

This is a peer-reviewed, final published version of the following document, © 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>) and is licensed under Creative Commons: Attribution-Noncommercial-No Derivative Works 4.0 license:

**Soriano, Bárbara, Garrido, Alberto, Bertolozzi-Caredio, Daniele, Accatino, Francesco, Antonioli, Federico, Krupin, Vitaliy, Meuwissen, Miranda, Ollendorf, Fransiska, Rommel, Jens, Spiegel, Alisa, Tudor, Monica, Urquhart, Julie ORCID logo ORCID: <https://orcid.org/0000-0001-5000-4630>, Vigani, Mauro ORCID logo ORCID: <https://orcid.org/0000-0003-2442-7976> and Bardají, Isabel (2023) Actors and their roles for improving resilience of farming systems in Europe. *Journal of Rural Studies*, 98. pp. 134-146.
doi:10.1016/j.jrurstud.2023.02.003**

Official URL: <https://doi.org/10.1016/j.jrurstud.2023.02.003>

DOI: <http://dx.doi.org/10.1016/j.jrurstud.2023.02.003>

EPrint URI: <https://eprints.glos.ac.uk/id/eprint/12388>

Disclaimer

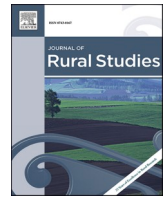
The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.



Actors and their roles for improving resilience of farming systems in Europe

Bárbara Soriano^{a,*}, Alberto Garrido^a, Daniele Bertolozzi-Caredio^a, Francesco Accatino^b, Federico Antonioli^c, Vitaliy Krupin^d, Miranda P.M. Meuwissen^e, Franziska Ollendorf^f, Jens Rommel^g, Alisa Spiegel^h, Monica Tudorⁱ, Julie Urquhart^j, Mauro Vigani^j, Isabel Bardají^a

^a CEIGRAM- Universidad Politécnica de Madrid, Spain

^b INRAE - National Research Institute for Agriculture, Food and the Environment, France

^c Department of Agricultural and Forestry Sciences, Università degli Studi della Tuscia, Italy

^d Institute of Rural and Agricultural Development, Polish Academy of Sciences, Poland

^e Business Economics Group, Wageningen University and Research, the Netherlands

^f Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Germany

^g Department of Economics, Swedish University of Agricultural Sciences, Sweden

^h Thuenen-Institut, Germany

ⁱ Institute of Agricultural Economics, Romania

^j Countryside and Community Research Institute, University of Gloucestershire, United Kingdom

ARTICLE INFO

Keywords:

Socio-ecological systems
Multi-actor approach
Focus groups
Agriculture
Resilience attributes
Resilience capacities

ABSTRACT

Finding pathways to enhance the resilience of farming systems (FSs) in Europe is key, given the increasing challenges threatening them. FSs are complex socio-ecological systems in which social and ecological components are strongly linked. Social actors have the capacity to shape the FSs' resilience, but there is a knowledge gap about how they can best do it. The aim of this paper is to analyse the roles played by the actors in FSs when dealing with challenges and assess how these roles may contribute to the resilience attributes (conditions that enable resilience) and resilience capacities (robustness, adaptability, and transformability). To this end, ten focus groups have been conducted across FSs in Europe. Results suggest that each actor in the FSs can shape and strengthen different resilience attributes which in turn result in combinations of resilience capacities that are specific to the FS. Thus, enabling resilience is best accomplished with actors taking different roles and jointly configuring the most adequate combination of capacities, which differs across FSs. This paper provides a set of resilience-enabling roles that delineate the pathways to make FSs more resilient. The diversity of actors and resilience-enabling pathways require flexible, coordinated and comprehensive policies that encompass the complexity of the socio-ecological systems.

1. Introduction

Farming systems (FSs) in Europe face a broad array of environmental, economic, social and institutional challenges (Komarek et al., 2020) that push them to their limits (Paas et al., 2021) and weaken their role as providers of functions (Schröter et al., 2005). FSs are socio-ecological systems (SESS) in which social, economic, ecological, cultural, political and technological components are strongly linked (Petrosillo et al., 2015). Berkes and Folke (1998) encouraged the use of the socio-ecological system concept to emphasize that humans and nature are closely interrelated and argued that the separation between social and ecological systems is artificial and arbitrary.

To address the dynamics in SESSs when responding to shocks and perturbations, resilience assessment can serve as a framework (Folke et al., 2010; Quinlan et al., 2016; Bullock et al., 2017), that encompasses the analysis of three resilience capacities: i) Robustness, defined as the capacity to withstand stresses and (un)anticipated shocks; ii) adaptability, described as the capacity to change in response to shocks and stresses while maintaining the overall structures and feedback mechanisms of the FS; and iii) transformability, understood as the capacity to significantly change the internal structure and feedback mechanisms of a FS in response to either severe shocks or enduring stresses that make business-as-usual untenable (Folke et al. (2010); Anderies et al. (2013); Darnhofer (2014); Meuwissen et al. (2019).

* Corresponding author. C/ Senda del Rey 13 Campus Sur de prácticas E.T.S. de Ingeniería Agronómica, Alimentaria y de Biosistemas. Madrid 28040, Spain.
E-mail address: barbara.soriano@upm.es (B. Soriano).

<https://doi.org/10.1016/j.jrurstud.2023.02.003>

Received 17 May 2022; Received in revised form 9 December 2022; Accepted 7 February 2023

Available online 19 February 2023

0743-0167/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Resilience literature acknowledges the fundamental role of actors, such as organizations and policy makers, in shaping SESs dynamics. Rounsevell et al. (2012) stated that services provided by SESs rely to a greater extent on the actions of the actors within the SESs than on its ecological components. Several authors demonstrated the link between the diversity of social actors and their roles and the resilience of SESs (Holling et al., 2002; Ostrom, 2009). The knowledge and experience brought in by the actors, as well as their interests and purposes, frame the structure and functions of the system (Scoones et al., 2007). Folke et al. (2005) identified common resilience-enabling roles provided by actors in SESs, such as leadership, trust, vision, knowledge systems and social memory (experience for dealing with change). Cabell and Oelofse (2012) identified indicators of social behavior, such as human capacity, social networks and shared learning, whose presence in the systems increase its resilience.

Delving into the resilience capacities, Walker et al. (2004) found that the adaptability of the system is mainly a function of the social component where the individuals influence resilience through their intentionally and unintentionally acts. For instance, Bertolozzi-Caredio et al. (2021a,b) found that farmers may enhance the robustness capacity by keeping buffers to anticipate losses and taking an off-farm job. More radical changes in production orientation pursued by farmers can influence the transformability of a system (Cumming et al., 2005; Ashkenazy et al., 2018).

Despite the progress already achieved, to our knowledge no studies have attempted to assess the roles that each actor may play to enable the three resilience capacities and there is a lack of large-scale and cross-case-study comparison evidence. To bridge these gaps, the aim of this paper is to analyse the roles performed by the actors belonging to FSs in Europe when dealing with challenges, and assess how these roles may contribute to robustness, adaptability and transformability. The main contribution of the paper is proposing a detailed set of resilience-enabling roles that can be played by the actors in FSs to enhance robustness, adaptability, and transformability capacities. The paper supports the new paradigm that not only farmers but also the whole spectrum of the actors in FSs are part of the solution (Chuku and Okoye, 2009; Antón and Kimura, 2011; Shiferaw et al., 2014; Mushtaq et al., 2020; Spiegel et al., 2020).

2. Methodological approach

2.1. Theoretical underpinning

Meuwissen et al. (2019) operationalized the dynamics and ability of FSs to deal with challenges in a five-step methodology (Fig. 1). Following such resilience assessment framework, FSs are threatened by a variety of economic, social, environmental, and institutional challenges. The literature provides rich examples of challenges such as farm

price risks (Angelucci and Conforti, 2010), structural barriers to gender equality (Glemarec, 2017), adverse climate events (Lobos et al., 2018) and frequent changes in agricultural policies (Iqbal et al., 2018). Challenges can be categorized into shocks and long-term pressures according to the length of their impact. A shock is a sudden change that influences (part of) the FS in the short term through negative effects on individuals' current state of well-being, level of assets, livelihoods, or safety, or on their ability to withstand future shocks (e.g. extreme price drops). Long-term pressures refer to stressors slowly changing the context of a FS, inherently leading to new uncertainties, such as the lack of inter-familial succession and thus farms' continuity (Bertolozzi-Caredio et al., 2020).

Meuwissen et al. (2019) argued that FSs are defined by the main product(s) of interest and the regional context, characterized by the local agro-ecological context, climate conditions, infrastructures and identity (Meuwissen et al., 2019). In addition, FSs are characterized by the actors involved in them, embracing not only farmers but also any other individual who keeps a close mutual connection to them, such as households, farmers' associations, cooperatives, value chain actors, financial institutions, advisors, policy makers, media, non-governmental organizations (NGOs) and consumers (Folke et al., 2005; Rounsevell et al., 2012).

The actors in the FSs play roles that influence the dynamics of the systems (Rounsevell et al., 2012). The actors' roles encompass actions, e.g. to keep economic buffers (Bertolozzi-Caredio et al., 2021) and to share information (Slijper et al., 2022), as well as attitudes, such as leadership and trust (Folke et al., 2005). The roles played by the actors influence the conditions (attributes) of the resilience environment and shape it. According to Darnhofer (2014), resilience assessment requires exploring not only the processes, but also the attributes enabling them. Several authors (Cabell and Oelofse, 2012; Worstell and Green, 2017; Paas et al., 2021a,b) studied the attributes whose presence creates a resilience-enabling environment for SESs (Cabell and Oelofse, 2012), food systems (Worstell and Green, 2017) and FSs (Paas et al., 2021a,b). Kerner and Thomas (2014) concluded that the assessment of the resilience attributes allows the translation of evidence into practical indications.

Built on the resilience attributes proposed in the literature and focusing on the social dimension of FSs, Table 1 shows the set and description of the resilience attributes that favour the resilience-enabling environment.

Resilience encompasses the robustness, adaptability and transformability capacities (Walker et al., 2004; Cumming et al., 2005; Folke et al., 2010; Anderies et al., 2013; Darnhofer, 2014). These three capacities allow systems to keep providing their functions even when under threat from present and expected challenges. Functions provided by FSs can be classified into the provision of private goods (i.e., the provision of food and a reasonable livelihood for people involved in

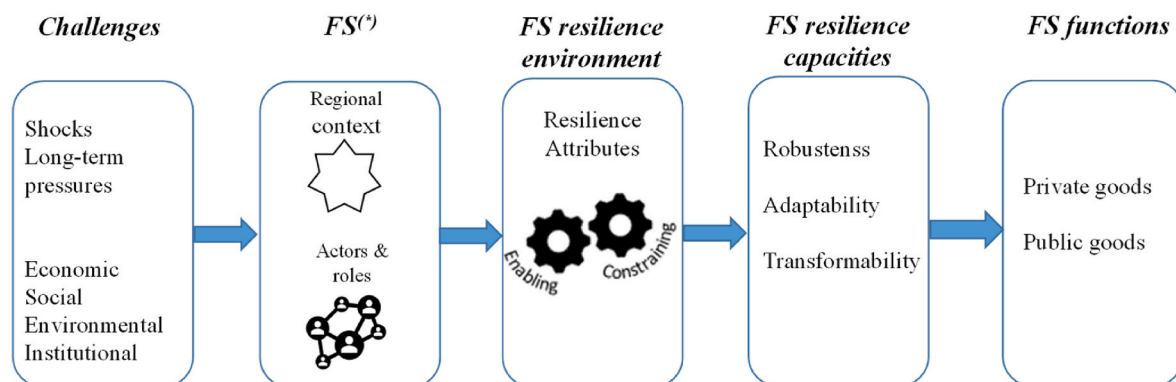


Fig. 1. Farming system resilience assessment framework.

Source: Adapted from (Meuwissen et al., 2019)(*) FS: Farming System

Table 1
Resilience attributes.

Resilience attributes	Definition	Explanation
Builds human capital (Cabell and Oelofse, 2012; Darijani et al., 2019)	The system takes advantages of, and builds on, resources that can be mobilized through social relationships and membership social networks.	The actors in FSs are open to change, flexible, persistence, motivated, engaged and committed with the sector; they seek reaching common FSs interests; they trust the other actors in the sector and the future of the sector.
Socially self-organized (Cabell and Oelofse, 2012; Kerner and Thomas, 2014; Worstell and Green, 2017)	The social components of the system can form their own configuration based on their needs and desires.	Actors in FSs have the ability to be attached to the FS' needs, to involve and support the other actors, to create close and balanced relationships between actors in value chain, to be well-structured to enhance the strength of the associations.
Appropriately connected (Cabell and Oelofse, 2012; Biggs et al., 2012; Paas et al., 2021)	Connectedness describes the quantity and quality of relationships with actors outside the system.	Farmers and other actors in the FS are able to reach out to policy makers, suppliers and markets that operate at the national and EU level mention classified under this resilience attribute.
Response diversity (Cabell and Oelofse, 2012; Kerner and Thomas, 2014; Carpenter et al., 2012; Walker, 2020)	Range of responses of social components to environmental change.	Actors develop a wide range of strategies to deal with challenges and have a wide variety of instruments to use (e.g. credits, liquidity and insurance products).
Optimally redundant (Cabell and Oelofse, 2012; Darijani et al., 2019)	Critical components and relationships with the systems are duplicated in preparation of failure.	There is an adequate combination of different actors in FSs that ensures labour and services provision and proper relationships within a FS.
Carefully exposed to disturbance (Cabell and Oelofse, 2012; Walker, 2020)	The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond critical thresholds.	Actors have the ability to adapt to the market demands, keep a reasonable level of dependency on markets, low exposure to climate change, low indebtedness level, conduct actions that maintain a FS exposed to a discrete disturbance.
Reflective and shared learning (Cabell and Oelofse, 2012; Kerner and Thomas, 2014)	Individuals and institutions learn from past experiences and present experimentation to anticipate change and create desirable futures.	Actors provide advisory, monitoring, assistance, information, awareness, training and know-how (e.g. on long-term planning, adaptation procedures, new technology, good practices).
Honors legacy (Cabell and Oelofse, 2012; Inwood and Sharp, 2012)	The current configuration and future trajectories and investments of systems are influenced and informed by past conditions and experiences.	Traditions, habits, history, succession and successors' effects, entrepreneurial culture existing in a FS.
Reasonably profitable (Cabell and Oelofse, 2012; Kerner and Thomas, 2014)	People involved in agriculture can make a livelihood from the work they do without relying too heavily on subsidies.	The actors have solid financial basis, liquidity and assets, search and provide a FS with buffer resources and certain funds.

Table 1 (continued)

Resilience attributes	Definition	Explanation
Diverse policies (Paas et al., 2021; Walker, 2020)	Policies stimulate all three capacities of resilience, i. e. robustness, adaptability, transformability.	Policy interventions require low bureaucracy and control measures, provide adapted instruments, in time and enough payments, flexible framework coordinated at different regional level.
Infrastructure for innovation (Paas et al., 2021)	Existing infrastructure facilitates knowledge and adoption of cutting-edge technologies (e.g. digital).	Existing infrastructure facilitates knowledge and adoption of cutting-edge technologies (e.g. digital).
Supports rural life (Paas et al., 2021)	The activities in the FS attract and maintain a healthy and adequate workforce, including young, intermediate and older people.	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).

farming) and public goods (*i.e.*, maintaining natural resources in good condition and ensuring that rural areas are attractive places to live) (Meuwissen et al., 2019).

When it comes to assessing resilience, it becomes relevant to understand how the actors in FSs can contribute to the resilience attributes as they are enablers of the resilience capacities. Based on this theoretical framing, this paper builds on the concepts of actors and their roles in FSs, resilience attributes and resilience capacities.

2.2. Data collection

Considering the goal of this research focused on the actors and their roles, a qualitative multi-actor approach has been followed. In a multi-actor approach, stakeholders representing the actors belonging to different activity sectors in the system (business, civil society, governments and academia) come together in order to find a common approach to an issue that affects them all (Selsky and Parker, 2005; Roloff, 2008). The multi-actor approach has featured prominently in several domains, including management theory (Bryson, 2003), policy design (Byrd, 2007) and agricultural and environmental research (Reed, 2008; Luyet et al., 2012; Podestá et al., 2013).

Following Reed's (2008) proposal to replicate and compare multi-actor participatory processes in different socio-cultural and physical contexts, focus groups were conducted in different FSs across Europe. The research was conducted as part of SURE-Farm, a H2020 funded project that considered ten case study regions in Europe: arable farming in Bulgaria (BG-Arable) and the United Kingdom (UK-Arable); mixed farming in Germany (DE-Mixed) and Romania (RO-Mixed); extensive livestock farming in France (FR-Beef) and Spain (ES-Sheep); intensive dairy farming in Belgium (BE-Dairy) and poultry in Sweden (SE-Poultry); perennial crops in Italy (IT-Perennial); and horticulture in Poland (PL-Horticulture).

To mitigate overrepresentation or power imbalance among the stakeholders participating in the FS' focus groups (from now on "participants"), the FS' focus groups leaders oversaw the composition of the groups and carefully select the participants, counting on previous experience in the case study region and knowledge about the sector's functioning and specificities. In order to ensure consistency across FSs, a common set of selection criteria was used to select participants (Kamberelis and Dimitriadis, 2013). The selection criteria followed by FS' focus groups leaders were: i) participants belong to the FS; ii) participants have proven experience and knowledge of the FS; and iii) the group of participants represent the diversity of actors in the FS.

Between 5 and 12 participants attended each 3.5-h focus groups held between March and July 2019. In total, 73 participants attended the ten

focus groups, representing the diversity of actors in FSs: 15 farmers, 12 insurance companies, 12 banks, ten farmers' organizations, ten advisory services, ten policy makers, three value chain actors and one researcher. In every FS' focus group participants represented at least three actors in the FS. The number and description of the participants attending each focus group are detailed in Annex I.

The focus groups agenda started with an introductory session, during which resilience and the three resilience capacities of the FS were defined. The following activity consisted of discussing the challenges that the FS is facing. Participants were asked to select the 10 most important challenges from a preselected list of challenges provided by the organizers and rank them from 1 to 10, from the least to the most influential challenge. Then, participants were invited to identify the actors in the FS and brainstorm about the roles they play when dealing with challenges. This way of collecting data may imply direct relationships between some of the identified roles and the challenges addressed. For example, one of the farmers' roles identified to deal with the lack of succession in FSs is to actively participate in private/public interventions that enable succession, increasing the likelihood of finding new entrants. After that, a debate was conducted to classify the roles of the actors according to the resilience capacity they enhance (current resilience-enabling roles) or constrain (current resilience-constraining roles). For example, participants in the FS' focus group in Sweden identified that farmers' associations enhance robustness as they play the role of negotiating good emergency payments; adaptability because they provide advisory services; and transformability as they address long-term challenges and find strategies to deal with them. Then, and based on the resilience-enabling roles and resilience-constraining roles identified in the previous activities, participants were asked to score¹ (on a scale of -3 to +3) the current contribution of the actors to the resilience capacities. The positive values (i.e., +1, +2, +3) meant that the actors enable resilience at different intensity levels, 0 meant that the actors' contribution to resilience is not clear, and negative values (i.e., -1, -2, -3) meant that the actors constrain resilience capacities at different intensity levels. Finally, time for general reflection was devoted to draw conclusions about the main insights from the focus groups.

As the data collection was conducted by different researchers in each FS, standardized guidelines were prepared to guarantee that all FS' focus groups pursued the same goal and followed the same approach (flexible to idiosyncrasy). The preliminary guidelines were tested and improved based on a pilot focus group. A coordinator team was in charge to support and coordinate the researchers' teams in different FSs. Focus groups were conducted in local languages, a condition that could lead to losing nuances and local expressions in the translation process to the common language (English). To deal with this limitation, it was recommended that the researchers who conducted the FS' focus group also translated in English and reported the information provided by participants in the FS' focus group.

2.3. Data analysis

The data analysis is based on a qualitative approach (Elo and Kyngäs, 2008). To address the complexity in integrating diverse evidence from ten FSs, challenges, actors, and roles have been grouped according to meaningful codes. Following Meuwissen et al. (2019), challenges have been coded according to their nature (economic, environmental, institutional and social spheres) and duration of their impact (shocks and long-term pressures). Challenges have been analysed following a ranking assessment. The ranking values are expressed as the percentage

share of the total ranking values assigned within a FS to identify the relevance of each type of challenge on the FS.

The actors have been coded into nine codes representative of actors in the FSs: Farmers (F), Farmers' Associations and Cooperatives (A&C), Financial Institutions (FI), Policy Makers (PM), Research and Education (R&E), Advisory Services (AS), Upstream actors in Value Chain (UVC), Downstream actors in Value Chain (DVC) and Civil Society (CS) -consumers, NGOs and media-.

The actors' roles have been coded following three criteria. First, and based on the participants' ideas, the actors' roles were coded into three codes referring to the resilience capacities (robustness, adaptability, and transformability). For example, participants in FS's focus group in Germany identified that financial institutions contribute to adaptability as they provide market information. Then, the role "providing market information" was coded under the code "adaptability". Second, the roles have been coded by considering if they are current resilience-enabling roles already played by the actors or potential resilience-enabling roles that could be played by the actors. To do so, as participants in the FS' focus groups mentioned the current resilience-enabling roles and the current resilience-constraining roles, the latter have been turned into potential resilience-enabling roles, so that the current resilience-constraining roles are the lack of/opposite to potential resilience-enabling roles. For example, a current resilience-constraining role of financial institutions mentioned by participants in the FS' focus group in Spain was "providing products that do not respond to farmers' needs". This role was turned into and coded as a potential resilience-enabling role "providing financial products that respond to farmers' needs" and coded as "potential resilience-enabling role". As a result, a set of resilience-enabling roles (current and potential) for future pathways is built. Third, the actors' roles have been coded by inferring the resilience attribute that they mainly reinforce. Addressing resilience attributes allows to shed light on the mechanisms through which the actors' roles contribute to different capacities. Following the previous example, the financial institutions' role "providing financial products that respond to farmers' needs" mainly reinforces diversity, and hence it was coded under the attribute "Response diversity" (Table 1).

3. Results

3.1. Challenges and the actors involved in dealing with them in farming systems

A wide variety of challenges faced by FSs were identified by participants in the FS' focus groups. As Fig. 2 shows, FSs in Europe are facing economic, environmental, institutional and social shocks and stresses. The number of bubbles by type of challenges (vertical line) suggests that economic (yellow bubbles) and social (blue bubbles) long-term pressures are challenges threatening all the FSs.

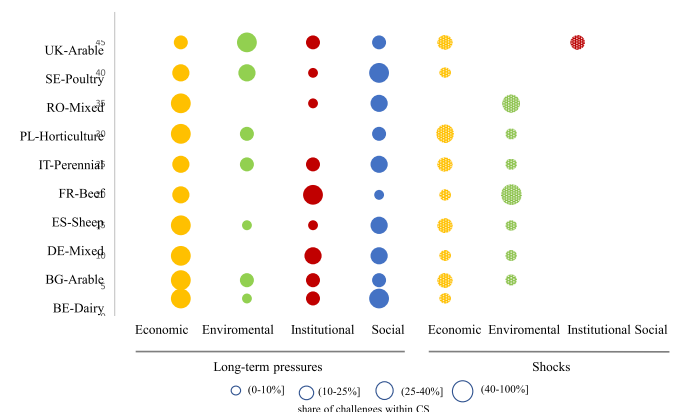


Fig. 2. Challenges threatening farming systems in Europe.

¹ In seven FS' focus groups (Bulgaria, Germany, Italy, Poland, Romania, Sweden, and United Kingdom) scoring was undertaken individually by participants, and an average of individual scores was taken as the collective group score. In the remaining FS' focus groups, scoring was set collectively after a collective discussion and agreement.

The size of the bubbles indicates the relative relevance of the challenges as perceived by participants in the FS' focus groups. Participants in 5 out of 10 FS' focus groups identified economic long-term pressures among the most important challenges to deal with. Some examples of economic long-term pressures are the persistent low profitability and prices identified by participants in the FS' focus groups in ES-Sheep, DE-Mixed and BE-Dairy, followed by market uncertainties identified in the FS' focus groups in PL-Horticulture and BG-Arable and the lack of markets prioritized in the FS' focus group in RO-Mixed. Social long-term pressures are identified among the most important challenges to face within two FS' focus groups: the decline in consumer demand for meat in the FS' focus group in SE-Poultry and lack of generational renewal and skilled labour in the FS' focus group in BE-Dairy. Environmental and institutional long-term challenges are also identified in most of the FS' focus groups but their relative importance is lower compared to economic and social ones, except in the FS' focus group in UK-Arable where participants prioritized climate change effects as an environmental long-term pressure and in the FS' focus group in FR-Beef where participants perceived that institutional long-term pressures, such as the changing policy orientation, is among the most important challenges to deal with (see Annex I for detailed challenges).

Referring to the shocks mentioned by FS' focus groups participants, Fig. 2 shows that the economic shocks have been identified in 9 out of 10 FS' focus groups. For example, participants in the FS' focus group in PL-Horticulture identified price volatility as one of the major challenges to deal with. Environmental shocks have been identified in 7 out of 10 FS' focus groups. This is the case of the FS' focus group in FR-Beef, where participants identified droughts as one of the major challenges to deal with. Social and institutional shocks have not been identified as major challenges except in the FS' focus group in UK-Arable where participants were worried about Brexit, a debate that dominated the policy arena at the time the focus group was held.

Fig. 3 shows the actors in FSs identified by participants in the FS' focus groups (see Annex I for detailed actors). The number of bubbles by actor (along vertical lines) shows the number of FS' focus groups in which participants identified that the actor is involved in dealing with challenges in the FS. Thus, farmers (in blue) as well as financial institutions (in green) have been identified in all the FS' focus groups as actors involved in dealing with challenges. Policy makers (in orange) have also been identified in almost all the FS' focus groups except in the FS' focus group in Sweden. This exception is explained by the absence of policy interventions in the poultry sector in this country. On the contrary, value chain actors and civil society were identified as actors involved in dealing with challenges in 3 and 4 out of 10 FS' focus groups

respectively.

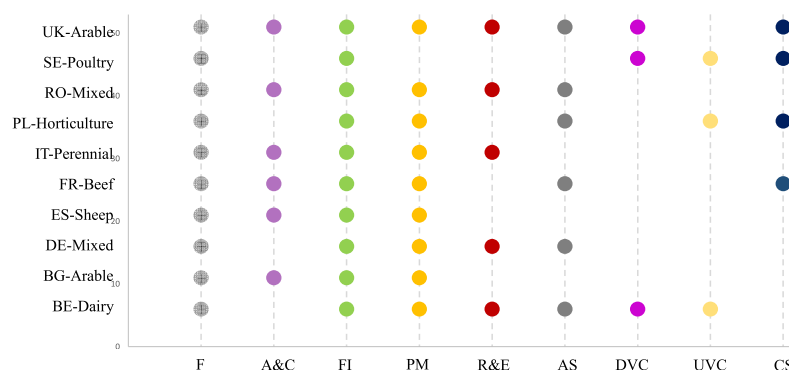
3.2. Actors' contribution to resilience capacities

Table 2 shows the current and potential (underlined) resilience-enabling roles classified by actor and capacity as explained by participants in the FS's focus groups.

Looking at the three resilience capacities, Table 2 shows that the actors in FSs are currently conducting roles that mainly enhance robustness and adaptability (first and second columns). On the contrary, actors in FSs are avoiding roles or playing them in opposite direction (underlined) that constrain transformability capacity of the FSs (third column). To gain more insight into the actor's contribution to resilience, Fig. 5 shows the scores of the actors' contribution to FS' resilience capacities given by participants in the FS' focus groups. Actors conducting resilience-enabling roles in FSs received positive scores. Actors who do not conduct or conduct resilience-enabling roles on the opposite-direction were ranked with negative scores. Fig. 5 shows, for each actor and resilience capacity, the scores of the FS' focus groups (in bullets) and the average scores (in line).

Fig. 5 shows, that farmers, farmers' associations and cooperatives and financial institutions are the actors contributing the most to robustness. For example, farmers provide FSs with extra effort and time, own capital and family work (Table 2). Farmers' associations and cooperatives are effective in providing short term and emergency support in times of crisis (Table 2); and financial institutions provide the system with insurances, credit, loans and anticipate payments (Table 2). Participants perceived that downstream value chain actors constrain robustness, mainly agreed in the FS' focus groups in DE-Mixed (−1), SE-Poultry (−1), IT-Perennial (−1) and the UK-Arable (−3), where participants explained that the goals of the downstream value chain actors are not aligned with the sector, and they do not offer enough flexibility when they negotiate contracts and define fair prices (Table 2). There are more diverse ranks on the contribution of policy makers to robustness. While participants in the FS' focus groups in BE-Dairy, BG-Arable, and RO-Mixed scored the policy makers' contribution to robustness with positive scores, the rest of FS' focus groups scored them with negative scores. The extreme case is in the FS' focus group in the UK-Arable (−3) where participants unanimously gave the negative score because of policy uncertainty, the lack of confidence in planners, resources and quick reactions, and the existence of barriers to sustainable business (Table 2).

Participants in most of the FS' focus groups perceived that all the actors in FSs contribute to adaptability, except policy makers. Fig. 5



(*) F: Farmers; A&C: Associations & Cooperatives; FI: Financial Institutions; PM: Policy Makers; R&E: Research & Education institutions; AS: Advisory Services; DVC: Downstream Value Chain actors; UVC: Upstream Value Chain actors; CS: Civil Society.

Fig. 3. Actors dealing with challenges in farming systems in Europe (*).

(*) F: Farmers; A&C: Associations & Cooperatives; FI: Financial Institutions; PM: Policy Makers; R&E: Research & Education institutions; AS: Advisory Services; DVC: Downstream Value Chain actors; UVC: Upstream Value Chain actors; CS: Civil Society.

Table 2

Current and potential (underlined) resilience-enabling roles by actor and resilience capacity (*).

	Robustness	Adaptability	Transformability
Farmers (F)	Be committed and attached to the sector (HC); dedicate extra effort and time (HC); be adverse to change (HC); be open to consumers' needs (ED); <u>implement practices to mitigate climate impacts (ED)</u> ; <u>reinforce market relationships (ED)</u> ; take out insurances (RD); look for off-farm income (RD); <u>look for proper financing structure (RD)</u> ; have traditional practices and history (HL); <u>hire skilled workers (OR)</u> ; keep savings (RP); invest own capital and family work (RP); pursue costs control (RP); maintain good assets base (RP); keep low indebtedness level (RP); <u>generate profits (RP)</u> ; share knowledge between experienced and new entrants, farmers specialized in different productions, and farmer's family members (RSL); conduct a proper management of the know-how (RSL); <u>be involved in associations (SSO)</u> .	Be oriented to consumers' needs (HC); look for new market orientation (HC); <u>be keen on changing (HC)</u> ; <u>be flexible and quick adaptable (HC)</u> ; <u>be confidence on other actors (HC)</u> ; <u>be open to novelties and new technology (HC)</u> ; have an external motivation to change (ED); have easy management and low investment production system (RD); overcome bureaucratic requirements to move to another sector (RD); keep manoeuvring room to implement strategies (RD); implement cost savings strategies (RD); use innovative plant varieties and additional crops (RD); boost local commerce (RD); production diversification (RD); <u>have a diverse and wide portfolio of strategies (RD)</u> ; have traditional practices and history to build new practices (HL); generate profits (RP); keep low indebtedness level (RP); look for financing opportunities (RP); manage savings to survive in the medium-long term (RP); design investments plans (RSL); attend training courses (RSL); ask for consultant services (RSL); study technical courses (RSL); <u>be involved in associations (SSO)</u> .	Be confident on the future of the sector (HC); <u>be keen on changing (HC)</u> ; <u>develop long-term planning (HC)</u> ; have the capacity to quickly change (HC); have a proactive attitude to have succession solved; have an external motivation to change (ED); have a diverse and wide portfolio of strategies (RD); define strategies to overcome bureaucratic requirements to move to another sector (e.g. organic) (RD); have easy management and low investment production system (RD); <u>share traditional practices with future generations to build innovative practices (HL)</u> ; <u>hire skilled workers (OR)</u> ; <u>participate in public/private interventions aim at fostering succession (OR)</u> ; <u>invest in technologies (II)</u> ; <u>look for innovation opportunities (II)</u> ; <u>earn enough funds to cover large investments (RP)</u> ; cooperate with other actors in transformative projects (SSO).
Associations and Cooperatives (A&C)	Be quickly reactive (HC); <u>define transparent procedures to keep members' confidence (HC)</u> ; provide short-term and emergency support in time of crisis (ED); stabilize market demand and prices (ED); ensure the entire production sales (ED); promote farm products (RD); support products quality schemes (RD); help to sell products and buy inputs (RD); intermediate with authorities (RD); <u>have qualified staff (OR)</u> ; <u>provide services in remote areas (OR)</u> ; provide financial buffers (RP); anticipate funds to farmers (RP); ensure income stabilization by providing stable sales prices (RP); <u>ask for low membership fee (RP)</u> ; provide pertinent information (RSL); training, and knowledge transfer (RSL); facilitate advise and monitoring (RSL); promote compliance with good practices (RSL); encourage farmers to associate to increase bargaining power (SSO); facilitate different size structures (SSO); have closer relationship with policy makers to effectively lobby (SSO).	<u>Have an outlook in the short, medium and long-term (HC)</u> ; develop new products adapted to consumers' needs (RD); support quality products and labels (RD); open new commercialization channels (RD); have a diverse and wide portfolio of strategies (RD); invest in Research and Development (II); <u>define fair membership requirements and duties (RP)</u> ; provide relevant information (RSL); advise and monitoring (RSL); training and knowledge transfer (RSL); promotes compliance with good practices (RSL); conduct market analysis (RSL); raise awareness (RSL); encourage farmers to associate to increase bargaining power (SSO); have closer relationship with financial institutions to negotiate favourable financial products (SSO); support farmers to implementing adaptability measures (SSO); facilitate communication between farmers (SSO); provide flexible support adapted to farmers' needs (SSO).	<u>Have long-term perspective (HC)</u> ; encourage common interests/goals among members (HC); <u>keep open to other production sectors (ED)</u> ; <u>have a external motivation to transform (ED)</u> ; <u>provide non-farming services and flexible services (RD)</u> ; <u>promote a legal framework to conduct transformative actions (DL)</u> ; invest in R&D (II); <u>profit level does not limit the willingness to transform (RP)</u> ; conduct transformative actions into its own board structures that may be followed by farmers (RSL); encourage farmers to associate (SSO); <u>maintain close relationship with policy makers to lobby (SSO)</u> .
Financial Institutions (FI)	Be quickly reactive (HC); be committed and close to the sector (HC); be well-structured and stable (HC); provide transparent procedures (HC); <u>have goals aligned with the sector (HC)</u> ; ensure extreme events (ED); provide insurances, credit, loans and anticipate payments (RD); <u>provide products adapted to farmer's needs (RD)</u> ; <u>have skilled staff closed to farmers in rural areas (OR)</u> ; <u>open bank branches in rural areas (OR)</u> ; provide income insurances (RP).	Be open to changes (HC); have quick adaptation capacity (HC); <u>have goals aligned with the sector (HC)</u> ; <u>be knowledgeable of agricultural sector (HC)</u> ; be tightened to market needs (ED); provide long-term finance products and guarantees (RD); provide finance products dedicated to young farmers (RD); provide flexible financing products (RD); share finance costs between several investments (RD); provide mixed products (RD); <u>design products that meet farmers' needs (RD)</u> ; <u>provide specialized insurances by product (RD)</u> ; provide labour replacement service insurances for replacing farmers when they are sick or on holidays (OR); have skilled staff close to farmers in rural areas (OR); facilitate funds for investments-credit, loans, and anticipations (RP); provide relevant information and advisory (RSL); analyse market trends (RSL); collaborate with farmers to improve insurance products (SSO).	Be keen on supporting innovative activities (HC); <u>be flexible (HC)</u> ; <u>count on a reliable administration (HC)</u> ; <u>have the goals aligned with the sector (HC)</u> ; <u>reinforce FI market competition (ED)</u> ; access to international markets (ED); <u>have the need to transform (ED)</u> ; find the best insurance schemes (RD); provide long-term products, guarantees, products adapted to current situation (RD); keep low bureaucracy (RD); <u>define staff incentives to finance transformative projects (RD)</u> ; <u>encourage farmers to move to the most productive sector and practices (RD)</u> ; <u>promote that the legal framework of the supervisory authority support transformation (DL)</u> ; <u>have skilled staff closed to farmers in rural areas (OR)</u> ; presence of several banks branches to <u>keep competency (OR)</u> ; invest in Research and Development (II); facilitates funds for investments-credit, loans, and anticipations- (RP); provide advisory (RSL); provide relevant and in time information (RSL).
Policy makers (PM)	<u>Have sector knowledgeable and qualified staff (HC)</u> ; implement robustness enabling measures (sanitary campaigns, direct payments ...) (DL); <u>keep the legal framework logic with the agricultural sector (DL)</u> ; <u>keep low level of bureaucracy and control procedure (DL)</u> ; <u>keep low policy uncertainty (DL)</u> ; <u>be flexible (DL)</u> ; <u>generate confidence among the actors (DL)</u> ; <u>develop a quick decision making system (DL)</u> ; <u>define accessible instruments (DL)</u> ; define quick	<u>Be open to changes, skilled and experienced (HC)</u> ; <u>keep the legal framework logic with the agricultural sector (DL)</u> ; <u>keep low bureaucracy (DL)</u> ; encourage adopting sustainable practices (DL); <u>define flexible programs (DL)</u> ; provides certain interventions with <u>limited entry barriers for beneficiaries (DL)</u> ; provide quick response (DL); define interventions adapted to farmers' needs (DL); <u>well- structured and coordinated planning of policy interventions across different regional levels (DL)</u> ; <u>define easy</u>	<u>PM: have the capacity to easily transform (HC)</u> ; dispose motivated staff (HC); <u>keep the legal framework logic with the agricultural sector (DL)</u> ; <u>keep low bureaucracy (DL)</u> ; <u>ensure payments in time (DL)</u> ; <u>keep low dependency on political constellation in place (DL)</u> ; <u>provide proper licensing practices (DL)</u> ; keep policies interventions stable in the middle-long run (DL); <u>define flexible legislation (DL)</u> ; <u>have skilled staff close to farmers in rural areas (OR)</u> ; <u>support funds</u>

(continued on next page)

Table 2 (continued)

	Robustness	Adaptability	Transformability
	<u>implementation measures with clear structure and procedures (DL); provide labour supply services (OR); have skilled staff close to farmers in rural areas (OR); support investment for innovation (II); support investments (RP); provide sufficient aids (RP); make secure payments in time (RP); make immediate payments in shocks (RP).</u>	<u>procedures (DL); have skilled staff close to farmers in rural areas (OR); support investment for innovation (II); promote measures that support farm financing (RP); support training courses (RSL); provide advisory and technical aid (RSL); develop good communication channels with farmers (SSO).</u>	<u>for transformative actions (RP); support activities different to agricultural production (RP); timely decision making (RP); provide technical assistance (RSL); cooperate with other actors (SSO).</u>
Advisory Services (AS)	Be knowledgeable of proven success methods (HC); be committed with advisory services (HC); be quickly reactive (HC); support preventive actions and reactions against shocks (RD); <u>define consultancy cost affordable by farmers (RP); provide knowledge (RSL); have tight relationship with policy makers to lobby (SSO).</u>	Be interested in and have the capacity to acquire new knowledge quickly (HC); be adapted to markets and farmers' needs (HC); <u>be quickly reactive (HC); be good at pushing new inputs and marketing new products and varieties (RD); provide assistance in implementing new practices (RSL); provide training and advising on future business strategies (RSL); advise on regulation and policy implementation (RSL).</u>	Be open to radical changes (HC); <u>be oriented to farmers' needs in the long run (HC); count on the administration confidence (HC); share best practices based on cross-sectorial business (RSL); develop non-dependent relationship with administrative bodies (SSO).</u>
Research and education (R&E)	Generate confidence among farmers (HC); <u>be quickly reactive (HC); conduct short-term innovation (II); research on short-term innovation (II); transfer and dissemination of the research results (RSL).</u>	Capacity to generate confidence among farmers (HC); define multifunctional strategy (RD); develop applied research (II); pursue medium-term innovation (II); promote research in new techniques and varieties (II); <u>get funds to support research (RP); provide qualified technical assistance (RSL); promote knowledge transfer and two-way communication (RSL).</u>	<u>Have a quick reorganization capacity (HC); conduct research in long-term innovation (II); have a structure easy to transform (RP); provide qualified technical assistance (RSL); promote knowledge transfer and two-way communication (RSL).</u>
Upstream value chain (UVC)	Offer supply contracts (ED); <u>favour stable prices (ED).</u>	Be willing to change (HC); provide quick technology adaptation (HC); be tightened to market needs (ED).	Be willing to change (HC); provide quick technology adaptation (HC); be tightened to market needs (ED).
Downstream Value Chain (DVC)	<u>Have goals aligned with the sector in the long term (HC); be flexible in the short term (HC); provide stabilize prices (ED); keep independence on markets to determine prices (ED); facilitate short term alternatives (RD); develop markets (OR); cooperate at large geographical scale (SSO); define fair quality requirements to cooperate (SSO); keep fair bargaining power and prices (SSO).</u>	Be open minded (HC); <u>have goals aligned with the sector (HC); be tightened to market needs (ED); define diverse commercial strategies according to supplied quantity (RD); provide advice (RSL); facilitate new ideas on doing business - storage, cooling, etc.- (RSL); boost knowledge (RSL); push the implementation of the environmentally-friendly practices (RSL); reinforce the link between farmers and markets (SSO); cooperate in certain investment activities (SSO); keep fair bargaining power and prices (SSO).</u>	<u>Have the capacity/need/interest to transform (HC); have goals aligned with the sector (HC); be tightened to market needs (ED); look for commercial diversification (RD); pursue products diversification (RD); cooperate to move towards new production models (SSO); keep fair bargaining power and prices (SSO).</u>
Civil Society (CS)	Like to keep habits (HC); <u>be confident about farmers' practices (HC); do not pursue drastic changes in consumption habits (ED); do not initiate harmful lobby (ED); avoid short-term scandals (ED).</u>	Like new products (HC); demand quality products (HC); <u>be confident about farmers' practices (HC); do not pursue drastic changes in consumption habits (ED); encourage soil and environmental conservation (RD).</u>	Like new products (HC); demand quality products (HC); <u>be confident about farmers' practices (HC); do not pursue drastic changes in consumption habits (ED).</u>

* The resilience attribute mainly reinforced by the resilience-enabling role is informed in brackets: HC: Builds Human Capital; ED: Exposed to Disturbance; RD: Response Diversity; HL: Honors Legacy; DL: Diverse Legislation; OR: Optimally Redundant; II: Infrastructure for Innovation; RP: Reasonably Profitable; RSL: Reflective and Shared Learning SSO: Socially Self-Organized.

shows that the policy makers' scores vary from positive values: BE-Dairy (1), RO-Mixed (1) and ES-Sheep (1) - to negative values - BG-Arable (-2), DE-Mixed (-1), IT-Perennial (-1), and UK-Arable (-2). Not implementing enabling resilience roles such as keeping bureaucracy levels low, provide quick responses, or defining flexible programmes explains these negatives scores (Table 2).

There is a common perception that transformability is mainly enhanced by: i) research and education, as they conduct innovative long-term research (Table 2); ii) advisory services as they act as the main promoters of knowledge and best practices (Table 2); iii) civil society because it triggers changes when it changes consumption habits looking for new products (Table 2); and iv) financial institutions as they provide long-term finance products to undertake far-reaching changes (Table 2). Participants in FS' focus groups perceived that policy makers constrains transformability because they neither keep policy interventions stable in the middle-long run, which is key for radical changes, nor provide the resources required for transformative actions (Table 2). Downstream value chain actors also hinder transformability as they are not interested in transformation (Table 2). For example, product specialization tightened to markets in hazelnut production in Viterbo (IT-Perennial) is intensive investment, and radical changes imply taking on high opportunity costs.

3.3. Mechanism through which actors contribute to resilience capacities

Considering the set of (current and potential) resilience-enabling roles, the double entry Table 3 shows the combination of the three codification criteria of the roles: actors and resilience capacities informed by participants in FS' focus groups (in columns) and inferred resilience attributes (in rows). In this way, resilience-enabling roles are classified at once along three capacities and twelve resilience attributes, resulting in 36 combinations by actor. Each cell of Table 3 contains the names (geographical location acronyms) of the FS's focus group where the mentioned actor's role meets with the corresponding combination of resilience attribute and capacity. The cells in grey are those in which most of the FS' focus groups identified the actors' roles that meet the corresponding combination of resilience attribute and capacity.

Two main results are displayed in Table 3. First, each actor in the FS fulfills roles that reinforce a set of resilience attributes and combination of resilience capacities. Starting from the first column (F-Farmers), Table 3 shows that farmers' resilience-enabling roles enhance robustness by enhancing the following combination of resilience attributes: build human capital, social self-organization, response diversity, optimally redundant, carefully exposed to disturbance, reflective and shared learning, honors legacy and reasonably profitable. For example,

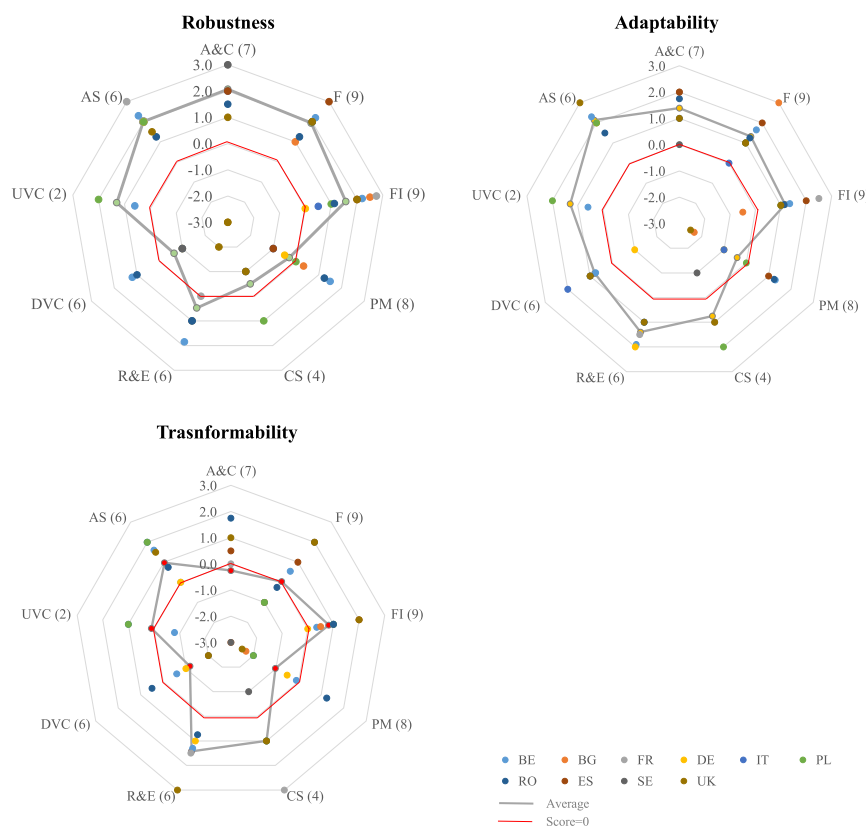


Fig. 5. Scores of actors' contribution to farming systems' resilience capacities (*).
 (*) F: Farmers; A&C: Associations & Cooperatives; FI: Financial Institutions; PM: Policy Makers; R&E: Research & Education institutions; AS: Advisory Services; UVC: Upstream Value Chain actors; DVC: Downstream Value Chain actors; CS: Civil Society. Figures in brackets show the number the FS' focus groups in which participants score the corresponding actor's contribution to the resilience capacities.

(*) F: Farmers; A&C: Associations & Cooperatives; FI: Financial Institutions; PM: Policy Makers; R&E: Research & Education institutions; AS: Advisory Services; UVC: Upstream Value Chain actors; DVC: Downstream Value Chain actors; CS: Civil Society.

participants in the FS' focus group in BE-Dairy (informed in the cell Builds human capital-Robustness) identified that farmers enhance robustness as they are committed to the sector. This role mainly reinforces the attribute of building human capital (Table 2- resilience attributes in brackets). In addition to this resilience attribute, participants in the BG-Arable focus group pointed out that farmers also enhance robustness when they keep traditional practices and history i.e., reinforcing honors legacy (Table 2- resilience attributes in brackets).

Second, the grey cells in Table 3 allow to identify common pathways across FSs, i.e. combinations of resilient attributes that the actors in FSs mainly reinforce to enable resilience capacities across FSs in Europe. The pathways to enhance robustness are the following (roles' examples in brackets and italics reported in Table 2).

- Farmers: by building human capital (e.g., by being committed and attached to the sector, dedicating extra effort and time, and remaining averse to change) and by enhancing reasonably profitable (e.g., by generating profits, maintaining a good assets base, keeping savings and low indebtedness level).
- Farmers' associations and cooperatives: by promoting shared learning (e.g., by transferring pertinent information, training, and knowledge and promoting compliance with good practices), and by enhancing the diversity of responses (e.g., by promoting farm products, supporting product quality schemes, and supporting inputs purchases and products sales).
- Financial institutions: by building human capital (e.g., by being quickly reactive, committed, close to the sector, well-structured and stable), and by promoting response diversity (e.g. by providing insurance, loans/credits and anticipating payments and provide products adapted to farmers' needs).

- Policy makers: by defining diverse policies (e.g., by keeping legal framework logic with the agricultural sector, ensuring low bureaucracy and control procedures, and generating confidence among the actors).
- Advisory services: by building human capital (e.g., by being knowledgeable of proven success methods, committed with advisory services and quickly reactive).
- Downstream value chain actors: by building human capital (e.g., by having goals aligned with the sector), and by keeping FS carefully exposed to disturbance (e.g., by stabilizing prices and keeping independence on markets to define prices).
- Civil society: by keeping FS carefully exposed to disturbance (e.g., by being confident about farmers' practices, not pursuing drastic changes in habits, avoiding short-term scandals, and not initiating harmful lobbying).

The pathways to enhance adaptability are the following (roles' examples in brackets and italics reported in Table 2).

- Farmers: by building human capital (e.g., by being oriented to consumers' needs, open to change, flexible and quick adaptable), and by providing the system with diverse responses (e.g., by building a diverse and wide portfolio of strategies, using innovative plant varieties and additional crops and boosting local commerce).
- Farmers' associations and cooperatives: by promoting diverse responses (e.g. developing new products adapted to consumers' needs, supporting quality products and labels, opening new commercialization channels), by sharing learning (e.g. by providing relevant information, advice and monitoring, promoting compliance with good practices and conducting market analysis), and by promoting social organisation (e.

Combined classification of the roles by actor, resilience capacity and resilience attribute (*).

[illegible]

* **F:** Farmers; **A&C:** Associations & Cooperatives; **FI:** Financial Institutions; **PM:** Policy Makers; **R&E:** Research & Education institutions; **AS:** Advisory Services; **UVC:** Upstream Value Chain actors; **DVC:** Downstream Value Chain actors; **CS:** Civil Society. Capacities are **R:** Robustness; **A:** Adaptability; **T:** Transformability.

g., by encouraging farmers to associate and having closer relationships with financial institutions).

- Financial institutions: by building human capital (e.g., by being knowledgeable of agricultural markets and having goals aligned with the sector), and by facilitating diverse responses (e.g., by designing product that meet farmers' needs, specializing insurances by products and developing mixed products).
- Policy makers: by defining diverse policies (e.g. by defining flexible programmes and certain interventions with limited entry barriers for beneficiaries).
- Advisory services: by sharing learning (e.g., by providing assistance in implementing new practices, training and advising on future business strategies and policy implementation).
- Research and education: by enhancing reflective and shared learning (e.g., by providing qualified technical assistance and disseminating up to date research results) and by promoting structures for innovation (e.g., by developing applied research, pursuing medium-term innovation and promoting research in new techniques and varieties).
- Downstream value chain actors: by reinforcing social organisation (e.g., by reinforcing the link between farmers and markets), and sharing learning (e.g., by providing advice and facilitate new ideas on doing business).
- Civil society: by building human capital (e.g., by being eager for new products and demanding quality products), and by keeping FS carefully exposed to disturbance (e.g., by not pursuing drastic changes in consumption habits).

Finally, the pathways to enhance transformability are the following (roles' examples *in brackets and italics* reported in [Table 2](#)).

- Farmers: by promoting reasonable profits (e.g., *by earning enough revenues to cover large investments*).
- Farmers' associations and cooperatives: by promoting infrastructure for innovation (e.g., *by investing in research and development*).
- Financial institutions: by building human capital (e.g., *by being keen on supporting innovative activities and counting on a reliable administration*) and reinforcing response diversity (e.g., *by encouraging farmers to move to the most productive sector and practices, defining the best insurance schemes, and defining incentives for the staff to finance transformative projects*).
- Policy makers: by defining diverse policies (e.g., *by maintaining low dependency on political constellation in place and keeping policies interventions stable in the middle-long run*).
- Downstream value chain actors: by building human capital (e.g., *by having the capacity/need/interest to transform*), by keeping the FS exposed to discrete disturbance (e.g., *by being tightened to market needs*), and by providing diverse responses (e.g., *by pursuing products diversification and looking for commercial diversification*).
- Civil society: by building human capital (e.g., *by being confident about farmers' practices*) and keeping the FS exposed to low disturbance (e.g., *by not pursuing drastic changes in consumption habits*).

4. Discussion - pathways to enable FSs to become more resilient

Based on the information provided by the stakeholders participating in the focus groups held in ten FSs across Europe, this research addresses how the actors may contribute to make FSs more resilient. Participants perceived that FSs have to deal with a wide variety of challenges (Komarek et al., 2020), mainly economic and social long-term pressures. The relevance of the long-term economic pressures was identified by Spiegel et al. (2021) at farm level, who found that farmers across Europe perceived long-term low market prices, long-term high input prices and low bargaining power towards processors as the long-term pressures with the highest relevance. Regarding social long-term pressures, Bertolozzi-Caredio et al. (2020) found that the lack of family succession is perceived by farmers in extensive livestock farming as one of the most

important challenges to deal with. FSs' specific challenges have also been identified. This is the case of the FS' focus groups in SE-Poultry and BE-Dairy, where participants prioritized the long-term social challenges as they are concerned about the public image of the sector, changing diets and environmental impacts (Tukker et al., 2011). Participants in the FS' focus group in UK-Arable prioritize long-term environmental challenges as the large scale crop production in East Anglia is being threatened by lowering water availability (Dessai and Hulme, 2007). Environmental shocks (droughts) have been prioritized by participants in the French focus group as the FS is dedicated to extensive beef farming that relies on pastures productivity.

The first result that sets the basis on which the discussion builds is that participants in most of the FS' focus groups identified that, in addition to farmers, farmers' associations and cooperatives, financial institutions, advisory services, and policy makers are actors involved in dealing with challenges in farming systems. This result contributes to the literature strand that proposes that dealing with challenges depends not only on the farmers' risk attitudes, perceptions and strategies (Flaten et al., 2005; Van Winsen et al., 2016; Meraner and Finger, 2019; Duong et al., 2019; Iyer et al., 2020) but also, and even as importantly, on other actors in the system (Chuku and Okoye, 2009; Antón and Kimura, 2011; Shiferaw et al., 2014; Mushtaq et al., 2020; Spiegel et al., 2020; Bertolozzi-Caredio et al., 2021a,b). Research and education, value chain actors, and civil society have been also identified by participants in some of the focus groups (less than half of the FS' focus groups). The different combination of actors involved in dealing with challenges in FSs could be explained by the diverse social dynamics that define the mutual relationships between farmers and the other actors in a FS (Meuwissen et al., 2019).

Diving into the actors' roles discussion, actors in FSs mainly contribute to robustness and adaptability capacities. Indeed, the ability to contribute to resilience capacities seems to differ across actors. While farmers, farmers' associations and cooperatives contribute to the greatest extent to FS' robustness capacity, advisory services are the actor with the major contribution to adaptability. Kamruzzaman et al. (2020) concluded that the advisory services are key actors to enhance the adaptation of the agricultural sector to deal with climate change by assuming roles such as deepening and broadening knowledge, connecting domestic and international markets, performing lobby and advocacy communication, and dealing with multiple actors beyond the agricultural sector.

Actors in FSs contributes to the lowest extent to transformability capacity, what reveals that there is an opportunity for the actors in FSs to reinforce transformability by conducting potential resilience-enabling roles (Table 2). According to Davoudi et al. (2012) and Scott (2013) resilient systems are those that have the ability to 'bounce back' and 'bounce forward'. The research conducted reveals that there are actor-specific opportunities to improve transformability. This is the case, for example, of the downstream value chain actors. They may support to a greater extent FSs' transformability capacity by aligning their goals with those of the agricultural sector and engaging in balanced negotiations (Table 2). Kangogo et al. (2020) concluded that building resilience requires coordinated farmer-buyer responses, that in turn depend on trust and commitment (Mandal and Sarathy, 2018). Higher trust reduces uncertainties and minimizes the likelihood of an actor exiting the trading relationship (Wu et al., 2012).

In this sense, it is worth mentioning the emerging opportunities for policy makers to leave behind the constraining transformability roles identified by participants in FS' focus groups and enhance FS' resilience. Some of the potential resilience-enabling roles to be conducted by policy makers are to define a legal framework adapted to the FS logic, to promote flexible programmes with low bureaucracy levels, and to implement stable policy interventions with no dependence on the political constellation. The resilience-constraining roles of the policy makers identified in this research are in line with previous assessment on the Common Agricultural Policy (CAP) that found that the CAP provides

low support to adaptability and rather constrains transformability (Buitenhuis et al., 2020). Anania et al. (2015) concluded that CAP mainly support the robustness as it focuses on retaining the status quo.

Finally, though it has been found that the set of resilience-enabling roles reinforces a wide diversity of resilient attributes, four resilience attributes can be highlighted as the main mechanism through which the actors enhance FS resilience: i) by building human capital, which is in line with previous studies that found that the individual skills, attitudes and education (Shava et al., 2010) and trust (Carpenter et al., 2012) enhance systems' resilience; ii) by providing diverse responses, as diversity cushions shocks and impacts and allows new opportunities to be explored to improve the capacity to change of farmers (Darnhofer et al., 2016) and agribusinesses (Shiferaw et al., 2014). Actors' response diversity may mediate radical changes in SESs and contribute to maintaining the long-term provision of ecosystem services (Grêt-Regamey et al., 2011); iii) by reinforcing social self-organization, as social networks provide resources needed to cope with challenges (Adger, 2003; Moore and Westley, 2011), and build resilience by fostering collective actions and social innovation (Folke et al., 2005; Newman and Dale, 2005). Slijper et al. (2022) found that different kinds of social networks contribute to different resilience capacities of the FSs; while informal networks enhance robustness, formal and more open networks facilitate more adaptability and transformability; iv) by participating in reflective and shared learning. Actors in agriculture participate in knowledge networking and learning process (Suman et al., 2018) and disseminate good practices (Carpenter et al., 2012; Darnhofer et al., 2010; Urquhart et al., 2019). Seidl (2014) concluded that systems are more robust when knowledge about the consequences of alternative actions is shared by all relevant actors.

5. Conclusions

This paper builds on the SES theory that recognises the influence of social actors in shaping systems and their dynamics. FSs are SESs in which farmers and the actors with a mutual relationship (e.g., farmers' organizations, advisory services and policy makers) play different roles (actions and attitudes) that influence the FSs' resilience. The aim of this paper is to analyse the roles played by the actors in FSs and address how these roles may enhance or constrain FSs' resilience capacities.

The results reveal that each actor in FS has the capacity to enhance resilience capacities by reinforcing different sets of resilience attributes. Resilient FSs are the result of the combination of the resilience-enabling roles played by the actors belonging to the system. Hence, all the actors in FSs are relevant to jointly reinforce the broadest number of resilience attributes that turn FSs more resilient.

Based on stakeholders' perceptions, there are gaps between what the actors in FSs are already doing (current resilience-enabling roles) and what they could do to enhance FSs' resilience (potential resilience-enabling roles). This research provides a detailed list of resilience-enabling roles that could be played by the actors in FSs to bridge the gap between the current and potential actors' resilience impact and move towards more resilient FSs. This is not an easy process as it implies the combination of diverse actors, roles, resilience attributes and capacities. The diversity of actors and pathways to make the FSs more resilient requires flexible, coordinated, and comprehensive policies that encompasses the complexity of the SESs as well as more in-depth research about the actors belonging to the FSs, their relationships, roles and potential to shape FSs resilience capacities.

Author statement

Soriano, Bárbara: Writing; Investigation; Visualization; Formal Analysis; Conceptualization; Review and Editing. Garrido, Alberto: Investigation; Visualization; Validation; Review and Editing. Bertolozzi-Caredio, Daniele: Investigation; Validation; Review and Editing. Accatino, Francesco: Data collection; Validation; Review and Editing.

Antonoli, Federico: Data collection; Validation; Review and Editing. Krupin, Vitaliy: Data collection; Validation; Review and Editing. Meuwissen, Miranda P.M: Data collection; Visualization; Validation; Review and Editing. Ollendorf, Franziska: Data collection; Validation; Review and Editing. Rommel, Jens: Data collection; Validation; Review and Editing. Spiegel, Alisa: Data collection; Validation; Review and Editing. Tudor, Monica: Data collection; Validation; Review and Editing. Urquhart, Julie: Data collection; Validation; Review and Editing. Vigan, Mauro: Data collection; Validation; Review and Editing. Bardaj, Isabel: Investigation; Visualization; Validation; Review and Editing.

Data availability

Data will be made available on request.

Acknowledgment

This research has been carried out within the framework of the SURE-Farm Project - Towards Sustainable and Resilient EU FARMing systems, a H2020 project funded by the European Commission (no.727520).

Annex I.- Description of the focus groups' participants, challenges and actors in farming systems

Farming system	Focus groups participants and activity sector	Challenges identified	Actors
Belgium (Flanders) Dairy intensive livestock	12: 6 banks and insurance companies. 2 policy makers; 2 advisory services; 2 processing industry	Low profitability; Land availability and prices; Succession; Labour pressure, ageing workforce; Keeping up to date with (changing) legislation.	Farmers; Banks; Government; Insurance companies, Advisory services; Family; Input suppliers; Processing industry; Research and Education; Distribution.
Bulgaria (North-East) Arable farming	6: 3 agricultural producers; 1 insurance company; 1 local administration; 1 cooperative	Climate change; Market uncertainty; Lack of working force; Policy instability; Technological challenges.	Farmers; Farmers' associations; Ministry of agriculture, food and forestry (MAFF); Insurance services; Labour Office; SFA - Paying Agency; Financial Services.
France (Bourbonnais) Extensive beef farming	8: 4 producers' organisation; 2 insurance companies; 2 banks	Reduction of CAP direct payments; Increase in extreme weather events; Increased administrative complexity and increasing burden of administrative tasks on operations; Appearance and/or explosion of diseases, pests and bio-aggressors.	Farmers; Feed suppliers; Farm advisors; Research and Education; Retailers/Food shops; Banks; Equipment suppliers; Policymakers; Operators/Cooperatives; Insurance companies; Accountants; Mutual Insurance/Social Security; Media; Consumer/Citizen.
Germany (Altmark) Arable and mixed farming	6: 3 farmers; 2 financial sector; 1 consulting service	Strict regulations (e.g. environmental, animal welfare, or competition); Persistently low market prices; Low societal acceptance of agriculture; Low bargaining power towards processors and retailers; Public distrust in agriculture; Persistent extreme weather events (e.g. floods, droughts, frost).	Farmers; Local Government; Public Funder; Financial Services; Consultants; Insurance companies; Research and Development; Consumers.
Italy (Viterbo) Perennial crops - Hazelnuts	6: 2 agricultural producers; 2 insurance companies (1 Agronomist); 1 producer organisation's president; 1 technical & financial advisory service	Diversification of production and activities; Improve the productivity; Negative price trend; Climate change.	Farmers; Financial Services; Insurance companies; Public Administration; Producers organizations and cooperatives; Research & Technical Assistants; Industrial processors.
Poland (Mazowieckie and Lubelkie) Horticulture farming	9: 1 insurance company; 2 chamber of agriculture representative; 1 plant health inspector; 1 parliament assistant; 1 advisory service; 1 scientist; 1 producer; 1 employment office representative	Extreme weather events and other environmental risks; market uncertainty.	Farmers; Suppliers of goods; Suppliers of financial services; Legislators and administration; Consumers; Advisors.
Romania (North East) Mixed farming	5: 2 farmers (1 representing a Farmers' association too); 2 banks (1 also representing an insurance company); 1 insurance company	Climate change (drought); Lack of markets and low prices; Lack of labour; aging farmers; illness, succession problems; Lack of cash/poverty.	Farmers; Farmers' associations and cooperatives; Processors; Distribution; Banking-financial system; Insurances; Technical assistants; Public administration; Research.
Spain (Huesca) Extensive sheep farming	9: 1 farmer; 2 farmers' organisation; 1 bank; 1 insurance company; 1 cooperative; 1 policy maker; 2 local administration	Low profitability; stagnation in lamb prices; Increasing costs; Quality of life (intense labour demanding); Lack of skilled labour; Changing policies and bureaucracy.	Farmers; Farmer's associations and cooperatives; Banks and insurance companies; Public sector.
Sweden (South) Intensive egg & broiler farming	5: 3 farmers; 1 banker; 1 branch organisation representative	Low income/profitability; Environmental conditions; Climate change; Lowering demand; Farm succession.	Farmers; Processors; Input suppliers; Branch organizations; Employees; Banks; Media; Civil Society (NGOs, activists); Consumers.
UK- East Arable farming	7: 4 business advisory, 2 bankers, 1 national farmers' union representative	Profitability/Economic sustainability; BREXIT; Agrochemical; Labour supply/affordability.	Farmers; Bankers; Business adviser; Traders (commodity market); Co-ops and buying groups; Agronomists; Research/Education Institutes; Policy makers; Planners; Wider economy/non-agri networks; NGOs.

References

- Adger, W.N., 2003. A computer movie simulation urban growth in detroit region. *Econ. Geogr.* 79 (4), 387–404. <http://www.sciencemag.org/cgi/doi/10.1126/science.11.277.620>.
- Anania, G., Balmann, A., Buckwell, A., Bureau, J.-C., De Castro, P., Di Mambro, A., Erjavec, E., Erjavec, K., FertHo, I., Garrone, M., others, 2015. *The Political Economy of the 2014-2020 Common Agricultural Policy: an Imperfect Storm*, vol. 17. CEPS Paperback.
- Anderies, J.M., Folke, C., Walker, B., Ostrom, E., 2013. Aligning key concepts for global change policy: robustness, resilience, and sustainability. *Ecol. Soc.* 18 (2) <https://doi.org/10.5751/ES-05178-180208>.
- Angelucci, F., Conforti, P., 2010. Risk management and finance along value chains of small island developing states. Evidence from the caribbean and the pacific. *Food Pol.* 35 (6), 565–575. <https://doi.org/10.1016/j.foodpol.2010.07.001>.
- Antón, J., Kimura, S., 2011. Risk management in agriculture in Spain, 43. <https://doi.org/10.1787/5kgj0d57w0wd-en>.
- Ashkenazy, A., Calvão Chebach, T., Knickel, K., Peter, S., Horowitz, B., Offenbach, R., 2018. Operationalising resilience in farms and rural regions – findings from fourteen

- case studies. *J. Rural Stud.* 59, 211–221. <https://doi.org/10.1016/j.jrurstud.2017.07.008>.
- Berkes, F., Folke, C., 1998. Linking social and ecological systems for resilience and sustainability. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience* 1 (4), 4.
- Bertolozzi-Caredio, D., Bardaji, I., Coopmans, I., Soriano, B., Garrido, A., 2020. Key steps and dynamics of family farm succession in marginal extensive livestock farming. *J. Rural Stud.* 76, 131–141. <https://doi.org/10.1016/j.jrurstud.2020.04.030>.
- Bertolozzi-Caredio, D., Bardaji, I., Garrido, A., Berry, R., Bijttebier, J., Gavrilescu, C., Harizanova, H., Jendrzewski, B., Meuwissen, M.M.P., Ollendorf, F., Pinsard, C., Rommel, J., Severini, S., Soriano, B., 2021a. Stakeholder perspectives to improve risk management in European farming systems. *J. Rural Stud.* 84 (February), 147–161. <https://doi.org/10.1016/j.jrurstud.2021.04.004>.
- Bertolozzi-Caredio, D., Garrido, A., Soriano, B., Bardaji, I., 2021b. Implications of alternative farm management patterns to promote resilience in extensive sheep farming. A Spanish case study. *J. Rural Stud.* 86, 633–644. <https://doi.org/10.1016/j.jrurstud.2021.08.007>.
- Biggs, R., Schlüter, M., Biggs, D., Bohensky, E.L., BurnSilver, S., Cundill, G., Dakos, V., Daw, T.M., Evans, L.S., Kotschy, K., Leitch, A.M., Meek, C., Quinlan, A., Raudsepp-Hearne, C., Robards, M.D., Schoon, M.L., Schultz, L., West, P.C., 2012. Toward principles for enhancing the resilience of ecosystem services. *Annu. Rev. Environ. Resour.* 37 (1), 421–448. <https://doi.org/10.1146/annurev-environ-051211-123836>.
- Bryson, J.M., 2003. What to do when stakeholders matter: a guide to stakeholder identification and analysis techniques. *Acad. Manag. J.* 15 (3), 281–292. <https://doi.org/10.1016/j.lrp.2010.08.001>.
- Buitenhuis, Y., Candel, J.J.L., Termeer, C.J.A.M. P.H., Feindt, C. J. A. M., 2020. Improving the resilience-enabling capacity of the Common Agricultural Policy: policy recommendations for more resilient EU farming systems. *EuroChoices* 19 (2), 63–71. <https://doi.org/10.1111/1746-692X.12286>.
- Bullock, J.M., Dhanjal-Adams, K.L., Milne, A., Oliver, T.H., Todman, L.C., Whitmore, A. P., Pywell, R.F., 2017. Resilience and food security: rethinking an ecological concept. *J. Ecol.* 105 (4), 880–884. <https://doi.org/10.1111/1365-2745.12791>.
- Byrd, E.T., 2007. Stakeholders in sustainable tourism development and their roles: applying stakeholder theory to sustainable tourism development. *Tour. Rev.* 62 (2), 8. <https://doi.org/10.1108/16605370780000309>.
- Cabell, J.F., Oelofse, M., 2012. An indicator framework for assessing agroecosystem resilience. *Ecol. Soc.* 17 (1), art18. <https://doi.org/10.5751/ES-04666-170118>.
- Carpenter, S.R., Arrow, K.J., Barrett, S., Biggs, R., Brock, W.A., Crépin, A.S., Engström, G., Folke, C., Hughes, T.P., Kautsky, N., Li, C.Z., Mccarney, G., Meng, K., Mäler, K.G., Polasky, S., Scheffer, M., Shogren, J., Sterner, T., Vincent, J.R., et al., 2012. General resilience to cope with extreme events. *Sustainability* 4 (12), 3248–3259. <https://doi.org/10.3390/su4123248>.
- Chuku, C.A., Okoye, C., 2009. Increasing resilience and reducing vulnerability in sub-Saharan African agriculture: strategies for risk coping and management. *Afr. J. Agric. Res.* 4 (13), 1524–1535.
- Cumming, G.S., Barnes, G., Perz, S., Schmink, M., Sieving, K.E., Southworth, J., Binford, M., Holt, R.D., Stickler, C., Van Holt, T., 2005. An exploratory framework for the empirical measurement of resilience. *Ecosystems* 8 (8), 975–987. <https://doi.org/10.1007/s10021-005-0129-z>.
- Darjani, F., Veisi, H., Liaghati, H., Nazari, M.R., Khosbakhht, K., 2019. Assessment of resilience of pistachio agroecosystems in Rafsanjan plain in Iran. *Sustainability* 11 (6). <https://doi.org/10.3390/su11061656>.
- Darnhofer, I., 2014. Resilience and why it matters for farm management. *Eur. Rev. Agric. Econ.* 41 (3), 461–484. <https://doi.org/10.1093/erae/jbu012>.
- Darnhofer, I., Fairweather, J., Moller, H., 2010. Assessing a farm's sustainability: insights from resilience thinking. *Int. J. Agric. Sustain.* 8 (3), 186–198. <https://doi.org/10.3763/ijas.2010.0480>.
- Darnhofer, I., Lamine, C., Strauss, A., Navarrete, M., 2016. The resilience of family farms: towards a relational approach. *J. Rural Stud.* 44 (April), 111–122. <https://doi.org/10.1016/j.jrurstud.2016.01.013>.
- Davoudi, S., Shaw, K., Haider, L.J., Quinlan, A.E., Peterson, G.D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L., 2012. Resilience: a bridging concept or a dead end? "Reframing" resilience: challenges for planning theory and practice interacting traps: resilience assessment of a pasture management system in northern Afghanistan urban resilience: what does it mean in planni. *Plann. Theor. Pract.* 13 (2), 299–333. <https://doi.org/10.1080/14649357.2012.677124>.
- Dessai, S., Hulme, M., 2007. Assessing the robustness of adaptation decisions to climate change uncertainties: a case study on water resources management in the East of England. *Global Environ. Change* 17 (1), 59–72. <https://doi.org/10.1016/j.gloenvcha.2006.11.005>.
- Duong, T.T., Brewer, T., Luck, J., Zander, K., 2019. A global review of farmers' perceptions of agricultural risks and risk management strategies. *Agriculture* (Switzerland) 9 (1). <https://doi.org/10.3390/agriculture9010010>.
- Elo, S., Kyngäs, H., 2008. The qualitative content analysis process. *J. Adv. Nurs.* 62 (1).
- Flaten, O., Lien, G., Koesling, M., Valle, P.S., Ebbesvik, M., 2005. Comparing risk perceptions and risk management in organic and conventional dairy farming: empirical results from Norway. *Livest. Prod. Sci.* 95 (1), 11–25. <https://doi.org/10.1016/j.livprodsci.2004.10.014>.
- Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., Rockström, J., 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecol. Soc.* 15 (4).
- Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* 30, 441–473. <https://doi.org/10.1146/annurev.energy.30.050504.144511>.
- Glemarec, Y., 2017. Addressing the gender differentiated investment risks to climate-smart agriculture. *AIMS Agriculture and Food* 2 (1), 56–74. <https://doi.org/10.3934/agrfod.2017.1.56>.
- Grêt-Regamey, A., Huber, S.H., Huber, R., 2011. Actors' diversity and the resilience of social-ecological systems to global change. *Research Collection, ETH Zürich* 44 (6), 12–19. <https://doi.org/10.3929/ethz-a-010025751>.
- Holling, C.S., Gunderson, L.H., Peterson, G.D., 2002. *Panarchy: understanding transformations in human and natural systems*. In: Gunderson, L.H., Holling, C.S. (Eds.), *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington D.C., USA, pp. 63–102.
- Inwood, S.M., Sharp, J.S., 2012. Farm persistence and adaptation at the rural-urban interface: succession and farm adjustment. *J. Rural Stud.* 28 (1), 107–117. <https://doi.org/10.1016/j.jrurstud.2011.07.005>.
- Iqbal, M.A., Ping, Q., Zafar, M.U., Abbas, A., Bashir, M.K., Ali, A., Kousar, R., 2018. Farm risk sources and their mitigation: a case of cotton growers in Punjab. *Pakistan J. Agric. Sci.* 55 (3), 683–690. <https://doi.org/10.21162/PAKJAS/18.7070>.
- Iyer, P., Bozzola, M., Hirsch, S., Meraner, M., Finger, R., 2020. Measuring farmer risk preferences in Europe: a systematic review. *J. Agric. Econ.* 71 (1), 3–26. <https://doi.org/10.1111/1477-9552.12325>.
- Kamberelis, G., Dimitriadis, G., 2013. *Focus Groups*. Routledge, London.
- Kamruzzaman, M., Daniell, K.A., Chowdhury, A., Crimp, S., James, H., 2020. How can agricultural extension and rural advisory services support agricultural innovation to adapt to climate change in the agriculture sector? *Advancements in Agricultural Development* 1 (1), 48–62. <https://doi.org/10.37433/aad.v1i1.9>.
- Kangodo, D., Dentoni, D., Bijman, J., 2020. Determinants of farm resilience to climate change: the role of farmer entrepreneurship and value chain collaborations. *Sustainability* 12 (3). <https://doi.org/10.3390/su12030868>.
- Kerner, D.A., Thomas, J.S., 2014. Resilience attributes of social-ecological systems: framing metrics for management. *Resources* 3 (4), 672–702. <https://doi.org/10.3390/resources3040672>.
- Komarek, A.M., De Pinto, A., Smith, V.H., 2020. A review of types of risks in agriculture: what we know and what we need to know. *Agric. Syst.* 178, 102738. <https://doi.org/10.1016/j.agsy.2019.102738>.
- Lobos, G., Schnettler, B., Mena, C., Ormazábal, Y., Cantillana, J.C., Retamales, J.B., 2018. Perception of risk sources by Chilean blueberry producers. *Rev. Bras. Frutic.* 40. <https://doi.org/10.1590/0100-29452018248>.
- Luyet, V., Schlaepfer, R., Parlange, M.B., Buttler, A., 2012. A framework to implement Stakeholder participation in environmental projects. *J. Environ. Manag.* 111, 213–219. <https://doi.org/10.1016/j.jenvman.2012.06.026>.
- Mandal, S., Sarathy, R., 2018. The effect of supply chain relationships on resilience: empirical evidence from India. *Global Bus. Rev.* 19 (3), 196–217. <https://doi.org/10.1177/0972150918758094>.
- Meraner, M., Finger, R., 2019. Risk perceptions, preferences and management strategies: evidence from a case study using German livestock farmers. *J. Risk Res.* 22 (1), 110–135. <https://doi.org/10.1080/13669877.2017.1351476>.
- Meuwissen, M.P.M., Feindt, P.H., Spiegel, A., Termeer, C.J.A.M., Mathijs, E., Mey, Y., de Finger, R., Balman, A., Wauters, E., Urquhart, J., Vignani, M., Zawalińska, K., Herrera, H., Nicholas-Davies, P., Hansson, H., Paas, W., Slijter, T., Coopmans, I., Vroeghe, W., Reidsma, P., 2019. A framework to assess the resilience of farming systems. *Agric. Syst.* 176, 102656. <https://doi.org/10.1016/j.agsy.2019.102656>.
- Moore, M.L., Westley, F., 2011. Surmountable chasms: networks and social innovation for resilient systems. *Ecol. Soc.* 16 (1). <https://doi.org/10.5751/ES-03812-160105>.
- Mushtaq, S., Kath, J., Stone, R., Henry, R., Läderach, P., Reardon-Smith, K., Cobon, D., Marcussen, T., Cliffe, N., Kristiansen, P., others, 2020. Creating positive synergies between risk management and transfer to accelerate food system climate resilience. *Climatic Change* 1. <https://doi.org/10.1007/s10584-020-02679-5>. - 14.
- Newman, L., Dale, A., 2005. Network structure, diversity, and proactive resilience building: a response to Tompkins and Adger. *Ecol. Soc.* 10 (1). <https://doi.org/10.5751/ES-01396-100102>, 0–4.
- Ostrom, E., 2009. *Understanding Institutional Diversity*. Princeton university press.
- Paas, W., Accatino, F., Bijttebier, J., Black, J.E., Gavrilescu, C., Krupin, V., Manevska-Tasevska, G., Ollendorf, F., Peneva, M., San Martín, C., Zinnanti, C., Appel, F., Courtney, P., Severini, S., Soriano, B., Vignani, M., Zawalińska, K., van Ittersum, M.K., Meuwissen, M.P.M., Reidsma, P., 2021a. Participatory assessment of critical thresholds for resilient and sustainable European farming systems. *J. Rural Stud.* 88, 214–226. <https://doi.org/10.1016/j.jrurstud.2021.10.016>.
- Paas, W., San Martín, C., Soriano, B., van Ittersum, M.K., Meuwissen, M.P.M., Reidsma, P., 2021b. Assessing sustainability and resilience of future farming systems with a participatory method: a case study on extensive sheep farming in Huesca, Spain. *Ecol. Indic.* 132, 108236. <https://doi.org/10.1016/j.ecolind.2021.108236>.
- Petrosillo, I., Aretano, R., Zurlini, G., 2015. Socioecological systems. Reference Module in Earth Systems and Environmental Sciences 1–7. <https://doi.org/10.1016/B978-0-12-409548-9.09518-X>.
- Podestà, G.P., Natenzon, C.E., Hidalgo, C., Ruiz Toranzo, F., 2013. Interdisciplinary production of knowledge with participation of stakeholders: a case study of a collaborative project on climate variability, human decisions and agricultural ecosystems in the Argentine Pampas. *Environ. Sci. Pol.* 26, 40–48. <https://doi.org/10.1016/j.envsci.2012.07.008>.
- Quinlan, A.E., Berbé-Blázquez, M., Haider, L.J., Peterson, G.D., 2016. Measuring and assessing resilience: broadening understanding through multiple disciplinary perspectives. *J. Appl. Ecol.* 53 (3), 677–687. <https://doi.org/10.1111/1365-2664.12550>.
- Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. *Biol. Conserv.* 141 (10), 2417–2431. <https://doi.org/10.1016/j.biocon.2008.07.014>.

- Roloff, J., 2008. Learning from multi-stakeholder networks: issue-focussed stakeholder management. *J. Bus. Ethics* 82 (1), 233–250. <https://doi.org/10.1007/s10551-007-9573-3>.
- Rounsevell, M.D.A., Robinson, D.T., Murray-Rust, D., 2012. From actors to agents in socio-ecological systems models. *Phil. Trans. Biol. Sci.* 367, 259–269. <https://doi.org/10.1098/rstb.2011.0187>.
- Schröter, D., Cramer, W., Leemans, R., Prentice, I.C., Araújo, M.B., Arnell, N.W., Bondeau, A., Bugmann, H., Carter, T.R., Gracia, C.A., De La Vega-Leinert, A.C., Erhard, M., Ewert, F., Glendining, M., House, J.I., Kankaanpää, S., Klein, R.J.T., Lavorel, S., Lindner, M., et al., 2005. Ecology: ecosystem service supply and vulnerability to global change in Europe. *Science* 310 (5752), 1333–1337. <https://doi.org/10.1126/science.1115233>.
- Scoones, I., Leach, M., Smith, A., Stagl, S., Stirling, A., Thompson, J., 2007. Dynamic Systems and the Challenge of Sustainability. STEPS Centre. <https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/2470>.
- Scott, M., 2013. Resilience: a conceptual lens for rural studies? *Geography Compass* 7 (9), 597–610. <https://doi.org/10.1111/gec3.12066>.
- Seidl, R., 2014. The shape of ecosystem management to come: anticipating risks and fostering resilience. *Bioscience* 64 (12), 1159–1169. <https://doi.org/10.1093/biosci/biu172>.
- Selsky, J.W., Parker, B., 2005. Cross-sector partnerships to address social issues: challenges to theory and practice. *J. Manag.* 31 (6), 849–873. <https://doi.org/10.1177/0149206305279601>.
- Shava, S., Krasny, M.E., Tidball, K.G., Zazu, C., 2010. Agricultural knowledge in urban and resettled communities: applications to social-ecological resilience and environmental education. *Environ. Educ. Res.* 16 (5–6), 575–589. <https://doi.org/10.1080/13504622.2010.505436>.
- Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B.M., Menkir, A., 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: technological, institutional and policy options. *Weather Clim. Extrem.* 3, 67–79. <https://doi.org/10.1016/j.wace.2014.04.004>.
- Slijper, T., Urquhart, J., Poortvliet, P.M., Soriano, B., Meuwissen, M.P.M., 2022. Exploring how social capital and learning are related to the resilience of Dutch arable farmers. *Agric. Syst.* 198, 103385 <https://doi.org/10.1016/j.agsy.2022.103385>.
- Spiegel, A., Soriano, B., de Mey, Y., Slijper, T., Urquhart, J., Bardaji, I., Vigani, M., Severini, S., Meuwissen, M.P.M., 2020. Risk management and its role in enhancing perceived resilience capacities of farms and farming systems in Europe. *EuroChoices* 19 (2), 45–53. <https://doi.org/10.1111/1746-692X.12284>.
- Spiegel, Alisa, Slijper, T., de Mey, Y., Meuwissen, M.P.M., Poortvliet, P.M., Rommel, J., Hansson, H., Vigani, M., Soriano, B., Wauters, E., Appel, F., Antonoili, F., Gavrilescu, C., Gradziuk, P., Finger, R., Feindt, P.H., 2021. Resilience capacities as perceived by European farmers. *Agric. Syst.* 193, 103224 <https://doi.org/10.1016/j.agsy.2021.103224>.
- Sūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I. des I., Rivera, M., Chebach, T., Ashkenazy, A., 2018. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *J. Rural Stud.* 59, 232–241. <https://doi.org/10.1016/j.jrurstud.2017.01.020>.
- Tukker, A., Goldbohm, R.A., De Koning, A., Verheijden, M., Kleijn, R., Wolf, O., Pérez-Domínguez, I., Rueda-Cantuche, J.M., 2011. Environmental impacts of changes to healthier diets in Europe. *Ecol. Econ.* 70 (10), 1776–1788. <https://doi.org/10.1016/j.ecolecon.2011.05.001>.
- Urquhart, J., Accatino, F., Appel, F., Antonoili, F., Berry, R., Bertolozzi, D., Black, J., 2019. Report on farmers' learning capacity and networks of influence in 11 European case studies. SURE-Farm Deliverable. H2020 project 727520. <https://surefarmproject.eu/wordpress/wp-content/uploads/2019/07/D2.3-Report-on-farmers-learning-capacity-and-networks-of-influence.pdf>.
- Van Winsen, F., De Mey, Y., Lauwers, L., Van Passel, S., Vancauteren, M., Wauters, E., 2016. Determinants of risk behaviour: effects of perceived risks and risk attitude on farmers adoption of risk management strategies. *J. Risk Res.* 19 (1), 56–78. <https://doi.org/10.1080/13669877.2014.940597>.
- Walker, B.H., 2020. Resilience: what it is and is not. *Ecol. Soc.* 25 (2), 1–3. <https://doi.org/10.5751/ES-11647-250211>.
- Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A., 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecol. Soc.* 9 (2) <https://doi.org/10.5751/ES-00650-090205>.
- Worstell, J., Green, J., 2017. Eight qualities of resilient food systems: toward a sustainability/resilience index. *Journal of Agriculture, Food Systems, and Community Development* 7 (3), 1–19. <https://doi.org/10.5304/jafscd.2017.073.001>.
- Wu, M.-Y., Weng, Y.-C., Huang, I.-C., 2012. A study of supply chain partnerships based on the commitment-trust theory. *Asia Pac. J. Market. Logist.* <https://doi.org/10.1108/13555851211259098>.