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1 *SURE-Farm Approach to Assess the Resilience of European Farming Systems*

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Resilience is a latent property of a system.

The concept denotes a potential which is activated – and can be observed – only when a system is hit by stress or shocks.

It can thus be understood by learning from past trajectories and discussing future scenarios, and from assessing how actual shocks are dealt with.

(Meuwissen et al., 2021)

1.1 The Resilience Challenge for Europe's Farming Systems

Farming systems in Europe face accumulating economic, environmental, institutional, and social challenges. Examples include the impact of extreme weather events, reduced access to markets and value chains (e.g. due to trade wars, political boycotts or Brexit), less stable and less protective policy environments, increasing controversies about agricultural mainstream practices, and more recently the interruptions caused by the COVID-19 pandemic. These uncertainties exacerbate demographic issues such as a lack of successors to enable generational renewal at the farm level, and insufficient availability of qualified seasonal and permanent labour (Pitson et al., 2020). The compounding challenges raise concerns about the resilience of Europe's farming systems.

The ability of farming systems to cope with challenges can be conceptualized as resilience (Folke, 2016). Resilience theory emphasizes change, uncertainty, and the capacity of systems to adapt (Holling et al., 2002). Several resilience frameworks had already been developed and applied to systems at levels below or above the farming system, such as farms (e.g. Darnhofer, 2014), food supply chains (Stone and

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Rahimifard, 2018) and socio-ecological systems (Walker et al., 2004). These frameworks provide useful insights into capacities and attributes that enhance or constrain resilience. However, it was still unclear how these and other attributes were to be assessed at the level of farming systems, where farmers compete and collaborate, interact with non-farm neighbours, contribute to variegated value chains and cooperate across sectors. How farming systems are expected to deliver their various functions differs across places and changes over time in response to inter alia changing consumer and societal preferences. Against this background we developed the SURE-Farm[1] approach. This approach consists of the SURE-Farm framework (Meuwissen et al., 2019) and the systematic consideration of regional contexts, the collaboration of multiple disciplines and the deployment of mixed methods. Each component of the approach is elaborated below.

1.2 The SURE-Farm Resilience Framework

In developing the SURE-Farm resilience framework (Meuwissen et al., 2019), we built on the social-ecological tradition of resilience thinking (Holling et al., 2002; Walker and Salt, 2006; Folke, 2016) and defined the resilience of a farming system as *its ability to ensure the provision of its desired functions in the face of often complex and accumulating economic, social, environmental and institutional shocks and stresses, through capacities of robustness, adaptability and transformability* (Meuwissen et al., 2019). In addition, we referred to insights from the Resilience Alliance (2010) that the resilience of a system is affected by its specific characteristics, i.e. the system's resilience attributes. This is brought together in the SURE-Farm resilience framework (Figure 1.1). The framework is designed to assess resilience to known and specific challenges such as extreme weather events (*specified resilience*) as well as a farming system's capacity to deal with the unknown, uncertain and surprise (*general resilience*). Due to the complex multifaceted nature of resilience, the framework suggests to follow five analytical steps with guiding questions: (1) characterization of the farming system – resilience of what, (2) identification of challenges – resilience to what, (3) analysis of system functions – resilience for what purpose, (4) evaluation of system responses – what resilience

[1] Towards SUstainable and REsilient EU-FARMing systems (SURE-Farm).

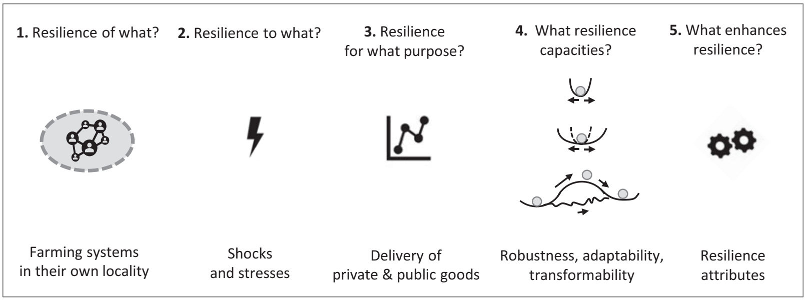

Figure 1.1 The five steps of the SURE-Farm resilience framework (Meuwissen et al., 2019).

capacities, and (5) examination of resilience attributes – what enhances resilience.

The first step of the framework (*resilience of what*) addresses the identification of farming systems in their own locality. A farming system consists of farmers producing (main) product(s) of interest, e.g. fruits and vegetables, and the regional context, e.g. the Mazovian region in Poland. Not all farms in a region are necessarily part of the same farming system, i.e. there may be several farming systems in one region which focus on different products. Besides farmers, further actors, including other members of the supply chain and local institutions, belong to the farming system. The other farming system actors are identified based on patterns of influence; farms and other farming system actors mutually influence each other. Because farming systems work in open agro-ecological systems and are linked to various social networks, value chains, economic processes and ecological systems, their activities can have multiple effects, e.g. through job and income creation, network effects, resource use, landscape impacts and emissions (see Step 3). These external effects and public goods also characterize the farming system. While the framework focuses on the farming system level, analyses include nested levels, such as the household, farm and farmer level, the farming system and higher levels which form the context of the farming system, such as national regulations; societal, economic and environmental macro-trends; or transnational flows of goods and services. This reflects the open character of farming systems.

The second step of the framework (*resilience to what*) identifies shocks and stresses that affect the farming system. We consider economic, environmental, social and institutional challenges that could

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impede the ability of the farming system to deliver the desired public and private goods. Stresses develop with gradual changes of the system's environment, such as the steady diffusion of pests and diseases, ageing of rural populations or changing consumer preferences. Looking back at historic trajectories, also shocks which were unknown, unexpected and unimagined at that moment can be assessed. For instance, the SURE-Farm approach was used to assess the impact of COVID-19 and to understand how and why systems were able to cope (Meuwissen et al., 2021).

The third step (*resilience for what purpose*) addresses the desired functions of the farming system. Farming systems' functions can be divided into the provision of private and public goods (Table 1.1). Private goods include the production of food and other bio-based resources, but also ensuring a reasonable livelihood and quality of life for people involved in farming. Public goods include maintaining natural resources and biodiversity in good condition, animal welfare

Table 1.1. ***Typology of farming system functions in SURE-Farm (Meuwissen et al., 2019)***

	Short name
Private goods	
Deliver healthy and affordable food products	Food production
Deliver other bio-based resources for the processing sector	Bio-based resources
Ensure economic viability (viable farms help to strengthen the economy and contribute to balanced territorial development)	Economic viability
Improve quality of life in rural areas by providing employment and offering decent working conditions	Quality of life
Public goods	
Maintain natural resources in good condition (water, soil, air)	Natural resources
Protect biodiversity of habitats, genes and species	Biodiversity and habitat
Ensure that rural areas are attractive places for residence and tourism (countryside, social structures)	Attractiveness of the area
Ensure animal health and welfare	Animal health and welfare

and ensuring that rural areas are attractive places for residence and tourism. Farming systems generally provide multiple functions. Performance and importance of each function can be represented by one or more indicators.

In the fourth step (*what resilience capacities*) we distinguish three resilience capacities: robustness, adaptability and transformability. Robustness is the coping capacity of a farming system, i.e. its capacity to withstand stresses and (un)anticipated shocks. Adaptability is the capacity to change the composition of inputs, production, marketing and risk management in response to shocks and stresses but without changing the structures and feedback mechanisms of the farming system. Transformability is the capacity to significantly change the internal structure and feedback mechanisms of the farming system into a desired direction in response to either severe shocks or enduring stress that make business as usual impossible. The distinction between three resilience capacities (robustness, adaptability, transformability) ensures that the framework goes beyond narrow definitions that limit resilience to robustness. Furthermore, it highlights the importance of middle- and long-term analysis and strategies, as adaptation and especially transformation take time.

The fifth step of the framework (*what enhances resilience*) assesses the resilience-enhancing attributes defined as those system and enabling environment characteristics that contribute to resilience. We modified the list of Cabell and Oelofse (2012) as described by Paas et al. (2021a). Attributes are listed in Table 1.2. Most attributes relate to characteristics of the farming systems, such as 'reasonably profitable' (attribute 1) and 'optimally redundant farms' (attribute 7), while other attributes illustrate the role of the enabling environment. For instance, actors and institutions in the enabling environment can support the provision of functions as in attribute 8 ('supports rural life'), stimulate resilience capacities through 'diverse policies' (attribute 13) or invest resources, e.g. through 'reflective and shared learning' (attribute 20).

1.3 The Relevance of Regional Context

The resilience of farming systems must be understood in the regional context. Each farming system has co-evolved with a specific social-ecological environment. The activities of the different actors which constitute a farming system – e.g. farms, farmers' organizations, service

Table 1.2. ***Resilience attributes in the SURE-Farm framework and short explanation of each attribute (based on Reidsma et al., 2020 and Paas et al., 2021a)***[1]

Resilience attributes[2]	Explanation
1. Reasonable profitability[a1]	Farmers and farm workers earn a livable wage while not depending heavily on subsidies.
2. Production coupled with local and natural capital[a2,b]	Soil fertility, water resources and existing nature are maintained well.
3. Functional diversity[c]	There is a high variety of inputs, outputs, income sources and markets.
4. Response diversity[c]	There is a high diversity of risk management strategies, e.g. different types of pest control, weather insurance, flexible payment arrangements.
5. Exposure to disturbance[d]	The amount of year-to-year economic, environmental, social or institutional disturbance is small in order to timely adapt to a changing environment.
6. Spatial and temporal heterogeneity of farm types[c,e]	There is a high diversity of farm types with regard to economic size, intensity, orientation and degree of specialization.
7. Redundancy between farms[e]	Farmers can stop without endangering continuation of the farming system and new farmers can enter the farming system easily.
8. Support of rural life[a3]	Rural life is supported by the presence of people from all generations, and also supported by enough facilities in the nearby area (e.g. supermarkets, hospital).
9. Social self-organization[a3,b]	Farmers are able to organize themselves into networks and institutions such as cooperatives, community associations, advisory networks and clusters with the processing industry.
10. Appropriate connectedness with actors outside the farming system[b]	Farmers and other actors in the farming system are able to reach out to policy makers, suppliers and markets that operate at the national and EU level.

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Table 1.2. (*cont.*)

Resilience attributes[2]	Explanation
11. Legislation coupled with local and natural capital[a3]	Norms, legislation and regulatory frameworks are well adapted to the local conditions.
12. Infrastructure for innovation[a,d]	Existing infrastructure facilitates knowledge and adoption of cutting-edge technologies (e.g. digital).
13. Diverse policies[c]	Policies stimulate all three capacities of resilience, i.e. robustness, adaptability, transformability.
14. Ecological self-regulation[b]	Farms maintain plant cover and incorporate more perennials, provide habitat for predators, use ecosystem engineers and align production with local ecological parameters.
15. Redundancy of crops[e]	Planting multiple varieties per crop rather than one; keeping equipment for various crops.
16. Redundancy of nutrients and water[e]	Getting nutrients and water from multiple sources.
17. Redundancy of labour[e]	Labour comes from multiple sources.
18. Spatial and temporal heterogeneity (land use)[c,e]	Diverse land use on the farm and across the landscape; mosaic pattern of managed and unmanaged land; diverse cultivation practices; crop rotations.
19. Global autonomy and local interdependence[d]	Less reliance on commodity markets and reduced external inputs, more sales to local markets, reliance on local resources, existence of farmer cooperatives, close relationships between producers and consumers, shared resources such as equipment
20. Reflectivity and shared learning[d]	Extension and advisory services for farmers; collaboration between universities, research centres, and farmers; cooperation and knowledge sharing between farmers; record keeping; baseline knowledge about the state of the agroecosystem.

Table 1.2. (*cont.*)

Resilience attributes[2]	Explanation
21. Honoured legacy[b,a3]	Maintenance of old varieties and engagement of elders; incorporation of traditional cultivation techniques with modern knowledge.
22. Building up of human capital[a3]	Investment in infrastructure and institutions for the education of children and adults; support for social events in farming communities; programs for preservation of local knowledge.

[1] Attributes 1–13 were central in most of the SURE-Farm analyses; attributes 14–22 were used in the assessment of resilience in the future (Chapter 17).
[2] Superscripts indicate links with the general resilience attributes (Resilience Alliance, 2010), i.e. a: system reserves (a1: economic capital, a2: natural capital, a3: social capital); b: tightness of feedbacks; c: diversity; d: openness; e: modularity. General resilience attributes are reported in the annexes of the case study chapters (Chapters 6–16).

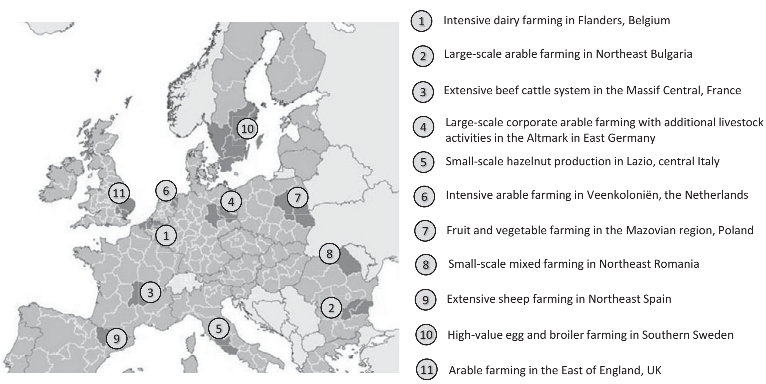

Figure 1.2 The eleven farming systems included in the SURE-Farm assessments.

suppliers and supply chain actors – are enabled by regional environments and deliver the specific functions of the farming system, in particular agricultural products and public goods. The SURE-Farm approach was applied to eleven farming systems which represent different challenges, farm types, agro-ecological zones, products and public goods (Figure 1.2).

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1.4 Involvement of Multiple Disciplines

Resilience is a multi-faceted concept and thus requires the involvement of multiple disciplines. We assessed adaptive cycle processes of risk management, farm demographics (including the availability of labour), governance with a focus on EU and local policies, and agricultural practices (Figure 1.3). These are the main processes informing the operational, tactical and strategic decisions on farms (Kay et al., 2016).

The concept of adaptive cycles originates in ecological systems thinking, where they represent different stages (growth, conservation, collapse, reorganization) through which systems might pass in response to changing environments and internal dynamics (Holling et al., 2002). Farming systems and their key processes differ from ecological systems in their production purpose and deliberate attempts to control their environment and to escape collapse. When applied to farming systems, the concept of adaptive cycles therefore serves not as a model but as a heuristic that guides the attention to system change (Meuwissen et al., 2019).

1.5 Mixed Methods

To obtain insights from the five steps of the framework, the SURE-Farm approach deploys mixed methods: qualitative methods, such as

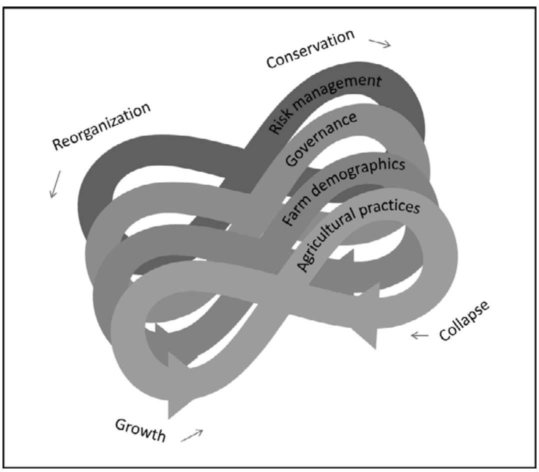

Figure 1.3 Resilience assessment requires knowledge from multiple disciplines.

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interviews, participatory approaches and stakeholder workshops access experiential and contextual knowledge and provide holistic and nuanced insights; while quantitative methods, such as statistics and modelling, are used to identify underlying patterns and likely contributing factors, and focus more on specific challenges, functions and attributes. In total, we designed twenty-one different methods: fourteen qualitative methods and seven quantitative methods (Table 1.3). The methods address the level of farming systems, or the farm or household level (see first column for a specification per method). With regard to the qualitative methods, resource-intensive methods, such as the narrative interviews (method 4) and the co-design of policy options (method 10) were applied to fewer farming systems and had a lower number of total participants than some of the other qualitative methods. The highest number of participants was achieved with the farmer surveys, which included a total number of 996 farmers across farming systems.

Addressing the guiding questions of the framework requires an integration of very different perspectives and types of information. Methodologically, SURE-Farm therefore embraces a pragmatic eclecticism, i.e. a practical combination of methods rooted in different theoretical traditions, to arrive at a holistic and epistemologically robust assessment of the farming systems' state of resilience and resilience dynamics. Multiple methods are linked to each step of the SURE-Farm framework (Table 1.3). Some methods address all steps, such as the qualitative and quantitative system dynamics (methods 12 and 17, respectively) and the workshops on current resilience (method 7) and resilience in the future (method 11), while other methods focus on specific steps of the framework.

Farming system actors (Step 1) were identified based on patterns of influence, with mutual influence defining a farming system actor. In the narrative analysis, patterns of influence were assessed from the farmers' perspective. In the other methods, system actors were elicited through assessments in groups of stakeholders. With regard to the identification of challenges (Step 2), scenarios built on the Shared Socio-economic Pathways for European agriculture (Mitter et al., 2020). Other methods identified challenges by checking for structured predefined lists of challenges (e.g. in surveys and digital co-creation platforms), or they identified challenges inductively from open story-telling (narrative interviews) or semi-structured expert interviews (e.g. with members of farm households).

Table 1.3. ***Methods employed in the SURE-Farm assessments, number of farming systems (FS) considered and steps of the framework covered***

Method[1,2]	No. of FS (and total no. of participants)	Steps of the SURE-Farm framework covered[3]				
		1	2	3	4[4]	5[5]
Qualitative methods						
1. Scenarios linked to Eur-Agri-SSPs[6]	–		X	X		
2. Survey (F)	11 (996)		X	X	X[a]1	X[b]
3. Learning interviews (F)	11 (130)		X	X	X[b]1	X[b]
4. Narratives (F)	5 (46)	X	X		X[b]1	
5. Interviews with households (F, HH)	11 (169)		X	X	X[b]1	X[b]
6. Focus groups on risk management (FS)	11 (78)	X	X		X[a]2	
7. Workshops on current resilience (FS)[7]	11 (184)	X	X	X	X[a]3,[b]1,[b]2	X[a]
8. Assessment of policy instruments (FS)	11 (56)	X	X	X	X[a]2	
9. Bottom-up analysis of policy (FS)	5 (135)		X	X	X[b]1	X[b]
10. Co-design of policy options (FS)	7 (71)		X		X[b]1	X[b]
11. Workshops on resilience in future (FS)[7]	9 (130)	X	X	X	X[b]2,[b]3	X[b]
12. Qualitative system dynamics (FS)	5	X	X	X	X[b]1	X[b]
13. Digital co-creation platform (F, FS)	– (27)	X	X	X	X[a]2,[a]3,[b]1,[b]2	X[a]
14. Workshops on the enabling environment	11 (tbd)	X	X	X	X[b]1	X[b]
Quantitative methods						
15. Data analysis of ecosystem services (FS)	10			X		X[c]
16. Modelling of ecosystem services (FS)	11		X	X	X[c]1	
17. Quantitative system dynamics (FS)	2	X	X	X	X[b]1	X[b]
18. Statistical analysis of capacities (F)	Europe				X[c]1,[c]2	X[b]

Table 1.3. (*cont.*)

		Steps of the SURE-Farm framework covered[3]				
Method[1,2]	No. of FS (and total no. of participants)	1	2	3	4[4]	5[5]
19. Statistical analysis of functions (F)	1		X	X	X^{b}2	X^{b}
20. Simulation of structural change (FS)	2	X	X	X	X^{b}2,^{c}1	X^{b}
21. Economic modelling of risk management (F)	1		X	X	X^{b}1	

[1] For qualitative methods, brackets indicate type of actors involved: farmers (F), other household members (HH) and multiple farming system actors (FS). For quantitative methods, brackets indicate level of analysis, i.e. at the level of farming systems (FS) or farms (F).

[2] Details of methods are described in 1: Mathijs et al. (2018); 2: Spiegel et al. (2021); 3: Urquhart et al. (2021); 4: Nicholas-Davies et al. (2021); 5: Coopmans et al. (2019); 6: Soriano et al. (2021); 7: Paas et al. (2021a); 8: Termeer et al. (2018); Buitenhuis et al. (2020a); 9: Buitenhuis et al. (2019); 10: Buitenhuis et al. (2020b); 11: Paas et al. (2021b); 12: Herrera et al. (2018) and Reidsma et al. (2020); 13: Soriano et al. (2020); 14: Wauters et al. (2021); 15: Reidsma et al. (2019); 16/17: Accatino et al. (2020); 18: Slijper et al. (2021); 19: Paas et al. (2021c); 20: Pitson et al. (2019); 21: Zinnanti et al. (2019).

[3] The steps of the framework are 1: resilience of what, 2: resilience to what, 3: resilience for what purpose, 4: what resilience capacities, and 5: what enhances resilience. An 'X' indicates that the step was included in the method.

[4] Resilience capacities were assessed through a: *measurement of perceived capacities* with a1: current capacities and capacities to deal with expected challenges over the next five and twenty years; a2: contribution of instruments to the capacities; a3: the contribution of attributes to the capacities; b *inferring capacities* from b1: responses and strategies used by FS actors and the enabling environment to enhance resilience; b2: performance of functions, including whether critical thresholds are passed; b3: requirements for resilience attributes, strategies and enabling conditions to realize more sustainable and resilient systems in 2030; c: *statistical analysis and simulation* of c1: past and simulated robustness; c2: past adaptations and transformations.

[5] Performance of resilience attributes was assessed through a: *measurement of perceived performance* of attributes; b: *inferring performance of attributes* from responses and strategies used to deal with challenges; c: *calculated performance* (in method 15 specified to the attribute of diversity).

[6] Shared Socio-economic Pathways for European agriculture.

[7] Chapters refer to the participatory workshops on current resilience and resilience in the future as FoPIA-SURE-Farm 1 and FoPIA-SURE-Farm 2, respectively.

In the statistical analysis of functions, challenges were derived from, e.g., weather data. Some methods also built on information derived from other methods. For instance, the focus groups on risk management and the workshops on current resilience used challenges identified from the survey as a starting point, and the workshops on resilience in the future built on findings from the workshops on current resilience and used information from the scenarios. The importance of functions (Step 3) was identified through stakeholders weighing predefined private and public goods in surveys, workshops on current resilience and through a digital co-creation platform. The performance and trends of functions were assessed through scoring exercises to elicit stakeholder assessments in the workshops on current resilience, and from existing ecosystem and economic data, such as the analysis of ecosystem services and the statistical analysis of farm income.

Resilience capacities (Step 4) were assessed through the measurement of perceived current capacities and perceived capacities to deal with expected challenges over the next five and twenty years, and through perceived contributions from risk management and policy instruments to resilience capacities. In addition, insights into, among others, past responses and strategies used by farming system actors to enhance resilience and requirements for strategies and enabling conditions to realize more sustainable and resilient systems in 2030 were used to infer capacities. In the quantitative methods, we also used statistics and simulation to inform about capacities (e.g. quick farm income recovery rates indicate robustness). Similarly, performance of resilience attributes (Step 5) was assessed through measurement of their perceived performance, inferring performance from responses and strategies used to deal with challenges, and from calculations (see superscripts in Table 1.3).

1.6 Outline of the Book

Building on the systematic steps of the SURE-Farm framework, this book first presents findings on four key processes that affect the resilience of farming systems (Figure 1.3), i.e. risk management (Chapter 2), farm demographics (Chapter 3), governance (Chapter 4) and agricultural practices (Chapter 5). Findings are substantiated through a combination of methods and measurement approaches and build on results from multiple farming systems and their nested levels. For each process, the authors identify pathways to enhance resilience.

The empirical centrepiece of the book are the eleven case study chapters (Chapters 6–16). Each of these chapters provides a synthesis of the findings for one farming system based on the results from multiple methods and perspectives. The case study chapters provide in-depth insights into the challenges and resilience capacities and strategies of very different farming systems across Europe. Each of these chapters ends with an annex that summarizes the case study findings on each step of the framework and includes suggestions for future strategies.

In the final part of the book, insights from the systematic assessments are synthesized regarding the integrated assessments of farming systems (Chapter 17), roadmaps for the enabling environment (Chapter 18), lessons learned from the various co-creation methods (Chapter 19) and a synthesis of the findings and reflection on the SURE-Farm approach to assess the resilience of Europe's diverse farming systems (Chapter 20).

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