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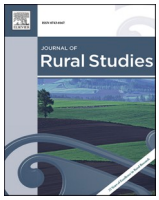

Systemic barriers and untapped potentials: a SWOT study on the implementation of natural/small water retention measures in Europe

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ABSTRACT

There is strong evidence that ecosystem-based approaches, such as Natural/Small Water Retention Measures (NSWRMs) can be an important solution to problems associated with managing water quality and quantity, soil erosion, and nutrient loss. Moreover, they deliver multiple co-benefits such as increased biodiversity, climate change adaptation and mitigation, alongside aesthetic and recreational functions. However, despite their apparent advantages and significant political momentum for their expanded deployment, implementation of NSWRMs remains slow. This study asks why this is the case and employs a methodologically rigorous variant of the SWOT framework combining qualitative and quantitative (scoring and cluster analysis) elements to assess the exact barriers and potentials for increasing the NSWRMs' implementation across Europe. The empirical analysis draws on case studies of fourteen small watersheds distributed across twelve European countries to explore the factors affecting the NSWRMs adoption, evaluate their relative importance, and identify necessary intervention areas for their better uptake. Our findings indicate that the main drivers for NSWRMs implementation are high knowledge availability through formal and informal networks, as well as support through advisory services. On the other hand, the main hindrances are inadequate financing schemes but also uncertain societal attitudes and perceptions. Financing schemes rarely account for indirect costs, and bureaucratic procedures further discourage practitioners from pursuing these measures. Negative attitudes are linked to mismatched time horizons as well as the gap between theoretical benefits and practical implementation challenges.

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1. Introduction

Sustainable land use and resilient agriculture face many challenges, often linked to various water-related issues. Examples include water quantity conflicts (agricultural water uses vs. drinking water vs. maintenance of environmental flows), extreme weather events such as droughts and heavy rainfalls, issues of nutrients runoff and erosion, but also water quality problems and challenges in achieving ecological status targets (Bindi and Olesen, 2011; De Fraiture and Wichelns, 2010; Ingrao et al., 2023; Pereira, 2017).

Strategies for optimal water retention and water management are urgently needed across different biogeographical regions in Europe (Cervellini et al., 2020; Dias et al., 2024; Praprotnik Kastelic et al., 2025; Rice et al., 2011). Better water management in small agricultural catchments in various pedoclimatic zones and farming systems can contribute significantly to a more resilient society (Martínez-Fernández et al., 2023). Although a range of comprehensive measures for water retention are available at farm and catchment levels, their implementation and combinations are relatively sparse in many regions. At farm level, these can include practices like conservation tillage, crop rotations, cover crops, buffer strips etc., while at catchment level they extend to i.a. wetland restoration, retention ponds, afforestation, terracing to slow, store, and infiltrate water across the landscape (GWP, 2020; Praprotnik Kastelic et al., 2025; Tal-maon et al., 2024; Wittekind et al., 2025).

Natural/Small Water Retention Measures (NSWRMs) are an umbrella concept for "small and multi-functional measures for the retention/management of water" (OPTAIN, 2021). NSWRMs are in line with the NWRMs (Natural Water Retention Measures) concept but have a slightly different scope (Burek et al., 2012; Collentine and Futter, 2018). While the NWRMs' primary focus is on natural means, NSWRMs also encompass small technical water retention measures (SWRMs), including small reservoirs and cultivation technologies to increase soil structure and soil retention properties (GWP, 2015; OPTAIN, 2021). Other partly overlapping and relevant ecosystem-based concepts include natural infrastructure, green infrastructure, ecosystem-based adaptation (Eba), ecosystems and nature-based approaches, nature-based solutions (NbS) and runoff attenuation features, soil-based practices, soil conservation measures, natural, small scale forestry measures etc. (Collentine and Futter, 2018; Mrozik and Idczak, 2017). Treating NSWRMs as a distinct concept proves useful to stress their attributes as modestly sized and localised solutions to problems associated with water management, sediment, and nutrient loss (Magnier et al., 2024).

NSWRMs are important because of their ability to increase water retention based on natural processes, and they also bring significant co-benefits (Collentine and Futter, 2018; Škute et al., 2008). These include better nutrient management, flood and drought mitigation, reduced erosion and sediment transport (Kvítek et al., 2023), increased biodiversity and soil fertility, climate change mitigation, and aesthetic and recreational functionalities (Sušnik et al., 2022).

NSWRMs contribute to the priorities of the European Green Deal, Common Agricultural Policy (CAP), Farm to Fork Strategy, Nitrates Directive, Flood Directive, and Water Framework Directive (EC, 2019, 2020, 2022; EUR-Lex, 1991, 2000, 2007). The EU Flood Directive has inspired at least 26 member states to include NSWRMs in their plans, but large differences remain in the uptake (Gerritsen et al., 2021). To an even greater extent than its predecessor, the current 2023-2027 Common Agricultural Policy (CAP) supports the implementation of NSWRMs as part of its environmental and climate objectives (EC, 2023a). NSWRMs are perceived as an important tool to enhance the resilience and sustainability of the EU's agricultural sector. Soil protection becomes one of the priorities with an array of mandatory and voluntary measures (EC, 2018, 2021b). CAP encourages farmers to adopt sustainable practices that increase water retention capacity of their soils and landscapes. It also provides various instruments and incentives for farmers to implement NSWRMs, including standards for good agricultural and environmental conditions (GAECs) and direct payments for voluntary climate and environmentally sustainable practices, the so-called eco-schemes. Several of the rural development programs (RDPs) promote NSWRMs (EC, 2021a, 2024b, 2024c, 2024a). The new Strategic Plans (CSPs) became now the key tool for delivering CAP between 2023 and 2027 and a new set of GAECs adopted marks an overall increase in environmental requirements, including measures contributing towards addressing water retention (EC, 2023b, 2023a).

Although there is a growing recognition of the importance of NSWRMs and an increasing body of literature dedicated to this subject, the motivations behind their systematic implementation remain quite underexplored. While NSWRMs/NbS in the urban environment have received significant scholarly attention (Duffaut et al., 2022; Ferreira et al., 2020; Tsatsou et al., 2023) their agricultural counterparts are still mostly studied at the individual measure level (Ryfisch et al., 2023; Vanino et al., 2024). Research on aggregated measures or cross-country comparisons on measure implementation is rare (Graversgaard et al., 2021).

Furthermore, for agricultural measures, greater emphasis is placed on stakeholder communication (Giordano et al., 2020) and public acceptance of measures (Anderson et al., 2021; Anderson and Renaud, 2021), than the opinions of practitioners which are scarcely investigated (O'Leary et al., 2024). Studies on agri-environmental measures point out that their uptake "remains below expectation" (Wittstock et al., 2022) and give diverse recommendations to better understand the practitioner perspective and mainstream the measure uptake.

Studies of NSWRMs should better integrate the literature dedicated to agricultural retention (agri-environmental measures), landscape retention (wetlands and forestry measures) and technical retention (small reservoirs, damming on watercourses), offering a holistic approach to water retention management (Lemann et al., 2022; Piniewski et al., 2024; Scholz, 2022). It is highly important to address the above-mentioned gaps and understand the various factors that affect the adoption of NSWRMs. Many single measures are supported with various forms of payments to implementers and there exists an extensive literature on the adoption of single measures (Franzén et al., 2016; Lindahl and Söderqvist, 2004). However, looking at the aggregated measure level and bringing a wider European practitioner perspective is very uncommon.

We ask: *why are NSWRMs adopted slowly and in limited numbers in agricultural landscapes, despite their benefits and strong political* support *at the global and European level?*

To answer this question, we developed a comprehensive SWOT (Strengths, Weaknesses, Opportunities, Threats) framework dedicated to NSWRMs' analysis and applied it to fourteen case study locations with various soil and climatic conditions and agricultural systems in Europe. Case studies build on data from the H2020 OPTAIN project, investigating small agricultural catchments distributed across Europe. This approach allows us to unravel the main research question in two subquestions: *What are the main drivers for NSWRM based on their strengths and opportunities? And what are the main hindrances rooted in their weaknesses and threats?* To move beyond listing individual, sometimes context-specific observations, we quantify the results of the SWOT analysis across case studies and use mean scores in the four SWOT pillars to compare different 'Topics' and identify drivers and hindrances in a more rigorous manner. The SWOT analysis provides a diagnosis of the status-quo and identifies future areas that need to be addressed to promote better NSWRM mainstreaming by reducing hindrances and building on the identified drivers.

2. Theory and methods

2.1. Case-studies

We investigate 14 case study sites representing small agricultural

catchments, distributed across 12 European countries[1](Fig. 1 and Table 1).

Except for Norway and Switzerland, all countries are Member States of the European Union. Both Norway and Switzerland remain outside some EU regulatory areas, such as CAP. Norway, being a member of the European Economic Area (EEA) and following the European Free Trade Association agreement, has direct access to the single market and implements several EU directives on the protection of water resources. In contrast, Switzerland has more limited access to the EU market with a series of bilateral agreements. It is worth noting that the agricultural sector in Norway and Switzerland has also been heavily supported with subsidies exceeding those in the EU (Donald et al., 2002).

Most of the case study sites are highly agricultural, with cropland shares exceeding 40% of the total area, except from La Wimbe (7), Csorsza (3) and Tetves (11), where it is 32%, 36% and 31% respectively. They present different combinations of key challenges, including high flood and drought risk, soil erosion, soil compaction, nutrient leaching, and loss of soil organic matter. Depending on the case-specific problems, supporting conditions, and local actor's engagement, various NSWRMs are implemented in the case study sites.

2.2. SWOT framework

The SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is an established tool for (self)evaluation and assessment of future potentials (Helms and Nixon, 2010). It is widely used as a project evaluation tool and for preliminarily screening of key features and potentials of a complex system (Elwalda and Benzaghta, 2021). Recently, SWOT analyses are increasingly used in environmental management (Szulecka and Monges Zalazar, 2017), including water resource management, to evaluate factors and to develop and implement future strategies (Balzan et al., 2022), and to study complex interdisciplinary issues (Nagara et al., 2015). SWOT as a method is represented in the scientific literature evaluating environmental management but often also used to design relevant policies and interventions. It has been successfully used in the European rural development policies (Knierim and Nowicki, 2010) or in the development of the CAP objectives (Toma et al., 2021). Classical SWOT can be modified to accommodate more dimensions (Nazarko et al., 2017).

Our framework builds on a classical SWOT matrix (Sammut-Bonnici and Galea, 2015) designed to assess beneficial (Strengths and Opportunities) and harmful factors (Weaknesses and Threats) – hereafter referred to as the SWOT *pillars* – and to systematize the importance of individual factors (Table 2). However, we expand on this largely qualitative framework by introducing a quantitative component of scores, mean values, and their clustering analysis, explained in the following section.

2.3. Adapting the SWOT framework to NSWRMs analysis

Adjusting the SWOT framework to capture NSWRMs' particularities in our study followed four steps: (1) translating the SWOT approach to NSWRMs by proposing most important Topics and Factors (2) testing the SWOT framework on selected case studies (3) refining the framework based on the feedback (4) introducing an evaluation scale with both qualitative and quantitative components.

To tailor the generic SWOT approach to the purpose of our analysis, we developed a set of six Topics, which are analyzed in each of the SWOT pillars (see Table 3). The Topics are always consistent across the SWOT pillars, while Factors within the Topics are adjusted to logically correspond to the respective SWOT pillar. The list of Topics has been first developed in an inductive process building on a desktop literature analysis and has been anchored in the data gathered and key issues identified within the OPTAIN project (Čerkasova and Idzelytė, 2021; Krzeminska and Monaco, 2022; Piniewski et al., 2024; Van den Brink et al., 2022). Our framework further builds on a comparative study of agricultural water management policies across the case studies (Glavan et al., 2022), a SWOT study on Nature-based Solutions (Balzan et al., 2022), and a study of opportunities and limitations for NbS in Europe (Ryfisch et al., 2023). These studies share conceptual overlap with respect to scale and key ecosystems of NSWRMs (Magnier et al., 2024).

2.3.1. Topic 1: attitudes and perceptions

Social attitudes and perceptions have been identified as a crucial factor for land use change (Laroche et al., 2019). New models of farming and land use depend on the ability and motivation of actors (predominantly farmers and advisors) to question the post-war intensive farming paradigm, their understanding of new environmental concerns, interests and values of other actors (Del Corso et al., 2015). Land use management strategies should rely more on stakeholder perceptions to find optimal solutions (Kaim et al., 2020).

2.3.2. Topic 2: knowledge

Literature on Nature-based Solutions identifies a significant lack of knowledge on ecosystem-based, near-natural or nature-based solutions (Lupp et al., 2021). NSWRMs require interdisciplinary knowledge approaches, drawing upon insights from diverse fields, including the ecological sciences. Some restoration measures combine ecological sciences and engineering. Moreover, there is a need for a shared ecosystem service perspective that bridges the gap between ecological and social sciences (Nesshöver et al., 2017). In addition to scientific knowledge of the measures, a two-way flow of knowledge is needed between practitioners and scientists (ecological models and socio-economic parameters).

Farming requires more complex and interdisciplinary knowledge and skills to navigate the changing environment, but most European farmers lack formal education and training. Only 8.5% of farmers in Europe have received full agricultural training and 70% have only practical experience (European Parliamentary Research Service, 2017). Therefore, most of the farmers rely on practical experience and knowledge dissemination through their formal and informal networks.

Spillover of knowledge and information between the different actors requires some networks and arenas, and the development of social capital (Polman and Slangen, 2008). This can be done in projects or through the traditional use of agricultural advisory and extension services as channels for providing knowledge, information and best-practice (Osawe and Curtis, 2024).

2.3.3. Topic 3: institutional capacity

Understanding the institutional context is another key issue for implementing NSWRMs. Institutional barriers include the legal framework (same measures can be mandatory or voluntary depending on the country or specific case location), division of departmental responsibilities, permit schemes etc. (Mendes et al., 2020). Governance of measures requires active cooperation and coordinated action between stakeholders and needs to build on strong institutions, well-established planning and instruments (Seddon et al., 2020).

2.3.4. Topic 4: financing schemes

Despite the existing financing mechanisms (mainly the CAP), the economic aspects of many measures are often negatively perceived. High expected maintenance costs, lack of valuation of co-benefits (recreation, aesthetics etc.) are often referred to as financial barriers for NbS implementation (Lupp et al., 2021).

A recent United Nations Environmental Programme (UNEP) report shows that investments in NbS will need to triple by 2030 and increase four-fold by 2050 to deal with the planetary emergencies and both public, private, national and international funds need to be widely

[1] Hungary has three case-study sites, including one transboundary catchment at the Hungarian/Slovenian border.

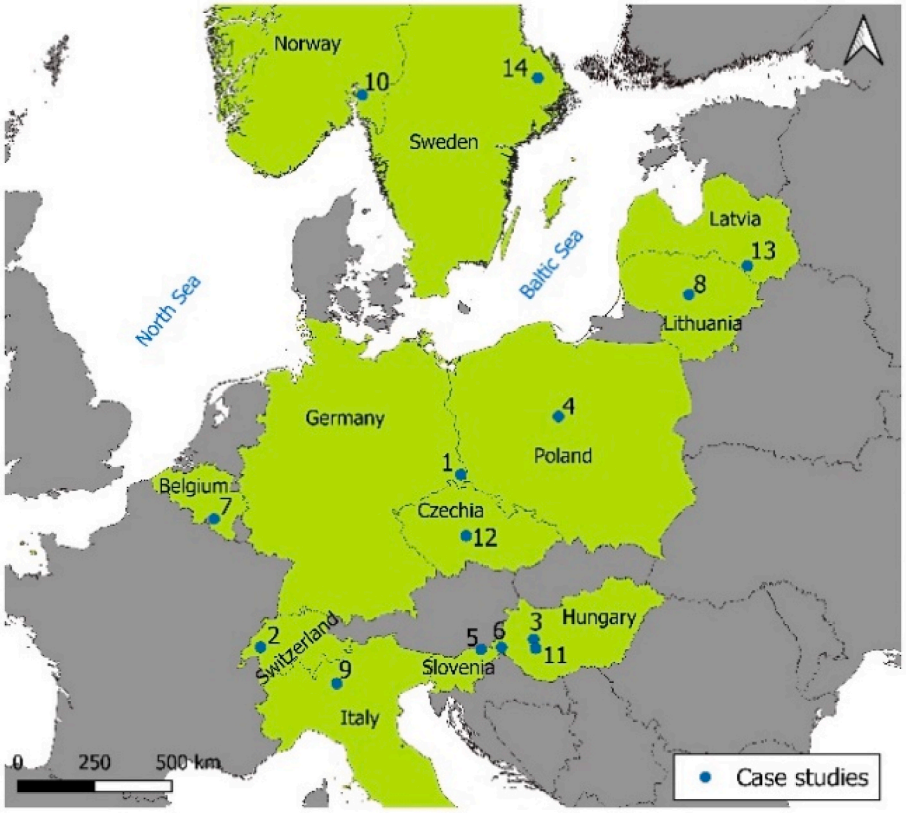

Fig. 1. Map of case study sites.

Table 1
Overview of case study sites, including existing measures studied within the OPTAIN project (Lemann et al., 2022; Marval et al., 2022).

Country	Case study (Number on a map)	Agricultural area (%)	Catchment area [km^2]	Main pressures	Measures
Belgium	La Wimbe (7)	32	112	Floods and droughts, soil erosion	Buffer strips, constructed wetlands, riparian buffers, catch crops
Czech Rep.	Čechtický (12)	65	72	Floods, phosphorus and nitrogen losses	Grassland cover, constructed wetlands, no till agriculture
Germany	Schwarzer Schöps (1)	72	136	Floods, phosphorus losses	Buffer strips, grassed waterways, hedgerows, retention ponds, low till, catch crops
Hungary	Csorsza (3)/Tetves (11)/Kebele patak (6)	36-59	21/72/247	Floods, phosphorus losses	Buffer strips, crop rotation, catch crops, mulching, forest riparian buffers, afforestation, meadows and pastures, early sowing, low till
Italy	Cherio (9)	45	153	Floods, droughts, nitrogen losses	Retention ponds, terracing, crop rotation, cover crops
Latvia	Dviete (13)	47	254	Floods, phosphorus, and nitrogen losses	Retention ponds, buffer strips
Lithuania	Dotnuvele (8)	69	193	Phosphorus and nitrogen losses	Constructed wetlands, buffer strips, cover crops, no till
Norway	Hobøl- Kråkstad chatchment (10)	41	56	Soil erosion, floods, phosphorus, and nitrogen losses	Reduced tillage (no tillage in autumn), grassed buffer zones, grassed waterways, constructed wetlands, grass on areas prone to flooding and erosion risk, sedimentation ponds in the forest
Poland	Upper Zglowiaczka (4)	>90	78	Floods, droughts, phosphorus, and nitrogen losses	Afforestation, wetlands restoration and management, mulching, subsoiling
Slovenia	Pesnica (5)/Kobiljski potok (6)	55-65	137/247	Floods, droughts, phosphorus, and nitrogen losses	Green cover of arable land, retention ponds, low till agriculture, crop rotation, early sowing, protective buffers along the streams
Sweden	Sävjaån (14)	60	125	Floods, droughts, phosphorus losses	Constructed wetlands
Switzerland	Petite Glâne (2)	79	101	Droughts, phosphorus losses	Buffer strips, no till agriculture, crop rotation, intercropping, drought resistant plants

mobilized (UNEP, 2021). Natural measures are globally perceived as "undercapitalized", and lack of funding is widely recognized as one of the main barriers to the implementation and monitoring of NbS (Seddon et al., 2020). However, there are already studies showing that investments in NSWRMs can be cost-efficient and be quickly returned via enhanced production (Sušnik et al., 2022).

Table 2
SWOT pillars and their relevance for NSWRMs' implementation, adapted from Comino and Ferretti (2016).

	Drivers	Hindrances
Internal (attributes of the NSWRMs) and current situation	**Strengths**: endogenous factors with which the system is equipped, and which can be used to achieve the adoption of NSWRMs.	**Weaknesses**: endogenous factors representing deficiencies of the system and obstacles for the adoption of NSWRMs.
External (attributes of the environment) and future situation	**Opportunities**: exogenous factors that can be utilized or enhanced by proper politics to increase NSWRMs adoption.	**Threats**: exogenous factors which could weaken the strengths of the system, exacerbate the weaknesses, prevent the system from catching the opportunities and hinder NSWRMs adoption.

2.3.5. Topic 5: technology and infrastructure

Access to technology in agriculture is unevenly distributed in Europe, linked to wealth, farm size and historical legacies. Only in some countries more than 90% of farmers own a tractor, but this number can be as low as 20% (Florea et al., 2021). Especially small, family-run farms rely on old and outdated equipment and replacing it is unaffordable. Difficulties of small-scale farmers to access technology and infrastructure are very visible in the NSWRM context. Average farm size differs substantially across Europe and average farms are bigger in Southern Sweden, Czechia and Eastern Germany as compared to farms in Poland, Italy, Hungary, Slovenia or the Baltic states (Mizik, 2018). Several of our case study countries (Slovenia, Hungary, Poland, Italy) have small farms below 10 ha as the most typical land holding (Eurostat, 2018).

2.3.6. Topic 6: communication and dissemination

Communication and knowledge dissemination can have various forms, but it has been proven that direct knowledge transfers, such as on-farm visits are the most effective means of communication with practitioners (Dixon, 1994). Agri-environmental advisors play a particularly important role as knowledge disseminators and can be responsible for the 'environmental re-skilling' of landowners and farmers (Curry and Winter 2000). Still, there has not been much research on how agri-environmental advisors can better promote the adoption of environment enhancing activities and measures (Geranmayeh et al., 2024).

The initial SWOT framework, including the Topics, was tested on three case studies (Italy, Slovenia, and Poland) for further refinement and adaptation. For each Topic, a list of potential Factors was proposed, and local experts from each of these case studies provided information relevant for each Factor. These Factors were then discussed between the cases and evaluated by the case study experts. Given the exploratory nature of this stage, a systematization process was initiated, leading to the identification of three key Factors for each Topic.

2.4. Application and data analysis

Having refined the framework, the research team built a questionnaire and introduced an evaluation scale with both quantitative and qualitative components allowing for quantifying and comparing the importance of Topics and Factors. Each Factor received the following scores from the experts: 0, which stands for 'not relevant/does not exist', 'very low' = 1, 'low' = 2, 'medium' = 3, 'high' = 4 and 'very high' = 5. These scores then allowed for a comparison of mean values between the different SWOT pillars and across Topics.

Assessing all collected Factors with the developed scale allowed, firstly, to compare Factors within each Topic and later to identify the most important Factors for each of the Topics under each SWOT category. We aggregated the case study data in a cross-case synthesis and

Table 3
– SWOT framework for NSWRMs (Source: own elaboration).

	Topics	Factors
STRENGTHS [a]Strengths are internal and present; future and external factors will be captured in Opportunities. High values for Strengths are positive for NSWRM.	**Attitudes and perceptions**	*The need for measures to tackle water retention and/or nutrient runoff challenges is acknowledged* in the area. *Win-win with other objectives* (e.g. *yield).* *A general perception that NSWRMs are good for the natural environment.*
	Knowledge situation	*Scientific research on NSWRMs has been ongoing for long.* *Local practical knowledge on the benefits of NSWRMs exists in the case study area.* *Farmers/practitioners trained in agronomy and/or have long experience of agricultural NSWRMs.*
	Institutional capacity	*An institutional set up on local or regional level that discusses NSWRMs to be listed in POM (WFD)*[a]. *Advisory system/courses on NSWRMs in the case study area.* *NSWRMs are mandatory in specific conditions/areas.*
	Available financing schemes	*Sufficient support for direct costs.* *Sufficient support for indirect costs.* *Flexible, easy bureaucracy for funding.*
	Technology and infrastructure	*Practitioners have access to machinery & equipment.* *Networks of actors and some collaboration for better access to the machinery and equipment.* *Rental is easy, convenient & user friendly.*
	Communication/ dissemination	*Adequate Guidelines for NSWRMs.* *Advisory services are relevant for NSWRMs.* *Arenas for farmer-to-farmer exchange of experiences exist and are widely used.*
OPPORTUNITIES [a]Here you can think broader about future trends and other external developments. High values for Opportunities are positive for NSWRMs.	**Attitudes/ perceptions**	*Expectations of multiple benefits provided by NSWRMs to implementers and local community.* *Increasing interest in conservation agriculture and low-input practices.* *More interest in NSWRMs because of environmental concerns & strategies to face climate change effects.*
	Knowledge	*Experiments/demonstration sites provide knowledge on the practice of NSWRMs.* *More knowledge on the benefits of NSWRMs by means of experiments or practice can be expected.* *Provision of formal and informal education & practice about NSWRMs is likely to enhance implementation.*
	Institutional capacity	*More possibilities to include NSWRMs in POM (WFD)*

(continued on next page)

Table 3 (*continued*)

	Topics	Factors
		representing a link to CAP or other regulations for economic support.
		New ways for improved advisory services are expected in the future.
		Expected more favorable regulation framework.
	Available financing schemes	*Expected Increased support for direct costs.*
		Expected Increased support for indirect costs.
		Expected reduced administrative and bureaucratic burden for funding.
	Technology and infrastructure situation	*Better access to machinery will be available in the future.*
		Better network/system for machinery rental and sharing.
		Rental of machinery will be easier & costs reduced.
	Communication/ dissemination	*Better learning environment for NSWRMs implementation.*
		Good and available advisory services in the future.
		Better arenas to discuss, share experiences expected in the future.
WEAKNESSES [a]Weaknesses are internal and present; future and external factors will be captured in Threats. High values for Weaknesses are negative for NSWRMs.	**Attitudes and perceptions:**	*Skepticism due to long waiting time for the benefits.*
		Complicated implementation planning/execution/ investment.
		Lack of interest in changing practices and habits.
	Knowledge situation	*Scarce research activities on NSWRMs carried out.*
		Scarce knowledge on the benefits of NSWRMs in the case study area.
		Lack of practical experience and expertise on (agricultural) NSWRMs.
	Institutional capacity	*Regulations do not address NSWRMs in the case study area.*
		Local advisors do not address NSWRMs or there is not sufficient capacity to follow up on this.
		Incoherent legislation.
	Available financing schemes	*Insufficient support for direct costs.*
		Insufficient support for indirect costs.
		Administration and bureaucracy are barriers for funding.
	Technology and infrastructure situation	*High investment needs in new technology.*
		Limited networks and collaborations for machinery access and equipment.
		Rental is inconvenient and too expensive.
	Communication/ dissemination	*Lack of information at hand on technical & practical implementation.*
		Insufficient advisory services.
		Few current arenas to discuss and share experiences are in place.
THREATS [a]Here you can think broader about future trends and other external developments. High values for Threats are negative for NSWRMs.	**Attitudes and perceptions**	*Skepticism and scarce perception of the possible benefits provided by NSWRMs to environment and society.*
		Focus on short-term economic situation.
		Risk aversion of practitioners with NSWRMs difficult to complement or replace consolidated practices.
	Knowledge	*There will be low funding opportunity for field experiments.*
		Knowledge of NSWRMs will show negative cost-benefit ratios.
		There will be no pioneers implementing measures - hence experience based knowledge will not develop.
	Institutional capacity	*Poor integration of NSWRMs in the upcoming regulations and policies.*
		Policy inertia and lack of political will.
		Unfavorable regulation framework.
	Available financing schemes	*Low or null amount of the relevant subsidies by public policies.*
		Indirect costs will not be covered.
		High and complex administration and bureaucracy.
	Technology and infrastructure	*Machinery will not be available in the future.*
		Platforms for sharing will remain uncommon.
		Rental of machinery will be more difficult and expensive.
	Communication/ dissemination	*No trust in future communication/ dissemination material & techniques.*
		Advisory services will not address NSWRMs.
		Arenas for practitioners-to-practitioners exchange of experience will not be developed or used.

[a] WDF: Water Framework Directive, POM: Programme of Measures.

used mean values for all Topics and Factors to identify common Strengths, Weaknesses, Opportunities and Threats. Additionally, for each Factor qualitative information was provided explaining the reasons for each evaluation.

Altogether, 27 experts from twelve case-study countries with fourteen case-study sites took part in the questionnaire. For each case study country, they prepared their own SWOT analysis providing a ranking of Factors within all SWOT pillars, alongside some extensive qualitative information for further analysis. Interesting examples of qualitative statements are used as quotations in the Results section.

The final quantitative evaluations were results of internal dialogues between the experts. All experts possess relevant NSWRM knowledge and experience derived from their case study sites. It should be noted that they are not farmers but rather work with farmers as researchers

and/or advisors. All case study sites have established stakeholder fora, known as Multi-Actor-Reference Groups (MARGs), as part of the OPTAIN research project, where different actors (farmers, farmers associations, landowners, researchers, local authorities, waterworks, etc.) have been encouraged to discuss NSWRMs in the area (Nesheim and Enge, 2022; Van den Brink et al., 2022). The MARGs promote knowledge exchange between actors and facilitate activities, workshops, meetings, and field visits. MARG platforms have been important for our case study experts (informants to the SWOT study) to understand the local dynamics and farmers' perceptions of NSWRMs. Thanks to MARGs (and other relevant fora), expert judgements should be more informed, representative and inclusive of all stakeholders' views.

Data collected for the dedicated framework provides insights on strengths, weaknesses, opportunities, and threats for NSWRMs implementation in Europe. We elaborated the data to provide a cross-case synthesis of aggregated average scores for each topic across SWOT pillars. We also visualized data using spider graphs. A cluster analysis was employed to establish the mutual geometric similarity of such charts (Górnisiewicz et al., 2024). It was performed using STATA (StataCorp, release 15) to assess similarity between the Topics and to find plausible cross-case study patterns. Case-level data can be found in Annex 1 with bar charts illustrating individual Factors across all SWOT pillars.

The final framework (Table 3) has six Topics for each SWOT pillar, further represented by three selected Factors. The first Topic "Attitudes/perceptions" reports on NSWRMs' perceptions in the case-study area. The second Topic "Knowledge" investigates knowledge for NSWRMs implementation. Furthermore, the Topic on "Institutional capacity" explores existing regulatory frameworks for NSWRMs. The fourth Topic evaluates the "Financial support" for NSWRM implementation across the SWOT categories. The fifth Topic focuses on "Available technology and infrastructure" for NSWRMs in the case study areas and the last Topic evaluates "Communication/information dissemination" activities that target NSWRMs. Some Factors, advisory services being a good example, can appear similar but are listed under different Topics because of their different focus. In this case we refer to the advisory services either as an institutional component (in the Topic on Institutions) or to their special task in knowledge communication and dissemination (here within the Communication/information dissemination Topic).

3. Results

We have summarized overall scores for all analyzed Topics and Factors across the SWOT pillars in Table 4. The scores are further visualized in spider graphs presented in Fig. 2 where shapes illustrate the four SWOT pillars and help comparing the studied Topics.

The cross-case synthesis illustrates small deviations in the scores attributed to single Factors and Topics, suggesting commonalities in the opinions of different experts though in different sites.

Fig. 2 is a visual representation of the overall results from Table 4. By plotting the average aggregated scores for each Topic in Fig. 2, a certain similarity of the charts can be observed. It also allows for a visualization of the dominant pillars and their orders, so that each of the Topics can be described with a different ordering of the SWOT acronym letters: e.g. W/T/O/S for financing schemes, allowing for quick identification of areas in which weaknesses and/or threats dominate. The cluster analysis carried out identified three distinct groups at a geometrical similarity, which reflects similarity in the average scores. As shown in Fig. 3, the first cluster links the charts related to Attitudes/perceptions and Financing schemes. Another cluster showing significant similarities groups the Topics of Knowledge, Institutions and Communication/dissemination. Finally, the Topic of Technology/infrastructure is more distinct from the previous, though with more similarities with the second cluster than with Attitudes/perceptions and Financing schemes.

3.1. Attitudes and Financing schemes

Two Topics (Attitudes and Financing schemes) follow a W/O/T/S and W/T/O/S pattern (as explained above) - a constellation which indicates that the expert judgments were negative, ranking weaknesses as the first pillar and strengths as the last one.

3.1.1. Attitudes/perceptions

The Attitudes/perceptions Topic (referring to the situation where the need for measures is acknowledged, win-win and possible trade-offs between various management goals and perception of NSWRMs are emphasized by practitioners) follows the W/O/T/S pattern. However, the values don't show any extremes across pillars, ranging between 3.36 (the highest value for weaknesses) and 2.94 (the lowest value for strengths). Therefore, the shape in the spider graph is evenly distributed. However, one Factor dedicated to the win-win and possible trade-offs

Table 4
– SWOT synthesis with average values and standard deviation for Factors and Topics across the case studies.

Topic	Factor	Strengths	Weaknesses	Opportunities	Threats
Attitudes/perceptions	Need for measures is acknowledged	3.50 ± 0.67	3.58 ± 0.90	3.42 ± 0.67	2.64 ± 0.81
	Win-win with other objectives	2.25 ± 0.62	3.25 ± 0.87	2.92 ± 0.67	3.75 ± 0.75
	Interest by practitioners	3.08 ± 0.67	3.25 ± 0.75	3.17 ± 0.72	2.83 ± 1.03
	Mean value and SD for the Topic	**2.94** ± 0.55	**3.36** ± 0.48	**3.17** ± 0.48	**3.10** ± 0.54
Knowledge	Scientific research	3.50 ± 0.67	2.92 ± 0.90	3.67 ± 0.98	2.25 ± 1.06
	Knowledge on benefits	2.75 ± 0.97	3.42 ± 1.08	3.50 ± 1.00	2.92 ± 1.08
	Education and practice	3.25 ± 0.62	2.33 ± 0.89	3.50 ± 0.52	1.50 ± 1.24
	Mean value and SD for the Topic	**3.17** ± 0.50	**2.89** ± 0.74	**3.56** ± 0.66	**2.22** ± 0.74
Institutions	Integration into regulations	3.00 ± 1.34	2.50 ± 1.17	3.42 ± 0.79	2.42 ± 1.16
	Advisory system	3.58 ± 0.79	2.17 ± 0.72	2.75 ± 1.14	3.00 ± 0.85
	Regulation/legislation framework	2.25 ± 1.14	3.00 ± 1.21	2.58 ± 1.00	2.91 ± 0.54
	Mean value and SD for the Topic	**2.96** ± 0.77	**2.56** ± 0.52	**2.92** ± 0.78	**2.81** ± 0.73
Financing schemes	Support for direct costs	2.67 ± 0.78	3.42 ± 0.90	3.42 ± 1.00	3.08 ± 1.08
	Support for indirect costs	1.45 ± 0.82	3.73 ± 0.90	2.75 ± 0.62	3.25 ± 1.36
	Bureaucracy	1.83 ± 1.11	3.75 ± 0.62	2.92 ± 1.00	3.67 ± 0.65
	Mean value and SD for the Topic	**1.99** ± 0.72	**3.63** ± 0.56	**3.03** ± 0.69	**3.33** ± 0.74
Technology/infrastructure	Access to machinery	3.42 ± 0.51	3.00 ± 0.85	2.58 ± 1.08	1.17 ± 0.83
	Collective networks	2.92 ± 1.16	2.58 ± 1.08	2.50 ± 1.38	1.67 ± 0.65
	Machinery rental	2.25 ± 1.14	2.25 ± 0.87	2.25 ± 1.06	2.00 ± 0.85
	Mean value and SD for the Topic	**2.86** ± 0.77	**2.61** ± 0.83	**2.44** ± 1.09	**1.61** ± 0.58
Communication/dissemination	Guidelines for NSWRMs	2.67 ± 0.65	2.92 ± 0.79	3.33 ± 0.49	2.58 ± 0.90
	Role of the advisory services	3.75 ± 0.75	1.92 ± 0.67	3.42 ± 0.79	1.50 ± 1.00
	Arenas for discussion	3.17 ± 0.72	2.08 ± 0.90	3.08 ± 0.67	2.08 ± 1.00
	Mean value and SD for the Topic	**3.19** ± 0.54	**2.31** ± 0.36	**3.28** ± 0.42	**2.06** ± 0.83

Fig. 2. – Spider graphs illustrating average SWOT Pillar values by Topics across the case studies.

between various management goals shows a significant span: it has been ranked as a strength with 2.25 but as a threat with 3.75, representing the biggest threat among all analyzed Factors.

Although the need for NSWRMs is widely acknowledged (this Factor was ranked high as a strength with 3.50 average score) the tendency is not straightforward, because the same Factor has been ranked as an even more significant weakness with 3.58. In the qualitative material, our experts often elaborated on the attitudes and perceptions, mentioning multiple reasons for skepticism about the measures and concerns about practical challenges. "Farmers often cling to tradition, especially when they cannot be presented with quick positive change" (Hungary). Many cases (Italy, Poland, Slovenia, Czechia, Belgium, Hungary, Lithuania) mentioned scepticisms due to uncertainties, long waiting time and difficulties in assessing effectiveness. In Norway, "tradition and economic habits are still important, but attitudes are changing. More farmers are aware of environmental issues".

An important condition for changing attitudes and perceptions are weather shocks and extreme events that change practitioners' opinions: a statement from the Swiss case points out that "long-held traditions and how we have always done things economically are important, but that is changing due to own experiences of extreme events [dry and warm summers, extreme rainfall events etc.]". Similar observations were made in the Polish and Slovenian case studies pointing to the effects of climate change on practitioners' attitudes towards the NSWRMs: "Long-cultivated traditions and tried-and-tested ways of doing things are difficult to change, at least in the eyes of practitioners. Especially when they require significant effort and carry uncertainty about the outcome. The situation is changing somewhat with the growing awareness of climate change and environmental deterioration" (Poland) and "tradition and economic habits have played a significant role, but attitudes are changing, especially with increasing awareness of climate change" (Slovenia). It is noted that extreme weather events increasingly disrupt European agriculture (Lakatos and Csabai, 2025) and European farmers demonstrate increasing openness to NSWRMs.

While our ranking criteria did not include farmers' age, the qualitative data suggests that it is a factor worth considering. Some respondents highlighted that young farmers are more likely to adopt new measures and practices. A statement from the Lithuanian case-study refers to two groups with "a community of farmers/agencies that are well versed in NSWRMs and the need (usually young farmers)" vs. "a community of farmers that are only driven by profits (usually large-scale or older generation farmers". This is ambivalent, could be seen as a strength with young farmers being more open towards the new measures, and a considerable weakness, with older farmers being resistant to new practices.

Our respondents pointed out different attitudes towards different measures, e.g. there is high level of acceptance for conservation tillage in the German case, crop rotation and controlled traffic farming in the Hungarian case, or cover crops in Slovenia. Land management measures are more accepted by farmers than structural measures while public

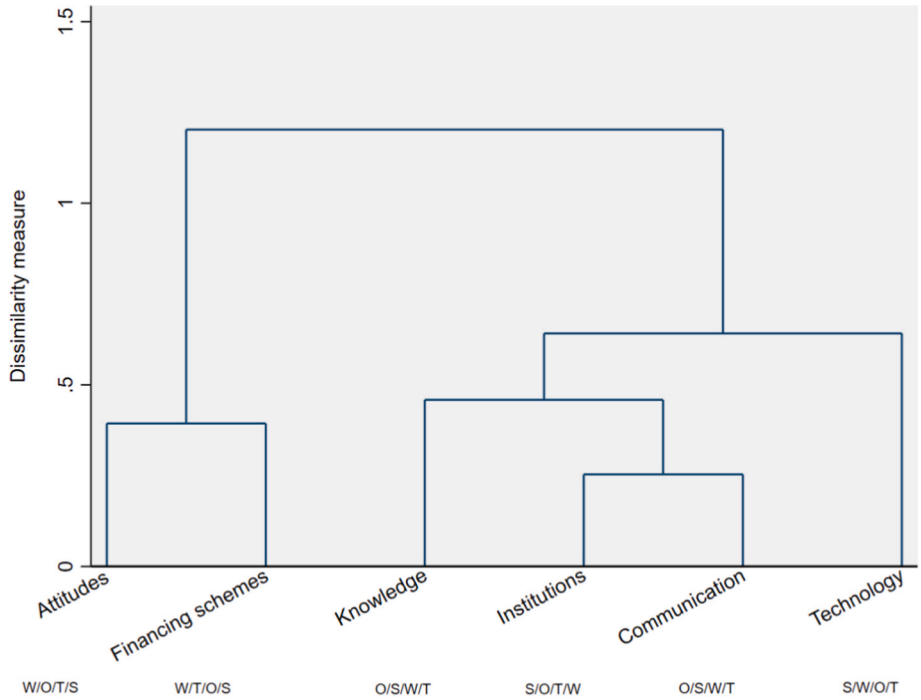

Fig. 3. – Dendrogram for clusterization of Topics, with patterns of importance for SWOT pillars (S - Strengths, W - Weaknesses, O - Opportunities, T – Threats), descending order of relevance.

authorities value structural measures "diminishing the overland flow and mud from fields at the streets or strengthening groundwater resources" (Czech Republic). On the contrary, farmers in the Hungarian case are reluctant to introduce measures concerning land use change (afforestation).

3.1.2. Financing schemes

Financing schemes follow the W/T/O/S logic. The Topic included the following Factors: support for direct costs, support for indirect costs, and bureaucracy for financial support and expert judgments show a similar negative tendency. Here, our SWOT results clearly show wide gaps between - positive and negative numbers. According to our analysis, financing schemes are ranked as a significant weakness (3.63) rather than a strength (1.99) for NSWRM implementation. Improving the situation represents an opportunity (3.03), but keeping the status quo represents a significant threat (3.33) to NSWRM implementation. The span between the values is the highest within the same Topic. Factors show that both support for indirect costs and bureaucracy have been ranked as very high weaknesses (3.73 and 3.75 respectively).

Qualitative data from the SWOT analysis confirm that there is financial support for direct costs to implement many measures, but it is not always covering all the costs. For indirect costs, the situation worsens significantly, and further discouragement is caused by the bureaucratic procedures. From the Hungarian case we can learn that "simplification of administration is necessary. Farmers find it difficult to keep up with the changes in the subsidy system's rules. Simplification would be a highly relevant opportunity for the implementation of measures". Many statements from the case studies stress the administrative burden as "discouraging", "frustrating" and "demanding" (Poland, Slovenia, Czech Republic). Some cases expect reduced administrative burdens for funding in the future: "the public administration also sees problems in obtaining funds by farmers and is making some efforts to simplify this process" (Poland). On the contrary, the German case reports that "administrative bureaucracy is not expected to be significantly reduced" and the Slovenian case notes that "there's an opportunity for improvement, but less likely, as sustainability reporting will still be required".

3.2. Knowledge, Institutions and Communication

In this cluster, two Topics (Knowledge and Communication/dissemination) follow the O/S/W/T pattern, while Institutions are categorized according to S/O/T/W. Both constellations indicate two positive pillars coming before two negative pillars but differ in terms of whether these are seen to be primarily current or primarily in the future: while Knowledge and Communication display future opportunities rather than current strengths, Institutions boast current strengths before future opportunities.

3.2.1. Knowledge

The Topic on Knowledge (referring to the Factors of scientific research, knowledge about NSWRM benefits, and education and practice) is considered as providing opportunities (3.56) and already showing significant strengths (3.17). Yet considerable weaknesses (2.89) and threats (2.22) are still indicated for the Topic. On the Factor level (Table 3), some variation can be indicated, for example, scientific research is the Factor that is seen as the biggest strength and providing most opportunities, and Knowledge on benefits of adopting measures, on the other hand, is considered as a weakness.

Qualitative data from the case studies report a satisfactory level of knowledge or positive knowledge dissemination, with both substantial research and practical implementation of many measures. All cases report numerous research projects and NSWRMs have been described as a "hot topic now and research is picking up" (Lithuania). Still, many case-studies report that despite the scientific research carried out in the area, holistic assessments combining more measures or aspects (impacts on water, biodiversity, productivity, cost analysis etc.) are rare, and there is a large variation of knowledge pools between measures. The Swedish case reports on wetlands as measures studied for over 30 years as compared to the two-stage ditches that have only been researched very recently. The Swiss case study reports on scarce research on resistance crops and intercropping while reduced tillage is very well investigated.

Although research is carried out, some experts point to the research and practice gap. The Hungarian case is a good illustration and reports

"a significant gap between farmers and scientific actors; farmers often unaware of research findings (and in many cases, researchers unaware of farmers' practices and experiences)". Some cases report bridging the gap, with the spillover of knowledge, especially through farmers networks. The Norwegian case illustrates NSWRMs learning via farmers networks: "if a farmer has implemented an NSWRM, others may follow".

The Hungarian, German, Italian, Polish and Czech cases point out that monitoring of measures is lacking or insufficient. Many also see lack of cost-benefit research on measures as a significant weakness.

3.2.2. Communication and dissemination

For the Topic on Communication/dissemination (referring to available guidelines for NSWRMs, role of advisory services, and arenas for discussion) current situation has been ranked as a significant strength (3.19) while its overall weakness score was 2.31, the lowest overall value among the Topics. The highest ranked Factor among the strengths was the advisory services relevant for NSWRMs. This has been followed by Arenas for farmer-to-farmer exchange and Available guidelines for measure implementation. In line with this, Communication and dissemination activities are not seen as a threat but rather an opportunity.

It was often stressed by the experts, that the advisory services "play a crucial role in disseminating information and aiding with administrative tasks" (Slovenia), "are familiar with most NSWRMs and help with some administrative tasks" and there are also expectations that "NSWRMs will become more relevant for advisory services" (Switzerland).

Many respondents pointed out that the measures covered by CAP have much better guidelines, instructions, and knowledge pools. It proves successful communication and dissemination of the CAP measures but also vulnerability for measures not included in current CAPs. "There is a lack of guidelines, instructions, and knowledge for measures not included in the CAP" (Slovenia), "guidelines for the measures not included in the CAP or local policy/promotion are not being addressed well enough" (Lithuania).

There are some significant limitations mentioned in the knowledge dissemination context. One is the theory-practice gap already signaled in the Knowledge Topic. It can be illustrated by the statements from the Hungarian case: "guidelines for some measures produced by research institutions are often theoretical and not always available in Hungarian" (…) "there is not enough trust in research projects, the results must be made understandable and put into practice". Another issue was the age gap linked to digital training and knowledge dissemination, illustrated by the Lithuanian case: "where virtual spaces invite younger generation, whereas the face-to-face meetings invite more mature practitioners". Finally, some cases have reported general high participation turnouts for diverse knowledge sharing fora (Norway), while others reported more passive attitudes and lack of interest in such knowledge dissemination activities, for example in Hungary where "there are relevant events, but interest is often low" (Hungary).

3.2.3. Institutions

This topic, referring to the Factors of integration into regulations, advisory services implemented, regulation/legislation framework, seems positive but also ambivalent. The ranking as a current strength, or a weakness does not differ much, and it is also not seen to represent a clear opportunity, while it is also not perceived as an important threat (all SWOT pillars range between 2.56 and 2.96). Interestingly, at the Factor level, Regulations/legislative framework is seen more as a weakness than a strength, but it is not perceived as an important opportunity or threat. The advisory system Factor stands out and has received the best evaluation for strengths within the Topic, but it is also considered as being exposed to significant threats.

Many experts further elaborated on the role of the advisory system. As the Lithuanian case reports "they provide many courses as well as advice on practices, including NSWRMs" and "doing a good job". The Norwegian case also acknowledges the advisory system for "courses/workshops, regular meetings and updates from research projects". Still, some cases note shortcomings of the advisory systems, e.g. the Czech case states that the services "do not cover the whole NSWRM portfolio". The Hungarian case concludes that "local advisory organizations already work well enough, but there is a need to involve other sectors and to develop dialogue with farmers (…) there should be a closer cooperation between local farmers and water and agricultural organizations".

Advisory services provide assistance for the measures in connection to CAP within the EU cases. A perspective shared and illustrated with the Czech statement is that "more possibilities to include NSWRMs in POM (WFD) representing a link to CAP would certainly help". Also, from the German case we learn that "including NSWRM in POM (WFD) with a link to CAP or other funding policies could be a good opportunity to increase NSWRM implementation". The Hungarian case states that some local arrangements are needed, especially regulating measures on properties with multiple owners: "the regulation about some NSWRM is covered in the CAP and national legislation (e.g., crop rotation, cover crop, buffer zone). Local regulations would be beneficial for many NSWRMs, especially when the measure affects the properties of multiple owners (e.g., construction of ditches or drainage systems)".

A key issue in the institutional Topic covered under the Factor on the regulation/legislation framework is the division between mandatory and voluntary measures, with the mandatory measures receiving more institutional support. But the division between the mandatory vs. voluntary is often case dependent, varies significantly between the countries and erosion-prone areas. "Agricultural NSWRMs are not fully mandatory by law" (Italy), "in general not mandatory in the case study area" (Poland), "in certain situations/conditions, some basic measures are mandatory" (Slovenia), "in general, on soil erosion threatened field blocks and for certain crops, the soil protection agricultural measures are mandatory (tillage, crop rotations)" (Czechia), "farmers are obliged to implement water retention measures in areas affected by severe erosion" (Hungary), "a limited subset of NSWRM is mandatory, e.g. in water protection areas" (Germany).

3.3. Technology and infrastructure as a distinct topic

The Topic on Technology and infrastructure follows the S/W/O/T pattern. In this case, expert judgments were mixed but emphasis was put on the current situation with less importance to the future.

3.3.1. Technology and infrastructure

The Topic covers access to machinery, collective networks, and machinery rental. Overall, for NSWRMs it is perceived a bit more as a strength (2.86) than a weakness (2.61), opportunities were ranked with 2.44 but threats only with 1.61.

Our respondents indicated that practitioners have access to machinery and equipment. But when asked about the details they were more skeptical regarding networks for collaboration for better access and even more skeptical about the statement that current rental arrangements for the machinery and equipment are easy and convenient for the users.

It can be noted from the qualitative statements that affordability – not availability – is addressed as a major weakness in this Topic. "Practitioners have fairly good access and options, but financing is a challenge" (Slovenia) or "the machinery and equipment are available for rent. Question is whether all interested/in need practitioners (farmers) can afford a rent" (Poland), "technology will be available, just maybe not affordable to all" (Hungary).

New, modern technologies are rarely used for NSWRMs, as indicated by respondents. As the Slovenian case reports "they [farmers] work with outdated and non-modern equipment" and "there is certainly an opportunity, especially with modernization and digitalization" but "modern technology may be expensive and inaccessible for small-scale farmers". The Hungarian case also reports that "it can be expensive and

not accessible for small farmers". Similarly, the German case reports that "affordability, particularly for smaller farms, remains an issue" but "those on larger farms, may already own much of the equipment needed to implement and maintain NSWRMs".

However, it has been noted that there may be more opportunities to "apply for funding from EU and national programs to invest in modern technology" (Hungary). As the Swiss case notes "if a new agricultural NSWRM is seen as successful, there will be soon a contractor with the new machinery" and that in the case area "the sharing systems are very important for measures which require specific machineries and are becoming more common".

4. Discussion

The results show that Attitudes/perceptions and Financing schemes form a cluster of Topics hindering NSWRMs' implementation. Both have been ranked as starting with major weaknesses. By looking at the factor level and the data from the qualitative statements, we identified four main elements that explain current slow NSWRM adoption. Although they are rooted in specific Factors already presented in the Results, here we problematize them in a wider context, also by linking several Factors and relationships between the Topics. We start with two main hindrances that are related to attitudes, but also knowledge application, and continue with two that relate to financing schemes, amplified by other relevant challenges.

4.1. Long waiting time sparks skepticism on NSWRMs benefits

One of the major weaknesses for the adoption of NSWRMs is the skepticism towards such measures resulting from the long time-horizon of their tangible benefits, corresponding to the first Factor in the Weaknesses for the Attitudes/perceptions Topic with a mean value of 3.58. This is not surprising and is a typical problem for environmental interventions that need long time horizons for evaluations. Some authors claim that for environmental projects we need timescales of 100+ years for adequate impact evaluation (O'Mahony, 2021). This could fundamentally change the results ((Fennell et al., 2023) quoted earlier used a 25-years framework) but it would be even more difficult to link the benefits to the actual NSWRMs as there is lots of "background noise", the impact of exogenous variables that might interfere with the impact of particular measures (Bernauer, 1995). Although it is widely acknowledged that NSWRMs bring many additional co-benefits in terms of the provision of ecosystem services (Pagliacci et al., 2022), the exact benefits and causal effects are still vague and insufficiently studied. It is difficult to determine the real impact of selected measures, how much they exactly contribute to the ecosystem services, with their specific roles for drought and flood control, erosion reduction, soil improvements, biodiversity enhancement etc. (Mrozik and Idczak, 2017). Having better assessments of the impact of single measures and their combination will not decrease the time to wait for the impacts but provide evidence that it is worth investing and waiting. Some measures (e.g. reduced tillage, cf. (Vakali et al., 2011)) can also bring quicker effects compared to, for instance, forestry measures (e.g. afforestation) and designing sets of measures should optimize the benefits in time.

4.2. The theory-practice gap

Knowledge and communication/dissemination Topics are similarly and positively assessed (spider graphs from Fig. 2 show that have similar shapes and scores and they are close in the cluster analysis), which is not surprising given their interconnection. Interestingly, for both Topics, future threats are a small concern, but the current situation brings many existing strengths along equally many existing weaknesses. The theory-practice gap appeared as a critical hindrance for the implementation and has already been signaled in the Results section as a cross-cutting subject. Although it is not covered by a specific Factor, the problem with translating the theory into practice has been widely mentioned by our experts.

Known in the literature as the "theory-practice gap", it refers to the situation where theory cannot be fully translated into practice (Arteaga et al., 2024). For NSWRMs it refers to the disconnection between academic knowledge and real-world practices and might have implications for adequate measure design and implementation, what can further affect agricultural productivity, sustainability, and food security.

It can be observed that advisory services already help to bridge the theory-practice gap. According to expert quotes, measures supported by CAP or national programs could more easily overcome barriers compared to those without such support. Still, previous CAP evaluation showed that CAP-funded training, advice, and innovation measures are not reaching the majority of farmers, it was estimated that only around 10% of farm holdings and around 20% of CAP beneficiaries have used such opportunities (EC, 2020). There is space for local networks and institutions to work together in reducing the gap. An example could be local water partnerships helping to facilitate dialogue among various stakeholders, to understand and jointly solve complex problems related to rational water management (Kłos, 2023).

4.3. Financing schemes rarely consider indirect costs

Current Weaknesses of NSWRMs across the case studies highlight the inadequate financing system and the main deficiency is related to the inadequate support for indirect costs for measure implementation (scoring 3.73). While direct costs are typically assigned to given products or measures, indirect costs are much more difficult to track; these can be the costs of owning and operating a tractor used for many issues. Indirect costs can relate to management, administration costs, utility expenses, and also non-production costs (putting land aside for certain measures) (Markina et al., 2018). An element of the indirect costs is also related to the administrative burdens, and we can assume that with more complex and demanding administrative procedures for practitioners, indirect costs increase with more time and resources needed.

A similar observation is made in a review paper on nature-based solutions by (Price, 2021) and listed as a key barrier for scaling-up of measures. Price emphasized "flawed approaches to economic appraisal led to underinvestment in NbS" and states that "existing direct and indirect subsidies continue to favor the engineered solutions. It is stated that more costs could be covered for many measures, if we could better "monetize the value generated through the provisioning of ecosystem services, as well as the multiple co-benefits that NbS provide" (Uzsoki et al., 2021). Current studies show that some drought and flood measures (tree-planting, buffer strips, storage ponds) can be already cost-effective but outcomes are very design-dependent and also depend on the time horizon used in the evaluation framework (Fennell et al., 2023). Although revenues from the measures are case specific and understudied, macro assessments point out that measures helping to restore nature, and its functions are not a net cost. The European Commission estimates that every 1 EUR invested in nature restoration provides a return of between 8 EUR and 38 EUR due to the "broader benefits of the ecosystem services that support food security, human health and well-being, and climate mitigation and adaptation" ((EU Commission, 2022)). Such messages about the long-term profitability of various measures and their wider positive benefits for nature and society are still under communicated.

A key issue related to costs and revenues is the long-time horizons needed before the benefits can be observed. The interplay of these constraints (financing issues and long-term benefits) amplifies skepticism and is reflected in the highest ranked future Threat across all Factors. Our experts emphasized the Threat connected to the attitudes of short-term economic gains (scoring 3.75), where NSWRMs cannot compete on delivering the expected results quickly and with rapid economic revenues.

4.4. Bureaucratic procedures for funding further discourage practitioners

It needs to be emphasized that bureaucracy has been perceived as a strong weakness and threat in the funding context. Administrative and bureaucratic barriers for funding are a Factor perceived as the highest weaknesses across the case study sites (average value of 3.75). There was very low standard deviation for this Factor (0,62) meaning little difference among the case-study countries, although non-EU cases (Norway and Switzerland) provided slightly more positive scores compared to the average. In line with this, a major threat is the expectation of future complex administration and bureaucracy for funding (3.67), that might further discourage those initially interested in NSWRMs. Other aspects (covered in the Institutional Topic) have not been assessed with such strong judgments. Furthermore, Integration into regulations is perceived more as a strength than a weakness.

Modern farming and the evolution of funding mechanisms, such as the European CAP, increased the amount of red tape, perceived as complex, time-consuming and discouraging by the practitioners: farmers feel that instead of being near their land, they need to focus on paperwork (Brown et al., 2021). Similarly, farm advisors increasingly play a role of "interface bureaucrats" due to substantial bureaucratization of their work (Clement et al., 2024). Mack et al. (2021) point out, that bureaucratic procedures in agricultural policy matter not only because they imply public and private costs, but they are also important for farmers' attitudes of agricultural and environmental policies and measure acceptance. Here, it is relevant to continue the debate on the proportionality of the administrative burdens and administrative costs to the support given and with the achieved results from the "small" measures perspective (EC, 2021c).

4.5. Limitations and future research needs

It needs to be noted, that the SWOT analysis presented has its limitations. These are related firstly to our case-selection. Although the analysis builds on fourteen case studies located in twelve European countries, some of the findings may not be generalizable. Each case-study delivered only one SWOT evaluation, but it involved more local experts and required internal dialogue and agreement for each score. Importantly, our three test cases selected for refining the framework (Italy, Slovenia and Poland), got the opportunity to co-design the framework, one that for practical reasons could not be given to all case studies.

We have also focused on small watershed areas that are covered by an ongoing research project. Larger watersheds and areas that have not been covered by many research projects can have different perspectives, especially on Topics related to Knowledge and its Communication/dissemination.

Furthermore, by adopting a NSWRMs perspective and grouping various measures within the umbrella, we needed to reduce the complexity of the situation of the single measures by putting emphasis on generalizations and simplifications needed to study their entire phenomenon. Although we believe that experts have good and representative knowledge of the case-study areas, their judgment is still subjective. We tried to reduce this bias with interview statements explaining all given values and inviting more experts for each case study to reach a compromise.

Although there are some clearer extremes, many results are clustered around the value of 3 with little deviation in the individual scores. Future studies could consider adjusting the scale with more significant spread to better capture differences in expert opinions.

Finally, our SWOT framework could be effectively applied to gather additional perspectives from farmers and landowners, providing deeper insights into their views, challenges, and motivations regarding the implementation of NSWRMs. As stated earlier, our respondents were experts that work with farmers as researchers and/or advisors and interacted closely with farmers during the OPTAIN project duration. Targeting farmers perspectives directly can help tailor policies and incentives to better align with stakeholder needs and enhance adoption rates.

The SWOT analysis provides a relevant diagnosis focusing on current and future Topics (further operationalized with Factors) that constrain or constitute mainstreaming of NSWRMs. It is also an attempt to provide a holistic picture, bridging different disciplinary lenses and scales.

5. Conclusions

Despite the growing recognition of the benefits of NSWRMs, their implementation remains slow. Using a multi-step research process based on the SWOT framework, operationalized for our specific issue area with the two additional layers of Topics and Factors, and expanded with a quantitative scoring, our study identified and discussed precise barriers and pointed to tangible potentials that can be further developed to increase NSWRMs implementation.

SWOT findings help to understand where the potentials for action are to mainstream NSWRMs and what are the most critical hindrances that need special attention. This is highly relevant for policy development, starting from local and national support systems to the evaluation of the new Common Agriculture Policy on the European level. There are also lessons to be learned by other countries considering the development of NSWRMs.

Knowledge and Communication/Dissemination are clearly driving the NSWRMs', with the expectation of knowledge availability and sharing through formal and informal networks, as well as good work from advisory services. Highest scores for strengths can be a proxy for current best practices, and they clearly point to available scientific research documenting the benefits of NSWRMs and a positive role of advisory services in NSWRM implementation. That said, Knowledge and Communication/Dissemination can be strengthened further and employed strategically to address many of the hindrances identified in our analysis. It will be crucial to find the best strategies for research, knowledge creation, but also translating the available knowledge to concreate problems faced on the ground and finding best ways for knowledge transfer. Advisory services are paramount for this role, but we can also expect more farmer-to-farmer learning or use of digital technologies and innovation to support such processes.

Our research also highlights that Financing schemes and Attitudes/Perceptions are major hindrances to NSWRM implementation. Technology and infrastructure seem most ambivalent and while access to technology is not a problem, affordability and collective action around technological solutions and tools are.

The diagnoses obtained through SWOT analyses lead to identifying four concrete challenges (4.1- 4.4) of NSWRM expansion, and hindrances that explain their slow adoption. All these challenges can, however, be mitigated. *Long time horizons* are not equal for all measures, so NSWRMs guidelines could address this issue specifically and let the practitioners select appropriate measures that will start delivering the expected results in a shorter and specified timeframe. The *theory-practice gap* is critical, also given the limited professional education of European farmers. On the other hand, where training possibilities exist (e.g. CAP-funded training) they often do not attract many farmers and practitioners. Understanding the reasons why and trying to find adequate solutions could significantly help addressing the issue. Similarly, although costs for the measures are high and many *hidden costs are not covered*, macro level data shows that investments in restoration measures are profitable when a broader benefit framework is considered, and this is clearly under-communicated. Finally, spending public money needs to be transparent and follow clear procedures but the *proportionality issue in bureaucratic practices and results* should be an important element in support scheme design. Especially for "small" measures as many NSWRMs, simplification of the procedures could be considered.

Addressing those barriers will be fundamental for mainstreaming of NSWRMs. Although there is no panacea for such complex, systemic and

interlinked problems, we tried to conclude each paragraph with constructive points that can serve as a springboard for addressing challenges. We should, however, note that analyses like ours, are constrained by their specific positionality and nesting within the problems and proposed solutions currently on the agenda. There are also broader, external factors which may influence the expansion of NSWRMs in the medium and longer term, e.g. the acceleration of climate change. Moreover, there are solutions which depend on broader political processes, such as an expansion of nature-based solutions and more funding becoming available from other sources, lying beyond the scope of our study.

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CRediT authorship contribution statement

Julia Szulecka: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Ingrid Nesheim:** Conceptualization, Methodology, Writing – review & editing. **Federica Monaco:** Conceptualization, Data curation, Methodology, Visualization, Writing – review & editing. **Anne-Grete Buseth Blankenberg:** Data curation, Writing – review & editing. **Veronika Čápová:** Data curation, Writing – review & editing. **Natalja Čerkasova:** Data curation, Writing – review & editing. **Jovita Mėžinė:** Data curation, Visualization, Writing – review & editing. **Joana Eichenberger:** Data curation, Writing – review & editing. **Kinga Farkas-Iványi:** Data curation, Writing – review & editing. **Marie Anne Eurie Forio:** Data curation, Writing – review & editing. **Petr Fučík:** Data curation, Writing – review & editing. **Martyn N. Futter:** Data curation, Writing – review & editing. **Marek Giełczewski:** Data curation, Writing – review & editing. **Wiesława Kasperska-Wołowicz:** Data curation, Writing – review & editing. **Piroska Kassai:** Data curation, Writing – review & editing. **Gregor Kramberger:** Data curation, Writing – review & editing. **Dominika Krzeminska:** Data curation, Writing – review & editing. **Tatenda Lemann:** Data curation, Writing – review & editing. **Michael Strauch:** Data curation, Writing – review & editing. **Brigitta Szabó:** Data curation, Writing – review & editing. **Artūrs Škute:** Data curation, Writing – review & editing. **Felix Witing:** Data curation, Writing – review & editing. **Antonín Zajíček:** Data curation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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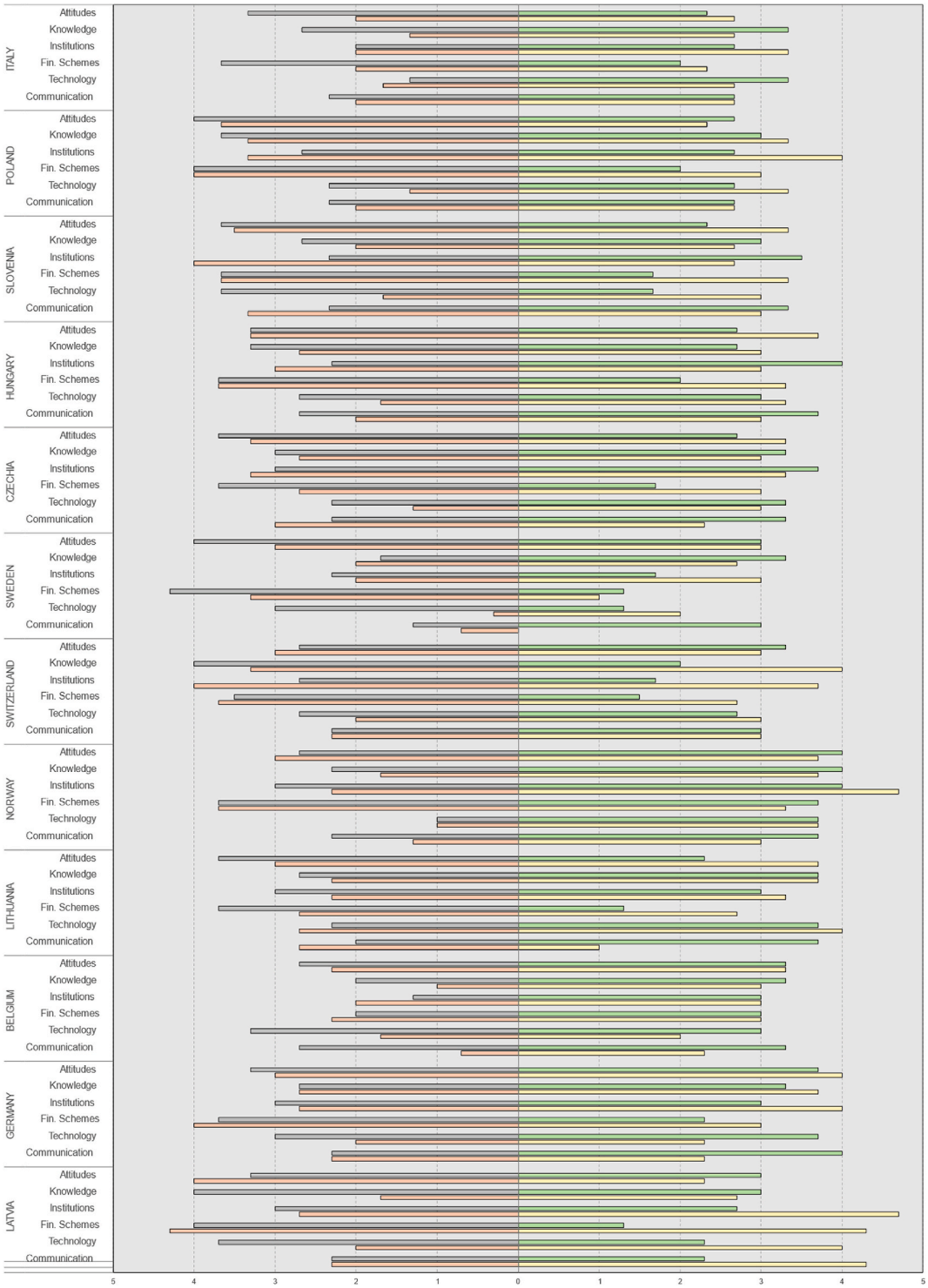
Annex



Annex 1. SWOT analysis at the case study level (green for Strengths, yellow for Opportunities, Grey for Weaknesses and orange for Threats)

Data availability

Data will be made available on request.

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