureproof. That means that, according to the stakeholders, for all soil challenges there is still a way to go before aspirational goals will be met. The soil challenges that are considered to have the largest gap between realizations and current policy targets are in descending order of magnitude: avoiding soil sealing, enhancing water storage capacity, avoiding N_2O and CH_4 emissions, enhancing soil biodiversity, optimal soil structure and maintaining/increasing SOC. In most countries the policy targets are considered halfway or far from reached, while the current targets are mostly evaluated far from futureproof.

Many of the top 6 soil challenge priorities, also face large policy challenges**.** The total policy gap is not even considered halfway in reaching a fully realised and futureproof policy. Soil nutrient retention/use efficiency and soil erosion, are regarded closest as they are halfway in reaching the total policy gap. Similarly, at the level of the regional zones, high priority soil challenges seem unable to realize the current targets and seem to lack futureproof policy targets. There is, however, no one-to-one match between prioritization of soil challenges and policy evaluation. Generally, there is an urgency for policy updates, because the current policy is unable to tackle the prominent soil challenges.

(v) Soil management

In general, the most prominent difference between policy and stakeholders ranking of soil management categories, is on the use of buffer strips/small landscape elements to tackle the soil challenges. Buffer strips are ranked 14% in policy, while only ranked 5% by the stakeholders. There is some agreement between the stakeholders and policy documents for soil management, but there are also specific differences. On the one hand manure storage, buffer strips and hedges, are highly ranked in policy documents, but less ranked by stakeholders. While, on the other hand, conservation agriculture, agro-ecological farming, precision agriculture, incorporation of crop residues and controlled traffic farming are soil management techniques highly listed by the stakeholders, but less in policy. We hypothesize that for the latter techniques there is either insufficient knowledge on the effects to already include the measure in policy or there are other obstacles that hinder the uptake in policy, for instance clear definitions.

(vi) Knowledge needs

Specific knowledge needs were emphasized in the country reports for almost all soil challenges and for the following land management categories: agricultural systems, tillage and traffic, organic matter/nutrient management and crop rotations.

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(vii) Recommendations

Apart from specific questions on management options or instruments to achieve soil challenge aspirations, five themes of recommendations could be extracted from the country reports:

- *Multi-stakeholder participation in a holistic perspective*, which includes (a.o.) the following key words: participation, multi-stakeholder, holistic, systems thinking, integrated, agro-food chain, trade-offs, farm-specific.
- *Appropriate policy targets, indicators and monitoring systems*, which includes (a.o.) the following key words: systematic monitoring, clear/quantified targets, time horizon, indicators, soil management information, new monitoring programs, soil monitoring system, evaluation, reaching targets.
- *(Marker-driven) economic incentives*, which includes (a.o.) the following key words: accurate and cost-effective, financial stimulation, compensation, market-driven, payments for ecosystem services, payments for soil carbon sequestration, business models.
- *Knowledge and knowledge sharing*, which includes (a.o.) the following key words: access to knowledge, knowledge sharing, demonstration farms, peer-to-peer learning, advisors.
- *Innovative and data-driven soil management*, which includes (a.o.) the following key words: Data driven soil management, innovative approaches.

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3. Current policy ambitions and future soil aspirational goals at the EU level

3.1 Approach

The national policy analyses of Chapter 2 are based on a screening of national policy documents. At the EU level, already a number of projects/reports exist that screened EU policies on (agricultural) soils. Therefore, at this level, we have built on the existing knowledge by screening published policy analysis reports (Annex VI). These reports are supplemented with recent documents on the new CAP, green deal, farm to fork strategy and biodiversity strategy.

The policies considered are situated in the fields of agriculture, food, water, climate, nature, energy and waste. From the published policy analyses the following elements are extracted:

- Policy targets on soil challenges, ecosystem services and functions
- Indicators used to follow the status of policy targets
- Monitoring tools
- Recommended soil management practices
- Research gaps and needs
- Recommendations, barriers and opportunities for knowledge development

Because the analysis is not based on the original policy documents, the output does not aim to be exhaustive. Yet, we are confident that the report highlights the most relevant policy issues.

In parallel with the stakeholder view on the national policy, the EU stakeholders have also been consulted. For the EU consultation an EU policy forum has been organized on 28 January 2021 with the ambition to identify and discuss what should be the EU policy prioritization and ambitions according to the stakeholders.

Twenty-five key EU stakeholders participated in the EU policy forum, of which 9 from different directorates of the European Commission (Table 16).

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Table 16: List of organizations participating in the UE policy forum on 28 January 2021

List of participating organizations	Number of Participants
European Commission (DG Agriculture and rural development, DG CLIMA, DG ENV, SOIL, ERA NET, REA)	9
Global Soil Partnership (GSP), Food and Agriculture Organization of the United Nations (FAO)	2
European council of young farmers (CEJA)	1
COPA-COGECA	2
Ecologic Institute	2
European Environment Agency (EEA)	1
European Landowners' Organization (ELO)	1
Institute of Soil Science and Plant Cultivation (IUNG)	1
4 per 1000 initiative	1
Permanent Representation of the Netherlands to the European Union	1
RISE Foundation	1
Milieu*	1
United Nations Convention to Combat Desertification (UNCCD)	2
Total	25

*MILIEU LTD, a consultancy focusing on environmental law and policy

3.2 Policy analysis

In the policy analysis, the current EU policy ambitions and targets were scanned for the different soil challenges. The soil targets were analyzed based on their characteristics: soil challenge, target type (qualitative/quantitative), indicator status, monitoring status and their specificity for (agricultural) soils.

3.2.1 General overview of EU policy targets

In total, 41 policy reports (listed in Annex VII) were screened to identify if they contain targets on soil challenges, ecosystem services and functions. Some of the policy reports covered multiple policies or parts of policies. Policy targets that address several soil challenges were considered as separate entries in the database. This resulted in a total of 129 unique combinations of policy documents (or sub-documents), targets and soil challenges.

The repartition of policy targets over the soil challenges is summed and shown in Figure 24, this gives a proxy of the relative prominence of the soil challenge in EU policy. The soil challenges *Avoid contamination* and *Maintain/ increase SOC* are addressed by the largest number of policy targets (26 and 22 hits respectively). The soil challenges *Enhance water storage capacity* and *Avoid salinization* are explicitly addressed by only one policy target. Other environmental stakes beyond the predefined list of soil challenges found in the policy targets included ‘protection of water resources’ and ‘agricultural landscape quality’.

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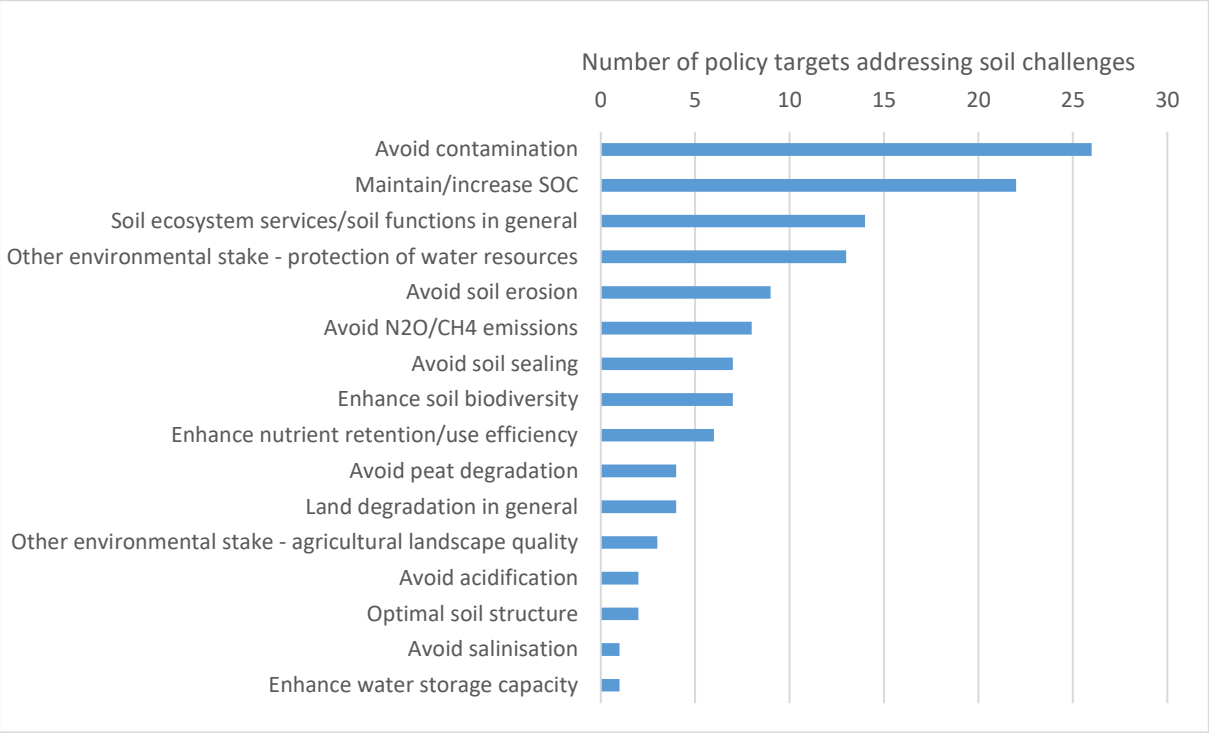

Figure 24: Policy targets addressing soil challenges.

About half of the targets (51%) found were not specifically referring to soils (unspecific for soils), but instead to other policy fields, economic sectors or covering more environmental domains than soils only (Figure 25). For example, the overall objectives of the Sustainable Use of Pesticides Directive are to reduce harmful impacts from pesticide use on human health and on the environment, in particular the aquatic environment and drinking water. Other targets refer to soils but cover more land uses than agriculture alone (soil specific; 20%). Only around one third of the targets (31 counts; 29%) referred specifically to agricultural soils.

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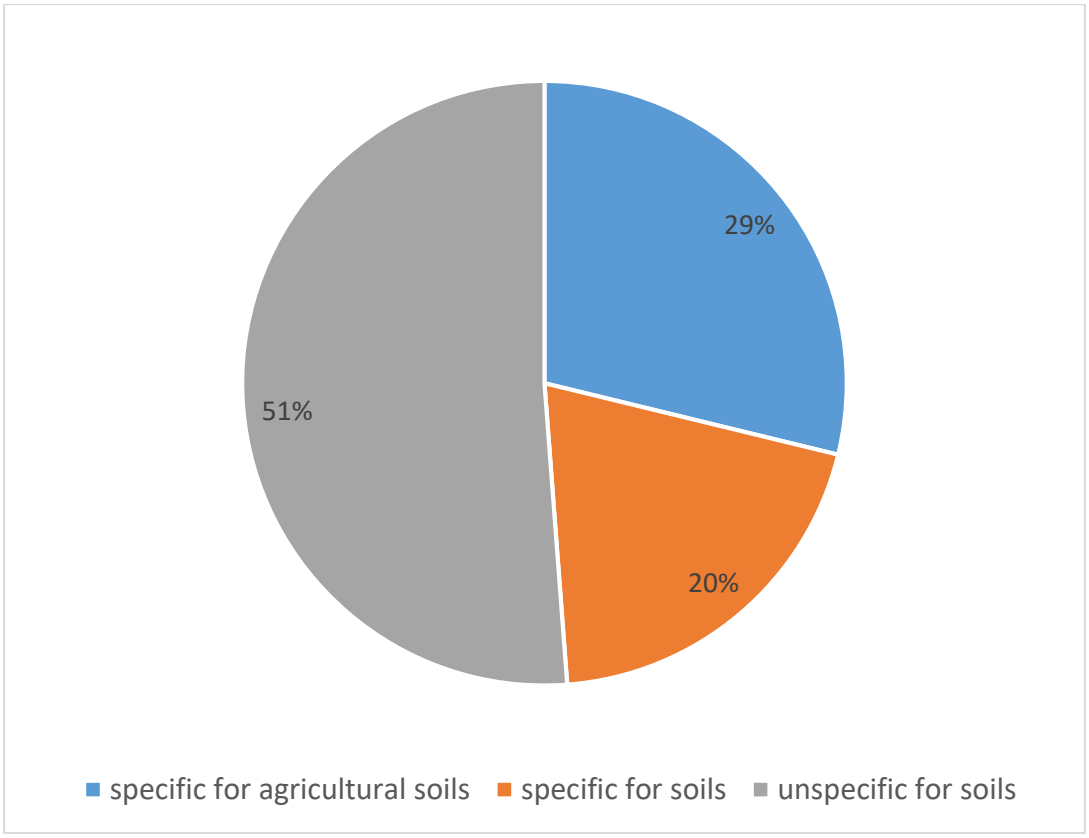

Figure 25: References to soils in targets of policy documents (based on 156 entries).

In addition, the policy targets were screened and subdivided into quantitative and qualitative targets. A detailed overview can be consulted in Annex VIII. The major number of policy targets (89 out of 129) found are not expressed in quantitative terms, Most quantitative targets are formulated for instruments addressing the soil challenge *Maintain increase SOC* (Figure 26). These are formulated in, a.o. the Horizon Europe mission area on soil health and food (HMSHF) and LULUCF (details for all soil challenges can be consulted in Annex VIII).

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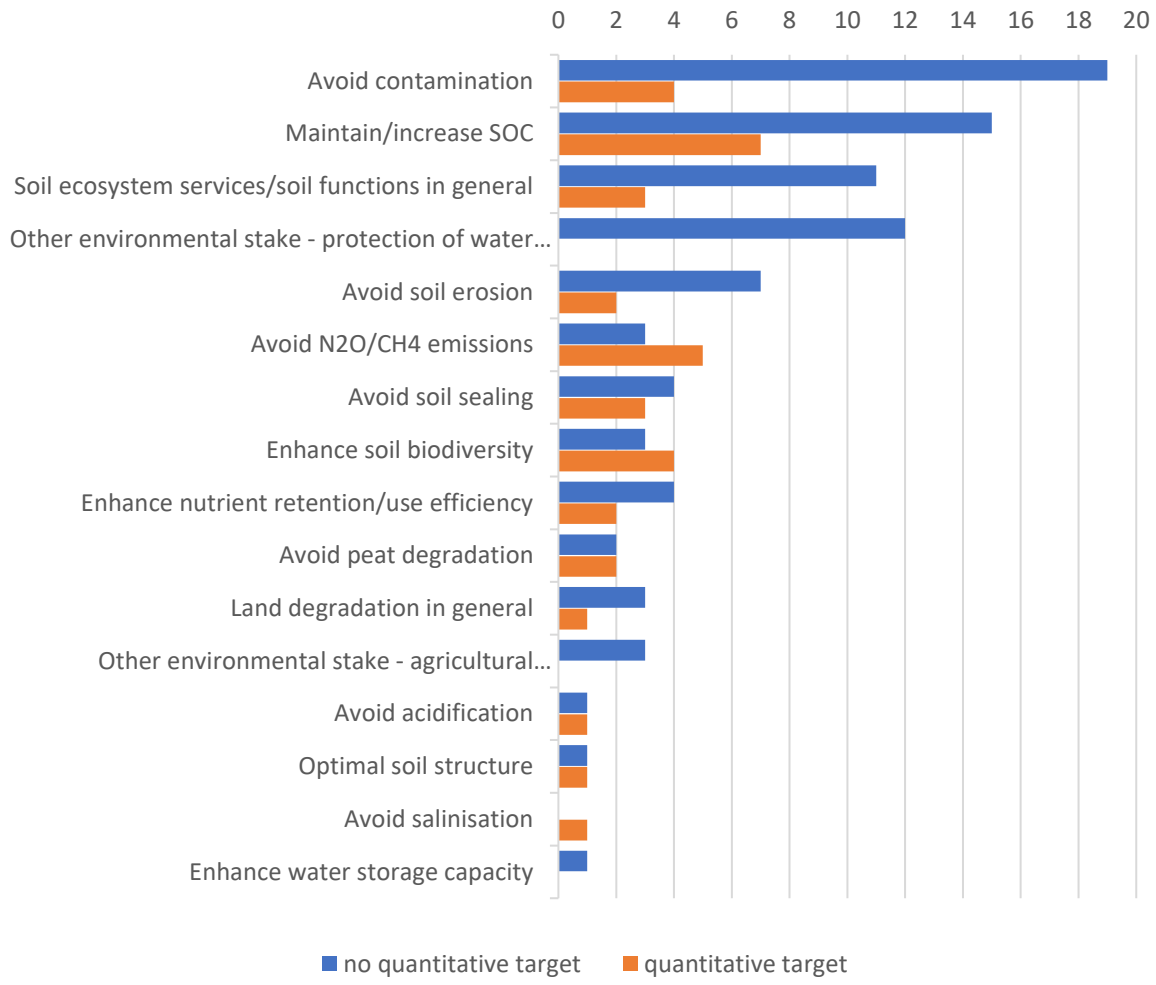

Figure 26: Number of targets per soil challenge, subdivided between quantitative and qualitative targets (based on 156 entries).

3.2.2 General overview of EU policy indicators

In total, in 58 cases (out of 129), policy documents mention indicators to monitor targets. The indicators can be categorized in three types of indicators (Table 17).

(i) Indicators expressing the condition of soil, water bodies or protected areas.
(ii) Indicators listing the use or management of land and water
(iii) Indicators defining quality and safety criteria for agricultural inputs

Most cases have indicators on category II (n: 31), followed by indicators on category I (n: 25). There are only little cases in category III (n: 3). Note that one indicator is double counted both in category I and II (i.e. SMR1 Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Objectives are to reduce water

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pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution).

Table 17: Indicators for monitoring policy targets.

Category	Examples given with [policy document]	Number identified
(I) Indicators expressing the condition of soil, water bodies or protected areas or of the pressure on these (i.e. the presence or contents of substances in soil, water or air deriving from human activities, or thresholds for these)	*- Nutrient and pesticide loads on agricultural soils, soil pollution from industry, and abstraction of water for irrigation or industrial purposes, status of water bodies [Water Framework Directive]* *- Nitrate content of surface and groundwater [SMR 1 under CAP Pillar 1]* *- Defined limit values for cadmium, copper, nickel, lead, zinc, mercury and chromium of soil at a pH 6 to 7 [Sewage Sludge Directive]*	25
(ii) Indicators of the use or management of land and water (i.e. indicators of progress or performance)	- Timing, conditions or procedures of land management activities, e.g. the use of crop rotation systems and the proportion of the land area devoted to permanent crops relative to annual tillage crops [items in the codes for Good Agricultural Practice in the Action Programs of the Member States under the SMR 1] - Percentage of agricultural land under management contracts to improve soil management and/or prevent soil erosion [R.10, focus area 4C, GAEC 5 under CAP Pillar 1] - Result indicators for Specific objectives in the new performance, monitoring and evaluation framework [PMEF, New CAP]	31
(iii) Quality and safety criteria for agricultural inputs (i.e. fertiliser, plant protection products, sludge and source materials)	- Quality criteria for fertilisers and source materials, including regulations for contaminants, organic matter and EC (minimum levels in compost) [Fertiliser Regulation]	3

Current status of EU policy indicators

The current status of several indicators could not structurally be identified from the policy reports. Some reported the current status of the phenomena addressed in the policy targets or in the soil

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challenge(s) to which the policy document(s) referred. Reflections of these in the most recent reviews and policy documents are collated in Table 18.

For a comprehensive overview of the current status of the soil challenges addressed in the policy documents we refer to the reviews by European Environment Agency (2019) and Keestra et al. (2020) and to the interim report of the Mission in the area of Soil health and food (2020). The overall impression derived from these reports and the quotes in Table 18 is that soils are in unhealthy conditions in large tracts of land in the EU.

Table 18: Reflections of current status of soil challenges.

Soil challenge	Description of current status	Reference
Avoid acidification	*'There are 2.93 million km^2 (69%) of European land where critical loads are exceeded for acidification and 2.65 million km^2 (62%) of semi-natural ecosystems are subjected to nutrient nitrogen deposition leading to eutrophication in 2017 (CIAM IIASA 2018).'*	Mission Board for Soil health and food (2020)
Avoid contamination	*'In terms of local soil pollution, JRC (Paya Perezet al. 2018) reported 2.8 million potentially contaminated sites in EEA-39 but the area of land is not known;* *Of LUCAS soils tested, 83% of soils contained one or more residue of pesticides and 58% contained mixtures (Silva et al. 2019);* *De Vries et al. (In prep) and cited in EEA (2020) state 21% of agricultural soils have cadmium concentrations in the topsoils which exceed groundwater limits used for drinking waters;* *Plastics Europe (2016) reported that 3.3% of total EU plastic demand (49 million tonnes) was used in agriculture. Agriculture produced 5% of plastic waste of EU (EC, 2018).'*	Mission Board for Soil health and food (2020)
Avoid N2O/CH4 emissions	*'In 2017, N2O emissions from agriculture accounted for 43% of agriculture emissions and 3.9% of total anthropogenic emissions in the EU (EEA (2019). Annual European Union greenhouse gas inventory 1990-2017 and Inventory report 2019);* *Agriculture is responsible for 10.3% of the EU's GHG emissions and nearly 70% of those come from the animal sector (EEA (2019). Annual European Union greenhouse gas inventory 1990-2017 and Inventory report 2019;*	European Commission (2020a)

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	(These figures do not include CO_2 emissions from land use and land use change.)'	
Avoid peat degradation	*'Peats cover 8% of EU land area, of which 50% of peatlands are estimated to be drained which will result in the oxidising of the peat and loss carbon to the atmosphere (JRC 2016);* *Results from hydrological reconstructions indicated 60% of peatlands are drier than they were 1000 years ago due to these direct human impacts and climatic drying (Swindleset al. 2019).'*	Mission Board for Soil health and food (2020)
Avoid salinization	*'The extent of salinization in EU is still uncertain. Ranges estimate 1 to 4 million hectares (enlarged EU), mainly in the Mediterranean and Central European countries (JRC 2008);* *In 2016, 10.2 million hectares was actually irrigated (5.9 % of EU), 25% of this area is at risk of secondary salinization i.e. 1.5% of EU...(JRC 2016).'*	Mission Board for Soil health and food (2020)
Avoid soil erosion	*'... contracts to prevent soil erosion and to improve soil management on 9 % of Utilised Agricultural Areas (COM(2018) 790 final, report on implementation of the CMEF)'* *'A new report by JRC (Panagos et al. 2020) shows erosion by water on arable land is 10% greater than the mean for the EU (this means that we can consider all 23% of cropland as affected);* *Permanent crops have highest soil erosion rates. Arable and permanent crops cover 30% of EU land (not including permanent grassland);* *A JRC erosion model (Borelli et al. 2017) shows wind erosion in EU is 0.53 Mg ha−1 y−1. 9.7% of arable land has problems with wind erosion, with 5.3% and 4.4% displaying moderate and high rates of wind erosion, respectively.'*	Prokop and Esteve (2019) Mission Board for Soil health and food (2020)
Avoid soil sealing	*'Artificial areas cover 4.2% of the EU (EUROSTAT 2017) of which about 50% is sealed. This would imply that 2.5% of urban land is exposed to pressures (e.g. low inputs, compaction, pollution);*	Mission Board for Soil health and food (2020)

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	Between 2000 and 2018, 78 % of land take in the EU-28 affected agricultural areas (EEA 2018).'	
Enhance nutrient retention/use efficiency	*'The impact of the use of sewage sludge on agricultural practices ... specifically consists in lower use of mineral fertilisers, particularly with regard to phosphorus needs.'*	McNeill et al. (2018) Elbersen et al. (2019)
Enhance soil biodiversity	*'The EU has legal frameworks, strategies and action plans to protect nature and restore habitats and species. But protection has been incomplete, restoration has been small-scale, and the implementation and enforcement of legislation has been insufficient (Mid-term review of the EU Biodiversity Strategy to 2020 (COM(2015) 478 and SWD(2015) 187); Fitness Check of the EU Nature Legislation (Birds and Habitats Directives) (SWD(2016) 472); Fitness Check of the EU Water Legislation (SWD(2019) 439).'*	European Commission (2020b)
Maintain/increase SOC	*'Agricultural land in the EU contains around 51 billion tonnes of CO2-equivalent in the topsoil as soil organic matter. This is a huge amount compared to the 4.4 billion tonnes of CO2-equivalent emitted annually in EU Member States (2016), all sectors together.* *The 2015 LUCAS survey shows that cropland exhibits much lower soil organic carbon concentrations compared to grasslands and natural vegetation (eg. 17.8, 40.3 and 77.5 g per kg, respectively). Around 75% of all EU croplands are below 2% of organic content.'*	Brief summary of the nine proposed specific objectives of the future CAP, https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/future-cap/key-policy-objectives-future-cap_en
Optimal soil structure	*'23% of land in the EU was estimated at critically high densities by JRC (2016); JRC 2009 estimated that 33% of soils are susceptible to compaction, of which 20% moderately so.'*	Mission Board for Soil health and food (2020)
Land degradation in general	*'From 2000 to 2015, more than one fifth of the Earth's total land area was degraded, largely due to human-induced processes, such as desertification, cropland expansion and urbanization. During the same period, there were significant productivity declines in land cover, with grasslands incurring some of the greatest losses. (SDG Progress Report for 2019)'*	Prokop and Esteve (2019)
Other environmental stake - protection of water resources	*'assessment of tangible results is missing in the absence of measurable targets in most national action plans'*	McNeill et al. (2020)
Soil ecosystem services/soil functions in general	*'A review of the current evidence of the state of EU soils by the Mission Board and JRC is that current management practices result in, approximately, 60-70% of EU soils being unhealthy*	Mission Board for Soil health and food (2020)

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	with a further as yet uncertain percentage unhealthy due to poorly quantified pollution issues.'	

3.2.3 Monitoring tools of EU policy

For 18 (out of 41) policy reports, the use of monitoring tools was identified in the reports analysed. Two broad categories emerged:

- Mechanisms for monitoring and review of policy implementation that Member States are required to apply;
- Data networks, monitoring facilities and data spaces at the European level, that are operated by institutions under the EU or beyond.

An example of the first group that is currently designed is the new performance, monitoring and evaluation framework (PMEF) under the new CAP. This will be used to assess the progress of EU countries in reaching the CAP objectives. The PMEF will cover all instruments of the future CAP, using a common set of result indicators. Another example is the Data Platform to monitor the progress of National Plans to Achieve to implement the Renewable Energy Directive. This group of monitoring tools also covers tools used by policy frameworks at the international level, such as the annual Sustainable Development Goals Report and the SDG Voluntary National Reviews (VNRs), and the United Nations Greenhouse Gas Inventory Data that are detailed by partner countries.

Examples in the second group of monitoring tools include the regular data surveys of imperviousness change (referring to the soil challenge *Avoid soil sealing*) by the Copernicus Land Monitoring Service, the Biodiversity Information System Europe and the Land Use and Coverage Area frame Survey (referring to multiple soil challenges). Also in this category is the new EU Soil Observatory that is proposed for collecting policy relevant data and developing indicators for the regular assessment and progress towards the ambitious targets of the Green Deal (Montanarella and Panagos. 2021).

Monitoring tools of the first category were identified in 11 out of 41 policy reports, and of the second category in 6 reports. Both categories were identified for the Farm to fork Strategy, that will develop a Farm Sustainability Data Network and a common European agriculture data space. For the remaining policy reports, monitoring tools could not be identified. This would need to be verified based on the original policy documentation.

3.2.4 Comparison between the EU level and national levels

In both EU and national policy documents (chapter 2.2) the soil challenges 'Maintain/increase SOC' and 'Avoid contamination' are considered very important soil challenges with the highest share of quantitative and qualitative targets. In contrast, less attention is paid to the soil challenge 'Enhance nutrient retention/use efficiency' in EU policy documents compared to the national policy documents.

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Indeed, in national policy, maintaining/ increasing SOC has the highest policy share, followed by (in reducing order) avoiding contamination, enhancing nutrient retention/use efficiency, enhancing soil biodiversity, avoiding soil erosion, avoiding CH_4 and N_2O emissions, optimal soil structure and soil sealing. While, the remaining soil challenges peat degradation, enhancing water storage capacity, avoiding acidification and salinization have a smaller share.

In EU policy, there is a large difference between avoiding contamination and maintaining/ increasing SOC. Those two soil challenges have the largest share of targets mentioned in policy documents, in contrast to the other soil challenges which have much smaller shares (less than half of the number of policy targets).

3.3 EU stakeholders view

This section reports the results of the EU policy forum held January 28 2021 and includes EU stakeholder views on (i) soil challenge prioritization and (ii) policy realizations and aspirations for soil challenges that were ranked high in the participating country reports (Chapter 2).

3.3.1 Prioritization

To identify the key soil themes at EU level, 25 key stakeholders were asked to prioritize the soil challenges, by attributing a total of 100 points between the various soil challenges, keeping the following question in mind:

"***What do you expect will be the main soil challenges in the upcoming decades in Europe***?"

Based on their inputs, the average prioritization weight of the successive soil challenges for Europe in the upcoming decades have been calculated (Figure 27).

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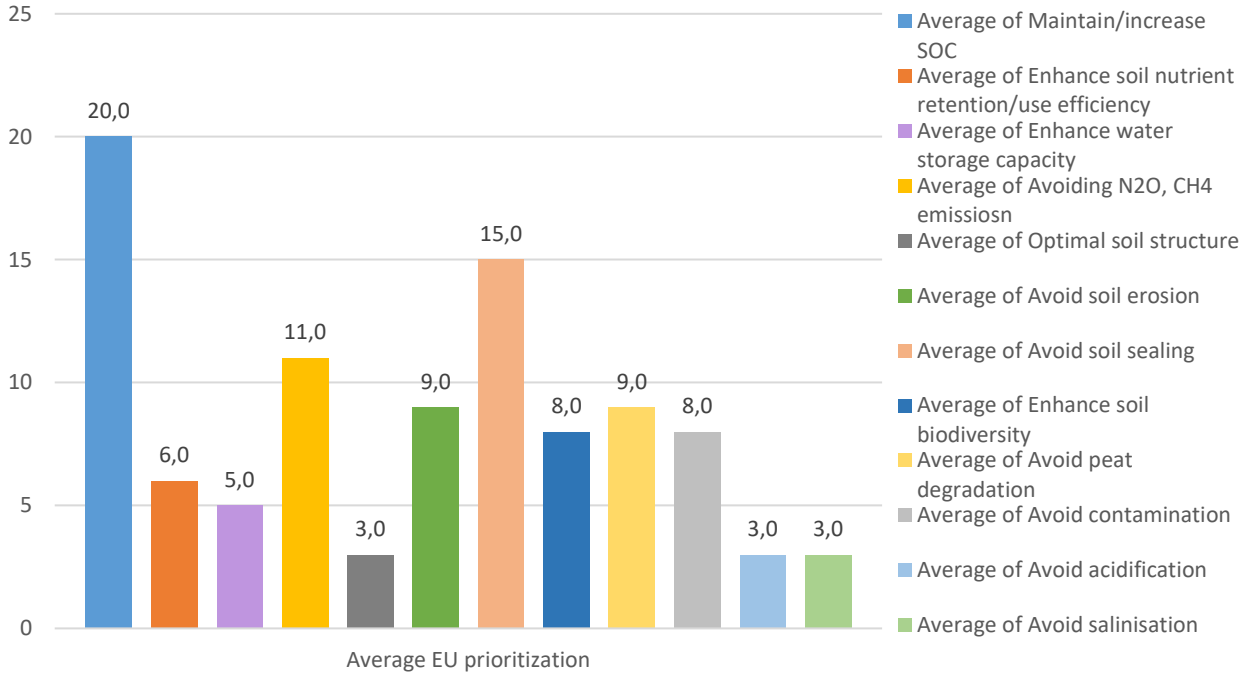

Figure 27: Prioritization of soil challenges by EU stakeholders

Ranked soil challenges in Europe (top 10)

1. Maintain/increase SOC (20%)
2. Avoid soil sealing (15%)
3. Avoid N_2O and CH_4 emissions (11%)
4. Avoid soil erosion (9%)
4. Peat degradation (9%)
6. Enhance soil biodiversity (8%)
6. Avoid contamination (8%)
8. Enhance soil nutrient retention/use efficiency (6%)
9. Enhance water storage capacity (5%)
10. Optimal soil structure (3%)
10. Avoid acidification (3%)
10. Avoid salinization (3%)

Maintaining/increasing SOC is the highest ranked priority with a share of 20%. The stakeholders explain the key role of maintaining/increasing SOC in its importance for climate change mitigation and adaptation and in the multiple co-benefits of increasing SOC for other soil challenges such as increased water and nutrient retention, improved soil structure and increased biodiversity. Increasing the soil carbon content of the soil is therefore considered key for different soil services such as climate change mitigation, food security and the SDGs.

The second highest ranked prioritization is **soil sealing** with a share of 15%. The stakeholders attribute the high score to the practically irreversible nature of soil sealing and the low land recycling rates. Soil sealing threatens fertile (agricultural) land, puts biodiversity at risk, increases the risk of flooding and water scarcity. Moreover, population growth aggravates the risk. Soil sealing in Europe is constantly increasing, and one stakeholder points out that every year the agricultural soil of the size of Berlin is lost. To tackle the risk of sealing of fertile agriculture soils through urban expansion, the EAP 7 target

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includes no net land take by 2050. Moreover, for young farmers, soil sealing is one of the main challenges in relation to access to land.

These priorities are successively followed by avoiding N_2O and CH_4 emissions (11%), avoiding soil erosion (9%) and peat degradation (9%), avoiding contamination (8%) and enhancing soil biodiversity (8%), enhancing soil nutrient retention/use efficiency (6%) and enhancing water storage capacity (5%).

The lower ranking of several of the soil challenges is linked to their interaction with SOC. This is particularly important to explain the low rank of the soil challenge *enhance water storage capacity*, which is partly tackled by its linkages with *Maintain/increase SOC*. In addition, some targets of other soil challenges such as *Avoid soil erosion* and *Optimal soil structure* may indirectly aim at an improved water storage capacity as well.

Optimal soil structure, avoiding acidification and avoiding salinization are the lowest ranked priorities with a share of 3%.

3.3.2 Policy ambitions and aspirational goals

The four soil challenges that were ranked highest by the stakeholders in the national reports (Chapter 2.3) were also evaluated and discussed at the EU policy forum.

First, for these soil challenges, the most ambitious targets were presented, extracted from the overview of policy targets listed in Annex VIII. Next, the stakeholders were asked to evaluate EU soil policy, by answering the following questions:

1) How wide is the gap between the current policy target and realization for the soil challenges in Europe?

2) Are the current policy targets for the soil challenges futureproof with a horizon to 2050?

For all four soil challenges, the stakeholders evaluate the realization gap to achieve the current EU policy targets as large (median score). For avoiding N_2O and CH_4 emissions and enhanced soil nutrient retention/use efficiency the policy is considered almost futureproof (Figure 28). The largest policy challenges are expected for maintaining/increasing SOC and enhancing water storage capacity because current policy targets are considered to be far from futureproof.

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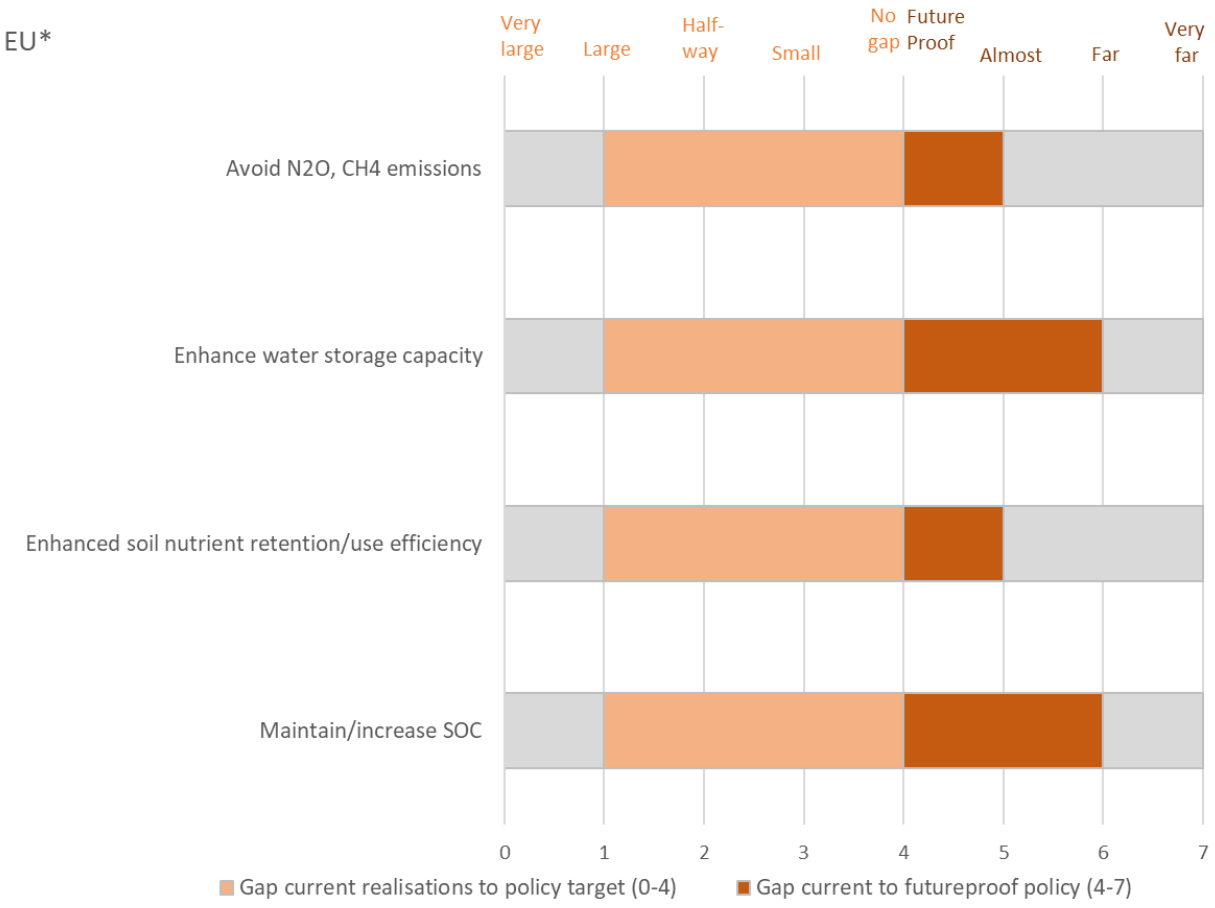

Figure 28: Policy realization and aspiration gaps by EU stakeholders

*For **maintaining/increasing SOC** the following arguments are provided by the stakeholders for the large policy gap:*

EU policy has the ambition to be climate neutral by 2050, but incentives for implementation are lacking. It is important to note, that the targets from the Horizon Europe mission area on soil health and food (HMSHF) are not yet approved targets, but rather inspirational targets. The current policy targets and directions are not supported by sustainable soil management incentives. SOC is not clearly appearing in the EU policy, starting with CAP. Yet, the time is now, since soils have a slow reaction on policies and implementation measures. There is no doubt that SOC is important, the commission is setting up a Carbon Farming Initiative with also a focus on the agricultural sector. However, there is still a need for indicators to monitor agricultural soils. The scientific community can guide this by working on monitoring, verification and reporting tools to follow the evolution of SOC in European farms. Extrapolation of the LUCAS survey with parcel specific soil sampling points and the farm sustainability tool including all greenhouse gas emissions are mentioned as key priorities for monitoring soil quality. Some even indicate the potential of an international dashboard to follow SOC at all levels. Quantifying the sequestration potential, the economic and ecological functions of SOC is important to facilitate incentives. There is a need for a Carbon Farming Initiative to boost such incentives, but care is needed and the risks should be discussed sufficiently. At the same time SOC

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needs to become a cross-cutting subject within the EU policy work. The need for research on the carbon sequestration potential in Europe and the feasibility to meet the quantitative targets of climate neutrality was highlighted.

*For **enhancing soil nutrient retention/use efficiency** the following arguments are provided for the large policy gap:*

Both the Nitrates and Water Framework Directives are insufficiently implemented. There is a need for more data driven evidence, for example on the effectiveness of (CAP) measures for enhancing nutrient retention/use efficiency. Potentially, data collection could be integrated in the LUCAS soil monitoring system and the newly established EU Soil Observatory. The commission is also engaged in developing a farm sustainability tool which will include a greenhouse gas module with among others soil N_2O emissions. But then again, the current strategies do not set out a clear pathway to achieve the targets, so it currently remains a dream. Tools and support for farmers are still missing to empower them to improve nutrient management. Interlinkages between nutrient use efficiency, nutrient losses, eutrophication and acidification should be clarified. Obviously, this soil challenge is also closely linked to intensive livestock production, which has a high impact, while being insufficiently regulated up to present. Optimized fertilization application is important to achieve soil nutrient use efficiency, but generic objectives can be challenging due to regional differences. Overall, policy goals need to be feasible in practice and should provide the tools to achieve them. Research should not only focus on data, but also on practical and socio-economic aspects.

*For **enhancing water storage capacity** the following arguments are provided for the large policy gap:*

Enhancing soil water storage capacity is not a policy target, it is a soil function influenced by policy targets. For example for the threats by compaction, erosion or SOC loss indicators are existing, where policy is weaved around. But water storage capacity is an essential inherent soil function. Yet, the topic is justified because we will have more extreme climatic situations with enormous amounts of water in spring and dry spells in summer. In practice drought risk and actual droughts are already driving farmers to think about water holding capacity. Also waterlogging affecting workability of soils is a concern. Yet, the advisory system and CAP do not incentivize practices. There is often a focus on modernizing irrigation in water scarce areas, but there needs to be more focus on water retention/water storage options for drought management. Water retention capacity increase seems not to be the priority at the policy level, but increase of SOC will also address part of that question in improving soil water retention. There is lots of knowledge about water infiltration, water flow regulation and fresh water provision related to erosion and compaction, but there are still many research needs; for example knowledge on crops adapted to more dry conditions. Water management for farmers will become even more challenging in the future.

*For **avoiding N_2O and CH_4 emissions** the following arguments are provided for the large policy gap:*

There is no specific target for emissions from agricultural soils at the EU level. Only under Effort Sharing but it does not oblige most of the member states to do anything on their emissions. Moreover, it is important to understand potential emission trade-offs and therefore the complete system should be considered. There is still uncertainty on the effectiveness of agricultural measures to reduce/avoid

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emissions and the protection of peatlands is not fully effective. The commission only just started to tackle the Horizon Europe mission area on soil health and food (HMSHF) target to reduce 30-50% of peatland area loosing carbon and we still have a large gap to close. Yet, there should be particular care for peatland soils. Fertilizer use and intensive livestock breeding are under monitoring for agricultural productions, and there is growing awareness with the policy makers about the issue of GHG emissions. But there is still a lot to be done. For example, private initiatives tackling SOC sequestration are not addressing the full GHG balance associated with soil management.

3.3.3 Comparison between EU and national stakeholders

The stakeholder surveys at the national (Chapter 2.3) and EU level were conducted using the same methodology, which justifies a direct comparison of the outcomes. The differences in the prioritization of soil challenges scored by the national stakeholders (light blue) and EU stakeholders (dark blue) are visualized in Figure 29.

All stakeholders, national and EU, agree that the key soil challenge in the upcoming decades is maintaining/increasing soil organic carbon.

Remarkable is the high prioritization of avoiding soil sealing by the EU stakeholders in comparison to the national stakeholders. But care is needed in interpretation, because this soil challenge is not always well understood by the national stakeholders since some of them also considered compaction or crusting as sealing. In a pragmatic perspective, it is simple: we need fertile land and thus need to end sealing of fertile agricultural soils. But in a national policy perspective, spatial planning also requires compensation measures, which makes it more delicate.

On the other hand, optimal soil structure, enhancing water storage and enhancing soil nutrient/use efficiency are lower prioritized by the EU stakeholders in comparison to the national stakeholders.

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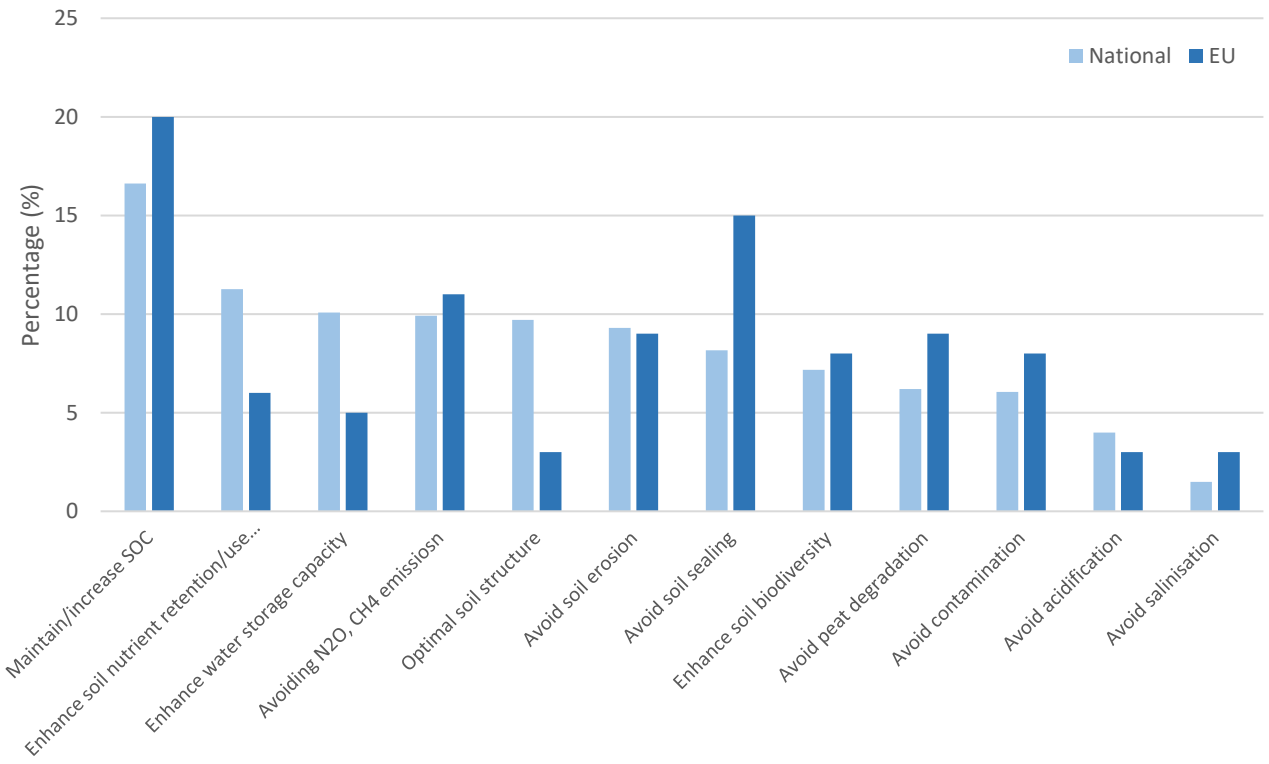

Figure 29 Comparison of prioritization between national and EU stakeholders.

The differences in views on current and future policy gaps between the national stakeholders (N) and EU stakeholders (EU) are visualized in Figure 30.

Overall, both at the EU level and at the national level stakeholders seems to agree that the gaps towards a realized and futureproof policy are still large for the four key soil challenges. However, the soil challenges avoid N_2O and CH_4 emissions and enhanced soil nutrient retention/use efficiency are considered as almost futureproof at the EU level, which is a slightly better score than at the national level. In addition, the gap for the current status of realization for all four soil challenges is considered slightly larger by the EU stakeholders than by the national stakeholders.

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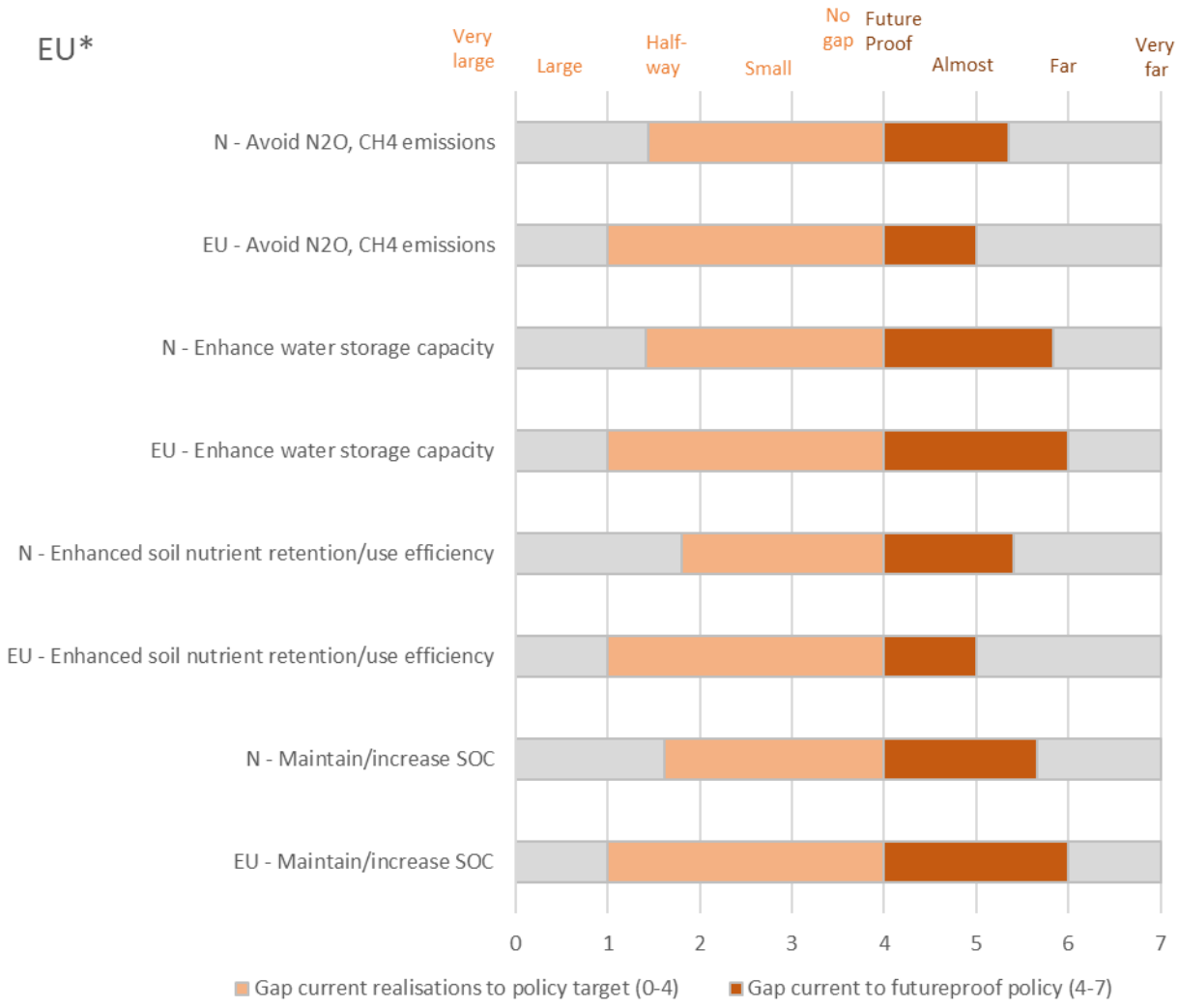

Figure 30: Realization and aspiration policy gaps at EU and national level (N)

3.4 Land management practices – an EU policy perspective

The different land management practices to tackle specific soil challenges as proposed in EU policy reports are counted to derive the relative weight of the land management categories. Each entry in Figure 31, represents a combination of a soil challenge, a policy document or sub-document and a category of land management practices.

The numbers differ strongly between the soil challenges, from 40 to 60 cases (out of 287) for the soil challenges *Avoid contamination*, *Enhance soil biodiversity* and *Protection of water resources*. Besides, *Maintain/increase SOC* proves to be an important soil challenge and also, but to a lesser extent *Avoid soil erosion* and *Enhance nutrient retention/use efficiency.* Only a few or no cases were identified for the soil challenges *Avoid peat degradation*, *Avoid salinization*, *Avoid soil sealing*, *Enhance water storage capacity* and *Agricultural landscape quality* (Figure 31).

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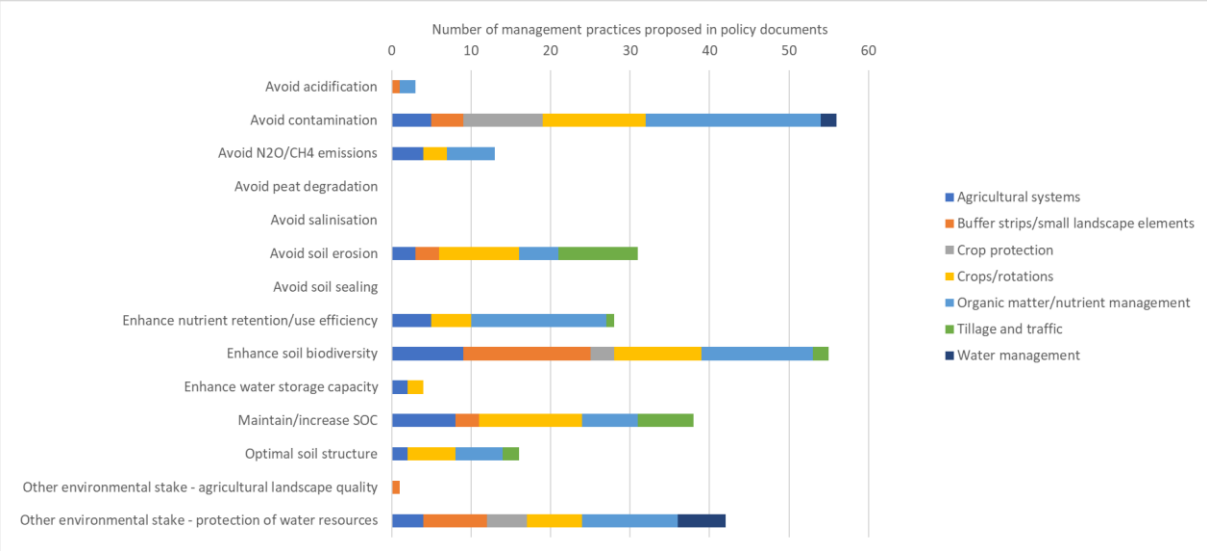

Figure 31: Number of management practices proposed in policy documents, divided in several land management categories, in response to soil challenges (based on 287 entries).

Summed over all soil challenges, the largest part of the policy documents proposed land management practices in the category *Organic matter/nutrient management* (91), followed by *Crops/ rotations* (70) (Figure 32).

The lowest number (8) was found in the category Water management. Practices in this category were only identified to address the soil challenges avoiding contamination and protection of water resources.

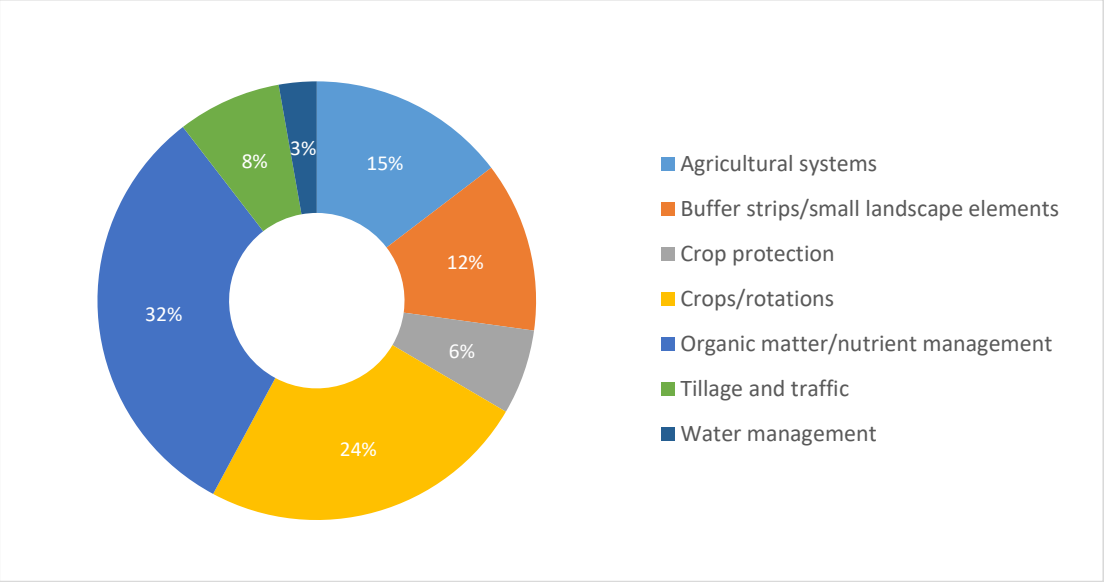

Figure 32: Proportions of policy documents proposing management practices according to main land management categories (based on 287 entries).

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The detailed management practice scores are shown in Table 19. The practices most frequently proposed by policy documents in addressing the soil challenges include: strategies of crop rotation ('Other') (27 out of 287 entries), cover and catch crops (24), reduced/more precise mineral fertilizer application (21), organic farming (18), agroforestry (17) and appropriate application of compost (14) and farmyard manure (14) (Table 19).

Table 19: Management practices proposed by policy documents and divided in main land management categories.

Land management categories	Farm management practices	Number of policy document[1]	Relative number of policy documents[2]
Agricultural systems		**42**	**14.6[1]**
	Agro-ecological farming	2	4.8
	Agroforestry	17	40.5
	Organic farming	18	42.9
	Precision agriculture	4	9.5
	Other	1	2.4
Buffer strips/small landscape elements		**36**	**12.5[1]**
	Grass buffer strips	1	2.8
	Hedges	12	33.3
	Other	10	37.8
	Other buffer strips	13	36.1
Crop protection		**18**	**6.3[1]**
	Mechanical weeding	5	27.8
	Other	11	61.1
	Precision herbicide application	2	11.1
Crops/rotations		**70**	**24.4[1]**
	Cover/catch crops	24	34.3
	Intercropping/multiple cropping	8	11.4
	More grassland	2	2.9
	More legume crops	8	11.4
	Other	27	38.6
	Permanent grazing	1	1.4
Organic matter/nutrient management		**91**	**31.7[1]**
	Appropriate compost application	14	15.4
	Appropriate farmyard manure application	14	15.4
	Better manure storage	7	7.7
	Biochar application	6	6.6
	Fertilisation plan/advice	4	4.4
	Incorporation of crop residues	8	8.8
	Manure treatment	4	4.4
	Reduced/more precise mineral fertiliser application	21	23.1
	Valorisation of waste streams	13	14.3
Tillage and traffic		**22**	**7.7[1]**
	Contour ploughing	1	4.5
	No till	5	22.7
	Non-inversion/reduced tillage	3	13.6
	Other	8	36.4
	Terrace farming	5	22.7
Water management		**8**	**2.8[1]**
	Irrigation	5	62.5
	Other	3	37.5

Aggregated over all soil challenges. A policy instrument may propose the same practice in response to different soil challenges.

[2] Relative number expressed per category of land management

3.5 Knowledge needs

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Research gaps and needs that were identified in the policy reports are listed in Table 20. These were clustered into six topics:

(i) Soil health in relation to societal themes including food quality and safety, human health, the production of biofuels and environmental footprints on soils in other parts of the world;

(ii) Understanding and the knowledge base of soil functioning and condition, and indicators, thresholds or standards to evaluate these;

(iii) Techniques, approaches and arrangements for sustainable soil or land management;

(iv) Recycling and reuse of resources;

(v) Techniques and facilities for measuring, monitoring, modelling soil conditions or related aspects or activities;

(vi) Data, information and statistics on soil condition or related aspects or activities.

In addition, specific research needs identified at the EU policy forum were:

- There is a lot of knowledge about water infiltration, water flow regulation and fresh water provision related to erosion and compaction. However, still many research needs remain and water management for farmers will become even more challenging in the future. An example of a research need is knowledge on crops adapted to more dry conditions;
- Soil loss due to sealing in urban environments is a priority of soil research;
- There is a need for better monitoring SOC pools and a carbon market initiative. Besides, the definition of an ecological and economical value for SOC is required;
- There is a need for more evidence on the effectiveness of the carbon measurements;
- There is a need for more parcel information points. Information points on soil characteristics which can be used as an input for more detailed soil mapping;
- There is a need for improved advice on the optimization of fertilizer application to the needs of the crop;
- The trade-offs between CO_2 and N_2O emissions should be unravelled.

Table 20: Research gaps and needs relating to agricultural soils identified in selected documentation.

Topic	Research gap or need	Source
Soil health related to societal themes	Increasing awareness about links between soil health, food/ product quality and safety and human health	Mission Board for Soil health and food (2020)
	Systemic innovation of relationships between diets, land use practices, ecosystem services and soil health	Mission Board for Soil health and food (2020)
	Insight in the effects of the promotion of biofuels on the intensification of production with potential effects on crop diversification, soil erosion, loss of organic matter, compaction, salinization	Kulovesi and Oberthür (2020) Keesstra et al. (2020)

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Topic	Research gap or need	Source
	Understanding and monitoring footprints on soils outside Europe (e.g. soil carbon, land degradation, pollution, water use)	Mission Board for Soil health and food (2020)
Soil functioning and condition, indicators thereof, thresholds, standards	Potential of the soil biome for carbon sequestration	Mission Board for Soil health and food (2020)
	The area at risk of saline intrusions in coastal areas due to sea-level rise	Mission Board for Soil health and food (2020)
	Agreed thresholds of soil health indicators for soil type, land use and climate zone	Mission Board for Soil health and food (2020)
	Development of an indicator '% of utilised agricultural area covered by landscape features' using information from Copernicus	European Commission (2020)
	Defining the conditions for the 'good ecological status' of soils	European Commission (2020b)
	Critical thresholds of chemical pollutants in soils (e.g. from heavy metals, pesticides, drugs and plastics)	Mission Board for Soil health and food (2020)
	Enhancing the knowledge base on the capacity of terrestrial (agricultural and forest) and marine ecosystems to serve as a sustainable domestic biomass source, to sequester carbon and to increase climate resilience	European Commission (2018b)
	Enhance the knowledge base on the availability of sustainable biomass	European Commission (2018b)
Techniques, approaches and arrangements for sustainable soil or land management	Integrated Nutrient Management	Mission Board for Soil health and food (2020)
	Remediation of contaminated and otherwise degraded soils (e.g. by phyto-remediation and conversion of land to non-food uses)	Mission Board for Soil health and food (2020)
	Organic farming and use of agroecological principles	Mission Board for Soil health and food (2020)
	Certification of carbon storage	Mission Board for Soil health and food (2020)
	Quantifying the effectiveness of funds stimulating practices enhancing soil conditions (ERFD)	Prokop and Esteve (2019)
	Reliable and comparable information on environmental performance of biobased innovations	European Commission (2018b)
	For the development of precision farming: 1. Knowledge: tools and context for land users enabling them to analyse their own data and informing them on the extent to which their data are stored, traded and analysed for future use, e.g. farm information management systems like the Farm Sustainability Tool for Nutrients (FaST);	European Commission (2020)

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Topic	Research gap or need	Source
	2. Application: potential digital divide between big and small or less educated farmers, who may be unable to keep up with new technologies; 3. Advisory system and services to provide required levels of digital skills and broadband availability in rural areas.	
Recycling and reuse of resources	Waste management systems	Mission Board for Soil health and food (2020)
	Recycling of organic waste into renewable fertiliser	Mission Board for Soil health and food (2020)
	Circular use of excavated soils	Mission Board for Soil health and food (2020)
Techniques and facilities for measuring, monitoring, modelling	Measuring and monitoring techniques for indicators of soil health or soil quality, including proximal and remote sensing	Mission Board for Soil health and food (2020) European Commission (2020b) European Environment Agency (2019)
	Closer integration between existing pan-European monitoring instruments (e.g. the LUCAS Soil Module) and Member State national programmes	Mission Board for Soil health and food (2020)
	Exploitation of information ('big data') and communication technologies such as precision farming, artificial intelligence and remote sensing	Mission Board for Soil health and food (2020)
	Methodology, coordination mechanisms or guidance at EU level to monitor Land Degradation Neutrality	Keesstra et al. (2020)
	Identifying contaminated soil sites	European Commission (2020b)
	Integration of data from citizen science and crowd sourcing, multimedia	Mission Board for Soil health and food (2020)
Data, information and statistics	Data gaps in statistics on pesticides; Quantitative monitoring of pesticide types and loads (in soils)	European Commission (2020a) Expert review in Prokop and Esteve (2019)
	Measurements on the application of sludge to agricultural soils, on the quality of the sludge and on the quality of the soils receiving sludge	Expert review in Prokop and Esteve (2019)
	Emerging pollutants in sewage sludge that may contaminate soil	Keesstra et al. (2020)

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Topic	Research gap or need	Source
	Information underlying models to derive critical values for contaminants (in soil or products like fertilisers)	Expert review in Prokop and Esteve (2019)
	Systematic tracking of farm landscape features in the EU over the long term	European Commission (2020)
	Map layer of 'small woody areas' (currently missed in Copernicus)	European Commission (2020)

At the EU level, there are several facilities and organizations intended to support the development of knowledge but also for knowledge organization and storing. Its sharing, transfer and application were mentioned in some of the policy reports and documents analysed. In most cases these were explicitly linked to a policy document and address several soil challenges of the EJP SOIL Concept. The facilities and organisations are listed in Table 21.

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Table 21: Facilities and organizations supporting knowledge systems.

Facility of organisation	Description	Development phase[3]	Related policy instrument(s)[4]	Reference
Knowledge Centre for Biodiversity	To be established in 2020 by the EC in close cooperation with the EEA. The Centre will: (i) track and assess progress by the EU and its partners in relation to implementation of biodiversity related international instruments; (ii) foster cooperation and partnership, including between climate and biodiversity scientists; and (iii) underpin policy development	I	BDS2030	European Commission (2020b)
'Living labs' and 'Lighthouses' in regional clusters	'Living labs' are proposed in the Mission area for Soil health and food as spaces for co-innovation through participatory, transdisciplinary and systemic research in collaborations of committed landowners and land managers, stakeholders from various sectors, public authorities and citizens, including consumers. 'Lighthouses' are places for demonstration of solutions, training and communication between land managers, advisors and citizens.	R. ?[5]	HMSHF BIOECS2018	Mission Board for Soil health and food (2020) European Commission (2018b)

[3] E: established, P: in progress, I: in initial stage, R: recommended.
[4] Abbreviations explained in Annex 2.
[5] Not much information was found on living labs established under the Bioeconomy Strategy 2018; might be reported in the EU-funded BioSTEP project (http://www.bio-step.eu/biostep/about-biostep/).

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Facility of organisation	Description	Development phase[3]	Related policy instrument(s)[4]	Reference
	The Mission Board proposes to group Living labs and Lighthouses in regional clusters of 10-15 units (farms, forests, industrial areas and urban settings) which will allow co-innovation at landscape and watershed levels. 'Living labs' were also planned under the Updated Bioeconomy Strategy 2018 to develop and test place-based innovations based on ecological approaches and circularity in primary production and food systems.			
Agricultural Knowledge and Innovation Systems (AKIS).	Strategies for agricultural knowledge and innovation systems (AKIS), promoted by the EC and involving all food chain actors. Four groups of actions are envisaged: 1. enhancing knowledge flows between research and practice; 2. strengthening farm advisory services and promoting connection with AKIS; 3. enhancing cross-thematic and cross-border innovation; 4. supporting the digital transition in agriculture. Member States will need to scale up support for AKIS in their CAP Strategic Plans.	E	F2F newCAP HMSHF	European Commission (2020a) European Commission (2020) Mission Board for Soil health and food (2020)
Horizon Europe Program	The EC has proposed to reserve 10 billion € in the Horizon Europe program for research and innovation in food, agriculture, rural development and the bioeconomy.	P	newCAP	European Commission (2020)

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Facility of organisation	Description	Development phase[3]	Related policy instrument(s)[4]	Reference
EIP-AGRI	The agricultural European innovation partnership EIP-AGRI is supposed to pool funding sources from Horizon Europe and rural development to support competitive and sustainable farming and forestry.	E	newCAP	European Commission (2020)
Copernicus Climate Change Service (C3S) Copernicus Land Monitoring Service	Earth observation programme (EC, 2017d), including satellite missions, in situ sensors, numerical models and related services enabling monitoring of atmosphere, marine environment, land use and climate change. Aim is to provide open data daily to public and private users to allow a better understanding of and response to environmental and climate issues.	E	NAS	www.copernicus.eu/en/services/climate-change land.copernicus.eu European Environment Agency (2019)
Climate-ADAPT	The Climate-ADAPT platform facilitates the exchange of knowledge relevant to adaptation across Europe, complementary to the national adaptation portals.	E	NAS	climate-adapt.eea.europa.eu European Environment Agency (2019)
Common European Agricultural Data Space	The data space is Intended to facilitate the trustworthy pooling and sharing of data throughout agricultural value chains. In addition to private data, the data space may also include public data and has the potential to serve common good purposes, such as Research and Innovation (R&I).	I	European Strategy for Data and Digital Europe Programme newCAP	ec.europa.eu/digital-single-market/en/news/expert-workshop-common-european-agricultural-data-space-0

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Facility of organisation	Description	Development phase[3]	Related policy instrument(s)[4]	Reference
European Innovation Council (EIC) European Institute of Innovation and Technology (EIT)	Organizations put in place by the EU to 'develop innovative and cost-effective zero-carbon solutions, that have the potential to be deployed by 2050' The Enhanced European Innovation Council (EIC) pilot aims to support innovators, start-ups, small companies and researchers with bright ideas that are radically different from existing products, services or business models, are highly risky and have the potential to scale up internationally. Under Horizon Europe the initiative will be part of pillar 3 (Innovative Europe). The European Institute of Innovation and Technology supports young innovators and start-ups across Europe	E	Horizon 2020 Horizon Europe NLS	ec.europa.eu/research/eic/pdf/ec_rtd_eic-vision-roadmap-impact.pdf eit.europa.eu European Commission (2018)
Bio-Based Industries (BBI)	EU public-private partnership on the development and deployment of new bio-based value chains, based on the use of renewable resources including waste	E	Horizon 2020 BIOECS2018	www.bbi-europe.eu European Commission (2018)
Knowledge Centre for Bioeconomy	Initiative of the EC on better knowledge management for policymaking on the bioeconomy	E	BIOECS2018	ec.europa.eu/knowledge4policy/bioeconomy_en European Commission (2018)
Horizon Results Platform	Central pillar for the exploitation of EC-funded research results for many audiences	E	-	ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform

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3.4 Conclusions

41 policy reports at EU level of various types were screened from a selected set of policy analyses, reviews and original policy documents. The following conclusions can be deducted:

EU policy targets:

- Policy documents most frequently address the soil challenges *Avoiding contamination* and *Maintaining/ increasing SOC*;
- Soil challenges *Avoiding salinization*, *Enhancing water storage capacity* and *Avoiding acidification* are explicitly addressed by only one or two policy documents;
- Around half of the targets in policy documents were not specifically referring to soils, but instead to other policy fields, economic sectors or covering more environmental domains than soils only;
- Policy targets addressing soil challenges are mostly not expressed in quantitative terms;

EU policy indicators:

- Indicators for monitoring policy targets with reference to soil challenges were identified for less than half of the cases;
- Indicators can be divided in three main groups: expressing conditions of soil, water or protected areas or pressures on these, indicators of use or management of land and water; quality and safety criteria for agricultural inputs and source materials;
- The current status of indicators for monitoring policy targets could not be derived from the documents selected for this analysis;
- The evidence cited in recent reviews suggests that large tracts of land in the EU carry soils in an unhealthy condition.

EU Monitoring tools

- For around half of the policy targets monitoring tools were identified;
- These include monitoring and review mechanisms in EU policy to which Member States are subject and data networks, spaces and monitoring facilities at the European level;

Stakeholder view

- Maintaining/increasing SOC is the highest ranked priority for stakeholders working at the EU level with a share of 20%. The stakeholders explain the key role of maintaining/increasing SOC through the multiple interactions of increasing SOC with other soil challenges and its importance for climate change mitigation and adaptation. This matches the national stakeholders prioritization;
- The second highest ranked prioritization is soil sealing with a share of 15%. The stakeholders explain the high score in the practically irreversible nature of soil sealing;
- Optimal soil structure, avoid acidification and avoid salinization are lowest ranked priorities with a share of 3%;
- For all key soil challenges, the policy challenges remain large. The gap to realization is large and the policies are ‘almost’ to ‘far’ from futureproof. This is in agreement with the national stakeholders views.

Land management

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- Most land management practices proposed in policy documents refer to the soil challenges *Avoiding contamination*, *Enhancing soil biodiversity*, *Protecting water resources* and *maintain/increase SOC*;
- Soil challenges *Avoiding peat degradation*, *Avoiding salinization, Avoiding soil sealing, Enhancing water storage capacity* and *Agricultural landscape quality* are least addressed through farm management practices;
- Most land management practices are proposed in response to a soil challenge in the categories *Organic matter/nutrient management* and *Crops/ rotations*;

Research gaps

EU policy reports:

- A wide range of research gaps and needs was identified in the documentation screened, some of which address specific soil challenges or farm management practices;
- Research gaps and needs identified concern soil health in relation to societal themes, an enlarged understanding of the condition and functioning of soils and indicators and thresholds to evaluate these;
- Other research gaps and needs refer to techniques, approaches and arrangements for sustainable soil management, facilities for monitoring and modelling soil condition, and data, information and statistics;
- Several facilities and organisations supporting knowledge systems with connections to agricultural soils have been/ are being put in place by the EC under recent or upcoming policy instruments. These include partnerships, platforms, research programs, data spaces, pilots and knowledge centres.

EU policy forum:

- There is a lot of knowledge about water infiltration, water flow regulation and fresh water provision related to erosion and compaction. However, still many research needs remain and water management for farmers will become even more challenging in the future. An example of a research need is knowledge on crops adapted to more dry conditions;
- Soil loss due to sealing in urban environments is a priority of soil research;
- There is a need for better monitoring SOC pools and a carbon market initiative. Besides, the definition of an ecological and economical value for SOC is required;
- There is a need for more evidence on the effectiveness of the carbon measurements;
- There is a need for more parcel information points. Information points on soil characteristics which can be used as an input for more detailed soil mapping;
- There is a need for improved advice on the optimization of fertilizer application to the needs of the crop;
- The trade-offs between CO_2 and N_2O emissions should be unravelled.

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5. General conclusions

Based on the current agricultural soil related policies, and the stakeholder consultation at the regional/national (Chapter 2) and European scale (Chapter 3), the following key conclusions can be drawn (Figure 33):

- The policy analysis, demonstrates that large differences exist between the number of policy targets per soil challenge. In general, at all levels, the soil challenge 'Maintaining/increasing soil organic carbon' can be considered as the most important soil challenge.
- There is a shared need, at all levels, for appropriate clear policy targets with a specific time horizon, well-defined indicators and a monitoring systems. Policy targets addressing soil challenges are mostly not expressed in quantitative terms and indicators for monitoring policy targets with references to soil challenges were identified for less than half of the cases.
- Maintaining/increasing SOC is by far the most relevant soil challenge in the upcoming decades. The stakeholders explain the key role of maintaining/increasing soil organic carbon through the multiple interactions with other soil challenges and for mitigating climate change.
- From the stakeholder consultations, at all levels, it becomes clear that for all soil challenges there is still a way to go before future aspirational goals will be met. For all key soil challenges, the gap to realization is large and the policies are 'almost' to 'far' from futureproof.
- Generally, there is an urgency for policy updates, because the current policy is considered unable to tackle the prominent soil challenges.
- Regarding the most appropriate management practices to tackle the different soil challenges, there is some agreement between the stakeholders' and policy perspective, but there are also some specific differences:
    - Manure storage, buffer strips and hedges, are highly ranked in policy documents, but ranked less high by stakeholders;
    - Conservation agriculture, agro-ecological farming, precision agriculture, incorporation of crop residues and controlled traffic farming are soil management techniques highly listed by the stakeholders, but less in policy.
- Specific knowledge needs were highlighted for almost all soil challenges and for the land management categories at the regional/national and EU level. At the EU level these were clustered in six topics: soil health and societal themes; soil functioning and conditions; approaches for land management; recycling of resources; monitoring and modelling of soil conditions; data and information.
- Apart from answers to specific questions on management options or instruments to achieve soil challenge aspirations, five themes of recommendations could be extracted from the country reports:
    - (i) Multi-stakeholder participation in a holistic perspective
    - (ii) Appropriate policy targets, indicators and monitoring systems
    - (iii) (Marker-driven) economic incentives
    - (iv) Knowledge and knowledge sharing
    - (v) Innovative and data-driven soil management

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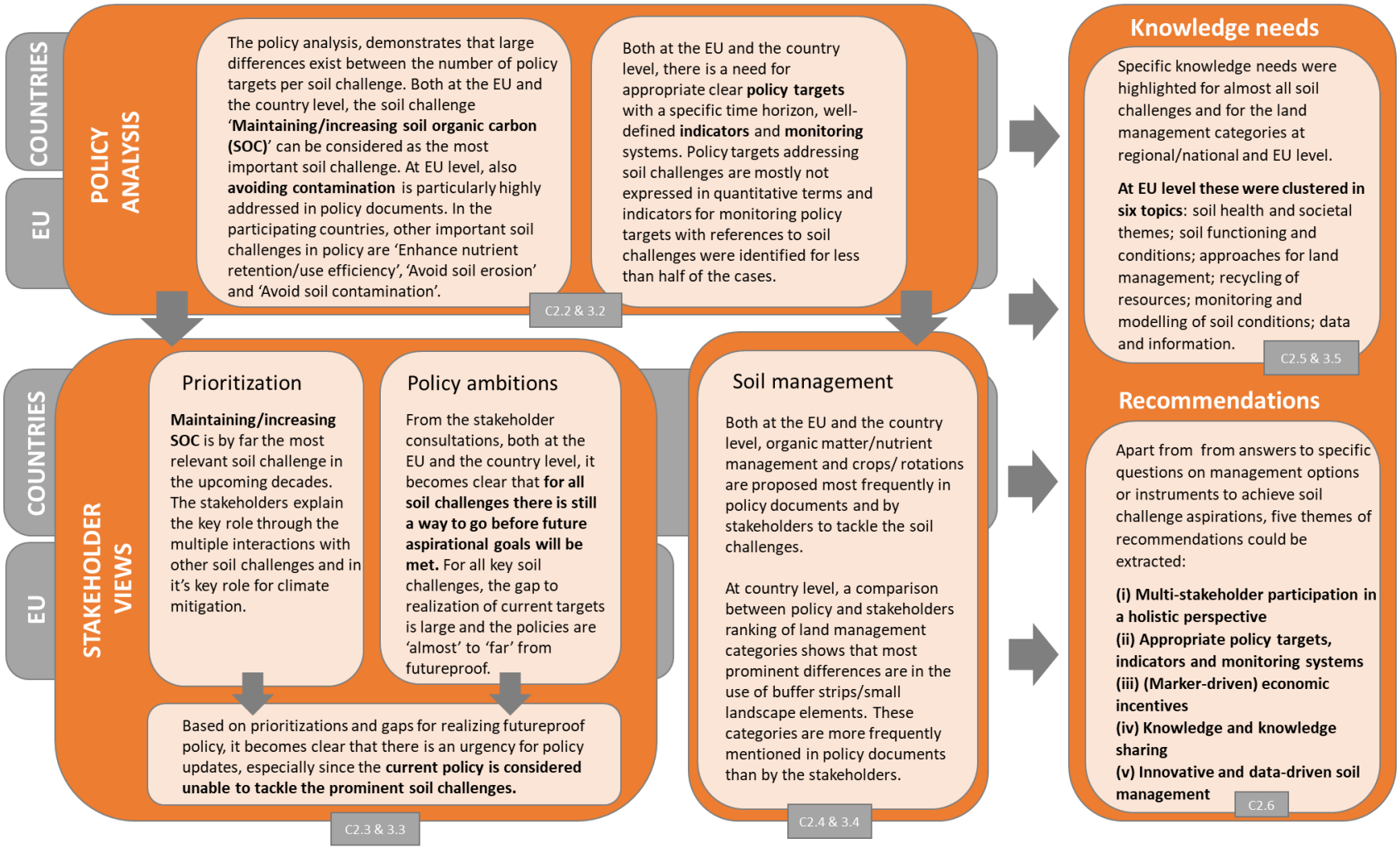

Figure 33 Key outcomes and linkages on current policy ambitions and future soil aspirational goals at regional/national and EU level (C: chapter numbers)

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Annex I: EJP SOIL glossary

Aspirational goal: A hope or ambition of achieving something. In this document, aspirational goals are the long-term goals (2050) to work towards, expressed by national and EU stakeholders.

Climate Smart and Sustainable Agriculture (CSSA): an approach, developed by the FAO, that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate (FAO, 2020).

Climate Smart Sustainable Soil Management – soil management for CCSA. The elements Climate smart sustainable soil management are improve water storage & water use efficiency, control soil erosion & land degradation, improved soil biodiversity, improved soil structure management, improved nutrient management and soil organic matter (SOM) management for C-sequestration (Paustian et al., 2016[6]).

Land management categories:

a) **Crops and crop rotations**
   Choices that farmers make regarding the crop types and rotations; e.g. cover crops, shift towards more protein crops, grasslands;
b) **Organic matter and nutrient management**
   Choices that farmers make regarding, e.g., fertilization types and doses, precision fertilization techniques, crop residue management, on-farm composting, manure treatment, crop residue management and manure treatments;
c) **Tillage and traffic**
   Choices that farmers make regarding types, depth and intensity of tillage practices such as ploughing vs. non-inversion tillage, contour ploughing, intensity of seedbed preparation Traffic choices include size and weight of field machinery, tires and inflation pressure regulation, field traffic intensity.
d) **Crop protection**
   Choices that farmers make regarding pest, disease and weed control, e.g. mechanical weeding vs. chemical weed control.
e) **Water management**

[6] Paustian, K., Lehmann, J., Ogle, S., Reay, D., Robertson, G. P., & Smith, P. (2016). Climate-smart soils. *Nature*, *532*(7597), 49-57.

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Choices that farmers make regarding for example irrigation, regulating ground water levels for rewetting or drainage

f) **Agricultural systems**
Sometimes farmers make clear choices towards a certain farming system, such as agro-ecological production methods, agroforestry, conservation agriculture or organic agriculture. These systems have a holistic approach and integrate choices regarding crops/rotations, organic matter and nutrient management, tillage and traffic, and crop protection. The reason why agricultural systems are a separate category here, is that they are often mentioned in policy documents and are understandable by multiple stakeholders.

g) **Buffer strips and small landscape elements** (eg grass buffer strips, hedges).
Buffer strips and small landscape elements do not only have a local impact, but they affect also soil functions and processes and ecosystem services in the wider area. Small landscape elements might be a source of organic residues that can be used to improve soils in the area.

Goal: something important that policy intends to achieve in the future, even though it may take a long time. The **overarching EJP goals** are: 'good agricultural soil management for: climate change mitigation and adaptation, sustainable production, ecosystem services and less soil degradation.'

Indicator: Parameter used to quantify and valuate impacts of agricultural soil practices on soil quality and the environment to draw conclusions for the farming practice or agricultural policy (modified after Piorr, 2003)[7].

Policy ambition: In this document, the term policy ambition refers to the broader description of what a policy package (at the EU, national or regional level) wants to achieve and how. It assembles some (quantified) targets, policy monitoring tools, management practices encouraged by policy and other policy instruments.

Policy instruments the instruments/tools that are used to reach policy targets. Four categories of instruments are typically identified: mandatory regulation, economic instruments, voluntary approaches and educational/informational instruments (Cocklin et al., 2007[8], McNeill et al., 2018[9]). This includes financing mechanisms such as carbon markets and management practices that will be encouraged.

Policy monitoring tools: the tools that are used or need to be developed to monitor policy targets.

Soil threats and soil challenges: soil threats can be defined as processes or agents that could deteriorate (some of) the functions of soils and the services that soils provide. For the European soils major soil threats are: soil erosion by water and wind, decline in soil organic matter in peat and mineral

[7] Piorr, H. P. (2003). Environmental policy, agri-environmental indicators and landscape indicators. *Agriculture, Ecosystems & Environment*, *98*(1-3), 17-33.

[8] Cocklin, C., Mautner, N., & Dibden, J. 2007. Public policy, private landholders: Perspectives on policy mechanisms for sustainable land management, Journal of Environmental Management 85(4): 986-998.

[9] McNeill, A., Bradley, H., Muro, M., Merriman, N., Pederson, R., Tugran, T., Lukacova, Z., (2018), Inventory of opportunities and bottlenecks in policy to facilitate the adoption of soil-improving techniques. Scientific Report No. 9, www.soilcare-project.eu

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soils, soil compaction, sealing, contamination, salinization, desertification, decline in soil biodiversity (EU, 2006[10]). Each soil threat represents also a challenge to be overcome for preserving soil from degradation. In this document we will refer to these matters as soil challenges. By converting the negative into the positive, farmers can optimise primary soil functions and related ecosystem services (see glossary for an overview of the **agricultural soil ecosystem services (ASES**)).

Soil challenges: different soil processes that need to be prevented or reinforced to prevent soil degradation and to maximize soil functions and ecosystem services and to reach policy ambitions, aspirational goals and EJP SOIL goals:

- Maintain/increase SOC
- Avoiding N2O, CH4 emissions from soils
- Avoid peat degradation
- Avoid soil erosion
- Avoid soil sealing
- Avoid salinisation
- Avoid acidification
- Avoid contamination
- Optimal soil structure
- Enhance soil biodiversity
- Enhance soil nutrient retention/use efficiency
- Enhance water storage capacity

Target: Specific goals that have to be reached within a given time frame. Usually, targets are quantified and to be reached within a given time frame e.g., to decrease greenhouse gas emissions by 35% by 2030 compared to 2005.

[10] European Commission (EC): Communication from the Commis- sion to the Council, the European Parliament, the European Eco- nomic and Social Committee and the Committee of the Regions, Thematic Strategy for Soil Protection, COM 231 Final, Brussels, 2006.

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Annex II Questionnaire template provided to the national coordinators for stakeholder consultation at the country level

Note for the national coordinator of task 2.1: You can use this template document for sending questionnaires of task 2.1 to your national stakeholders, translated when necessary. If applicable, we advise to ask for an informed consent. In this document, yellow highlighted red text between '[ ]' should be adapted to your situation and removed afterwards together with this box

Stakeholder questionnaire
EJP SOIL Task 2.1

Validating current policy ambitions and defining aspirational goals on agricultural soils

EJP SOIL

*This questionnaire is part of the European Joint Programme Soil (**EJP SOIL**). The overall objective of EJP SOIL is to provide solutions for sustainable soil management that contribute to addressing key societal challenges including climate change and future food supply. Please see www.ejpsoil.org for further information.*

*EJP SOIL invites you to participate as a valuable **stakeholder** and to engage in the programme to represent the breadth of agricultural systems and soil management practices in your country.*

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Background information questionnaire

The specific aim of this questionnaire is to **validate** the policy analysis of current policy ambitions and realisations on agricultural soils and soil management in your country, to evaluate the **realisations** of the current agricultural soil policy and to set the **aspirational** future goals.

Step-by-step

The questionnaire template comprises **5 steps**: (0) Background information, (1) Policy framework validation, (2) policy realisation and defining aspirational goals, (3) how to achieve policy aspirational goals and (4) policy prioritization.

IMPORTANT: The answers you provide should be your own opinion based on your knowledge and expertise and do not have to be official statements of your organisation (if applicable). In the final and public report, results will be clustered by stakeholder group only, so it will not be possible to trace the answers back to your name, institute or organisation.

Questions?

Should anything be unclear, please contact the national coordinator for this task, being [include name, email address and other contact details].

Thank you for your valuable inputs!

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Step 0: Background information

In this introductory step we ask you to provide some basic background information by answering the questions in the table below. Names are for the track record of the national coordinator of this task only, because there might be an interview afterwards for clarifications. In the final and public report, results will be clustered by stakeholder group only, so it will not be possible to trace the answers back to your name, institute or organisation.

Background information table

Background information	
Can you provide your full name and job title?	*Name, Job title*
What stakeholder group do you identify yourself with most?	☐ *National European soil partnership representatives* ☐ *National policy stakeholders (local governance and policy implementing representatives)* ☐ *Research communities* ☐ *Research funders* ☐ *Middle & Higher educational institutions* ☐ *Farmer Schools* ☐ *Farmers and demonstration farms* ☐ *Advisors* ☐ *Farmers' organisations* ☐ *Agro-industry* ☐ *Laboratories, National science testing, Verification centers etc.* ☐ *Industry, Supply & Retail* ☐ *NGOs and community-based organizations*
If applicable, what institute or organisation do you work for?	*Institute/organisation*
What is the relevance of agricultural soils and soil management within your job?	*Relevance agricultural soils and soil management*
Have you completed the questionnaire on your own or have you consulted any	*[to be filled after finishing the questionnaire]*

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colleagues? How many persons did you consult? And who are these persons? (*To be clear: it is not mandatory for this questionnaire that you have consulted your colleagues. This should not be an official answer of your organisation, rather your opinion based on your expertise*)	
Other (general remarks)	*[open question]*

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Step 1: Validation of the policy analysis report.

Important note: In this step we ask an objective assessment of the policy analysis conducted by the project partners. The analysis reflects what is written in official policy documents. We do NOT ask for your opinion. Your opinion will be asked for in the steps 2, 3 and 4.

Even if you are not familiar with policy documents and are not able to validate this analysis, we would like to ask you to read through this step, so that each stakeholder can start with the same understanding at the next steps.

What: Validation of the policy analysis drafted by the national project partners, i.e. the draft task 2.1 member state report attached in annex I [Note for the national coordinator: the part of the draft member state report you have written for phase 1 (including the tables) should be attached in annex I. This yellow highlighted text can be deleted once the annex is attached]. This includes, where necessary, complementing the draft with your expert knowledge.

How: Key validation questions that should be addressed are:

- Are all policies targeting agricultural soils and soil management included – indirect and direct policies? Is there any main market-based initiative missing? And if available, are the targets, currently used indicators and current status of the indicators complete? Are all policy monitoring tools and policy instruments that are mentioned in the policy documents listed (table 2)?
- Are the policy packages/market-based initiatives and targets correctly positioned in the soil challenges – Climate smart sustainable soil management cross table (table 3)?
- If specified, are the soil management practices mentioned in the policy documents/documents of market-based initiatives correctly indicated (table 4)?

For the validation of the draft policy analysis, a review table is provided. This table allows to structurally answer the key questions listed above. The question is answered by indicating "YES" or "NO" in the appropriate cell. In case the answer is "NO" provide suggestions and feedback in this table to complete or correct the draft. Additionally, general remarks can be provided in the last column.

The validation table is provided on the next page.

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STEP 1 - Validation table

		Complete	**Correct**	**General remarks**
Table 2 Are all policies targeting agricultural soils and soil management included – indirect and direct policies? Is there any main market-based initiative missing? And if available, are the targets, currently used indicators and current status of the indicators complete? Are all policy monitoring tools and policy instruments that are mentioned in the policy documents listed?	*All policies included*			
	All major market-based initiatives listed			
	Policy targets listed			
	Policy indicators listed			
	Current status of indicators listed			
	Policy monitoring tools listed			
	Policy instruments listed			
Table 3 Are the policy packages/market-based initiatives and targets correctly positioned in the soil challenges – Climate smart sustainable soil management cross table (table 3)?		*Not applicable*		
Table 4 If specified, are the soil management practices mentioned in the policy documents/documents of market-		*Not applicable*	*Not applicable*	

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based initiatives correctly indicated (table 4)?			

Step 2: Policy realisation and defining aspirational goals

Important note: *in contrast with the first step of the questionnaire, we do ask for* ***your stakeholder opinion*** *in the following steps.*

What: The soil policy assessment (including market-based initiatives when relevant), validated in step 1, provides an overview of the current policy ambitions. For some policy targets, indicator values are available that track the current status of policy targets, but that is not the case for all policy targets. In this step we try to identify **the potential gap between the current realisation of the policy ambitions and the targets that are set**. In case there is no indicator value, we ask to evaluate the policy based on your expert knowledge.

At the same time, one could also question **whether the current policy ambition is sufficient in light of the societal challenges** (climate change, land and soil degradation, loss of ecosystem services) that we face towards 2050 and if not, where new policy targets are required? This is addressed in question 2, referred to as 'futureproof'.

The aim of this step is to identify the current realisations and aspirational targets for the soil challenges, by addressing these two central questions:

(Q1) How wide is the gap between the current policy target and realisation?

(Q2) Are the current policy targets futureproof with a horizon to 2050?

How*:* We prepared a policy evaluation exercise for the different soil challenges (Table 5).

Question 1

The first 2 columns of Table 5 (grey), are completed by the national project partners from the analysis of policy documents (validated in step 1) to show the current targets and status [Note for the national coordinator: pre-fill the first 2 columns of table 5 from the policy analysis (Table2). This yellow highlighted text can be deleted once the columns are filled]. In the third column a Likert scale is presented for evaluating the realisation of the current policy in sight of the current policy ambition for the different soil challenges. The advantage of this Likert scale is that it allows the evaluation of policy realisations, even for policies without clearly defined indicators, but the Likert scale should also be used when indicators are available.

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The gap between the policy target and realisation is **very large**	The gap between the policy target and realisation is **large**	The realisation is **halfway** the policy target	The gap between the policy target and realisation is **small**	The policy target is already **achieved**
1	2	3	4	5

Question 2

After evaluating the current policy realisations, the aim is to think 'out-of-the-box', independent of the current policy limits, and to set the **aspirational goals by 2050.**

To answer the question, whether the current policy targets are futureproof with a horizon to 2050, another Likert scale is presented:

The policy ambition is **already** futureproof	The policy ambition is **almost** futureproof	The policy ambition is **far** from being futureproof	The policy ambition is **very far** from being futureproof
1	2	3	4

For every vote in table 5 it is important that you also **provide a short argumentation** for your vote. The argumentation can define whether the vote was scientifically supported or rather an intuitive choice based on your expert knowledge.

In case you have no insight on the soil challenge at all, you can leave the specific soil challenge blank and explain this in the argumentation, but we do encourage you to complete as much as possible.

Table 5 is provided on the next page.

[Important note for the national project partners: in this table we have inserted a row 'example'. We think you can keep this row 'example' in the questionnaire.]

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STEP 2 - Table 5: Current policy realisations and aspirational goals per soil challenge

	Current policy target	Current status of policy targets (when Indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Argumentation	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Argumentation
			1	2	3	4	5		1	2	3	4	
	Policy target extracted from table 2	*Policy indicator + status extracted from table 2*	*Very large*	*Large*	*Half way*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
EXAMPLE Maintain/increase SOC	*- NECP LULUCF: no debit in 2021-2030 period for entire LULUCF sector* *- NECP: LULUCF: more carbon storage in agricultural soil*	*Not available* *Not available*		*X*				*Based on lab analyses of soil fertility ordered by farmers, soil carbon contents of agricultural soils are still declining*			*X*		*Agricultural soils should become a net sink of carbon*
Maintain/increase SOC													

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Avoiding N_2O, CH_4 emissions from soils													
Avoid peat degradation													
Avoid soil erosion													
Avoid soil sealing													
Avoid salinisation													
Avoid acidification													
Avoid contamination													
Optimal soil structure													
Enhance soil biodiversity													
Enhance soil nutrient retention/use efficiency													
Enhance water storage capacity													

***NECP**: Flemish Energy and Climate plan*

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Step 3: How to achieve the aspirational goals

What: After setting the aspirational goals, the question remains **how to achieve this goal?** Or in other words, which soil management practices are most appropriate to achieve the aspirational goal. In this step, you are asked to address the question:

> (Q3) What soil related farm management practices are most promising to achieve the aspirational goals?

How: To answer the question, the same table as table 4 from the draft member state report is displayed (see Annex I), but empty. The aim is to select soil management practices that are most useable to achieve the aspirational goal for each soil challenge, in your opinion, regardless of the management practices that have been extracted from current policy documents.

Select three priority management practices for each soil challenge by putting '**X**' in the cells. So, each column should have three cells marked with '**X**' (table 6).

Additional there is an open question for every soil challenge (which is filled in table 7):

> (Q4) Is there **another instrument** that should be considered to achieve the aspirational goal?

These instruments can be very broad and can also include *for example* the stimulation of market-based and grassroots initiatives or informational campaigns. This is an open question you can think out-of-the box here.

Output table 6 and 7 are provided on the next pages.

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STEP 3 - Table 6: Ranking table of soil management practices to achieve aspirational goals – three priority management practices for each challenge, indicated by X (so three 'X' per column) (if other is selected, please specify what management practice you are thinking of)

	Maintain/increase SOC	**Avoid N_2O/CH_4 emissions**	**Avoid peat degradation**	**Avoid soil erosion**	**Avoid soil sealing**	**Avoid salinisation**	**Avoid acidification**	**Avoid contamination**	**Optimal soil structure**	**Enhance soil biodiversity**	**Enhance nutrient retention/use efficiency**	**Enhance water storage capacity**	**Other environmental stakes**
Crops/rotations													
More cereals													
More legume crops													
More grassland													
Intercropping/multiple cropping													
Cover/catch crops													
Perennial crops													
Permanent grazing													
Rotational grazing													
Zero grazing													
Other													
Tillage and traffic													
No till													

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Non-inversion/reduced tillage													
Non-inversion/minimum tillage													
Non inversion tillage													
Deep ploughing													
Contour plouging													
Terrace farming													
Controlled traffic farming													
Other													
Organic matter/nutrient management													
Reduced/more precise mineral fertiliser application													
Appropriate compost application													
Appropriate farmyard manure application													
Biochar application													

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incorporation of crop residues													
Fertilisation plan/advice													
Better manure storage													
Manure treatment													
Valorisation of waste streams													
Enhanced weathering													
Other													
Crop protection													
Mechanical weeding													
Precision herbicide application													
Other													
Water management													
Irrigation													
Subsurface drainage													
Increasing water tables													
Allow flooding													
Other													

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Buffer strips/small landscape elements													
Grass buffer strips													
Other buffer strips													
Hedges													
Other													
Agricultural systems													
Organic farming													
Agro-ecological farming													
Precision agriculture													
Agroforestry													
Conservation agriculture													
Other													

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Remarks on table 6

[Optionally, if applicable, clarifications and comments related to the choices in table 6 or general remarks can be addressed in this box]

STEP 3 - Table 7: Other instruments to achieve aspirational goals per soil challenge

	Possible instruments to achieve aspirational goal (short explanation)
	Is there another instrument, beside soil management practices, that should be considered to achieve the aspirational goal? These instruments can be out-of-the-box and include market-based instruments
Maintain/increase SOC	
Avoiding N_2O, CH_4 emissions	
Avoid peat degradation	
Avoid soil erosion	
Avoid soil sealing	
Avoid salinisation	
Avoid acidification	
Avoid contamination	
Optimal soil structure	
Enhance soil biodiversity	
Enhance soil nutrient retention/use efficiency	
Enhance water storage capacity	

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Remarks on table 7

[Optionally, if applicable, general remarks on table 7 can be addressed in this box]

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Step 4: Policy prioritization

***What*:** Prioritization of the soil challenges to identify the **key themes** in the dominant environmental zones as defined by Metzger et al. (2005) (see map and explanation in Annex II). [you do not need to include Annex II and the name of the zones when there is only 1 zone in your country]

(Q5) *What do you expect that will be the main soil challenges that are most relevant for the dominant environmental zones of your country in the upcoming decades?*

***How*:** For this exercise, you should attribute a total of 100 points between the various soil challenges in the dominant environmental zones.

[not for the national partners: you can keep the example in the questionnaire)

STEP 4 - Table 8: Policy prioritization

		Policy prioritization (Per zone, a total of 100 points should be attributed between the various soil challenges)		
	Example	*[Write name of environmental zone1 here]*	*[Write name of environmental zone 2 here]*	*[…]*
Maintain/increase SOC	*30*			
Avoiding N_2O, CH_4 emissiosn	*10*			
Avoid peat degradation				
Avoid soil erosion	*10*			
Avoid soil sealing				
Avoid salinisation				
Avoid acidification				
Avoid contamination				
Optimal soil structure				
Enhance soil biodiversity				

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Enhance soil nutrient retention/use efficiency	*20*			
Enhance water storage capacity	*30*			
Total sum:	***100***	**100**	**100**	

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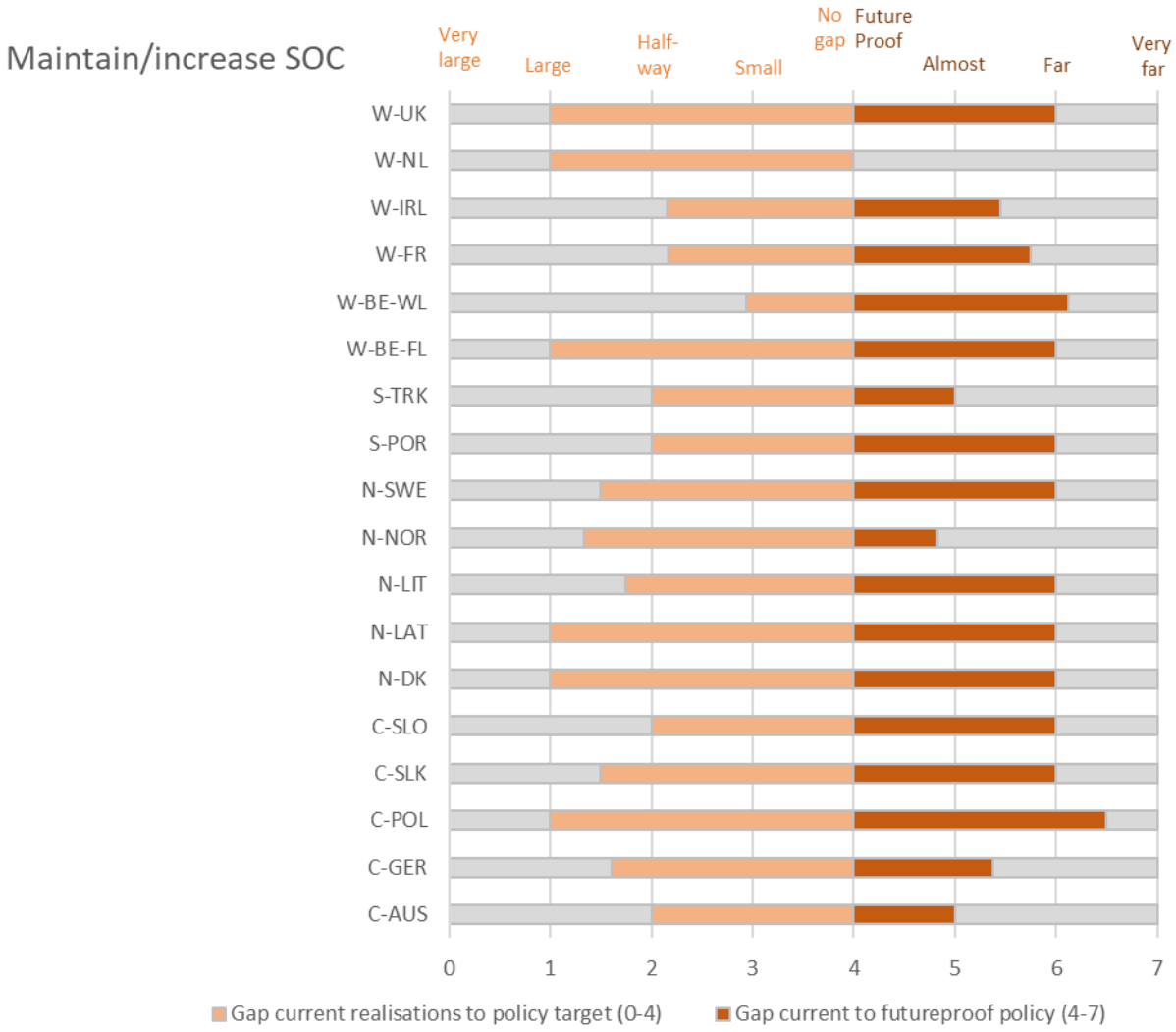
Annex III: Policy ambitions (soil challenges)

In the following an overview of the policy analysis and soil management results are listed per soil challenges.

Maintain increase SOC



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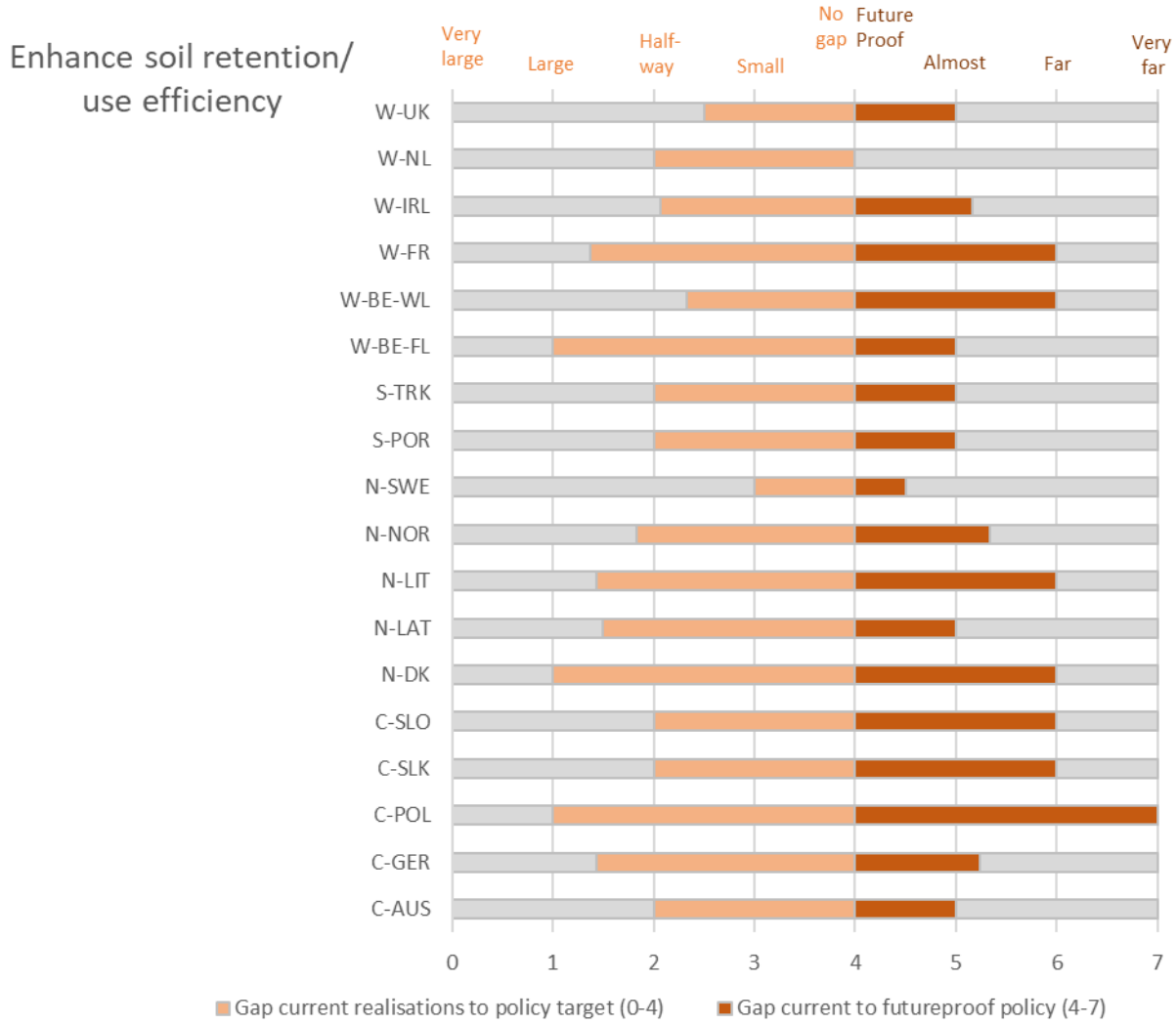
Enhance soil nutrient retention/use efficiency



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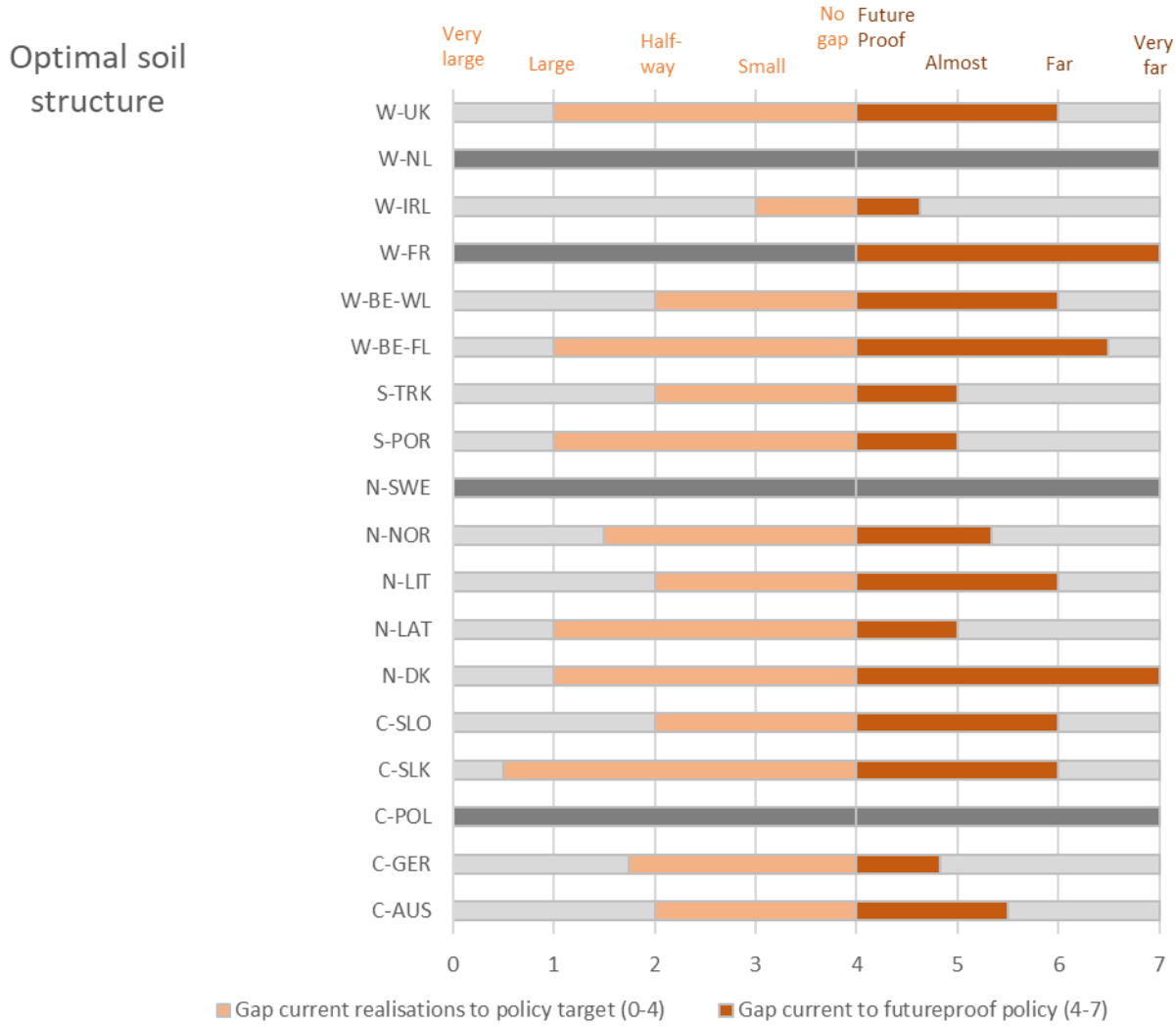
Optimal soil structure



*For the dark grey bars no data is provided.

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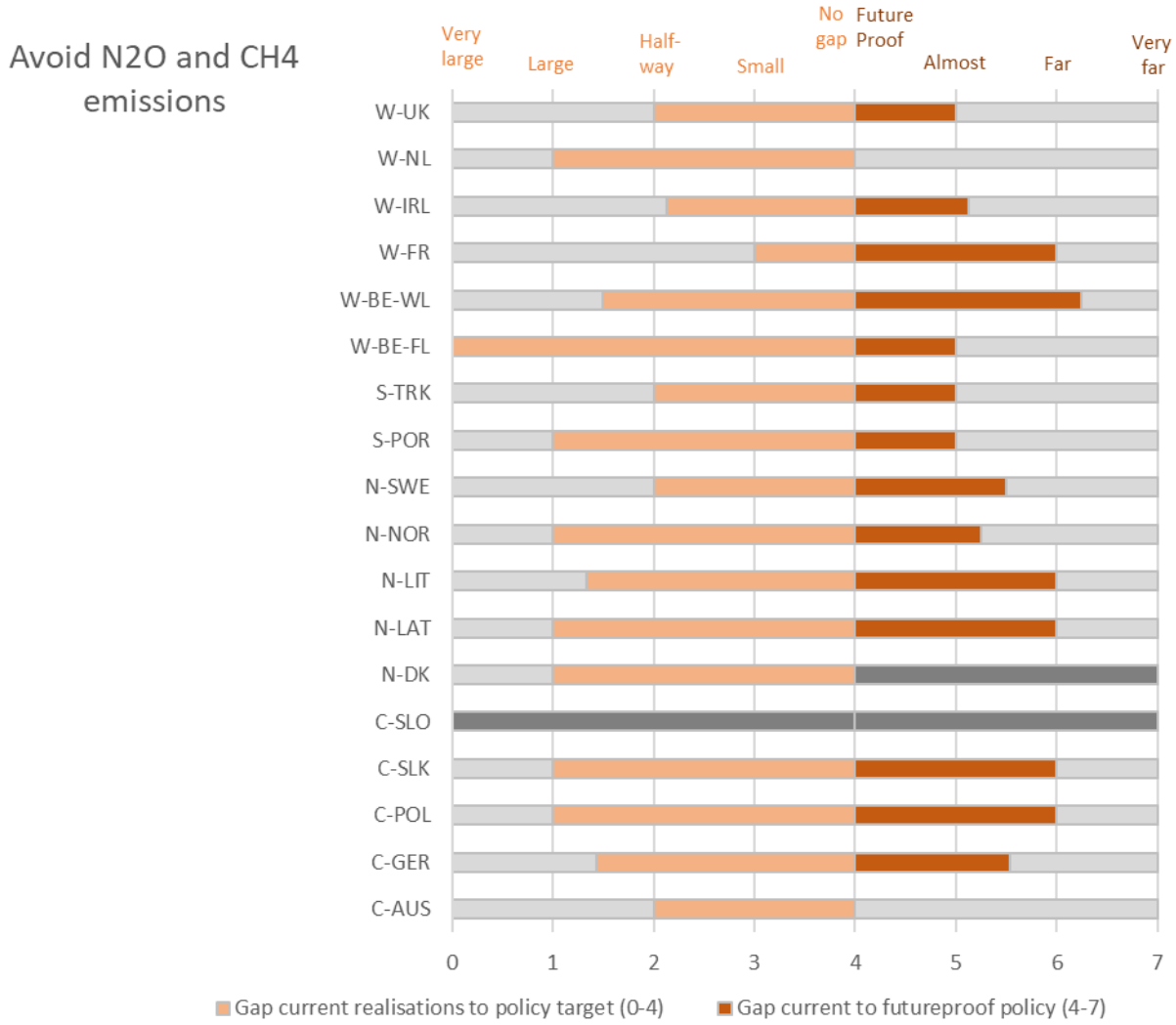
Avoid N2O and CH4 emissions



*For the dark grey bars no data is provided.

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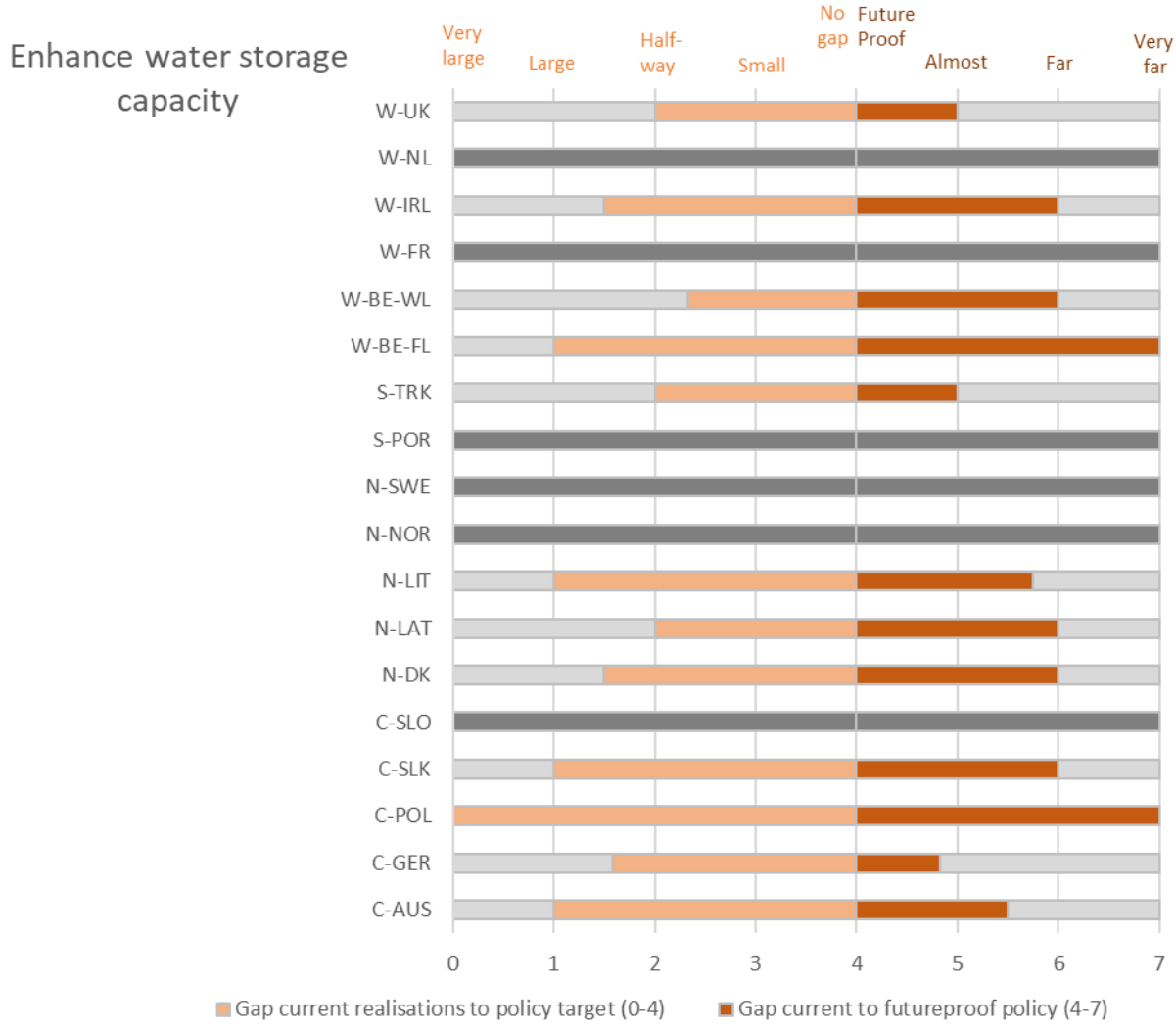
Enhance water storage capacity



*For the dark grey bars no data is provided.

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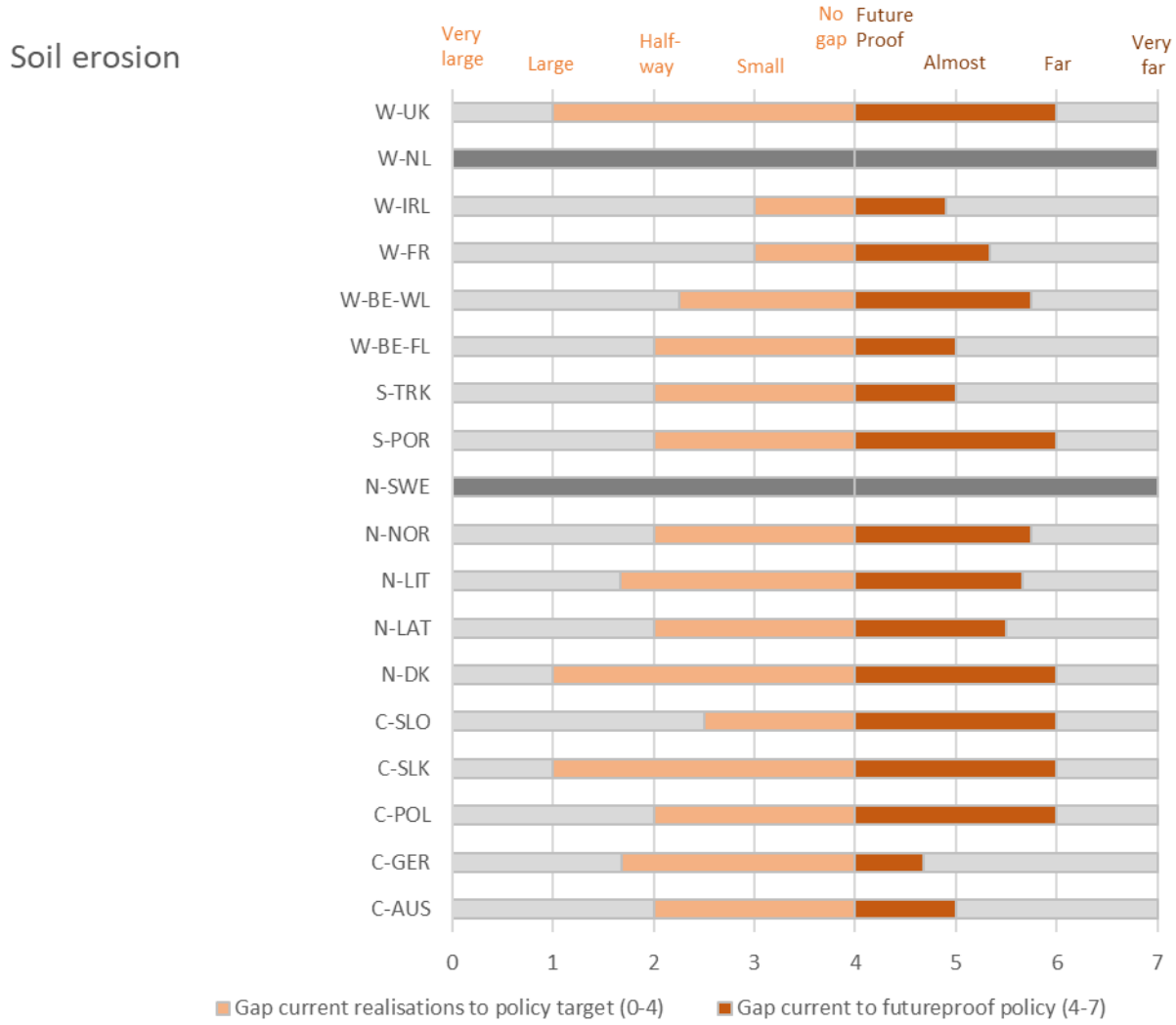
Avoid soil erosion



*For the dark grey bars no data is provided.

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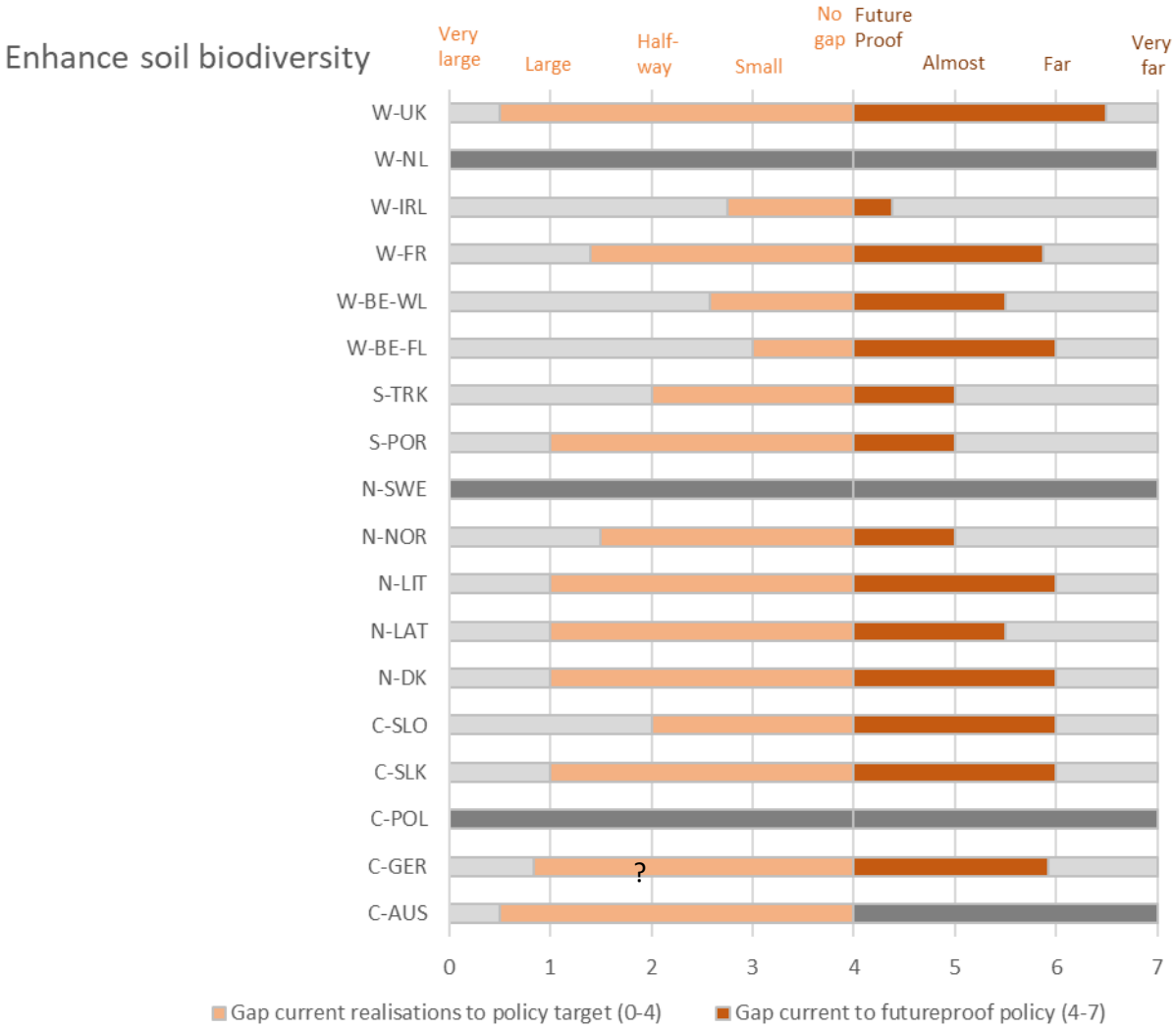
Enhance soil biodiversity



*For the dark grey bars no data is provided.

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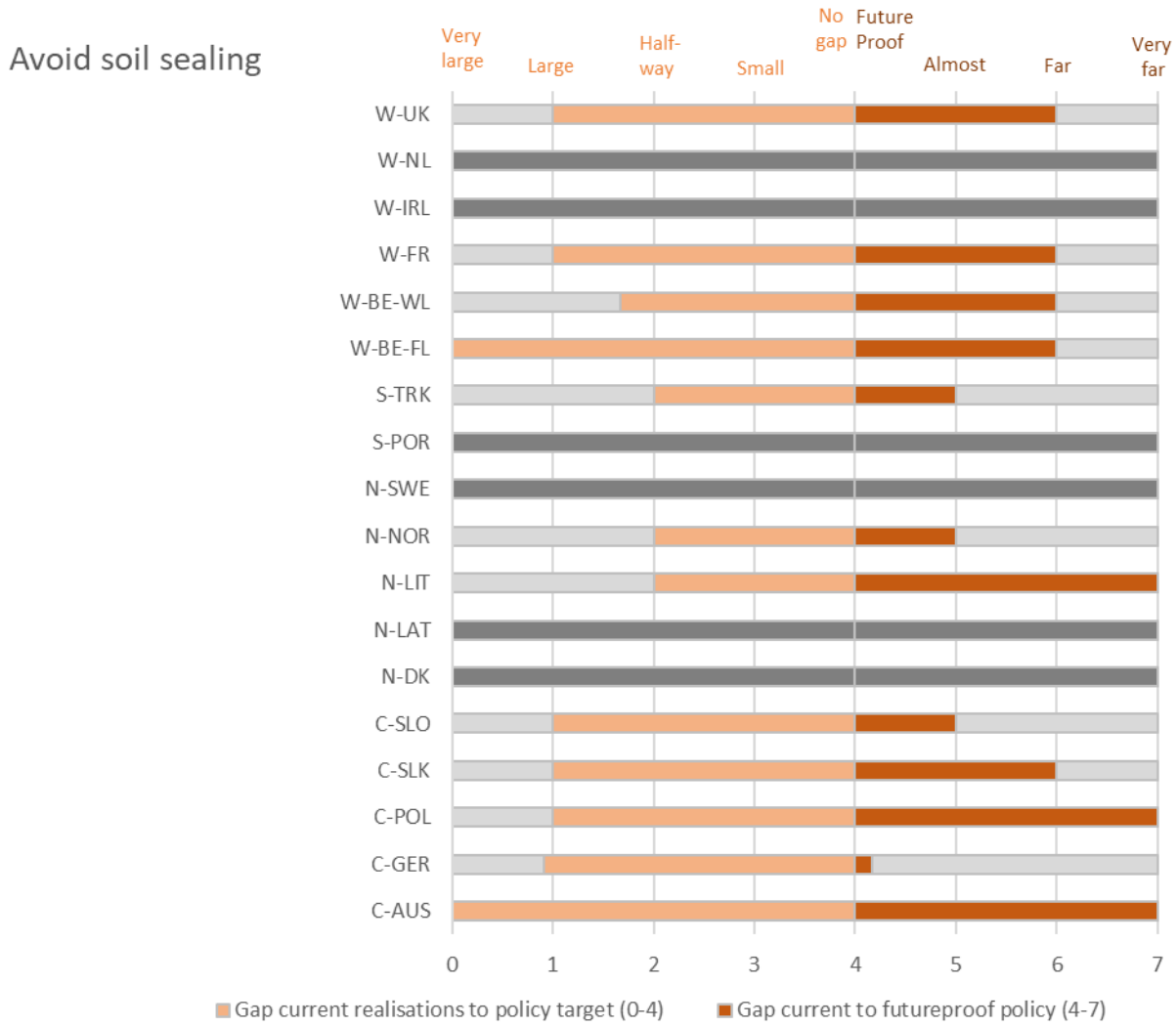
Avoid soil sealing



*For the dark grey bars no data is provided.

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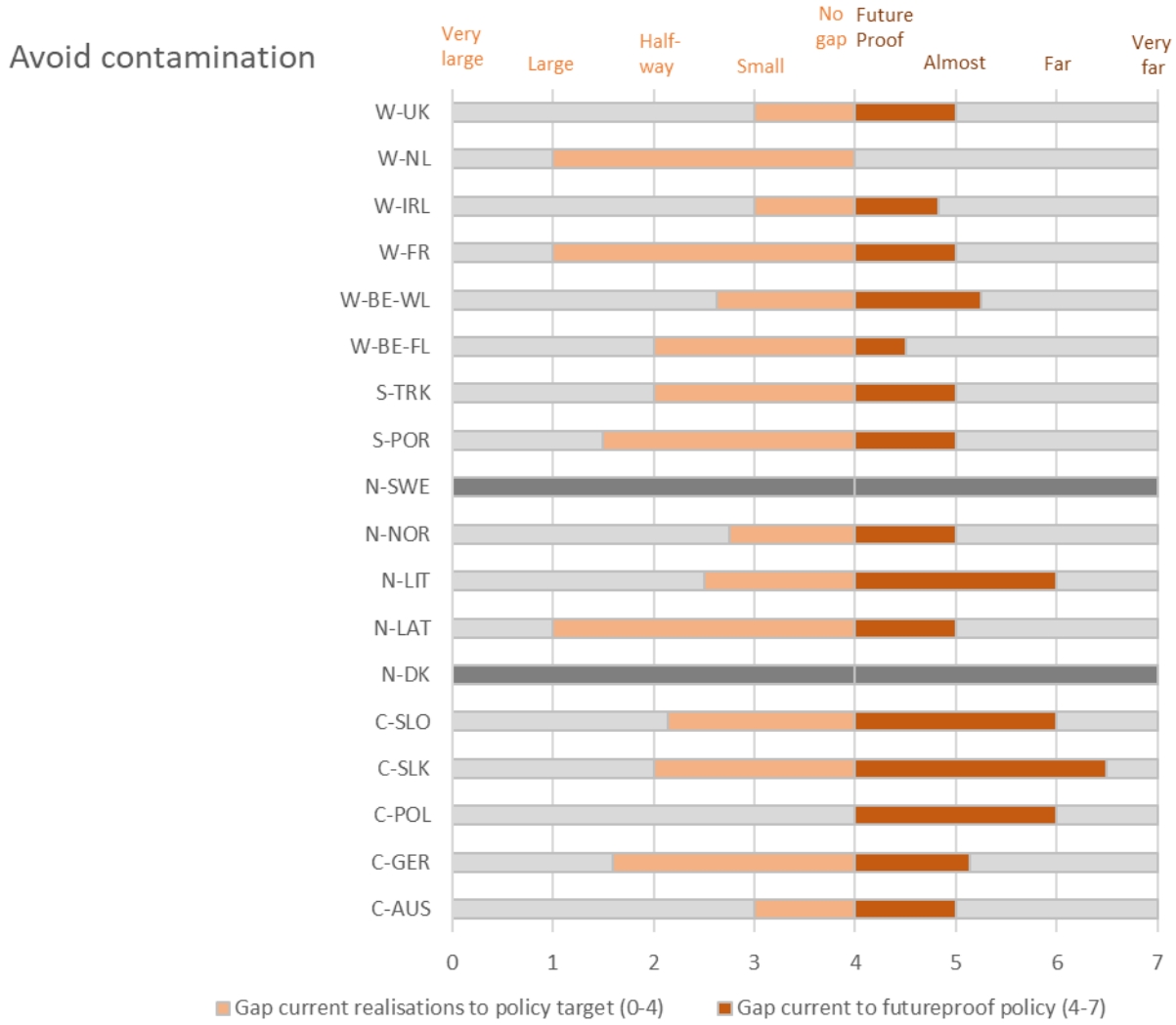
Avoid contamination



*For the dark grey bars no data is provided.

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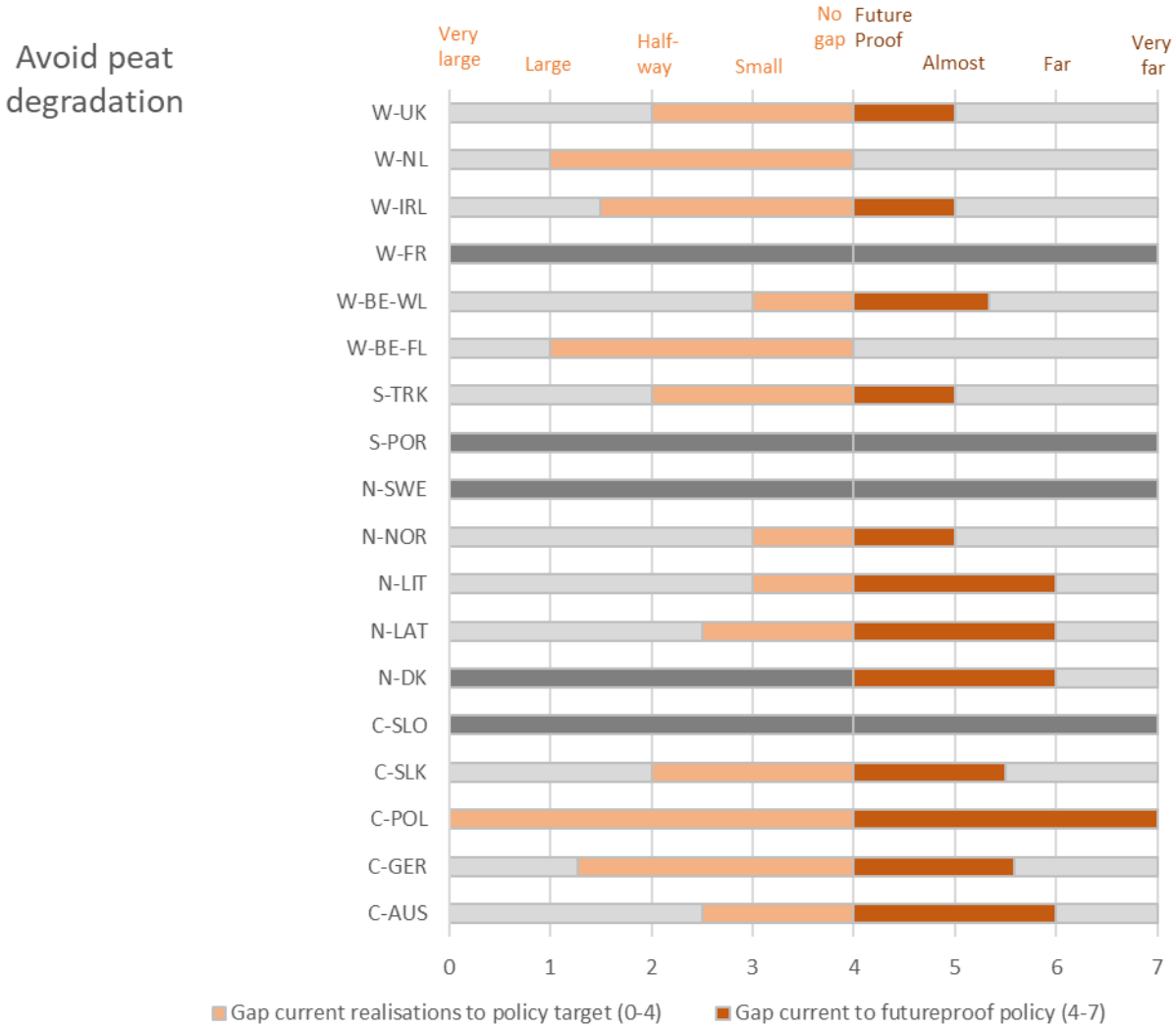
Peat degradation



*For the dark grey bars no data is provided.

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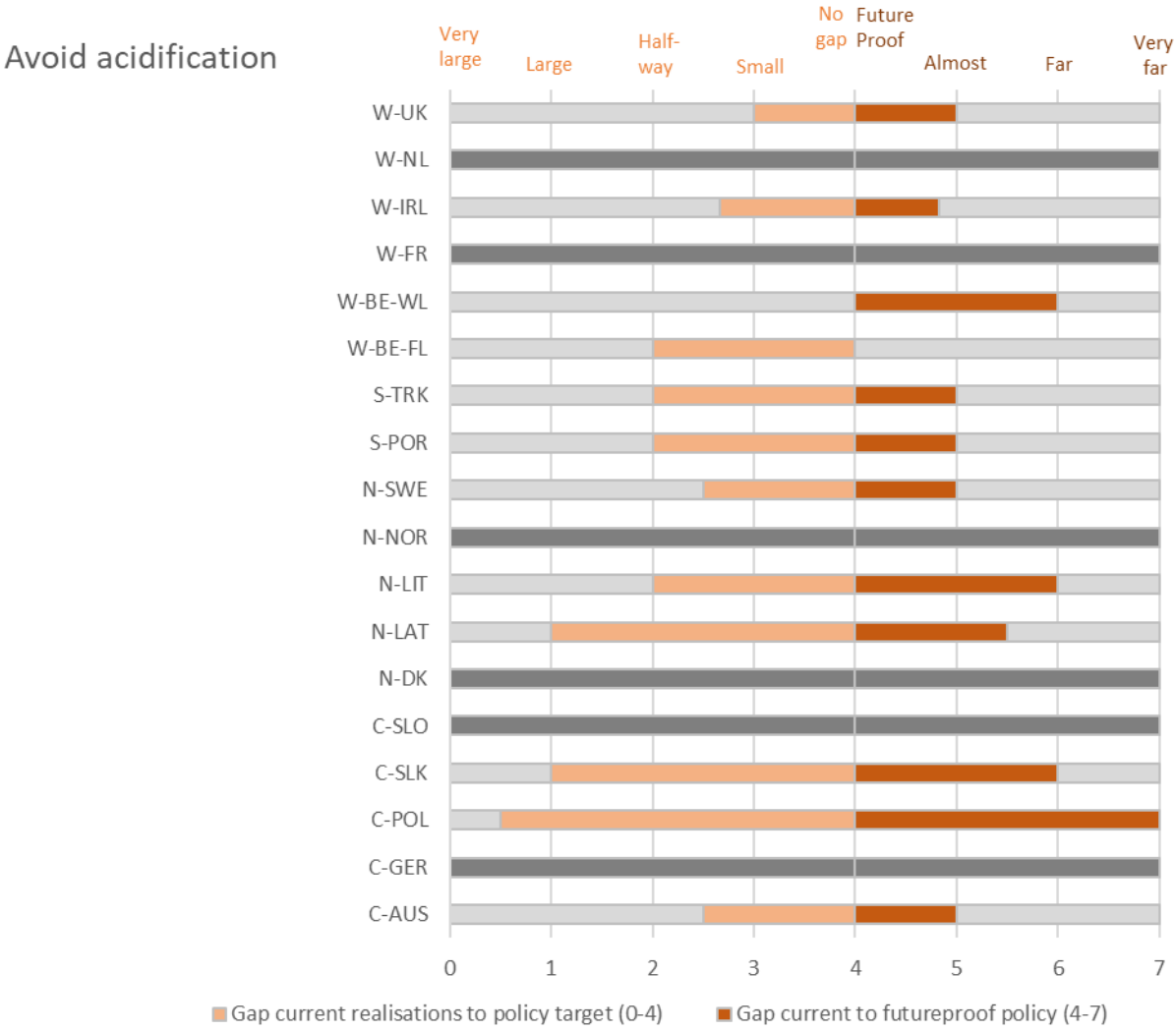
Avoid acidification



*For the dark grey bars no data is provided.

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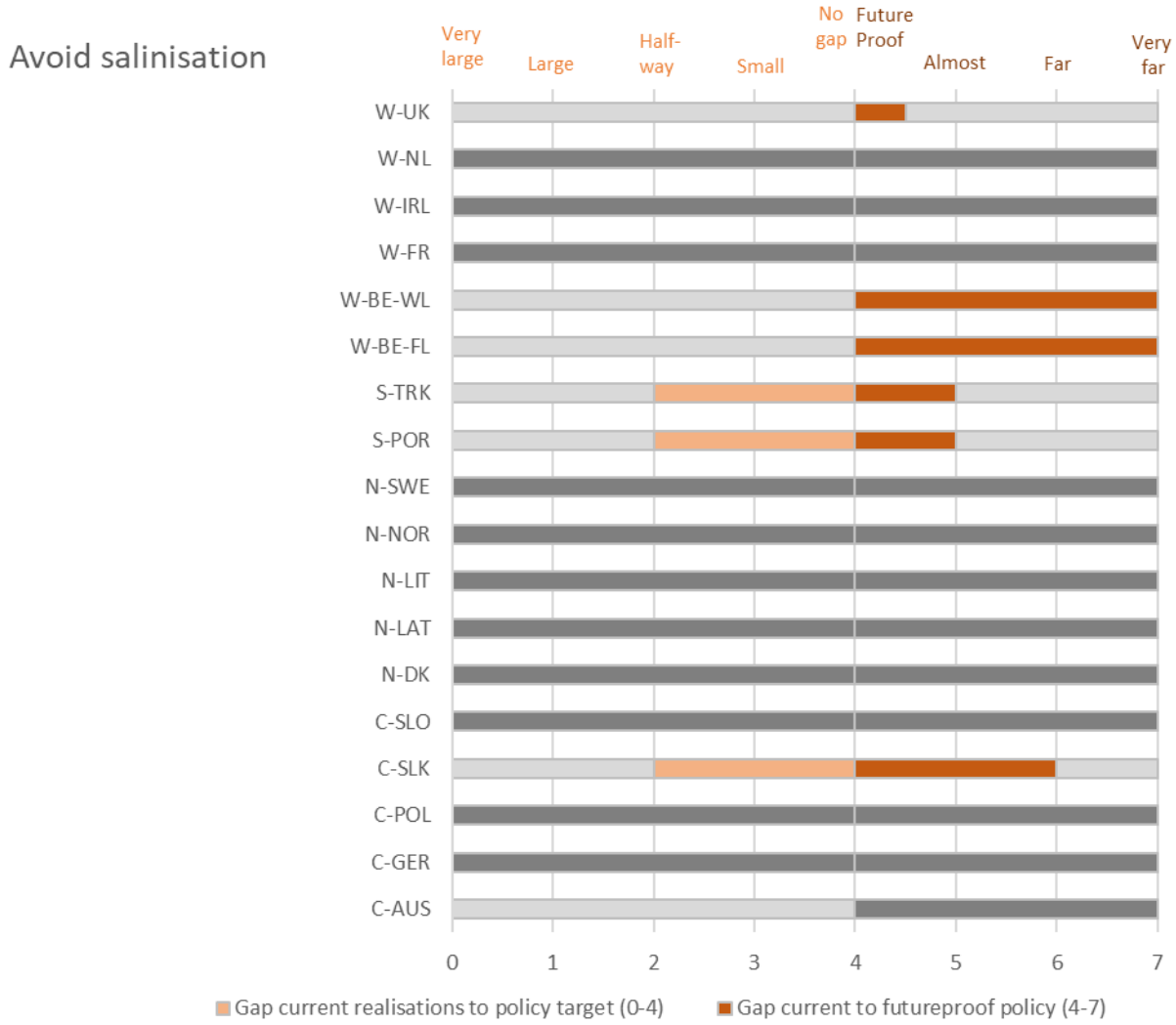
Avoid salinisation



*For the dark grey bars no data is provided.

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Annex IV: Extended list soil-related management practices

In this Annex the shortlist of soil-related management practices (see chapter 2.4 soil management), is extended from only a top list covering all soil challenges, to a grouped list, including the top soil management techniques of each soil challenges. The most important soil management techniques for each soil challenge are identified by the 50% top off for the successive soil challenges, that means that the relative weight of the soil management techniques is at least 50% of the total weight. Also techniques with an equal share above the 50% top off are included.

Soil management - policy

Table 22: Key soil-related management techniques listed in policy documents for the different soil challenges (excl. soil sealing, as there has been confusion with soil structure for this challenge)

Soil management listed by POLICY(*)	Maint/increase SOC	Enhance soil nutrient retention/use efficiency	Optimal soil structure	Avoid N_2O/CH_4 emissions	Enhance water storage capacity	Avoid soil erosion	Enhance soil biodiversity	Contamination	Peat degradation (**)	Acidification (**)	Salinization (**)	Relative Weight (***)
Crops rotations												
Cover/catch crops	20	16	7	4	9	25	8	3	0	0	0	92
More grassland	17	9	6	8	11	9	6	5	3	2	1	77
More legume crops	6	10	2	8	1	1	3	2	0	0	0	33
Intercropping/multiple cropping	7	5	4	5	1	6	3	3	0	1	2	37
Perennial crops	9	1	1	1	1	3	0	0	0	0	0	16
Other- landscape features and buffer strips	0	0	0	1	4	6	4	0	1	0	0	16
Other:rotations	4	5	5	4	4	2	4	3	2	0	0	33
Organic matter/nutrient management												
Appropriate compost application	17	9	9	6	11	5	6	12	0	4	0	79
Better manure storage	2	8	0	16	2	0	2	9	0	0	0	39
Manure treatment	2	9	3	7	2	2	2	10	0	0	0	37
Fertilisation plan/advice	8	19	4	24	4	0	9	15	1	5	4	93
Reduced/more precise mineral fertiliser application	5	30	1	27	4	0	12	19	2	5	0	105
Incorporation of crop residues	9	6	5	2	4	5	6	1	0	0	0	38
Appropriate farmyard manure application	14	16	6	19	9	5	8	18	0	5	0	100
Other: Increase SOM	1	2	3	0	4	1	2	1	0	0	0	14
Other:organic	1	1	0	4	0	2	0	1	2	1	0	12
Agricultural systems												
Agroforestry	10	3	2	2	3	5	3	1	0	0	0	29
Organic farming	11	9	8	4	4	2	10	5	2	0	0	55
Conservation agriculture	6	4	3	2	0	0	3	2	2	0	0	22
Agro-ecological farming	5	6	4	2	1	1	4	4	2	0	0	29
Precision agriculture	0	6	0	13	0	0	1	2	0	0	0	22
Other:systems	1	1	0	2	0	0	2	1	2	0	0	9
Buffer strips/small landscape elements												
Grass buffer strips	6	1	2	3	6	29	13	6	1	0	0	67
Hedges	4	0	0	1	4	14	16	1	1	0	0	41
Other- trees in group	0	0	0	1	4	6	4	0	1	0	0	16
Other buffer strips	4	2	0	2	6	17	19	6	1	0	0	57
Tillage and traffic												
Decision support system for risk of soil compaction	0	2	5	0	4	6	3	0	0	0	0	20
No till	5	1	8	0	2	15	3	0	1	0	0	35
Low pressure (in) tires	0	0	9	2	1	6	2	0	0	0	0	20
Non-inversion/reduced tillage	7	6	14	2	10	22	11	3	0	0	0	75
Other:tillage	1	2	4	0	1	4	1	0	2	0	0	15
Water management												
Allow flooding	2	0	3	0	4	3	1	0	0	0	0	13
Subsurface drainage	1	1	1	2	1	1	3	1	2	1	0	14
Increasing water tables	2	1	2	3	2	0	3	0	6	1	0	20
Other: Wetland Cultivation	0	0	0	0	0	0	0	0	2	0	0	2
Other:water	1	2	0	1	3	2	0	1	2	0	1	13
Crop protection												
Precision herbicide application	0	0	0	0	0	0	2	10	0	0	0	12

(*) The list of soil management techniques represent the summed group of the most important management techniques of the soil challenges. From these, the 25% most important soil management techniques (third quartile) for each soil challenges are indicated in grey.
(**) The results for peat degradation, acidification and salinization are based on a limited amount of policy documents and should therefore be interpreted carefully.
(*) The list of soil management techniques represent the summed group of the most important management techniques of the soil challenges

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Soil management – stakeholders

The extended table is similarly drafted for the stakeholder inputs as for the policy analysis. The most important soil management techniques per soil challenge are identified by the 50% top off, that means that the relative weight of the soil management techniques is at least 50% of the total weight.

Table 23: Key soil-related management techniques listed by the stakeholders for the different soil challenges (excl. soil sealing, as there has been confusion with soil structure for this challenge)

Soil management listed by STAKEHOLDERS(*)	Maint/increase SOC	Enhance soil nutrient retention/use efficiency	Optimal soil structure	Avoid N_2O/CH_4 emissions	Enhance water storage capacity	Avoid soil erosion	Enhance soil biodiversity	Contamination	Peat degradation (**)	Acidification	Salinization	Weight (**)
Crops rotations												
Cover/catch crops	156	112	88	64	92	263	97	17	14	20	18	941
More grassland	166	47	61	36	120	116	141	26	134	19	12	878
Permanent grazing	55	7	27	37	3	9	9	5	71	0	0	223
Intercropping/multiple cropping	59	42	85	21	22	48	116	27	6	11	13	449
More legume crops	57	91	58	79	14	11	42	12	1	16	5	385
Perennial crops	71	11	24	24	38	128	30	15	56	2	2	401
Organic matter/nutrient management												
Appropriate farmyard manure application	77	125	71	86	96	16	56	84	16	92	17	737
Appropriate compost application	75	54	103	19	87	13	58	71	11	61	8	561
Better manure storage	9	37	14	127	6	5	11	33	7	2	8	259
Manure treatment	8	15	9	79	7	5	6	14	4	10	0	157
Valorisation of waste streams	15	68	16	17	15	7	7	28	1	10	17	200
Reduced/more precise mineral fertiliser application	9	164	16	238	4	4	72	124	13	192	99	935
Fertilisation plan/advice	26	161	19	141	12	12	28	138	16	268	106	925
Incorporation of crop residues	135	75	94	11	67	18	51	15	14	22	2	504
Other: it is advisable to increase organic inputs to reduce soil mining of key plant nutrients	0	0	0	0	0	0	0	0	0	100	50	150
Liming	0	0	20	0	0	0	0	0	0	133	17	170
Agricultural systems												
Conservation agriculture	61	22	57	24	76	68	59	43	94	25	18	546
Precision agriculture	37	107	15	88	10	8	13	51	7	59	113	507
Organic farming	50	28	32	40	33	24	91	128	12	22	44	505
Agro-ecological farming	32	66	45	14	26	38	103	75	41	28	73	541
Buffer strips/small landscape elements												
Grass buffer strips	23	32	22	22	41	125	50	48	31	0	0	393
Tillage and traffic												
No till	83	15	70	16	89	118	100	4	133	9	0	637
Controlled traffic farming	18	16	133	29	71	44	20	44	20	6	0	400
Non-inversion/reduced tillage	134	42	167	70	71	160	146	13	82	25	7	918
Water management												
Allow flooding	3	15	4	4	20	8	3	12	73	0	31	172
Increasing water tables	18	8	3	26	51	5	2	3	319	0	19	453
Irrigation	6	44	23	3	99	25	5	8	10	0	184	406
Subsurface drainage	9	18	40	38	44	26	4	12	48	3	106	348
Crop protection												
Mechanical weeding	0	19	19	6	12	3	24	136	5	18	3	245
Precision herbicide application	5	20	14	11	5	8	39	168	2	33	25	330

(*) The list of soil management techniques represents the summed group of the most important management techniques of the soil challenges. From these, the 25% most important soil management techniques (third quartile) for each soil challenges are indicated in grey.

(**) The weight gives the sum of the soil challenges addressed by the soil management technique, In shades of red the importance of the techniques is visualized.

Comparison between policy and stakeholders

Additionally, we present a comparison based on the extended soil management lists of both the policy analysis and the stakeholder views.

The table below provides insights whether or not key soil management practices (from Table 22 and Table 23) are shared between the stakeholders and policy documents.

- Green: soil management techniques listed by both stakeholders and policy
- Light red: soil management techniques listed by stakeholders but not in policy
- Dark red: soil management techniques listed by policy, but not mentioned by the stakeholders

In the table, also the targeted soil challenges with the soil management techniques are identified.

- Grey marked: 25% top ranked soil management technique in policy

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- Blue marked: 25% top ranked soil management technique listed by stakeholders

Table 24: Comparison between key soil-related management techniques listed in the policy documents and by the stakeholders for the different soil challenges (excl. soil sealing, as there has been confusion with soil structure for this challenge). P: policy; S: stakeholders; Green: both by policy and stakeholders; light orange: only by stakeholders; dark orange: only by policy

	Maint/increase SOC		Enhance soil nutrient retention/use efficiency		Optimal soil structure		Avoid N_20/CH_4 emissions		Enhance water storage capacity		Avoid soil erosion		Enhance soil biodiversity		Contamination		Peat degradatio		Acidification		Salinization	
	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P
Agricultural systems																						
Agro-ecological farming																						
Agroforestry																						
Conservation agriculture																						
Organic farming																						
Other:systems																						
Precision agriculture																						
Buffer strips/small landscape elements																						
Grass buffer strips																						
Hedges																						
Other buffer strips																						
Other- trees in group																						
Crop protection																						
Mechanical weeding																						
Precision herbicide application																						
Crops rotations																						
Cover/catch crops																						
Intercropping/ multiple cropping																						
More grassland																						
More legume crops																						
Other-landscape features and buffer strips																						
Other:rotations																						
Perennial crops																						
Permanent grazing																						
Organic matter/nutrient management																						
Other: Increase SOM																						
Other:organic																						
Appropriate compost application																						
Appropriate farmyard manure application																						
Better manure storage																						
Fertilisation plan/advice																						

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Incorporation of crop residues																					
Liming																					
Manure treatment																					
Other: it is advisable to increase organic inputs to reduce soil mining of key plant nutrients																					
Reduced/more precise mineral fertiliser application																					
Valorisation of waste streams																					
Tillage and traffic																					
Controlled traffic farming																					
Decision support system for risk of soil compaction																					
Low pressure (in) tires																					
No till																					
Non-inversion/reduced tillage																					
Other:tillage																					
Water management																					
Allow flooding																					
Increasing water tables																					
Irrigation																					
Other: Wetland Cultivation																					
Other:water																					
Subsurface drainage																					

(*) The list of soil management techniques represents the summed group of the most important management techniques of the soil challenges. From these, the 25% most important soil management techniques (third quartile) for each soil challenges are indicated in grey for the stakeholders and blue for the policy documents.
*

Observations:

- There is some agreement between the stakeholders and policy documents, but there also specific differences:
- Mechanical weeding, permanent grazing, liming, increasing organic inputs, valorization of waste stream, controlled traffic farming and irrigation are soil management techniques listed by the stakeholders, while not high listed in policy documents.
- On the other hand: agroforestry, hedges, other buffer strips, group of trees, increase SOM, decision support system for risk of soil compaction, low pressure in tires and wetland cultivation are listed in policy documents, while not highly listed by the stakeholders.

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Annex V: Instruments to achieve aspirational goals as suggested by the national stakeholders

This annex lists instruments/measures as suggested by the stakeholders in Table 7 of the questionnaire see (Annex II) to achieve aspirational goals. These instruments/measures were suggested per soil challenge. For each soil challenge, the instruments/measures were grouped into several different clusters. These clusters were ranked according to 1) the number of unique EJP SOIL countries from which stakeholders suggested instruments/measures and 2) the number of instruments/measures per cluster.

In a final category 'Other', a variety of instruments/measures were listed by the stakeholders. Therefore, no clusters were defined and all these instruments/measures are listed (per EJP SOIL countries).

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Maintain/Increase SOC

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Establish SOC monitoring	In order to establish a carbon market a cost-effective yet accurate SOC monitoring system at the field/farm level is needed.	BE-FL
		Soil carbon monitoring under supervision of State Plant Protection Service	Latvia
		Soil analysis to document status and trend of SOC. Moreover, to subsidise/stimuli for increased SOC in RMP. E.g. cover crops and crop rotations.	Norway
		It remains essential that the future of the Square Grid soil sampling C-content is secured. Important to Improve the visibility of SOC content by improving modelling.	Denmark
		Develop National method to calculate biochar carbon storage.	Norway
		Many challenges can be derived from the instrument "Determination of the SOC Content"	Austria
2	Establish C-market	Develop carbon trading or credit carbon for increasing SOC. Measures are based on SOC content targets and are left to the farmer to take the necessary measures	BE-WL
		A carbon market that includes carbon sequestration in soils that engages actors across the whole system. This requires: Research is required to show rates of carbon sequestration for different soils and management practices (so options can be ranked). Tools to spatially map soils/stocks and tools to collect activity data to realize and verify the options.	Ireland
		Enable farmers to accumulate funding for good practices related to soil carbon: carbon credit, CAP aid, etc.	France
		C trading schemes/ C markets	UK
		Several stakeholders mention a carbon market for rewarding farmers who sequester carbon	BE-FL
		A European carbon market would be beneficial because this would guarantee the level playing field in Europe.	BE-FL
		Market Based Domestic Carbon offsetting programmes need to be transparant in accounting carbon (no double accounting), certification method and organisation is needed.	BE-FL

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3	Reduce tillage	Avoid too many weeded crops. They require intensive tillage which accelerates the mineralisation of the SOC.	BE-WL
		No till or reduced tillage practices	Latvia
		Reduce soil tillage and encourage soil conservation agriculture	BE-WL
		Reduce tillage depth and overall reduce the amount of tillage operations.	BE-FL
		Further experiments on conservation agriculture	Portugal
3	Increase OM supply	The supply of organic matter could be facilitated. Financial tools could ensure that it is economically more profitable to sequester carbon than to remove e.g. crop residues for biobased fuels and the bioeconomy.	BE-FL
		Increase the use of valorisation of waste streams such as wood chips to increase SOC.	BE-FL
		support and fund initiatives for returning organic wastes of different origins to soils	UK
		Provide financial support for farms, who use green manure (these fields do not provide sufficient income during the green manure application season). Also support for animal manure and vermicompost use	Latvia
		As it is difficult to import organic matter, local exchanges of raw materials must be encouraged.	BE-WL
4	Compost/ manure/ biochar application	Recoupling plant and animal production. Regular application of farmyard fertilizers (manure, slurry, compost...)	BE-WL
		Use of compost or bedding animal manure	Latvia
		Facilitate the use of compost, organic fertilisers and bokashi.	BE-FL
		In areas with low SOC status, apply compost/biochar	Norway
5	Improve Education	Improve the advice	BE-WL
		Knowledge on complex approach for C content and sequestration in soil – scientific studies on topic within Latvian climatic conditions. Also management practices impact on soil C loss	Latvia
		Create awareness of agronomic advantages of high humus content	Austria

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5	Organic farming/ increase OM addition	Encourage organic farming which this implies a regular supply of OM	BE-WL
		Bio-Suisse', the swiss organic label promotes maintenance and increase in SOM	Switzerland
		Increasing organic matter addition	Turkey
6	Use Grassland	Maintenance of permanent grasslands (avoid ploughing them, more restriction of CAP derogations)	BE-WL
		Optimize the management of grasslands	BE-WL
		Land use change such as conversion of cropland to grassland/forest	UK
7	Crop residue incorporation	Long rotation, integration of temporary meadows with legumes, incorporation of crop residues	BE-WL
		Encourage soil cover and restitution of the crops residues	BE-WL
		Encourage crops with a high return of residues (e.g. grain maize).	BE-WL
8	Establish concept of C-balance	Establish a carbon balance at the farm level which should reach a positive balance	BE-WL
		Achieve at least the status of SOC inputs = SOC outputs	Slovakia

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Avoiding N_2O, CH_4 emissions

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Improve manure storage/spreading	We need to be stricter on the techniques of spreading and burying manure in the soil. Encourage the group purchase of such machines, which are often expensive. Increase investment aids	BE-WL
		Better manage storage of farmyard fertilizers	BE-WL
		Amend the legislation on the setting of dates for the application of farmyard manure and allow the application to be modulated according to optimal weather conditions (e.g. on cold, cloudy days) in order to limit N2O emissions	BE-WL
		Rapid animal manure incorporation in soil	Latvia
		Economic incentives for methods for manure spreading.	Norway
		Regulatory instruments in the framework of the manure legislation (Nitrates Directive)	BE-FL
		Requirements for manure storage, methods for spreading	Norway
2	Reduce fertilizer use	Reduction of mineral fertiliser use	BE-WL
		Reducing excess N fertilizer	Turkey
		Improve intrinsic soil fertility and promote natural cycles in order to be less dependent on mineral fertilisers	BE-WL
		Focus on nitrogen-use-efficiency as a breeding target (by enhanced breeding methods and gene-editing) --> less fertiliser application necessary	Austria
		Measures that reduces soil compaction, improve current drainage systems and reduces fertilizer level.	Norway
		limit N fertiliser use	UK
3	Improve crop (residue) management	Avoid leaving coverings or crop residues on the soil surface. This creates anaerobiosis, which increases the formation of GHGs	BE-WL
		Encourage the surface incorporation of all types of OM (crop residues, farmyard fertilisers...) and better at the end of winter.	BE-WL
		Provide soil cover for longer periods	Latvia

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4	Improve education	Better support for the farmer and not linked to the fertiliser seller	BE-WL
		Research based recommendation on emission reduction practices	Latvia
4	Reduce livestock	Cattle reduction and extensification	BE-WL
		Significantly reduce livestock production/consumption	UK

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Avoid peat degradation

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Improve Protection	Areas with maximum protection status and funded management	BE-WL
		Keep peat areas	Turkey
		Land consolidation is needed to ensure that agricultural production is relocated from the low lying peatlands.	Denmark
		Action plan to protect carbon hotspots such as peat areas and wet grasslands based on accurate mapping of these hotspots and appropriate business models for farmers on these sites	BE-FL
		Limit peat bog extraction	Latvia
		No more property development	UK
		prevent all agricultural production from lowland peats	UK
2	Alternative management	Research documenting effect of different cultivation methods of peatland (on emissions).	Norway
		Create management plans for all peats in Norway, differentiated by type	Norway
		There should be no arable land on peat soils	BE-FL
		To favor proper recultivation of degraded soils, limit development of new drainage systems, respectively – degradation of wetlands	Latvia
		Reduced, extensive management of organic soils	Latvia
		Research into management alternatives for farmers and landowners.	Ireland
3	Rewet/restore peat areas	Rewetting is employed as the main policy response to reduce peat degradation.	Denmark
		Construction of water retention facilities in the country.	Slovakia
		Restoration of abandoned meanders of watercourses.	Slovakia
		Restoring cultivated peat (shallow).	Norway
4	Reduce use of peat	Facilitate alternative plant substrates (lignin based hydrogel application)	Austria

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		promote/enforce use of peat free compost for non-commercial uses	UK

Avoid soil erosion

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Change agricultural management system	Better support for farmers with a view to changing practices. Specific follow-up with incentives for farmers who adopt anti-erosive partices	BE-WL
		Change of land management system.	Slovakia
		Limiting the monocultures areas in LPIS reference parcels	Slovakia
		Encouraging coordinated management of agricultural areas to alternate winter and spring crops.	BE-WL
		Encourage agro-forestry and soil conservation agriculture that reduce soil tillage, increase soil cover, promote crops association…	BE-WL
		Combination of agricultural, forestry and water management measures in the country with regard to natural production conditions	Slovakia
		Contour farming, contour agroforestry, or planting hedgerows or food/crop trees on contour/keyline	BE-FL
		ban growing of crops harvested after September on high risk sites	UK
2	Reduce tillage	Encourage limited tillage measures. Decrease the intensive mechanisation of the agriculture	BE-WL
		Support of conservation tillage using modern technology.	Slovakia
		reduce soi tillage	Latvia
		Have soil types / areas where autumn bare soil is banned	UK
		Autumn ploughed area must be reduced and use of cover crops must increase.	Norway
2	Improve education	Education and knowledge transfer is vital across AKIS to build adaptive capacity.	Ireland

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		It would also be better if they could get access to farm-specific advice. This needs advisors that are specialised in the matter.	BE-FL
		Thus, subsidies and disseminations should be intensified	Norway
		Reinforcing support services for farmers.	BE-WL
		Good agricultural practices	Turkey
3	Adapt Crop rotation	Control the rotation. Reduce the proportion of spring crops/weeded crops (beet, potatoes, maize) on a catchment area	BE-WL
		More perennial crops, grasslands	Latvia
		Rotations with less erosion sensitive crops in between crops that are more erosion sensitive.	BE-FL
3	Landscape elements	Landscape approach to reduce run-off with landscape elements were water can infiltrate so that downstream erosion is reduced.	BE-FL
		Trees as natural barriers to avoid wind erosion	Latvia
		nstallation of hedges	BE-WL
4	Maximize Soil cover	Encourage 100 % of the soil cover (catch/cover crops, long winter crop, perennial crop...)	BE-WL
		Enhance soil cover, contour plow on slopes	Latvia
		Limit the bare soil time per farm. A farm would have a maximum bare soil time depending on its crop rotation.	BE-WL
5	Adapt tillage	Annual change of direction of soil tillage and aversion	Latvia
		Continuous efforts to improve techniques that combat soil erosion on-site in co-creation with farmers. These continuous efforts are needed to keep the attention of farmers towards the problem.	BE-FL
5	Increase SOC content	Paying farmers for maintaining soil carbon or increasing SOC is also beneficial for avoiding soil erosion.	BE-FL
		Increase COS: application of OM, SEI	BE-WL

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Avoid soil sealing

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Improve land use planning	Urban planning policy: take soil quality into account in town planning documents	France
		Local spatial planning programmes of communities	Austria
		Spatially sensitive land use planning that considers the implications of sealing.	Ireland
		Need awards or scheme for construction	UK
		need of much closer links between urban planners and managers of the rural landscape	UK
		There are many different tactics from the field of planning law and property rights that could be beneficial for the prevention of soil sealing.	BE-FL
2	Prohibit/limit land use change of agricultural soil	Re-enforce land use planning measures and prohibiting land use change for agricultural land, specially for very productive soil	BE-WL
		Reallocation of land for other purposes than agriculture should be strict.	Norway
		Just like natural protected sites, all agricultural areas can be declared protected sites	Turkey
		Conversion of farmland to other land uses than farming is prohibited by law.	Denmark
3	Prohibit/restrict soil sealing	To legislate and prohibit new construction. State right of seizure in the sale of agricultural land.	BE-WL
		Building tax assigned to soil knowledge	France
		The restriction of SOIL SEALING in water management areas is crucial	Slovakia
4	Transform existing soil sealing	Reuse of soil (Land recycling): redevelopment of previously developed land (brownfield) for economic purpose.ecological upgrading of land for the purpose of softuse (e.g. green or open areas in the urban centres), re-naturalisation of land (transforming it back to nature) by removing existing structures and/or desealing surfaces	Austria

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		This is/needs to be embedded in spatial policies: e.g. decrease % of sealed surface or minimum % of non-sealed surface during infrastructure works.	BE-FL

Avoid salinization

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Research on efficient water management	Be careful with irrigation development due to climate change and increase of periods of drought.	BE-WL
		Develop alternative to irrigation.	BE-WL
		The main task is the high level of mineralized groundwater.	Slovakia
		Effective drainage	Turkey
2	Correct fertilizer use	Use of fertilizers with acid reaction	Slovakia
		Reducing fertilizer and excess water use, soil- crop management	Turkey

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Avoid acidification

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Stimulate liming	Encourage liming with coarser products with long-lasting action	BE-WL
		Liming	Slovenia
		Subsidy for soil liming.	Slovakia
		Targeted soil liming	Slovakia
		Develop and offer farmers simple tools to diagnose the need for liming.	BE-WL
		National liming strategy under development – this requires research in relation to co-benefits of such a strategy (integrated assessment)	Ireland
		Increasing the application of limestone and dolomite to the soil.	Slovakia
		Government supported measures for liming as well as liming as an action embedded in political documents (6)	Latvia
2	Avoid ammonium fertilizer	Avoid acidifying mineral fertilisers (e.g. ammonium sulphate).	BE-WL
		Reducing excess NH4 fertilizer use and proper fertilization	Turkey
3	Stimulate organic fertilizers	Encourage application of farmyard fertilizers with long-lasting action.	BE-WL
		Encourage restitution of crops residues	BE-WL

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Avoid contamination

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Management of alternative (organic) fertilizers	Waste stream verification/certification before land application	UK
		value the waste streams more effectively	UK
		Natural fertilizers that are available in Latvia should be used and not chemicals	Latvia
		requirements for environmentally friendly spreading of livestock manure	Norway
		Mandatory qualitative analysis for all organic matter spread (excluding farmyard fertilizers). Be careful with the impact on soil quality at long terms.	BE-WL
		Encourage Organic Farming that use the natural cycles of struggle.	BE-WL
		Another possibility is mixing usage of natural fertilizers with using chemicals setting a definite goal for farmers to use specific amount of natural fertilizers and embed it into the fertilization plan.	Latvia
		Be careful with by-products (station sludge, circular economy).	BE-WL
		Be careful with phosphate fertilizers.	BE-WL
		Government supported program for building or updating manure storages	Latvia
		Accurate monitoring and localization of inputs, as well as quality control of fertilizers on the market.	Slovakia
2	Improve nutrient management	Water buffer strips to prevent rinsing of nutrients and plant protection products	Slovenia
		Fertilizer plans needs to be followed up (2)	Norway
		Reduce excess P and micro nutrient base fertilize use. And avoid use heavy metal contaminated organic wastes	Turkey
		Be careful with the new EU Fertilizer Regulation. Improve the characterization/contol of fertilizer. Improve the characterization of soil, in order to avoid any exceeding of contaminant limits.	BE-WL

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3	Improve use of plant protection products	Reduction of pesticides use. Particular attention to pesticides using heavy metals (Bordeaux mixture, sulphurous mixture, etc.).	BE-WL
		Development of a mapping tool for areas at risk or sensitive to pesticides.	BE-WL
		requirements for use of pesticides	Norway
		Use of agricultural chemicals should be closely monitored	Latvia
		Developing an independent advisory service for pesticide use and integrated pest management (e.g. : AKIS)	BE-WL
3	Management of degraded soil	Research to identify and remediate high risk soils and cropping strategies that low affinity for contaminants.	Ireland
		To avoid further spreading of contaminated soils. information on soil quality (including contamination) should be readily available to all users of land. Monitoring data are needed to complete databases.	BE-FL
		We foresee in the future more emphasis on management of contaminated sites. i.e. prevention of further spreading and exposure, rather than excavation, using the soil certificate as instrument to achieve this.	BE-FL
		Quality of brought in soil (contamination, stone content) for relief changes should be ensured.	BE-FL
		Revitalization of degraded land	Slovenia

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Optimal soil structure

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Equipment: Technological development	Reduce the size of agricultural equipment	BE-WL
		Support of conservation tillage using modern technology, use of post-harvest residues.	Slovakia
		reduced tractor size.	Norway
		Encourage the use of specific equipments and technics: direct seeding. Simplified cultural technics, decomposed beet harvesting machines, etc.	BE-WL
		Wider tires for better weight distribution. Rotation/ avoidance of repeated technological roads in field. Remark: hart to achieve with current field configuration and tools/ tractors	Latvia
		Mechanical weeding	Slovenia
		Grants for introduction of new technology (e.g. robots) to reduce soil compaction.	Norway
2	Adapt crop rotation	Extension of the grassy area of valleys and shallow soils.	Slovakia
		Avoid Rotations in which spring crops are dominant.	BE-WL
		Recommended to grow plants in secondary cultures with deeper root systems – buckwheat, oil radish, etc.	Latvia
		Crop rotation for cereals	Latvia
		Maintaining sequence of plants and green manure incorporation into the soil	Latvia
		To oblige cover crops when not obliged yet by the manure decree.	BE-FL
		crop rotation	Slovakia
		Increase the diversity of the cover crops/catch crops/winter crops	BE-WL
3	Increase SOC content	Increase the OM input (cover crops, crop residues. diversification of rotations, hedges....) which will stimulate microbial life which in turn will improve the soil structure.	BE-WL
		Financial remuneration for increasing SOC (see above).	BE-FL
		Set a C min rate per region or soil type.	BE-WL

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		Advice and measures for increased SOC (e.g. catch crops), advice on crop rotation.	Norway
		Positive balance of soil organic matter, reduction of heavy mechanization.	Slovakia
4	Improve education	research on remediation and amendments.	Ireland
		Farmer education on soil management practices – right time and with the right technics/tools	Latvia
		Education on more effective/planned approach, where several technics can be merged and executed during the one session	Latvia
		Illustration videos and demonstration fields.	Norway
		Proper sowing procedure.	Slovakia
5	Supporting tools	Further developed of VSA tools for advisors	Ireland
		greater KT on tools already developed	Ireland
		Tools for controlled traffic farming (CTF).	Ireland
		Decision support tool is available that enable farmers to assess the potential impact on their fieldwork on soil structure, could be supported in policy interventions.	Denmark
		Terranimo® is a model for prediction of the risk of soil compaction due to agricultural field traffic.	Switzerland
6	Stimulate organic fertilizers	Encourage the application of farmyard fertilizers (manure. slurry). Recoupling plant and animal production	BE-WL
		Encourage liming	BE-WL
		Organic fertilizer use	Turkey
6	Mechanical loosening	Occasional loosening	Slovenia
		Tillage with cultivator (deep loosening of heavy soils)	Slovenia
		Deep ploughing	Latvia
7	Responsibility for external contractors	External contractors should be included in support schemes as they perform the majority of the field work and account for 50 % of machinery investments.	Denmark
		Require agricultural contractors to have a “soil quality” mark	UK

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Enhance soil biodiversity

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Improve education	Advice, demonstration fields showing effective measures.	Norway
		Research to understand, quantify and translate the benefits of soil biodiversity and the tangible returns to agriculture and society.	Ireland
		Government supported set of measures to choose from introduced to farmers, after up to date condition of soil is determined, for example reduced usage of herbicides	Latvia
		more effective and meaningful assessment toolkit – linking soil biodiversity to soil functions	UK
		documentation based on soil samples	Norway
2	Stimulate organic fertilizer/ Reduce mineral fertilizer	Crop-soil management and organic, organomineral fertilizers use	Turkey
		Mixed farms should be introduced in different areas, where animal manure mixed with stray and hay is used to fertilize fields.	Latvia
		Reduction of mineral fertiliser use.	BE-WL
		Microbial fertilizer use	Turkey
		Fertilisation must be rethought and focused on the needs of the plant and not on the effluents to be "eliminated".	BE-WL
3	Stimulate organic farming	Encourage organic farming	BE-WL
		Bio-Suisse' label: fertilization and soil management has to promote soil life. Prohibition of synthetic fertilizers, promotion of conservation tillage	Switzerland
		Organic farming.	Slovakia
3	Reduce use of plant protection products and stimulate mechanical weed control	Reduction of pesticides use. Encourage mechanical weed control	BE-WL
		Precise use of effective plant protection products in combination with preventive, mechanical and biotic measures	Slovenia
		reduced use of pesticides	Norway
3		supplementary measures such as crop rotation	Norway

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	Improve crop rotation	Recommended usage of mixed cultures as well as grass used in plant sequence over the harvest seasons.	Latvia
		Crop residues left on the field; some farmers that practising reduced tillage or Conservation Agriculture are very keen on growing many different catch crops in order to increase soil biodiversity.	Denmark
4	Reduce tillage	Reduction of soil tillage. Encourage agricultural system towards conservation of soil (cover crop, restitution of residues, reduction of soil tillage...).	BE-WL
		reduced tillage	Norway
4	Adapt grassland management	Grazing should be used on secondary cultures.	Latvia
		A combination of annual mowing and occasional grazing	Slovenia

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Enhance soil nutrient retention/use efficiency

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Develop fertilizer plans	Develop good fertilisation plan. Fertilisation must be rethought and focused on the needs of the plant and not on the effluents to be "eliminated".	BE-WL
		Bio-Suisse: Nutrient balance has to be reduced to a minimum and has to be adapted to the specific location	Switzerland
		Improved fertilizer planning - follow-up of fertilizer plans	Norway
		Impose that 100% of plant proteins be produced in France (or in Europe)	France
		(fertilization) tool based on mineral balance	Netherlands
		Split fertilizer levels use, use fertilizers according to soil and plant analysis results	Turkey
		provide funding that allows schemes and practices with long-term benefit to be operationalised in the short-term	UK
		Requirement to have overview of nutrient balance.	Norway
2	Apply precision fertilisation	Mandatory use of precise fertilization system with precise fertilization plans and harder measures taken on farmers who do not obey it	Latvia
		Precision fertilization system.	Norway
		Farmers report a potential for improving the use of precision farming, as an opportunity to reduce nutrient loss, but lack policy incentives and knowledge for practitioners.	Denmark
3	Improve crop rotation	Supporting new sectors that lead to diversification and longer rotations.	BE-WL
		Rotational measures seem to be indispensable. A maximum average Potential Lixiviable Nitrogen per farm calculated according to its plot, so that each farm is limited in the area of crops at risk. Example: for each hectare of at-risk crops, 1 hectare of grassland must be compensated for.	BE-WL
		Permanent soil cover.	BE-WL
		crop rotation	Slovakia
4		Increase SOC and improve clay-humic complex.	BE-WL

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	Increase SOC content	Measures and instruments that increase soil organic content and improve soil structure	Norway
4	Improve education	There is a need to promote crop rotations	Norway
		better understanding of the interaction among multiple elements in soils	UK
5	Stimulate improved organic fertilizer use	Livestock manure - improvements in both storage and spreading	Norway
		Stimulate to use of organic waste products as fertilizers by: increased knowledge, incentives, requirements, subsidy schemes (ex. Delivery of livestock manure to biogas)	Norway

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Enhance water storage capacity

Rank	Cluster	Instrument/measure	EJP SOIL country
1	Stimulate soil water management initiatives	Involve water companies or local authorities to fund new initiatives	UK
		To increase the accumulation of water in the soil is possible only by maximally limiting its outflow on the surface during intense rainfall. Accumulation of water takes place in capillary pores. which cannot be artificially created; therefore the increase of the accumulation capacity is possible by measures similar as by water erosion of the soil (year-round coverage of the soil by vegetation. formation of macropores in the surface. etc.). Small terrain modification, inside LPIS reference parcels to reduce surface runoff and increasing rainwater infiltration.	Slovakia
		Sewing belts, windbreaks, drainage channels with sluices for water retention	Slovakia
		Infiltration and drainage of agricultural soils – requires additional research that can identify the threshold tipping points -indicators. Education pollution swopping/trade-off – e.g. nitrate/carbon losses versus N20 etc.	Ireland
		Increasing impact of climate change, calls for the introductoin of new management strategies for water storage and infiltration.	Denmark
		A number of stakeholder representing farmers note that for them issues about draining is a most central concern in the protection of the production potential of farmland.	Denmark
		consider natural flood management activities such as scrapes, leaky debris dams, beavers, and flooded areas	UK
		Government funding for drainage system repairs and/or maintenance	Latvia
		Proper bank management, more pastures that can be flooded, contour farming pools	BE-FL
2	Increase SOC content	Increase the SOC.	BE-WL
		Balance the importation-exportation of organic matter.	BE-WL
		to financially renumarate farmers that increase SOC	BE-FL

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3	Adapt crop rotation	Encourage crop practices such as inter-row partition in potato cropping, hoeing of weeded crops…	BE-WL
		Encourage the soil cover (catch/cover crops, long winter crop, perennial crop...) that improve soil porosity. Avoid leaving the ground bare.	BE-WL

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Other

Instrument/measure	EJP SOIL country
Encouraging the change of agricultural systems towards better soil conservation. with an intensification and diversification of the crops (cash, cover, catch, winter crops). Develop more productive cover crops. Rethinking the rotations and the practices to better soil conservation.	BE-WL
Limit the maximum size of field.	BE-WL
Encourage farmer who valorises exogenous organic matter.	BE-WL
Forage autonomy, diversification and a certain circular management of the farm can have a cross-cutting effect on many aspirational goals.	BE-WL
Improve intrinsic soil fertility in order to eliminate exogenous inputs and improve soil resilience (erosion, drought...).	BE-WL
The NFP68 recommends: to consider soil quality, the individual soil functions and ecosystem services for future land use decisions	Switzerland
The NFP68 recommends: a comprehensive mapping of Swiss soils	Switzerland
The NFP68 recommends: The establishment of a Swiss Soil Information Platform. which develops standardized sampling methods, ensures the nationwide harmonisation of soil information, makes interactive products such user and soil function maps available and ensures access to them for science, authorities and practice.	Switzerland
The NFP68 recommends: to provide consumers with information on sustainable use of soil in Switzerland and abroad	Switzerland
The NFP68 recommends: Cooperation between the various stakeholders - in particular between environmental, agricultural and spatial planning experts - should be deepened and coordinated at all levels of government	Switzerland
The NFP68 recommends: to promote the implementation of the Swiss Soil Strategy and to raise awareness of soil issues in society	Switzerland
Education events: Letting farmers talk to farmers. You have to make the farmers understand the soil system and the connections, because one-dimensional thinking does not work in the field of reaching soil targets (1).	Austria
"Systemic measures": More effort should be made not to focus only on 1 target, but to think about other environmental impacts as well and to take measures that are not specific but that cover many objectives halfway. Otherwise you will soon find yourself in a conflict of objectives which, in the worst case, could lead to you doing nothing at all (1).	Austria

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• Nature conservation contracts with farmers / Vertragsnaturschutz: sustainable, site-specific agricultural management of semi-natural, valuable areas incl. regular mappings (1)	Austria
Mountain Farming Protocol of the Alpine Convention: mountain farming which suits local conditions and is environmentally compatible (1);	Austria
AG6 EUSALP - Declaration on sustainable land use and soil protection, Oct. 2018 (1)	Austria
UN Sustainable development goals (UN. 2015), in particular goal 15.3 combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world, indicator 15.3.1: Proportion of land that is degraded over total land area (1)	Austria
Training of farmers and advisors on sustainable practices (5)	Portugal
Model experimental farms at regional level (2)	Portugal
Definition of eco-regions for targets related to agricultural soil	Portugal
Implementation of national monitoring system of soil quality.	Portugal
"The challenges need to be considered in all-encompassing way i.e. what are the synergies and conflicts (if any) between them.	Ireland
There is a need to create workable solutions that farmers will engage with, and be suitably rewarded for.	Ireland
One practice that comes to mind is the use of cattle grazing a way to manage multi-species swards/high biodiversity swards.	Ireland
The use of cover crops in tillage farming also has potential benefits for SOC, nutrient cycles and biodiversity.	Ireland
Workable solutions that farmers can engage with and be sufficiently rewarded to deliver on for society.	Ireland
One of the most important instruments for farmers is a financial one. They ask for more funds to update their farms so they could manage them more sustainable. for example bigger support for maintaining grasslands. There are many biological farmers that ask for appropriate financial support that would live up to the money and effort that they put into managing their farms (7).	Latvia
More attention and support should be brought to the small farms - up to 100 ha.	Latvia
Other very important instrument is knowledge. For farmers, especially the new ones it should be mandatory to have appropriate education in specialized university. For the old ones a possibility of more specialized courses should be available. It would give them the opportunity to learn about alternative	Latvia

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management (especially fertilizing), they would get a new perspective on agricultural systems as most of them still use methods from the Soviet Union (12).	
More well-trained consultants that specialize in sustainable agriculture and soil systems are needed to help farmers with planning their land management (4).	Latvia
Equal conditions for all farmers in all EU countries as well as rationalized allocation of EU funds (max limit set for big farmers) (3)	Latvia
Soil passport (currently being developed by the policy department of agriculture and ILVO).	BE-FL
One stakeholders says to miss the link between the soil, the soil type, the landscape (the natural system including water) and the soil management solutions. If you consider the whole system you can work on an integrated management (crop choice, fertilization methods, choice of machinery).	BE-FL
There should be more attention to agricultural soils in spatial planning. The most suitable soils should get the most suitable land use and management (cfr permaculture principles)	BE-FL
Binding thresholds in e.g. CAP	BE-FL
To compensate farmers for ecosystem services (so not only for carbon).	BE-FL
Introduction of vouchers (3)	Netherlands
subsidies/financial rewarding on the basis of key performance indicators (2)	Netherlands
training of advisors/farm visitants (4).	Netherlands
comprehensive tool at farm level to monitor the soil condition in relation to targets (2)	Netherlands
subsidies for soil testing (1).	Netherlands
a set of best practices (1)	Netherlands

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Annex VI List of published policy analysis reports considered in the EU policy analysis

Nr	Document citation	Type of publication
1	McNeill. A.. Bradley. H.. Muro. M.. Merriman. N.. Pederson. R.. Tugran. T.. & Lukacova.. Z. (2018). Inventory of opportunities and bottlenecks in policy to facilitate the adoption of soil-improving techniques. SoilCare Report 09. EU SoilCare Project. Retrieved from https://www.soilcare-project.eu	research project report (H2020)
2	European Academies Science Advisory Council. (2018). Opportunities for soil sustainability in Europe. EASAC policy report 36. German National Academy of Sciences Leopoldina 2018. Retrieved from http://www.easac.eu/	policy advice report
3	Keesstra. S.D.. M. Muro. L. Maring. B. Arellano Jaimerana. M. Van Eupen. B. Elbersen. A. McNeill. T. Tugran. and A. Markowska (2020). Providing Support in Relation to the Implementation of Soil and Land Related Sustainable Development Goals at EU Level. Final Report. Report 3032. Wageningen Environmental Research. 2020.	policy advice report
4	Prokop. G. and Esteve. J. F. (2019). SOIL-RELATED POLICIES: GAPS AND NEEDS. ETC/ULS - Task 1833 – Milestone 4. European Environment Agency. Draft version Nov 2019. With permission.	policy advice report
8	Olazabal. C. (2019). The EU strategy for an integrated soil management. Presentation on behalf of the European Comission. DG ENV. in the colloquium 'GOOD SOIL'. 5 december 2019. Leefmilieu Brussel. https://leefmilieu.brussels/news/5-december-2019-colloquium-good-soil-naar-een-duurzaam-beheer-van-de-brusselse-bodems	communication from the EC
9	Chenu. C. (2020). Presentation in kick-off meeting EJP SOIL	communication from research
10	European Environment Agency (2019). The European environment - state and outlook 2020: knowledge for transition to a sustainable Europe. European Environment. https://doi.org/10.2800/96749	policy advice report
11	Elbersen. B.. Römkens. P.. Verzandvoort. S.. & Staritsky. I. (2019). SCOPING PAPER: EFFECTS AND ENVIRONMENTAL IMPLICATIONS OF DIFFERENT FARM MANAGEMENT ACTIVITIES. Framework Contract: EEA/NSS/17/002/Lot 1.	policy advice report
12	European Commission (2020a). The European Green Deal - Strategy From Farm to Fork COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT. THE COUNCIL. THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Farm to Fork Strategy for a fair. healthy and environmentally-friendly food system. COM/2020/381 final. Downloaded from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0381&from=EN	communication from the EC
13	Mission Board for Soil health and food (2020). Caring for soil is caring for life – Ensure 75% of soils are healthy by 2030 for healthy food. people. nature and climate. Interim report for the European Commission. Directorate-General for Research and Innovation and Directorate-General for Agriculture and Rural Development. First edition. 56 pp.	policy advice report
14	European Commission (2020). Future of the common agricultural policy. Briefs summarising the nine proposed specific objectives of the future CAP. https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/future-cap/key-policy-objectives-future-cap_en	briefs on legislative proposals of the EC
15	Massot Marti. A. (2020). Research for AGRI Committee – The Farm to Fork Strategy implications for agriculture and the CAP. European Union.	policy advice report
16	European Commission (2020b). Communication from the Commission to the European Parliament. the Council. the European Economic and Social Committee and the Committee of the Regions. EU Biodiversity Strategy for 2030. European Commission.	communication from the EC
17	European Commission (2020c). How the future CAP will contribute to the EU Green Deal. Factsheet. 2 p. Retrieved from: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/future-cap-and-green-deal_en.pdf	communication from the EC
18	European Commission (2019). The Post-2020 Common Agricultural Policy: Environmental Benefits What the Future CAP Will Bring to the Table. Agriculture and Rural Development. 2019. Retrieved from: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/cap-post-2020-environ-benefits-simplification_en.pdf	communication from the EC
19	European Commission (2018a). EU Budget: The CAP after 2020. 2018. Brochure. 4 p. PDF ISBN 978-92-79-87374-4 doi:10.2762/11307 KF-04-18-548-EN-N	communication from the EC

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20	Bas-Defossez. F.. and S. Meredith. (2019). CAP 2021-27: Comparative Analysis of Environmental Performance of COMENVI and COMAGRI Reports. Report for NABU by the Institute for European Environmental Policy. 2019. 21 p.	policy advice report
21	Mcneill. A.A.. M. Muro. T. Tugran. and Z. Lukacova (2020). Report on the Selection of Good Policy Alternatives at EU and Study Site Level. Draft Deliverable for the EU SoilCare Project (GA 677407). Vol. Report 13. Vol. Report 13. Wageningen Environmental Research. 2020.	research project report (H2020)
22	European Commission (2018b). A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy. Society. COM(2018) 673 Final. 2018.	communication from the EC
23	European Commission (2018). A Clean Planet for All. A European Long-Term Strategic Vision for a Prosperous. Modern. Competitive and Climate Neutral Economy. Com(2018) 773.	communication from the EC
24	Kulovesi K. and Oberthür S. (2020). Assessing the EU's 2030 Climate and Energy Policy Framework: Incremental change toward radical transformation?. RECIEL. 2020;29:151–166. https://doi.org/10.1111/reel.12358	scientific paper

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Annex VII Policy documents at EU-level considered in the analysis.

Abbreviation used in database	Policy instrument	Reference number
A-GM	CAP Pillar 1: CAP-Greening EC Regulation (green direct payments)	1307/2013
A-CC	CAP Pillar 1: CAP- Cross compliance requirements (SMR and GAEC)	1306/2013
A-RD	CAP Pillar 2: CAP-Rural development programmes and agri-environment-climate measures	1305/2013
newCAP	Common Agricultural Policy (CAP) for the 2021-2027 period	COM/2018/392 final - 2018/0216 (COD)
EAFRD	Support for rural development by the European Agricultural Fund for Rural Development (EAFRD)	1305/2013/EU
ERDF	European Regional Development Fund	1301/2013/EU
CEF	2030 Climate and Energy Framework - national energy and climate plan (NECP) and long-term strategies (LTS)	COM/2015/80
NECD	National Emission Ceilings Directive	2001/81/EC
ESR	Effort Sharing Regulation	2018/842/EU
NLS	2050 long-term climate strategy: A Clean Planet for all A European strategic long-term vision for a prosperous. modern. competitive and climate neutral economy	COM/2018/773
NAS	EU Strategy on Adaptation to Climate Change - national adaptation strategies	COM/2013/206
LULUCF	Land Use. Land Use Change and Forestry Regulation or Decision (LULUCF) (in force to end 2020)	2018/841; 529/2013/EU
ND	Nitrates Directive	91/676/EEC
WFD	Water Framework Directive	2008/98/EC
GD	Groundwater Directive	2006/118/EC
FD	Floods Directive	2007/60/EC
HD	Habitats Directive	92/43/EC
BD	Birds Directive	2009/147/EC
SSD	Sewage Sludge Directive	86/278/EEC
SUP	Sustainable Use of Pesticides Directive	2009/128/EC
PPPR	Plant Protection Products Regulation	91/414/EEC
EIA	Environmental Impact Directive (EIA Directive)	2011/92/EU
SEA	Strategic Environmental Impact Assessment Directive (SEA Directive)	2001/42/EC
ELD	Environmental Liability Directive	2011/92/EU
IED	Industrial Emissions Directive	2010/75/EU
LFD	Landfill Directive	1999/31/EC recast by 2018/850/EU
WasteFD	Waste Framework Directive	2018/851/EU
FR	Fertiliser Regulation and New Fertiliser Regulation (EU)	2003/2003 2019/1009/EU
REDII	Renewable Energy Directive (RED II)	2018/2001/EU
OFR	Organic production and labelling of organic products Regulation and New EU regulation 2018/848 of 30 May 2018 on organic production and labelling of organic products to come into force in 2021	834/2007 2092/91 2018/848/EU
RREE	Roadmap to Resource Efficient Europe	COM/2011/571

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STS	Soil Thematic Strategy	COM/2006/23
EAP7	7th Environmental Action Plan	DEC1386/2013
AG2030	2030 Agenda	
CEAP	EU Action Plan for the Circular Economy (CEAP)	COM/2020/98
F2F	Farm to Fork Strategy	COM/2020/381
BDS2030	EU Biodiversity Strategy for 2030	COM/2020/380
ECP	European Climate Pact	
HMSHF	Horizon Europe mission area on soil health and food	
ACS	Protocol on the implementation of the Alpine Convention of 1991 in the field of soil conservation	
BIOECS2018	Updated Bioeconomy Strategy 2018	COM/2018/673

Annex VIII Overview of EU policy targets per soil challenge

At the EU level. a number of projects have published EU policy analyses on soils. These existing policy analysis were screened and supplemented with recent documents on the new CAP. green deal. farm to fork strategy and biodiversity strategy. The policies considered are in the fields of agriculture. food. water. climate. nature. energy and waste. In the table below targets extracted from these documents are clustered per soil challenge and a distinction is made between qualitative and quantitative targets. Moreover the table also summarizes reflections on the current status of the soil challenges. For the abbreviations is referred to Annex VII. In addition. following abbreviations are used: SAS (agricultural soil specific). SS (soil specific). NS (non-soil specific) to identify the specificity of the policy targets.

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Soil challenge	Current EU policy **Qualitative targets (15)**	Current EU policy **Quantitative targets (7)**	REFLECTIONS **(current status)**
Maintain/increase SOC	*CAP Cross compliance* **A-CC** **GAEC 6** (Maintenance of soil organic matter level) prescribes **maintenance of soil organic matter level through appropriate practices**. including ban on burning arable stubble. except for plant health reasons **(SAS)** *CAP Greening EC regulation* **A-GM** **Regulation 1307/2013 (EC. 2013): 2)** the **maintenance of permanent grassland**. including traditional orchards where fruit trees are grown in low density on grassland; permanent grasslands should be 'maintained for the sake of the environmental benefits of permanent grassland and in particular carbon sequestration' **(SAS)** *CAP Rural development programmes AECM* **A-RD** **RDP Measure 4.4** Support for non-productive investments linked to the achievement of agri-environment-climate objectives: priority 5(e**) fostering carbon conservation and sequestration in agriculture and forestry**; **RDP Measure 10.1** (Payment for agri-environment-climate commitments) (AECM) aims to preserve and promote 'agricultural practices that make a positive contribution to the environment and climate'. Focus area - 5(e) **fostering carbon conservation and sequestration** in agriculture and forestry. **RDP Measure 8.2** Support of establishment and **maintenance of agro-forestry systems** (**SAS**); **RDP Measure 11.1** Payment to convert to organic farming practices and methods has as objective to stimulate the **conversion of farmers to organic farming practices**. The regulations on organic production govern all areas of organic production and are based on a number of key principles (…) (**NS**) *2030 Agenda* **AG2030** **SDG2.4** By 2030. ensure sustainable food production systems and implement **resilient agricultural practices** that increase productivity and production. that help maintain ecosystems. that strengthen capacity for adaptation to climate change. extreme weather. drought. flooding and other disasters and that progressively improve land and soil quality **(SAS)**. **SDG 13.2 Integrate climate change measures** into national policies. strategies. and planning. **SDG 15.1** By 2020. ensure the **conservation. restoration and sustainable use of terrestrial and inland freshwater ecosystems** and their services. in particular forests. wetlands. mountains and drylands. in line with obligations under international agreements **SDG 15.2** By 2020. promote the implementation **of sustainable management of all types of forests**. halt deforestation. restore degraded forests and substantially increase afforestation and reforestation globally **(NS)** *EU Biodiversity Strategy for 2030* **BDS2030** **new EU Nature Restoration Plan**: improve **the health of existing and new protected areas**. and bring diverse and resilient nature back to all landscapes and ecosystems; key commitments by 2030: 1. Legally binding EU nature restoration targets to be proposed in 2021. subject to an impact assessment. By 2030**. significant areas of degraded and carbon-rich ecosystems are restored**; habitats and species show no deterioration in conservation trends and status; and at least 30% reach favourable conservation status or at least show a positive trend. **(NS)**	*Horizon Europe mission area on soil health and food* **HMSHF** Conservation of high carbon soils (e.g. in forests. permanent pastures. wetlands); Reverse of carbon loss in croplands. **A switch from a 0.5 % loss per year to a 0.1-0.4% increase in SOC concentration in cropland soils 30-50% reduced area of peatland losing carbon** (**SS**) *Land Use. Land Use Change and Forestry Regulation or Decision* **LULUCF** 1- To ensure the contribution of the LULUCF sector to the achievement of **the Union's emission reduction target of at least 40 % and to the long-term goal of the Paris Agreement in the period 2021 to 2030 (NS)** 2- The regulation sets Member States targets for the LULUCF sector to contribute to **meeting the GHG reduction commitment of the EU's** 2030 target and its nationally determined contribution under the Paris Agreement (**NS**) 3- The cornerstone of the LULUCF Regulation is the **no-debit rule**. an obligation for Member States to ensure that their emissions from the LULUCF sector do not exceed the amount of greenhouse gases that the sector absorbs. Compliance with this requirement will be assessed during two five-year periods (2021–2025 and 2026–2030). Changes in carbon stock during these periods will be accounted for in accordance with the rules of the Regulation. (**NS**) The Regulation initially includes five mandatory accounting categories: afforested land. deforested land. managed cropland. managed grassland and managed forests.117 As of 2026. managed wetlands will be added as a sixth mandatory category *Renewable Energy Directive* **REDII** 1 - Member States lay down national targets to achieve the target of 32% renewable energy by 2030 In the National Renewable Energy Action Plans. An increase in the share of wind and solar energy is proposed. but also **an increase of biomass production from forestry and agriculture.** The Governance Regulation under the Climate and Energy Framework indirectly establishes **indicative targets for individual Member States** by defining criteria and a formula for their calculation (**NS**) 2 - To use energy from renewable energy sources and to **limit GHG emissions**; Directive sets mandatory **RE targets for EU Member States and requires adoption of national renewable energy action plans**; 3 - REDII establishes **sustainability criteria to protect lands with high biodiversity value and land with high carbon stock**. **and to prevent indirect land use change.** The Governance Regulation under the Climate and Energy Framework indirectly establishes indicative targets for individual Member States by defining criteria and a formula for their calculation (**NS**) *Roadmap to Resource Efficient Europe* **RREE** By 2020. **SOM levels do not decrease overall and increase for soils currently with less than 3.5 % organic matter** (**SS**)	**HMSHF** > Most croplands in EU are most likely to be already at sub-optimal levels; 1.5% of all land use have SOC levels below 1% C; 2.6% of arable soils has this (JRC LUCAS). Estimates of overall SOC stock changes (all soils) indicate that the total SOC change between LUCAS 2009/12 and 2015 show that about 60 % of EU agricultural areas experienced changes below 0.2% of the average stock. The trend in in carbon stocks in grassland was loss of about 0.04 % and in arable land a loss of about 0.06% (Panagos et al 2020). 10% of the area is predicted to have changes larger than ± 12 g kg–1 over the 6 year interval LULUCF > According to the 2018 Annual European Union greenhouse gas inventory report the LULUCF sector is a stable carbon sink **NewCAP** > Agricultural land in the EU contains around 51 billion tonnes of CO2-equivalent in the topsoil as soil organic matter. This is a huge amount compared to the 4.4 billion tonnes The 2015 LUCAS survey shows that cropland exhibits much lower soil organic carbon concentrations compared to grasslands and natural vegetation (eg. 17.8. 40.3 and 77.5 g per kg. respectively). Around 75% of all EU croplands are below 2% of organic content of CO2-equivalent emitted annually in EU Member States (2016). all sectors together.

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	7th Environmental Action Plan **EAP7** (…) **increasing efforts to reduce soil erosion and increase soil organic matter**. to remediate contaminated sites and to enhance the integration of land use aspects into coordinated decision-making involving all relevant levels of government. supported by the adoption of targets on soil and on land as a resource. and land planning objectives **(SS)** *European Climate Pact* **ECP** An EU **carbon farming initiative under the Climate Pact** will promote new green business **(SAS)** *Common Agricultural Policy (CAP) for the 2021-2027 period* **newCAP** **specific objective 4** - Contribute to **climate change mitigation and adaptation**. as well as sustainable energy **(NS)** *2050 long-term climate strategy* **NLS** Maintaining and further **increasing the natural sink of forests. soils. and agricultural lands** and coastal wetlands is crucial for the success of the Strategy. as it allows the offsetting of residual emissions from sectors where decarbonisation is the most challenging. including agriculture itself. (**SS**)		
Soil challenge	Current EU policy **Qualitative targets (1)**	Current EU policy **Quantitative targets (1)**	REFLECTIONS **(current status)**
Optimal soil structure	*CAP Cross compliance* **A-CC** Standards for good agricultural and environmental condition of land (GAEC) are designed to ... maintain ... soil structure **(SAS)**	*Horizon Europe mission area on soil health and food* **HMSHF** 50% degraded land restored; Reduction by 30-50% of soil with (subsoil) compaction (**SS**)	**HMSHF >** 23% of land in the EU was estimated at critically high densities by JRC (2016); JRC 2009 estimated that 33% of soils are susceptible to compaction. of which 20% moderately so.
Soil challenge	Current EU policy **Qualitative targets (1)**	Current EU policy **Quantitative targets (0)**	REFLECTIONS **(current status)**
Enhance water storage capacity	*2030 Agenda* **AG2030** **SDG 6.4** By 2030. substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity. (**NS**)		

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Soil challenge	Current EU policy **Qualitative targets (3)**	Current EU policy **Quantitative targets (4)**	REFLECTIONS **(current status)**
Enhance soil biodiversity	*CAP Greening EC regulation* **A-GM** The compulsory practices that 'go beyond cross-compliance and that are linked to agriculture are divided into 3 practices which are 1) crop diversification. 2) the maintenance of permanent grassland. including traditional orchards where fruit trees are grown in low density on grassland. and 3) the establishment of ecological focus areas'. Each Greening measure has its own more specific objective as specified in the Regulation 1307/2013 (EC. 2013): for 'ecological focus areas' the objective is to safeguard and improve biodiversity on farms. **(SAS)** *CAP Rural development programmes AECM* **A-RD** **RDP Measure 11.1** Payment to convert to organic farming practices and methods has as objective to stimulate the conversion of farmers to organic farming practices. The regulations on organic production govern all areas of organic production and are based on a number of key principles (**NS**) Environmental Liability Directive (**ELD)** The Directive establishes a framework of environmental liability based on the 'polluter-pays' principle. to prevent and remedy environmental damage. The Directive covers damage to land. water and biodiversity with (or under) land. It directly contributes to reducing soil contamination and the loss of soil biodiversity. (**NS**)	Farm to Fork Strategy (**F2F)** to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030 (**NS**) to reduce overall EU sales of antimicrobials for farmed animals and in aquaculture by 50% by 2030 (**NS**) organic farming needs to be further promoted ... to reach the objective of at least 25% of the EU's agricultural land under organic farming by 2030 and a significant increase in organic aquaculture (**SAS**)	***F2F*** *- 20% decrease in risk from pesticide use in the past five years*

Soil challenge	Current EU policy **Qualitative targets (4)**	Current EU policy **Quantitative targets (2)**	REFLECTIONS **(current status)**
Enhance nutrient retention/use efficiency	*CAP Rural development programmes AECM* **A-RD** ***RDP Measure 11.1*** *Payment to convert to organic farming practices and methods has as objective to stimulate the conversion of farmers to organic farming practices. The regulations on organic production govern all areas of organic production and are based on a number of key principles (…) (**NS**)* *7th Environmental Action Plan* **EAP7** to ensure that by 2020 'the nutrient cycle (nitrogen and phosphorus) is managed in a more sustainable and resource-efficient way.' (**SAS**) *Common Agricultural Policy (CAP) for the 2021-2027 period* **newCAP** to reduce nutrient leakage and GHG emissions while contributing positively to soil quality (moreover. the recommendations will bring economic benefits by helping to avoid over- or under-fertilisation) The proposal for the CAP post-2020 introduces new standards for the use of the farm sustainability tool for nutrients (GAEC 5) (**SAS**) *Nitrates Directive* **ND** - key objective is to reduce nutrient input in agricultural soils **(SAS)** Member States shall ... designate as vulnerable zones all known areas of land in their territories which drain into the waters identified...and which contribute to pollution (Article 3.2). Member States shall review.. revise or add to the designation of vulnerable zones as appropriate. and at last every four years. to take into account changes and factors unforeseen at the time of the previous designation (Article 3.4).	*EU Biodiversity Strategy for 2030* **BDS2030** EU Nature Restoration Plan: key commitments by 2030: 10. The losses of nutrients from fertilisers are reduced by 50%. resulting in the reduction of the use of fertilisers by at least 20%.(**SAS**) Farm to Fork Strategy (**F2F)** to reduce nutrient losses by at least 50%. while ensuring that there is no deterioration in soil fertility. This will reduce the use of fertilisers by at least 20% by 2030 (**SAS**)	**ND** > 12 Member States and two regions predicted a further reduction in nitrate concentrations in groundwater and surface waters. due to measures in the action programmes combined with the implementation of several agro -environmental measures included in the Rural Development Programmes. Seven Member States and three regions did not come out with a clear forecast about future water quality. for instance by predicting an improvement of water quality for certain water bodies as well as a deterioration of water quality for other water bodies (Report on the Implementation of the Nitrates Directive 2012 – 2015)

Soil challenge	Current EU policy **Qualitative targets (4)**	Current EU policy **Quantitative targets (3)**	REFLECTIONS **(current status)**
Avoid soil sealing	*Protocol on the implementation of the Alpine Convention of 1991 in the field of soil conservation* ***ACS*** **Article (7)** avoidance and mitigation of soil sealing along building activities (**SS**) *2030 Agenda* **AG2030** **SDG 11.3** By 2030. enhance inclusive and sustainable urbanization and capacity for participatory. integrated. and sustainable human settlement planning and management in all countries. (**NS**) Floods Directive **FD**	*Horizon Europe mission area on soil health and food* **HMSHF** Urban recycling of land from 13 to 50%; No net land take by 2050; Switch from 2.4% to no net soil sealing **(SS)** *Roadmap to Resource Efficient Europe* **RREE** Achieve no net land take by 2050 (**NS**) *7th Environmental Action Plan* **EAP7**	**HMSHF** - Artificial areas cover 4.2% of the EU (EUROSTAT 2017) of which about 50% is sealed. This would imply that 2.5% of urban land is exposed to pressures (e.g. low inputs. compaction. pollution); Between 2000 and 2018. 78 % of land take in the EU-28 affected agricultural areas (EEA 2018).

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	Article (6) Member States shall. at the level of the river basin district. or unit of management referred to in Article 3(2)(b). prepare flood hazard maps and flood risk maps. at the most appropriate scale for the areas identified under Article 5(1). **Article (7)** On the basis of the maps referred to in Article 6. Member States shall establish flood risk management plans coordinated at the level of the river basin district. or unit of management referred to in Article 3(2)(b). for the areas identified under Article 5(1) and the areas covered by Article 13(1)(b) in accordance with paragraphs 2 and 3 of this Article. (**NS**) EU Strategy on Adaptation to Climate Change - national adaptation strategies **NAS** Resilient infrastructure (**NS)**	… make progress towards the objective of 'no net land take'. by 2050 (**SS**)	
Soil challenge	Current EU policy **Qualitative targets (7)**	Current EU policy **Quantitative targets (2)**	REFLECTIONS **(current status)**
Avoid soil erosion	*CAP Cross compliance* **A-CC** prevent soil erosion by defining minimum soil cover and minimum land management practices: **GAEC 5** (Minimum land management reflecting site specific conditions to limit erosion) requires minimum land management reflecting site specific conditions to limit erosion (**SAS)** prevent soil erosion by defining minimum soil cover and minimum land management practices: **GAEC 4** (minimum soil cover) requires that a cover of growing plants or other organic and non-organic residues that protects the soil surface should be maintained to reduce erosion by water and wind (**SAS)** *CAP Rural development programmes AECM* **A-RD** ***RDP measure 4.4*** *Support for non-productive investments linked to the achievement of agri-environment-climate objectives: priority 4(c) preventing soil erosion and improving soil management (**SAS**)* ***RDP measure 5.1/5.2****: to maintain and restore agricultural productivity in the context of harmful extreme natural events (**SAS**)* ***RDP Measure 10.1*** *(Payment for agri-environment-climate commitments) (AECM) aims to preserve and promote 'agricultural practices that make a positive contribution to the environment and climate'. Focus area 4(c) preventing soil erosion and improving soil management (**SAS**)* *7th Environmental Action Plan* **EAP7** ..increasing efforts to reduce soil erosion and increase soil organic matter. to remediate contaminated sites and to enhance the integration of land use aspects into coordinated decision-making involving all relevant levels of government. supported by the adoption of targets on soil and on land as a resource. and land planning objectives (**SS**) 'Land is managed sustainably in the Union. soil is adequately protected and the remediation of contaminated sites is well underway.' (**SS**)	*Horizon Europe mission area on soil health and food* **HMSHF** 50% degraded land restored; Prevention on 30-50% of land with unsustainable erosion risk (**SS**) *Roadmap to Resource Efficient Europe* **RREE** By 2020. the area of land in the EU that is subject to soil erosion of more than 10 tonnes per hectare per year should be reduced by at least 25 % **(SS)**	**A-CC** - contracts to prevent soil erosion and to improve soil management on 9 % of Utilised Agricultural Areas (COM(2018) 790 final. report on implementation of the CMEF) **HMSHF -** A new report by JRC (Panagos et al. 2020) shows erosion by water on arable land is 10% greater than the mean for the EU (this means that we can consider all 23% of cropland as affected). Permanent crops have highest soil erosion rates. Arable and permanent crops cover 30% of EU land. A JRC erosion model (Borelli et al. 2017) shows wind erosion in EU is 0.53 Mg ha−1 y−1. 9·7% of arable land has problems with wind erosion. with 5·3% and 4·4% displaying moderate and high rates of wind erosion. respectively.
Soil challenge	Current EU policy **Qualitative targets (0)**	Current EU policy **Quantitative targets (1)**	REFLECTIONS **(current status)**
Avoid salinization		*Horizon Europe mission area on soil health and food* **HMSHF** 25% of land under organic farming; Doubling of rate of remediated sites; Prioritising brown field sites; 5-25% additional land (i.e. over and above the 25% in full organic) with reduced risk from a range of pollutants (**SS**)	**HMSHF** - The extent of salinisation in EU is still uncertain. Ranges estimate 1 to 4 million hectares (enlarged EU). mainly in the Mediterranean and Central European countries (JRC 2008). In 2016. 10.2 million hectares was actually irrigated (5.9 % of EU). 25% of this area is at risk of secondary salinization i.e. 1.5% of EU. Spain (15.7 %) and Italy (32.6 %) had the largest shares of irrigable areas in the agricultural areas of the EU (JRC 2016). T
Soil challenge	Current EU policy **Qualitative targets (2)**	Current EU policy **Quantitative targets (2)**	REFLECTIONS **(current status)**
Avoid peat degradation	*Protocol on the implementation of the Alpine Convention of 1991 in the field of soil conservation* ***ACS*** **Article (9)** maximum protection of peatland *(**SS**)* *Common Agricultural Policy (CAP) for the 2021-2027 period* **newCAP** CAP Specific objective 4: Contribute to climate change mitigation and adaptation. as well as sustainable energy. The proposal for the CAP post-2020 introduces new standards for the appropriate protection of wetlands and peatlands (GAEC 2). **(SS)**	*Horizon Europe mission area on soil health and food* **HMSHF** Conservation of high carbon soils (e.g. in forests. permanent pastures. wetlands); Reverse of carbon loss in croplands. A switch from a 0.5 % loss per year to a 0.1-0.4% increase in SOC concentration in cropland soils 30-50% reduced area of peatland losing carbon **(SS)**	**HMSHF** - Peats cover 8% of EU land area. of which 50% of peatlands are estimated to be drained which will result in the oxidising of the peat and loss carbon to the atmosphere (JRC 2016). Results from hydrological reconstructions indicated 60% of peatlands are drier than they were 1000 years ago due to these direct human impacts and climatic drying (Swindleset al. 2019). **newCAP** - The distribution of peatlands in the EU is quite concentrated in a few MS with relatively high surfaces. When drained. peatlands become net sources of greenhouse gas (GHG) emissions and the accumulation of carbon is reversed and released very rapidly into

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		Renewable Energy Directive **REDII** Renewable energy should account for at least 32% of EU energy consumption in 2030 and a review by 2023 with a view to increasing the target Member States have to 'collectively ensure' that the 32 percent target is achieved as a 'binding overall Union target' The Governance Regulation under the Climate and Energy Framework indirectly establishes indicative targets for individual Member States by defining criteria and a formula for their calculation (**NS**)	the atmosphere. It is possible to combine agriculture and peatland but peatland management or restoration means often rewetting of the land. which can result in the need to change the existing agricultural management practices (FAO 2014).
Soil challenge	Current EU policy **Qualitative targets (3)**	Current EU policy **Quantitative targets (5)**	REFLECTIONS **(current status)**
Avoid N2O/CH4 emissions	*CAP Rural development programmes AECM* **A-RD** **RDP measure 4.4** Support for non-productive investments linked to the achievement of agri-environment-climate objectives: priority 5(d) reducing greenhouse gas and ammonia emissions from agriculture (**SAS**) **RDP Measure 10.1** (Payment for agri-environment-climate commitments) (AECM) aims to preserve and promote 'agricultural practices that make a positive contribution to the environment and climate'. Focus area 5(d) reducing greenhouse gas and ammonia emissions from agriculture (**SAS**) *Common Agricultural Policy (CAP) for the 2021-2027 period* **newCAP** **CAP Specific objective 4:** Contribute to climate change mitigation and adaptation. as well as sustainable energy. (**NS**)	*2030 Climate and Energy Framework - national energy and climate plan (NECP) and long-term strategies (LTS)* ***CEF*** *target year: 2030 (**NS**)* *At least 40 % cuts in GHG emissions (from 1990 levels)* *At least 32% of EU energy from renewable sources* *At least 32.5 % improvement in energy efficiency* *Effort Sharing Regulation **ESR*** *defines the minimum contributions Member States need to make from 2021-2031 to fulfil the EU's target of reducing GHG emissions by 30% below 2005 levels from energy. industrial processes and product use. agriculture and waste* *Under the 2030 Framework. the effort sharing sectors – transport. waste. buildings. agriculture and industry not included in the ETS – must collectively reduce emissions by 30 percent from 2005 levels. (**NS**)* *Land Use. Land Use Change and Forestry Regulation or Decision* **LULUCF** *The cornerstone of the LULUCF Regulation is the no-debit rule. an obligation for Member States to ensure that their emissions from the LULUCF sector do not exceed the amount of greenhouse gases that the sector absorbs. Compliance with this requirement will be assessed during two five-year periods (2021–2025 and 2026–2030). Changes in carbon stock during these periods will be accounted for in accordance with the rules of the Regulation.* *The Regulation initially includes five mandatory accounting categories: afforested land. deforested land. managed cropland. managed grassland and managed forests.117 As of 2026. managed wetlands will be added as a sixth mandatory category (**NS**)* 2050 long-term climate strategy: A Clean Planet for all A European strategic long-term vision for a prosperous. modern. competitive and climate neutral economy **NLS** achieving net-zero greenhouse gas emissions by 2050 through a socially-fair transition in a cost-efficient manner (**NS**)	**F2F** - In 2017. N2O emissions from agriculture accounted for 43% of agriculture emissions and 3.9% of total anthropogenic emissions in the EU (EEA (2019). Annual European Union greenhouse gas inventory 1990-2017 and Inventory report 2019); Agriculture is responsible for 10.3% of the EU's GHG emissions and nearly 70% of those come from the animal sector (EEA (2019). Annual European Union greenhouse gas inventory 1990-2017 and Inventory report 2019. These figures do not include CO2 emissions from land use and land use change.) **newCAP** - EU agriculture. including land use and land use change (LULUC) of grassland and cropland. represented 12 % of all EU greenhouse gas (GHG) emissions in 2016; EU agriculture is more vulnerable than most other sectors of the economy to climate change.
Soil challenge	Current EU policy **Qualitative targets (1)**	Current EU policy **Quantitative targets (1)**	REFLECTIONS **(current status)**
Avoid acidification	National Emission Ceilings Directive **NECD** **Article 4 (1)** Member States shall. as a minimum. limit their annual anthropogenic emissions of sulphur dioxide. nitrogen oxides. non-methane volatile organic compounds. ammonia and fine particulate matter in accordance with the national emission reduction commitments applicable from 2020 to 2029 and from 2030 onwards (**NS**)	*Horizon Europe mission area on soil health and food* **HMSHF** *25% of land under organic farming; Doubling of rate of remediated sites; Prioritising brown field sites; 5-25% additional land (i.e. over and above the 25% in full organic) with reduced risk from a range of pollutants (**SS**)*	**HMSHF** - There are 2.93 million km2 (69%) of European land where critical loads are exceeded for acidification and 2.65 million km2 (62%) of semi-natural ecosystems are subjected to nutrient nitrogen deposition leading to eutrophication in 2017 (CIAM IIASA 2018).

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Soil challenge	Current EU policy **Qualitative targets (19)**	Current EU policy **Quantitative targets (4)**	REFLECTIONS **(current status)**
Avoid contamination	*CAP Cross compliance* **A-CC (SAS)** **SMR-10** Restrictions on use of Plant protection products ((EC) No 1107/2009): objective is to 'achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as nonchemical alternatives to pesticides.' **GAEC 3** Protection of groundwater against pollution: Prohibition of direct discharge into groundwater and measures to prevent indirect pollution of groundwater through discharge on the ground and percolation through the soil of dangerous substances. as listed in the Annex to the Directive 80/68/EEC in its version in force on the last day of its validity. as far as it relates to agricultural activity **SMR1** Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Objectives are to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution *2030 Agenda* **AG2030** **SDG 3.9** By 2030. substantially reduce the number of deaths and illnesses from hazardous chemicals and air. water. and soil pollution. and contamination. (**NS**) EU Action Plan for the Circular Economy **(CEAP)** address pressure from plastics (**NS**) Support for rural development by the European Agricultural Fund for Rural Development **(EAFRD)** restoring. preserving and enhancing ecosystems related to agriculture and forestry; sub-priority Article (5)(4)(b): improving water management. including fertiliser and pesticide management (**NS**) *7th Environmental Action Plan* **EAP7** By 2020 the remediation of contaminated sites is well underway; (ref 4) to ensure. by 2020. that the use of plant protection products does not harm human health or the environment and such products are used sustainably.(ref 10) (**NS**) *Environmental Liability Directive* ***ELD*** The Directive establishes a framework of environmental liability based on the 'polluter-pays' principle. to prevent and remedy environmental damage. The Directive covers damage to land. water and biodiversity with (or under) land. It directly contributes to reducing soil contamination and the loss of soil biodiversity. (**NS**) *Fertiliser Regulation and New Fertiliser Regulation (EU)* ***FR (SAS)*** *The 2003 Regulation aims to implement the principles of the free internal market for mineral fertilisers used in agriculture. while ensuring certain quality standards regarding nutrient content. safety. and environmental impacts.* *From the perspective of the circular economy. the European Commission wishes to incentivise large scale fertiliser production in the EU from domestic organic or secondary raw materials in line with the circular economy model. by transforming waste into nutrients for crops. For this purpose. these categories were included in the legislative proposal for the New Fertilisers Regulation. It has two objectives:* *(1) to incentivise large scale fertiliser production from domestic sources. transforming waste into nutrients for crops; and* *(2) to introduce harmonised cadmium limits for phosphate fertilisers.* *The proposed new Regulation also aims to address concerns shared by nearly all Member States over the risk of contamination by heavy metals. particularly cadmium. present in phosphate-rich fertilisers. both organic and inorganic.* *The (New) Fertilisers Regulation does not directly target agricultural practices. but conditions the marketing of fertilisers in the EU. However. it can indirectly influence farmers' choices of agricultural practices through market responses and conditions. and through the requirements on the information to be displayed on fertiliser labels. through handling instructions and environmental precautions. This may encourage responsible use of fertilisers.* *The Regulation's requirements regarding fertilisers' impacts on human. animal or plant health. and on the environment. may also influence agricultural practices: products suspected of a negative impact on the environment may be refused approval and be removed from the EU market. Yet manufacturers may still market fertilisers under national legislations.* *To achieve sustainable use of fertiliser application* *Groundwater Directive* ***GD***	*EU Biodiversity Strategy for 2030* **BDS2030** ***(SS)*** EU Nature Restoration Plan: key commitments by 2030: **3.** The risk and use of chemical pesticides is reduced by 50% and the use of more hazardous pesticides is reduced by 50%. **7.** Significant progress has been made in the remediation of contaminated soil sites. *Farm to Fork Strategy* ***F2F (NS)*** to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030 reduction by 50% of the sales of antimicrobials for farmed animals by 2030 *Horizon Europe mission area on soil health and food* **HMSHF** ***(SS)*** 25% of land under organic farming; Doubling of rate of remediated sites; Prioritising brown field sites; 5-25% additional land (i.e. over and above the 25% in full organic) with reduced risk from a range of pollutants	EAP7 - The mid-term review of the European Parliament from 2017 concludes that the target is insufficiently implemented at both EU and Member State level (p21). F2F - 20% decrease in risk from pesticide use in the past five years FR - The impact assessment for the new fertiliser regulation (SWD. 2016) highlighted that access to domestic raw materials (e.g. compost) is currently hampered by their classification as waste or by variations in the implementation of waste legislation in Member States. It also highlighted that access to such materials is potentially in conflict with new agri-environmental measures under the Rural Development Programs to promote the use of organic fertilisers with the aim to increase the organic matter content of arable soils; There is no evidence supporting the argument that the Regulation has led to improvements regarding fertilisers' impacts on the environment. particularly regarding the presence of heavy metals in fertilisers. hich may leach into soils. HMSHF - In terms of local soil pollution. JRC (Paya Perezet al. 2018) reported 2.8 million potentially contaminated sites in EEA-39 but the area of land is not known. The Cocoom InterReg Project estimated that there are more than 500.000 landfills in EU. 90% are in regarded as non-sanitary landfills (i.e. predating the Landfill Directive (1999)). Of LUCAS soils tested. 83% of soils contained one or more residue of pesticides and 58% contained mixtures. (Silva et al. 2019). De Vries et al. (In prep) and cited in EEA (2020) state 21% of agricultural soils have cadmium concentrations in the topsoils which exceed groundwater limits used for drinking waters. There are 2.93 million km2 (69%) of European land where critical loads are exceeded for acidification and 2.65 million km2 (62%) of semi-natural ecosystems are subjected to nutrient nitrogen deposition leading to eutrophication in 2017 (CIAM IIASA 2018) Plastics Europe (2016) reported that 3.3% of total EU plastic demand (49 million tonnes) was used in agriculture. Agriculture produced 5% of plastic waste of EU (EC. 2018). Other figures on soil contamination in ref 13 SSD - application rates relative to production across EU members ranges from 0 to 80%; on average 40% of the sludge is used in agriculture (comment P. Romkens in ref 4); he use of sewage sludge in agriculture varies widely between MS and most MS have chosen to enforce more stringent limits on pollutants than the directive requires. Almost all have adopted limit values for heavy metals in sewage sludge. or limit values for the amount of heavy metals that may be applied to soils through sewage sludge that are inferior to the ranges provided in Annex I B and Annex I C of the Directive respectively. SUP - assessment of tangible results is missing in the absence of measurable targets in most national action plans WFD - WFD Assessment Report 2018: The main significant pressures on surface water bodies are hydromorphological pressures (40 %). diffuse sources (38 %). particularly from agriculture. and atmospheric deposition (38 %). particularly of mercury. followed by point sources (18 %) and water abstraction (7 %).

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	*the Groundwater Directive aims to prevent the deterioration of the chemical status of all ground water bodies (**NS**)* *Industrial Emissions Directive **IED*** *reduce and prevent emissions to air. water and land and reduce environmental impacts from industrial activities through a system of integrated permitting; covers diffuse and point source pollutants from industry/ combustion plants/ waste installations. and explicitly covers impacts on soils (**US**)* *Landfill Directive **LFD*** *prevent or reduce the negative effects of landfilling of waste on the environment through permits and technical standards for facilities and waste (**NS**)* *Nitrates Directive* **ND** protection of waters against pollution caused by nitrates from agricultural sources *(**NS**)* Plant Protection Products Regulation **PPPR** requires that plant protection products have no unacceptable effects on the environment. specifically mentioning the contamination of soil *(**SAS**)* Sewage Sludge Directive **SSD** Article 5: 1. Member States shall prohibit the use of sludge where the concentration of one or more heavy metals in the soil exceeds the limit values which they lay down in accordance with Annex I A and shall take the necessary steps to ensure that those limit values are not exceeded as a result of the use of sludge. 2. Member States shall regulate the use of sludge in such a way that the accumulation of heavy metals in the soil does not lead to the exceedance of limit values referred to in … *(**SS**)* To prevent harmful impacts on soil. human beings. animals. plants and the environment of the application of sewage sludge on agricultural land; and to encourage such application with the aim to valorise the contained nutrients; specific objective to limit the quantity of the heavy metals cadmium. copper. nickel. lead. zinc. mercury and chromium. *(**SAS**)* Sustainable Use of Pesticides Directive **SUP** *(**NS**)* Article 11 Specific measures to protect the aquatic environment and drinking water Article 12 Reduction of pesticide use or risks in specific areas Article 14 Integrated pest management The overall objectives of the SUPD are to reduce harmful impacts from pesticide use on a) human health (through spray drift and food) and b) the environment (in particular the aquatic environment and drinking water).		

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