Regenerative Agriculture in the EU: Exploring the transition

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WAGENINGEN UNIVERSITY & RESEARCH

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In this report building bricks are described for the further development of the Regenerative Agriculture (RegenAg) concept in Europe, by providing insight in: 1) measuring performance and 2) understanding adoption barriers and drivers by farmers. The results build forth on an overview report on the state of RegenAg in Europe. In Part 1 the analysis of key performance indicators (KPIs) are described, emphasising the need for scientifically validated context-specific indicators. In Part 2, barriers and drivers of the widespread adoption of RegenAg in Europe are identified, based on interviews with farmers across Europe. With these findings a further foundation is laid for developing the RegenAg concept across diverse European contexts.

Key words: regenerative agriculture, RegenAg key performance indicators, barriers for adoption, drivers for transition, farmer perceptions.

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Preface

To study the improvement of the state of European agriculture by wide adoption of RegenAg practices with sustainable impact, Wageningen University & Research (WUR) started the project 'Regenerative agriculture in Europe: Accelerating the transition', supported by a donation from Cargill Incorporated via University Fund Wageningen.

The first phase of this project provided an overview of the current state of RegenAg in Europe for arable farming. The results reflected current gaps and future opportunities for next steps, described in the overview publication 'Identifying the Current State of Regenerative Agriculture in Europe' (Manshanden et al., 2023). This second phase of the project was introduced to incorporate these learnings, on the one hand, and to explore the feasibility of accelerating the RegenAg concept on the other hand. The aim is to come to a detailed scope and set-up for optimising an approach, to boost the transition of RegenAg towards sustainable agriculture. Therefore, this second project phase included the following four activities, of which 2 parts are described in this report:

1. Defining a target point, together with general RegenAg principles, for analysing the costs and benefits of RegenAg transitions in EU areas. We explored which indicator(s) and at which indicator value(s) farmers could be positioned and distinguished as 'RegenAg agricultural entrepreneurs', creating positive impact.
2. Providing initial insights into drivers and barriers of RegenAg frontrunner farmers, by selecting 29 frontrunners who match the RegenAg requirements, in four selected EU countries: France, Germany, Poland and Hungary. Based on in-depth interviews, the results contribute to a wider understanding of farmers' key drivers, barriers, and behavioural characteristics for shifting to RegenAg.

We would like to thank the interviewed farmers and our local partners; Dorota Labanowska (PL), Annie Duparque and Tanguy Dervaux from Agrotransfert, (FR), Adrian Schmickler and Sara Kuschnereit from Kompetenzzentrum Ökolandbau Niedersachsen (DE) and Gerda Jonasz and Korinna Varga from Ömki (HU), for conducting the interviews and providing us with the local context.

The third project activity (3) involved an inception phase for setting up a European network of demo farms, to enhance the adoption of RegenAg practices, education and demonstration of RegenAg measures for farmers and advisors. A proposal has been developed for the further structuring and organisation of an approach and multi-actor collaboration in a European network of demo farms, to enhance the transition towards RegenAg.

In the fourth project activity (4), the project focused on setting-up collaboration and an action plan with a core group of EU public and private organisations, supported by local European knowledge partners. The aim of this consortium is to accelerate the transition of RegenAg by assessing the cost-benefits in the public-private partnership 'Regenomics' project.[1]

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[1] https://www.wur.nl/en/research-results/research-funded-by-the-ministry-of-lvvn/types-research/soorten-onderzoek/kennisonline/regenomics-assessing-the-cost-benefits-of-the-transition-towards-regenerative-arable-farming-in-europe.htm

Summary

S.1 General introduction

Our current food system needs to shift towards more sustainable food production and related consumption. Many sustainability impacts relate to farm-level and surrounding landscapes. Regenerative Agriculture (RegenAg) is increasingly seen as an adequate approach to improve long-term sustainability in agriculture. In our report we use the following definition of RegenAg:

> ‘Regenerative agriculture is an integral approach to farming that uses soil conservation as the basis to regenerate multiple provisioning, regulating and supporting services, to actively enhance the ecological performance of farming systems, while sustaining socio-economic viability.’

Compared to the original definition by Schreefel et al. (2020) we added ‘integral’ to avoid focusing on individual measures. Furthermore, we simplified some wording to move beyond intentions to concrete improvement of farming system performance, and gave greater attention to ecological performance, reflecting the urgency of addressing ecological challenges.

This research project was carried out by WUR, supported by a donation from Cargill Incorporated via University Fund Wageningen. The aim is to contribute to the acceleration of the transition towards sustainable agricultural practices across the continent, promoting the adoption of RegenAg as a basis for long-term environmental, economic, and social benefits in European agriculture.

As initial step, an overview report with the title *Regenerative Agriculture in Europe: An overview paper on the state of knowledge and innovation in Europe* was published in April 2023, providing a foundation for understanding the current landscape, knowledge gaps, and emerging innovations within RegenAg in Europe (Manshanden et al., 2023).

Building on the insights gained from this first report, we present the following results on the feasibility of advancing RegenAg in Europe in this second project report:
1. Gaining insights into measuring the performance of RegenAg
2. Exploring the barriers and drivers concerning the widespread adoption of RegenAg.

These two objectives were explored in-depth in two distinct parts, each dedicated to addressing specific key aspects of advancing RegenAg in Europe. By delivering the results as building blocks, we challenge actors related to RegenAg (farmers, chain partners, NGOs, policymakers, advisers, researchers, educators, and others). The joint aim is to follow up on measuring RegenAg performances and further improve the concept of RegenAg through multi-actor learning and co-creation, thus providing farmers with a promising approach to sustainable agriculture.

S.2 Part 1: Measuring Regenerative Agriculture performance

To gain a comprehensive understanding of the current state of key performance indicators (KPIs) specifically utilised in the context of RegenAg, an extensive literature analysis was conducted. This analysis aimed at compiling and evaluating the various KPIs that have been proposed or implemented within RegenAg frameworks, exploring their relevance, effectiveness, and potential for driving positive change in agricultural

practices. This analysis has been conducted in order to support a next step of modelling the economics of regenerative agriculture, carried out in the public-private partnership 'Regenomics' project.[2]

The literature analysis was based on a comprehensive body of literature, encompassing a diverse range of sources such as scientific articles, corporate strategies and white papers (see Appendix 1 for an overview of the analysed literature).

Our study revealed that KPIs are used by multiple actors in the agrifood system, including farmers, governments, and corporations. KPIs primarily serve the purpose of measuring performance. Larger corporations also include these in performance schemes and for setting targets on five key aspects, including:

1. soil health improvement
2. biodiversity and ecosystem enhancement
3. water management improvement and conservation
4. GHG emission reduction and positive impact on climate
5. presence of farmer support and improved community resilience.

KPIs are set on different topics, which can be divided into three categories:

1. ecological
2. business-economic
3. socio-economically oriented KPIs.

The main conclusions on the use of KPIs within the concept of RegenAg, are as follows. First, KPIs or indicators are formulated on three different levels: practice-, result- and outcome-based. Practice-based indicators were commonly formulated as a continuous practice, which should be implemented. Result-based indicators were formulated in the literature in different ways: in absolute measures (e.g. total nitrogen input), as reduction measures (e.g. reduction of nitrogen use), or as relative measures (e.g. the nitrogen use should be lower than the average farm use in the region). Outcome-based indicators are mostly observed within ecological indicators (soil carbon content, groundwater pollution). Second, a wide range of indicators and associated metrics or practices appeared from the literature, of which many were not scientifically underpinned. This may create ambiguity in their understanding and use. Third, quantitative technical measures are both hard to measure and objectify, due to their context specific nature and different applied methodologies to measure outcomes. Thorough validation is critical for correct use of KPIs in different contexts. Related to this third aspect, we argue that even after scientific underpinning, practical selection of indicators, metrics and measuring methods, should at least be based on and validated for country, region, farm, and soil type specific characteristics.

S.3 Part 2: Barriers and drivers

The adoption rate of RegenAg can be related to perceived barriers in the transition to a regenerative farming system. Simultaneously, farmers can also be motivated to adopt regenerative practices by perceived drivers of RegenAg. These barriers and drivers were explored through structured in-depth interviews with farmers who match the RegenAg criteria, from four countries in Europe: France, Germany, Hungary, and Poland. In addition, behavioural characteristics of farmers in the context of adopting regenerative practices were explored. Farmers were selected based on application of regenerative practices, which resulted in a sample (n=29) of frontrunner farmers.

The results show that one of the primary drivers for most farmers who are currently switching to RegenAg, were personal values and intrinsic motivation to have a positive impact on soil life, the responsibility for the environment and nature, climate in general, and future generations. However, some farmers also indicated that the trigger for transitioning was mainly driven by economic purposes. In general, barriers and drivers showed both similarities and differences across the four concerned regions. Most important barriers were

[2] https://www.wur.nl/en/research-results/research-funded-by-the-ministry-of-lvvn/types-research/soorten-onderzoek/kennisonline/regenomics-assessing-the-cost-benefits-of-the-transition-towards-regenerative-arable-farming-in-europe.htm

identified as economic and political aspects, and to a lesser extent as socio-demographic aspects. This particularly concerns the lack of capital to invest in new equipment, the lack of good market opportunities and the ability to gain premium prices.

Strategies of farmers dealing with barriers varied largely. The assessment showed that most respondents feel in control managing RegenAg farming. However, they do expect their farm to be impacted by external risks factors.

Considering the limited sample size and qualitative nature of the observations, results should be interpreted with care. More quantitative assessments including larger sample sizes are needed in future research to draw conclusions with high external validity. This work has been done to better shape larger questionnaires in the future. Nevertheless, this study displays informative insights and sheds a first light on the perception of farmers switching to RegenAg.

1 Introduction: Shifting towards Regenerative Agriculture

Our current food system urgently needs a shift towards more sustainable food production and related consumption. Food production is one of the main drivers of climate change (Lynch et al., 2021) and biodiversity loss (Chaudhary et al., 2016; Benton et al., 2021). A substantial proportion of the impact of food production stems from farm-level practices and their surrounding landscapes. Regenerative Agriculture (RegenAg) is considered an effective approach to reduce the impact of agriculture on climate and biodiversity.

Adopting a clear and actionable definition is key to support the focus and effectiveness of RegenAg. A clear definition facilitates alignment among stakeholders, sharing similar values and beliefs about sustainable agriculture. The definition should also be accurate and exclusive, to enable assessment of performance and avoiding the possibility for greenwashing, while also open to different innovation pathways (Giller et al., 2021). Adapted from Schreefel et al. (2020), we use the following definition:

> ‘Regenerative agriculture is an integral approach to farming that uses soil conservation as the basis to regenerate multiple provisioning, regulating and supporting services, to actively enhance the ecological performance of farming systems, while sustaining the socio-economic viability.’

Compared to the original definition by Schreefel et al. (2020), we added ‘integral’ to avoid focusing on individual measures. We simplified some wording to move beyond intentions for concrete improvement of farming system performance, and gave greater attention to ecological performance, reflecting the urgency of addressing ecological challenges. In translating this definition into practical measures and actions, it should be consciously avoided that the focus is narrowed down to implementing specific practices and that the objective to regenerate the agri-ecosystem, is lost out of sight. Measures are the means for regenerating the eco-system. To stick to this perspective, it is important to actively monitor progress towards specific regenerative targets.

We acknowledge that measures make the concept tangible and relatable. The measures combined aim at regenerating the agri-ecosystem. Measures to reduce soil disturbance such as no-till farming, year round soil coverage, minimal (and working towards ultimately no) use of chemical inputs and diversity in the crop rotation, are key elements in regenerative arable farming. These measures together, implemented as part of an integral system, form the concept of RegenAg.

Recognising the importance of the RegenAg approach, Cargill Incorporated began supporting WUR in 2022 to study the state of RegenAg in Europe. The goal is to gain more insight in the concept for accelerating the transition to sustainable agricultural practices across the continent. Therefore, this study focused on the adoption of RegenAg by farmers as a basis for long-term environmental, economic, and social benefits, in European agriculture.

As an initial step in this effort, an overview report titled *Regenerative Agriculture in Europe: An overview paper on the state of knowledge and innovation in Europe* was published in April 2023. This publication provided a foundation for understanding the current landscape, knowledge gaps, and emerging innovations within RegenAg in Europe. It serves as a valuable resource for policymakers, researchers, and practitioners, providing definitions, comparisons with other agricultural concepts, initial mapping of RegenAg in Europe, insights into policy and market developments, and options to measure RegenAg performance.

Building forth on these insights gained from this first report, we present the following results on the feasibility of advancing RegenAg in Europe in this next report:

1. *Gaining insights into measuring the performance of RegenAg*
   Evaluating RegenAg performance across farms, companies, regions, and countries requires a strong qualification system, achievable through Key Performance Indicators (KPIs). To advance the use of KPIs, we conducted a literature analysis to deepen our understanding of KPIs for RegenAg, identifying essential goals, themes, and how these KPIs are applied by various stakeholders, such as corporations and governments. We also explored the rationale behind setting specific target values for these KPIs.
2. *Exploring the barriers and drivers to the widespread adoption of RegenAg*
   Farmers face social, economic, and technological factors that can either hinder or encourage the adoption of RegenAg in Europe. Identifying these barriers and drivers, is crucial for promoting RegenAg. This study investigated the experiences of regenerative farmers across four European regions, through structured interviews. The survey assessed farm demographics, adoption challenges, behavioural aspects (using aspects of the Theory of Planned Behaviour), and interests in a potential RegenAg network.

2 Part 1: Measuring Regenerative Agriculture performance

2.1 Introduction

To improve the sustainability of agriculture through production methods such as RegenAg, it is essential to measure this performance effectively and in a relevant way. Evaluating RegenAg performance across farms, companies, regions, and countries requires a robust system of quantification. This measurement system can serve multiple purposes, such as providing accountability to customers and society, assessing the impact of specific measures, and continually enhancing farm performance. In Manshanden et al. (2023) one specific recommendation (7.2.5) emphasised the relevance of defining indicators and targets for RegenAg.

To quantify performance, it is crucial to start by understanding the objectives of the specific production method, RegenAg in this study (Manshanden et al., 2023). These objectives form the foundation, from which Key Performance Indicators (KPIs) can be derived. The indicators allow us to measure how well the objectives are being met. KPIs are gaining ground in agriculture. The body of literature on KPIs used for agricultural purposes is growing, as is the number of companies actively applying KPIs to measure the sustainability performance of their suppliers, reflecting the growing recognition of their importance in promoting sustainable agricultural practices.

To gain a comprehensive understanding of the current state of specifically utilised KPIs in the context of RegenAg, an extensive literature analysis was conducted.

2.1.1 Reading guide

Section 2.2 will elaborate on the methodology employed to conduct the literature analysis. This is followed by an in-depth explanation of the concept of KPIs and their application in section 2.3. Section 2.4 explores how KPIs can be used. The initial findings from the literature analysis are then presented, starting in section 2.5 with how corporations use KPIs, and in section 2.6 how governments apply them. Section 2.7 provides an overview of the different KPIs that were identified in the literature. The chapter concludes in section 2.8, with a discussion of the findings.

2.2 Methodology

The literature analysis was conducted, based on a comprehensive body of literature, encompassing a diverse range of sources, such as scientific articles, corporate strategies and white papers (see Appendix 1 for an overview of the analysed literature). By analysing these various sources, our analysis is well-rounded, ensuring a thorough and multifaceted exploration of KPIs.

With this literature analysis, we aim to address the following aims:

1. *Explore what goals/objectives/themes have to be quantified with indicators*
   Identify the key goals, objectives, and themes within regenerative agriculture that need to be measured and monitored through indicators.
2. *Explore the purpose of use, users, and system boundaries of indicators*
   Investigate the intended purposes of these indicators and who will use them. This includes the understanding of how these indicators can be used for farmers’ learning, accountability, and remuneration. We will focus on whether these indicators are based on the number of measures, proxies for performance metrics, or actual performance metrics.
3. *Conduct a literature review on indicator sets and models*
   Reviewing existing sets of indicators.

4. *Explore the rationale behind target values, limits, or minimum values*
   Understand the reasoning and justification behind setting target values, limits, or minimum values for these indicators, and how these thresholds are determined and applied in practice.

For our literature analysis, we employed the qualitative data analysis tool ATLAS.ti. This software allows us to systematically code and categorise the data, enabling a thorough and nuanced interpretation of the analysed literature. By leveraging this tool, we can identify key themes, patterns, and relationships within the literature, enhancing our analysis' depth and rigour.

The insights we gained from our literature analysis were regularly presented and discussed with team members and experts in the fields of e.g. arable farming, RegenAg, and key performance indicators (KPIs). These collaborative sessions served multiple purposes. First, they provided an opportunity to validate our findings by leveraging the expertise and perspectives of experts. Second, these discussions fostered a deeper understanding and contextualisation of the data, allowing us to refine our interpretations and conclusions. By integrating feedback and insights from these experts, we enhanced the robustness and credibility of the analysis.

2.2.1 Demarcation

Via a literature analysis, we examined KPIs in arable farming. We focused specifically on Europe, because of the diverse agricultural landscape, growing emphasis on regenerative practices, and policies such as the Farm to Fork strategy and the Common Agricultural Policy, enhancing sustainable farming practices. Although the focus was on KPIs for arable farming, KPIs related to animal husbandry were also addressed. This inclusion was required because of the interconnected nature of agricultural systems. Consequently, some KPI systems integrate both arable farming and animal husbandry KPIs to provide a comprehensive assessment of overall farm performance. While RegenAg is considered to be a sustainable agricultural approach, not all forms of sustainable agriculture are classified as regenerative. Although this analysis specifically focused on RegenAg, many of the KPIs examined encompass sustainability more broadly. As a result, this analysis addressed both general sustainability considerations as well as more specific aspects of RegenAg.

2.3 KPIs: The basics

2.3.1 What are indicators?

Nowadays, a growing number of sustainability assessment tools are being developed to support farmers, supply chain stakeholders and policymakers in their quest to improve agricultural sustainability (Marchand et al., 2014; De Olde et al., 2017a). A wide range of these assessment tools are indicator-based. These indicators are used to measure the current status of systems to identify trends, provide early warnings of critical threshold breaches, and monitor the success of interventions aimed at improving sustainability (De Olde et al., 2017b). They are used for different purposes, such as research, monitoring, policy advice, certification, farm advice, self-assessment, and consumer information (Schader et al., 2014). For example, indicators enable governments and industries to monitor their progress towards the Sustainable Development Goals (SDGs). They provide policymakers with data to create supportive policies for stakeholders, offer researchers a scientific foundation for knowledge accumulation, and help farmers evaluate and adjust their activities accordingly (Schreefel et al., 2020).

But what are indicators? The term indicator is used in various ways and used interchangeably with terms such as 'metric' and 'measurement', yet different definitions are often given to these three terms (Schreefel et al., 2023). In addition, there is no clear-cut, generally accepted definition of the term 'indicator', which can lead to variability in its interpretation and application across different fields and contexts. To add to the complexity, the term 'key performance indicators' (KPIs) is also frequently used. In the literature, there is often no clear distinction between what constitutes an 'ordinary' indicator and a key performance indicator, further complicating the discussion.

Although the term ‘indicator’ is surrounded by ambiguity, indicator-based sustainability tools are generally structured according to four hierarchical or aggression levels (FAO, 2013; Gasso et al., 2015; De Olde et al., 2016). This report follows this structure, providing a useful tool that helps to clarify the concept of ‘indicator’. The most general level is comprised of dimensions (see Figure 2.1). A ‘dimension’ refers to a fundamental pillar or category of sustainability. It can be described as a big umbrella that covers the most important aspects of sustainability. Dimensions are often differentiated by environmental, social and economic characteristics (Gasso et al., 2015). At the second level, dimensions are translated into themes and in some instances, at the third level, made more explicit with subthemes (De Olde et al., 2016). When themes are subdivided into sub-themes, overarching goals are linked to the themes, and detailed objectives are linked to the subthemes. Each theme or subtheme is in turn linked to one or more indicators. Whereas dimensions form the most general level of the structure, indicators form the most specific level (Gasso et al., 2015).

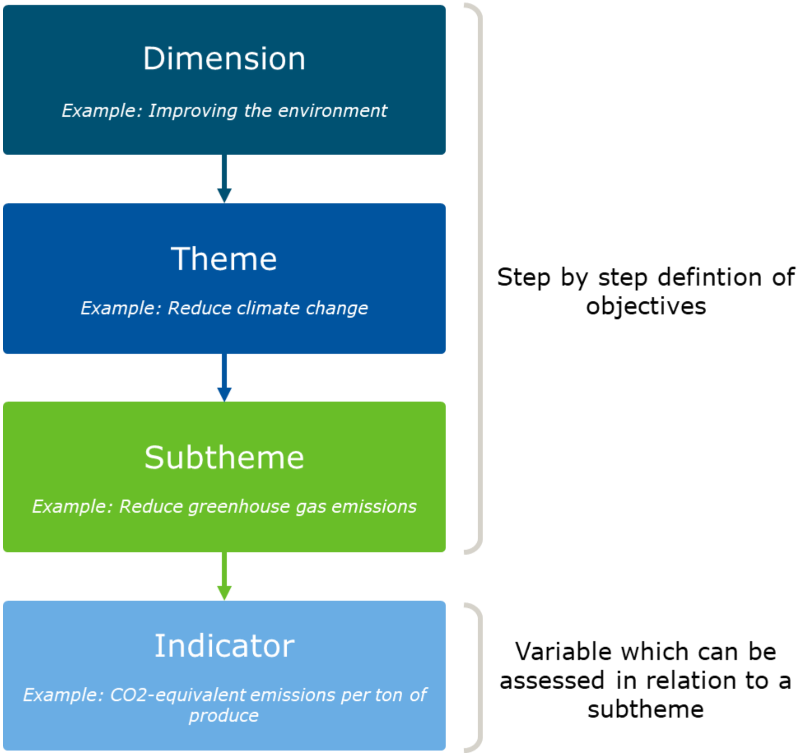

Figure 2.1 *Hierarchical levels in sustainability assessment*
Source: based on FAO (2013).

As illustrated in Figure 2.1, the first three levels (dimension, theme, and subtheme), can essentially be viewed as objectives. These levels become increasingly specific, starting with the most general level (dimension) and gradually becoming more concrete towards the third level (sub-theme). This clearly distinguishes the last level (indicator) from the first three levels, as it is not an objective but a variable that can be assessed in relation to the second and third level (depending on whether a sub-theme is formulated). As such, the indicator verifies whether objectives set in levels 2 or 3 are being met. This indicator can be both quantitative and qualitative, and should always be applied in an objective and verifiable way (Lammerts van Bueren and Blom, 1997; Van Cauwenbergh et al., 2007). An indicator should not be seen as a measurement tool. Instead, an indicator is a variable. To determine the value of an indicator, measurement tools and/or calculation procedures (e.g. modelling or expert-based evaluations) are required (Van Cauwenbergh et al., 2007).

2.3.2 Deployment of indicators

Indicators can be deployed in various forms: (1) individually (e.g. an indicator measuring the reduction of greenhouse gas emissions), (2) as components of a set (see Figure 2.2), or (3) integrated into a composite index that consolidates individual indicator scores into a single number. The composite index can effectively communicate overall sustainability. However, the methods used for aggregation are often subjective (Van Passel et al., 2007).

The deployment of indicators as components of a set is advantageous, especially when the indicators are integrated into a cohesive framework. However, it is challenging to make such an integrated system. Firstly, there are numerous sustainability goals, which increases the risk that an integrated set of indicators may become overly large and complex for farmers and other stakeholders to effectively use. Secondly, designing a set that is to be used by multiple stakeholders (e.g. farmers, chain parties, governments) is challenging because these users may have diverse needs and priorities. For example, some stakeholders may prioritise climate change, while others may focus more on biodiversity. These differing priorities can lead to variations in how indicators are used (Jellema et al., 2023a).

2.3.3 Reference values

Reference values define desired sustainability levels for each indicator, guiding users towards continuous improvement for sustainability (Van Cauwenbergh et al., 2007). Therefore, reference values help to interpret the indicator value (Acosta-Alba and Van der Werf, 2011). Reference values are based on scientific or empirical evidence (Van Cauwenbergh et al., 2007). Van Cauwenbergh et al. (2007) distinguish two main types of reference value: scientific and legal. Scientific values are based on the latest research and the precautionary principle, which aims to prevent harm before it happens. Legal values are mandatory and result from negotiations among policymakers, farmers, advisors, and scientists (Van Cauwenbergh et al., 2007). Legal values[3] are usually a compromise based on science, on the one hand and societal considerations (cost, political feasibility), on the other hand. Consequently, legal-based values are generally less strict than science-based reference values (Acosta-Alba and Van der Werf., 2011). Smit et al. (2023) also identified a third level of practical reference values, reflecting practically achievable targets regarding the reality of farming practices. Reference values can be further divided into target values and threshold values (see Figure 2.2). Target values define the desired or ideal conditions for a specific KPI. Threshold values, on the other hand, set critical limits, either by acceptable minimum levels that should be exceeded or maximum levels that should not be exceeded (Van Cauwenbergh et al., 2007). Threshold and target values are different from reference values. Reference values are comparative and target values and threshold values are absolute. Both target and threshold values can come from scientific sources or be influenced by politics. Legal norms are usually threshold values but can sometimes coincide with target values when policies prioritise ideal outcomes over minimal acceptability.

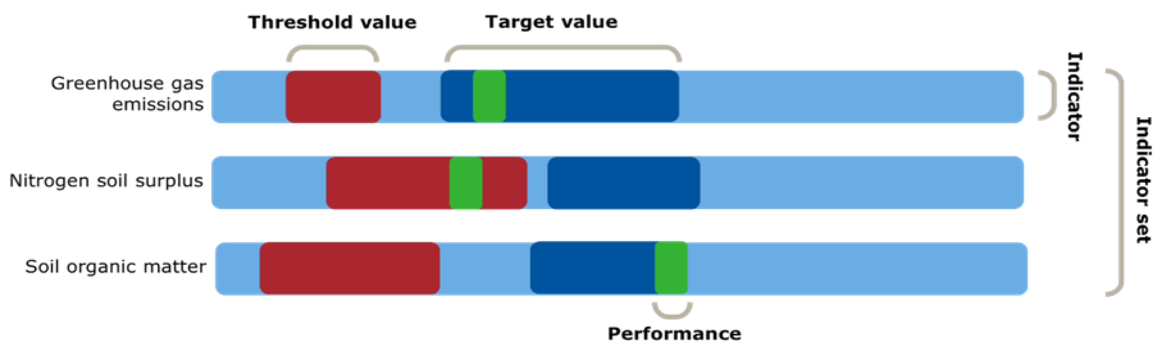

Figure 2.2 *Threshold values and target values for 3 indicators, only for illustration (based on Jellema et al., 2023a). The green bar illustrates how a stakeholder (e.g. a farmer) has performed in relation to the threshold values and target values, set for each one of the indicators.*

[3] Different terms are used to describe legal values. For example, Acosta-Alba and Van der Werf (2011) refer to legal reference values as policy-based reference values.

2.3.4 Design process of indicator-based assessment tools

Over the years many different indicator-based assessment tools have been developed. According to Acosta-Alba and Van der Werf (2011), these tools are usually designed in several stages. The following stages are included in these processes:

1. *Define the system*
   Describe the system (e.g. agricultural production system) to be assessed.
2. *Set goals and dimensions*
   Identify the overall goal and define the sustainability (environmental, economic, social) dimension(s) to be considered.
3. *Identify objectives*
   Determine the specific issues or concerns within each dimension.
4. *Select indicators*
   Choose or create indicators to measure the objective.
5. *Set reference values*
   Establish threshold values and target values for each indicator.
6. *Calculate indicator values*
   Measure and calculate the values of each indicator.
7. *Interpret results*
   Analyse the results, identify areas for improvement, and suggest options for enhancement.

Steps 2 to 5 are similar to the levels described in Figure 2.1, where levels 1, 2, and 3 (dimension, theme, and subtheme) form the step-by-step process of defining concrete objectives.

2.4 Measuring, reporting and validation (MRV)

As mentioned, KPIs can be used for different purposes,

> ‘indicators enable governments and industries to monitor their progress towards the Sustainable Development Goals (SDGs). They provide policymakers with data to create supportive policies for stakeholders, offer researchers a scientific foundation for knowledge accumulation, and help farmers evaluate and adjust their activities accordingly’ (Schreefel et al., 2020).

These different purposes come with different implications for the so-called Measuring, Reporting and Validation (MRV) framework. MRV is a commonly used term to describe the process of measuring the impact, reporting on the result and validating the indicators.

When a farmer uses KPIs for evaluation and adjusting purposes, the data used to provide this insight need to have a certain accuracy. However, there is a larger margin for error than there would be if the KPIs were used for certification schemes, for which the data should be transparent and legally sound.
The KPI and the purpose of the KPI impact the MRV requirements. As this could be a study by itself, we will only describe this briefly.

Measuring
The measuring method used can impact the accuracy, time requirement and cost of measuring. There are several ways of measuring, amongst other things, remote sensing (satellite imagery), sampling (soil measurements) and farm accounting (reported farm data). Remote sensing is an upcoming method that can be very cost-effective and lower the administrative burden for farmers (Schreefel et al., 2023). The downside can be the accuracy. Some data are only available on a 10 km by 10 km grid. However, the grid size is improving. Sampling is often very accurate, but sampling methods can differ in accuracy and cost. In general, the high costs are the drawback. Farm accounting is often a source with the most available data but the drawback is that it can come with a high administrative burden.

The choice of measuring methods differs for each indicator and a careful balance has to be found between accuracy, administrative burdens, costs and availability.

Reporting
Reporting should consider international standards for indicators. The key focus of this chapter is the process of deciding which indicators to include and which to leave out, as is shown above. This decision-making is central to the analysis in this chapter.

Validation
Validation is about making sure the data used in calculating the indicator is sound. There needs to be transparency and accountability. When claims about sustainability are made based on the KPIs, there needs to be a guarantee that the targets have really been met. This concerns the data used but also the calculations and measuring methods.

2.5 Usage of KPIs: Corporations

This section displays the objectives as well as the qualitative and quantitative targets set by corporations based on the results of the literature analysis. KPIs or indicators are linked to the general objectives and specific targets which are set by large corporations.

2.5.1 General objectives of corporations

The literature analysis and a web search revealed that several corporations set ambitious objectives to integrate RegenAg practices into their operations and supply chains, aligning those with their overall sustainability goals. For instance, the ambition to implement regenerative agriculture practices in the entire supply chain by 2030 is observed. Others formulated the goal to advance RegenAg to achieve sustainable food systems and positive environmental aspects. It was also found that RegenAg is part of the overall sustainability strategy and climate goals of corporations, rather than a separate corporate objectives. A key focus of some companies is to partner with growers and leverage technology to foster sustainable agriculture practices. Most of the ambitions are set for the corporations themselves, some corporations also translate these towards their suppliers: farmers.

2.5.2 Targets of corporations

From the literature and web search it appeared that in general the objectives and targets (which are described below) of adopting RegenAg, focus on five key aspects which all emphasise the resilience of agricultural systems in relation to nature. Comparing the objectives and targets of the different corporations, five key topics emerge:

1. improvement of soil health
2. enhancement of biodiversity and ecosystems
3. improved water management and conservation
4. positive climate impact and reduction of carbon
5. farmer support and community resilience.

The key themes around RegenAg are largely similar for the mentioned corporations, but the priority in focal points differs. This aligns with their core business. Furthermore, it stands out that all corporations seek to collaborate with farmers or support farmers to facilitate the transition to regenerative agriculture.

Table 2.1 and Table 2.2 outline the sustainability and RegenAg targets of several corporates (those considered in the literature analysis see Appendix 1) in the food and beverage industry. These targets span both broad, principle-based (indicated as qualitative targets – Table 2.1) and specific, measurable outcomes (indicated as quantitative targets – Table 2.2). The corporations for which these targets are described are those which appeared in the literature search, exemplifying their wide communication and efforts in transitioning towards RegenAg. This does not mean that other large corporations forsake to include RegenAg in their targets. In addition, the presentation of the targets is not meant to compare the different companies, but rather to distil key themes which are prioritised by large corporations. Each company has set various targets and practices aimed at promoting environmental stewardship and supporting farmers.

Table 2.1 describes the qualitative targets. The targets are structured according to main themes (see the left column), which emerged as focal points for the majority of the companies. From the qualitative targets listed in Table 2.1, it appears that most companies set targets on technical aspects such as improving soil health, enhancing biodiversity, improving water use efficiency, and reducing chemical inputs. These more technical targets are accompanied by socio-economic targets to further enhance the adoption and implementation of regenerative practices. Focal points in these socio-economic targets include farmer support, capacity building, and enhancing farm resilience.

Table 2.1 *Qualitative targets of corporations displayed per key theme*

Key theme	
General	• Drive innovation in agricultural practices to support regeneration and technology adoption • Scale up cover cropping[1]
Regenerative practices	• Support farmers in a transition to regenerative agriculture through knowledge, resources, and financial incentives • Promote regenerative practices like cover cropping and reduced tillage after key crops
Sustainability	• Align with global sustainability goals
Biodiversity	• Promote (practices that enhance) biodiversity
Water	• Improve water use efficiency,[2] stewardship, and management[3]
Soil health	• Protect and rebuild soil health[4] • Increase organic matter • Promote soil health[5]
Inputs	• Reduce (dependency on) chemical and synthetic inputs[5]
Social resilience	• Enhance farm and social resilience • Support farmer livelihoods and community well-being
Capacity building	• Build knowledge and capacity among farmers • Train and education for the transition process
Wellbeing	• Foster farmer livelihoods and community well-being[7]
Supply chain	• Transparency and traceability • Strengthen supply chain resilience • Ensure that the benefits of regenerative agriculture extend through supply chains

[1] Crop diversification, agroforestry, natural habitats; [2] Water-efficient methods and technologies; [3] Optimise water use and water conservation on farms; [4] Focus on soil organic matter, soil fertility, promote soil biodiversity; [5] Soil organic matter, soil biodiversity, soil structure; [6] E.g. promoting natural pest control, organic fertilisers; [7] Focus on fair labour practices, support economic viability, and social equity.

In addition to qualitative targets, the quantitative targets are outlined in Table 2.2. The numeric goals provide insight into the schemes of corporations to achieve substantial impact. The targets describe that most corporations target a considerable shift to sourcing their key ingredients from RegenAg in 2030, displaying that large-scale adoption of regenerative practices is necessary to achieve these ambitions. Along with the implementation of regenerative practices, with expected outcomes on soil health and water use, an important focus is observed on sustainable sourcing and reduction of greenhouse gas emissions. The more socio-economic targets, which were rather elaborately described in qualitative targets, are made measurable in quantitative targets, including engagement of farmers, investing money into support programmes, and education. Table 2.1 and 2.2 show formulations of targets by corporations, identified in the document analysis. These targets are the basis for formulating KPIs.

Table 2.2 *Quantitative targets of corporations displayed per key theme. Where # indicates different numbers for different corporations*

Key theme	Individual targets of multiple corporations
General	• Achieve 100% regenerative agriculture by 2030 • Expand regenerative agriculture programmes to millions of acres engaging thousands of farmers globally • Source a significant proportion (expressed in percentage) of key ingredients through regenerative agriculture by 2030
Regenerative practices	• Source a proportion (expressed in percentage) of key crop volume from farms practicing regenerative agriculture by 2025 • Implement regenerative practices on # million hectares by 2030 (globally)[1]
Sustainability	• 75% reduction of carbon footprint per ton of key crop by 2030[2] • 100% sustainable sourcing by 2030 (of key crops)
Reduction of greenhouse emissions	• Reduce greenhouse gas emissions by 25-60% by 2035 or earlier[3] • Achieve net zero emissions by 2050 or earlier
Water	• Reduce water use by 20-50% by 2030 (with a focus on priority watersheds) • Improve water use efficiency by 10-15% by 2025-2035
Soil	• Improve soil health across # million hectares by 2030[4] • improve soil health and sequestering carbon across # million acres by 2030
Other	• Launch number demonstration farms by 2025 • Enhance biodiversity across a certain proportion (expressed in percentage) of key crops. • Investment of # monetary value (expressed in local currency) by 2025 to support the transition to regenerative agriculture[5] • Invest # million dollars in farmer livelihoods and resilience programmes[6]
Other	• Engage # farmers in adopting regenerative practices by 2030 • Engage # people[7] in education and training programmes related to regenerative agriculture by 2030

[1]100% of the lands used to grow key crops (crops can differ per corporation); [2]As compared to the baseline in 2017; [3]Including avoided greenhouse gas emissions achieved by sequestering carbon in the soil; [4]Improving soil organic matter, soil structure, and enhancing biodiversity in the soils which are used to produce key ingredients; [5]Training, education, and financial support; [6]Including regenerative agriculture programmes for training and resources; [7]Includes farmers, workers, community members.

From both Tables 2.1 and 2.2, it can be concluded that the targets can be diverse and are multi-interpretable. Terms like key crops, key ingredients, improve, enhance and expand can be interpreted very broadly. Making the actual ambition difficult to asses.

2.6 Usage of KPIs: governments

Targets have been established at international, EU, and national levels to address climate change, protect the environment, and preserve biodiversity. Internationally, agreements such as the Paris Climate Agreement (UN, 2015), the Kunming-Montreal Global Biodiversity Framework (UNEP, 2022), the European Birds and Habitat Directive (BHD) (EC, 2015), the European Water Framework Directive (WFD) (EC, 2000), and the European Green Deal (EC, 2020) set goals for climate, biodiversity, and air and water quality. EU member states have committed themselves to these targets.

Many of these targets also involve the agricultural sector. Consequently, governments across the EU have established sustainability goals for agriculture. For example, in 2022, the Dutch government introduced the National Programme for Rural Areas (NPLG). This programme is aimed at improving and making Dutch rural areas more sustainable. The programmeaddresses various challenges such as nitrogen leaching, water quality, biodiversity, climate change and the socioeconomic vitality of rural areas. Agriculture plays a significant role in this programme (Rijksoverheid, 2023).

To efficiently achieve these goals, there is a widespread desire among stakeholders in agriculture to prioritise outcome-based targets over prescriptive regulations (Reijs et al., 2022). A key feature of outcome-based management is the autonomy it grants farmers to achieve (governmental) goals in a manner of their preference facilitating them to adapt to their specific farm conditions, and to optimally use their knowledge and creativity. In contrast, prescriptive regulations involve restrictions, prohibitions, and mandatory measures, offering farmers far less flexibility in shaping the execution themselves (Nieuwenhuizen et al., 2024).

Outcome-based management requires measuring the results that farmers achieve in meeting sustainability goals. This approach focuses on assessing the outcomes rather than just the actions taken. KPIs can play a crucial role here. Utilising a comprehensive set of KPIs, presents a promising opportunity to measure the contributions of farmers to the goals set by governments (Jellema et al., 2023a). To facilitate this, it is essential that individual farm performances can be aggregated at higher levels, enabling the assessment of whether national, regional, local, and/or sectoral objectives are being met.

Currently, there are no national KPI systems in place across the EU capable of fulfilling this role. However, the Netherlands is currently developing such a system. In collaboration with multiple organisations, WUR is developing a KPI system for sustainable agriculture (referred to as the KPI-K system, where the 'K' stands for *Kernset*, or *Core set*) on behalf of the Dutch government. This initiative aims to create a robust, comprehensive set of KPIs that will represent the sustainability performance of farms in a clear and coherent manner (Jellema et al., 2023a). The KPI-K system can guide farmers by showing the impact of their management practices, on how they can contribute to the goals of circular agriculture. This enables other stakeholders, such as governments, customers, banks, and land management organisations, to recognise and value these contributions, for example by rewarding farmers financially for their achievements (Reijs et al., 2022).

To effectively manage KPIs in Dutch agriculture, the set of KPIs being developed is intended to be as compact as possible but large enough to cover all relevant goals and subsectors. The aim is not to develop a separate KPI for each goal but to establish an integrated set of KPIs that collectively drive better performance across all goals, set by the Dutch government. One single KPI often influences multiple goals, and one goal is often driven by various KPIs. Using an integrated set prevents goal trade-offs and provides clarity for farmers (Reijs en van Doorn, 2023). In addition, when multiple parties use the same KPIs, it simplifies the process of managing and coordinating evaluations and rewards. This consistency allows for clearer communication and understanding among all involved, leading to a more effective alignment of goals and performance expectations.

The KPI system has not yet been implemented in practice by the national government. There are also no instances where individual KPIs are currently used by the government to evaluate the sustainability performance of farms (Jellema et al., 2023a). However, several regional governments in the Netherlands have implemented programmes that reward farmers for their sustainability efforts. These programmes utilise KPI systems as a tool to showcase these sustainability performances (Jellema et al., 2023b). In Box 2.1, one of these programmes is further explored, including the KPIs used.

Box 2.1 Reward programme province of Drenthe

In the Dutch province of Drenthe, located in the Northeastern part of the country, dairy farmers can receive financial rewards for their sustainability efforts. The Sustainable Farmer Drenthe reward programme (Duurzaam Boeren Drenthe) incentivises farmers to enhance the sustainability of their agricultural practices. The programme focuses on improving sustainability performance in crucial areas such as water management, soil health, climate resilience, and nitrogen efficiency. The assessment of farmers' sustainability efforts is structured around an integrated framework comprising 11 KPIs (see Table 2.3).

The reward structure within the programme is designed to correlate directly with the achievement levels of these KPIs. Farmers who excel in these areas stand to receive higher rewards, with each participant eligible for a maximum annual incentive of €5,000, provided they attain optimal scores across all KPIs.

Financial support for this programme is sourced from multiple funding streams, including the investment agenda, the Regional Deal Nature-Inclusive Agriculture (Regiodeal Natuurinclusieve Landbouw), and the National Programme for Rural Areas (NPLG) acceleration mission. Currently, 387 dairy farmers are enrolled in the programme. The objective is to expand the programme towards arable farming in 2024.

Box 2.1 Reward programme province of Drenthe

Table 2.3 *KPIs as used in the Province of Drenthe (Provincie Drenthe, 2023)*

KPI		Score	Reward per dairy farm (euro)
Ammonia emission Kg NH_3 per hectare		≤40	300
		≤50	200
		≤60	150
Grazing Hours per year		≤2,160	600
		≤1,440	300
		≤720	200
Crude protein content in feed ration Grams of crude protein per kilogram of dry matter		≤155	700
		≤160	350
		≤165	200
Tank milk urea content Milligrams per 100 grams		≤18	700
		≤19	350
		≤20	200
% Protein from own land % of fed protein sourced from self-grown		≥65%	700
		≥60%	350
		≥55%	200
Crop rotation index Weighting of root/cereal crops & legumes		≥0.8	250
		≥0.7	200
		≥0.6	150
Total environmental impact of crop protection Impact on soil life, groundwater, surface water	Environmental impact points for soil life per farm (MBP[1]/ha)	≤100	500
		≤200	250
		≤300	150
		≤400	100
	Environmental impact points for groundwater per farm (MBP/ha)	≤100	500
		≤200	250
		≤300	150
		≤400	100
	Environmental impact points for surface water per farm (MBP/ha)	≤100	500
		≤200	250
		≤300	150
		≤400	100
Phosphate soil surplus Kg P_2O_5/ha		≥-5 - ≤5	250
		≥-10 - ≤10	200
Carbon balance Inputting data from the Nutrient Cycling Calculator		*No data*	50
Nitrogen soil surplus Kg N total per hectare for grass/corn/arable land	Grassland (kg N/ha)	≤80	500
		≤105	250
		≤130	150
		≤155	100
	Maize land (kg N/ha)	≤45	700
		≤55	350
		≤70	250
		80	150
	Arable land (kg N/ha)	≤45	700
		≤60	350
		≤75	250
		≤95	150
Greenhouse gas emissions CO_2 eq per kg of milk produced		≤775	250
		≤1,000	200

[1](CLM, 2024).

2.7 Overview of different KPIs used in the literature

The literature analysis revealed a lack of quantitative and uniform KPIs and metrices, which can be attributed to both the ambiguity around the terminology of KPIs, RegenAg and their use, as well as to the novelty and broadness of the RegenAg concept. Also the target and threshold values seem to be missing, as well as the evidence of the impact of practices on long-term soil health and on other relevant agricultural indicators. Consequently, corporations cannot set specific quantitative standards (KPIs) for their suppliers yet. The unknowns and uncertainties are still too large to incorporate these measures into supplier schemes or contracts. However, larger corporations also have ambitions to improve their sustainability goals and incorporate regenerative practices into their business. The literature analysis exemplified that this is often done by aiming to find a middle ground, which motivates their suppliers to adopt or experiment with regenerative practices.

From the literature analysis, it was observed that some large corporations have schemes built up of several practices aligning with the core principles built on the corporate's objectives for RegenAg. These schemes are mainly practice-based or based on a qualitative outcome. It was found that for each mentioned RegenAg practice, three or more levels of compliance were described, based on which a supplier could be categorised. Generally, the schemes were customised to specific crops or specific regions. In particular, Unilever seems to apply a concept of comparing to 'the average in the region' or to 'averages for the same crop'. Overall, the quantification of RegenAg KPIs is still an area to be further explored and validated.

The KPIs used in scientific articles, corporate strategies and white papers were aggregated with coding used in the literature analysis. This resulted in a list of KPIs including many overlapping KPIs and metrices as well as similar KPIs and metrices with different wording. To get to a robust set of used KPIs and metrices, some have been merged. Many KPI themes also reflect more than one target. This is inherent to the system of KPIs whereas mentioned before 'one KPI often influences multiple goals, and one goal is often driven by various KPIs'. The complete overview with KPIs coded from the literature can be found in Table A2.1 (Appendix 2). This table also includes the frequency with which the KPIs were mentioned in the literature. A summary of Table A1 is presented in Table 2.4. The KPI themes are structured and divided into three main categories: ecological, business-economic, and socio-economically focused KPIs.

As can be seen from Table 2.4, RegenAg utilises a broad scope of indicators to assess its impact on ecological and economic levels, which reflects the complexity and multifaceted nature of the RegenAg concept. However, several indicators were prominent in the literature. The interfaces of the KPIs and metrices intersected with concepts of circular agriculture and sustainability in general.

2.7.1 Ecological KPIs

Optimising soil conditions appeared a primary focus for RegenAg, and soil health can be measured through indicators such as organic matter content, microbial activity, and soil bulk density, which are correlated to soil fertility and soil resilience. Practices which contribute to this target encompassed the use of cover crops and crop rotation. Furthermore, biodiversity indicators, including species diversity, livestock integration, and (natural) habitat diversity, were used as indicators for the health and vitality of ecosystems to support nature.

A crucial indicator related to climate is carbon, with soil carbon storage and reducing greenhouse gas emissions as key metrics. These two indicators concern a similar theme but are vastly different in their practical application. Where carbon storage concerns soil health and maximising the carbon stored in the soil, through changing management. Reducing emissions relies on a reduction in fossil fuel use and manure emissions. Efficient management of nutrients and resources was considered another important aspect, correct management of fertiliser inputs targeting waste prevention and soil health enhancement. In the context of circular agriculture, resource efficiency in particular aims to keep outputs stable or maximise them, while minimising inputs and environmental impacts.

Water management metrics, such as water quality improvement, protection of waterways, and implementation of riparian buffers, are critical in regions facing water scarcity and/or extreme weather events, such as droughts and floodings. Related to the management of water, the prevention of soil erosion was considered a key aspect with indicators including soil cover and landscape management practices that maintain soil integrity and reduce runoff. Besides these, the more general water management (improvement) KPI is also used, including infiltration capacity and water holding capacity.

2.7.2 Business-economic KPIs

For business-economic dimensions, indicators such as farm profitability and market access aimed to reflect the financial viability of regenerative practices, ensuring that regenerative practices provide competitive returns and opportunities for farmers.

Yield and productivity were indicators used as a measure for food security by evaluating both the quantity and the sustainability of agricultural output, balancing immediate production with long-term soil health.

2.7.3 Socio-Economic KPIs

Regenerative practices were believed to enhance the resilience and reliability of food systems against climatic and economic shocks. Furthermore, human well-being is a critical element, encompassing cultural, educational, gender, and safety dimensions of and for communities. Another relevant socio-economic indicator encompassed animal health and well-being, but these were not further defined as such in the literature concerning RegenAg.

The broad range of indicators reflects the complexity of regenerative agriculture and demands a holistic approach, which requires balancing these diverse indicators to achieve comprehensive and sustainable outcomes. The combination of different indicators should be balanced according to their specific context. The KPI themes as displayed in Table 2.4 are elaborated on hereafter.

Table 2.4 *Ecological, economic and socio-economic KPI themes*

Category	Target	KPI theme
Ecological	**Optimise soil conditions**	Soil carbon content/carbon sequestration
		Soil organic matter
		Cover crops
		Cropping/crop rotation
		Soil quality
		Soil microbiome
		Soil biodiversity
		Fertiliser use
		Soil disturbance
	Enhance biodiversity	Crop diversification
		Animal diversification
		Livestock integration and grazing
		Natural habitat integration
		Landscape diversification
		Pesticide use
		Insects integration
		Persistent Organic Pollutants (POP)
		Soil carbon content/Carbon sequestration
	Reduce carbon emissions and increase carbon sequestration	Carbon footprint/GHG emissions
		Fossil fuel use
		Nutrient management/fertiliser management
	Increase nutrient and resource efficiency	Nitrogen management
		Potassium management
		Phosphorus management
		Calcium management
		Exchangeable cations (CEC)

Category	Target	KPI theme
		Precision agriculture
		Groundwater pollution
		Resource efficiency
		Resource use
		Water quality improvement
	Improve water management and prevent of soil erosion	Riparian buffers implementation
		Water footprint reduction
		Water ways protection
		Water use optimisation
		Water management improvement
		Soil erosion prevention
		Efficient irrigation
		Water management
		Income
Business Economic	**Farm profitability**	Profitability
		Yield
	Yield and productivity	Yield quality
		Crops
		Land
		Livestock
		Expected loss due to trade-offs
		Production
Socio Economic	**Food security**	Physical output
		Global yield
		Cultural
	Human wellbeing	Education
		Gender
		Safety
		Workers
		Improving animal health and wellbeing
	Animal health and wellbeing	

2.8 Conclusions and discussion

This literature analysis was initiated with the goal to describe the current state of KPIs, specifically used in the context of RegenAg in Europe. To provide a comprehensive picture of these KPIs, both scientific and so-called grey literature were analysed.

The theoretical background and literature analysis revealed that KPIs are used by farmers, larger corporations (for their suppliers), and governments. Generally, KPIs are used to represent the performance of a farm on a specific dimension. Large corporations appeared to also use KPIs in performance schemes, in which they classify and rate their farmers by the adoption rate of regenerative practices. The literature analysis showed that large corporations set goals on five key dimensions: improvement of soil health, enhancement of biodiversity and ecosystems, improved water management and conservation, positive climate impact and reduction of carbon emission, and farmer support and community resilience.

The KPIs used for RegenAg, based on the literature, were divided in three categories: ecological, business-economic, and socio-economic KPIs. Ecological KPIs included those on optimising soil health, enhancing biodiversity, reducing carbon emissions and increasing carbon sequestration, increasing nutrient and resource use efficiency, as well as improving water management and prevention of soil erosion. KPIs concerning the theme of business economics merged around topics such as farm profitability, yield and productivity. Socio-economic KPIs included those on food security, human well-being, as well as animal health and well-being.

First, indicators were practice-, result- and outcome-based. Indicators with a binary outcome were those which describe the implementation or the presence or absence of that specific practice (e.g. implementation of riparian buffers). Practice-based indicators were commonly formulated as a continuous practice which should be implemented (on the farm). Result-based indicators were formulated in the literature in different ways: in absolute measures (e.g. total nitrogen input), as reduction measures (e.g. reduction of nitrogen use), or as relative measures (e.g. nitrogen use should be lower than average farm use in the region). Outcome-based indicators are mostly observed in the ecological indicators (soil carbon content, groundwater pollution). In general, corporations appeared to use a combination of the three types of indicators.

Second, a wide range of different indicators and associated metrics or practices was observed. This could be related to the broad concept of sustainability. However, it also exemplified the lack of standardised and scientific-based KPIs in the literature and potentially in practice as well. Additionally, multiple definitions were used for similar KPIs and metrics, which complicates a common understanding from the literature and may create ambiguity in the application of these KPIs.

Third, some outcome-based indicators included quantitative measures (with or without reference values). It should be noted, however, that many technical parameters (in particular those concerning soil values) are often hard to measure and subject to a large variety of variables as well as measurement methods. In many cases, there are no final conclusions and validations for these technical parameters (or indicators). This forms a crucial concern about the implementation and use of KPIs by farmers, but even more by corporations or governments who use KPIs in a reward-oriented system. In this context, we emphasise the importance of using validated and adjusted measurement methods and reference values. Validation and adjustment should be performed, for instance for soil type, region, and baseline values.

Fourth, in the practical selection of indicators, metrics, and measuring methods the country, region, farm, and soil type should be taken into account. Countries might, for instance, face water-scarce or rather highly fertile areas, which require balancing of the KPIs. Additionally, some outcomes such as biodiversity might be a high priority in sustainability goals for specific countries. On a regional level, soil and landscape characteristics and differences should further refine the selection for KPIs. This will result in lower comparability between countries, but the context specificity is key in RegenAg. At the farm level, differences in KPIs could be rooted in the application of certain practices influencing outcomes. This observation thus calls for the development of robust indicators and a practically applicable framework that considers these difference in context, but also considers the need for comparability. Such a framework should be customised to different landscapes, agricultural systems, and climates.

Furthermore, implementing bodies should consider to which extent the applied framework needs to represent multiple disciplines. In particular, business and socio-economic indicators might be more relevant in contexts in which a basic income is not guaranteed. This advice is in line with the last observation for the business economic and socio-economic indicators, which seem to be more widely used in the context of developing countries, in particular by smallholder farmers. This is understandable from the perspective of protecting smallholders from the imposition of stringent requirements that may affect their (economic) viability. Additionally, it should be considered that the collection of data is challenging, and in particular the collection of economic – often business-sensitive – data. This may complicate the validation and standardisation of reference values for economic indicators, but also the data collection in their application.

Concluding, the landscape of KPIs for agriculture is rather new, which is reflected by the ambiguity around the definition of KPIs as well as the large number of different KPIs identified in the literature. Already in 2001, Riley (2001) observed an 'indicator explosion'. The author concluded that indicators proposed in a wide range of studies are numerous as well as inconsistent across studies, often based upon different definitions (Riley, 2001). In 2012, Pintér et al. concluded that 'we continue moving towards an "indicators zoo", characterized by a multitude of approaches'. In the last few years, a lot of progress has been made on indicators of circular agriculture, as explained earlier in this report. Findings and lessons learned from the use of these KPIs are highly relevant to take along in the journey towards a validated and standardised set of

KPIs for RegenAg. In this literature analysis, we attempted to shed light on the KPIs used for RegenAg, from which it became clear that there is still a way to go towards a robust framework. Nevertheless, this report displays an exploration and first insights which could aid in the development of such a framework. The Dutch KPI-K is a good example of a standardised set. With the developments in the Farm Sustainability Data Network (FSDN, 2024) in Europe, there will be a good basis to develop this EU wide as well. In addition, considerations for use could be adopted by companies to prevent incorrect or inconsistent use of indicators.

3 Part 2: Barriers and drivers

3.1 Introduction

The (ecological) benefits of RegenAg are increasingly suggested in literature, but the adoption of regenerative practices appears to be as challenging in Europe as in other continents (Miller-Klugesherz et al., 2023). RegenAg can be considered as an innovative approach to farming and the adoption rate can be related to perceived barriers in the transition to a regenerative farming system. Simultaneously, farmers can also be motivated to adopt regenerative practices by perceived drivers of RegenAg. In addition to perceived barriers and drivers, the behavioural aspects of farmers play a role in the decision making on transitioning to RegenAg. Understanding farmers' perceptions of these barriers, drivers, and behavioural characteristics is crucial to design and implement sustainable solutions facilitating the transition to regenerative agriculture.

The present literature on perceived barriers and drivers for farmers to switch to RegenAg is scarce. Kenny and Castilla-Rho (2022) highlighted that farmers consider the upfront investment as hindering the adoption of innovative agricultural practices, especially for those who are already burdened by debt and resource limitations. A related barrier encompasses the perceived high transition costs. Vermunt et al. (2022) emphasised that, although the long-term economic benefits—such as resilience to climate change and reduced input costs are significant, the short-term financial uncertainties and burdens often discourage farmers from adopting regenerative practices. These observations were made for the Dutch dairy context, in which the lack of financial incentives was a major obstacle, in particular while focusing on optimal yields Vermunt et al. (2022).

Furthermore, a lack of supportive policies and technical guidance are identified in the literature as obstacles in the transition to RegenAg (Dipu et al., 2022). Beacham et al. (2023) underscored that the uncertainty in the regulatory environment makes farmers hesitant to transition to RegenAg. Vermunt et al. (2022) argued that the uncertainty for farmers in implementing sustainable practices is also related to a lack of a shared, explicit vision for sustainable agriculture, which creates ambiguity around the path forward for farmers. In addition to economic and political factors, also social and psychological factors can play an important role in the decision-making of farmers to adopt RegenAg. These include for instance a fear of change or social judgement from other farmers (Beacham et al., 2023; Kenny and Castilla-Rho, 2022).

Despite these barriers, also important drivers for adopting regenerative practices on the farm have been identified. Gosnell (2022) described that social learning through community of practices, such as peer networks or study groups, can be a driving force in the adoption of practices. Beacham et al. (2023) described further that farmers experience the ability to connect with nature as well as the responsibility for future generations as an important motivator in taking up regenerative practices. In addition, the authors identified economic drivers, including cost savings on fuel and fertiliser usage which could positively impact financial viability in some cases. Eventually, even though social pressure can form a barrier, the positive relationship between farmers and communities also drives some farmers in the transition. In this context, it is important to emphasise that social pressure can work both negative (hindring) and positive (stimulating) (De Lauwere et al., 2023).

This chapter explores the barriers and drivers experienced by farmers from four European countries in the transition to regenerative agriculture through in-depth interviews. In addition, it explores the behavioural characteristics of farmers in the context of adopting regenerative practices.

3.1.1 Reading guide

The following section (3.2) details the methodology used to conduct the in-depth interviews and analyse the results. Section 3.3 presents the results beginning with an overview of the regenerative practices applied by the farmers participating in this study. This is followed by a presentation of the barriers and drivers perceived by the interviewed farmers when it comes to RegenAg. Next, we analyse the farmers' behavioural beliefs, normative beliefs, and perceived behavioural controls regarding RegenAg. This chapter concludes with a discussion and final conclusions in Section 3.4.

3.2 Methodology

3.2.1 Survey design

To structurally assess perceived barriers and drivers for adoption of regenerative practices, interviews were conducted with farmers from Picardie France – FR (n=7), Niedersachsen Germany – DE (n=7), Hungary – HU (no particular region; n=8), and Dolnośląskie Poland – PL (n=7), who matched criteria of regenerative farmers (see Figure 3.1). This work with more limited sample size has been done in preparation for future larger sample size questionnaires. It should be noted that, except in Hungary, participating farmers were selected from a single region in each country. In Hungary this approach could not be used due to the limited number of regenerative farmers. The interviews were conducted on a regional level rather than nationwide to enhance the representativity of the results of those areas. These specific regions were selected primarily due to the high concentration of arable farming and, secondly, because they were part of the supply chains of major agricultural traders and processors interested in sourcing more regenerative products. The beforementioned regions will be referred to by the names of their respective countries.

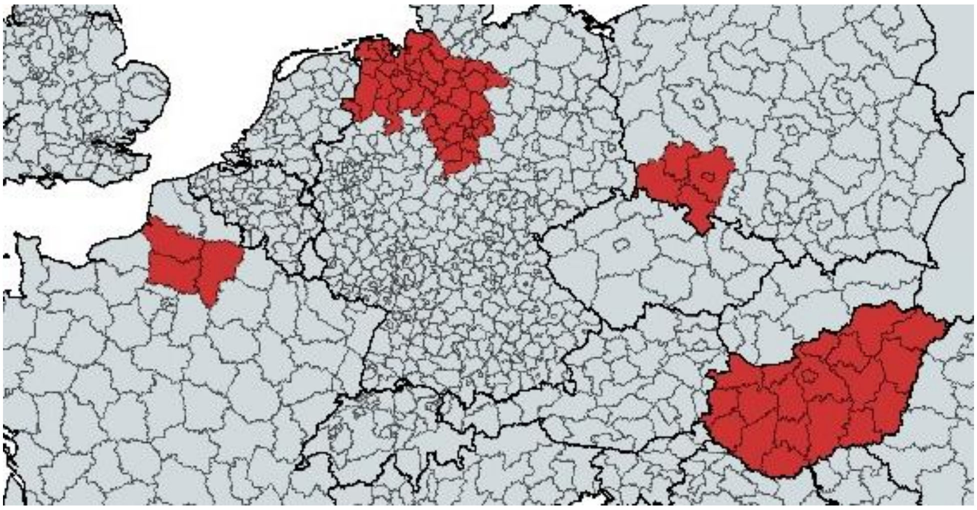

Figure 3.1 *Visualisation of the regions*

A survey was designed by two researchers from WUR and conducted by external local partners. Using a survey for conducting these structured interviews allowed for aggregated data analysis and minimum interviewer bias, given that the interviews were conducted by four different partners across the countries under investigation. The survey consisted of four parts: (1) demographics, (2) an assessment of perceived barriers and drivers for adopting regenerative practices, (3) an assessment of behavioural characteristics considered relevant for adopting regenerative practices, and (4) the needs and expectations of a potential network of regenerative farmers.

The first part assessed questions on the demographics of the farm and farmers, such as *farmers' age, size of the farm,* and *crops produced* to understand the farm context and the sample characteristics. The second part included the assessment of barriers and drivers for adopting regenerative practices. The set-up of this part of the survey was inspired based on comparable studies in different agricultural areas, see for instance Da Silveira et al. (2023) and Niyonsaba et al. (2023). This section started with questions to understand the farmers' motivation to transition to regenerative agriculture. After that, barriers were structurally assessed, meaning that farmers were asked to first indicate which barriers they experienced or still experience in adopting regenerative practices and to rate on a scale from 1 (not important at all) to 5 (very important) how important each of the barriers was for them. In addition to these open questions on barriers, farmers were confronted with 15 pre-identified barriers and asked to rate the importance of these barriers on a scale from 1 (not important at all) to 5 (very important).

Pre-identified barriers were divided into five categories: demographic, social, technical, economic, and political barriers. These barriers were based on a longlist which was derived from a literature search (Agroecology-TRANSECT project, 2024; FORA Initiative, 2022; Frankel-Goldwater et al., 2024; Inherited Seeds, n.d.; Lemke et al., 2024; Rayner and Wildman, 2022; Western University, 2024). From this longlist, three experts selected individually the three most important barriers from each of the mentioned categories. The three highest-scored barriers (per category) were included in the survey. To complete the assessment of barriers, farmers were asked whether they applied any measures or changed strategies for the most important barrier. For the assessment of drivers, a similar procedure as the assessment of barriers was followed.

The third part of the survey assessed behavioural characteristics considered relevant for adopting regenerative practices. To assess behavioural characteristics, the Theory of Planned Behaviour (TPB) was used, since the TPB provides a framework on understanding how the three key factors: behavioural beliefs, perceived behavioural control, and normative beliefs impact individual's engagement in specific behaviour and decision making (in this case the adoption of regenerative farming or practices) (Sok et al., 2021). In this study, the first factor, behavioural beliefs (attitude towards the behaviour), displays how the farmer feels about engaging regenerative farming. The second factor, perceived behavioural control, reflects the farmers' perception on their ability to engage in regenerative farming. The third factor, subjective norm, presents farmers' perception on what important other think they should do (i.e. whether or not to engage in regenerative farming). The TPB has been widely used to asses behavioural intentions, in particular where internal and external factors influencing behaviours intersect (Sok et al., 2021). Even though farmers are already engaged in regenerative farming, the components of the TPB were deemed relevant in structurally assessing the behavioural characteristics of farmers related to adopting regenerative practices. It should be further noted that in this study, the TPB provided a guidance on framing the questions for farmers in the context of regenerative farming, but that these were only loosely based on the theory. Farmers were confronted in total with 26 multiple choice questions, to be answered on a 5-point scale.

In the fourth part, the needs for and the expectations of a potential network for regenerative farmers were investigated. This part consisted of multiple-choice questions on what the motivation would be to participate in such a network.

The content of the survey was reviewed by one researcher, one expert, and one regenerative farmer. Based on these reviews, adjustments were made. After completion, the survey was pre-tested with one researcher and one farmer, based on which additional minor adjustments were made. In addition, the final survey was discussed with partners (who collected data) from France, Germany, Hungary, and Poland.

3.2.2 Data collection

Upon finalisation of the survey design, the survey and suggested data collection process were discussed with the local partners. Surveys were translated into the local languages (French, German, Hungarian, and Polish) to facilitate a smooth interview process. Local partners were provided with instructions on conducting the interviews during an online meeting. Potential participants were selected by the local partners based on a minimum number of regenerative practices which were applied by the farmers.

The inclusion criteria were, first, that the farmer should apply most of the practices with a regenerative purpose (and not only with the purpose to be organic for instance), and second, that the farmer should apply at least three essential and three less essential practices from a list of practices which was set up by two researchers from WUR. The list can be found in Appendix 3. This list was based on a matrix with regenerative practices being the output of a previous project on regenerative agriculture.

After selecting farmers, local partners planned interviews with the farmers. Interviews were then conducted in the months of September and October 2024. Before the start of the interview, a consent form was signed by the farmers. At the start of the interview, farmers were given a short explanation of the interview process and its context. Depending on the agreement of the farmer, conducted interviews were recorded for data processing purposes. Answers were recorded using a data-collection sheet (Excel). After conducting the interviews, farmers received a short explanation of the further procedure mentioning that each farmer would receive an overview of individual results, aggregated results from the concerned country, and aggregated results for all four countries.

3.2.3 Data analysis and presentation of results

Data were analysed using Excel. The analysis of the data concerned merely descriptive data. Quantitative descriptive data include averages, minimum and maximum values, and frequency of answers (if applicable). Further statistical analysis was not possible due to the limited sample size (total n=29). For assessed qualitative data, a written description is given to better understand the context of regenerative farmers and as an elaboration on quantitative results.

First, an overview of the frequency with which practices are applied in each country is provided. Second, the demographics of the farmer and farm characteristics are both qualitatively and quantitatively described. Third, the pre-identified barriers and drivers are analysed quantitatively (including averages, minimum and maximum values of the Likert scale ratings) and elaborated on by qualitative descriptive results. For the analysis of behavioural characteristics, the most 'negative' response is assigned a value of 1, while the most 'positive' response is assigned a value of 5. The averages are presented for each of the key components of the TPB.

3.3 Results

3.3.1 Applied regenerative practices

Table 3.1 presents the frequency with which different regenerative agricultural practices were applied in the analysed regions. While the use of cover crops and minimum or no tillage were a commonly applied regenerative practice across the four regions, the data also highlight differences in the adoption of other practices. Farmers from France and Germany demonstrate for instance higher engagement in the reduction of artificial fertilisers and pesticides compared to Poland. Apparently, the reduction of synthetic pesticides did not have priority for the interviewed Polish farmers at this moment. The regional context such as manure availability could play a role in the use of artificial fertilisers. Manure availability was also mentioned as a barrier in Poland.

Furthermore, applying an extensive crop rotation and growing leguminous crops was a commonly applied practice among all regions. Examples of leguminous crops were canned peas, field beans, and protein peas. The last remarkable observation is that water related practices and the use of compost tea, as well as effective microorganisms, shows limited adoption across the regions. Most farmers indicated to know about these practices and have experimented (or still are experimenting) with these, but they stopped because they did not see effects.

Farmers were asked to explain their understanding on regenerative agriculture. For most farmers, regenerative agriculture meant to apply agriculture practices which focus on preserving and improving soil life. Some farmers specifically emphasised the increase of soil fertility, others focused more on the regeneration of the soil at the chemical, biological, and physical level. Other farmers understood it as a way of doing agriculture while considering the environment and providing a sustainable future for generations. This was also in line with one farmer understanding it as a way to provide ecological and socio-economic meaningful jobs. One farmer understood it as producing high yields without significant intervention. The different visions show commonalities in farmers' understanding on RegenAg, but the results also show some individual deviations from this common understanding.

Table 3.1 *Frequency of application of regenerative practices across France, Germany, Hungary, and Poland. In bold practices which were applied > 5 times per region*

Description of practices	FR (n=7)		DE (n=7)		HU (n=8)		PL (n=7)	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Essential practices (minimum of 3 practices should be applied)								
Use of cover crops	**7**	0	**6**	1	**8**	0	**7**	0
Minimum or no tillage	**7**	0	**6**	1	**8**	0	**6**	1
High crop diversity (minimum of 6 crops)	**5**	2	3	4	**7**	1	**6**	1
Minimal or no use of artificial fertilisers	4	3	**6**	1	**7**	1	3	4
Minimal or no use of synthetic pesticides	4	3	**5**	2	5	3	1	**6**
Less essential practices (minimum of 3 practices should be applied)								
Use of buffers to prevent erosion and run-off	2	5	3	4	1	**7**	**5**	2
Extensive crop rotation (maximum of 50% root crops)	**7**	0	**5**	2	4	4	**5**	2
Implementation of field margins	2	**5**	**5**	2	**5**	3	3	4
Growing leguminous crops	**7**	0	**6**	1	**7**	1	**6**	1
Cooperate with livestock farmers	1	**6**	0	**7**	**8**	0	3	4
Use Organic Matter rich fertiliser	**5**	2	**6**	1	**8**	0	4	3
Grow rugged vegetation	0	**7**	**5**	2	**6**	2	0	**7**
Grow deep rooting crops	**7**	0	4	3	**6**	2	**7**	0
Use of light machinery	**5**	2	3	4	**5**	3	**7**	0
Use of perennials	1	**6**	4	3	**5**	3	0	**7**
Use of renewable energy	3	4	4	3	4	4	4	3
Use of water saving technologies/minimise irrigation	1	**6**	2	**5**	**6**	2	2	**5**
Water storage (e.g. through water buffers)	0	**7**	1	**6**	1	**7**	4	3
Use of compost tea	0	**7**	3	4	3	5	0	**7**
Use of effective microorganisms or mycorrhiza	2	**5**	4	3	4	4	3	4

3.3.2 Demographics

France

The French farmers who were interviewed were on average 54 years old, and most of them started farming early in their career (see Table 3.2). Five farmers held a university degree and two finished secondary education. Four farmers were certain about a successor, but two middle-aged farmers were not. All farmers owned (with an average percentage of 37% owned land) and leased the land which they used for agriculture. The range of farm sizes between farmers was quite large, which could be explained by the relatively small farms being mixed farms (livestock and arable agriculture).

Most farmers started using regenerative practices after 10-15 years of farming, and all had been practicing this already for many years at the time of the interviews. The regenerative practices were mostly applied on the whole farm, only three farmers indicated that part of the practices were applied on a minimum of 75% of their land.

When it comes to using metrics or indicators for their regenerative practices, farmers mostly mentioned ecological indicators including soil observation (spade test, 3D mini-profile, earthworm activity), crop observations (paleness), MERCI method (biomass of plant covers), soil analysis (organic matter, biological activity, visual observations), and decision support tools (Farmstar, plantnet). One farmer indicated to use economic indicators, namely the crop margin. All farmers supplied to national markets, and five also supplied to international markets. 71% of the farmers participated in study groups, but the participation in eco-schemes was less popular and practised by 43% of the farmers.

Some farmers indicated that improving soil fertility, getting closer to the natural processes, and reducing environmental aspects were their main motivations for transitioning to RegenAg. Also, the reduction of plant protection products was among the reasons of several French farmers. In addition, reduction of mechanisation costs and input costs, as well as mitigating risks, were mentioned several times as economic motivations to adopt regenerative practices. In the French sample, farmers often mentioned the reduction of erosion after implementing regenerative practices.

Table 3.2 *Demographic Characteristics of Farmers from France (FR), Germany (DE), Hungary (HU), and Poland (PL)*

Variable	**FR (n=7)**	**DE (n=7)**	**HU (n=8)**	**PL (n=7)**
	Avg (min-max)	**Avg (min-max)**	**Avg (min-max)**	**Avg (min-max)**
Age	54 (39-66)	45 (30-61)	45 (35-68)	54 (43-66)
Years of being a farmer	27 (8-44)	21 (5-31)	22 (8-40)	29 (11-45)
Having a farm successor (%)	57	29	75	69
Farm size (ha)	152 (47-235)	143 (25-400)	428 (70-1,600)	403 (110-900)
Share of land owned (%)	37 (10-70) *n=6	49 (1-100)	42 (20-80)	69 (48-95)
Supplying to national markets (%)	100	100	100	100
Supplying to international markets (%)	74	0	43	67
Using metrics or indicators to evaluate regenerative agricultural methods (%)	100	100	100	100
Participation in study groups (%)	71	86	75	29
Participation in eco-schemes (%)	43	100	88	100

Germany

The German farmers in the sample were on average 45 years old and started farming early in their career (Table 3.2). Two farmers finished secondary education as their highest education level and five farmers held a university degree. Only two farmers were certain about having a successor, but it is important to notice that these were among the oldest farmers, so probably it was not yet a concern for the younger farmers. The majority of farmers owned (with an average percentage of 49% owned land) and leased the land, which they used for agriculture. The range of farm sizes between farmers was quite large. This can be explained by the relatively small farms being mixed farms (livestock and arable).

Most farmers had applied the regenerative practices for approximately 5 years. However, two farmers indicated to have practiced RegenAg for over 25 years. Most of the practices which were applied were also used on the full farm. Only two farmers indicated to apply the practices on approximately half of their arable land.

When it comes to using metrics or indicators for their regenerative practices, farmers mostly mentioned ecological indicators such as plant and soil health and one farmer indicated to look at costs versus yield. Ecological indicators were sometimes subjectively measured, while other farmers mentioned measuring these via soil samples. All farmers supplied to national markets, of which one mentioned to sell directly to consumers. Most farmers participated in study groups and all of them participated in eco-schemes.

The motivations of German farmers to start regenerative practices were diverse, ranging from labour and cost saving to more ecological motivations to preserve healthy soils and pass these on to the next generation. Some of the farmers started after visiting seminars or other farms, but some also realised that the conventional way of working was not sustainable for the future.

Hungary
The interviewed Hungarian farmers were on average 45 years old and started farming early in their careers (Table 3.2). 75% of the interviewed farmers obtained a university degree. Those who did not have a successor (yet), were relatively young farmers. The farms in the sample of Hungary had on average the largest farms (428 ha). However, the average share of owned land (42%) was relatively low compared to the other regions. Notably, the range of farm sizes was very large (70-1,600 ha). All farmers supplied to national markets and 43% also supplied to international markets.

Except for one farmer who applied regenerative practices on a small part of the land, all farmers applied regenerative practices on most of their land. The range of years in which regenerative practices were applied was rather large (2-30 years).

Regarding used metrics or indicators, farmers mostly indicated to use ecological metrics such as visual inspection of the soil (earthworm population, texture, moisture, water retention potential), analysis of the soil's humus content, and presence of wildlife on the fields. Economic indicators mentioned were the reduction of inputs, cost savings, and the profitability of regenerative practices. Farmers indicated that economic resilience of the system was highly relevant to them. Participation in study groups was rather popular (with an average of 75% participating farmers) as well as the participation in eco-schemes (average 88%).

The motivations of Hungarian farmers were more or less threefold. Approximately half of the farmers in the sample indicated that costs drove or even forced them to stop tilling and from there on, they got into contact with the concept of RegenAg practices. Other economic motivations included the reduction of input and labour, both in terms of input (time or quantity) and costs. A notable remark was from one farmer, mentioning that reduction of input and operational costs is highly crucial to remain competitive in the future global market. Other farmers also indicated to be motivated by visual observations of the soil, i.e. seeing the soil deteriorate, and having a strong drive to preserve soils for future generations. Other important ecological motivations were the level of erosion, as well as the resilience to unpredictable rainfall.

Poland
The Polish farmers in the sample were on average 54 years old and had been farming on average for 29 years at the moment of the interviews (Table 3.2). Two farmers obtained their highest degree from secondary education, three from high school, and two from university. Sixty-nine percent of the farmers indicated that they have a farm successor; this high percentage could be related to the relatively higher age of participating farmers, as compared to those from the other participating regions. All farmers both owned and leased land. They owned on average 69% of the land, which amounts in total (rented and owned) to an average of 403 hectares.

When it comes to using metrics or indicators for their regenerative practices, farmers mostly mentioned ecological indicators such as degree of soil fertility, soil analysis (for organic matter, nitrogen or humus), soil quality, and the water content in the soil. In addition, specific water-related indicators included the effectiveness of soil water retention, fewer problems with land drainage and less evaporation of water. Further indicators included those on economic aspects, such as farm income, quality and quantity of yield, and costs savings for fertilisers and tillage. All farmers supplied to national, and four of them also to international, markets. From the seven farmers, four participated in study groups and all participated in eco-schemes.

The motivations of Polish farmers were both economic and ecological. Some farmers were mainly motivated by the reduction of operational inputs and costs, the reduction of financial risk due to the cultivation of many different species, and the availability of subsidies. Others were more motivated to stimulate natural plant health without using plant protection products. Interesting to note is that the majority of the farmers became motivated after discussing with or by demonstrations from other farmers, following trainings, or watching television programmes in which RegenAg was discussed.

> 'I try to invest cautiously and as a result, I do not always apply all the proposed RegenAg rules.' (strategy of a Polish farmer)

3.3.3 Barriers

France

The most important barriers experienced by French farmers included high perceived risks of potential yield reduction. Farmers elaborated that the risk would be especially high if the transition is too abrupt and that the high risks were also related to the lack of knowledge on the effectiveness of practices. One farmer highlighted, however, that even though the yields can be lower, the input costs are also lower, which can serve as a compensation.

Other important barriers were experienced on the social and demographic aspects and included first the *uncertainty about the effectiveness of practices,* in which context it was in particular mentioned that: 'one works with living systems in RegenAg, which reduces the certainty about the things farmers are doing.' One farmer mentioned that 'this uncertainty becomes a risk when upscaling regenerative practices'. A second barrier is *a lack of willingness to change farm management or farm practices*. This barrier was not necessarily experienced by the farmers interviewed, but they indicated that this could be relevant for conventional farmers transitioning to RegenAg. The third barrier included the *lack of certification of regenerative practices and/or products*. Such certification was seen as a great advantage to increase the revenues (through the opportunity of higher pricing), but farmers were also cautious considering the (time-consuming) administration included.

In addition to pre-identified barriers, French farmers mentioned primarily economic and technical barriers limiting the adoption of RegenAg. Important economic barriers included the need for investment into specific equipment, the economic risks during the transition due to yield reduction, the lack of outlets and remuneration for specific (including organic) crops, and the lack of profitability. More technical barriers include the increased need for (observation) time and expertise, the difficulty of stopping tillage, the lack of knowledge on plant-soil interactions, and the lack of knowledge among farm advisors. Some social barriers were mentioned, specifically the inability to replicate examples from other farmers, and the (negative) social pressure from neighbouring farmers.

Table 3.3 *Average ratings (1-5) of perceived barriers by regenerative farmers in transitioning to regenerative agriculture across France (FR), Germany (DE), Hungary (HU), and Poland (PL). The four most important barriers per region are highlighted in bold*

Categories	**Description barrier**	**FR (n=7)**	**DE (n=7)**	**HU (n=8)**	**PL (n=7)**
		Avg.	**Avg.**	**Avg.**	**Avg.**
Demographic	A lack of knowledge and awareness of regenerative agriculture	3.00	2.86	**3.00**	3.14
	A lack of willingness to change farm management or farm practices	**3.86**	2.00	1.57	3.00
	Regenerative agriculture is not in line with personal values	2.86	1.86	1.57	2.71
Social	A lack of knowledge and advice how to adopt practices	3.14	3.00	2.00	3.00
	Uncertainty about effectiveness of practices	**3.86**	3.00	**2.71**	3.00
	Lack of certification of RA practices and/or products	**3.29**	2.71	1.86	**3.71**
Technical	Lack of access to inputs needed for regenerative agriculture practices	1.71	1.71	1.00	2.86
	Lack of regenerative supply chains	1.71	3.14	2.14	3.14
	Lack of 'regenerative alternatives' to conventional techniques	3.14	1.71	**3.00**	3.43
Economic	Lack of market demand for products produced from regenerative agriculture	2.86	**3.43**	2.29	**3.71**
	High perceived risks on potential yield reduction	**4.14**	3.14	1.86	2.86
	Low prices for products produced with regenerative practices/not being able to secure price premiums	3.14	**3.57**	1.43	**4.00**
Political	Lack of enabling and supportive policies or legislation	3.00	**3.43**	2.43	3.57
	Lack of subsidies and support programmes for adopting or investing in regenerative practices	2.71	**3.29**	**2.57**	**3.71**
	Lack of trade facilitation (e.g. exporting products)	2.00	3.14	2.14	**3.71**

Germany

With regard to the pre-identified barriers, German farmers considered economic and political barriers as the most important hindering them in the adoption of regenerative practices (Table 3.3). These included *low prices for products produced with regenerative practices/not being able to secure price premiums*, *lack of market demand for products produced from RegenAg*, *lack of enabling and supportive policies or legislation*, and a *lack of subsidies and support programmes for adopting of or investing in regenerative practices*. Barriers such as a *lack of knowledge and awareness of RegenAg* and *uncertainty about the effectiveness of practices* were considered less important. This can be regarded as remarkable, considering that similar types of barriers were spontaneously mentioned by farmers themselves.

Aside from pre-identified barriers, German farmers experienced diverse barriers which hindered them from adopting regenerative practices. Most of the mentioned barriers were rated as being important or very important. These barriers can be roughly divided into four types. First, farmers indicated that a lack of knowledge, education and scientific support hindered the implementation of practices. This was related to the lack of affordable and knowledgeable farm advisors, urging farmers to pioneer and try out practices at their own risk. Second, farmers indicated that the lack of experience and direct links between practices and outcomes are missing. Therefore, monitoring becomes challenging and is often absent. In addition, the measurable effects were indicated to take a long time, which made it rather difficult for farmers to experiment and draw conclusions on short terms. Third, farmers indicated that legislative and economic hurdles were important obstacles. Economic barriers which were specifically mentioned, included the costs of machinery, lack of subsidies, and unfair competition (by conventional farming). Fourth, farmers mentioned technical barriers, specifically that they experienced difficulty implementing RegenAg in large areas.

‘No way to tell which measures have an effect and if effects are noticed, you do not know which measure was responsible.’ (German farmer on the barrier of lacking information on effectiveness)

Hungary

The most important barriers experienced by Hungarian farmers were all in different categories (Table 3.3). The most important experienced barrier included *a lack of knowledge and awareness of RegenAg*. Farmers indicated that there is a lot of information, but that accessibility (in local language) and applicability to their own context remains a challenge. A second important barrier experienced included the *lack of ‘regenerative alternatives’ to conventional techniques.* Two farmers specified that the lack of alternatives was particularly true for the use of chemical inputs and herbicides. It was further mentioned that knowing which ‘alternatives’ to apply, how to combine them, and when to implement them is an additional challenge. One farmer had a different opinion on this aspect. He mentioned not to look for alternatives, but rather to forget everything he knew about farming and start from the beginning, since regenerative farming consists of completely different methods.

The third important barrier was the *uncertainty on the lack of effectiveness of practices.* According to farmers the uncertainty was mainly rooted in the application on each field and the combination of practices. Some farmers, however, mentioned that uncertainty comes with every major change on the farm, and that uncertainty is inherent to farming. Uncertainty was mostly experienced at the beginning of applying practices. The last important practice enhanced the *lack of subsidies and support programmes for adopting or investing in regenerative practices*. Here the opinions of farmers differed: some farmers mentioned these were available, whereas others mentioned they were only available for specific regenerative practices and not available for capital investments, or only accessible by larger scale farmers. Most likely this perception of the farmer is different for each type and size of the farm.

The average rating of pre-identified barriers was relatively low for Hungarian farmers. This does not mean that barriers were not experienced as farmers came up with many other barriers. Social barriers that were mentioned multiple times, included the social pressure or criticism, not only from neighbours or other farmers, but also from their own employees and between the generations. On this particular aspect, farmers mentioned the emotional attachment to the old way of cultivating fields. In addition, they also experienced a lack of awareness from consumers or outsiders. Hungarian farmers also raised the lack of experience, being expressed as *the accumulated knowledge from previous generations that is applicable to the exact fields and regions*. This is in line with the lack of knowledge described under the pre-identified barriers.

On the technical aspect, Hungarian farmers faced challenges with unstable local weather conditions, the lack of a blue-print to follow, and in particular the challenges to control weed. Economically, farmers mainly experienced a lack of financial stability and capacity to invest in RegenAg, in particular the investments for machinery and improving the soil’s humus content were mentioned. In particular, smaller-scale farmers mentioned that there are no leasing possibilities for machines within the RegenAg concept. Eventually, farmers indicated that the regulatory frameworks were not yet adapted to regenerative farming and that these were often too rigid and caused high additional administrative burdens, in particular for small-scale farms.

‘Buyers want to buy from you, only if you can provide large quantities. The requirements of the potential buyers are that they need large quantities of the same thing. They only want a few types of produce, and if you grow something special, they only deal with you if you can sell a whole truck load. But you cannot do that if you want to achieve diversity on your fields. This goes entirely against what we do. It makes it impossible to serve these buyers, if you have a small farm like us (70ha) and you want to keep up a certain level of crop diversity.’
(Hungarian farmer on lack of market access)

Poland

Generally, the main perceived pre-identified barriers by Polish farmers to adopt regenerative practices, included those on economic and political aspects (Table 3.3). These were *low prices for products produced with regenerative practices/not being able to secure price premiums* and *a lack of market demand for* *products produced from regenerative agriculture.* Farmers primarily attributed the two barriers to the lack of branding. They were followed by an important social barrier on *the lack of certification of RegenAg practices and/or products* which could aid farmers in getting more income for their products*.* The last important barriers encompassed the *lack of subsidies and support programmes for adopting or investing in regenerative practices* and *lack of trade facilitation (e.g. exporting products),* which impacted the ability to make long-term investment decisions.

In addition to pre-identified barriers, Polish farmers mentioned important barriers, specifically referring to a lack of knowledge on RegenAg among farmers, as well as among society in general. Furthermore, farmers indicated that the high costs of buying new machines needed for RegenAg as well as high input costs hamper the adoption of regenerative practices. Another political-economic barrier was the absence of a financial incentive and supporting policies for converting to RegenAg. Specifically, among Polish farmers, barriers regarding the availability of inputs such as organic manure, alternatives for chemical control agents, and organic fertilisers were mentioned.

> ‘In order to get more farmers interested in RegenAg, a promotional campaign is necessary, among the farmers themselves but also among consumers, so that the latter also learn about the advantages. The second way to overcome this barrier is to organize courses, trainings, perhaps also a demo farm, where you can see in practice how the various practices have been implemented.’ (Polish farmer on overcoming the barriers)

General concern

Several farmers were very concerned with glyphosate use in RegenAg. The concerns were both in favour of, and against the use of glyphosate. For instance, the scrutiny of nature conservation organisations on the use of glyphosate was mentioned, but also the need to control weeds with glyphosate in a no-till system raised concerns, although with great reluctance. The acceptance of the use of glyphosate in RegenAg also concerned some farmers. Most concerns focused on the comparison with organic farming, whether regenerative is as sustainable or not. This illustrates that the debate whether regenerative agriculture should be organic or not, is still very relevant.

3.3.4 Drivers

France

From the assessment of pre-identified drivers, it appeared that French farmers were mainly driven by demographic drivers (Table 3.4) such as *having access to a farm cooperative or a network,* since it enabled them to exchange experiences when the members are close enough. In addition, *having personal values which are supporting RegenAg,* was considered an important motivator as this is the main thing which ‘keeps you going’. Furthermore, *Living in close proximity to other farmers* helped farmers getting reassurance through observing neighbouring farmers implementing similar practices*.* Farmers not only exchanged experiences and knowledge with neighbouring farmers, but also the exchange of equipment was facilitated by living close to other regenerative farmers. The last important driver to motivate the transition to RegenAg encompassed *the profitability or economic viability of RegenAg.* On this aspect, farmers noted that the profitability is not motivating at the moment, but that it will be a great motivator once RegenAg becomes profitable.

Aside from pre-identified drivers, French farmers mentioned economic and social drivers as motivators to adopt regenerative practices. Economic drivers included those on cost reduction of for instance mechanisation, and the remuneration through sector bonuses or other financial aid. In addition, French farmers repeatedly mentioned the connection and exchange of information with other farmers as very important drivers for the transition. Eventually, technical drivers such as the interest in and the persuasion to practice regenerative agriculture were considered essential.

> ‘Seeing that other neighbouring farmers are following and trying the same practices, is quite reassuring.’ (French farmer on drivers)

‘The more farmers there are who implement these practices, the more others will want to do the same; farmers discuss it among themselves’ (French farmer on drivers)

Table 3.4 *Average ratings (1-5) of perceived barriers by regenerative farmers in transitioning to regenerative agriculture across France (FR), Germany (DE), Hungary (HU), and Poland (PL). The four most important drivers per region are highlighted in bold*

Category	Description drivers	FR (n=7)	DE (n=7)	HU (n=8)	PL (n=7)
		Avg.	Avg.	Avg.	Avg.
Demographic	Living in close proximity to other regenerative farmers	**4.00**	1.86	3.43	2.57
	Personal values are supporting regenerative agriculture	**4.00**	**4.57**	**4.71**	**4.14**
	Having access to a farm cooperative or a network	**4.29**	2.71	2.43	2.43
Social	Being a pioneer in regenerative farming	2.00	2.14	4.57	3.29
	Feeling (socially) responsible for the environment	3.43	**4.71**	**4.71**	**4.43**
	Taking care of nature through working or farming. (e.g. through biodiversity improvement)	**3.86**	**4.57**	**4.71**	**4.29**
Technical	An increasing level of research and developments for regenerative agriculture	3.57	4.00	4.14	3.29
	Interest in technology for ecology (e.g. precision agriculture techniques, strip tilling)	3.57	3.29	4.57	3.71
	Farmers constructing homemade machines used for regenerative techniques or practices	3.14	2.86	2.14	2.71
Economic	Being able to supply to premium or niche markets	2.43	3.00	3.00	3.86
	Reduction of input costs	3.14	3.14	4.43	**4.00**
	Profitability or economic viability of regenerative agriculture	**3.86**	**4.29**	**4.71**	3.43
Political	Enabling and supportive policies or legislation	2.29	3.57	3.86	2.57
	Involvement in networks and projects that increase visibility of farmers	3.71	3.29	3.29	2.00
	Participation in eco-schemes	3.29	2.57	3.71	3.29

Germany

From the assessment of pre-identified drivers, social drivers were most important to German farmers (Table 3.4). These were followed by economic and demographic drivers. This is well in line with the drivers spontaneously mentioned by farmers. The most important social drivers included *feeling (socially) responsible for the environment* and *taking care of nature through working or farming (e.g. through biodiversity improvement).* The most important economic driver is the enhanced *profitability or economic viability of RegenAg.* Even though not being rated as the most important, *reduction of input costs* and *being able to supply to premium or niche markets* were also considered important drivers for adopting regenerative practices. On the social aspect, having *personal values supporting RegenAg,* were on average considered very important in driving the transition to RegenAg. The results also show that increasing knowledge and a supportive political environment are important factors to stimulate the transition to RegenAg.

In addition to pre-identified drivers, German farmers also experienced other drivers which motivated them to adopt regenerative practices. Generally, three types of drivers were distinguished. First, the majority of farmers indicated that ecological reasons drove them to adopt regenerative practices. These included for instance conservation of soil, nature, and the planet, as well as enhancing climate resilience and preventing further exhaustion of the soil. Second, farmers indicated that work time savings and economic advantages drove them towards adopting regenerative practices. Third, a few farmers indicated that being a pioneer and personal motivations were large drivers to adopt regenerative practices. Most of the mentioned drivers were rated as important or very important.

> 'Trying to preserve the planet: Land use as an essential lever for global hurdles.' (German farmer on drivers for RegenAg)

Hungary
The transition to RegenAg appeared to be primarily driven by socio-demographic factors (Table 3.4). The most important experienced pre-identified drivers included *feeling (socially) responsible for the environment* and *taking care of nature through working or farming*. Farmers mentioned on this aspect that they try to make use of subsidies and fit into programmes that focus on the protection of the environment. By focusing on the nature aspect of farming, they hoped to be a showcase to others. In line with these drivers, farmers rated the driver of having *personal values supporting RegenAg* as one of the most relevant. The last important driver included the *reduction of input costs*. This seemed obvious to farmers, but some mentioned that the focus should be on profitability and not only on input costs.

Drivers mentioned spontaneously by farmers, were in line with their ratings from the pre-identified assessments. Farmers indicated that getting inspired by (international) experiences as well as knowledge exchange with neighbours or other farmers, is motivating to transition to RegenAg. In addition, recognising the impacts of industrial or conventional agriculture on nature and climate change emerged as an important driver for transitioning to RegenAg.

On the technical side, the ability to use cover crops to combat weeds was mentioned as an important driver as it helps to avoid using herbicides, which saves money. Economic-wise, farmers indicated that seeing positive impacts on cost savings and profitability was a relevant driver. Ways of achieving this were currently cost savings, getting subsidies or working with companies who are looking for regenerative produce and maintaining a fixed price premium to compensate for potential losses through lower yields. However, companies like these are scarce. In line with that, farmers elaborated that market protection as well as demand for alternative products is highly relevant to sustain revenues.

> 'If we want to produce more and better quality, you require better soil and you need to set up the right circumstances for that - and that is where regenerative practices come in.' (The only real driver, according to one Hungarian farmer.)

> 'The ability of cover crops to combat weeds like ragweed in minimally disturbed soils in the stubble, helps us avoid using herbicides, which saves us money. Ragweed seems to thrive in soils that are regularly tilled. Plus, some weeds are developing resistance to herbicides; for example, glyphosate might not be effective against common lambsquarters anymore.' (Hungarian farmer)

Poland
Comparable to farmers from other regions, Polish farmers were also mainly driven by social and demographic reasons (Table 3.4). Important drivers included *feeling (socially) responsible for the environment* (in particular for future generations), and *taking care of nature through working or farming. (e.g. through biodiversity improvement),* and *having personal values that support RegenAg.* In line with their motivations, Polish farmers were also driven by economic drivers such as *the reduction of input costs.*

When it comes to drivers mentioned by Polish farmers, these mainly include socio-economic and ecological drivers. Economic drivers encompass for instance the reduction of production costs (fuel, labour), availability of subsidies, and innovativeness of new agro-technical solutions on the farm. Ecological drivers included good soil conditions (fertility, structure), greater diversity (crops, living organisms), reduction of pests, and protection from the consequences of climate change.

‘I was having problems with the profitability in conventional farming. It led me to make some changes. The option to take up the RegenAg strategy, became the most profitable and allowed to get more income from farming due to cost reduction.’ (Polish farmer)

3.3.5 Behavioural characteristics

This section gives insights into aspects of the attitude of farmers towards regenerative farming (behavioural beliefs), farmers’ perception on what – for them important other people - think they should do with respect to adopting or continuing regenerative farming (subjective norm), and their perception on their ability to engage in regenerative farming (perceived behavioural control). Average ratings for behavioural beliefs, perceived behavioural control, and normative beliefs were similar among the farmers from the different countries (Figure 3.1).

When it comes to behavioural beliefs, the farmers in this sample generally had a positive attitude towards RegenAg and considered its impact on the environment as beneficial. This is not surprising considering that these farmers are frontrunners in the sector. One farmer mentioned, however, that he still had some reservations. Farmers expected RegenAg to have a neutral/positive impact on crop yields and economics, which are related factors. At farm level, the respondents enjoy implementing RegenAg a lot and it is mostly expected to result in positive outcomes. Furthermore, farmers felt that they had a positive impact on slowing down climate change through regenerative practices. Farmers do not only believe they have a positive impact, they also believe that regenerative practices can improve resilience on the farm.

All countries scored lowest on the normative beliefs. Results demonstrated that farmers sought the opinions of agricultural advisors, but not much. Some farmers mentioned to seek advice from different sources, in particular those which they trust. The social pressure from the external environment, including environmental organisations, was not much experienced. With regard to decision-making on the farm, and in particular on regenerative practices, the importance of the opinion of family members was felt most important in Germany and less in France and Poland. This was also the only factor which showed a 2-point difference on the scale from 1 to 5 between the different regions, where all the others were only at 1 point difference. Furthermore, farmers were neutral about other farmers supporting the transition and more positive about the public perception.

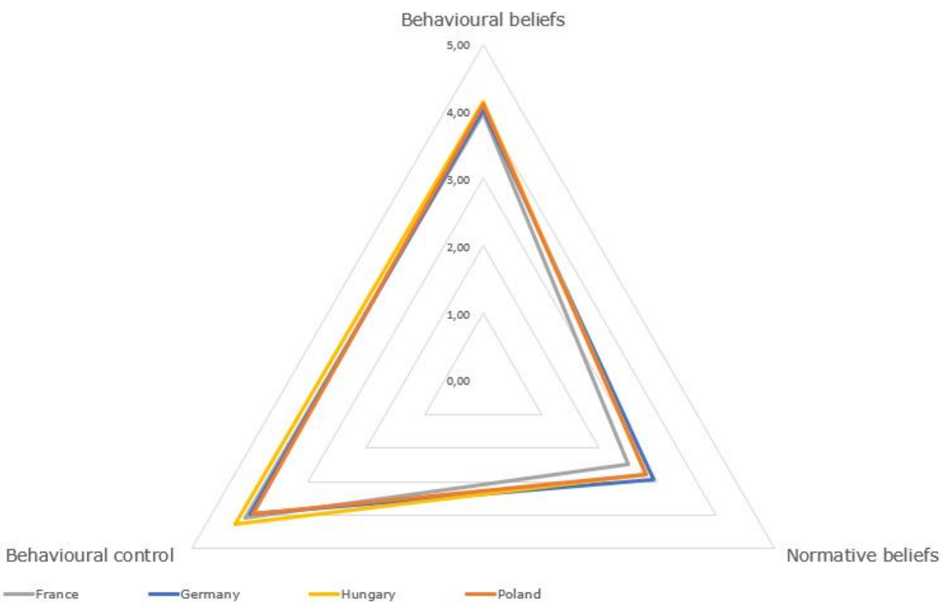

Figure 4.1 *Average Scores of Behavioural Beliefs, Normative Beliefs, and Behavioural Control across France (FR), Germany (DE), Hungary (HU), and Poland (PL)*

Regarding behavioural control, farmers were positive in general. Farmers felt in control, very equipped and confident in their ability to implement regenerative practices. Overall, they felt in control in implementing practices, but did expect that external factors would impact their ability to adopt practices to a moderate extent. In conclusion, it was observed that farmers behavioural aspects in RegenAg were rather positive, which indicated that they are very likely to continue engaging in regenerative farming, in the next three years.

3.3.6 Farmers' need for a network of RegenAg

Finally, the survey results provided insights to better understand the motivations driving farmers to participate in a network for RegenAg for learning, knowledge sharing and exchanging experiences. For this, we prepared a list of seven different possible motivations. The frontrunners could answer 'yes' or 'no' to the question of whether these motivations apply to them. They were also asked for comments regarding each motivation and if they had additional motivations. The responses showed diverse needs and expectations.

As shown in Table 3.5, the agreement or disagreement regarding certain motivations of farmers to join a RegenAg network vary, with the most prominent drivers being access to new technologies (26 responded 'yes') and sharing knowledge (26 responded 'yes'). These findings can be used as recommendations for demonstration activities within the network, emphasizing technology transfer and knowledge exchange.

Table 3.5 *Overview of answers on the motivation to join a network for RegenAg*

Motivation to join a network of RegenAg	The answer was 'Yes'	The answer was 'No'
Access to new technologies	26	3
Market opportunities	23	6
Advocacy and support	20	9
Social connections	22	7
Influencing policymakers	20	9
Sharing knowledge	26	3
Exchanging mechanisation (such as specific tractors for stubble sowing)	16	13

Less prominent, but still frequently cited motivations include market opportunities, advocacy and support, influencing policymakers, and exchanging mechanisation. Still, more than two-thirds of the respondents answered affirmatively to these motives, which suggests a broad interest in diverse aspects of the network. Therefore, the network should provide a comprehensive range of opportunities to address the varied needs of participating farmers.

We also included an open-ended question section in the survey, through which we gathered individual responses from a group of French and Hungarian frontrunner farmers. The most frequently mentioned reason for joining such a network was the desire for shared resources and knowledge, cited by five participants. One respondent mentioned advocacy and support as key motivators, while another emphasised that successful participation would depend on farmers sharing similar beliefs and values. Hungarian frontrunners mentioned that they would like a network that shows the successes and failures of RegenAg, with field excursions and more operational support. Several logistic concerns were also raised. Language barriers, particularly in the context of international farmer-to-farmer exchanges, were mentioned by three respondents. One farmer argued that an additional network was unnecessary, citing the existence of numerous similar networks in France. Challenges related to geographic distances, farmers' availability to participate in network activities, and the need for financial support were also highlighted, with one and two mentions respectively.

3.4 Discussion and conclusions

Discussion

RegenAg is becoming a well-known emerging concept, gaining ground in the agri-food sector. The adoption of regenerative practices by farmers is one of the components crucial for a successful implementation of RegenAg. In this chapter, the barriers and drivers for farmers to transition to RegenAg from four countries across Europe have been investigated. In this section (3.4), results are discussed, the research process is reflected on, and concluding remarks are provided.

The definition and understanding of RegenAg is broad and not yet practically defined. In addition, other relatively new agricultural concepts such as conservation agriculture and agri-ecological farming partly have identical principles. In addition, not all farmers and countries are equally familiar with the concept. These factors made it challenging to identify and recruit pure 'regenerative farms'. In this study, we attempted to overcome this challenge by selecting farms based on the application of a minimal number of agricultural practices, which can be considered as 'regenerative'. By using such a practical approach we minimised the information required from farmers upfront and obtained the sample size planned for this study. The sample size was rather small due to the qualitative nature of the study and its goal to develop hypotheses as a basis for more extended future research. Another approach would include gathering information on the farm structure and management practices such as fertiliser use, pesticide use, tillage strategy, cropping plan, and farm strategy. However, that would require substantial data gathering in order to select regenerative farms. The used approach is practical, but it could be argued that a regenerative farm is not simply a farm implementing a set of practices; it is a integral approach of farming including a context-specific set of practices that strive for more regenerative outcomes. In our view, the resulting interview data do reflect arable systems in which 'regenerative practices' are an important component of their operations. It is an important point for future research to quantify measures like minimal or reduced use pesticide and chemical fertilisers or reduced tillage, as this currently could include too many interpretations.

In this study, farms were selected from specific regions within the countries (except for Hungary). This regional approach was used to increase the representativeness of the results for those regions. Considering that the sample size per country was limited to 7 or 8, selecting farms from different regions of the country would have limited comparability of the results to a great extent. Despite carefully selecting the farms per region, the sample size was still too small to conduct advanced statistical analyses and to draw conclusive evidence. Furthermore, it should be noted that the results cannot be considered representative for an average European farmer. However, we do argue that the descriptive results in our study, both quantitative and qualitative, provide valuable insights into the factors hindering and motivating farmers to transition to RegenAg. We observe for instance that some perceived barriers and drivers are very specific for the regions, but that some (such as the barrier *inability to sell 'regenerative' products for a premium price* or the driver of *sharing knowledge with colleague farmers*) were also rather similar across the countries. The assessment of barriers and drivers based on farmers' own input, revealed largely the region-specific challenges faced. Interestingly, the assessment of behavioural characteristics which could influence the uptake of regenerative practices revealed that there were no large differences between the different regions. Despite not being able to do statistical analyses, the qualitative results from farmers were very informative and rich in content which provided us with a solid basis to report the results. For future studies, we highly recommend increasing the sample size required for statistical analyses and potentially doing (online) questionnaires as a follow-up of our in-depth (hypothesis forming) interviews.

Even though we presented aggregated data for all the farms, the interpretation of these aggregated results should be considered with care, given that the farm size of the total sample varied between 25 and 1,600 ha. The differences between the regions show a split in the data where French and German farms as well as Polish and Hungarian farms were more comparable in size and regional aspects. The size effect could for instance have implications for RegenAg, as size might allow for certain investments needed or making some regenerative management decisions infeasible - or the other way around. It could also impact the ability to collaborate with chain partners or meet specific requirements to apply for funding or schemes, which could support adopting (more) regenerative practices. The difference in farm size, could also explain the variety in implemented regenerative practices. Where larger farms could for instance primarily focus on minimum or zero tillage, practices such as local food supply and agroforestry could better fit for smaller farms. Despite these large differences in size, we believe that the descriptive results on perceived barriers and drivers are highly relevant.

The assessment of barriers and drivers was divided into two sections, i.e. a section where farmers could provide their own input and a section in which farmers had to rate pre-identified barriers and drivers. To avoid bias the section with own input was dealt with first, after which the pre-identified barriers were assessed. Even though this sequence seemed the best to avoid biases, the assessment based on own input might have influenced the ratings of the section afterwards. This was also observed in the data as some farmers rated their own barriers which were rather similar to some pre-identified barriers with different scores. Particularly, the ratings from the sample of Hungary showed a relatively low rating of pre-identified barriers, but high ratings of own input barriers, while partly being similar.

For assessing the behavioural characteristics, which could be related to the uptake of regenerative practices, we designed statements following elements of the TPB. We could not assess all the aspects of the TPB in full detail, as it would have made the survey too long and increased the risk for dropouts. Averaging the scores per category was done to give an impression of the different aspects of the theory.
However, the survey results do not provide conclusive evidence on these aspects, also considering the small sample size. In hindsight, the results might be slightly biased towards the positive aspect, considering that the TPB is commonly used to assess behavioural factors, prior to adopting innovative practices or strategies. Despite this limitation, we consider the descriptive results as informative and an underpinning of the results on barriers and drivers. Thus, while the use of TPB might not encompass all behavioural aspects in this study, it was nonetheless instrumental in exploring behavioural characteristics among regenerative farmers. Future research may benefit from combined TPB with other theories, to provide more conclusive evidence.

Conclusions
In general, it is observed that the perceived barriers differ between the regions. However, these are still being experienced in similar areas. The perception of drivers showed a more similar pattern among the different regions. Across the different regions, the perceived barriers were primarily experienced in the economic, political, and socio-demographic category. Even though barriers for scaling up were mentioned, technical barriers seemed less relevant compared to the other categories. Outstanding barriers included the *uncertainty about effectiveness of practices*, *the lack of market demand* in combination with *the inability to secure price premiums,* and *the lack of subsidies and support programmes for adopting regenerative practices.* While barriers were mostly experienced in the economic and political categories, drivers and motivations to transition to RegenAg were primarily experienced in the socio-demographic categories. Remarkable were the concerns about the use of glyphosate. Some farmers were concerned about its use, while other famers were concerned about not being able to use it. This illustrates that the debate, whether regenerative agriculture should be organic or not, is still very relevant.

Across the regions, farmers appeared to be largely driven by *personal values supporting RegenAg*, *feeling (socially) responsible for the environment* in the present and for future generations, and *taking care of nature through farming.* An interesting observation was that the profitability of RegenAg was considered both a barrier but also a large driver for some regions. For farmers from one region in specific, the primary reason to transition to RegenAg was because they would otherwise not be able to continue their farming practices for economic reasons.

From the assessment of behavioural characteristics, it appeared that the farmers in the sample have a positive attitude towards RegenAg and that they did not experience much pressure from the external environment. Farmers felt in control managing regenerative practices, but also mentioned that external risks and factors might influence their uptake.

Finally, while the most significant motivators for joining a RegenAg network were knowledge sharing and technological access, attention should also be given to logistic challenges such as language barriers, farmer availability, and geographical distances. Offering a diverse set of services and support mechanisms will be crucial in ensuring the network’s success.

4 Literature

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Appendix 2 KPIs found in literature

Ecological KPIs

Table A2.1 *Key performance indicators (KPIs) themes, used indicators, and quantification (if available) for the ecological target of optimising soil conditions based on used literature*

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
Optimise soil conditions	Carbon sequestration (9)	Mass balance measured at different depths	Measure	
	Cropping (20)	*Breeding crop varieties that produce more root (exudates)*	Practice	
		Modifying crop management techniques	Practice	
		Undersown cropping	Practice	
		Intercropping	Practice	
		Use of crops with shorter biological cycles	Practice	
		Strip cropping	Practice	
		Understanding crop/weed interactions under changing conditions	Practice	
		Breeding more resilient cultivars	Practice	
		Intercropping a wider variety of tree species in the plantation	Practice	
		Perennial crops or pasture	Practice	
		Number of crops	Measure	# of crops per ha per crop cycle
				n percentage of crop land with n different crops over n year
		Cropping index intensity	Measure	Cropping Intensity = Gross Cropped Area/Net Sown Area x 100
	Cover crops (42)	Duration of soil cover	Measure	% of the year with cover crops
		Living soil cover	Practice	
	Crop rotation (16)	Diverse crop rotations	Measure	
		Double cropping	Measure	
		Herbal leys and summer fallows	Measure	
		Intercropping or cover cropping	Measure	
	Soil quality (30)	pH	Measure	
		Dry bulk density	Measure	
		Structure	Measure	
		Colour	Measure	
		Root content	Measure	
		Smell	Measure	
		Moisture	Measure	
		Infiltration capacity	Measure	
		Stability	Measure	
		N-balance	Measure	Nitrogen balance = N inputs−N outputs−changes in soil total N
		Resilient soil food web	Measure	
	Soil microbiome (7)	Microbial activity is higher than for average soil type	Measure	
		Microbial respiration	Measure	
		# of earthworms present	Measure	
		Total soil microbial biomass	Measure	

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
		Soil microbial activity	Measure	
	Soil organic matter (14)	SOM (farm type dependent)	Measure	4-8%
		Organic matter balance	Measure	Kg/ha
	Fertiliser use (4)	(Organic) fertiliser use	Measure	
		Reduction of synthetic fertiliser use	Measure	
		Use of (green) manure or compost	Practice	
		Use of biochar	Practice	
	Soil disturbance (31)	Area under minimum tillage	Measure	
		Minimum, zero or reduced tillage	Practice	
	Soil biodiversity (8)	Use of lower risk pesticides	Measure	
		Soil microbial diversity	Measure	
		Soil microbial community abundance	Measure	

Table A2.2 *Key performance indicators (KPIs) themes, used indicators, and quantification (if available) for the ecological targets reduced carbon emissions and increase carbon sequestration*

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
Reduce carbon emissions and increase carbon sequestration	Soil carbon content (9)	Carbon balance indicator	Practice	
		Soil organic carbon	Measure	
		Labile carbon	Measure	
		Recalcitrant carbon	Measure	
		Agriculture and nature combined are a 'net carbon sink'	Practice	
		Maintain soil carbon and structure	Practice	
		Increased soil organic carbon matter	Measure	
	Carbon sequestration (9)	% fallow crops in rotation	Practice	
		Soil carbon sequestration	Measure	(CO2e/ha/year)
		Trees and other vegetative carbon	Practice	
	Carbon footprint (4)	Crop carbon footprint	Measure	
		Carbon foot printing implemented to monitor climate impacts	Practice	
		Crop carbon footprint lower than average for crop grown in same region	Measure	
	GHG emissions (10)	Emissions of GHG from agricultural activities	Measure	E.g. measured in kg CO2eq. Following standardised methods
		N2O and CH4 emission reduction	Measure	
		CO2 emissions from on-farm energy use	Measure	
		Net emission for all land uses	Measure	
		Total estimated change in GHG emissions	Measure	
	Fossil fuel use (3)	Fossil fuel use on farm	Measure	
		Reducing fossil fuel use on farm sustained for several seasons	Measure	
		Fossil fuel use on farm lower than average for farming system	Measure	
	POP (1)	No accumulation of persistent organic pollutants (POPs) in soils, water or air.	Measure	

Table A2.3 *Key performance indicators (KPIs) themes, used indicators, and quantification (if available) for the ecological targets enhanced nutrient and resource efficiency*

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
Enhance nutrient and resource efficiency	Nutrient management (10)	(Plant) nutrient availability	Measure	
		Nutrient balance	Measure	(input-(output + losses)) in kg/ha
		Nutritional value for forage	Measure	
		Nutrients come from renewable sources	Measure	

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
		Reduction in N+P+K fertiliser relative to final production (yield)	Measure	
		Sufficient nutrient status	Measure	
		Integrated nutrient management practices	Measure	
	Nitrogen management (27)	Percentage of synthetic versus total nitrogen	Measure	
		Avoid nitrogen fertilisers	Practice	
		Optimising rate and timing of nitrogen fertilisers/precision application	Practice	
		N deposition in natural habitats should be lower than critical deposition level	Measure	
		Total nitrogen	Measure	Input nitrogen–nitrogen disposal through harvested product
		Nitrogen balance	Measure	Kg N/ha
		Biological nitrogen fixation	Measure	Kg/ha
		(Increased) N use efficiency	Measure	
		Documented nitrogen management plan	Practice	
		Nitrogen input reduction	Practice	
		N balance calculator	Measure	Nitrogen balance=Nitrogen input–Nitrogen removed/safe levels between 25 –75 lbs. N/acre
	Potassium management (3)	Available potassium	Measure	
		Leaf K	Measure	
		K balance	Measure	Kg K/ha
	Phosphorus management (3)	Total phosphorus	Measure	
		Available phosphorus	Measure	Kg P/ha
	Calcium (1)	Presence of calcium carbonates	Measure	
	Exchangeable cations (2)	Effective cation-exchange capacity	Measure	
	Precision agriculture (2)	Implementation of precision farming technologies	Practice	
	Fertiliser management (18)	Reduced chemical impact	Measure	
		Incentives for use of certain biologicals	Practice	
		Organic fertiliser usage	Practice	
		Fertiliser Usage	Practice	Nitrogen use efficiency (NUE)
		Maximize the value of manure	Practice	
	Groundwater pollution (1)	Reduction of groundwater pollution	Practice	
	Resource efficiency (4)	Imported fertilisers	Measure	Currency/year
		Imported fertilisers	Measure	Kg N/ha
		Imported crop products	Measure	Kg N/ha
		Circular flow of energy & nutrients from barn to soil.	Practice	
	Resource use (4)	Avoid or reduce insecticides, fungicides and herbicides.	Practice	Percentage of area without application of pesticides and herbicides
		Inputs (nutrients and fertiliser) of renewable sources	Measure	
		Use of circular ingredients	Practice	
		Pesticide usage	Measure	(EIQ – Environmental Impact Quotation)
		Implementation of IPM practices and use natural or biological pest control	Practice	
		Input productivity	Measure	Total output/quantity of input (Currency/ha)
		Labour productivity	Measure	Farm income/annual work unit
		Agricultural output/labour input		Currency/annual work unit

Table A2.4 *Key performance indicators (KPIs) themes, used indicators, and quantification (if available) for the ecological targets improved water management and preventing soil erosion*

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
Improve of water management and preventing soil erosion	Water quality improvement (7)	Nitrate levels in tile water	Measure	
		Nitrate and phosphorus levels in drainage or local surface water less than threshold for eutrophication	Measure	
		Turbidity or sedimentation rate in water bodies adjacent to farmland	Measure	
		Water quality very good according to EU water framework directive	Measure	
		Qualitative Water Withdrawal Reduction	Measure	Measured through water sampling on parameters such as pH – dissolved oxygen – nutrient levels – pollutant concentrations (water quality index)
	Riparian buffers implementation (5)	Length and width of riparian buffers	Measure	
	Water footprint reduction (2)	Water footprint of irrigated crops lower than average for crop type	Measure	
		Blue water withdrawals	Measure	
	Water ways protection (3)	No negative impacts on water in natural areas and for local communities	Measure	
		Protect waterways from nutrient leaching	Practice	
	Water use optimisation (12)	Water stress level	Measure	Fresh water demand relative to the available water – taking into account both quantity and quality
		Water usage < naturally available	Measure	
		Water surpluses are collected as buffer	Practice	
		Optimised water use	Measure	
		Water monitoring total water usage at the farm	Practice	
		Monitoring of water consumption	Practice	
		Optimising water use efficiency by matching demand to water availability	Practice	
	Water management improvement (1)	Hydrological performance indicator	Measure	
	Soil erosion prevention (5)	Water infiltration and storage capacity of soil sufficient to prevent water erosion	Measure	
		Inlet systems for surface runoff	Measure	
		Cover-management factor	Measure	
		Erosion plots	Measure	
		Sediment plots	Measure	
		Erosion (e.g., revised universal soil loss equation (RUSLE)	Measure	
		Water holding and drainage capacity of soil	Measure	
	Efficient irrigation (8)	Efficient irrigation systems and practices	Practice	
		Documented irrigation planning at watershed level	Practice	
		Irrigation scheduling	Practice	
		Optimise irrigation plans in accordance with water availability in the water shed and the water needs from the crop	Practice	
		Use irrigation scheduling and water management	Practice	
		Assess irrigation need	Practice	Considering crop demand, net rainfall, and demand of other use of surface and groundwater

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
		Select most efficient irrigation technology and equipment (e.g. drip irrigation)	Practice	
		Adopt sprinkler irrigation systems where possible	Practice	
		Adopt drip irrigation systems where possible	Practice	
		Implement sustainable drainage systems.	Practice	
	Water management (2)	Prevent erosion through e.g. cover cropping, mulching, terracing.	Practice	

Business-economic KPIs

Table A2.5 *Key performance indicators (KPIs) themes, used indicators, and quantification (if available) for the business-economic target farm profitability*

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
Farm profitability	Income (6)	Net farm income	Measure	
		Off-farm income	Measure	
		Household income	Measure	
		Farmers income	Measure	
		Cost and income tracking	Practice	
	Profitability (13)	Farm profitability	Measure	
		Profitability ability	Measure	
		ROA	Measure	
		Gross margin	Measure	
		Operating cash flow	Measure	
		Cost-benefit ratio	Measure	
		Labour costs	Measure	
		Operational costs	Measure	
		Operating profit	Measure	
Market access	Product prices (currency) (1)	Market-based pricing determined by supply and demand dynamics	Practice	
Yield and productivity	Yield (4)	Yield stability	Measure	
		Long term yield	Measure	
		Changes in global yields	Measure	
		Yield	Measure	Kg/ha
				Currency/ha
				Land equivalent ratio
				Biomass
	Yield quality (3)	Quality indices	Measure	
		Nutrient density of food production	Measure	
		Energy production	Measure	
	Crops (7)	Number of crops	Measure	# of crops/ha/crop cycle
		Crop productivity	Measure	(t/ha)
		Crop biomass	Measure	
		Leaf area index	Measure	
		Plant height	Measure	
		Individual crop/ha	Measure	
		Grass production	Measure	
		Crop yield	Measure	
		Crop/yield ratio	Measure	
	Land (1)	Land productivity	Measure	crop/land area in t/ha
	Livestock (2)	Output obtained from animal production per unit	Measure	kg/day or year
	Expected loss (2)	Average expected loss	Measure	conditional value at risk in currency
		Average expected loss in certain scenarios	Measure	

Socio-economic KPIs

Table A2.6 *Key performance indicators (KPIs) themes, used indicators, and quantification (if available) for the socio-economic targets food security, human wellbeing, animal health and wellbeing*

Target	KPI theme	Used indicators	Practice/ Metrics	Additional provided details
Food security	Production (1)	Average production per ha high enough to produce sufficient food and biomass on	Measure	11-15M/km^2 cropland, globally
	Physical output (1)	Physical output encompassing the diversity of corps, incorporating risk management and income diversity.	Measure	(total yield for food and non-food products)
	Global yield (1)	Changes in global yields, total (cropland and pasture land) and food security of populations based on nutritional outcomes.	Measure	
Human wellbeing	Cultural (1)	Good connection between rural and urban communities	Practice	
	Education (3)	# farmers organised in cooperatives	Measure	
		# farmers trained	Measure	
		Level of education and educational attainment among farmers	Measure	
		Assessment of educational qualifications and attainment levels among farmers	Measure	
	Gender (1)	Number of women engaged in economic empowerment programmes	Measure	
	Safety (1)	Overall well-being and quality of life of farmers	Measure	
		Assessment of factors such as income, health, education, housing, and social well-being among farmers.	Practice	
	Workers (6)	Salary for workers	Measure	
		Attractive and meaningful work provided	Practice	
		Total number of individuals engaged in farm labor	Measure	
		High quality and safety of working conditions (rights, occupational safety, and working environment)	Practice	
		Labour balance	Measure	(h/year)
Animal health and wellbeing	Improving animal health and wellbeing (4)	Farm animals have a life worth living	Measure	
		Tracking and use of hormones and antibiotics on farm	Practice	
		Forage quality	Measure	
		Animal welfare and health (assessment of animal health, care, and welfare practices – measure of welfare score)	Measure	

Appendix 3 Barriers and drivers

Table A3.1 *Frequency of application of regenerative practices across France (FR), Germany (DE), Hungary (HU), and Poland (PL). In bold practices which were applied > 5 times per region*

	FR (n=7)		**DE (n=7)**		**HU (n=8)**		**PL (n=7)**	
Description of practices	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Essential practices (minimum of 3 practices should be applied)								
Use of cover crops	**7**	0	**6**	1	**8**	0	**7**	0
Minimum or no tillage	**7**	0	**6**	1	**8**	0	**6**	1
High crop diversity (minimum of 6 crops)	**5**	2	3	4	**7**	1	**6**	1
Minimal or no use of artificial fertilisers	4	3	**6**	1	**7**	1	3	4
Minimal or no use of synthetic pesticides	4	3	**5**	2	5	3	1	**6**
Less essential practices (minimum of 3 practices should be applied)								
Use of buffers to prevent erosion and run-off	2	5	3	4	1	**7**	**5**	2
Extensive crop rotation (maximum of 50% root crops)	**7**	0	**5**	2	4	4	**5**	2
Implementation of field margins	2	**5**	**5**	2	**5**	3	3	4
Growing leguminous crops	**7**	0	**6**	1	**7**	1	**6**	1
Cooperate with livestock farmers	1	**6**	0	**7**	**8**	0	3	4
Use Organic Matter rich fertiliser	**5**	2	**6**	1	**8**	0	4	3
Grow rugged vegetation	0	**7**	**5**	2	**6**	2	0	**7**
Grow deep rooting crops	**7**	0	4	3	**6**	2	**7**	0
Use of light machinery	**5**	2	3	4	**5**	3	**7**	0
Use of perennials	1	**6**	4	3	**5**	3	0	**7**
Use of renewable energy	3	4	4	3	4	4	4	3
Use of water saving technologies/minimise irrigation	1	**6**	2	**5**	**6**	2	2	**5**
Water storage (e.g. through water buffers)	0	**7**	1	**6**	1	**7**	4	3
Use of compost tea	0	**7**	3	4	3	5	0	**7**
Use of effective microorganisms or mycorrhiza	2	**5**	4	3	4	4	3	4

France

Table A3.2 *Descriptive statistics of perceived barriers by regenerative farmers from France (FR) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Categories	Description barrier	France - FR (n=7)								
		Descriptives				Frequency (scale 1-5)				
		Avg.	Med.	Min.	Max.	1	2	3	4	5
Demographic	A lack of knowledge and awareness of regenerative agriculture	3.00	3	1	5	2	0	2	2	1
	A lack of willingness to change farm management or farm practices	3.86	5	1	5	1	1	0	1	4
	Regenerative agriculture is not in line with personal values	2.86	4	1	5	3	0	0	3	1
Social	A lack of knowledge and advice how to adopt practices	3.14	4	1	4	1	1	1	4	0
	Uncertainty about effectiveness of practices	3.86	4	2	5	0	1	1	3	2
	Lack of certification of RA practices and/or products	3.29	3	1	5	1	1	2	1	2
Technical	Lack of access to inputs needed for regenerative agriculture practices	1.71	1	1	3	4	1	2	0	0
	Lack of regenerative supply chains	1.71	1	1	3	4	1	2	0	0
	Lack of ‘regenerative alternatives’ to conventional techniques	3.14	4	1	4	1	1	1	4	0
Economic	Lack of market demand for products produced from regenerative agriculture	2.86	3	1	5	2	0	3	1	1
	High perceived risks on potential yield reduction	4.14	4	3	5	0	0	1	4	2
	Low prices for products produced with regenerative practices/not being able to secure price premiums	3.14	3	1	5	2	0	2	1	2
Political	Lack of enabling and supportive policies or legislation	3.00	3	1	5	1	2	1	2	1
	Lack of subsidies and support programmes for adopting or investing in regenerative practices	2.71	3	1	5	3	0	1	2	1
	Lack of trade facilitation (e.g. exporting products)	2.00	2	1	5	3	3	0	0	1

Table A3.3 *Descriptive statistics of perceived barriers by regenerative farmers from France (FR) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Categories	Description drivers	France – FR (n=7)								
		Descriptives				Frequency (count)				
		Avg.	Med.	Min.	Max.	1	2	3	4	5
Demographic	Living in close proximity to other regenerative farmers	4.00	4.00	2	5	0	1	1	2	3
	Personal values are supporting regenerative agriculture	4.00	4.00	2	5	0	1	0	4	2
	Having access to a farm cooperative or a network	4.29	4.00	3	5	0	0	1	3	3
Social	Being a pioneer in regenerative farming	2.00	2.00	1	4	2	4	0	1	0
	Feeling (socially) responsible for the environment	3.43	4.00	1	4	1	0	1	5	0
	Taking care of nature through working or farming. (e.g. through biodiversity improvement)	3.86	4.00	2	5	0	1	0	5	1
Technical	An increasing level of research and developments for regenerative agriculture	3.57	4.00	2	5	0	1	2	3	1
	Interest in technology for ecology (e.g. precision agriculture techniques, strip tilling)	3.57	3.00	3	5	0	0	4	2	1
	Farmers constructing homemade machines used for regenerative techniques or practices	3.14	3.00	1	5	1	1	2	2	1
Economic	Being able to supply to premium or niche markets	2.43	2.00	1	4	2	2	1	2	0
	Reduction of input costs	3.14	3.00	1	5	2	0	2	1	2
	Profitability or economic viability of regenerative agriculture	3.86	4.00	1	5	1	0	1	2	3
Political	Enabling and supportive policies or legislation	2.29	2.00	1	5	3	1	2	0	1
	Involvement in networks and projects that increase visibility of farmers	3.71	4.00	2	5	0	1	2	2	2
	Participation in eco-schemes	3.29	3.00	1	5	1	0	3	2	1

Table A3.4 *Descriptive statistics for behavioural beliefs, normative beliefs, and behavioural control related to transitioning to regenerative agriculture for France (FR) including minimum and maximum scale values, and average responses from the survey*

Behavioural beliefs	**France – FR (n=7)**			
	Lowest end scale (1)	**Highest end scale (5)**	**Average**	**Value (1-5)**
What is your general attitude toward regenerative farming practices? (e.g., cover cropping, no-till farming, rotational grazing)	Very negative	Very positive	Very positive	5.00
How do you perceive the impact of regenerative farming on the environment, soil health and biodiversity?	Very harmful	Very beneficial	Very beneficial	4.86
How do you perceive the impact of regenerative agriculture on crop yields?	Very negative	Very positive	Neutral	3.29
To what extent do you enjoy implementing regenerative farming practices on your farm?	Not at all	A lot	A lot	5.00
To what extent do you believe that implementing regenerative agriculture will result in negative outcomes?	Strongly disagree	Strongly agree	Neutral	2.71
How do you view the potential economic impact of regenerative agriculture on your farm?	Very negative	Very positive	Neutral	3.29
To what extent do you believe that regenerative agriculture activities have impact on slowing or even stopping climate change.	No extent	Great extent	Moderate extent	2.86
To what extent do you believe that regenerative agriculture can improve the resilience of your farm toward climate change? (heavy rain, long drought, temperature).	No extent	Great extent	Significant extent	4.14
Normative beliefs				
How much do you consider the opinions of agricultural advisors or experts when deciding to adopt regenerative farming practices?	Not at all	Very much	Somewhat	3.71
To what extent do you feel social pressure from peers, family, or the agricultural community to engage in regenerative farming?	Not at all	Very much	Not much	1.57
How important is the opinion of your family members in decisions making on your farm?	Not important at all	Very important	Slightly important	1.71
How important is the opinion of your family members in your decision to adopt regenerative agriculture?	Not important at all	Very important	Slightly important	1.71
Do you think other farmers in your community support the adoption of regenerative agriculture?	Strongly disagree	Strongly agree	Neutral	3.29
What do you believe is the public’s perception of farmers who adopt regenerative agriculture practices?	Very negative	Very positive	Positive	3.86
To what extent do you feel pressure from environmental organisations to implement regenerative agriculture?	No pressure	Very strong pressure	Little pressure	1.57
Behavioural control				
How much control do you feel you have over the implementations and developments of regenerative farming practices on your farm?	Not at all	A lot	Somewhat	4.29
To what extent do you have the resources (e.g., equipment, knowledge, labour) and skills necessary to engage in regenerative farming?	Not at all	A lot	Somewhat	4.71
How easy or difficult is it for you to adopt and maintain regenerative farming practices?	Very easy	Very difficult	Neutral	2.71
How confident are you in your ability to successfully implement regenerative agriculture practices?	Not confident at all	Very confident	Confident	3.71
How necessary do you think resources (e.g., knowledge, financial support, equipment) are for practicing regenerative agriculture?	Not necessary at all	Very necessary	Necessary	4.29
To what extent do you believe that external factors (e.g., weather, market conditions) will affect your ability to adopt regenerative agriculture?	No extent	Great extent	Moderate extent	3.14
How likely are you to continue engaging in regenerative farming practices in the next year?	Very unlikely	Very likely	Very likely	4.86
How likely are you to continue engaging in regenerative farming practices in the next 3 years?	Very unlikely	Very likely	Very likely	4.86

Germany

Table A3.5 *Descriptive statistics of perceived barriers by regenerative farmers from Germany (DE) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Categories	Description barrier	Germany – DE (n=7)								
		Descriptives				Frequency (count)				
		Avg.	**Med.**	**Min.**	**Max.**	**1**	**2**	**3**	**4**	**5**
Demographic	A lack of knowledge and awareness of regenerative agriculture	2.86	3	1	4	1	1	3	2	0
	A lack of willingness to change farm management or farm practices	2.00	2	1	5	3	3	0	0	1
	Regenerative agriculture is not in line with personal values	1.86	1	1	5	4	2	0	0	1
Social	A lack of knowledge and advice how to adopt practices	3.00	3	1	4	1	1	2	3	0
	Uncertainty about effectiveness of practices	3.00	3	1	5	1	2	1	2	1
	Lack of certification of RA practices and/or products	2.71	2	1	5	1	3	1	1	1
Technical	Lack of access to inputs needed for regenerative agriculture practices	1.71	2	1	2	2	5	0	0	0
	Lack of regenerative supply chains	3.14	3	1	5	2	0	2	1	2
	Lack of ‘regenerative alternatives’ to conventional techniques	1.71	1	1	3	4	1	2	0	0
Economic	Lack of market demand for products produced from regenerative agriculture	**3.43**	4	1	5	1	1	1	2	2
	High perceived risks on potential yield reduction	3.14	4	1	4	1	1	1	4	0
	Low prices for products produced with regenerative practices/not being able to secure price premiums	**3.57**	4	1	5	2	0	0	2	3
Political	Lack of enabling and supportive policies or legislation	**3.43**	4	1	5	2	0	1	1	3
	Lack of subsidies and support programmes for adopting or investing in regenerative practices	3.29	4	1	5	2	1	0	1	3
	Lack of trade facilitation (e.g. exporting products)	3.14		1	5	2	0	2	1	2

Table A3.6 *Descriptive statistics of perceived drivers by regenerative farmers from Germany (DE) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Category	Description drivers	Germany – DE (n=7)								
		Descriptives				Frequency (count)				
		Avg.	**Med.**	**Min.**	**Max.**	**1**	**2**	**3**	**4**	**5**
Demographic	Living in close proximity to other regenerative farmers	1.86	2	1	3	3	2	2	0	0
	Personal values are supporting regenerative agriculture	**4.57**	5	4	5	0	0	0	3	4
	Having access to a farm cooperative or a network	2.71	3	1	5	3	0	1	2	1
Social	Being a pioneer in regenerative farming	2.14	2	1	4	2	3	1	1	0
	Feeling (socially) responsible for the environment	4.71	5	4	5	0	0	0	2	5
	Taking care of nature through working or farming. (e.g. through biodiversity improvement)	**4.57**	5	4	5	0	0	0	3	4
Technical	An increasing level of research and developments for regenerative agriculture	4.00	5	1	5	1	0	1	1	4
	Interest in technology for ecology (e.g. precision agriculture techniques, strip tilling)	3.29	4	2	4	0	2	1	4	0
	Farmers constructing homemade machines used for regenerative techniques or practices	2.86	4	1	5	3	0	0	3	1
Economic	Being able to supply to premium or niche markets	3.00	3	1	5	1	0	5	0	1
	Reduction of input costs	3.14	4	1	5	2	0	1	3	1
	Profitability or economic viability of regenerative agriculture	**4.29**	4	3	5	0	0	1	3	3
Political	Enabling and supportive policies or legislation	3.57	4	1	5	1	0	2	2	2
	Involvement in networks and projects that increase visibility of farmers	3.29	4	1	4	1	0	2	4	0
	Participation in eco-schemes	2.57	3	1	5	3	0	2	1	1

Table A3.7 *Descriptive statistics for behavioural beliefs, normative beliefs, and behavioural control related to transitioning to regenerative agriculture for Germany (DE) including minimum and maximum scale values, and average responses from the survey*

Behavioural beliefs	**Germany – DE (n=7)**			
	Lowest end scale (1)	**Highest end scale (5)**	**Average**	**Value (1-5)**
What is your general attitude toward regenerative farming practices? (e.g., cover cropping, no-till farming, rotational grazing)	Very negative	Very positive	Positive	4
How do you perceive the impact of regenerative farming on the environment, soil health and biodiversity?	Very harmful	Very beneficial	Very beneficial	5
How do you perceive the impact of regenerative agriculture on crop yields?	Very negative	Very positive	Neutral	3
To what extent do you enjoy implementing regenerative farming practices on your farm?	Not at all	A lot	Somewhat	5
To what extent do you believe that implementing regenerative agriculture will result in negative outcomes?	Strongly disagree	Strongly agree	Disagree	2
How do you view the potential economic impact of regenerative agriculture on your farm?	Very negative	Very positive	Positive	4
To what extent do you believe that regenerative agriculture activities have impact on slowing or even stopping climate change.	No extent	Great extent	Significant extent	4
To what extent do you believe that regenerative agriculture can improve the resilience of your farm toward climate change? (heavy rain, long drought, temperature).	No extent	Great extent	Significant extent	4
Normative beliefs				
How much do you consider the opinions of agricultural advisors or experts when deciding to adopt regenerative farming practices?	Not at all	Very much	Neutral	3
To what extent do you feel social pressure from peers, family, or the agricultural community to engage in regenerative farming?	Not at all	Very much	Not much	2
How important is the opinion of your family members in decisions making on your farm?	Not important at all	Very important	Somewhat	4
How important is the opinion of your family members in your decision to adopt regenerative agriculture?	Not important at all	Very important	Moderately important	3
Do you think other farmers in your community support the adoption of regenerative agriculture?	Strongly disagree	Strongly agree	Neutral	3
What do you believe is the public's perception of farmers who adopt regenerative agriculture practices?	Very negative	Very positive	Positive	4
To what extent do you feel pressure from environmental organisations to implement regenerative agriculture?	No pressure	Very strong pressure	Little pressure	2
Behavioural control				
How much control do you feel you have over the implementations and developments of regenerative farming practices on your farm?	Not at all	A lot	Somewhat	4
To what extent do you have the resources (e.g., equipment, knowledge, labour) and skills necessary to engage in regenerative farming?	Not at all	A lot	Somewhat	4
How easy or difficult is it for you to adopt and maintain regenerative farming practices?	Very easy	Very difficult	Neutral	3
How confident are you in your ability to successfully implement regenerative agriculture practices?	Not confident at all	Very confident	Moderately confident	3
How necessary do you think resources (e.g., knowledge, financial support, equipment) are for practicing regenerative agriculture?	Not necessary at all	Very necessary	Necessary	4
To what extent do you believe that external factors (e.g., weather, market conditions) will affect your ability to adopt regenerative agriculture?	No extent	Great extent	Moderate extent	3
How likely are you to continue engaging in regenerative farming practices in the next year?	Very unlikely	Very likely	Very likely	5
How likely are you to continue engaging in regenerative farming practices in the next 3 years?	Very unlikely	Very likely	Very likely	5

Hungary

Table A3.8 *Descriptive statistics of perceived drivers by regenerative farmers from Hungary (HU) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Categories	Description barrier	Hungary – HU (n=8)								
		Descriptives				Frequency (count)				
		Avg.	Med.	Min.	Max.	1	2	3	4	5
Demographic	A lack of knowledge and awareness of regenerative agriculture	3.00	4	1	5	3	0	0	3	2
	A lack of willingness to change farm management or farm practices	1.57	5	4	5	0	0	0	2	6
	Regenerative agriculture is not in line with personal values	1.57	3	1	3	3	0	5	0	0
Social	A lack of knowledge and advice how to adopt practices	2.00	5	3	5	0	0	1	1	6
	Uncertainty about effectiveness of practices	2.71	5	4	5	0	0	0	2	6
	Lack of certification of RA practices and/or products	1.86	5	4	5	0	0	0	2	6
Technical	Lack of access to inputs needed for regenerative agriculture practices	1.00	4	3	5	0	0	1	4	3
	Lack of regenerative supply chains	2.14	5	3	5	0	0	1	1	6
	Lack of ‘regenerative alternatives’ to conventional techniques	3.00	1	1	4	4	0	1	3	0
Economic	Lack of market demand for products produced from regenerative agriculture	2.29	3	1	5	2	1	3	1	1
	High perceived risks on potential yield reduction	1.86	5	3	5	0	0	2	0	6
	Low prices for products produced with regenerative practices/not being able to secure price premiums	1.43	5	3	5	0	0	1	1	6
Political	Lack of enabling and supportive policies or legislation	2.43	3	3	5	1	0	4	0	3
	Lack of subsidies and support programmes for adopting or investing in regenerative practices	2.57	3	1	5	2	0	3	0	3
	Lack of trade facilitation (e.g. exporting products)	2.14	4	3	5	0	1	3	3	1

Table A3.9 *Descriptive statistics of perceived drivers by regenerative farmers from Hungary (HU) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Categories	Description drivers	Hungary – HU (n=8)								
		Descriptives				Frequency (count)				
		Avg.	Med.	Min.	Max.	1	2	3	4	5
Demographic	Living in close proximity to other regenerative farmers	3.43	4	1	5	3	0	0	3	2
	Personal values are supporting regenerative agriculture	4.71	5	4	5	0	0	0	2	6
	Having access to a farm cooperative or a network	2.43	3	1	3	3	0	5	0	0
Social	Being a pioneer in regenerative farming	4.57	5	3	5	0	0	1	1	6
	Feeling (socially) responsible for the environment	4.71	5	4	5	0	0	0	2	6
	Taking care of nature through working or farming. (e.g. through biodiversity improvement)	4.71	5	4	5	0	0	0	2	6
Technical	An increasing level of research and developments for regenerative agriculture	4.14	4	3	5	0	0	1	4	3
	Interest in technology for ecology (e.g. precision agriculture techniques, strip tilling)	4.57	5	3	5	0	0	1	1	6
	Farmers constructing homemade machines used for regenerative techniques or practices	2.14	1	1	4	4	0	1	3	0
Economic	Being able to supply to premium or niche markets	3.00	3	1	5	2	1	3	1	1
	Reduction of input costs	4.43	5	3	5	0	0	2	0	6
	Profitability or economic viability of regenerative agriculture	4.71	5	3	5	0	0	1	1	6
Political	Enabling and supportive policies or legislation	3.86	3	3	5	1	0	4	0	3
	Involvement in networks and projects that increase visibility of farmers	3.29	3	1	5	2	0	3	0	3
	Participation in eco-schemes	3.71	4	3	5	0	1	3	3	1

Table A3.10 *Descriptive statistics for behavioural beliefs, normative beliefs, and behavioural control related to transitioning to regenerative agriculture for Hungary (HU) including minimum and maximum scale values, and average responses from the questionnaire*

Behavioural beliefs	**Hungary – HU (n=8)**			
	Lowest end scale (1)	**Highest end scale (5)**	**Average**	**Value (1-5)**
What is your general attitude toward regenerative farming practices? (e.g., cover cropping, no-till farming, rotational grazing)	Very negative	Very positive	Very positive	5
How do you perceive the impact of regenerative farming on the environment, soil health and biodiversity?	Very harmful	Very beneficial	Very beneficial	5
How do you perceive the impact of regenerative agriculture on crop yields?	Very negative	Very positive	Neutral	3
To what extent do you enjoy implementing regenerative farming practices on your farm?	Not at all	A lot	A lot	5
To what extent do you believe that implementing regenerative agriculture will result in negative outcomes?	Strongly disagree	Strongly agree	Neutral	3
How do you view the potential economic impact of regenerative agriculture on your farm?	Very negative	Very positive	Positive	4
To what extent do you believe that regenerative agriculture activities have impact on slowing or even stopping climate change.	No extent	Great extent	Significant extent	4
To what extent do you believe that regenerative agriculture can improve the resilience of your farm toward climate change? (heavy rain, long drought, temperature).	No extent	Great extent	Significant extent	4
Normative beliefs				
How much do you consider the opinions of agricultural advisors or experts when deciding to adopt regenerative farming practices?	Not at all	Very much	Somewhat	4
To what extent do you feel social pressure from peers, family, or the agricultural community to engage in regenerative farming?	Not at all	Very much	Not much	2
How important is the opinion of your family members in decisions making on your farm?	Not important at all	Very important	Slightly important	2
How important is the opinion of your family members in your decision to adopt regenerative agriculture?	Not important at all	Very important	Slightly important	2
Do you think other farmers in your community support the adoption of regenerative agriculture?	Strongly disagree	Strongly agree	Neutral	3
What do you believe is the public's perception of farmers who adopt regenerative agriculture practices?	Very negative	Very positive	Positive	4
To what extent do you feel pressure from environmental organisations to implement regenerative agriculture?	No pressure	Very strong pressure	Little pressure	2
Behavioural control				
How much control do you feel you have over the implementations and developments of regenerative farming practices on your farm?	Not at all	A lot	Somewhat	4
To what extent do you have the resources (e.g., equipment, knowledge, labour) and skills necessary to engage in regenerative farming?	Not at all	A lot	Somewhat	4
How easy or difficult is it for you to adopt and maintain regenerative farming practices?	Very easy	Very difficult	Easy	2
How confident are you in your ability to successfully implement regenerative agriculture practices?	Not confident at all	Very confident	Very confident	5
How necessary do you think resources (e.g., knowledge, financial support, equipment) are for practicing regenerative agriculture?	Not necessary at all	Very necessary	n.a.	n.a.
To what extent do you believe that external factors (e.g., weather, market conditions) will affect your ability to adopt regenerative agriculture?	No extent	Great extent	n.a.	n.a.
How likely are you to continue engaging in regenerative farming practices in the next year?	Very unlikely	Very likely	Very likely	5
How likely are you to continue engaging in regenerative farming practices in the next 3 years?	Very unlikely	Very likely	Very likely	5

Poland

Table A3.11 *Descriptive statistics of perceived barriers by regenerative farmers from Poland (PL) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

Categories	**Description barrier**	**Poland - PL (n=7)**								
		Descriptives				**Frequency (scale 1-5)**				
		Avg.	**Med.**	**Min.**	**Max.**	**1**	**2**	**3**	**4**	**5**
Demographic	A lack of knowledge and awareness of regenerative agriculture	3.14	4	1	5	3	0	0	1	3
	A lack of willingness to change farm management or farm practices	3.00	4	1	5	3	0	0	2	2
	Regenerative agriculture is not in line with personal values	2.71	3	1	5	3	0	2	0	2
Social	A lack of knowledge and advice how to adopt practices	3.00	3	1	5	3	0	1	0	3
	Uncertainty about effectiveness of practices	3.00	3	1	5	2	1	1	1	2
	Lack of certification of RA practices and/or products	3.71	5	1	5	2	0	0	1	4
Technical	Lack of access to inputs needed for regenerative agriculture practices	2.86	2	1	5	3	1	0	0	3
	Lack of regenerative supply chains	3.14	4	1	5	3	0	0	1	3
	Lack of 'regenerative alternatives' to conventional techniques	3.43	3	1	5	1	1	2	0	3
Economic	Lack of market demand for products produced from regenerative agriculture	3.71	5	1	5	2	0	0	1	4
	High perceived risks on potential yield reduction	2.86	3	1	5	2	1	2	0	2
	Low prices for products produced with regenerative practices/not being able to secure price premiums	4.00	5	1	5	1	0	1	1	4
Political	Lack of enabling and supportive policies or legislation	3.57	4	1	5	1	0	2	2	2
	Lack of subsidies and support programmes for adopting or investing in regenerative practices	3.71	4	2	5	0	2	1	1	3
	Lack of trade facilitation (e.g. exporting products)	3.71	5	1	5	2	0	0	1	4

Table A3.12 *Descriptive statistics of perceived drivers by regenerative farmers from Poland (PL) in transitioning to regenerative agriculture, including average, median, minimum, maximum, and frequency of responses*

	Description drivers	**Poland - PL (n=7)**								
		Descriptives				**Frequency (scale 1-5)**				
		Avg.	**Med.**	**Min.**	**Max.**	**1**	**2**	**3**	**4**	**5**
Demographic	Living in close proximity to other regenerative farmers	2.57	3	1	4	2	0	4	1	0
	Personal values are supporting regenerative agriculture	4.14	5	1	5	1	0	1	0	5
	Having access to a farm cooperative or a network	2.43	1	1	5	4	0	0	2	1
Social	Being a pioneer in regenerative farming	3.29	4	1	5	2	0	1	2	2
	Feeling (socially) responsible for the environment	4.43	5	3	5	0	0	1	2	4
	Taking care of nature through working or farming. (e.g. through biodiversity improvement)	4.29	5	3	5	0	0	2	1	4
Technical	An increasing level of research and developments for regenerative agriculture	3.29	4	1	5	1	1	1	3	1
	Interest in technology for ecology (e.g. precision agriculture techniques, strip tilling)	3.71	5	1	5	2	0	0	1	4
	Farmers constructing homemade machines used for regenerative techniques or practices	2.71	3	1	5	3	0	1	2	1
Economic	Being able to supply to premium or niche markets	3.86	5	1	5	2	0	0	0	5
	Reduction of input costs	4.00	4	1	5	1	0	0	3	3
	Profitability or economic viability of regenerative agriculture	3.43	4	2	5	0	3	0	2	2
Political	Enabling and supportive policies or legislation	2.57	2	1	5	3	1	1	0	2
	Involvement in networks and projects that increase visibility of farmers	2.00	1	1	5	4	1	1	0	1
	Participation in eco-schemes	3.29	3	1	5	1	0	3	2	1

Table A3.13 *Descriptive statistics for behavioural beliefs, normative beliefs, and behavioural control related to transitioning to regenerative agriculture for Poland (PL) including minimum and maximum scale values, and average responses from the survey*

Behavioural beliefs	**Poland - PL (n=7)**			
	Lowest end scale (1)	**Highest end scale (5)**	**Average**	**Value (1-5)**
What is your general attitude toward regenerative farming practices? (e.g., cover cropping, no-till farming, rotational grazing)	Very negative	Very positive	Very positive	5
How do you perceive the impact of regenerative farming on the environment, soil health and biodiversity?	Very harmful	Very beneficial	Very beneficial	5
How do you perceive the impact of regenerative agriculture on crop yields?	Very negative	Very positive	Positive	4
To what extent do you enjoy implementing regenerative farming practices on your farm?	Not at all	A lot	Somewhat	4
To what extent do you believe that implementing regenerative agriculture will result in negative outcomes?	Strongly disagree	Strongly agree	Disagree	2
How do you view the potential economic impact of regenerative agriculture on your farm?	Very negative	Very positive	Positive	4
Normative beliefs				
How much do you consider the opinions of agricultural advisors or experts when deciding to adopt regenerative farming practices?	Not at all	Very much	Somewhat	4
To what extent do you feel social pressure from peers, family, or the agricultural community to engage in regenerative farming?	Not at all	Very much	Not much	2
How important is the opinion of your family members in decisions making on your farm?	Not important at all	Very important	Moderately important	3
How important is the opinion of your family members in your decision to adopt regenerative agriculture?	Not important at all	Very important	Moderately important	3
Do you think other farmers in your community support the adoption of regenerative agriculture?	Strongly disagree	Strongly agree	Neutral	3
What do you believe is the public's perception of farmers who adopt regenerative agriculture practices?	Very negative	Very positive	Neutral	3
To what extent do you feel pressure from environmental organisations to implement regenerative agriculture?	No pressure	Very strong pressure	Little pressure	2
To what extent do you believe that regenerative agriculture activities have impact on slowing or even stopping climate change.	No extent	Great extent	Moderate extent	3
To what extent do you believe that regenerative agriculture can improve the resilience of your farm toward climate change? (heavy rain, long drought, temperature).	No extent	Great extent	Great extent	5
Behavioural control				
How much control do you feel you have over the implementations and developments of regenerative farming practices on your farm?	Not at all	A lot	Somewhat	4
To what extent do you have the resources (e.g., equipment, knowledge, labour) and skills necessary to engage in regenerative farming?	Not at all	A lot	A lot	5
How easy or difficult is it for you to adopt and maintain regenerative farming practices?	Very easy	Very difficult	Neutral	3
How confident are you in your ability to successfully implement regenerative agriculture practices?	Not confident at all	Very confident	Confident	4
How necessary do you think resources (e.g., knowledge, financial support, equipment) are for practicing regenerative agriculture?	Not necessary at all	Very necessary	Moderately necessary	3
To what extent do you believe that external factors (e.g., weather, market conditions) will affect your ability to adopt regenerative agriculture?	No extent	Great extent	Moderate extent	3
How likely are you to continue engaging in regenerative farming practices in the next year?	Very unlikely	Very likely	Very likely	5
How likely are you to continue engaging in regenerative farming practices in the next 3 years?	Very unlikely	Very likely	Likely	4

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To explore the potential of nature to improve the quality of life

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