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D5.2 Participatory impact assessment of sustainability and resilience of EU farming systems

Work performed by P1 WU (lead), P3 ILVO, P4 UoG, P6 SLU, P8 INRA, P9 UPM, P10 Unitus, P12 IAMO, P13 IEA-AR, P14 UNWE, P15 IRWiR PAN

Wim PAAS[1,2], Francesco ACCATINO[3], Federico ANTONIOLI[4], Franziska APPEL[5], Isabel BARDAJI[6], Isabeau COOPMANS[7], Paul COURTNEY[8], Camelia GAVRILESCU[9], Florian HEINRICH[5], Vitaliy KRUPIN[10], Gordana MANEVSKA-TASEVSKA[11], Delphine NEUMEISTER[12], Mariya PENEVA[13], Jens ROMMEL[11], Simone SEVERINI[4], Barbara SORIANO[6], Monica TUDOR[9], Julie URQUHART[8], Erwin WAUTERS[7], Katarzyna ZAWALINSKA[10], Miranda MEUWISSEN[2], Pytrik REIDSMA[1]

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*Corresponding author (wim.paas@wur.nl); [1]Plant Production Systems, Wageningen University, the Netherlands; [2]Business Economics, Wageningen University, the Netherlands; [3]UMR SADAPT, INRA, AgroParisTech, Université Paris-Saclay, 75005, Paris, France; [4]Department of Agricultural and Forestry Sciences, Università degli Studi della Tuscia, Italy; [5]Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Germany; [6]Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM), Universidad Politecnica de Madrid, Spain; [7]Agricultural and Farm Development, Institute for Agricultural and Fisheries Research (ILVO), Belgium; [8]Countryside and Community Research Institute, University of Gloucestershire, UK; [9]Institute of Agricultural Economics, Romanian Academy, Romania; [10]Institute of Rural and Agricultural Development, Polish Academy of Sciences, Poland; [11]Department of Economics, Sveriges Lantbruksuniversitet, Sweden; [12]Department of farm work and society, French Livestock Institute, France; [13]Department of Natural Resources Economics, University of National and World Economy, Bulgaria;

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Abstract

This report present the results of a participatory sustainability and resilience assessment of 11 farming systems in the European Union (EU). The assessments focused on 1) ranking the importance of functions and selecting representative indicators for these functions, 2) scoring the current performance of the representative indicators, 3) sketching dynamics of main representative indicators of functions, 4) linking these dynamics to challenges and resilience enhancing strategies, 5) assessing level of implementation of identified strategies and their potential contribution to the robustness, adaptability and transformability of the farming system, and 6) assessing level of presence of resilience enhancing system characteristics (resilience attributes) and their potential contribution to the robustness, adaptability and transformability of the farming system.

Overall, workshop results revealed a high allocated importance to the functions related to food production and economic viability. Maintaining natural resources is another function that was often scored with high importance. Aggregation of indicators performance to function level, revealed that farming system functions were perceived to perform poorly to well across case-studies. The function of food production is perceived to perform moderately to well in most case-studies. The functions related to economic viability and maintenance of natural resources were perceived to perform low to well across case-studies.

The selection of indicators for the sketching exercise followed more or less the perceived importance of functions, emphasizing the importance of food production and economic viability of farming systems. In general, participants felt confident to mention trends and to indicate where major changes happened that impacted the dynamics of the indicator. For most discussed indicators, participants were able to come up with strategies. Strategies could be categorized by evaluating links with resilience attributes to allow for comparisons. Most strategies related to resilience attributes associated with profitability, local and natural resources, diversity and innovation.

Overall resilience of studied farming systems is perceived to be low to moderate. Currently, most farming systems show more signs of robustness than adaptability or transformability. Multiple attributes, but not all, are important in building system resilience. Importance of attributes is case-study specific. Some generalizations can be made with caution. Currently, most important attributes contributing to resilience are related to having agricultural production coupled with the local and natural capital, spatial and temporal heterogeneity of farm types and social self-

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organization of actors in the farming system. A resilience attribute that is currently hardly present, but has high perceived potential is related to the profitability of the farming systems.

1 Introduction

European agriculture comprises many different farming systems (e.g. livestock, arable and mixed, extensive and intensive). Also in terms of economic, environmental and social performance, farming systems differ widely. From an economic and social perspective, European agriculture is in general associated with low labour productivity and income (DG-AGRI, 2017), an aging population and a decreasing number of farms and job opportunities. Approximately 70% of farmers in Europe earn less than an average competitive income; and over time, farmers experience a large variation in income (DG-AGRI, 2017). With further liberalization of the market, reduced subsidies, changing consumer preferences and increased weather variability, farmer incomes are expected to become even more variable.

In this dynamic environment, European agriculture is intensifying and farmers are trying to increase their farms' efficiency. However, from an environmental perspective, the room for manoeuvre is small for farms and farming systems. Intensive agricultural production is associated with a negative pressure on ecosystems (Rocha et al., 2015; Tilman et al. 2002). However, under certain conditions, agriculture can also provide ecosystem services (Power 2010; Dumont et al. 2018), e.g. habitat for farmland birds (Teillard et al. 2016) or carbon sequestration in grasslands (Accatino et al. 2019). In Europe, pressures and impacts of agriculture on the environment are monitored through so-called agri-environmental indicators (Eurostat 2019). Agri-environmental indicators show different temporal dynamics in Europe. For instance, the population of farmland birds is steadily decreasing, while pressure on the environment through nitrogen and phosphorus surpluses remains stable in many areas (DG-AGRI 2017b). Hence, next to market, weather and social conditions, agro-environmental indicators and their dynamics also need to be taken into account when developing strategies to anticipate change and variability in European agriculture. Especially now that the Common Agricultural Policy will put increasingly more emphasis on the environment and climate (DG-Agri 2019).

Evaluating economic, social as well as environmental dimensions of farms and farming systems needs an integrated approach. For developing strategies to anticipate change and variability, current and future resilience of farming systems needs to be assessed. SURE-Farm Working Package 5 (WP5) aims to analyse the integrated impact of resilience-enhancing strategies on the selected farming systems in the 11 SURE-Farm case studies, in particular regarding their delivery of private and public goods. In WP5, existing models (static and dynamic, quantitative

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and qualitative) are incorporated in an integrated assessment tool (D5.1; (Herrera et al. 2018). The IA-tool includes the Framework for Participatory Impact Assessment adapted for SURE-Farm (FoPIA-SureFarm). To serve the general aim of WP5, the IA tool will be specifically used to: 1) assess the current resilience and delivery of private and public goods for selected farming systems across the EU; 2) assess the impact of future challenges, and 3) assess the expected impact of resilience-enhancing strategies (and combinations of resilience-enhancing strategies) on the selected farming systems. The current study is part of the first aim, while the other aims are addressed in follow-up activities.

The quantitative models in the integrated assessment tool cannot be applied to all case studies because of 1) limited data availability, 2) a lack of model expertise of local partners and 3) incompatibility of available models with the type of farming system under study. Therefore, it is proposed in the integrated assessment tool to use FoPIA-Surefarm as a participatory, semi-quantitative approach in all case studies, as 1) the approach can be applied in all case studies, 2) it allows comparability among case studies, and 3) it complements (or in some cases replaces) the quantitative assessments. With regard to the latter: some variables are difficult to measure objectively (mainly social ones, such as pride of profession or unhealthy stress among farmers), and therefore participatory assessments are needed to assess these (van Calker et al. 2007). In addition, sustainability and resilience of farming systems partly depend on the perceived importance of different indicators. While changes in indicators may be measured and/or modelled, the perceived importance can only be understood when involving stakeholders in a participatory approach, provided there is agreement among stakeholders.

Overall, the participatory impact assessment aims to get a semi-quantitative overview of the sustainability and resilience of a farming system. Semi-quantitative implies that participants' assessments are obtained using a rating system that represents qualitative statements. This rating system is used for answering a discursive, but guided framework of questions. The choice for semi-quantitative is made to 1) consistently gather information in a guided framework of questions and 2) to quickly summarize results and present them to the participants during the workshop. FoPIA-Surefarm is the first methodology that completely follows the theoretical framework of SURE-Farm, following all proposed steps to assess farming systems resilience. In Section 3, the SURE-Farm theoretical framework is explained. Section 4 explains FoPIA-Surefarm and how it was applied in the case studies. Section 5 synthesizes results from the case-studies. Section 6 includes a discussion, followed by a conclusion in section 7. Case-study reports are included in Supplementary Materials A – K.

2 Framework to assess resilience of EU farming systems

A framework for assessing the resilience of EU farming systems was developed in SURE-Farm (Figure 1; Meuwissen et al. 2018). In Figure 1, the first three boxes refer to the delineation of the research and describe the dynamics of the subjects under study: resilience of what (farming system), to what (challenges) and for what purpose (functions) (Carpenter et al. 2001; Herrera 2017; Quinlan et al. 2016). Next steps are to define and explain resilience capacities and resilience attributes. The resilience of farming systems and their essential functions depends on their robustness, adaptability and transformability (resilience capacities). Resilience capacities narrate the dynamics of system functions, and resilience attributes are relatively easily measurable proxies that positively relate to at least one of the resilience capacities.

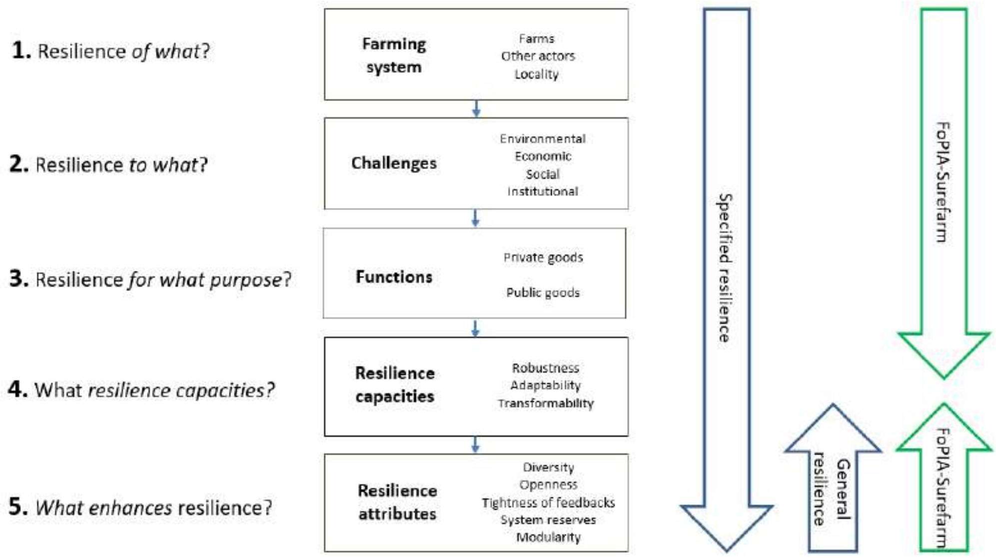

Figure 1. Framework to analyse the resilience of farming systems, including resilience capacities and attributes. In FoPIA-Surefarm the steps from 1 to 4 and from 5 to 4 are conducted (arrows with green outline).Source: adapted from Meuwissen et al. (2018)

In the framework, the social boundary of a farming system is such that we include actors who influence farms in a specified region, and, conversely, farms in that region that also influence these actors. In some cases, the processing industry is part of the farming system, while in others not. D1.3 (Unay-Gailhard et al. 2018) provides guidelines for developing a farm typology including interactions with the farming system, based on data and expert interviews. D3.1 (Bijttebier et al. 2018) describes the current farm demographics and trends per case-study. With regard to the next step, general challenges have been synthesized in D1.1 (Meuwissen et al. 2018). All case studies should consider these, but main risks differ per case-study. Also for essential functions, an overview has been provided in D1.1, but the importance of different functions may differ per case-study.

As farming systems, challenges, and functions differ, resilience capacities and attributes also differ per case-study. In addition, indicators of resilience capacities can differ per essential function. For example, recovery rate (or return time) is often ascribed to robustness (e.g. Scheffer et al. 2009), and it is appropriate for continuous processes like soil respiration (Todman et al. 2016), but it is less appropriate for functions related to annual processes, like crop yield in intensive systems (Peterson et al. 2018). In ecology, lakes have often served as an example to explain resilience theory (Carpenter et al. 2001; Scheffer et al. 2001). It has been shown that the slow changing variable 'sediment phosphorus' is a useful surrogate for resilience (or 'attribute'), when assessing the resilience of a clear-water or turbid water state. Dynamics of the fast variable 'water phosphorus' provide more direct information, but are more difficult to measure. In our terminology, 'sediment phosphorus' is the resilience attribute. It is however clear that this attribute refers to a specific system. Cabell & Oelofse (2012) defined 13 attributes for the resilience of agro-ecosystem resilience. In their paper, Cabell & Oelofse (2012) focus on "a scale greater than the individual farmer and his or her farm, but a scale small enough that an individual's voice can still make a difference". This is aligned with the social boundary setting of farming systems of FoPIA-Surefarm as described in the previous paragraph. Examples of proposed attributes are self-organization, connectedness and spatial and temporal heterogeneity, which are related to five generic resilience principles for social ecological systems: diversity, openness, tightness of feedbacks, system reserves and modularity (Resilience Alliance 2010; Walker & Salt 2012; Figure 1). While the attributes of Cabell & Oelofse (2012) are argued to be generally applicable, the distinction of how which attribute is related to which resilience capacities (robustness, adaptability, transformability) is not explicitly worked out by Cabell & Oelofse (2012). Moreover, enhancing different attribute levels can result in the competition for the same resources but also in synergies (Darnhofer et al. 2010).

3 The FoPIA-SureFarm approach

3.1 Building blocks

FoPIA-SureFarm builds on three frameworks that have been applied before: 1) The Framework for Participatory Impact Assessment (FoPIA; Morris et al. 2011), 2) Resilience Assessment Framework (RAF; Resilience Alliance 2010) and 3) the participatory approach used for system dynamics modelling by the University of Bergen (Herrera 2017). All methods have in common that they seek to raise awareness and support discussions among participants to understand the system under study.

FoPIA was developed within the EU FP5 project SENSOR. After that it was used in many other case studies, mainly in the EU FP6 project LUPIS (Konig et al. 2013; Reidsma et al. 2011). The aim of the original FoPIA is to assess the impact of policies on a set of indicators, encompassing sustainability. In FoPIA, a semi-quantitative approach is taken to quickly summarize judgments of participants on performance of sustainability indicators. As FoPIA does not address dynamics in these indicators, and hence does not address resilience, we also use RAF (Resilience Alliance 2010) to complement our participatory method. The resilience assessment is more in line with the SURE-Farm framework, addressing questions like resilience "of what?", "to what?" and "for what purpose?". It does not include a semi-quantitative assessment of the impact of changes on indicators reflecting sustainability (the system functions), and therefore both building blocks are needed. Lastly, the participatory approach used for system dynamics modelling by the University of Bergen (Herrera 2017) also includes aspects (sketches of past and future developments) that are useful for FoPIA-Surefarm.

3.2 Workshop overview

Within SURE-Farm, 11 case-studies were selected with diverse farming systems (Table 1). Farming systems in case-studies range from small-scale family farming to large-scale corporate agriculture. Arable, mixed, and livestock systems are included as well as perennial systems. More information on case-study regions can be found in SURE-Farm deliverable D3.1 (Bijttebier et al. 2018) and on the SURE-Farm website (SURE-Farm 2019a).

Table 1. Case-study regions and their farming system under study.

Country	Region	Farming system	Main product(s)
BE	Flanders	Intensive dairy farming	milk
BG	North East Bulgaria	Large-scale corporate arable farming	cereals
DE	Altmark, Saxony Anhalt	Large-scale corporate arable farming, mixed with livestock activities	cereals, milk
ES	Huesca, Aragon	Extensive sheep farming	meat
FR	Bourbonnais, Massif Central	Extensive beef cattle farming	meat
IT	Viterbo, Lazio, Central Italy	Perennial crops (hazelnuts)	hazelnuts
NL	Veenkolonien	Intensive arable farming	starch potato, sugar beets, cereals
PL	Mazowse i Podlasie	Smallholder horticulture	fruits
RO	Nord-Est	Smallholder mixed farming	cereals, oilseeds, fodder
SE	Mainly the southern part of Sweden	Egg and broiler systems	Eggs, meat
UK	East of England	Large-scale corporate arable farming	cereals

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To assess the current resilience of farming systems with FoPIA-Surefarm, workshops were conducted in autumn/winter of 2018/2019 in the 11 SURE-Farm case-studies (Table 2). The workshops were organized between 10am and 4pm, including 1-1.5 hours for breaks, leaving 4.5-5 hours effectively for the workshop. Invitation of stakeholders was done differently in each case-study, e.g. direct invitation via (e)mail or invitation via a local partner organization. Guidelines for invitation were to attract participants from different stakeholder groups, i.e. farmers, government, industry and NGOs.

Table 2. Overview workshop timing and number of participants.

Country	Date workshop 1	Participants (#)	Of which farmers (#)	Industry	Government	NGO	Research/advise	Other
BE	27-11-18	16	5	5	2	1	1	2
BG	11-1-2019	19	6	1	9	2	1	-
DE	9-1-2019	12	5	-	4	-	3	-
ES	31-1-2019	24	4	2	6	6	3	3
FR	14-2-2019	26	10	4	5	3	2	2
IT	21-1-2019	21	8	3	3	3	4	-
NL	11-12-2018	11	4	1	2	1	2	1
PL	5-3-2019	20	10	-	4	5	1	-
RO	6-2-2019	14	6	3	3	2	-	1
SE	22-01-2019	6	2	1	1	1	1	-
UK	16-1-2019	15	5	2	-	7	1	-

In brief, the workshops focused on current resilience and sustainability of the farming system, focusing on 1) ranking the importance of functions and selecting representative indicators for these functions, 2) scoring the current performance of the representative indicators, 3) sketching dynamics of main representative indicators of functions, 4) linking these dynamics to challenges and resilience enhancing strategies, 5) assessing level of implementation of identified strategies and their potential contribution to the robustness, adaptability and transformability of the farming system, and 6) assessing level of presence of resilience attributes and their potential contribution to the robustness, adaptability and transformability of the farming system. The different steps are detailed in this report below.

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3.3 Phases in FoPIA-SureFarm

FoPIA-Surefarm consists of three phases: the preparation phase, the stakeholder workshop and the evaluation phase. Parts of the preparation were covered by other SURE-Farm WPs/deliverables. The preparation was done by the involved researchers to increase efficiency during the stakeholder workshop. Workshop guidelines were developed with guiding questions to increase consistency and thus comparability between case-studies. Table 3 presents an overview of the steps taken during the workshop. In the evaluation phase, workshop results were compared with existing data and robustness, adaptability and transformability of the farming system was evaluated and reported per case-study. In the remainder of this section, the main research questions are presented. For a complete overview of the workshop see the workshop guidelines in Supplementary Materials L.

*Table 3. Activities during the FoPIA-Surefarm workshops on current resilience. *R=Research team, S=Stakeholders.*

Step	Activities	Who*	Time
Introduction	Use PowerPoint template to give an introduction to the workshop.	R	10 min
Farming system	Present actors, relationships and farm types.	R	5 min
	Confirm main actors and mutual relationships.	S	10 min
	Confirm main farm types.	S	5 min
Functions	Present system functions and indicators.	R	5 min
	Rank importance of functions, using 100 points divided over 8 functions. Rank indicators, 100 points divided per function. Per stakeholder.	S	20 min
	Assess current performance of indicators, scoring from 1 to 5. Per stakeholder.	S	20 min
	Evaluate ranking and select up to 6 main indicators that need to be evaluated to assess resilience.	R, S	25 min
Resilience capacities	Present the meaning of robustness, adaptability and transformability.	R	10 min
	Make groups of at least 3 persons (per selected main indicator) and continue in these groups throughout the workshop.	R	5 min
	Sketch dynamics of indicators over time.	S	15 min
	Show, in the graphs, which challenges have influenced historical dynamics of the indicator.	S	10 min
	Identify strategies that have been implemented to reduce or benefit from the impact of a challenge.	S	10 min
	Identify whether an indicator was robust, adaptive and/or transformed.	S	10 min
	Plenary discussion: compare historical dynamics of groups; identify alternate states of farming systems.	R, S	30 min
Resilience attributes	Present general resilience attributes and explain.	R	5 min
	Assess level of implementation of identified strategies from 1 to 5; score impact of strategy on resilience from -3 to +3. Only for strategies related to the same indicator as discussed before in group; filling in forms is done individually	S	10 min
	Assess level of presence of general resilience attributes from 1 to 5; score impact of strategy on resilience from -3 to +3. For the whole farming system; per stakeholder.	S	20 min
	Provide examples for most important resilience attributes in relation to robustness, adaptability and transformability	S	15 min
	Plenary discussion: evaluate robustness, adaptability and transformability of the indicators and the farming system in general; how do farming system level resilience attributes relate to farm level resilience attributes?	R, S	30 min

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3.4 Farming system

The type of challenges a system is facing, as well as its response, are largely affected by the characteristics/identity of the system. This relates to the question "resilience to what?" (step 1 in the resilience framework; Figure 1). The identity of a farming system depends on key actors, system components, and their interactions (Cumming & Peterson 2017). In FoPIA-Surefarm we mainly focussed on the social delineation of the farming system, i.e. identifying key actors and their interactions in terms of influence. Key actors within the system boundary are identified using the following selection criteria, i.e. *the boundary of a farming system is such that we include actors who influence farms, and, conversely, farms also influence these actors.* In contrast, we exclude actors who influence the farming system, but who are themselves scarcely influenced by the system. Figure 2 provides an example farming system. In the workshops, stakeholders were asked to confirm main actors and their mutual dependence, i.e. the level of influence that they have on each other.

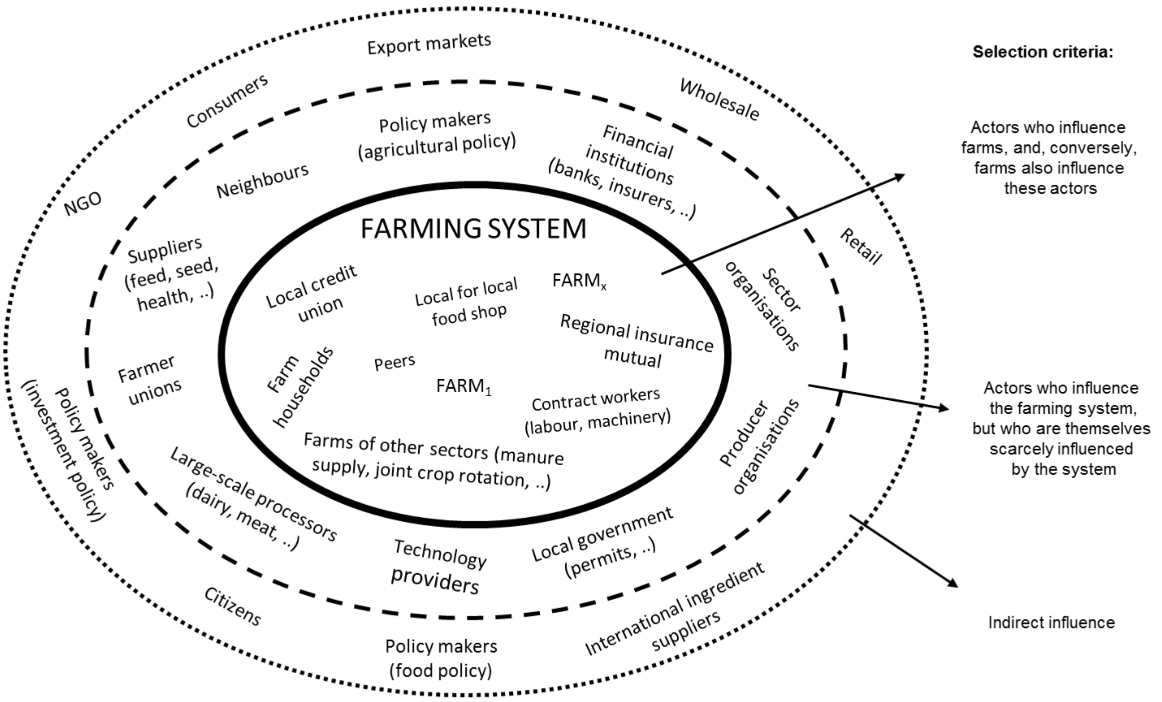

Figure 2. Selection criteria to identify actors within the system boundary of a farming system, incl. example actors. Source: Meuwissen et al. (2018).

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3.5 Challenges

In FoPIA-Surefarm, challenges relate to the question "resilience to what" (step 2 in the resilience framework; Figure 1). To identify the variety of challenges farming systems are confronted with, we categorised the challenges along four dimensions, i.e. economic, environmental, social and institutional risks. Also, we distinguished two ways of how these challenges affect farming systems: as a (non) permanent shock, or as a long-term pressure with inherent uncertainties. Agro-ecological conditions that are static in nature are not seen as challenges, e.g. low water holding capacity is not seen as a challenge, but an incident of drought is. Distinction between various dimensions and sub-classifications (shock, long-term pressure) is somewhat arbitrary, but the classification can be useful as a 'checklist' (see Annex 1 of Meuwissen et al. 2018).

Identified challenges were not presented during the stakeholder workshop. Instead the overview was used to guide the discussions. For instance when challenges had to be linked to dynamics of functions (section 3.7); if not mentioned by stakeholders, they could be asked about the influence of specific challenges.

3.6 Functions

The identity of a farming system depends on key actors, system components, and interactions (section 3.1), but also on the provision of functions. Functions relate to the questions "resilience for what purpose?" (Step 3 in the resilience framework; Figure 1). Which functions are deemed important for the farming system depends on stakeholder perspectives. A large change in a specific function can imply a collapse or transformation of a system. Therefore, for an integrated impact assessment, ranking the importance of essential functions is important. Often, the identity of a farming system is associated to a specific indicator. For example, in the case-study in the Netherlands, in the Veenkoloniën producing starch potato shapes the identity of the farming system and is associated with the function "Food production".

Depending on a system's location (e.g. close to a city centre, or remote), system functions may differ. In FoPIA-Surefarm, functions were subdivided towards the provisioning of private goods and public goods (Meuwissen et al. 2018; Table 4). In Table 4, short descriptions are provided for the farming system functions. These short descriptions will be used when presenting results.

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Table 4. Overview of farming system functions and their short descriptions.

Farming system function	*Short description*
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 farming 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 & habitat
Ensure that rural areas are attractive places for residence and tourism (countryside, social structures)	Attractiveness of the area
Ensure animal health & welfare	Animal health & welfare

We allowed to have a minimum of one and a maximum of four indicators that are associated to functions. The research team compiled the list of indicators that were relevant and easy to communicate and to understand. The research team also identified for which stakeholders these indicators were essential. Stakeholders were provided the opportunity to remove, change or add indicators in a plenary session. The final number of indicators differed between case-studies (Table 5).

Table 5. Number of selected indicators per farming system function for each case-study.

	Number of indicators per function											
Short description	**BE**	**BG**	**DE**	**ES**	**FR**	**IT**	**NL**	**PO**	**RO**	**SE**	**UK**	**Mean**
Food production	2	4	3	2	4	2	3	3	2	4	2	**2.8**
Bio-based resources	3	2	2	2	4	2	2	3	2	2	1	**2.3**
Economic viability	3	4	3	3	4	3	3	3	3	4	3	**3.3**
Quality of life	3	3	4	2	4	3	4	3	3	4	3	**3.3**
Natural resources	3	4	4	2	4	2	4	3	4	4	2	**3.3**
Biodiversity & habitat	3	3	3	2	4	2	3	3	3	3	3	**2.9**
Attractiveness of the area	3	4	4	2	3	2	3	3	4	4	3	**3.2**
Animal health & welfare	2	3	3	2	2	-	2	3	3	4	1	**2.5**
Total	**22**	**27**	**26**	**17**	**29**	**16**	**24**	**24**	**24**	**29**	**18**	**23.3**

During the workshop, stakeholders were asked to individually rank the perceived importance of the eight functions by distributing 100 points over eight functions. In case the allocated points did

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not add up to 100, the points were normalized to in order to make them sum up to 100. Allocated points for functions were summed up for private and public goods. Also the effective number of functions was calculated, following Equation 1.

$$Effective\ number\ of\ functions = \frac{1}{\sum_i (Importance\ Function_i/100)^2} \qquad Equation\ 1.$$

Where *i* accounts for the number of functions and the "Importance Function" is in %. The outcome of Equation 1 can be seen as the degree into which participants in the workshop allocate equal importance to functions. The lower the score, the more a few functions are preferred over the others.

After ranking the essential functions, participants were asked to evaluate the list with indicators. Stakeholders were invited to score the indicators for representativeness within each essential function, again distributing a total of 100 points this time per function. So, if three indicators were included for one function, a total of 100 points could be distributed over these three indicators. Ranking of all individual indicators over all functions was done afterwards, based on both rankings (function and indicator) and the number of indicators per function, following Equation 2.

$$TransIndicatorImp = FunctionImp_s * (IndicatorImp\ /100) * FunctionIndNr \qquad Equation\ 2.$$

Where "TransIndicatorImp" is the transformed importance of the indicator that allows for direct comparison between indicators of different functions, "$FunctionImp_S$" is the average importance allocated to the function by the stakeholder group a participant belongs to, "IndicatorImp" is the importance allocated to the indicator and "FunctionIndNr" is the number of indicators that the function concerned has.

After ranking importance of functions and indicators, stakeholders were asked to assess the perceived current performance of the indicators, scoring from 1 to 5, where 1: very low performance, 2: low performance, 3: medium performance, 4: good performance, 5: perfect performance.

Results of ranking function importance and indicator importance and performance were processed during the workshop and discussed in a plenary session. Results on indicator performance were summarized for each case-study at function level by means of weighted average, the weight being determined by the overall representativeness of indicators per function. For importance and performance of functions and indicators, Kruskal Wallis tests were performed for detecting significant differences between stakeholder groups at the 5% probability level. For these tests, statistical power is low and data was not drawn from a random sample.

Hence, these test are used in an explorative matter to highlight some differences between stakeholder groups without drawing strong conclusions. Linear regression models were used to assess correlations between function performance and function importance (where the case-studies were the observations: n=11; p<0.05). For these mentioned statistical tests, statistical power is low and data was not drawn from a random sample. Hence, results from these test are used in an explorative way to highlight some differences between stakeholder groups without drawing strong conclusions. P-values of statistical test can be found in Appendix A.

After the ranking and the scoring, a plenary discussion took place to identify most important indicators that represent the identity of the system. Bar graphs or a bubble graphs that included indicator importance and performance were used to support the discussion. These important indicators were evaluated in the next steps, to assess resilience. In case no consensus could be reached on which indicators to select, a compromise was regarded sufficient.

Function importance and performance was also assessed in the online co-creation platform of SURE-Farm (SURE-Farm 2019b). The assessments were done for the "EU agricultural sector". Results of these assessments are presented in Appendix B.

3.7 Resilience capacities

Understanding the resilience of a farming system requires understanding the dynamics of the representative indicators of the essential functions, and specifically the ones shaping the identity of the system. Hence, in the workshops the next step was exploring (i) the dynamics of the essential functions (robustness), (ii) the relation between risks (shocks, long-term pressures) and responses (adaptability), and (iii) the occurrence of tipping points (drastic system changes, regime shifts within one generation, changed identity) (transformability) (Meuwissen et al., 2018). The stakeholder workshop cannot answer all the questions, but can provide a good basis, upon which the researchers can build.

We asked the stakeholder to analyse historical dynamics from 2000-2018, but with reference to earlier time periods where relevant. The research teams did not prepare historical dynamics, but data on some indicators was collected before and after the workshop to compare with stakeholder input. Stakeholders were grouped, and each group focused on one representative indicator. Each group had at least 3 persons, and consisted of participants belonging to different stakeholder types. Stakeholders were allowed to change groups, in case they felt uncomfortable to work on a certain indicator and felt more knowledgeable about another.

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Stakeholders were asked to show, in the graphs, which challenges have influenced historical dynamics of the indicators. In case the sketches were far from reality (based on availability of data), researchers brought in their knowledge (from the datasets) and took notes of the intervention. The list of challenges (see section 3.5) was used to stimulate the discussions. In some specific cases, opportunities, rather than challenges had caused dynamics in the farming system performance. However, in general, the point of departure of FoPIA-Surefarm were the challenges, i.e. resilience to what. After the workshop, sketches of historical dynamics of main indicators were digitalized and presented in the individual case-study reports (Supplementary Materials A-K).

Stakeholders were asked to identify strategies (responses) that have been implemented to reduce or benefit from the impact of a challenge. Getting a list with identified strategies was an important aim of the whole sketching exercise. In case participants were not able to sketch the dynamics, the discussion on the indicator itself was used to come up with a list of strategies.

In a plenary session, the historical dynamics of the main representative indicators were presented, based on group presentations. In this session, robustness/adaptability/transformability of the farming system was evaluated, based on the main indicators.

3.8 Level and contribution of strategies

After identifying the strategies during the sketching exercise (previous section), strategies were evaluated for their level of implementation and their potential contribution towards the resilience capacities. For evaluating the strategies, participants remained in the same groups, and evaluated the implementation level and effect of identified strategies with regard to the farming system, i.e. not only for the indicator for which the strategy was implemented. Each individual stakeholder was asked to evaluate the strategies.

First, participants were asked to score the degree into which the strategy had been implemented: 1: not implemented, 2: slightly implemented, 3: moderately implemented, 4: well implemented, 5 perfectly implemented. Second, participants scored the relationship between the strategy and the robustness/adaptability/transformability of the farming system from -3 to +3. Although these were strategies identified as improving resilience, there might be trade-offs between robustness, adaptability and transformability, resulting in negative and positive scores. A 0 implies no relationship, a 1 or -1 a weak positive or negative relationship, a 2 or -2 a intermediate positive or negative relationship, and a 3 or -3 is a strong positive or negative relationship.

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3.9 Resilience attributes

The resilience assessment framework of the Resilience Alliance (2010) argues that there is a need to consider both general and specified resilience. Specified resilience relates to the question 'resilience of what, to what and for what purpose'. General resilience applies to the system as a whole (step 5 in the resilience framework; Figure 1). Given that there may be completely novel shocks, with system responses that are as yet unknown, are there parts of the system that exhibit low or declining levels of those attributes that confer general resilience? The Resilience Alliance (2010) argues that the following resilience principles are related to general resilience: diversity, openness, tightness of feedbacks, system reserves, and modularity. Cabell and Oelofse (2012) identified 13 general attributes contributing to the resilience of agroecosystems. We argue that these 13 resilience attributes of agro-ecological systems by Cabell and Oelofse (2012) can be seen as an extension of the resilience principles of Resilience Alliance (2010). But while these attributes relate to general resilience, they may not contribute to specified resilience. The relation between resilience attributes and main indicators reflecting the essential functions of a farming system, may differ per case-study. Relationships should therefore be investigated.

We related the 13 resilience attributes of Cabell & Oelofse (2012) to the five resilience principles and the four farming system processes on which SURE-Farm has its focus: farm demographics, governance, risk management and agricultural production. In some cases we split the attributes in sub-attributes to improve their explicability towards participants. In addition, we tuned the definition of the (sub-)attributes more towards characteristics at the farming system level that are relevant in SURE-Farm. Also we developed three extra attributes, to serve the particular interests of SURE-Farm. Finally, we had a list with 22 attributes from which we selected 13 to reduce overlap between attributes and to reduce the workload during the workshop (Table 6). The original and adapted list of attributes and their definitions are presented in Supplementary Materials L. In our resilience framework (Figure 1) we aim to further specify the level of these attributes and how these attributes contribute to specific resilience capacities, i.e. robustness, adaptability and transformability (step 4 in the resilience framework; Figure 1).

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Table 6. Attribute list based on Cabell & Oelofse (2012) and Meuwissen et al. (2018). Italic font indicates that these attributes are presenting only part of the original attribute in Cabell & Oelofse (2012). Bold font indicates adaptations made to tailor resilience attributes towards farming systems research within the SURE-Farm project (Meuwissen et al., 2018).

Resilience attribute	**Definition**	**Implications**	**Explanation statement**	**Link with resilience principle**	**Link with SURE-Farm processes**
Reasonably profitable	Persons and organizations in the farming system are able to make a livelihood and save money without relying on subsidies or secondary employment	Being reasonably profitable allows participants in the system to invest in the future; this adds buffering capacity, flexibility, and builds wealth that can be tapped into following release	Farmers and farm workers earn a liveable wage while not depending heavily on subsidies.	**Systems reserves (financial capital)**	**Agricultural production; risk management**
Coupled with local and natural capital **(production)**	The system functions as much as possible within the means of the bio-regionally available natural resource base and ecosystem services	Responsible use of local resources encourages a system to live within its means; this creates an agroecosystem that recycles waste, relies on healthy soil, and conserves water	Soil fertility, water resources and existing nature are maintained well.	**Systems reserves (natural capital)**	**Agricultural production**
Functional diversity	*Functional diversity is the variety of (ecosystem) services that components provide to the system;*	*Diversity buffers against perturbations (insurance) and provides seeds of renewal following disturbance*	*There is a high variety of inputs, outputs, income sources and markets.*	**Diversity**	**Risk management**
Response diversity	*Response diversity is the range of responses of these components to environmental change*	*Diversity buffers against perturbations (insurance) and provides seeds of renewal following disturbance*	*There is a high* ***diversity of risk management strategies****, e.g. different pest controls,* ***weather insurance, flexible payment arrangements.***	**Diversity**	**Risk management**
Exposed to disturbance	The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond a critical threshold	Such frequent, small-scale disturbances can increase system resilience and adaptability in the long term by promoting natural selection and novel configurations during the phase of renewal; described as "creative destruction"	The amount of year to economic, environmental, social or institutional disturbance is small (well dosaged) in order to timely adapt to a changing environment.	**Openness**	**Risk management**
Spatial and temporal heterogeneity **(farm types)**	Patchiness across the landscape and changes through time	Like diversity, spatial heterogeneity provides seeds of renewal following disturbance	**There is a high diversity of farm types with regard to economic size, intensity, orientation and degree of specialisation.**	**Modularity, diversity**	**Farm demographics, risk management**
Optimally redundant ***(farms)***	*Critical components and relationships within the system are duplicated in case of failure*	*Redundancy may decrease a system's efficiency, but it gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance*	***Farmers can stop without endangering continuation of the farming system and new farmers can enter the farming system easily.***	***Modularity***	***Farm demographics; risk management***
Supports rural life	**The activities in the farming system attract and maintain a healthy and adequate workforce, including young, intermediate and older people.**	**A healthy workforce that includes multiple generations will ensure continuation of activities and facilities in the area, and the timely transfer of knowledge.**	**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, shops).**	**Systems reserves (social and human capital)**	**Farm demographics**
Socially self-organized	The social components of the agroecosystem are able to form their own configuration based on their needs and desires	Systems that exhibit greater level of self-organization need fewer feedbacks introduced by managers and have greater intrinsic adaptive capacity	Farmers are able to organize themselves into networks and institutions such as co-ops, community associations, advisory networks **and clusters with the processing industry**.	**Tightness of feedbacks, system reserves (social capital)**	**Governance**
Appropriately connected **with actors outside the farming system**	**The social components of the agroecosystem are able to form ties with actors outside their farming system.**	**In case self-organization fails, signals can be send to actors that indirectly influence the farming system.**	**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.**	**Tightness of feedbacks**	**Governance**
Coupled with local and natural capital **(legislation)**	**Regulations are developed to let** the system function as much as possible within the means of the bio-regionally available natural resource base and ecosystem services	Responsible use of local resources encourages a system to live within its means; this creates an agroecosystem that recycles waste, relies on healthy soil, and conserves water	**Norms, legislation and regulatory frameworks are well adapted to the local conditions.**	**Systems reserves (social capital)**	**Governance, agricultural production**
Infrastructure for innovation	**Existing infrastructure facilitates diffusion of knowledge and adoption of cutting-edge technologies (e.g. digital)**	**Through timely adoption of new knowledge and technologies, a farming system can better navigate in a changing environment.**	**Existing infrastructure facilitates knowledge and adoption of cutting-edge technologies (e.g. digital).**	**Openness, system reserves**	**Governance, agricultural production**
Diverse policies	**Policies stimulate all three capacities of resilience, i.e. robustness, adaptability, transformability**	**Policies addressing all three resilience capacities avoid situations in which farming systems are permanently locked in a robust but unsustainable situation. Or situations in which adapting and transforming systems are increasingly vulnerable.**	**Policies stimulate all three capacities of resilience, i.e. robustness, adaptability, transformability.**	**Diversity**	**Governance**

In the workshop, we presented the attributes with accompanying explanation statement to participants. Participants were asked to individually score the extent into which the attribute and accompanying statement were the case in the farming system on a score from 1 to 5, where 1: not at all present, 2: present into a small extent, 3: moderate present, 4: present into a big extent, 5: present into a very big extent. After that, the strength of the relationship between attribute and resilience capacities of the whole farming system was scored between -3 and +3. It was expected that most relationships are positive, but negative relationships may also be possible. A 0 implies no relationship, a 1 a weak relationship, a 2 a relationship of intermediate strength, and a 3 is a strong relationship. For negative values, the same terminology applies. Participants could add and score case-study specific attributes when necessary.

Results were collected and processed during the workshop. However, they were not presented in all workshops. The exercise and the workshop were ended with a plenary discussion, concluding on main challenges, main strategies and resilience attributes, and synergies and trade-offs between indicators of the farming system.

By combining levels of presence and potential contribution of resilience attributes, an assessment of overall scores for the resilience capacities could be made following equation 3 and 4.

$$Overall\ resilience\ capacity_c = \frac{\sum_i PresenceScore_i * Potential\ contribution_{c,i}}{Number\ of\ scored\ attributes} \qquad Equation\ 3.$$

Where "PresenceScore$_i$" is calculated as in Equation 4.

$$PresenceScore_i = \frac{(level\ of\ presence_i - minimum\ level)}{(maximum\ level - minimum\ level)} = \frac{(level\ of\ presence_i - 1)}{(5-1)} \qquad Equation\ 4.$$

Values resulting from equation 3 will range between -3 and 3, where 3 indicates a situation in which all resilience attributes are perfectly present and contribute strongly positive to the resilience capacity concerned. For all case-studies, Kruskal Wallis tests were performed to discover significant differences between scores for resilience capacities, per attribute and for all attributes together.

Attribute presence was also assessed in the online co-creation platform of SURE-Farm (SURE-Farm 2019b). The assessments were done for the "EU agricultural sector". Results of these assessments are presented in Appendix B.

4 Results

4.1 Farming system

In all workshops, the SURE-Farm definition for delineating the social boundaries of the farming system was explained. This delineation relates to the question "resilience of what?" (step 1 of the resilience framework; Figure 1). Starting with the delineation of the social boundaries of the farming system was intended to support participants to look at farming system level instead of at for instance farm level or at a specific link in the value chain. In theory, participants found the definition a useful way of distinguishing between actors with different types of dependency and influence. However, in practice it was not always straightforward to determine in which ring certain actors should be placed. Consumers, for instance, could be placed in all circles in many case-studies. For example, Swedish consumers have had a big influence on egg production which has moved from a relatively low to a rather high share of organic production. Yet, there is little direct interaction between consumers and the farm. Also, it was sometimes challenging to distinguish between feedback about the current situation or a desired situation. In the Belgian case-study, for instance, the cooperative for dairy farms was put outside the farming system, while most participants in that workshop indicated that the cooperatives, regarding the impact of their working organization and activities, should be situated within the farming system. In the Swedish case-study, stakeholders argued that by having closer bi-directional relationships farms/organizations may be in a better position to influence authorities and decision-makers, in the long run.

The feedback of participants helped to include important actors that were omitted by the research team. In the Dutch case-study, for instance, the water board was added to the farming system as a strong co-dependency existed between de water board and farmers. In all workshops, an agreement was reached about the social delineation of the farming system.

Overall, feedback of participants was complementing the overview that researchers had made in the preparation phase. In the preparation phase, the research teams used mainly outputs from previous SURE-Farm activities. During the workshop, participants mainly changed the position of actors (9 times) and included new actors (14 times), while only two actors were removed (Table 7).

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Table 7. Position of actors before and after feedback of participants. Case-studies included are: BE, BG, DE, ES, FR, IT, NL, RO, SE.

Phase		After feedback			
	Actor types	farming system actor	direct influencer of FS	indirect influencer of FS	removed
Before feedback	farming system actor	70	2	0	2
	direct influencer of FS	5	85	1	0
	indirect influencer of FS	0	4	66	0
	not considered	9	17	3	0
	Grand Total	**84**	**108**	**70**	**2**

In the Belgian and Dutch case-studies, the highest number of farming system actor types were identified. In the German and Italian case-study, least farming system actors were identified. In the Dutch and Romanian case-study, most (in)direct influencers were identified, while in Spain and Italy the least.

4.2 Challenges

Research teams identified challenges for each case-study. This related to the question "resilience to what?" (step 2 in the resilience framework; Figure 1). For identifying challenges, research teams mainly used results from previous SURE-Farm activities. Overall, more long-term pressures were identified than (non-)permanent shocks in the preparation phase (Table 8). During the workshops, only a part of the identified challenges were mentioned and the emphasis on long-term pressures was increased (Table 9).

Table 8. Average number of challenges per case-study, identified in the preparation phase, specified for type and domain of challenge. Included case-studies: all

	Domain				
Challenge	**Economic**	**Environmental**	**Institutional**	**Social**	**Total**
(Non)-permanent shock	2.0	2.3	1.5	1.1	6.9
Long-term pressures	3.5	2.5	2.2	3.1	11.4
Grand Total	5.5	4.8	3.7	4.2	18.3

Table 9. Average number of challenges per case-study, identified during the workshop, specified for type and domain of challenge. Included case-studies: all

	Domain				
Challenge	**Economic**	**Environmental**	**Institutional**	**Social**	**Total**
(Non)-permanent shock	0.6	1.0	0.5	0.3	2.5
Long-term pressures	2.0	1.0	0.6	1.2	4.8
Grand Total	2.6	2.0	1.2	1.5	7.3

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4.3 Farming system functions and indicators

Importance and performance of functions and indicators relates to the question "resilience for what purpose?" (Step 3 in the resilience framework; Figure 1).

4.3.1 Importance functions

Overall, workshop results revealed a high allocated importance to the functions "Food production" and "Economic viability" (Figure 3). "Natural resources" is often scored with higher importance, compared to the remaining functions. All studied farming systems, except the Italian case-study, had at least some farms with livestock and valued "Animal health & welfare" with a score from 8-22%. For this function, the score from the Swedish case-study (22%) deviated much from the other case-studies (8-14%). This can be explained by the high importance placed on farm animal welfare in general in Sweden, which does also concern other livestock sectors such as dairy farming. "Bio-based resources" are often scored with the lowest scores (4-13%), where the mixed farming systems are among the highest scoring cases. "Maintaining biodiversity" and "Attractiveness of the countryside" score on average low. In the Belgian case-study, the participants indicated that low scores for these functions were due to the fact that the function "maintaining natural resources" was seen as a prerequisite for these functions and hence received a higher score. In none of the case-studies, for none of the functions, a significant difference at the 5% level between scores of different stakeholder groups was observed.

In the co-creation platform, participants also perceived a higher importance for "Food production", "Economic viability" and "Natural resources" for the EU agricultural sector (Appendix B). However, overall, importance was more equally divided over all functions in the co-creation platform than in the case-study workshops.

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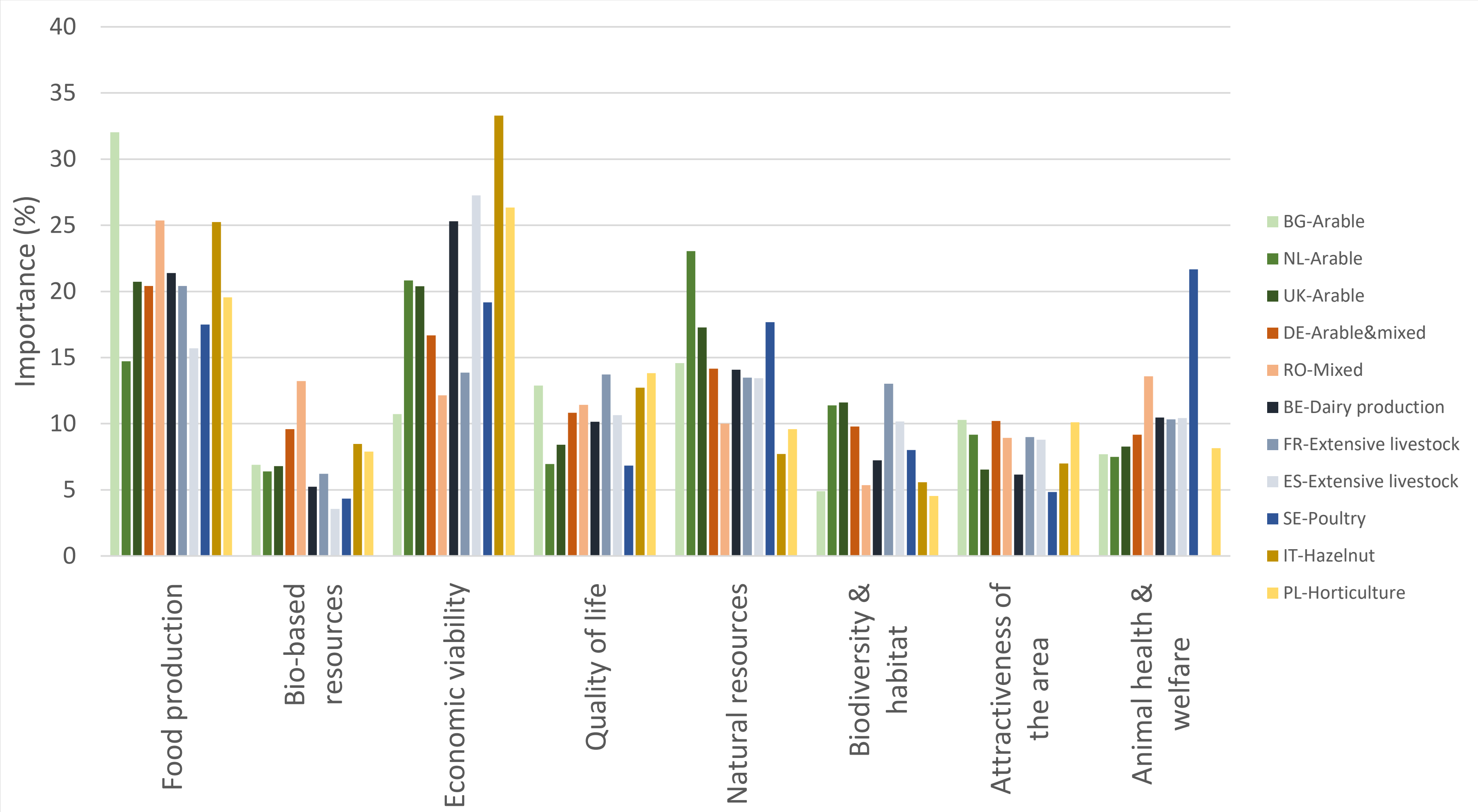

Figure 3. Allocated importance to farming system functions. Results are based on a division of 100 points by each participant in each case-study

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Case-studies allocated 48 to 80% of importance to functions that represented the delivery of private goods (Figure 4). This indicates a tendency in most case-studies to prefer private goods over public goods. The most extreme example of this is Italy with an importance of 80% for the functions that represent private goods. Participants from the *Farmers* group were more often allocating more importance to private goods than participants belonging to other stakeholder groups. Especially in the case-studies in BE, BG, NL, PL and SE, importance differs between stakeholder groups (Figure 4). In the case-studies FR, NL and SE, the average importance between private and public goods is more or less balanced. In the workshop in the Dutch case-study, participants indicated that the presented functions are all interacting. They stated that providing food and income in the farming system was only possible when taking care of natural resources, i.e. delivering the public goods was identified as essential for the delivery of private goods. In the Bulgarian case-study, with a strong focus on private goods, participants were indicating that developing their system for food production would imply lower importance and also performance of functions that represent public goods.

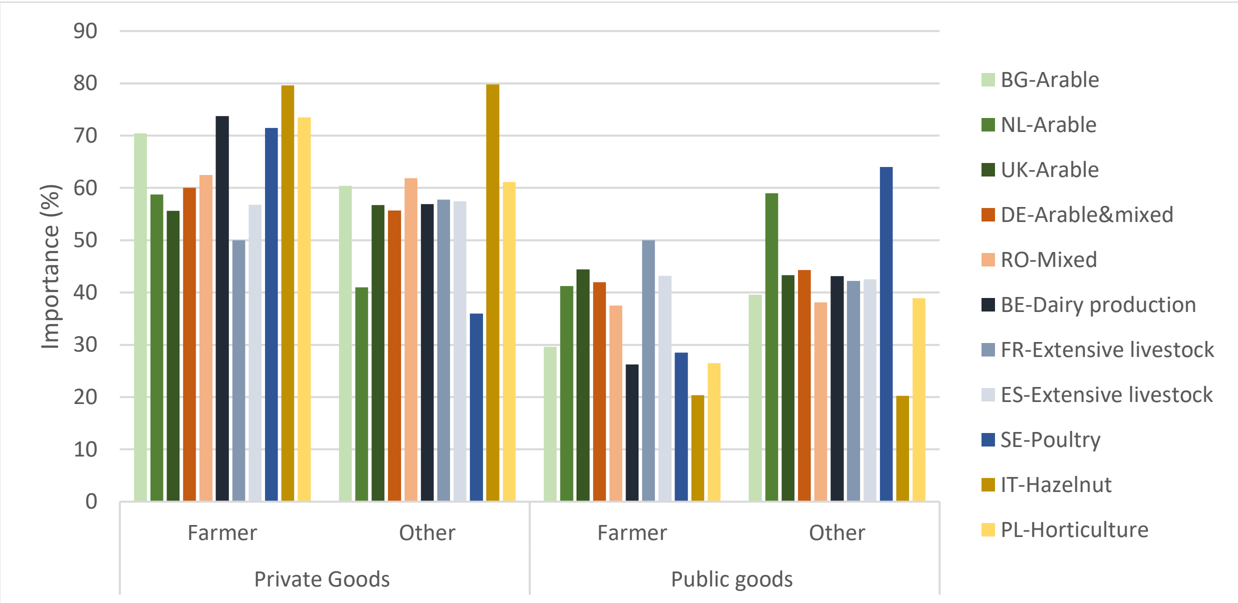

Figure 4. Allocated importance to functions that represent private and public goods per stakeholder group..

The effective number of functions based on scoring for function importance ranged between four and six (Figure 5). The case-studies DE, FR and UK had relatively high scores (close to 6), indicating that importance was relatively evenly spread over the different functions. The case-studies BG, IT, PL, RO and SE had relatively low scores (close to 4), indicating a high preference for a few functions.

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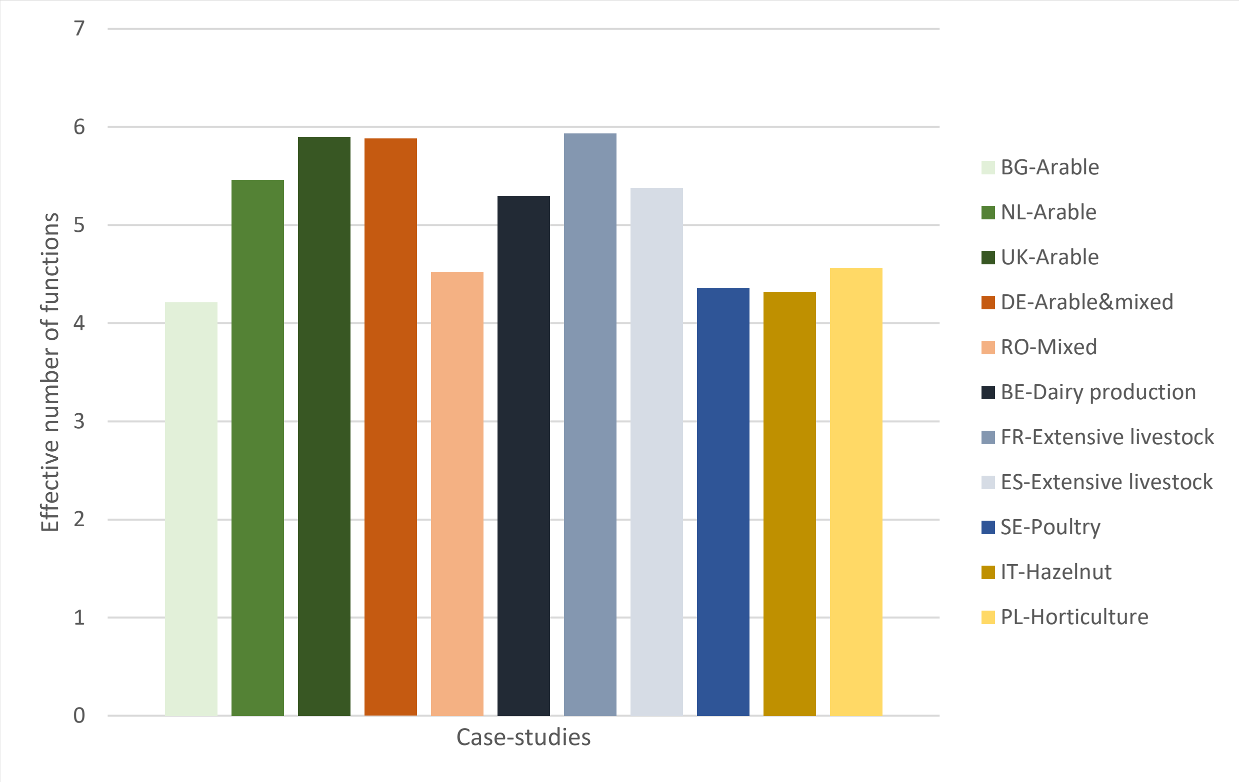

Figure 5. Effective number of functions based on scoring for function importance.

4.3.2 Performance of functions

"Food production" is perceived to perform moderately to well in most case-studies, except for the Polish and Spanish case-study (Figure 6). "Economic viability" and "Natural resources" are perceived to perform low to well across case-studies. In the Polish case-study, "Economic viability" was assessed to be low, based on three components targeting costs of agricultural production which are constantly rising: 1) financial input-output ratio; 2) prices of fertilisers, and 3) labour costs. Out of those three the most influential is the input-output ratio. "Animal health and welfare" is one of the most important functions in the Swedish case-study and is there scored moderately. In the Spanish case-study, the extensive sheep sector has been experiencing an important decrease in the number of farms and sheep in the region over the last 20 years. This explains why farming system's actors score the essential functions performance lower than the other CS regions. In the Spanish case-study, public goods have higher scores than those referred to private goods. Similar performance can be seen in the Polish case-study. Farming systems with relative high performance for private functions can be found in the Italian and the Romanian case-study regions. In the Romanian and French case-studies, both being extensive systems, performance of public goods is assessed to be relatively high, compared to other case-studies. Most intensive systems among the case-studies, i.e. NL, UK, BE, perform overall moderately.

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Only "Bio-based resources" shows a positive linear correlation between importance and performance (p=0.017; R^2=0.49; n=11; results aggregated per case-study), indicating that in the perception of stakeholders, higher importance could partly coincide with higher performance. Performance scores for "Biodiversity & habitat" and "Attractiveness of the area" are in most case-studies at a similar level as "Natural resources". This similar scoring leaves the option open, that indeed "Natural resources" is influencing the other two mentioned functions, as suggested by participants. In the DE case-study, "Attractiveness of the area" scores lower than "Natural resources" and is mostly related to the remoteness of the area. In the SE case-study, low scoring for this function is more sector related as much of production process is happening indoors.

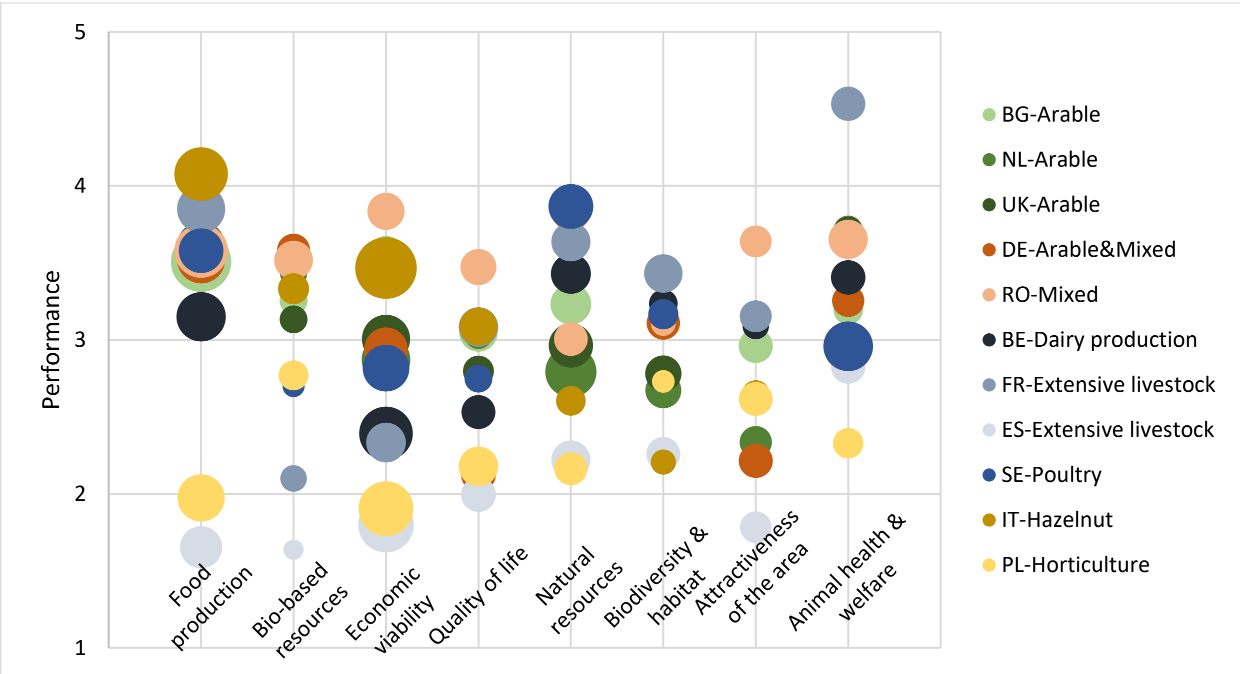

Figure 6. Function importance and performance of all case-studies. Performance scores are from 1 to 5, where 1 is very low, 2 is low, 3 is moderate, 4 is good and 5 is very good performance.

For some functions in some case-studies, results suggested differences between perceptions of stakeholder groups. In the Belgian and Dutch case-study for instance, farmers were more positive than other participants about the performance of "Natural resources". The participating farmers in the Dutch case-study were also more positive about the performance of "Biodiversity & habitat". In the Italian case-study, stakeholder groups differed in opinion about the performance of "Economic viability". In the Spanish case-study, stakeholder groups differed in opinion about "Quality of life": farmers were more pessimistic than other stakeholder groups.

In the co-creation platform, performance of the EU agricultural sector was perceived to perform well for "Food production" and moderate for the other functions (Appendix B).

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4.4 Farming system indicators

Within functions, participants often had a preference for one indicator. Sometimes this preference differed per stakeholder group. Outcomes of Kruskal Wallis tests suggested that there were differences in perceived importance between stakeholder groups in the case-studies BE, DE, IT, NL and UK for up to five indicators. When taking into account underlying importance of functions per stakeholder group, more significant differences between groups are found. In case-studies with multiple crops and/or food products, the indicators representing "Food production" received more or less equal importance. In the preparation phase it was proposed to include an indicator about gender-related issues, e.g. "share of women working in agriculture". In the case studies where this indicator was assessed (NL & IT), it was perceived as having low importance compared to other indicators. In the IT case-study four and in the NL case-study no women participated in the workshop.

When transforming indicator performance by including function importance and number of indicators per function (Equation 3 and 4), indicators across functions can be compared. Most indicators are not directly comparable across case-studies. However, by categorizing indicators a match was found between several indicators. In this report, a few examples will be provided of such a categorization to 1) provide insight in the data that was gathered during the FoPIA-Surefarm workshops and 2) to support the discussion of this report. More details on indicators can be found in the individual country reports that are attached to this deliverable (Supplementary Materials A-K).

In Figure 7, importance and performance of social indicators are presented. Social indicators were representative for the functions "Quality of life" and "Attractiveness of the area". Their performance is assessed low to moderate. Also, their importance is low compared to indicators that for instance represent the function "Economic viability".

In Figure 8, importance and performance of indicators related to nature friendly management are presented. The indicators all represent the function "Biodiversity & habitat". Their performance is around moderate and their relative importance is low.

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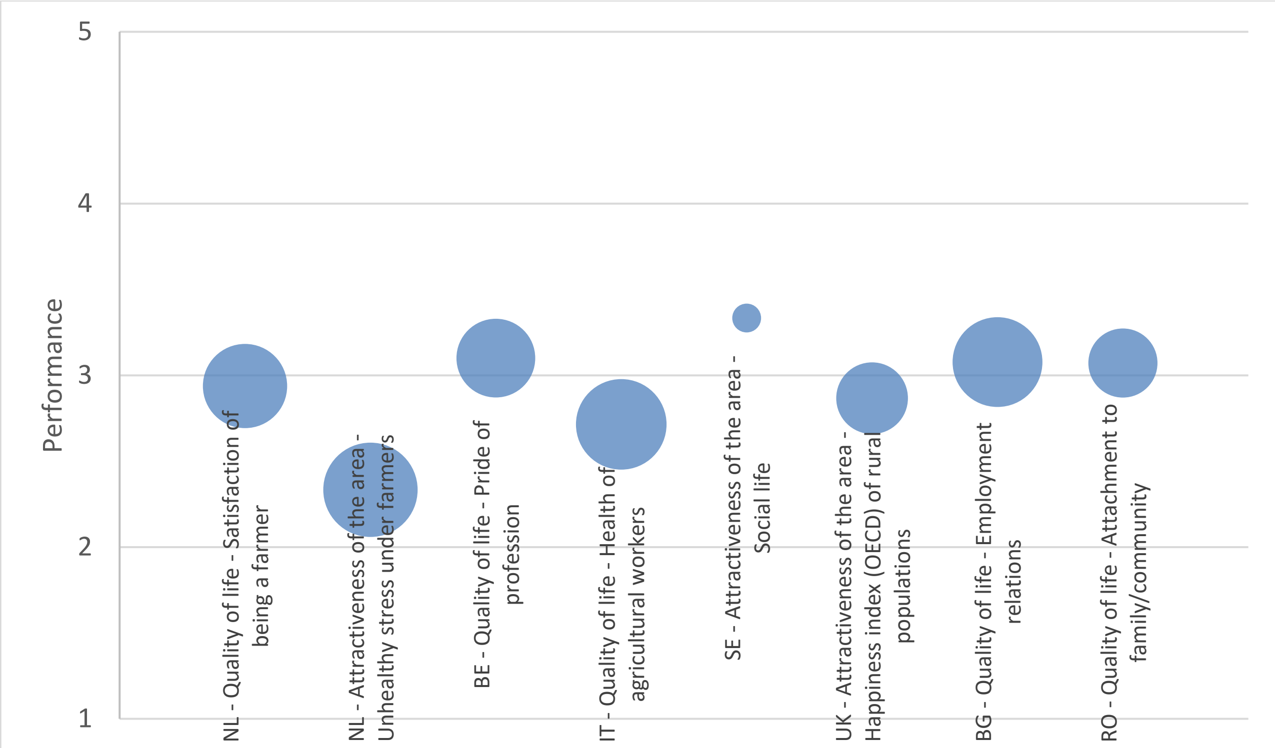

Figure 7. Perceived importance and performance of hard to measure social indicators. Importance is presented by the size of the bubbles and is on average more than three times smaller than indicators with highest importance.

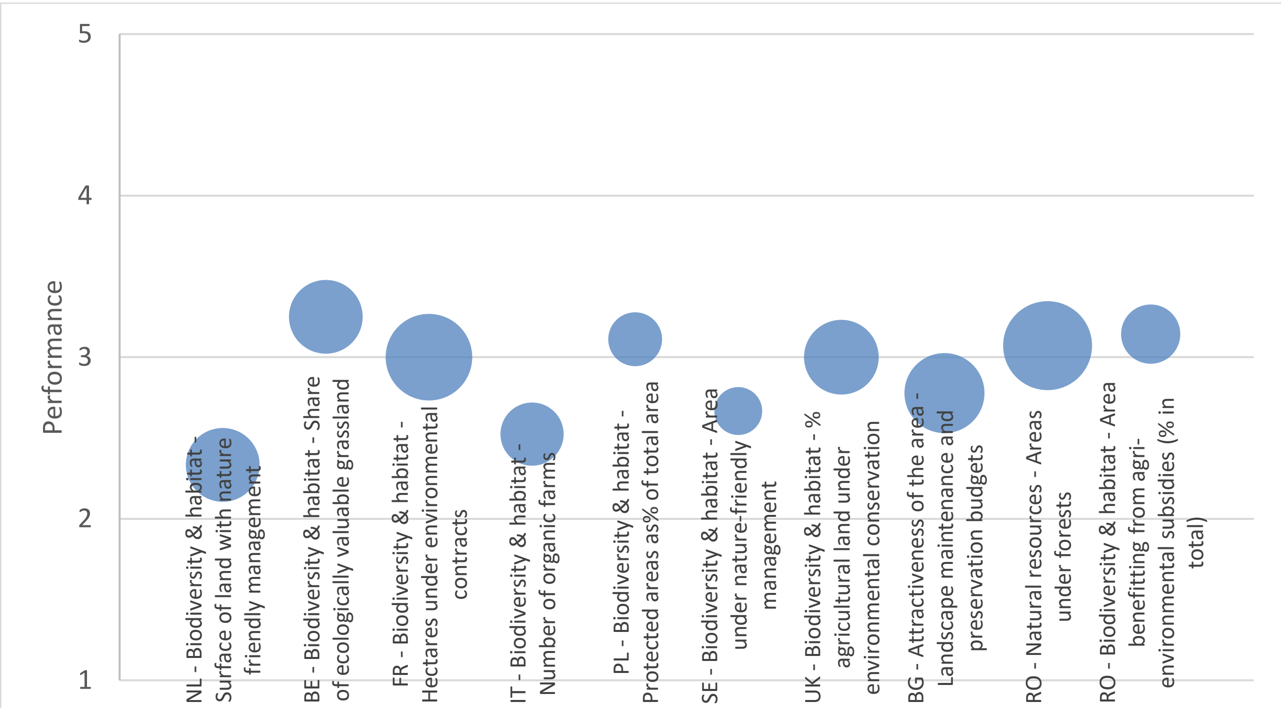

Figure 8. Perceived importance and performance of indicators related to nature friendly management. Importance is presented by the size of the bubbles and is on average more than three times smaller than indicators with highest importance.

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4.5 Indicator dynamics

Participants sketched dynamics of most important indicators of the system. The selection of indicators followed more or less the perceived importance of functions, emphasizing the importance of "Food production" and "Economic viability" (Table 10). Other, less important functions were also represented occasionally in different case-studies.

Table 10. Selection of main indicators that were used in the sketching exercise. Case-studies included: all.

Function	Number of indicators of which dynamics were discussed
Food production	7
Bio-based resources	0
Economic viability	10
Quality of life	2
Natural resources	4
Biodiversity & habitat	3
Attractiveness of the area	2
Animal health & welfare	1

During the sketching of indicator dynamics, participants often indicated that they were not aware of the exact year to year variation. However, in general, they felt confident to mention trends and to indicate where major changes happened that impacted the dynamics of the indicator. As a result, graphs in the workshops often show line segments that represent trends that are now and then interrupted to represent the impact of a major change. In general, participants were more capable of identifying the long-term stresses or developments that caused the observed trends. This could explain why there was an increased emphasize on long-term pressures during the workshop compared to the preparation phase (see section 1.2).

4.6 Strategies

By assessing implementation and effects of strategies (related to indicators) it is possible to move from the question "resilience for what purpose" to the question "what resilience capacities?" (From step 3 to 4 in the resilience framework; Figure 1).

4.6.1 Relation of strategies to resilience attributes

For most discussed indicators and identified challenges, participants were able to come up with strategies. Strategies are in general not directly comparable across case-studies. However, strategies could be categorized by evaluating links with resilience attributes. A link implies that a strategy is contributing to a specific resilience attribute. For "Infrastructure for innovation" dependence of strategies on the attribute is also seen as a contribution, because supply for innovation can only be sustained by and co-evolve with demand. Across case-studies, strategies

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could also be linked when they were based on similar principles, e.g. adding value, reducing costs, learning. In this report, a few examples will be provided of categorized strategies to provide insight in the data that was gathered during the FoPIA-Surefarm workshops. More details on strategies can be found in the individual case-study reports that are presented in the Supplementary Materials A-K.

"Reasonably profitable" is the attribute to which most strategies could be linked (Table 11). Other resilience attributes to which a high share of strategies could be linked are "Production coupled with local and natural capital", "Functional diversity", "Socially self-organized", "Infrastructure for innovation" and "Legislation coupled with local and natural capital". Taking into account that strategies were identified for indicators related to the important functions "Food production" and "Economic viability", it could be concluded that the resilience attributes with many links to strategies are important to the farming system. In that sense, strategies primarily designed to improve specified resilience can contribute to resilience attributes and hence general resilience. However, from another perspective it could also be said that typical concepts from resilience thinking are unintentionally contributed to by the strategies (such as diversity and self-organization), while the strategies are meant for keeping control over the functions of "Food production" and "Economic viability".

In multiple case-studies, strategies were mentioned that are related to reducing costs, technology implementation, scale enlargement. Strategies related to these categories were aimed at increasing production and/or cost efficiency. In most cases these strategies were related to improving the economic viability of a farming system, but also for instance to improve maintenance of natural resources by introducing more sustainable practices. Case-studies in which this kind of strategies got emphasis are BE, ES and BG. In the Belgian case, these strategies were positively affecting robustness, while mostly negatively affecting transformability. This was explained by the relative high investment costs for these strategies, causing a lock-in on the pathway to higher efficiency. In the case-studies ES and BG, where production is still less intensive than in BE, initial investments for implementing strategies for higher efficiency are lower than in BE.

Sometimes similar strategies were selected for different indicators. This happened for indicators that represented "Food production" and "Economic viability" in the NL and IT case-study. Indicators of these functions are linked in the sense that the level of food production per hectare is associated with profit per hectare and income of farmers.

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Table 11. Number of strategies linked to each of the FoPIA-Surefarm resilience attributes. Strategies can belong to multiple attributes. Linkages between strategies and attributes are made by the research team, based on discussions during the workshop and the function and indicator to which the strategies belong. Case-studies included: BE, BG, DE, ES, IT, NL, PL, RO, SE, UK.

Resilience attribute	Number of links between strategies and attribute
Reasonably profitable	54
Coupled with local and natural capital (production)	22
Functional diversity	15
Response diversity	8
Exposed to disturbance	4
Spatial and temporal heterogeneity (farm types)	3
Optimally redundant (farms)	1
Supports rural life	12
Socially self-organized	21
Appropriately connected with actors outside the farming system	5
Infrastructure for innovation	13
Coupled with local and natural capital (legislation)	12
Diverse policies	3
None	5

4.6.2 Level of implementation

Strategies related to “Socially self-organized” and related to organizational forms of farming system actors are poorly to well implemented (Figure 9). In the Spanish farming system there is one important cooperative in the sector that has grown strongly in the last years. The farmers do however not put full trust on that cooperative. So, there are some farmers who prefer not to belong to cooperatives anymore and find new commercialization channels on their own. As a result, the level of implementation of cooperatives in the ES case-study is low. In the Italian case-study, most hazelnut farmers are in a producer organization. In order to add value by processing hazelnuts more locally, further investment in and by cooperatives is needed.

Strategies related to “Infrastructure for innovation” are poorly to well implemented (Figure 10). In the Italian case-study, the introduction of self-propelled harvesting machines increased labour efficiency and profitability substantially. Participants in this case-study saw little room for further improvement. In the case-studies in NL and SE, participants experienced that applied strategies were not implemented to the fullest. However, in the Dutch case-study for instance, participants indicated that the current low profitability in the farming systems does not allow many farmers to invest in precision agriculture. In the Swedish case the level of implementation differed across the two production lines (egg and broilers production), and is to large extend driven by the market demand for these products.

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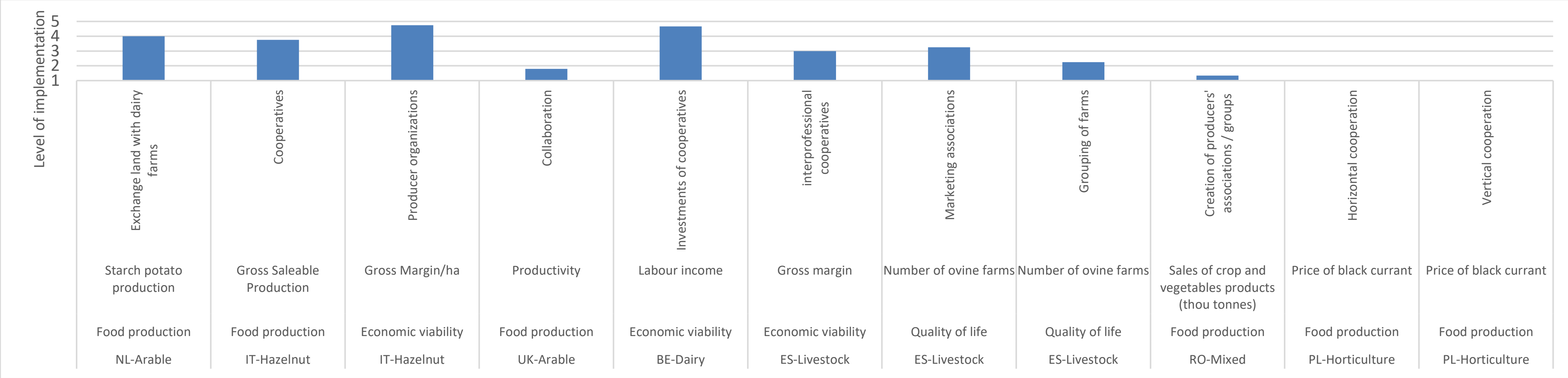

Figure 9. Implementation levels of strategies linked to "Socially self-organized" and related to organizational forms of farming system actors. Scores are from 1 to 5, where 1 is not/hardly implemented and 5 is perfectly implemented.

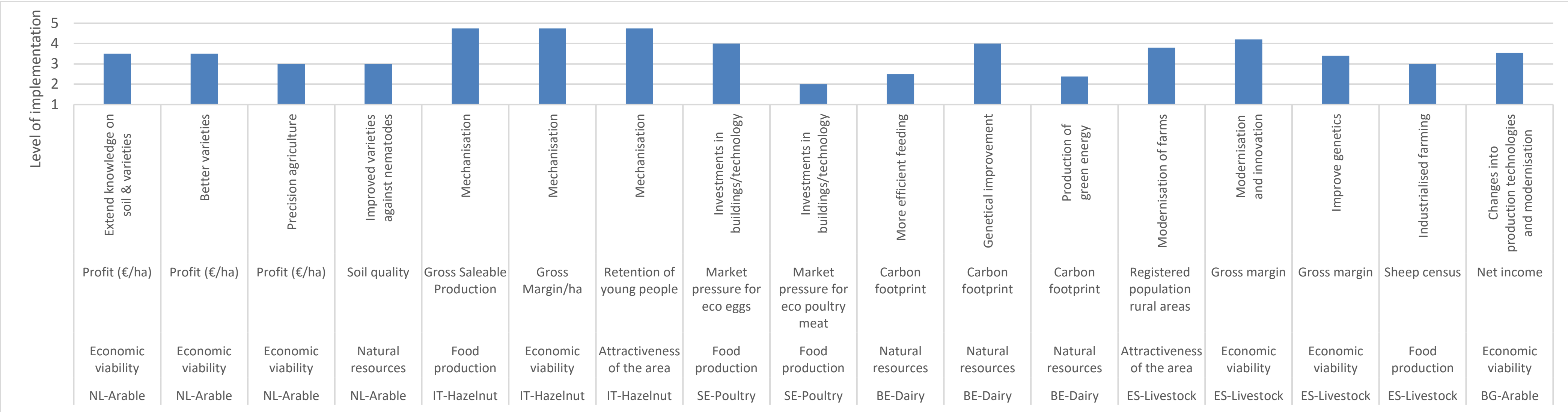

Figure 10. Implementation levels of strategies related to "Infrastructure for innovation". Scores are from 1 to 5, where 1 is not/hardly implemented and 5 is perfectly implemented

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4.6.3 Contribution to resilience capacities

Strategies related to organizational forms of farming system actors and linked to the resilience attribute “Socially self-organized” are mainly linked to the functions “Economic viability” and “Food production” (Figure 11). Strategies related to “Social self-organization” are perceived to positively contribute to all resilience capacities, except for “collaboration” in the UK case-study and “vertical cooperation” in the PL case-study, where the effect on transformability is expected to be negative. The expected effects differ across case-studies.

Strategies related to “Infrastructure for innovation” are mostly implemented to improve economic viability and food production through increased efficiency (Figure 12). Strategies related to “Infrastructure for innovation” are perceived to positively contribute to robustness and adaptability. Potential effects on these resilience capacities are mainly assessed to be low to moderate. However, for transformability, perceived contribution is often low or even negative. In the Belgian case-study for instance, the strategy “genetical improvement”, related to increasing production efficiency, was identified as supporting robustness, but negatively affecting transformability. In the Swedish case-study, “investment in buildings/technology” was evaluated as mainly contributing to adaptability, but negatively affecting transformability.

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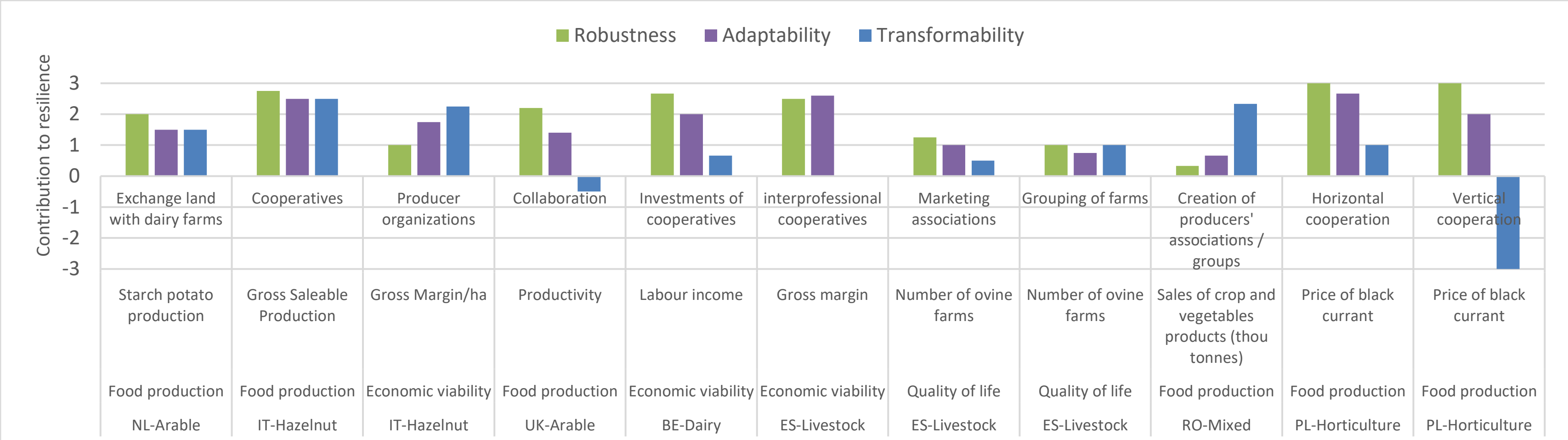

Figure 11. Assessed potential contributions of strategies to resilience capacities. Strategies are linked to the attribute "Socially self-organized" and related to organizational forms of farming system actors. Scores are from -3 to 3, where 0 is no, 1 is weak, 2 is moderate and 3 is a strong effect. A '-' indicates a negative effect. For the case-study ES-Livestock, transformability was not scored for strategies related to "Gross margin".

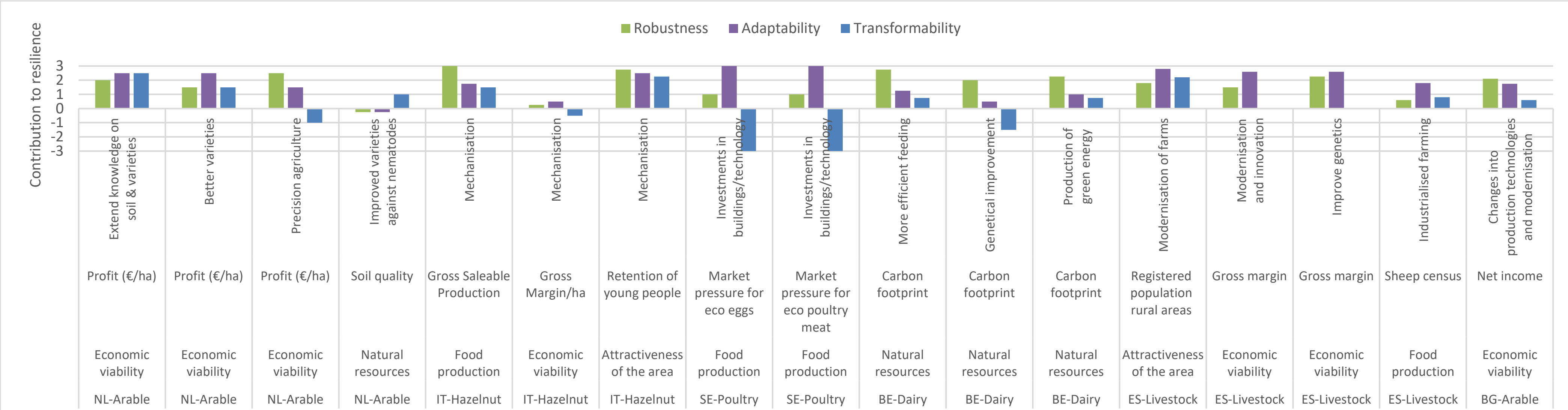

Figure 12. Assessed potential effects of strategies to resilience capacities. Strategies are linked to the attribute "Infrastructure for innovation". Scores are from -3 to 3, where 0 is no, 1 is weak, 2 is moderate and 3 is a strong effect. A '-' indicates a negative effect. For the case-study ES-Livestock, transformability was not scored for strategies related to "Gross margin".

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4.7 Resilience attributes

In nine case-studies, the scoring of the presence level of resilience attributes (Table 6) was conducted. In addition, the contribution of resilience attributes to resilience capacities was assessed. The proposed list of attributes (Table 6) is a response to the question "which resilience capacities" (step 5 of the resilience framework; Figure 1). By assessing level of presence and contribution of resilience attributes to resilience capacities, the question "what resilience capacities?" is addressed (step 4 in the resilience framework; Figure 1).

For the Spanish case-study, only importance of attributes was assessed, which can be seen as an exercise combining presence and contribution of attributes to resilience capacities. In this section, first the assessed level of attributes is communicated. After that, assessed potential contribution of attributes towards resilience capacities is communicated separately for robustness, adaptability and transformability. Finally, overall scores for resilience and resilience capacities are presented per case-study.

4.7.1 Level of presence

The extent into which resilience attributes are present in the case-studies differs (Figure 11). In general, resilience attributes are weakly to moderately present in the case-studies. The Italian and Swedish case-studies are an exception with multiple resilience attributes that are assessed to have a moderate to good presence. The Polish case-study often shows lowest scores. "Functional diversity" and "Legislation coupled with local and natural capital" are assessed to have a low to very low presence in all case-studies, except the Swedish case-study. The attribute "Functional diversity" – which means "high variety of inputs, outputs and income source and markets" – is scored low in the Polish case-study on horticulture, because stakeholders believe that there is a critical situation with regard to their income sources and the available markets for their products. Horticulture has quickly perishable products, so access to markets is a must for good functioning. Especially due to the Russian embargo the access to one of the key markets ceased. "Diverse policies" is scored low in all case-studies. Except for the Italian case-study, "Reasonably profitable" also is assessed to have a low to very low presence. "Production coupled with local and natural capital", "Response diversity", "Exposed to disturbance", "Spatial and temporal heterogeneity", "Supports rural life", "Socially self-organized" and "Infrastructure for innovation" often are assessed to have a low to moderate presence. In the co-creation platform, participants assessed that for the EU agricultural sector "spatial and temporal heterogeneity" and "Socially self-organized" were performing moderately to well and "Reasonably profitable" was performing low.

Mixed systems (Romanian and German case-study) are not scoring higher for perceived presence of "Functional diversity" compared to other case-studies. However, for "Response diversity" the

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Romanian and German case-study are among the higher scoring case-studies. In the German case-study, the low score for "supports rural life" is mainly explained by the remoteness of many farms to main cities, whereas in the Swedish case-study low scores were associated with the availability of and access to public services. In the Polish case-study however, "supports rural life" is scored low while the farms are located relatively close to the capital. "Spatial and temporal heterogeneity of farms" has a relatively high score for all case-studies, compared to other attributes. In many case-studies (e.g. NL, BE, DE, UK) many farms have stopped and remaining farms have grown bigger, reducing heterogeneity to some extent. Still, in most case-studies, heterogeneity was assessed to be moderately present. Related to this is the attribute "optimal redundancy (farms)", which scored lower. The low score for the NL case-study is mainly related to the difficulties for potential farm successors to take over the farm. In the Spanish case-study, it was explicitly mentioned that the fact of a farmer stopping farming imposed a problem for the system, indicating that redundancy is low. However, the attribute "optimal redundancy (farms)" was not assessed in the Spanish case-study.

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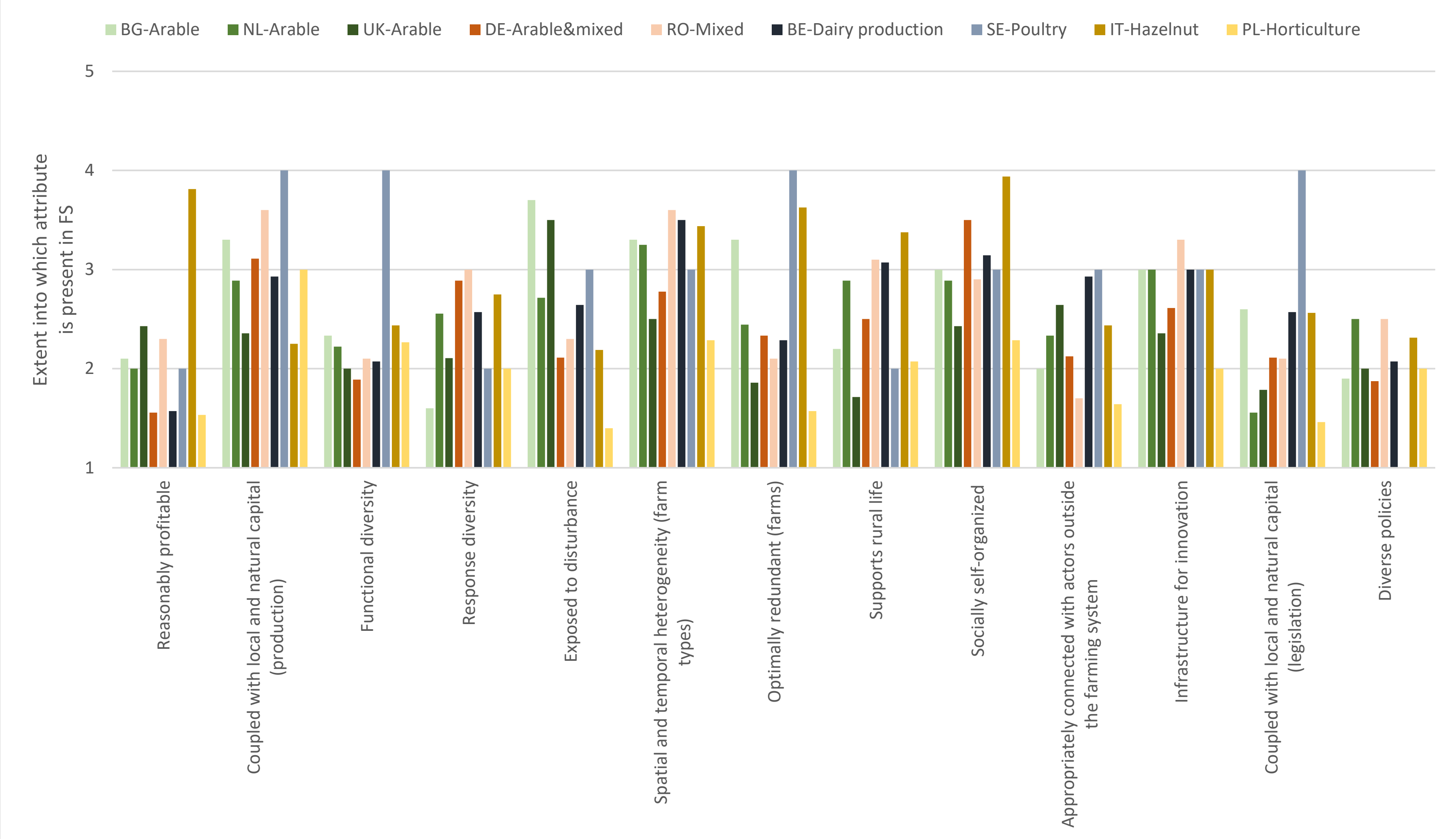

Figure 11. Perceived level of presence of resilience attributes. Score from 1 to 5: 1) no/very low, 2) low, 3) moderate, 4) high, 5) very high presence.

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4.7.2 Contribution to resilience capacities

4.7.2.1 Robustness

Overall, resilience attributes were assessed to have a very weak to moderate positive contribution to robustness, except for some attributes in the Polish, Romanian and Bulgarian case-study where negative contributions were perceived (Figure 12). With regard to the Polish case-study for instance, horticulture producers think that the current legislation in many cases is not helping them to be robust; on the contrary, it is restricting their activities which makes it even more difficult for them to be robust. For example, the Polish legislation on plant protection products was more restrictive than the legislation at EU-level. Also, according to participants in the Polish CS, current legislation does enhance regulation of the market not enough with regard to finding new markets after the Russian embargo, dealing with price fluctuations and improving market information.

PL, RO, BU and NL case-studies have often lowest scores compared to other case-studies. “Reasonably profitable” shows moderate positive contributions to robustness in all case-studies, except for the PL, BU and RO case-studies. “Production coupled with local and natural capital” also shows moderate contributions to robustness, except for case-studies in BU and RO. “Response diversity” shows weak to moderate contributions to robustness in all case-studies. All other attributes show large variation across case-studies. In the German case-study for instance, participants assessed the potential contribution of “Functional diversity” and “Socially self-organized” as moderate to high, where participants in the Polish case-study assessed these attributes’ potential to contribute as very weak. Low positive scores for “Exposed to disturbance” are in multiple case-studies due to contrasting views among stakeholders, e.g. the UK and NL case-study. A very low score has been given for “Appropriately connected with actors outside the farming system” in the Italian case-study, pointing specifically to the downstream industries processing hazelnuts that are perceived not enough linked to the local system. The attribute “Socially self-organized” scores relatively high in the Italian case-study due to the large presence of Producers Organizations.

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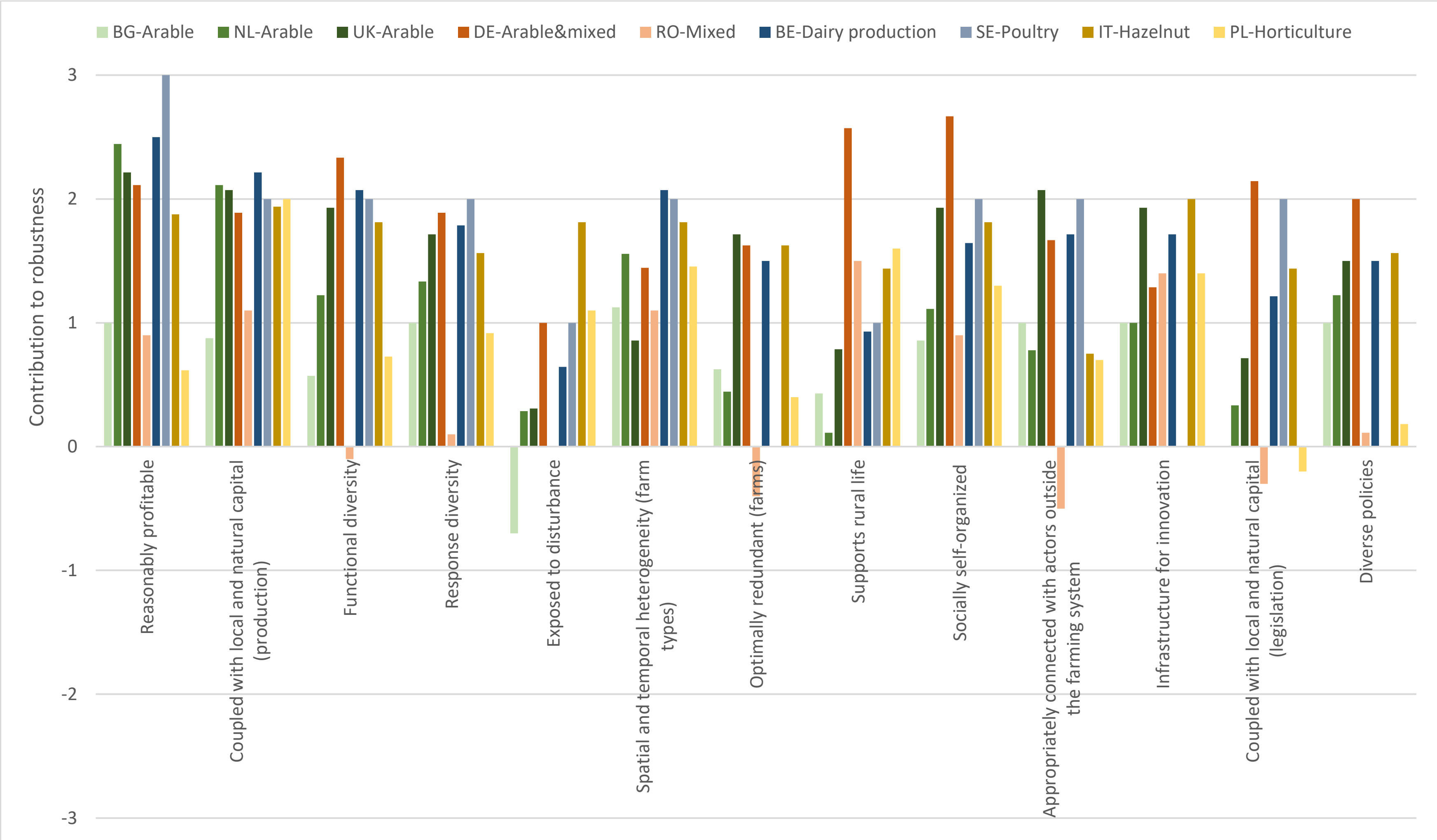

Figure 12. Perceived contribution of resilience attributes to robustness. Scores potentially can range from -3 to 3. Where a score of 1 = weak, 2 = moderate and 3 = strong contribution. '-' indicates a negative contribution.

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4.7.2.2 Adaptability

Contribution of attributes towards adaptability is mainly perceived as weakly to moderately positive (Figure 13). For “Reasonably profitable”, participants in the Polish case-study indicated a negative contribution to adaptability. In the perception of participants in the Polish case-study, the fact of economic viability being assured, makes the need for adaptation redundant. The contribution of “Production coupled with local and natural capital” to adaptability is relatively high compared to other attributes and showed relatively little variation across case-studies.

On average across case-studies, least contributions to adaptability is expected from the attributes “Exposed to disturbance”, “Optimally redundant (farms)”, “Supports rural life”, “Appropriately connect with actors outside the farming system” and “legislation coupled with local and natural capital”. Average scores for these attributes are indicating no to weak contributions to adaptability. However, for each of these attributes there are at least a few case-studies in which contribution to adaptability is assessed as weakly to moderately.

In case of Poland, the attribute “Functional diversity” scores high for adaptability. This can be understood in the context of changing in consumers’ preferences that create new markets. These markets create space for the farming system to adapt. Also, for the Polish case-study, the attribute “Supports rural life” is scored relatively high for adaptability, compared to the other attributes in that case-study. Participants in this case-study suggested that a high level of this attribute (e.g. through investments in infrastructure, provision of services for young and old generation, incentives for rural renewal) brings about a motivation for adaptation of the farming system as well.

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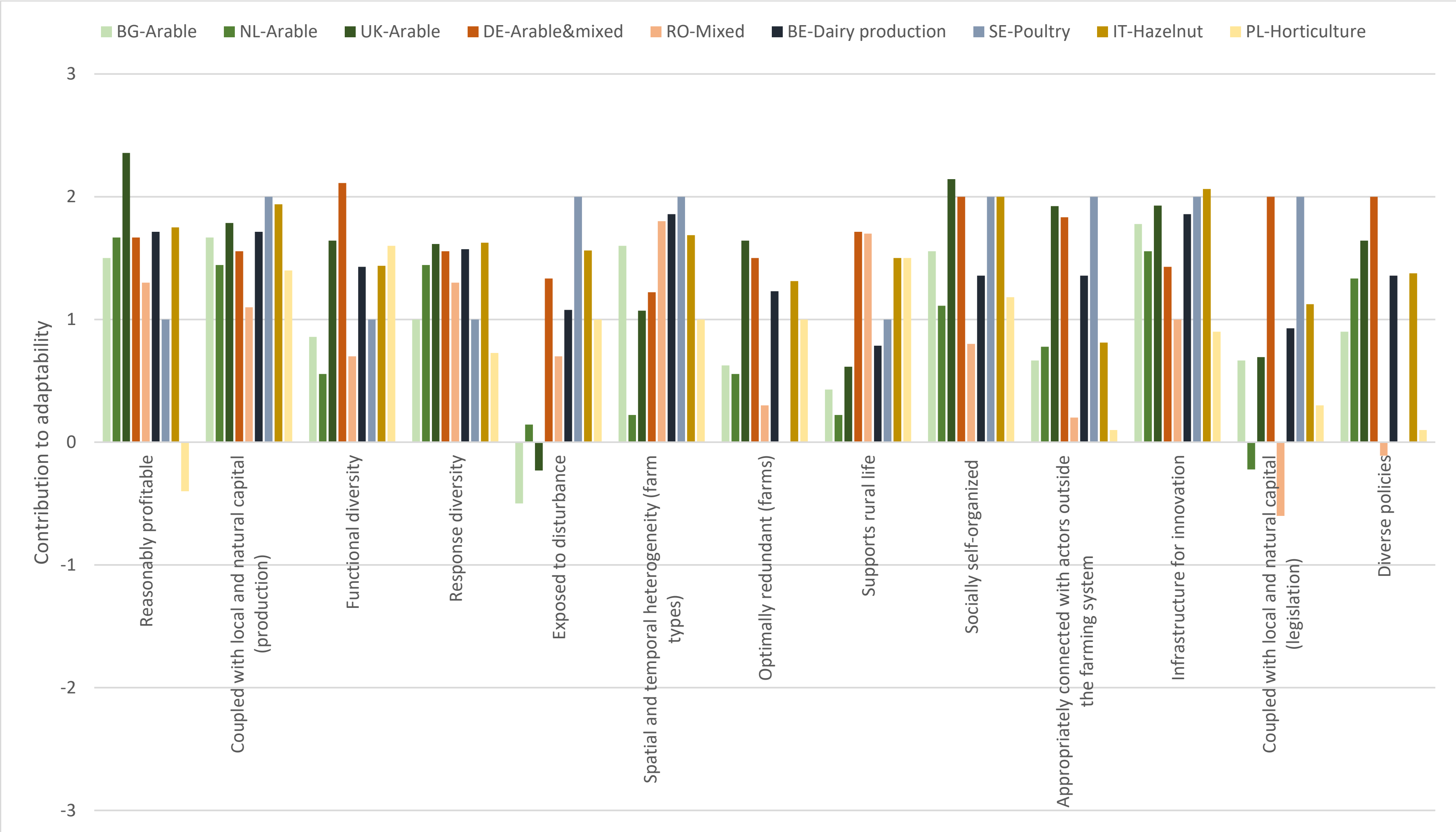

Figure 13. Perceived contribution of resilience attributes to adaptability. Scores potentially can range from -3 to 3. Where a score of 1 = weak, 2 = moderate and 3 = strong contribution. '-' indicates a negative contribution.

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4.7.2.3 Transformability

Contribution of resilience attributes to transformability is mainly perceived to be weakly positive (Figure 14). For “Reasonably profitable” there are two lines of thinking: 1) a high level of this attribute will help to build (financial) system reserves that could support a re-organization, e.g. to increase environmental sustainability; 2) a high level of this attribute will reduce incentives to change. “Legislation coupled with local and natural capital” is another attribute where case-studies show contrasting results for perceived contribution to transformability. “Infrastructure for innovation” receives relative high scores for transformability across all case-studies.

In the UK case-study, participants are overall most positive about the potential effect of attributes. For other case-studies there is often a perceived potential for around three attributes with regard to transformability, but these attributes differ per case-study. For instance, the Polish case-study assess the potential for “Functional diversity”, “Response diversity” and “Infrastructure for innovation” highest. In the Polish case-study, participants see how diversifying can support transformability, provided there are enough innovative solutions to in the first place make the diversification happen. For the Italian case-study, the attributes with highest contribution to transformability are “Functional diversity”, “Socially self-organized” and “Infrastructure for innovation”. Results from the Italian case-study show that diversification, in the form of processing hazelnuts within the farming system, is dependent on social self-organization in the form of cooperatives. In the Italian case-study, the attribute “Exposed to disturbance” had the lowest score for transformability. This points to the perceived preoccupation that external factors could have negative consequences and that the system, because both being very specialized and based on a perennial crop (i.e. hazelnut), will not easily transform in the case of large disturbances

The accompanying statement of “Diverse policies” was “Policies stimulate all three capacities of resilience, i.e. robustness, adaptability, transformability”. Scores for the level of implementation were low across case-studies. The perceived potential contribution to resilience capacities differed between case-studies and capacities. The relative low scores for transformability indicate that participants perceive little opportunities for policies to support farming systems to re-organize, when also robustness and adaptability are stimulated.

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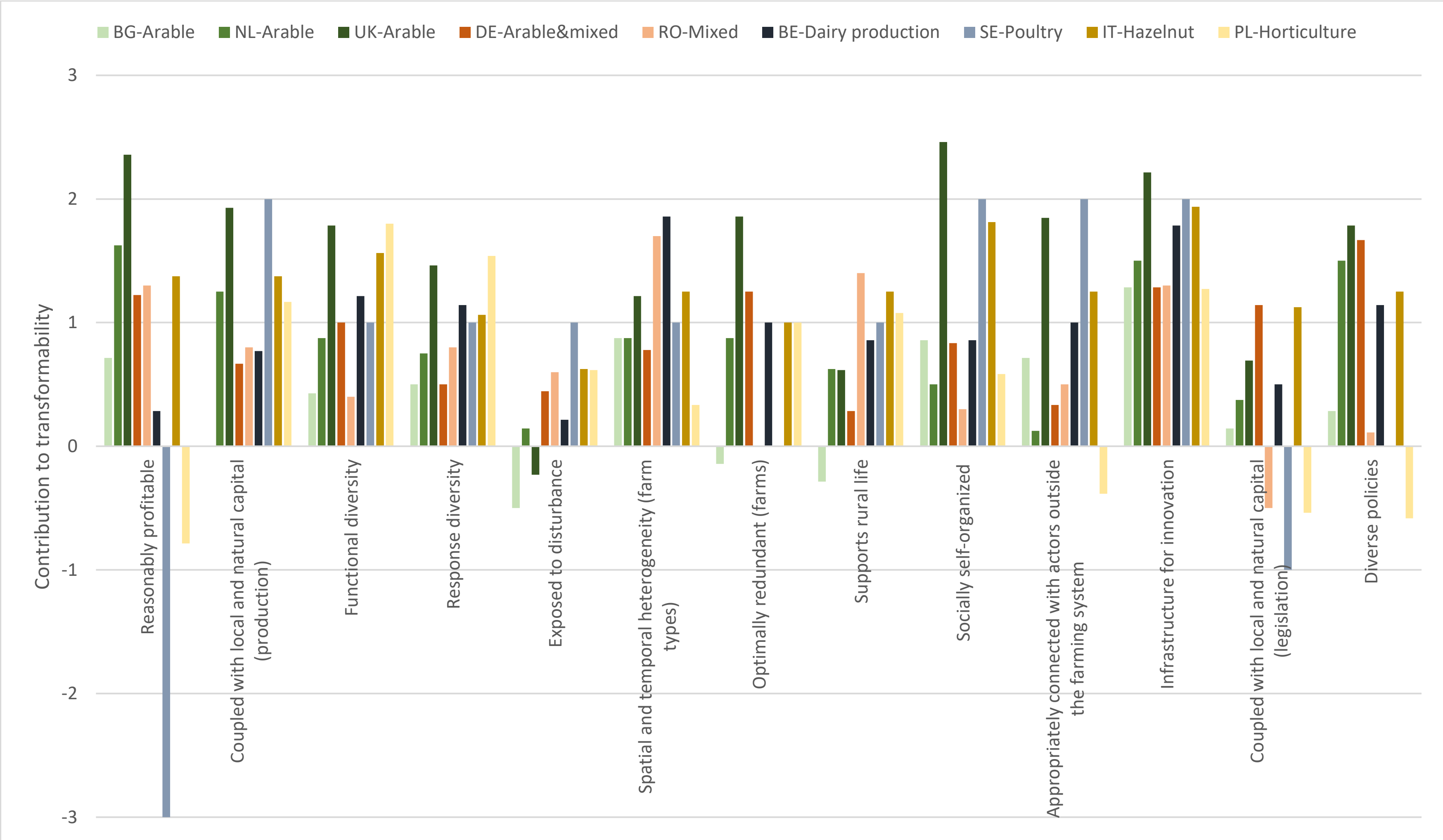

Figure 14. Perceived contribution of resilience attributes to transformability. Scores potentially can range from -3 to 3. Where a score of 1 = weak, 2 = moderate and 3 = strong contribution. '-' indicates a negative contribution.

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Literature suggests that small-scale disturbances help to avoid too much rigidity in the consolidation phase of a system (Fath et al. 2015) and to keep adaptability of the system during the phase of renewal (Cabell & Oelofse 2012). In many case-studies, the resilience attribute "Exposed to disturbances" got contrasting scores within case-studies with regard to its perceived potential contribution to the resilience capacities. This shows that for some participants, disturbances are not acceptable at all, while other participants see the value of it. This could be explained by the rate of time preference of participants: small disturbances likely affect performance of main functions such as "food production" and "economic viability" directly, while adaptability is something that could become beneficial in the intermediate- to long-term. This could be related to the perception of participants on where the system is in its adaptive cycle: if participants expect their system to be far from the "release phase" and a need for re-organizing, a general focus on growth and increased efficiency might be dominant over attention for adaptability. Moreover, participants' focus on "reasonably profitable" and "Production coupled with local and natural resources" might indicate a preference of increasing system reserves rather than disturbances as a basis for system adaptability and transformability.

4.7.2.4 Overall resilience

By combining levels of presence and assessed contributions to resilience capacities, a score for each resilience capacity was calculated (Equation 3 and 4). Based on presence alone, resilience is assessed to be low to moderately, assuming that all attributes contribute strongly to resilience (Figure 15). Taking into account the assessed contribution of attributes to each capacity, resilience is considered low. In the Bulgarian and Romanian case-studies, there is a relative large difference between resilience scores based on presence of attributes alone, compared to presence being combined with contribution. This indicates that potential contribution of resilience attributes is assessed to be low.

The arable systems and the horticulture system are among the lower scoring case-studies. The case-studies on poultry (SE) and hazelnut (IT) are the higher scoring. In most case-studies, resilience capacities are perceived to be different, based on scoring exercises and discussions. Kruskal Wallis tests suggest that transformability is lowest in BG, DE, BE, NL and IT. For the UK case-study the scoring of attributes and discussions suggest that there was a balance between the three resilience capacities. This balance was explained by the high possibility of BREXIT becoming a reality for the participants in this specific case-study, bringing transformability at equal levels with robustness and adaptability. For SE the conclusion was drawn that this case-study was more robust and adaptable then transformable. When talking about transformability, stakeholders in the Swedish case-study related the transformability with environment related transformations. The Bulgarian case-study shows higher adaptability, which was also supported by the outcome of the strategy scoring. The participants in this case-study indicated that

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adaptability is applied to become more robust and also efficient, while avoiding any kind of transformation.

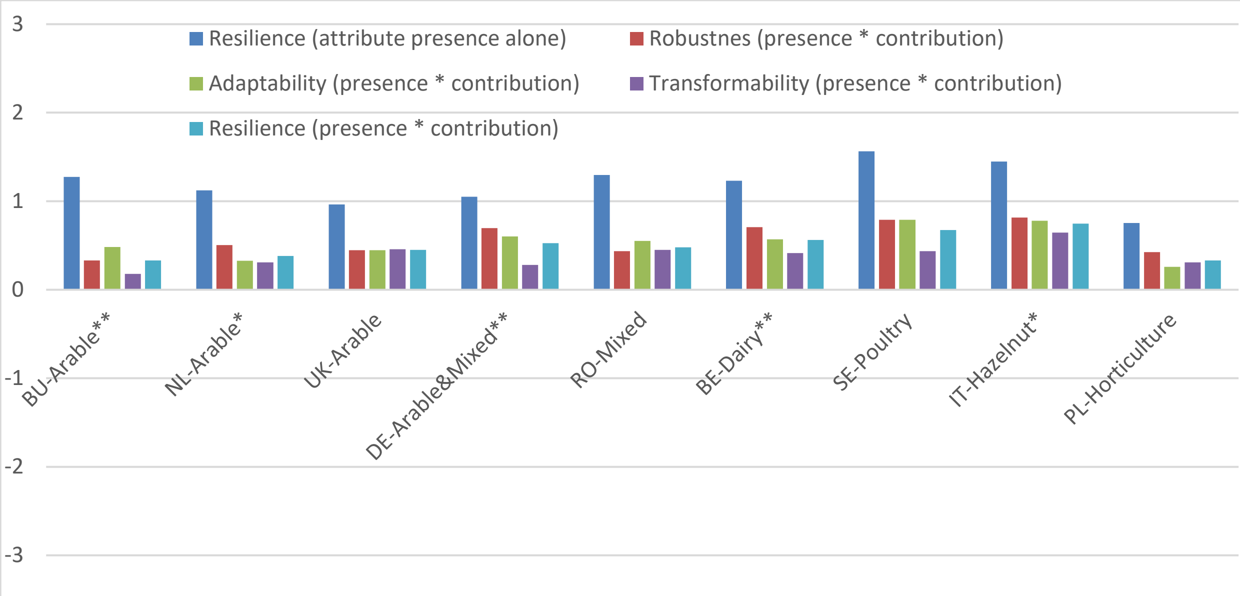

Figure 15. Overall resilience based on attribute presence scores alone (assuming a strong contribution of each attribute), and based on presence score times contribution scores for the different resilience capacities. Scores could potentially range from -3 to 3, where 3 would imply optimal presence of resilience attributes, all having a strong positive effect on resilience (capacities). '' and '**' indicate that Kruskal Wallis test suggest there are differences between scores for robustness, adaptability and transformability at the probability levels of 10 and 5%, respectively.*

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5 Discussion

5.1 Farming system identity

5.1.1 Main functions and indicators

FoPIA-Surefarm uses stakeholder perceptions of importance of functions and indicators to perceive the identity of the farming system, i.e. characteristics that define the system. Following this logic, results from the workshops show that the production of the most important crop(s) and livestock products, the economic viability and the maintenance of natural resources determine the identity of the system. The economic viability is often described in general economic terms, which makes it a good indicator for comparison among case-studies. The important crops are very different among case-studies and in most case-studies, quantity rather than quality of production is the more important indicator. This could indicate that stakeholders are in general satisfied with quality and therefore mainly aim at increasing quantity. Additionally, indicators that represent maintenance of natural resources are in most case-studies general and comparable, e.g. soil quality and water availability.

The function of providing bio-based resources is regarded as having low importance. This low importance seems in contrast with a transition towards a bio-based economy, propagated amongst others by the European Commission. The current theme of circularity in agriculture might help to increase the relative importance of bio-based products. Also the positive relation found between perceived importance and perceived performance of delivery of bio-based resources, might indicate that importance of this function can still grow, provided that a certain performance can be met.

Interestingly, the functions (and their representative indicators) that represent the social domain, “Quality of life” and “Attractiveness of the area” were not given much importance compared to most important functions. Winkler et al. (2018) also found that in research on land-based systems, social indicators are often not discussed, but potentially important. For the studied farming systems, it could be stated that there is an imbalance in importance among the economic, environmental and social domain. This imbalance could be caused by a more or less conscious trade-off by farming system actors. The trade-off is likely to be induced by perceptions of most important challenges and functions. Stakeholders that are faced with direct, immediate challenges in the economic and environmental domains could tune their decision making process to those domains and develop a lack of attention for the social domain. At the other hand, decisions of stakeholders are also based on existing perceptions of the context (Darnhofer, Fairweather, & Moller, 2010 citing Aerni, 2009) which in our view also includes the perceived importance of system functions. The prioritization of challenges and decision making based on

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the perceived context could enhance each other, creating a pathway towards the domination of a few functions and domains where the more urgent challenges lay, but not always the most important. With regard to this, Ericksen (2008) mentions that the degree into which reaction to fast processes is preferred over slow processes may indicate vulnerability of a (food) system. It should be noted that especially ecological resilience of systems depends on slow processes and variables (Ericksen 2008; Quinlan et al. 2016; Carpenter et al. 2001).

5.1.2 Performance

Across case-studies, functions that represent private goods are perceived to have low to good performance, while functions that represent public goods have a low to moderate performance. Configurations where all functions that represent public goods are performing well are lacking from the pallet with the 11 SURE-Farm case-studies. Although participants in some case-studies indicated that public functions were important for supporting private functions, it is very well possible that trade-offs occurred between functions. These trade-offs can happen at different scales (Groot et al. 2007), which could explain why, for instance, participants see how soil quality can improve yields at farm level, while trade-offs beyond the farm level such as water pollution and eutrophication are not considered.

Performance scores of highlighted social indicators, that are hard to measure otherwise, are low to moderate (section 4.4.2). The allocated low importance to functions that represent the social domain are in contrast with these performance scores: when stakeholders would increase their perception of importance of the social domain, the low performance might actually be the cause of a crisis: low to moderate performance will no longer be acceptable. When stakeholders are realizing that (components of) their farm(ing) system no longer are functioning, the consequent crisis does not need to imply the end of the system as also opportunities arise and a transformation may follow (Darnhofer 2014). However, with current low profitability in most case-studies, it does not seem likely that stakeholders will be inclined to allocate more importance to the social domain.

The previous paragraph could also apply for the performance and importance of highlighted indicators related to the function “Biodiversity & habitat” (section 4.4.2). However, with regard to this function, public opinion and legislation are more dominant, more or less forcing farming system actors already to respond. In the Dutch and German case-study for instance, certain strategies, although developed more for maintenance of natural resources, could also benefit biodiversity in the region.

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5.2 Farming system resilience

All farming systems show, at least to some extent, signs of robustness, adaptability and transformability. Regarding the identified strategies, contributions to the resilience capacities were mostly positive, but there were also quite a few cases where transformability was negatively affected. For strategies related to increasing efficiency, different patterns were found in for instance the Belgian case-study on the one hand and the Bulgarian and Spanish case-studies on the other hand. The farming systems in the Bulgarian and Spanish case-study are relatively recently affected by changes in the last two decades. The Spanish, Bulgarian and Belgian case-study could be considered as being in different phases of the adaptive cycle (Holling et al. 2002). The Spanish case-study could be considered to be in a phase of reorganization after more than half of the farms in the farming system disappeared. The Bulgarian case-study could be considered in the exploitation phase after Bulgaria joined the European Union, which made more intensified agriculture possible through increased payments to farmers. The Belgian case-study could be considered in a phase of conservation, i.e. keeping the system as it is, mainly focussing on robustness of current production levels, but being inflexible to transform. In the case-studies of Spain and Bulgaria, strategies related to an increase in efficiency are indicated to improve all three capacities and helping the systems further in their current phase. However, in the Belgian case-study, these strategies actually impede transformation, i.e. moving to the phases of release and re-organization, for instance to improve performance of moderately scoring environmental and social functions. Increasing efficiency can thus be understood as a phase-specific resilience attribute, which can explain why it is not among the more general resilience attributes as proposed by Cabell & Oelofse (2012). Increasing efficiency is also associated with the control rationale, focussing on robustness and contrasting the resilience rational, focussing on adaptability and transformability (Hoekstra et al. 2018). Hoekstra et al. (2018) present both rationales as two extremes of a spectrum and suggest that for most social-ecological systems a bit of both rationales is needed. From this point of view, increasing efficiency in farming systems can also co-exist and even contribute to other strategies, more in line with the resilience rationale.

Regarding the resilience attributes, the three resilience capacities are positively connected with one another, i.e. participants in the case-studies generally perceived a synergy between the three resilience capacities. However, levels of contribution to the resilience attributes differed from case to case. Also, in some case-studies, stakeholders even perceived a trade-off between the resilience capacities. Hence, caution is necessary when evaluating farming system resilience by means of presence of resilience attributes.

In most case-studies, attributes' individual contribution to resilience was at most moderately, indicating that farming system resilience is dependent on multiple attributes. Also levels of

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attributes differed within case-studies and were at highest moderately present in most case-studies. This could suggest that not all attributes can be high at the same time. For instance through competition for the same resources (Darnhofer et al. 2010) or by being mutually exclusive.

It could be argued that increasing the level of presence of attributes requires progressively more efforts and resources, i.e. following the logic of diminishing returns, often used in (economic) production functions. From this point of view, resilience of the studied farming systems can be most easily enhanced by improving the economic and legislative conditions for agricultural production. Resilience attributes that represent these conditions are in general assessed as the attributes with lowest presence (section 4.6.1). From the perspective of generalization across case-studies however, it would be better to address attributes that are scoring positively for all resilience capacities in all case-studies. This is not the case for attributes related to legislation, but it is the case for the attributes “production coupled with local and natural capital”, “spatial and temporal heterogeneity of farm types” and “Innovation for infrastructure”. However, these attributes were perceived to have already a relative high level of presence. Both points of departure lead to attributes that represent the resilience principles as presented by Walker & Salt (2012): “openness”, “tightness of feedbacks”, “modularity” and “systems reserves”, but not “diversity”. Related to this, also the farming system process of “risk management” as defined in the SURE-Farm project is not addressed. Diversity and risk management are mainly represented by the attributes “Functional diversity”, “Response diversity” and “Exposed to disturbance”. These show in general low to moderate implementation levels, but vary widely across case-studies. Also their perceived effect on resilience capacities is different across case-studies, although mainly positive. Hence, increasing diversity and risk management practices is a less generalizable entry-point across case-studies, but certainly important for some case-studies. This is also reflected, but not entirely, in the chosen strategies in case-studies: strategies related to “functional diversity”, “response diversity” and “exposed to disturbance” were identified in six, three and two case-studies respectively.

The question still remains whether actors within and/or actors outside the farming system are capable of improving economic and legislative conditions. Strategies that were identified in the workshop also are often associated with the attribute “Reasonably profitable”, which mirrors the economic conditions in the case-studies. Most of the identified strategies can be applied by actors within the farming system. However, adopting certain strategies involves legislative change. Farmers in the Dutch case-study for instance, indicated that they were willing to adopt more efficient practices that also could enhance resilience, but that current legislation is constraining. With regard to legislative conditions, farming systems are most of the time dependent on actors outside the farming system. Ericksen (2008) mentions that institutional weaknesses and inflexible

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policies may be a sign of food system vulnerability. The studied farming systems, as parts of the wider food system, show low levels of presence for the attributes "Legislation coupled with local and natural capital" and "Diverse policies" while only a few case-studies show capabilities to moderately reach out to decision makers beyond the farming system level. Also the perceived potential contribution of these attributes to resilience capacities is low, especially for transformability. Within SURE-Farm, Feindt et al. (2019) also found that in general, agricultural policies are more geared towards robustness and adaptability and less towards transformability.

For increasing specifically transformability, "Infrastructure for innovation" is a resilience attribute that is accepted across all case-studies. However, it only contributes weakly to moderately and its assessed contribution to robustness and adaptability is higher. This is a general pattern: efforts to increase transformability through addressing resilience attributes will probably lead to higher robustness and adaptability in the first place. In that respect it can also be explained that the attribute "Diverse policies", that represents the stimulation of all three resilience capacities, is expected to have least impact on transformability. In the individual case-studies it was possible to define some strategies that were perceived as equally contributing to all three resilience capacities, for instance some strategies related to the resilience attribute "Socially self-organized" (Figure 11). Overall, from the workshop results it seems that in order to make policies for stimulating transformability work, a single focus on transformability is necessary, where improvements on robustness and adaptability can be side-effects. Additionally, these policies need to be case-specific.

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5.3 Methodological issues and further developments

The method of allocating importance to functions and indicators helped to filter out most important indicators according to stakeholders views for further analysis. Kinzig *et al.* (2006) mention the fourth proposition of Walker *et al.* (2006) stating that "*critical changes in social-ecological systems are determined by a small set of three to five key-variables*". In the case-studies presented in Kinzig *et al.* (2006), generally over five key-processes with accompanying thresholds are defined. Results of FoPIA-Surefarm show that in most case-studies around five indicators stood out in terms of importance. These will serve as the starting point for further analysis on system resilience, e.g. to analyse future scenarios. It should be noted that social indicators which are often neglected in research on land-based systems (Winkler et al. 2018) were evaluated as having low importance and not discussed into much detail.

Using the sketching approach helped participants to identify past and current strategies for resilience. This way we could avoid too much emphasize on desired, but not yet implemented strategies, which are much more related to future resilience. In a follow-up workshop, future resilience and new strategies will be evaluated.

The followed methodology and workshop outcomes comprise a few simplifications with regard to the resilience concept: 1) only a few main indicators per case-study were followed in detail over time 2) only trends and major challenges were observed by stakeholders for main indicators 3) assessment of performance of indicators and level of implementation of strategies and attributes is static. As mentioned before, a few main indicators could be sufficient to evaluate main dynamics and resilience of agricultural systems (Kinzig et al. 2006; Walker et al. 2006). Still, we realize with Quinlan *et al.*, (2016) that the simplifications may have come at the cost of truly understanding farming system dynamics in the case-studies. Also, the level of specificity on indicators and strategies related to identified challenges (specific resilience), might have influenced scorings of resilience attributes that are considered to be related to general resilience. Hence, conclusions on general resilience need to be drawn with caution. At the other hand, more knowledge on general resilience for a farming system can only be developed after measuring system performance after specific shocks, i.e. measuring specific resilience. So after all, it seems not possible to completely separate specified and general resilience. Currently, workshop outcomes provide an assessment of current resilience, but only explain into a certain extent the 'how' and the 'why', by using participants inputs in discussions and comments on presented results. Further analyses are necessary to expose the underlying structure for resilience and to move further beyond the descriptive phase, i.e. explore shocks, plausible policies and visions for the future in order to perform a complete resilience analysis (Walker et al. 2002). This is also the second and third aim of the integrated analysis tool of WP5 in SURE-Farm, of which FoPIA-Surefarm is part

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(section 1; Herrera et al. 2018). Additional activities are, for instance, the study on interactions between function importance & performance and attribute presence & contribution to resilience capacities. Other statistical analyses, using data from individual farms, could reveal exposure and vulnerability to shocks (Martin et al. 2017). Also follow-up workshops that are planned for Winter 2019/2020 can contribute to reveal more of farming system dynamics, including insights in critical thresholds and possible pathways towards transformation.

The sustainability and resilience assessment presented in this report is based on perceptions from a limited number of participants per case-study. Statistical methods applied to test differences between perceptions of stakeholder groups and resilience capacities have limited meaning due to a low number of observations from a non-random sample. Hence, results of statistical tests are not hard proof for detected differences. Stakeholder selection and participation probably has influenced results. For instance, social indicators could have been evaluated with higher importance when organizations in the social domain would have participated more in the workshops. In the case-studies where a gender-related indicator was assessed, participation of women was below the critical mass of 30% to have adequate influence in the assessment (Dahlerup 1988). With regard to participation, it should be noted that towards the end of the workshops, participants' fatigue may have influenced reliability of answers for the last exercises. In those exercises, presence of strategies and attributes and their contribution to resilience capacities was assessed. Also participants understanding of robustness, adaptability and transformability might have deviated from the definitions as proposed in SURE-Farm. In the Dutch case-study for instance, we experienced from start to end that participants had different notions about resilience, but that they were happy to use the workshop format to discuss farming system challenges, i.e. using resilience as "boundary object" (Brand & Jax 2007). Hence, conclusions on effects of strategies and resilience attributes on resilience need to be drawn with caution.

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6 Conclusion

Main functions of the studied farming systems relate to food production, economic viability and the maintenance of natural resources. Most studied farming systems are perceived to perform moderately for most functions, indicating moderate levels of sustainability. Often there is cause for concern for at least one function with low performance.

Strategies in the past show that farming systems are adaptable, but mainly with regard to making the system more efficient, profitable and robust. Still, participants in workshops often perceived also positive contributions of strategies on adaptability and transformability.

Overall resilience of studied farming systems is low to moderate. Currently, most farming systems show more signs of robustness than adaptability or transformability. Multiple attributes, but not all, are important in building system resilience. Relative importance of attributes differs between the current and potential situation, i.e. there are certain attributes with low presence levels while having high potential for contributing to resilience.

Importance of attributes is case-study specific. Some generalizations can be made with caution. Currently, most important attributes contributing to resilience are related to having agricultural production coupled with the local and natural capital, spatial and temporal heterogeneity of farm types and social self-organization of actors in the farming system. Policies should be designed to safeguard the presence of these attributes. Especially in the light of ongoing trends of intensification and scale-enlargement that could diminish presence of these attributes in EU farming systems. An attribute that currently has low presence, but is perceived as having high potential for building resilience, is related to the profitability of the farming systems. Attributes related do diversity and risk management had varying and generally low to moderate perceived presence and contributions to resilience. Hence, although important in some case-studies, no generalizations can be made for these attributes.

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Appendix A: statistical tests

Table A1. Kruskal Wallis test p-values for differences between stakeholder groups for function importance. "Animal health & welfare" was not assessed in the Italian case-study.

	NL-Arable	DE-Arable&mixed	UK-Arable	IT-Hazelnut	ES-Extensive livestock	FR-Extensive livestock	BE-Dairy production	SE-Poultry	PL-Horticulture	BG-Arable	RO-Mixed
Food production	0.803255	0.362268	0.293914	0.227307	0.706168	0.194199	0.810097	0.784191	0.106182	0.629302	0.906059
Bio-based resources	0.898669	0.252991	0.674936	0.32905	0.648902	0.220164	0.331893	0.347558	0.818453	0.643656	0.247825
Economic viability	0.531615	0.063893	0.140945	0.697195	0.631704	0.285459	0.219892	0.10021	0.067882	0.368107	0.395918
Quality of life	0.796253	0.483332	0.483862	0.28506	0.314329	0.788466	0.056315	0.095205	0.038506	0.293353	0.829573
Natural resources	0.458664	0.96859	0.825831	0.388095	0.487101	0.268196	0.030649	0.164915	0.026653	0.548822	0.810751
Biodiversity & habitat	0.531615	0.21471	0.540965	0.633634	0.947699	0.447469	0.514506	0.638592	0.395987	0.517854	0.336662
Attractiveness of the area	0.420829	0.866012	0.438347	0.067067	0.843281	0.253966	0.746298	0.622812	0.841235	0.302356	0.342364
Animal health & welfare	0.434291	0.097713	0.060063	NA	0.037249	0.318905	0.5758	0.814337	0.738399	0.305157	0.346513

Table A1. Kruskal Wallis test p-values for difference between stakeholder groups for function importance. For France this exercise was done plenary with all stakeholder groups together. "Animal health & welfare" was not assessed in the Italian case-study.

	NL-Arable	DE-Arable&Mixed	UK-Arable	IT-Hazelnut	ES-Extensive livestock	FR-Extensive livestock	BE-Dairy production	SE-Poultry	PL-Horticulture	BG-Arable	RO-Mixed
Food production	0.327187	0.436941	0.35109	0.485757	0.091027	NA	0.658997	1	0.544822	0.171145	0.091151
Bio-based resources	0.769698	0.635623	0.267287	0.227512	0.7393	NA	0.67042	0.083265	0.901944	0.919773	0.111905
Economic viability	0.805701	0.559455	0.147053	0.01335	0.947704	NA	0.13746	0.317311	0.370582	0.263999	0.290061
Quality of life	0.386476	0.448847	0.080031	0.443575	0.04724	NA	0.461285	0.220671	0.09892	0.303148	0.037783
Natural resources	0.027486	0.297291	0.347844	0.579015	0.668525	NA	0.029973	0.317311	0.351038	0.055443	0.490099
Biodiversity & habitat	0.04909	0.286505	0.376993	0.384546	0.979353	NA	0.298621	0.317311	0.557546	0.376463	0.739931
Attractiveness of the area	0.710992	0.981982	0.308123	0.434121	0.581576	NA	0.959311	0.317311	0.356858	0.065875	0.523988
Animal.health & welfare	0.224765	0.633295	0.78923	NA	0.262197	NA	0.03292	NA	0.55643	0.78939	0.468005

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Table A2. Kruskal Wallis test p-values for differences between stakeholder groups for indicator importance (original values). As indicators differed across case-studies, codes for indicators are provided, where the first digit represents the function and the second digit the n^{th} indicator. The number of indicators per function differs across case-studies. For France, first all indicators were assessed plenary with all stakeholder groups together, second, some, but not all not all suggested indicators were assessed individually.

	BE-Dairy	BG-Arable	FR-Livestock	DE-Mixed	IT-Hazelnut	NL-Arable	PL-Horticulture	RO-Mixed	ES-Livestock	SE-Poultry	UK-Arable
X1.1	0.014116	0.131151	NA	0.424734	0.557574	0.608874	0.439277	0.943924	0.394268	0.48112	0.155273
X1.2	0.014116	0.263456	NA	0.830033	0.557574	0.15749	0.926877	0.943924	0.394268	0.133614	0.155273
X1.3	NA	0.383129	NA	0.34636	NA	0.608874	0.613625	NA	NA	0.340356	NA
X1.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.095205	NA
X2.2	0.032242	0.804789	NA	0.03428	0.170341	0.03498	0.889793	0.721745	0.994163	0.414216	NaN
X2.1	0.228787	0.804789	NA	0.03428	0.170341	0.03498	0.734862	0.721745	0.994163	0.414216	NA
X2.3	0.121116	NA	NA	NA	NA	NA	0.208074	NA	NA	NA	NA
X2.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
X3.1	0.550514	0.061181	0.220671	0.785201	0.131731	0.827259	0.523273	0.659936	0.692723	0.518605	0.455653
X3.2	0.433911	0.416276	0.157299	0.944201	0.488628	0.827259	0.481797	0.212571	0.970429	0.518605	0.137938
X3.3	0.303255	0.109107	0.4795	0.746195	0.095199	0.500184	0.062654	0.386818	0.473673	0.738883	0.800334
X3.4	NA	0.059951	0.157299	NA	NA	NA	NA	NA	NA	0.518605	NA
X4.1	0.664345	0.215925	0.788098	0.418938	0.641561	0.448891	0.171084	0.207653	0.375463	0.236137	0.455428
X4.2	0.489257	0.087808	0.40158	0.490802	0.191702	0.898669	0.44364	0.202547	0.375463	0.563703	0.959354
X4.3	0.446206	0.242356	0.226689	0.554776	0.454509	0.699854	0.222308	0.220147	NA	1	0.300447
X4.4	NA	NA	0.470874	0.591969	NA	0.796253	NA	NA	NA	0.563703	NA
X5.1	0.042378	0.825358	0.576772	0.0271	0.027705	0.103862	0.332912	0.471596	0.164625	0.48112	0.425662
X5.2	0.566378	0.687586	0.159841	0.123224	0.027705	0.097832	0.549421	0.179081	0.164625	0.811598	0.425662
X5.3	0.04086	0.688252	0.362769	0.1972	NA	0.247455	0.825013	0.419641	NA	1	NA
X5.4	NA	NA	0.532518	0.470311	NA	0.892738	NA	0.503141	NA	NaN	NA
X6.1	0.937715	0.581423	0.399437	0.563691	0.172845	0.218742	0.17374	0.423346	0.360131	0.075561	0.801352
X6.2	0.271005	0.294634	0.423025	0.840767	0.172845	0.109855	0.134698	0.245648	0.360131	0.767097	0.668856
X6.3	0.471129	0.446335	0.17867	0.805246	NA	0.536878	0.330307	0.670276	NA	0.374259	0.791501
X6.4	NA	NA	0.513297	NA	NA	NA	NA	NA	NA	NA	NA
X7.1	0.818516	0.616162	0.146022	0.283677	0.339391	0.460558	0.154412	0.860956	0.797009	0.411314	0.024959
X7.2	0.660597	0.11746	0.769265	0.960729	0.339391	0.619796	0.123548	0.128243	0.724491	0.643429	0.345836
X7.3	0.477351	0.3064	0.360998	0.620453	NA	0.522431	0.103101	0.366974	NA	1	0.087951
X7.4	NA	0.594507	NA	0.982032	NA	NA	NA	0.994746	NA	0.802587	NA
X8.1	0.758824	0.112784	0.05584	0.029403	NA	1	0.436252	0.077536	0.263833	0.248213	NaN
X8.2	0.667712	0.244247	0.05584	0.855927	NA	1	0.669987	0.075088	0.263833	0.075561	NA
X8.3	NA	0.175569	NA	0.750981	NA	NA	0.188712	0.617309	NA	0.248213	NA
X8.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.414216	NA

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Table A3. Kruskal Wallis test p-values for differences between stakeholder groups for indicator importance (transformed values; see Equation 2). As indicators differed across case-studies, codes for indicators are provided, where the first digit represents the function and the second digit the n^th indicator. The number of indicators per function differs across case-studies. For France, first all indicators were assessed plenary with all stakeholder groups together, second, some, but not all not all suggested indicators were assessed individually.

	BE-Dairy	BU-Arable	FR-Livestock	DE-Mixed	IT-Hazelnut	NL-Arable	PL-Horticulture	RO-Mixed	ES-Livestock	SE-Poultry	UK-Arable
X1.1	0.035424	0.080796	NA	0.015126	0.175933	1	0.171432	0.358405	0.144433	0.48112	0.01807
X1.2	0.005645	0.184019	NA	0.006593	0.150938	0.04814	0.408465	0.494686	0.593757	0.133614	0.565263
X1.3	NA	0.845362	NA	0.010323	NA	0.323121	0.072634	NA	NA	0.340356	NA
X1.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.095205	NA
X2.2	0.046374	0.384322	NA	0.007336	0.127352	0.04814	0.984474	0.079467	0.193233	0.05653	0.000912
X2.1	0.006547	0.670088	NA	0.018324	0.072367	0.026206	0.699568	0.031777	0.143444	0.4795	NA
X2.3	0.107134	NA	NA	NA	NA	NA	0.054588	NA	NA	NA	NA
X2.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
X3.1	0.15208	0.081987	0.220671	0.01565	0.058832	0.608874	0.006584	0.194857	0.972463	0.060289	0.01969
X3.2	0.013527	0.115122	0.157299	0.829789	0.262817	0.454817	0.029875	0.010303	0.36008	0.411314	0.159251
X3.3	0.006895	0.062917	0.220671	0.417171	0.085652	0.589639	0.89634	0.024048	0.148118	0.411314	0.640257
X3.4	NA	0.07083	0.157299	NA	NA	NA	NA	NA	NA	0.411314	NA
X4.1	0.047447	0.007359	0.513417	0.598889	0.425906	0.37908	0.627702	0.028681	0.015184	0.049128	0.315134
X4.2	0.199533	0.03936	0.778801	0.931728	0.221169	0.709815	0.29323	0.043356	0.176341	0.064078	0.276236
X4.3	0.277447	0.284405	0.132113	0.653243	0.352113	0.804896	0.007335	0.757581	NA	0.784191	0.042442
X4.4	NA	NA	0.363474	0.082051	NA	0.699854	NA	NA	NA	0.064078	NA
X5.1	0.086545	0.277331	0.431704	0.032605	0.00276	0.103862	0.003478	0.792688	0.041431	0.354539	0.606118
X5.2	0.037148	0.954788	0.053755	0.310301	0.016122	0.452862	0.005226	0.030275	0.151083	0.233329	0.074577
X5.3	0.021949	0.660328	0.046322	0.117856	NA	0.133277	0.057019	0.107053	NA	0.060289	NA
X5.4	NA	NA	0.887919	0.333568	NA	0.079856	NA	0.948811	NA	NaN	NA
X6.1	0.039021	0.53719	0.071362	0.067665	0.129818	0.803255	0.007794	0.231146	0.353183	0.140049	0.456894
X6.2	0.008557	0.063749	0.215847	0.476599	0.064078	0.050044	0.004362	0.056486	0.386264	0.622812	0.5575
X6.3	0.515817	0.224771	0.026826	0.393977	NA	0.622753	0.076458	0.058699	NA	0.622812	0.170902
X6.4	NA	NA	0.480668	NA	NA	NA	NA	NA	NA	NA	NA
X7.1	0.050826	0.050637	0.465697	0.039649	0.028536	0.805701	0.034151	0.044309	0.150727	0.784191	0.051936
X7.2	0.165593	0.138399	0.420901	0.365539	0.009665	0.321062	0.017778	0.085631	0.800279	0.354539	0.145029
X7.3	0.034453	0.683263	0.115678	0.532761	NA	0.318985	0.624349	0.098319	NA	0.158834	0.104981
X7.4	NA	0.638826	NA	0.160087	NA	NA	NA	0.216239	NA	0.622812	NA
X8.1	0.135437	0.242655	0.233838	0.028226	NA	0.605577	0.059511	0.021557	0.003325	0.240327	0.000912
X8.2	0.169126	0.166444	0.019497	0.183773	NA	0.318985	1	0.013724	0.238624	0.347558	NA
X8.3	NA	0.065464	NA	0.426127	NA	NA	0.445096	0.020497	NA	0.158834	NA
X8.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.4795	NA

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Table A4. Kruskal Wallis test p-values for differences between stakeholder groups for indicator performance. As indicators differed across case-studies, codes for indicators are provided, where the first digit represents the function and the second digit the n^{th} indicator. The number of indicators per function differs across case-studies. For France, all indicators were assessed plenary with all stakeholder groups together.

	BE-Dairy	BU-Arable	DE-Mixed	IT-Hazelnut	NL-Arable	PL-Horticulture	RO-Mixed	ES-Livestock	SE-Poultry	UK-Arable
X1.1	0.537645	0.373491	0.693041	0.399112	0.308325	0.134465	0.187933	0.008486	0.317311	0.130277
X1.2	0.741773	0.24402	0.543581	0.221065	0.70244	0.177192	0.07289	0.112689	0.683091	0.441827
X1.3	NA	0.672688	0.834996	NA	0.297183	0.941744	NA	NA	1	NA
X1.4	NA	NA	NA	NA	0.157299	0.066686	NA	NA	NaN	NA
X2.2	0.937909	0.729648	0.38176	0.779249	0.337331	0.730846	0.099355	0.955339	0.075561	0.267287
X2.1	0.904837	0.911836	0.446416	0.051936	0.083265	0.400314	0.906903	0.730274	0.414216	NA
X2.3	0.545956	NA	NA	NA	NA	0.476302	NA	NA	NA	NA
X2.4	NA	NA	NA	NA	NA	0.185591	NA	NA	NA	NA
X3.1	0.049396	0.704938	0.658834	0.329728	1	0.366151	0.164801	0.992228	1	0.356643
X3.2	0.193781	0.364086	0.051204	0.820571	0.179712	0.659102	0.233739	0.803255	0.317311	0.254893
X3.3	0.403912	0.175898	0.750137	0.058504	0.605577	0.446033	0.302568	0.838201	1	0.490516
X3.4	NA	0.245896	NA	NA	NA	NA	NA	NA	0.317311	NA
X4.1	0.348078	0.964919	0.367879	0.388636	0.740857	0.30289	0.024562	0.647984	0.4795	0.074395
X4.2	0.876246	0.118718	0.090718	0.025392	0.039833	0.739165	0.442336	0.017865	1	0.277926
X4.3	0.042522	0.615706	0.689584	0.869497	0.543866	0.150451	0.227647	NA	1	0.377525
X4.4	NA	NA	0.489542	NA	0.215476	NA	NA	NA	0.438578	NA
X5.1	0.60021	0.203872	0.69884	0.396138	0.15749	0.432276	0.727951	0.016222	1	0.31938
X5.2	0.0177	0.400168	0.627089	0.656352	0.009154	0.347902	0.5954	0.635762	0.317311	0.641003
X5.3	0.015789	0.291126	0.219636	NA	0.192535	0.543725	0.915703	NA	0.075561	0.317311
X5.4	NA	NA	0.145876	NA	0.224916	0.317311	0.172867	NA	NA	NA
X6.1	0.326635	0.433892	0.104347	0.232629	0.02846	0.883012	0.851038	0.794683	0.220671	0.439588
X6.2	0.097395	0.283955	0.435386	0.640946	0.151735	0.33229	0.715266	0.6678	0.220671	0.340691
X6.3	0.632829	0.414179	0.476707	NA	0.610492	0.345099	0.183463	NA	0.317311	0.141486
X6.4	NA	NA	NA	NA	NA	0.317311	NA	NA	NA	NA
X7.1	0.730838	0.190014	0.591555	0.745866	0.347654	0.954632	0.134428	0.862881	0.4795	0.377552
X7.2	0.833449	0.371482	0.737123	0.228284	0.371093	0.157367	0.726459	0.37582	0.317311	0.967152
X7.3	0.200069	0.437805	1	NA	0.694473	0.582225	0.683658	NA	0.157299	0.269636
X7.4	NA	0.15124	0.513417	NA	NA	0.317311	0.308146	NA	0.220671	NA
X8.1	0.11039	0.820957	0.54653	NA	0.154729	0.425145	0.540486	0.106553	1	0.78923
X8.2	0.019443	0.529036	0.871713	NA	0.342782	0.319367	0.726394	0.039741	0.052808	NA
X8.3	NA	0.12449	0.581432	NA	NA	0.66612	0.278314	NA	NA	NA
X8.4	NA	NA	NA	NA	NA	NaN	NA	NA	0.317311	NA

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Table A5. Kruskal Wallis test p-values for differences in resilience capacities, based on (level of implementation times) overall scoring of potential contribution of attributes (see Equation 3 and 4). In France and Spain, these assessments were not conducted.

Case-study	Potential contribution	Level of implementation * potential contribution
NL-Arable	0.352492	0.07718
DE-Arable&mixed	6.13E-07	2.67E-05
UK-Arable	0.643172	0.781529
IT-Hazelnut	0.054437	0.090612
BE-Dairy production	0.000149	0.000431
PL-Horticulture	0.294528	0.508992
BU-Arable	0.000158	0.000308
RO-Mixed	0.498925	0.717266
SE-Poultry	0.196605	0.390726

Table A7. P-values and R-squared values for linear models describing correlation between function importance and function performance, based on aggregated results from case-studies.

Function	p-value	R2
Food production	0.232564	0.154001
Bio-based production	0.017185	0.485545
Economic viability	0.210002	0.168388
Quality of life	0.992143	1.14E-05
Natural resources	0.364475	0.09203
Biodiversity & habitat	0.811791	0.006637
Attractiveness of the area	0.636033	0.025958
Animal health & welfare	0.760839	0.012249

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Appendix B. Results from the co-creation platform

Table A8. Summary statistics for assessments on function importance and performance of the EU agricultural sector.

Function	Function importance				Function performance			
	Mean	Median	First quartile	Third quartile	Mean	Median	First quartile	Third quartile
Food production	21	20	15	26	23	20	15	30
Bio-based production	8	9	5	10	12	10	5	10
Economic viability	13	15	10	16	13	14	9	15
Quality of life	12	11	8	15	11	10	6	15
Natural resources	15	15	10	20	14	15	10	20
Biodiversity & habitat	12	10	9	15	11	10	5	15
Attractiveness of the area	9	10	5	12	8	10	5	12
Animal health & welfare	9	10	6	11	9	10	5	10

Table A9. Summary statistics for assessments on resilience attribute presence in the EU agricultural sector

	Presence in the EU agricultural sector			
Resilience attribute	**mean**	**median**	**first quartile**	**third quartile**
Reasonably Profitable	2.2	2.0	1.5	3.0
Coupled with local and natural capital (production)	2.9	3.0	2.0	3.5
Functional Diversity	3.4	4.0	2.0	4.5
Response Diversity	3.1	3.0	2.5	3.5
Exposed to disturbance	2.7	3.0	2.5	3.0
Spatial and temporal heterogeneity (farm types)	3.9	4.0	3.0	5.0
Optimally redundant (farms)	2.2	2.0	1.5	3.0
Supports rural life	2.6	2.0	2.0	3.0
Socially self-organized	3.4	4.0	3.0	4.0
Appropriately connected with actors outside the FS	3.1	3.0	3.0	3.5
Coupled with local and natural capital (legislation)	2.7	3.0	2.0	3.5
Infrastructure for innovation	3.1	3.0	2.5	3.5
Diverse policies	2.6	2.0	2.0	3.0

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Table 2. Information on participants that assessed elements of FoPIA-Surefarm in the co-creation platform.

		Participation in the exercises		
Sector	Country	Function importance	Function performance	Presence Resilience attributes
University-Research centre	France	Yes	Yes	No
Value chain actor	Germany	Yes	No	Yes
Environmental -NGO	Spain	Yes	Yes	No
Farmer's organization	Germany	Yes	Yes	Yes
Insurance company	Switzerland	Yes	Yes	Yes
Insurance company	Spain	Yes	Yes	Yes
Policy maker	Spain	Yes	Yes	Yes
University-Research centre	Spain	Yes	Yes	Yes
Insurance company	Switzerland	Yes	Yes	Yes
University-Research centre	The Netherlands	Yes	Yes	No
Farmer's organization	Spain	Yes	No	No
Farmer's organization	Spain	Yes	Yes	No
University-Research centre	The Netherlands	Yes	Yes	Yes
Farmer's organization	Spain	Yes	Yes	No
University-Research centre	Spain	No	No	Yes
	Number of participants	14	12	9

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Appendix C. List of Supplementary Materials

Supplementary Materials A: FoPIA-Surefarm case-study report Belgium

Supplementary Materials B: FoPIA-Surefarm case-study report Bulgaria

Supplementary Materials C: FoPIA-Surefarm case-study report Germany

Supplementary Materials D: FoPIA-Surefarm case-study report Spain

Supplementary Materials E: FoPIA-Surefarm case-study report France

Supplementary Materials F: FoPIA-Surefarm case-study report Italy

Supplementary Materials G: FoPIA-Surefarm case-study report The Netherlands

Supplementary Materials H: FoPIA-Surefarm case-study report Poland

Supplementary Materials I: FoPIA-Surefarm case-study report Romania

Supplementary Materials J: FoPIA-Surefarm case-study report Sweden

Supplementary Materials K: FoPIA-Surefarm case-study report United Kingdom

Supplementary Materials L: FoPIA-Surefarm workshop guidelines

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