agronomy

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Soil-Water Effects of Good Agricultural and Environmental Conditions Should Be Weighed in Conjunction with Carbon Farming

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Abstract: Soil-water practice is essential for farm sustainability, thereby establishing the reference level for agricultural policy of the European Union (EU). This paper focuses on the critical gap in the knowledge surrounding comparison of soil-water effects of Good Agricultural and Environmental Conditions (GAEC) and carbon farming. We aim to interrogate the tasks assigned to soil-water standards during the 2005–2020 timeframe and identify soil-water effects under selected soil-water GAEC topics. The farm-level and landscape-scale effects were weighed for each standard. The investigation included an extensive meta-review of documents that featured scientific work on sustainable practice. In each GAEC document, soil-water sustainability was weighed vis-a-vis carbon farming. Our main finding was that the identification of soil-water effects within GAEC was addressed both at farm-enterprise level (E) and landscape scale (L). This identification was very similar among the sampled Member States (Czech Republic, Hungary, Poland, and Slovakia). A small differentiation was detected in how exact the guidance under each standard was in each of these Member States, and hence how the prioritization was scored, ranging from 1, most influential, to 5, least influential. The scores that prevailed were 2.5–5 on the part of the scoring instrument. Carbon farming is a welcome addition to the corpus of good farming practice and is complementary to GAEC.

Keywords: good agricultural practice; soil sustainability; standards; soil carbon; water use

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Citation: Poláková, J.; Janků, J.; Holec, J.; Soukup, J. Soil-Water Effects of Good Agricultural and Environmental Conditions Should Be Weighed in Conjunction with Carbon Farming. *Agronomy* **2023**, *13*, 1002. https://doi.org/10.3390/agronomy13041002

Academic Editor: Zhengqin Xiong

Received: 7 March 2023
Revised: 24 March 2023
Accepted: 27 March 2023
Published: 29 March 2023

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1. Introduction

Assessing the ongoing Common Agricultural Policy (CAP) reform by conducting a retroactive rural-policy analysis of a sample of research documents interrogating the future has become a well-established approach [1–3]. The CAP is a subsidy system to support farmer income and sustainability. Considerable research effort has been devoted to identifying the parameters of the future points of emphasis for soil water, to provide current input into the carbon-farming debate. Consequently, much of this research attempted to assess sustainable outcomes for soil, water, and landscape with regard to the recent and current CAP [3]. One of the recurring concepts in the CAP reform document included farm subsidies [4,5]. Subsidies were repeatedly identified as a barrier to environmental outcomes [6], but also as having effects on soil and water [3]. While soil water became the core of Good Agricultural and Environmental Condition (GAEC) standards, the standard to sequester soil carbon held its ground within the suite of measures. Over the years, GAEC has included the following topics: Cover Crop for Soil Vegetation; Protection of Permanent Pasture; Retention of Terraces; Inclusion of Buffer Areas; Requirement for Crop Rotation or Soil Carbon (C) Content; and Retention of Landscape Features [7]. Many of these topics were researched under land consolidation systems in the past [8] and in relation to climate change [9]. These topics have then been grouped together in a concept known as soil water.

Identifying the natural interactions of soil and water, this concept is commonly associated with the ecological consequences of management at farm level and landscape scale. In this study, farm level and landscape scale refer to the places identified in local conditions within the European Union (EU) [3,8]. In scientific literature, soil water may refer to: (a) water available to plants, whereby the coverage is more broadly Eurasia [10]. Furthermore, in local coordinates of the EU, soil water referred to: (b) the infiltration and retention properties associated with soil type, climate, and utilization in carbon farming [11,12]; and (c) differential utilization of water from different layers of soil exhibited by various plant genera. Additionally, soil water has been studied by economists [13], insofar as it is related to land capacity and farmland usage. Many research studies have focused on soil-water assessments within a relevant administrative unit: soil-water maps created as needed for local users' geographic information systems [14]; maps for a particular river basin [15]; assessment of applied regional soil conservation measures [16,17]; and monitoring of soil sub-sampling [11].

Carbon farming is the current focus of good farming practice with climate benefits from carbon sequestration in agricultural soils [17]. The levels of soil carbon are directly associated with levels of soil organic matter [18], while this property is inscribed in the structure, health, and nutritious aspect of the soil. Water retention can be affected by changes in soil organic matter due to both climate change and changes in management practices. Carbon farming is implemented through voluntary markets, and is in that sense different from GAEC measures that were introduced as a mandatory practice and as a preconditional measure with the valence of the reference level and with the purpose to set a framework for all farm subsidies within the CAP (Regulation (EU) 2021/2115). The Farm-to-Fork Strategy of the EU European Commission 2020 [19] follows up on the work by the 2006 Soil Thematic Strategy [20] in emphasizing the soil management agendas as a part of sustainability demands on farmers.

At farm level, the 2005 introduction of GAEC standards in agriculture was almost synchronous with the 2006 Soil Thematic Strategy, in that they both refer to management decisions that lead to sustainable outcomes for soil, water, and landscape. As the reference level, GAECs imply that the technical details are set "at national or regional level, as minimum requirements for good agricultural and environmental condition on the basis of the regulatory framework" (Article 5 of Regulation (EU) 1782/2003; further reiterated by article 13 of the current regulation which has been in place since 2021). Some pleas were made in favour of relieving small farms from GAEC obligations (given that there is a simplification precedent for small farms in a lump sum payment under Small Farmer Scheme, meaning that a small farm does not have to apply separately for different subsidies). However the plea was never fulfilled by the European Parliament as the prevailing opinion of lawmakers is that the GAEC as a reference level applies to all farms under subsidy system, small and big.

In response to scientists' identification of soil measures [3], GAECs have been adapted several times, wherewith the soil-water aspects have not changed profoundly and the modifications pertained rather to habitat and cover crop issues. In contrast, carbon farming is a suite of measures crucially focusing on no-till methods. In addition, carbon farming involves other soil practices pinpointed by voluntary carbon markets. In GAEC, focusing on soil water is a mandatory practice as a condition for receipt of farm subsidies. The focus on soil water created an unequal emphasis on the farm level as compared to the landscape scale in GAECs. Soil-water measures, as addressed in GAECs, were set out to be implemented at farm level. Of these measures, the GAEC requirement for Crop Rotation or Soil Carbon (C) Content involved from the beginning the farmer in the installation of cover crops and organic manuring, never requiring specific tillage, which became, by contrast, a prevalent practice in carbon farming. An ample body of literature addresses the beneficial effects of the installation of cover crops in good agricultural practice [21–24].

Conventional soil management associated with farm subsidies implies that all farmers comply with GAEC measures at the farm level and the landscape scale, whereas carbon farming has the farm-level remit determined by voluntary markets.

Therefore, thanks to GAEC scope including farm level and landscape scale, the outcomes are increasingly linked with insufficient resilience. Resilience is an ecosystem property wherewith the consequences of human activity at farm-enterprise level (E) and landscape scale (L) intersect. Resilience is a founding term, defined by [25] as the capacity to overcome economic or bioclimatic stress at farm level in order to moderate unexpected events, thereby achieving economic balance [26,27]. In addition to resilience, an ample body of literature documents GAEC at the time of its introduction [28,29]; in relation to good agricultural practice under the nitrates directive [30]; and in its positioning within the cross-compliance system [31].

Sustainable practice has always considered, directly or indirectly, the effect of farming on soil water because soil water is a crucial farm-level property. Soil water is also a landscape-scale capability. In the timeframe from 1994–2004, the focus of good agricultural practice was more on water infiltration impacts as such, whereas from 2004–2022, the focus equally included soil-water aspects (shown in Table 1).

Table 1. Overview of GAEC standards from 1994 to 2022.

Regulation at Farm Level	Point	For Period
Good Agricultural Practice (GAP)		
Nitrate directive requirements [s, re]	protect water resources reduce nitrates contamination in vulnerable zones	(1994–today)
'Environmental measures' and 'maximum stocking densities' [a]	reduce adverse environmental impacts	(1993–1999)
'Environmental protection requirements and 'usual good farming practice' [a]	reduce adverse environmental impacts	(2000–2004)
GAEC		
Ten requirements [a]	comply with soil-water protection practice to maintain agricultural land	(2004–2013)
Seven categories [s, re]	comply with soil-water protection practice to maintain agricultural land	(2015–2022)

Note: ([s]) standard; ([a]) adapted subsequently; ([re]) reference base. Source: adapted from Ministry of Agriculture [7] and Hart et al. 2012 [32].

2. Materials and Methods

2.1. Primary Data

In this paper the previous and current CAP measures for good farming practice underpin the evidence gathered herein. Our dataset is empirical in the sense that it is based on a medium-term study of relevant documents regarding the CAP reform, and thus it is based on narrowly focused, tangible observations established through manifold causal relationships, surveys, or case studies. As the first step, we obtained the empirical details pertaining to GAEC topics in the selected Member States sample. For each Member State, the data was lifted in 2005 (when GAECs were introduced) and 2011 (when the most recent implementation phase of the CAP was triggered). We assessed the topics listed in Table 2.

Evidence for and effectiveness of GAEC implementation were interrogated for the 2005–2020 timeframe. GAEC effectiveness was scored in the focus group insofar as the particular soil-water practice did or did not achieve the soil-water outcomes. The focus-group study was involved in the scoring exercise, using the gradient from 1, most important, to 5, least influential. In addition to the gradient of most important/least influential, the focus group assessed the identification of soil-water effects (1, most directly to 5, least directly) and thereby the effectiveness of this identification for each GAEC, while also applying the GAEC standard to either farm-enterprise level or landscape scale. The prevailing scale was identified as E, farm-level enterprise, and L, landscape scale. Scoring was applied to the prioritization of soil-water aspects (soil-science assessment) and to the effects for soil-water outcomes on the ground (including political aspects as well as a variety of ecological, economic, and farm-structure aspects). The ecological factors include the following: soil degradation (1:E, L); uninterrupted length of slope (1:E); size and shape of land parcels (1:E); loss of infiltration and retention capacity of soils, such as is associated with a decline in soil carbon content which partakes in the renewal of soil structure and porosity (2:E, L); issues in vegetation cover (2:E); soil sediment overflow (3:E, L); and soil moisture (3:E, L). Each of these factors is thereby associated precisely with either the farm-level or the landscape-scale intersection as a platform for a variety of outcomes affecting soil water.

Table 2. Overview of GAEC Topics.

GAEC Topics	Farm Level Enterprise (E)/Landscape Scale (L)
Cover Crop for Soil Vegetation	E
Retention of Terraces	E, L
Protection of Permanent Pasture	E, L
Requirement for Crop Rotation or Soil Carbon (C) Content	E
Retention of Landscape Features	E, L

Source: adapted from [32].

2.2. Studied Area

Methodologically, our sample of Member States includes the Czech Republic, Hungary, Poland, and Slovakia. We consulted the EU MarsWiki database for the details pertaining to GAEC in 2005 and 2011 in each Member State. Together with this sample, we consulted BMLFUW (2009) [33] to verify conformity with the details pertaining to Austria. However, for the sake of brevity, these Austrian details were not included in our analysis. The individual methodological steps followed the queries on the unit methodology by [34]. The denominated study area lies between 45°44′–54°49′ N and 12°6′–24°8′ E.

The bioclimatic characteristics of the studied area have a mild north-south gradient. The gradient ranges from areas generally characterized by a continental climate (constant global radiation and effective land-management days, with an increasing proportion of dry days; pertinent to the Czech Republic and Poland) to areas with a Pannonian climate (flat lowlands, increasingly dry summer, and significant decline in global radiation, thus decrease in soil-water availability; pertinent especially to the southeast of the Czech Republic and to Hungary).

2.3. Document Interrogation

The second step in our analysis focused on sampling documents dealing with, primarily, scientific research on water retention. In our research we examined three categories of published materials (scientific papers, books, and an array of policy documents). The search was set up to consider the main topic of water retention: the environmental impacts of water use. Specific search engines (e.g., Google Scholar platform) and Web-of-Knowledge libraries were used for the desk review. Analytical procedure also focused on the near-complete archive of EU policy work-group projects regarding soil-water aspects and water retention during the 2005–2020 timeframe. The goal was to trace agricultural-practice definitions and assess, step by step, how “good farming” practice developed as it was woven into the evolving EU Blueprint to Safeguard Europe’s Water Resources.

In each document, we interrogated the GAEC tasks. More generally, sustainability and “good farming” practice were reviewed vis-à-vis the role assigned to resilience; the valence and indeed sometimes also the absence of resilience. Thus, the role of resilience within the document was determined. Then we examined the interaction of "good farming" practice with the main topics of the particular policy document; we attempted to define practices, gauge interaction, identify issues, find linkages to farm level, and determine the strength of these linkages. Ultimately, we only included documents with clear links to farm-level agriculture. Thus, the EU document archive was updated to retain only documents which did not refrain from addressing the policy on sustainable soil-water practice directly related to GAECs. The exception was when the documents clearly stated that no resilience effect could be measured; in such situations, additional counterfactual comparison was conducted.

3. Results

3.1. GAEC Applicability to Soil-Water Aspects

On a mandatory basis, GAECs pertain to 100% of the agricultural area. The claim is valid only for the EU farms that apply for basic subsidy, not to farms remaining unsubsidized. In contrast, agri-environment payments pertain only to farmers who volunteer to participate, i.e., to about 25% of the EU agricultural area, and who do so through rural development programmes. Furthermore, carbon farming also operates for farmers who volunteer to participate, and does so on a local or regional range determined by voluntary markets. The agri-environment percentage aggregates the differences between Member States as well as the differences in the area percentage ascribed to water and soil. This means that data is available on the contracts linked only to soil and water in the four selected Member States: 23.79% (Czech R.), 11.96% (Hungary), 18.29% (Poland), and 21.04% (Slovakia), as shown in Table 3. In comparison, GAEC has the widest coverage.

Table 3. Percentage of the Agricultural Area Enclosed Within Mandatory Standards, Compared to Percentage of Agri-environment Contracts on Sustainable Water and Soil Management.

	GAEC (% of Area)	Agri-Environment Practice (% of Area)	
		Area of Water	Area of Soil Management
Czech Republic	100	11.38	12.41
Hungary	100	3.57	8.39
Poland	100	7.85	10.44
Slovakia	100	9.61	11.43

Source: adapted from Ref. [35].

These themes are now highlighted under the current CAP reform. GAECs include several soil-water topics, as set out in Table 2. In the next section, we present the identification of soil-water effects (1; most directly to 5, least directly) and the effectiveness of this identification (1, most influential, to 5, least influential) for each GAEC, while also applying the GAEC standard to either farm-enterprise level (E) or landscape scale (L).

3.2. GAECs in the Selected Member-States Sample

Table 4 offers an overview of how soil-water aspects are prioritized under each GAEC topic in the Czech Republic, Hungary, Poland, and Slovakia. The table shows the 2005 and 2011 temporal milestones. In 2005, GAECs were at the beginning of mandatory implementation, i.e., they had just been introduced as mandatory. At this time, the relevant policy documents, Regulation EU No. 1782/2003 and 1698/2005, did not yet mention the concept of either carbon sequestration or resilience at all. The standard for Soil Carbon (C) Content focuses legislation-wise on soil organic matter. All GAEC actions aim toward achieving sustainable management of natural resources at farm level. Soil-water aspects are most directly prioritized under the GAEC topics of Soil Vegetation Cover and Standard for Soil Carbon (C) Content. Soil-water aspects are also prioritized under Retention of Landscape Features. The same holds for Retention of Terraces, although for farms in the Central and Eastern Europe region, this is only a minor occurrence in vineyards. More general soil-water aspects at farm level were implemented not much later, focusing on buffer zones alongside rivers and water bodies and so addressing soil, water, and landscape.

Figure 1 shows the identification of soil-water effects by GAEC (1, most directly, to 5, least directly). In a nutshell, the figure interprets how significant the GAEC design is, ideally, for the implementation of sustainable practice for a specific soil-water issue. Figure 2 is different in that it does not deal with the ideal design but it shows the effects of GAEC on the ground (1, most influential, to 5, least influential). These differences have to be seen within the context of Table 4 that annotates the effects of GAEC at E, farm-enterprise Level, and L, landscape scale. In contrast to the previous Table, this figure could be interpreted, ultimately, as showing effectiveness, meaning what the effects of GAEC for the targeted soil-water effects actually are.

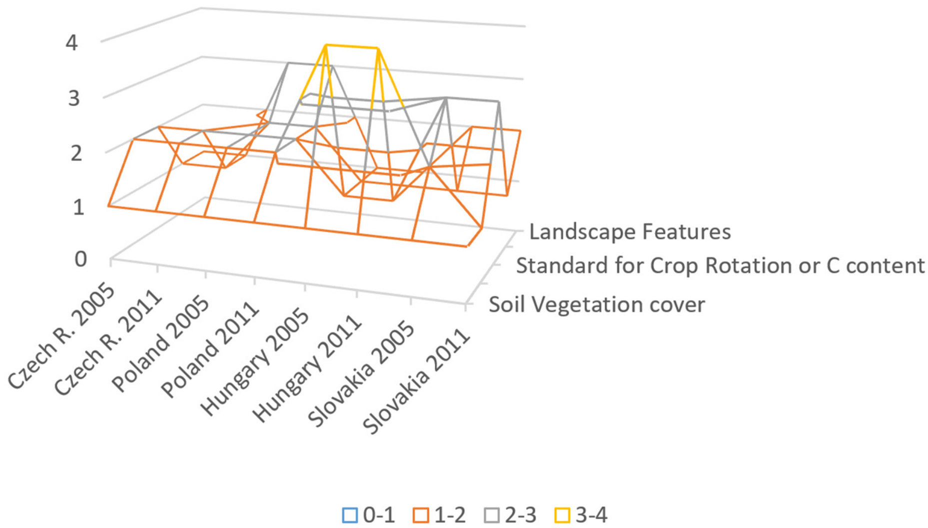

Figure 1. Identification of Soil-Water Effects. Note: 1, most directly; 5, least directly.

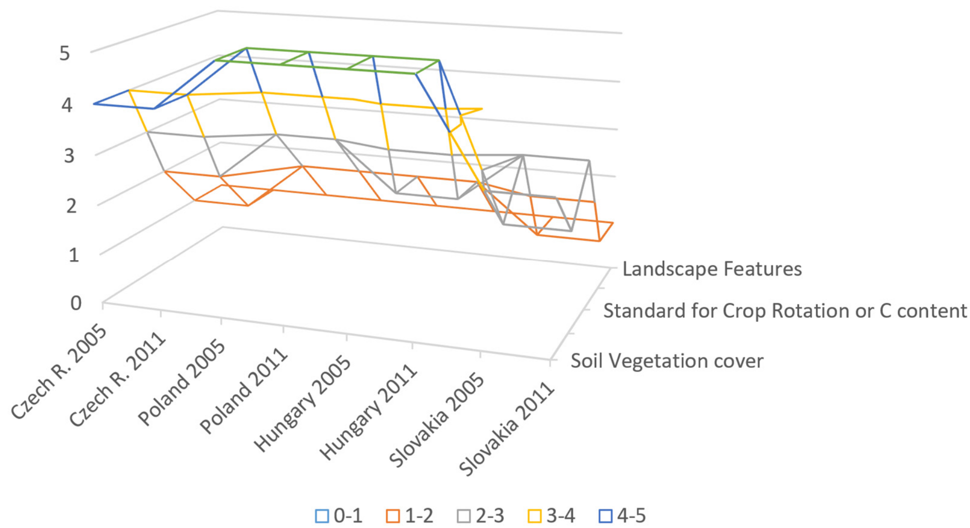

Figure 2. Effectiveness of the requirement in the prevention of the issue outlined by GAECs. Note: 1, most influential; 5, least influential.

Table 4. Identification of soil-water effects within GAEC topics.

Member State/GAEC Topic	Identification of Soil Water 1: Most Directly 5: Least Directly	Requirement Details	Effects of the Measure in the Prevention of the Issue Outlined by GAECs E, Farm Enterprise Level L, Landscape Scale	Effectiveness of the Measure in the Prevention of the Issue Outlined by GAECs 1: Most Influential 5: Least Influential
GAEC Topic: Cover Crop for Soil Vegetation				
2005: Czech R.	1	Exclusion of growing crops prone to soil erosion	E	4
2011: Czech R.	1	Until 30 November, arable land with a topography gradient steeper than 7% must have either soil cover (stubble) on all or part of the plot. The soil concerned is ploughed or tilled so as to enhance water absorption.	E	4
2005: Hungary	1	Before spring: sowed crops if vulnerable to erosion.	E	4.5
2011: Hungary	1	On arable land with a gradient steeper than 12%, there must be soil cover after the summer harvest and after the autumn harvest. Soil cover is a practice concerning: a) sowing autumn crops, or b) maintaining the stubble until 30 October; low stubble cleaning is allowed provided the stubble is kept weeded.	E	4.5
2005: Poland	1	For arable land with slope > 20%: retain soil cover, no crop cultivation with ridge along the slope and no black fallow.	E	4.5
2011: Poland	1	On arable land, the land must be cultivated or kept as a fallow land. Where land is fallow, it should be mown/managed at least once a year, by 31 July, to prevent the occurrence and spread of weeds.	E	4.5
2005: Slovakia	1	For areas prone to soil erosion at least one of the following five measures must be applied: (a) planting a protective green cover; (b) relief contour line agrotechnology is being used; (c) crop rotation with protective effect is applied; (d) the crop must be mulched and non-ploughing technology has to be used; (e) non-ploughing technology is applied.	E	3
2011: Slovakia	1	Minimum green soil cover (40%). Applies winter crops or perennial fodder crops or intercrop or stubble from 15 October to 1 March. Concerns the slope over 12 degrees.	E	3
GAEC Topic: Retention of Terraces				
2005: Czech R.	2	Basic	E, L	4

Table 4. *Cont.*

Member State/GAEC Topic	Identification of Soil Water 1: Most Directly 5: Least Directly	Requirement Details	Effects of the Measure in the Prevention of the Issue Outlined by GAECs E, Farm Enterprise Level L, Landscape Scale	Effectiveness of the Measure in the Prevention of the Issue Outlined by GAECs 1: Most Influential 5: Least Influential
2011: Czech R.	2	Basic	E, L	4
2005: Hungary	2	Basic	E, L	4.5
2011: Hungary	2	No data	E, L	4.5
2005: Poland	4	Basic	E, L	4.5
2011: Poland	4	No data	E, L	4.5
		GAEC Topic: Standards for Soil Carbon (C) Content		
2005: Czech R.	2	On sloping land (above 12°) no cultivation of row crops such as maize and tubers. Agrotechnical management and machinery use is applicable only in the form of contour tillage. Furthermore, slopes (gradient above 12°) either must be protected with continuous vegetation cover, or manure, organic and organomineral fertilizers used in soil.	E	2
2011: Czech R.	2	On at least 20% of arable land, one must apply solid farm fertilisers or solid organic fertilisers to a minimum dose of 25 tonnes per hectare, with the exception of solid fertiliser from poultry farming, where the minimum dose is 4 tonnes per hectare. For the ploughing in of waste products from growing plants (e.g., straw), a minimum dose is not set. Or cover this area or a corresponding part from 31 May to 31 July of the relevant calendar year with legumes. Crops may be sown as an under-sow into the covering crop or mixed with grasses under the condition that the proportion of grasses does not exceed 50%.	E	2
2005: Hungary	4	Contour tillage; row crops on slopes > 12%; preserve uncultivated greenspaces.	E	2
2011: Hungary	4	Exceptions: crop rotations where applicable.	E	2
2005: Poland	2	Fallow land no longer than 5 years.	E	3
2011: Poland	2	Fallow land no longer than 5 years.	E	3
		GAEC Topic: Protection of Permanent Pasture		

Table 4. *Cont.*

Member State/GAEC Topic	Identification of Soil Water 1: Most Directly 5: Least Directly	Requirement Details	Effects of the Measure in the Prevention of the Issue Outlined by GAECs E, Farm Enterprise Level L, Landscape Scale	Effectiveness of the Measure in the Prevention of the Issue Outlined by GAECs 1: Most Influential 5: Least Influential
GAEC Topic: Protection of Permanent Pasture				
2005: Czech R.	1	Rules are under discussion, the conversion of grassland into arable land is forbidden.	E, L	1
2011: Czech R.	1	Obligation to protect and maintain and permanent pasture.	E, L	1
2005: Hungary	2	If permanent pasture decreases 10%, re-establishment of permanent pasture that has been converted to arable land is obligatory.	E, L	3
2011: Hungary	2	Permanent grassland is protected on farms.	E, L	1
2005: Poland	1	Rules are under discussion, the conversion of grassland into arable land is forbidden.	E, L	2
2011: Poland	1	The farmer possessing land converted from land under permanent pasture is obliged to re-convert it into land under permanent pasture by May 15 following year.	E, L	2
GAEC topic: Retention of Landscape Features				
2005: Czech R.	1	Retention (not maintenance) of defined features.	E, L	1
2011: Czech R.	1	Retention (not maintenance) of defined features.	E, L	1
2005: Hungary	1	Basic	E, L	1
2011: Hungary	1	Basic	E, L	1
2005: Poland	3	Basic	E, L	1
2011: Poland	3	Basic	E, L	1

Source: author compilation adapted from Refs. [36,37]

4. Discussion

4.1. The Scientific Research Prompting GAEC Policy-Makers

In our research we set out to explore the importance of soil preservation. The basic scholarship found that loss of soil, whether by erosion or degradation, generates enormous damage to the productive sector, as it loses the soil's fertile horizon [3,8]. Water is indispensable in crop production, thus promotion of water retention measures can reduce loss of soil [38]. Adaptation of soil management practices is a way toward increasing water infiltration, soil moisture retention, and soil structure and cover [38], thus water retention enriches the soil and makes it more productive and good for plants [38]. Agricultural measures such as the GAEC soil-conservation practices contribute to reducing or slowing down runoff. Good farming practice is in this form a mainstay in the debate regarding the economics of the policies. EU guidance about good farming practice is collateral. For example, Refs. [4,30,39–42] support the emphasis that local economic policies place on guidance about synchronized concept of sustainability. Ref. [43] (Slamova et al. 2019) alerts about guidance on the importance of soil practice with regard to small-scale farms, an issue important in conceptualizing farm standards for several reasons (the prevalence of very large farms in the Czech Republic and Slovakia, and the dominance of small-scale farming in Poland). All authors examine guidance on the mandatory GAECs vs. the incentive-based agri-environment. However, none of them examine the role of resilience because resilience at farm level does not seem to be, by these authors, counteracted with any challenges. Ref. [31] (Musilová et al. 2016) links guidance to the legal dimension as such, noting that "the selected Standards for good agricultural and environmental conditions of land with regard to their potentiality contribute to soil and water protection, and also regarding their overlapping with the generally binding provisions in the Czech Republic because they are contained in law, especially on soil, water and nature protection". Ref. [4] also deals mainly with the legal aspects, focusing on the importance of the rural policy within the total area of land, insofar as land is farmed in compliance with the requirements under the relevant agri-environment measure.

4.2. GAEC Effects for Soils and Water

In this paper, we assessed how GAEC topics were implemented during the 2005–2020 timeframe. Specifically, we assessed (a) whether and to what extent GAEC topics addressed farm-enterprise level (E) and landscape scale (L) prioritization of soil water; and (b) how directly the standard within each GAEC topic focused on soil-water effects. GAEC effectiveness for soil and water outcomes at farm level was assessed by scoring empirical details in the study by two focus groups. Our main goal was to assess how GAECs form the baseline for sustainability at farm level whereby farmers receive farm subsidies. Additionally, in a step-by-step manner, we traced the development of good farming practice as it was woven into the evolving EU Blueprint to Safeguard Europe's Water Resources [43–50] and finally into the current Farm-to-Fork Strategy [20]. We assumed that soil-water retention was a critical driver associated with the strengthening of soil fertility, and thereby it affected the guidance about the extent to which the outcomes of soil-water usage for agricultural production were sustainable, economical, and ecological.

Our main finding was that the identification of soil-water effects within GAEC was addressed both at farm-enterprise level (E) and landscape scale (L). This identification was very similar among the sampled Member States (Czech Republic, Hungary, Poland, and Slovakia). A small differentiation was detected in how exact the guidance under each standard was in each of these Member States, and hence, how the prioritization was scored, ranging from 1, most influential, to 5, least influential. The scores that prevailed were 2.5–5 on the part of the scoring instrument. Further, GAEC topics, including Soil Vegetation Cover (E), Protection of Permanent Pasture (E, L), Retention of Terraces (E, L), Requirement for Crop Rotation or Soil Carbon (C) Content (E), and Retention of Landscape Features (E, L), are the baseline of sustainable farm practice and are linked to receiving farm subsidies at farm level.

Unlike the remunerated agri-environmental measures that are funded by rural development programmes [51,52], and unlike carbon farming that is remunerated by voluntary markets [53], GAECs encompass the reference-line commitments on soil water. Therefore, under GAECs, the standards are implemented by farmers and are not directly remunerated. An illustration of how GAECs function is the topic of Establishment of Buffer Areas. While the Nitrates Directive requires establishment of a buffer area as good farming practice (this is the standard for the designated zones), the GAEC buffer-area measure is twofold. GAECs require (a) a comparable buffer (meadow) alongside water courses; and (b) a protective crop buffer alongside the larger field of, e.g., maize, in fragile soils (under the Requirement for Crop Rotation and Soil Carbon (C) Content).

4.3. Resilience Connection

Apart from identifying soil-water effects of GAEC, we interrogated the outcomes for resilience. The EU task forces involved in the 2012 Blueprint drew on academic research at the pan-European level. Farmer et al. (2012) [54] highlighted achieving resilience together with efficiency; resilience needs to be established in the face of future uncertainties in precipitation and groundwater recharge (p. 299). In the EU Blueprint document, only marginal, and rather negative, attention was given to resilience. Yet there are eight occurrences of "resilience" in the more current legislative document on Pillar 2, and five occurrences of the term in the legislation on strategic plans currently (Appendix A). Apart from resilience, none of the Blueprint reports discussed great concerns about soil-water properties in European soils; specifically, concerns which were emphasized by Refs. [3,8,55–57]. Furthermore, none of the Blueprint reports mentioned the farmers' resistance to voluntary agri-environment schemes, an issue which was emphasized by Burton (2008) [58]. Yet the soil-water measures (see the key linkages in Figure 1) were enacted by Implementing Act (EU) 808/2014 with regard to the use of funds in the implementation of the recent CAP reform by the respective Member States.

Clearly, the need to strengthen resilience (as prompted by Ref. [26]) has until now become the key for the promoters of training and advising with regard to good farming practice. Ref. [59] put emphasis on training and advising services because they have a role to play in improving farmers' knowledge of sustainability benefits as well as of resilience at farm level with regard to the GAEC standards. This finding was echoed in our study. Most of the documents assessed in our research encouraged training and farm-advising measures to support soil protection at farm level. Additionally, we found support for the importance of training and advising in Ref. [4] with regard to Slovakia and in Ref. [33] with regard to Austria. Consequently, the landscape-scale effectiveness of GAEC compliance also depends on training and advising, especially on one-to-one advice and self-study in on-farm small groups.

4.4. Carbon Farming Field vs. GAEC

Recent international projects have focused on the carbon farming perspective. They begin from certain farm-level results to be attained, and promote incentives to farmers. This procedure is designed to overcome farmers' uncertainty about the scheme and encourage their participation in the scheme. The objective is to sequester soil carbon in soils [11]. The list offered includes the following result-based approaches to soil carbon practice: carbon farming, carbon audits, and regulation triggers at farm level.

In regard of carbon farming, we found that sustainable practice, as it is implemented in GAECs, invokes the partial principle of soil carbon management that is encapsulated by the specific GAEC standard on soil carbon management, in addition to further soil-water standards, all of which are legislatively described and mandatory. Soil carbon management revolves around the installation of cover crops and organic manuring and never requires specific tillage. In contrast, carbon farming assumes soil carbon management to be an overarching principle [11,18,53,60], while the type of soil management focuses on no-till, and further soil practices are determined by result-based voluntary markets. Finally, monitoring is a crucial tool for measuring the progress and success of carbon farming policies and management programs.

Mercier et al. (2021) [61] noted that remote sensing images should support landscape ecology because they allow for regular detailed monitoring. Farm-level principles in practise will thus automatically lead to landscape-scale outcomes for soils. However, when result-based approaches to soil carbon practice are implemented, as is promised by carbon farming, the argument is that it is up to the farmer to consider how to best utilize the assets of the farm. However, one of the barriers lies in consistency of detailed monitoring in terms of soil carbon effects at farm level. Furthermore, carbon farming approaches are not in agreement with the sociology view [62]. Additionally, farmers' perception and acceptance of standards continues to be a challenge [63,64].

The intersection of farm level and landscape scale is important in GAEC implementation, although the standards function as the guiding feature of a network that manages sustainability in agricultural practice, rather than regulation perceived in terms of command-and-control style. While such a network is managed in direct link to regulation, it is important to recognize that the level of farm subsidies exceeds the costs of GAEC compliance.

Gaining farm-level acceptance for soil-water conservation practice is not easy. Trnka et al. (2009) [65] and Thaler et al. (2012) [66] alerted about the impact of climate on the dry spells of weather and the associated soil-water practice in agriculture. Farmers must be convinced that such practice is good for farm economics as well as for the soil [67]. Farm subsidies are a flat, per-hectare payment decoupled from production. Many authors claim that farm subsidies are a form of policy support for output prices, leading to degradation and undermining both soil resilience and the efficiency of production. Thus, GAEC outcomes for soil-water retention represent the only remaining metrics that can be used to assess the results.

5. Conclusions

In conclusion, on a positive note, we emphasized that implementing GAEC with the goal of soil-water retention is often the priority of rural development funds. The main investigation was about sustainability outcomes when GAEC standards are implemented. Although resilience is a marginal topic in the Implementing Regulation as compared to the main rural development legislation (Appendix A), it does provide a negotiable frame. Aside from these successes, we have identified several key areas for improvement.

Carbon farming is a welcome addition to the corpus of good farming practice and is complementary to GAEC. While GAEC is a guiding network of producers in respect of regulation, carbon farming is likely to operate, when fine-scale monitoring is set up, through voluntary markets.

The legislative framework known as GAEC standards (Cover Crop for Soil Vegetation; Protection of Permanent Pasture; Retention of Terraces; Requirement for Crop Rotation or Soil Carbon Content; Retention of Landscape Features; Establishment of Buffer Strips) is focused on farm-level practice in order to protect Europe's waters and is the basis for voluntary markets such as carbon farming.

Priorities relevant to GAEC efficiency regarding soil water are set out through national- and regional-level GAECs. Such delineation interacts with the European level. At farm level, identifying soil-water GAECs is key. Land and soil management approaches aimed at improved resilience to face future uncertainties were supported by research on groundwater recharge. Soil-water management has been proven to support sustainability and resilience of farming as well as the health of ecosystems.

The public funds allocated to the soil-water agenda were not always used efficiently and effectively by farmers and national and regional administrators. This implies that the allocation of the funds could be better guided by a resilience rationale so that farm subsidies not serve as a substitute for economic methods of achieving soil-water retention at farm level. The number of indicators in the agricultural policy monitoring framework was excessive. Nevertheless, in the reduced list of indicators, soil-water retention may be included as one of the key indicators to measure the outcomes of farm-level practice.

Author Contributions: Conceptualization, J.P. and J.S.; methodology, J.P. and J.S.; validation, J.H. and J.J.; formal analysis, J.P.; investigation, J.P., J.J. and J.H.; data curation, J.P.; writing—original draft preparation, J.P., J.J. and J.H.; writing—review and editing, J.P. and J.H.; visualization, J.P.; supervision, J.S. All authors have read and agreed to the published version of the manuscript.

Funding: This project has received funding, for J.P. and J.J. work, from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862695, EJP Soil: Road4Schemes project.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available upon request from the corresponding authors.

Acknowledgments: Thanks to colleagues who participated in the evaluation in focus groups. Your comments were invaluable. Many thanks to the anonymous reviewer who provided us with serious and helpful comments.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Resilience-associated article in regulation (eu) 1305/2013 on rural development.

Article	Note
1	Preamble: "resilience of ecosystems to climate"
2	Article on Priorities: "resource-efficiency priority . . . resilient to climate"
3	Article on Tasks: "agricultural sector development resilient to climate"
4	Article on Advisory: "resilience of farm ownership, farm and climate-related investment"
5	Article on Forest Area Development: "resilience of woodland ecosystem"
6	Article on woodland ecosystem stability: "resilience of woodland ecosystem"
7	Article on European Innovation Partnership: "low-emission economics resilient to climate"
8	Annex on Measures

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