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Research

Resilience applied to farming: organic farmers' perspectives

Augustine Perrin [1], Rebecka Milestad [2] and Guillaume Martin [1]

ABSTRACT. The increasingly uncertain and changing agricultural context raises questions about the resilience, i.e., ability to cope with disturbances, of farms to climate change and other disturbances. To date, the resilience concept has been discussed mainly in the scientific field leading to an abundant literature on social-ecological system resilience and on livelihood resilience. A farm resilience framework is developing and borrows from those two frameworks. However, consistent application of the farm resilience concept remains difficult and requires better consideration of farmers' perspectives. Our objectives in this study were to highlight farmers' perceptions of farm resilience to the variety of disturbances they have to cope with in their daily farm management and to highlight resilience factors. We conducted 128 semistructured interviews on French organic dairy cattle (85) and sheep (43) farms. We asked farmers six open-ended questions about resilience in organic dairy farming. Inductive content analysis of the data was conducted. According to farmers, a resilient farm relies on a high degree of autonomy in investments, animal feeding, and decision making, and is economically efficient. Other resilience indicators include consistency of the farming plan, with, e.g., herd size corresponding to the production potential of the land, and transferability of the farm to relatives, through, e.g., the financial capital required to take over the farm. Farmers also highlighted different ways to achieve resilience. Because of the higher cost of organic inputs, converting to organic farming indirectly promotes adaptations of farms toward autonomy and economic efficiency, and is thus regarded as a major resilience factor. Farmers also highlighted the central role of pastures and grazing to achieve autonomy and improve cost control. Diversification within the farm via crop rotations, herd composition, and farm products was also considered to improve farm resilience. In this study, we are the first to explore organic farmers' perception of farm resilience. Better understanding farmers' perceptions is necessary for developing training and advisory programs to support farm resilience to a variety of disturbances.

Key Words: *content analysis; dairy farmer; organic farming; perception; resilience*

INTRODUCTION

Resilience of natural and human systems is increasingly emerging as a key property to address the challenges of a world marked by multiple interrelated crises, e.g., climate change, pandemics, and economic crises. Resilience of social-ecological systems (SES) is now well theorized (Colding and Barthel 2019) and the rich literature on the topic provides guidelines for its operationalization (González-Quintero and Avila-Foucat 2019). SES resilience can be defined as the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al. 2004) and illustrates the ability of the system to cope with adversity. A number of capacities have been suggested as preconditions to SES resilience, among others adaptability, transformability (Walker et al. 2004), capacity to absorb disturbances (also called buffer capacity), and to reorganize against those disturbances (Abel et al. 2006). These capacities involve applying a number of management principles: diversity and redundancy among SES components, connectivity among those components, management of slow variables and feedbacks, continuous learning and experimentation, active participation of relevant stakeholders in management, polycentric governance (Biggs et al. 2015). Another stream of resilience literature is livelihood resilience, which has enabled the establishment of conceptual (Ayeb-Karlsson et al. 2015, Sina et al. 2019) and indicator (Ifejika Speranza et al. 2014, Quandt 2018) frameworks. Livelihood resilience can be defined as the "capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social and political disturbances" (Tanner et al. 2015:23). Livelihood resilience places people at the center of the analysis and emphasizes their well-being. It is strongly focused on the human capital of the livelihood. Research communities on SES resilience and on livelihood resilience are close to each other (Mallick 2019). Accordingly, studies on livelihood resilience highlighted resilience capacities similar to those of SES resilience, among others buffer (or absorptive), adaptive, and transformative capacities (Mallick 2019), and capacity for self-organization, learning, and sharing knowledge (Ifejika Speranza et al. 2014). As for social-ecological resilience, principles, e.g., diversity (Marschke and Berkes 2006), emerged as promotors of those capacities and to reinforce livelihood capitals, i.e., social, human, financial, natural, and physical capitals.

Farms as production units are complex adaptive social-ecological systems in which farmers play a key role at the interface between society and the environment (Darnhofer 2010). Resilience of rural areas and farms is a growing concern (Knickel et al. 2018, Peterson et al. 2018). Similar to the capacities identified for SES and livelihood, a resilient farm is able to continue to exist and maintain its productive functions despite disturbances by relying on three capacities: buffer capacity (a system's ability to absorb a disturbance without being changed), adaptive capacity (a system's ability to make changes in response to disturbances), and transformative capacity (a system's ability to enact radical changes; Darnhofer 2014). Besides creating general frameworks and standards for farm resilience, many studies have assessed farm resilience from an objective perspective through on-farm measurement of quantitative indicators defined by researchers (Jacobi et al. 2015). Because farmers lie at the center of the farming system, researchers should also focus on the more

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Table 1. Specific features of organic dairy cattle and sheep sectors in France.

Feature	Organic dairy sector Cattle	Sheep
Percentage of total organic milk collection across sectors in 2019	96%	3%
Percentage of organic milk in total milk collection per sector in 2019	3.7%	8.7%
Organic milk price when delivered to a dairy	450[1] €/1000 L in January 2019 Average price greater than 400 €/1000 L since 2013 [2]	1280[3] €/1000 L in 2017 High and stable milk prices since 2013
Conventional milk price	340[1] €/1000 L in January 2019	964[4] €/1000 L in January 2019
Production regions in France	Five main regions: Bretagne, Pays de la Loire, Normandie, Grand-Est, and Rhône-Alpes	Two concentrated areas: Aveyron and Pyrénées-Atlantiques
Protected designation of origin for organic cheese in the survey regions	None	Roquefort and Ossau-Iraty
Sector organization	Good organization Much reference data available to farmers	Organic sector in expansion Little reference data available to farmers

[1] Baron 2020, [2] FranceAgriMer 2016, [3] Vial 2017 for the Roquefort region, [4] Agri'scopie Occitanie 2018

subjective dimension of the resilience concept (Jones and Tanner 2017) by considering farmers' perceptions of the issue. Few studies (Milestad and Hadatsch 2003, Kummer et al. 2012) have focused on understanding how farmers embrace the concept of resilience and, more importantly, how they make it operational in their day-to-day farm management. However, these studies often relied on small samples of farmers. The literature on resilience assessment also lacks studies in which resilience is defined and measured subjectively (Jones 2019). However, farmers are the ones who must manage disturbances over the short and long terms by monitoring their farm's status to verify its buffer capacity or decide on farm adaptations and transformations. Thus, farmers' perceptions of resilience are relevant, and their wealth of informal knowledge can be used to test scientific knowledge against complex local conditions, concerns, and experiences (Šūmane et al. 2018). Farmers' understanding of what qualities or attributes enhance or reduce resilience is necessary to maintain or build the resilience of farms (Kerner and Thomas 2014) and rural areas.

In this study, we considered French organic livestock (dairy cattle and dairy sheep) farms as an example of SES with a strong social component evolving in the face of specific disturbances. Through semistructured interviews with farmers, we highlighted (i) how organic dairy farmers define farm resilience to a variety of disturbances, i.e., general resilience, (ii) the indicators they use to assess farm resilience, and (iii) the resilience factors and hindrances they identify. When analyzing the data, we considered differences in perceptions related to sector (organic dairy cattle or sheep), farmers' experience with organic farming, and regional context of farms. We also discuss our findings with respect to available scientific knowledge on farm resilience, SES resilience, and livelihood resilience frameworks.

MATERIALS AND METHODS

Case study: French organic dairy cattle and sheep farms

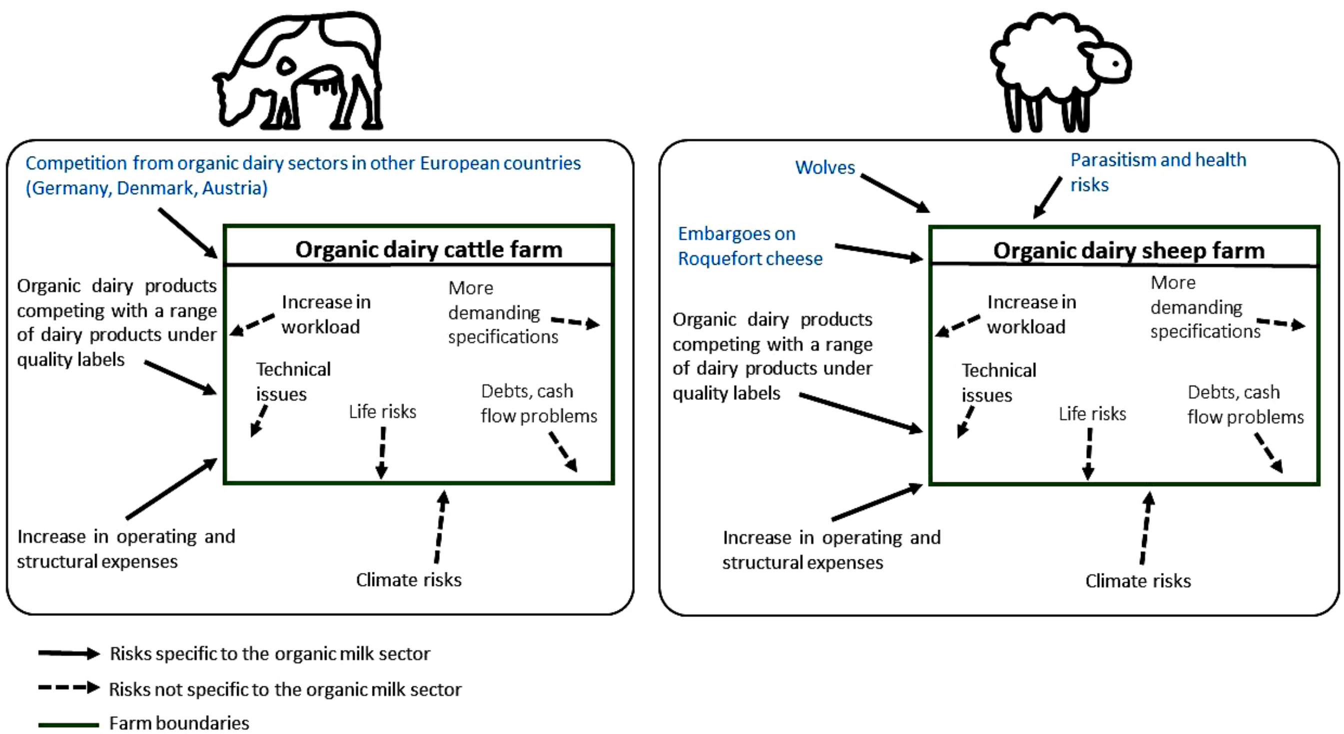
Organic farming in the European Union (EU) has been booming over the past decade (Agence Bio 2017). Development of the organic dairy sector is supported by high and stable prices paid to farmers, which favors conversion to organic farming (Table 1). Its sectors (mainly cattle and sheep) contribute differently to French national organic and total (organic + conventional) milk production and have different organizations. Whereas the organic dairy cattle sector is spread throughout the country, the sheep sector is concentrated in two production regions with protected designation of origin (PDO) for sheep cheese: Roquefort, on the southern border of the French Massif Central, and Ossau-Iraty, in the western Pyrenees. Most cattle and sheep farmers deliver their organic milk to dairies.

Despite the positive economic context for organic dairy production, French organic dairy farms remain exposed to a variety of risks (Fig. 1). When events that have risks occur on a farm, they become disturbances that can be defined as normal variations (i.e., slight disturbances that occur regularly), shocks (i.e., unexpected and sudden disturbances), cycles (cyclical disturbances), and trends (i.e., general changes that are easier to predict than shocks; Maxwell 1986). These disturbances, and farm adaptations to them, can be relatively sector-specific, i.e., more specific to cattle or to sheep milk production.

Climate change, particularly the successive droughts that occurred over the past decade, had adverse impacts on herd, crop, and pasture performances (Duru et al. 2012, Hill and Wall 2015) on both cattle and sheep farms. Droughts had distinct impacts in each sector because of differences in the geographic distribution of their farms (Table 1). Concentrating production in a small area, e.g., dairy sheep, can endanger an entire sector, while spreading farms over a larger geographical area can be an effective risk mitigation strategy at the sector scale. For example, one French dairy built milk-powder processing plants in two regions, Bretagne (northwestern France) and Occitanie (southwestern France), to better cope with climatic disturbances should they occur in one region but not the other.

Although the organic milk price has tended to increase steadily and has remained stable, farms and dairies are becoming exposed to market disturbances with the globalization of the organic dairy market. In coming years, the French internal market could no longer be able to absorb the increasing French organic milk production. The extra amount of milk will have to be sold on the

Fig. 1. Risks to the organic dairy cattle and sheep sectors in France. Risks in blue are sector-specific.

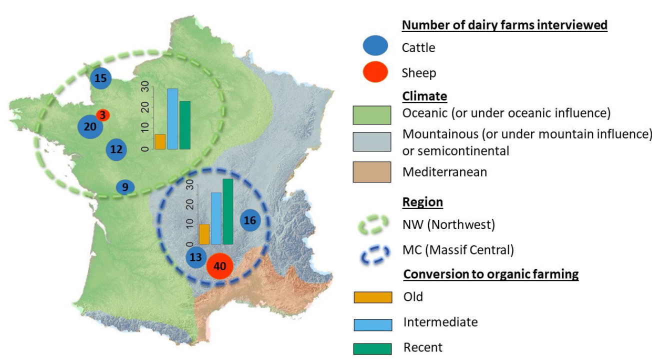


European or even on the global market and will directly compete with milk from other productive countries like Germany, Denmark, and Austria (Blanc and You 2017). This competitive context could lead to a drop in milk prices. Roquefort cheese is often hit by embargos, e.g., by China in 2017, (Boffet 2017). Because Roquefort is one of the most exported French cheeses, it is sometimes overtaxed abroad. These surtaxes may be in response to the French tax system or, more simply, to protect the dairy products of the importing country. Along with these changes and shocks, input prices are increasing, especially for livestock feed and energy (IDELE 2019). This partial list of disturbances raises questions about the resilience of organic dairy cattle and sheep farms to these disturbances.

Data collection in two French organic milk production regions

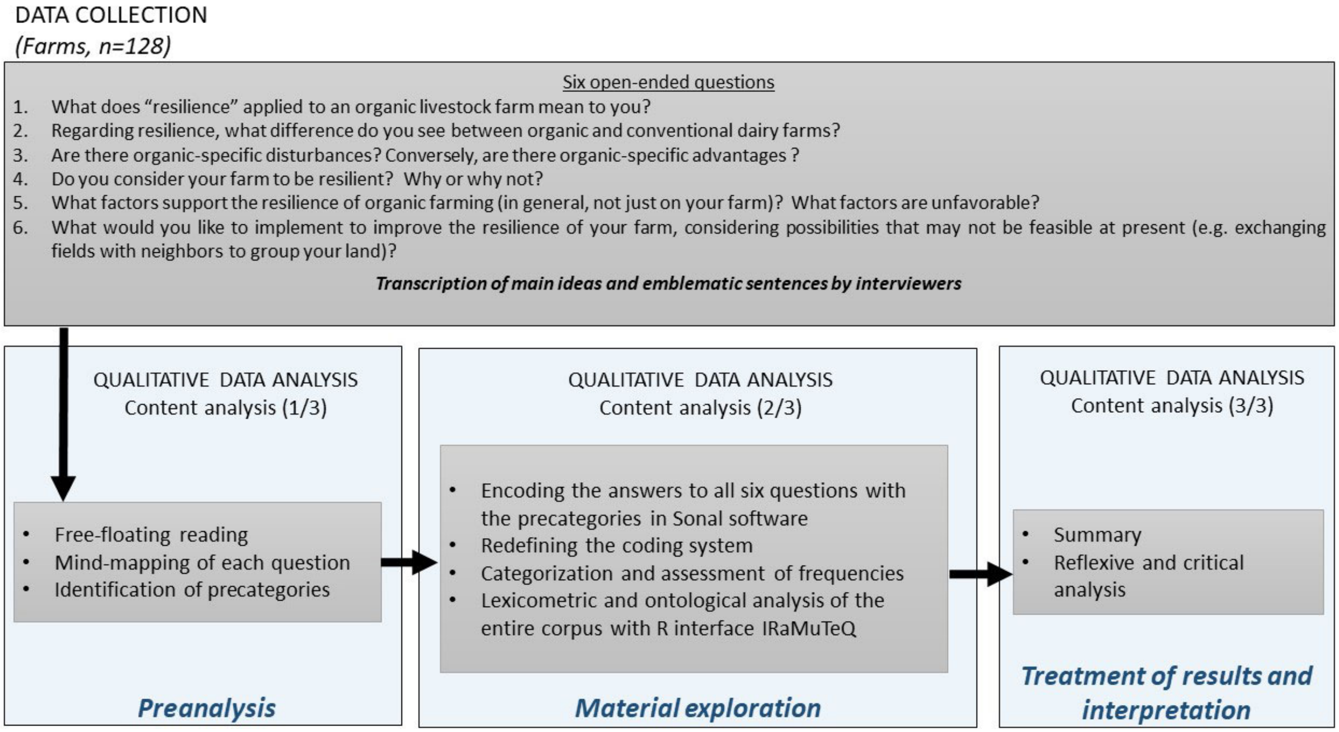
We conducted face-to-face, semistructured interviews on 128 organic dairy cattle (85) and sheep (43) farms in France (Fig. 2) from October 2017 to March 2018. Individuals from a variety of organizations involved in the Résilait project (http://itab.asso.fr/programmes/resilait.php) performed the interviews, e.g., chambers of agriculture and other advisory organizations, research and technical institutes, and agricultural high schools. Interviews with farmers lasted two to three hours and were conducted in order to collect a large range of data within the Résilait project: (i) quantitative data (which was not used in the present study) on farm structures, agricultural practices, and on the disturbances farms had faced over time together with their impact; (ii) qualitative data on farmers' perceptions of resilience, which was analyzed for the purpose of this article. Only individuals working on the farm were interviewed. All workers present on the day of the interview could participate. Each

Fig. 2. Location of the surveyed farms and distribution (bar charts) of their date of conversion to organic farming: old (1990–1997), intermediate (1998–2007), and recent (2008–2018).



organization involved in the project was assigned a number of farmers to interview and was responsible for identifying potential farms and contacting the farmers. Organizations solicited farmers from their own networks. Our sample represented 2.3% and 8.4% of the organic dairy cattle and dairy sheep farms in France in 2017, respectively. The farms were located in two production regions of France: the northwest (NW), mainly Bretagne and Normandie, which contained most cattle farms, and the southern border of the Massif Central (MC), mainly Aveyron, the area of Roquefort cheese production, which contained most sheep farms. These two regions differ particularly in their climatic and

Fig. 3. Phases of data collection and content analysis.



topographical features. Climate in the NW is oceanic, and its farms were located in lowland areas, while climate in the MC is semicontinental, and its farms were located mainly in hilly areas. We interviewed farmers in the two regions to cover a diversity of production contexts and then investigated potential differences in farmers' perceptions of farm resilience due to these contexts.

All farms surveyed had been certified organic for at least five years, with conversion dates ranging from 1990 to 2012, which provided diversity in farmers' experiences with organic farming. We classified this diversity into old (1990–1997), intermediate (1998–2007), and recent (2008–2018). This classification distinguished successive waves of dairy cattle farm conversions to organic, e.g., at the beginning of the 2000s and after both the 2008 financial crisis and the end of EU milk quotas in 2015 (FranceAgriMer 2016). Although conversions of sheep farms increased more linearly over time, this classification remained relevant and yielded periods of relatively similar length (~10 years).

Fifty-five interviewers, i.e., agricultural researchers and advisers, veterinarians, interns and students, conducted the interviews, and each was previously trained to ensure homogeneous data collection. To ensure transparency, the semistructured interview started by informing farmers about the project and the purpose of the interview. Then, six open-ended questions were asked (Fig. 3). If farmers did not know the concept of resilience (question 1) or provided an incorrect definition, e.g., confusing it with "cancellation," because "résilience" in French sounds like "résilier," which means to cancel a contract, interviewers provided the following definition: "Resilience is a measure of the speed of returning to a desired level after a disturbance. Therefore, a resilient system always returns to a desired level after a disturbance."

Defining resilience succinctly is complex (Walker et al. 2004). Because we needed a simple and concise definition to make the concept explicit in already lengthy interviews, we chose this definition because it was operational and meaningful. It is based on definitions from engineering and ecology (Holling 1996). It first refers to a farm's search for stability, which is enabled by its capacity to resist disturbances and recover from them at a speed that is sufficient to allow farming activities to continue. It also considers a return to one of many possible equilibrium states (Davoudi et al. 2012), which could differ from the one that existed just before the disturbance. Because of time and cost constraints, interviewers were asked to summarize farmers' answers and to transcribe only the most emblematic and illustrative sentences.

Data analysis

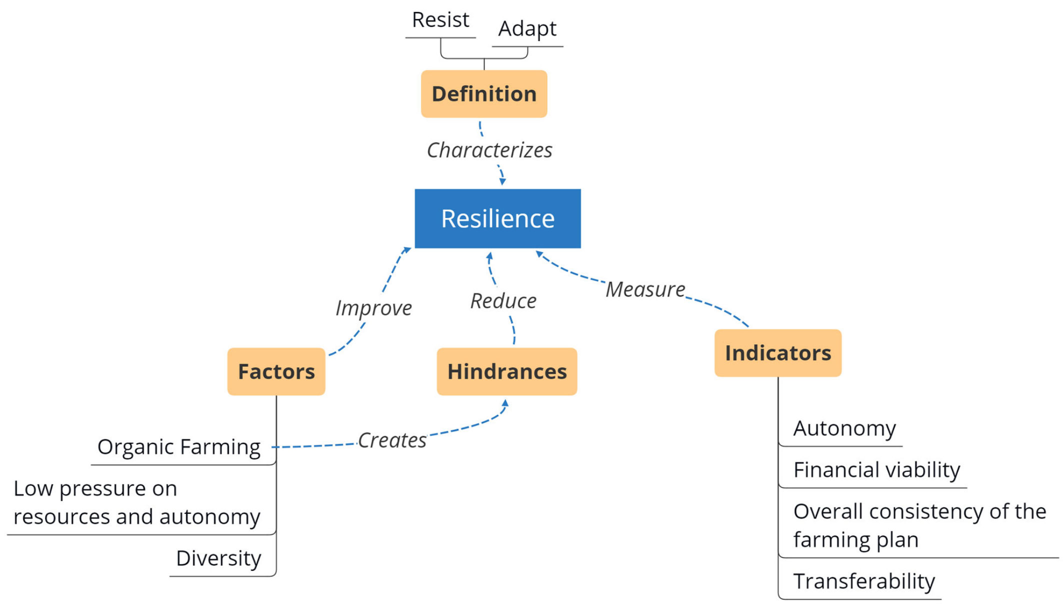
We performed inductive content analysis (Elo and Kyngäs, 2008), which is a research method for making replicable and valid inferences from transcribed discourses in the context of their use (Krippendorff 1984). Content analysis identifies important aspects of a discourse and highlights concepts or categories that describe an issue. We used it to analyze farmers' perspectives on farm resilience in an inductive way, as concepts and categories emerged from farmers' perspectives. Our method of content analysis followed recommendations of Bardin et al. (1997; general principles translated into English by Gomes et al. 2018; Fig. 3).

Initial data analysis, i.e., preanalysis (Fig. 3) consisted of a free-floating reading of farmers' answers to develop an outline of

Table 2. Categories identified in the farmers' resilience framework that correspond to the academic resilience framework of social-ecological systems.

Theme	Category	Main contents	Correspondence with research on resilience/ sustainability	Reference
Definition	Resist	Resistance, robustness, return to equilibrium after disturbance, conservation of current state	Buffer capacity; Ability of farming systems to cope with challenges	(Darnhofer 2014, Meuwissen et al. 2020)
	Adapt	Adapt, observe, learn, anticipate, react etc.	Learn to adapt; Learn to self-organize; Organic farming as a way to improve adaptive capacity and farm resilience; Adaptability to improve sustainability; Resilience through adaptability	(Berkes and Turner 2006, Darnhofer et al. 2010*b*, Anderies et al. 2013, Bouttes et al. 2019, Meuwissen et al. 2020)
Indicator	Autonomy	For fodder decision making, economics. Self-sufficiency, autonomy at the territory scale	Globally autonomous but locally interdependent; Self-sufficient farming is often related to the search for autonomous decision making. Mixed crop-dairy farms that are self-sufficient and have demonstrated their sustainability; "A farm that strives for autonomy, e.g. in fodder supply ... is more likely able to buffer shocks." Structured exchanges at the territory scale may contribute to farm resilience.	(Cabell and Oelofse 2012, Milestad et al. 2012:371, Coquil 2014, Moraine et al. 2017)
	Financial viability	Low investments, proper income, limit borrowing	Financial resources are used to improve farmers' ability to persist; Monetary indicators of farm resilience; Choosing modest technology can strengthen farm resilience; Financial viability can be considered as a slow variable; A resilient farm should be reasonably profitable.	(Milestad and Hadatsch 2003, Cabell and Oelofse 2012, Knickel et al. 2018, González-Quintero and Avila-Foucat 2019, Meuwissen et al. 2020)
	Overall consistency	Coherence between the breed and region, potential of the farm/production, etc.	Connectivity between farmers to find adapted solutions; Foster complex adaptive systems thinking, manage connectivity; Agroecosystem appropriately connected and ecologically self-regulated; Appropriate connectivity with the context; Overall consistency and self-organization for autonomy and resilience; Openness, connectivity between systems	(Berkes 2007, Darnhofer et al. 2010*c*, Cabell and Oelofse 2012, Ifejika Speranza et al. 2014, Biggs et al. 2015, Meuwissen et al. 2020)
	Transferability	A farm that can be transferred	Relation between generations and transferability; Farms handed down from one generation to the next thus showed resilience; A farm that provides well-being is easier to maintain; Honors legacy	(Landais 1999, Darnhofer 2010, Armitage et al. 2012, Cabell and Oelofse 2012)
Factors	Milk prices in a booming sector	Stable and high milk prices in the current context for OF	Stabile and high prices (highlighted by farmers in Austria)	(Milestad and Hadatsch 2003, Darnhofer 2010)
Organic Farming (OF)	Cost reduction or control	Fewer inputs needed and higher input prices resulting in a decrease in costs with OF	Under low milk prices, systems with a greater proportion of feed from pasture, and thus lower operational costs in general, have a greater margin	(Beukes et al. 2019)
	Soil and herd health	Soil life, animal health/welfare improved with OF	Soil health as one slow variable with many feedbacks; Maintain diversity and redundancy; Resilience as a universal criterion of health; Modularity of the system	(Carpenter et al. 2001, Biggs et al. 2015, Döring et al. 2015, Meuwissen et al. 2020)
	Satisfaction at work	Less polluting, societal perception of OF, OF is challenging	OF provides well-being and well-being interplays with resilience; OF brings high levels of satisfaction; OF is perceived as technically more challenging and increases professional satisfaction	(Armitage et al. 2012, Mzoughi 2014, Bouttes et al. 2019)
Low pressure on resources and autonomy	Land-herd balance	Proper stocking rate and farm size	Increased flexibility by adapting stocking density and herd composition	(Darnhofer et al. 2010*a*, Beukes et al. 2019)
	Role of grass	Importance of pastures and grazing	Maintain diversity and redundancy; Positive correlation between seminatural pastures and economic efficiency at the farm scale	(Biggs et al. 2015, Bouttes et al. 2019)
	Decrease workload	Hire employees, decrease herd size	Higher milk prices can result in reducing the herd size and workload, and thus reduce social vulnerability; Social capital as an attribute to increase resilience	(Bouttes et al. 2019, Meuwissen et al. 2020)
	Animal productivity	Accept a decrease in or having medium productivity	Maximizing animal production may reduce system sustainability.	(Schnyder and European Grassland Federation 2010)
	Importance of the network	Advisors, work groups, shared equipment	Broaden participation and encourage learning; Combine different types of knowledge and learning; Experiment	(Darnhofer 2010, Kummer et al. 2012, Biggs et al. 2015)
Diversity	Diversification	For crops, crop rotations, livestock, or production	Maintain diversity and redundancy; Diversification of markets at the enterprise scale; Nurture diversity in its various forms; Resilience through crop diversification; Diversity is crucial for absorption and reorganization; Diversity as an attribute to increase resilience	(Darnhofer 2010, Lin 2011, Carlisle 2014, Biggs et al. 2015, González-Quintero and Avila-Foucat 2019, Meuwissen et al. 2020)
Hindrances	Fewer treatments available	No antibiotics, chemicals, or synthetic fertilizers	Ecological factors, e.g., pests, impose constraints on increasing resilience	(Darnhofer et al. 2016)
	Input availability and prices	Lower availability, high prices	Farm resilience is threatened by widespread dependence on off-farm purchased inputs from specialist suppliers who are refashioning the organic sector into another sector that depends on external resources	(Milestad and Darnhofer 2003)

Fig. 4. Farmers' resilience framework.



farmers' perceptions. We then drew a mind map for each question to collate the main ideas in farmers' answers (precategories; see Appendix 1 for an example). Because of the strong relation between the answers and redundancies, we then used the same set of precategories to encode answers to all six questions, i.e., material exploration (Fig. 3), using the free software Sonal. Sonal software was also used to allocate the variables "sector" (cattle or sheep), "region" (NW or MC), and "conversion" (old, intermediate, or recent) to each interview to enable farmers' discourses to be compared. Because encoding requires time and attention, one way to avoid errors is to repeat the encoding process (Oliveira et al. 2016). We thus performed several rounds of coding to eliminate redundancies in categories and categories that were not sufficiently representative and to combine categories into common themes (Table 2). The encoded corpus was exported from Sonal software into IRaMuTeQ, an R interface for Multidimensional Text Analysis and Questionnaire Analysis (Loubère and Ratinaud 2014). It provided helpful tools to cross-validate farmers' perceptions of farm resilience that were observed during encoding, e.g., lexicometric analysis, similarity analysis. We then summarized the findings, i.e., treatment of results and interpretations (Fig. 3). Farmers' quotes, translated by the authors, are followed by their corresponding identification number, e.g., F1. Words in square brackets have been added by the authors to recontextualize certain sentences or to provide additional information.

RESULTS

Farmers' resilience framework

Definitions of farm resilience
Nearly 22% of the farmers (28 of the 128 farms) interviewed did not know what resilience meant and did not provide a definition of the concept. Nonetheless, the definition the interviewers provided enabled them to identify resilience indicators and factors (Fig. 4). Other farmers perceived resilience mainly as the ability of farms and farmers to resist and adapt.

Resist:

Most farmers perceived farm resilience as the ability to "hold out" (F53), to "address economic, social, or climatic difficulties" (F88). Many farmers related farm resilience to resistance: "it is the ability to resist external factors: drought, decrease in prices" (F26). Following this viewpoint, a resilient farm was perceived as a mechanical entity with resistance of the entire farm as well as each of its components. For example, resistance could apply to the livestock herd: "cows are more resistant to diseases" (F66), and to the entire farm: "It is when the farming system can resist" (F53). Farmers also identified farm "robustness" (F95) as a synonym of resilience. Because of the increasing interannual variability in the weather, farmers also defined resilience as a farm's ability to maintain its productivity despite climatic disturbances, such as summer droughts. "[Resilience is] maintaining a very good overall production level" (F96).

Adapt:

Farmers highlighted the capacity to adapt as a major concept that defines resilience. Adaptability was mentioned mainly in relation to external disturbances: "[A resilient farm has] a better adaptation capacity when there is a drop in prices" (F1), "[Resilience] is the capacity to adapt to climatic conditions" (F2). Farmers mentioned adapting both agricultural practices and performance goals to address external disturbances: "[Being resilient] is having production goals adapted to the farm's production conditions" (F3). Farmers mentioned how they can influence their farm's resilience. They highlighted certain skills of individuals that promote resilience. Being adaptive, one of the skills mentioned, depended on the farmers' ability to anticipate. If they could anticipate a disturbance, they could initiate changes and adapt in advance, as one farmer indicated: "Resilience evokes for me the need to anticipate" (F15). According to farmers, adaptive capacity was also related to reactivity when experiencing disturbances, i.e., the ability to adjust practices and objectives quickly. Adaptive capacity also included the capacity to recognize and seize opportunities: "[Being resilient is] being opportunistic and reactive" (F19). Farmers mentioned the complexity of organic farming and the influence of this complexity on farm management: "We need more reflection" (F56), and the need to learn to adapt deliberately "[Resilience evokes for me] learning continuously and always being on the move, not being locked into beliefs and not being alone" (F85).

Indicators of farm resilience

Farmers provided their own indicators of resilience, which reflected the variety of elements that they considered when assessing farm resilience.

Autonomy:

Farmers described a resilient farm as autonomous and that reaching autonomy was a goal: "We must seek autonomy" (F111). Autonomy was described at different levels: farm economics, livestock feed, and farmer decision making. Financial autonomy allowed farmers to remain independent from banks and freely decide their orientations "Resilience means financial autonomy" (F16). Farm autonomy in livestock feed, e.g., concentrates and fodder, often resulted in a decrease in livestock feeding costs and a decrease in exposure to the volatility of feed input prices: "[My farm is resilient] because I researched and achieved fodder autonomy. I think it's one of the essential elements of resilience. Good years are used to make surpluses for bad years" (F63); "[Resilience means] autonomy in concentrates" (F19). According to some farmers the degree of autonomy is directly related to the organic farming specifications, which makes farms more resilient: "Organic farming is more resilient because [organic farms are more] autonomous" (F74). Autonomy was also perceived as the ability of farmers to control the decision-making process, and some of them wished to "move toward decision-making autonomy" (F85). Overdependence on EU Common Agricultural Policy subsidies was also highlighted as a lack of resilience: "the reduction in ... subsidies causes problems for farmers who are too dependent on them" (F48).

Financial viability:

According to farmers, "reasonable investments" (F79) are key to ensuring economic viability before or after starting farming. Some farmers provided clear recommendations for financial viability: "We must borrow and invest reasonably to have a minimum interest rate. We should not behave like investors" (F86). Besides investments, farm economic viability implied a sufficient income and "cash flow" (F102) to address disturbances. Farmers' financial management skills also improved farm economic viability: "We are good managers: we think wisely about our investments" (F85).

Overall consistency of the farming plan:

Overall consistency of the farming plan was perceived as a fine-tuned balance between the potential of the resources managed and farmers' objectives. The need for consistency after experiencing a disturbance was sometimes mentioned: "We suffered unexpected events: we had problems with the building [the stable] and the cows. Then came the dissolution of our GAEC [Groupement Agricole d'Exploitation en Commun, i.e., collective farming group]. I also know now that you must first be in agreement with your own objectives and yourself before setting objectives for the farm" (F22). Farmers often mentioned the need to balance the number of livestock according to the potential of the land, beyond organic regulations, to have a locally adapted stocking rate: "[We need to] adapt livestock to the area available [for grazing to increase resilience]" (F59). Consistency also included locally adapted animals: "Have hardy breeds that can handle climate variations well" (F55). Overall consistency referred to systems thinking in farm management: "[My farm is resilient] because ... in my opinion, we leave room to maneuver in the cropping plan (for a possible increase) and we now have achieved consistency between the herd, work, and the cropping plan" (F87).

A farm that can be transferred:

Farms in the study were mainly family farms. According to farmers, farm resilience could include that the farm is transferable to relatives: "Yes, my farm is resilient ... the proof is that my son will take over the farm" (F80). This indicates sustainable management of resources, as the farm could be given to the next generation only if resources were not overexploited. For example, for soil and environmental health "[there is a need] to preserve, in relation to the farm as a production tool, soil and environmental heritage" (F23).

Farm resilience factors

Farmers highlighted that circumstances and agricultural practices can increase farm resilience. They recalled their own experiences and provided the contexts and agricultural practices that, according to their perceptions, had improved their farm's resilience over time. In the context of this study, these circumstances and practices were collected as perceived resilience factors.

Organic farming:

In the current context of high and stable milk prices, converting to organic farming improved the financial health of farms and was perceived as a strong factor of farm resilience. The high and stable milk price provided flexibility and economic viability, and increased the adaptive capacity. "[Higher milk] prices improve resilience" (F69). The financial viability of organic farms also improved because of better cost-control practices, which farmers related to the conversion to organic farming. High input prices tended to indirectly promote high feed autonomy, which generally reduced livestock feeding costs. "As far as expenses are concerned, the switch to organic farming has allowed me to reduce costs related to mechanization, fertilizers, veterinary costs, etc." (F29). Organic farming improved farmers' quality of life by simplifying the perceptions of the farming system: "[One advantage I see in organic farming is] a decrease in the workload" (F104), e.g., by changing to pasture-based systems that decreased the workload of feeding livestock. The relatively good financial health of farms meant that some farmers could hire employees, which decreased their personal workload.

Although farmers perceived organic farming as a good way to build farm resilience, they highlighted two main hindrances to resilience: organic farming regulations and the organic market context. Regulations restrict the management of health risks to the herd and crops. Avoiding and preventing these risks is crucial to prevent illness, but this is sometimes insufficient. Farmers highlighted a dearth of treatments, such as to manage weeds or cow mastitis, despite the permission to use antibiotics within certain limits: "Organic farming has particular problems with pressure from disease and weed. There are no chemical solutions to recover situations. Moreover, managing mastitis and udder health is not much simpler than in conventional farming" (F2). Because of the increasing organic market, many farmers also highlighted low availability of inputs and high input prices as a hindrance to farm resilience. Finding good hay in drought years seems particularly difficult: "Fodder is harder to find when the stock is low (less choice), and the quality is sometimes unsatisfactory" (F23).

Low pressure on resources and autonomy:

Farmers mentioned decreasing the pressure on farm resources as a resilience factor in that it promotes farm autonomy, which in turn builds farm resilience.

• Soil and animal resources

In accordance with the overall consistency of the farming plan, balancing the number of livestock with the land's potential could help reach the farm's production potential while remaining autonomous. Adapting the herd to the land's potential was especially important in difficult years, e.g., drought. Some farmers decreased the herd size or acquired new pastureland to decrease pressure on the farmland and mitigate climatic risks: "We would need at least five ha more to ensure our forage autonomy" (F64). Farmers perceived the proportion of pastures in their farm's agricultural area as crucial for resilience: "pasture is essential on a resilient farm" (F33). Farmers mentioned several practices to give pastures a prominent role on organic dairy farms, including increasing the proportion of pastures in the agricultural area and "improving pasture productivity [by over sowing]" (F101).

• Water resources

Pressure on water resources and low pasture productivity were real concerns because of the increasing frequency of pervasive droughts in France. Some farmers managed water shortages by installing irrigation systems and digging hillside reservoirs to keep or to improve the production level: "I would like to be able to irrigate some smaller fields [to increase my farm's resilience]" (F16).

• Human resources

Human resource management is crucial on farms. In relation to the decrease in (or lower) animal productivity and satisfaction at work, farmers indicated that decreasing the workload and improving working conditions is a way to increase resilience: "Resilience therefore ... requires a workload that is adapted and that allows us to work over the long term" (F16); "To improve resilience on my farm I would like to improve my working conditions .... I would also like to have more free time" (F29). The time thus freed up was used by some farmers to attend training days organized in their networks. These networks enabled the exchange of knowledge and know-how and were of particular importance in organic farming: farmers often tested new technologies or practices to adapt their systems. "Organic farming also provides resilience thanks to a denser and more open network (between farmers, technicians, etc.), which produces reactivity" (F22); "Participating in a group of organic breeders allows for exchanging and sharing the experiences of life on the farm" (F36).

Diversification:

Farmers mentioned diversification as a way to build farm resilience. Diversification was mentioned at the crop-rotation and field scales, i.e., a variety of crops and/or pastures in rotation: "[my farm is resilient] because of good diversity in my crop rotations" (F3). Farmers also diversified at the herd scale, i.e., rearing a variety of breeds or increasing genetic diversity of the herd: "We own rustic breeds" (F55). Diversification also occurred at the farm scale, i.e., managing several types of production, not only dairy production. Farmers mentioned several ways to develop diversity at the farm scale.

Differences in perception according to sector, region, and farmers' experience

The 128 interviews enabled us to grasp farmers' resilience framework. We then used the three variables sector, region, and conversion to organic farming to understand the differences in perceptions of farm resilience among farmers.

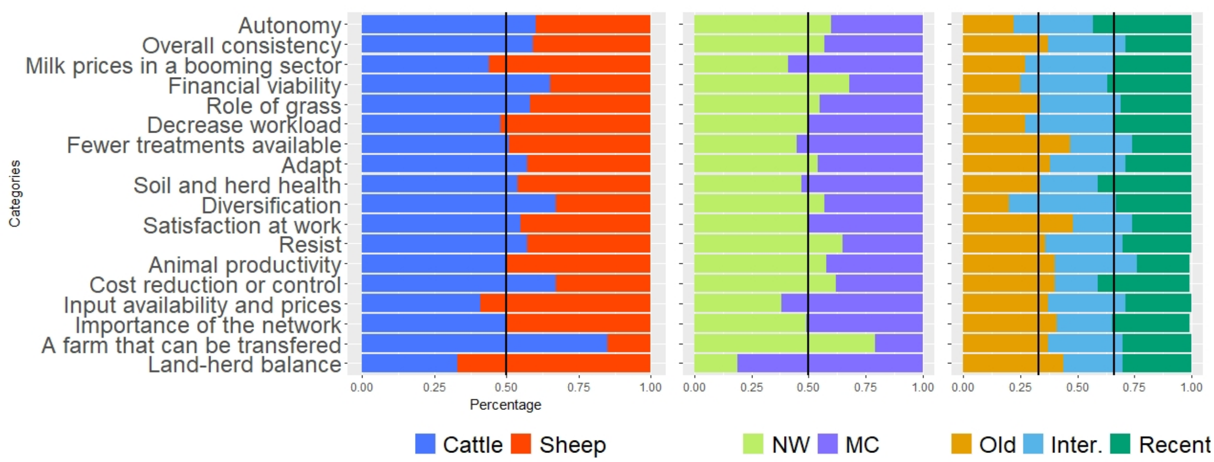
Similarity analysis highlighted differences among some of the farm resilience indicators farmers proposed:

1. The category "autonomy" was the most cited within the encoded corpus and this appeared more important to cattle than to sheep farmers. Autonomy was the 6th most-quoted word in cattle farmers' answers and the 13th most quoted word in sheep farmers' answers.
2. The category "financial viability" was more cited by cattle farmers than by sheep farmers (Fig. 5). The text analysis showed similar results: words from the lexical field of farm economics, e.g. "economics," "purchases," and "investments," ranked higher with cattle (41st, 53rd, 55th positions, respectively) compared to sheep farmers (112th, 59th, 108th positions, respectively).
3. The category "A farm that can be transferred" was more cited by cattle farmers than by sheep farmers (Fig. 5) and in the MC region compared to the NW region.

Differences were also highlighted regarding perceived resilience factors:

1. Farmers who recently converted to organic often mentioned the potential to control costs better than other categories of farmers (Fig. 5). The most experienced organic farmers reported more frequently an increase in satisfaction with their work in relation to organic farming. They mentioned the satisfaction of no longer using chemicals and having a good image with consumers: "For me, resilience means protecting the soil, stopping the use of pesticides, agreeing with what consumers want, respecting animal welfare, protecting water at the catchment scale, and protecting producers' health" (F24). Organic farming was highlighted as a resilience factor that increased farm financial viability and farmers often mentioned the high and remunerative milk prices (3rd most cited category). However, the similarity analysis showed that this connection between

Fig. 5. Distribution of categories that farmers cited by sector (cattle, sheep), location of farms (NW for Northwest and MC for Massif Central), and date of conversion to organic farming: Old (1990–1997), Inter(mediate) (1998–2007), Recent (2008–present). Categories are ranked in descending order of the number of times they were cited, i.e., “Autonomy” was cited most and “Land-herd balanced” cited least). All categories were cited at least 20 times in the entire corpus. The figure does not aim for precision, but is a guide for observing the main differences as a function of sector, region, and time since conversion to organic farming.



resilience and high milk prices was much stronger for sheep farmers (“milk” and “price” were the two words presenting the strongest co-occurrence index [17 co-occurrences] within the sheep farmer sample). Differences in the perception of hurdles related to organic farming also emerged among the two sectors considered. Sheep farmers were more concerned about health risks, particularly parasitism: “The health risk is more dangerous for organic [sheep] farming” (F119). They were also more concerned about the availability and price of concentrates: “The problem for our farm is the purchase of organic feed for the ewes. Organic feed is more expensive than conventional feed. At the beginning of our conversion to organic, we counted 100 euros more per ton of feed than for conventional feed, but sometimes the cost difference is even higher” (F101); “Oil cake is much more expensive” (F116).

2. The need to better balance land and herd emerged more frequently as a resilience factor among the MC farmers. Although most organic dairy cattle farmers mentioned the importance of herbage and the need to move toward more pasture-based systems, not all organic sheep farmers agreed (Fig. 5). The text analysis showed similar results: words from the lexical field of pasture-based systems, e.g., “grass,” or “graze,” ranked higher with cattle (49th, 72nd positions, respectively) compared to sheep farmers (92nd, 128th positions, respectively). The high milk prices and the policy of certain dairies encouraged several farmers to produce more milk: “We are paid more, we are asked for more volume, and that is what makes it work. We are surfing on [the current favorable context]” (F122). Sheep farmers often aimed for productivity and feed efficiency, which resulted in farming systems based mainly on indoor feeding at the expense of grazing and that were less autonomous than cattle farms. The threat of wolves in certain areas accentuated this phenomenon and resulted in a decrease in autonomy: “Because of wolves and the price of milk ... the ewes go on the rangeland less” (F39). Farm resilience was also strongly related to lower production pressure on animals than that in conventional farming, especially for cattle farmers: “By “pushing” the cows less, they are more resistant, they can tolerate variations in their diets better and they are less sick” (F36). The similarity analysis showed differences in the use of “production” between cattle and sheep farmers. Cattle farmers related the word “production” to words such as “adapt,” “low,” and “level.” They tended to consider production at the farm scale as a variable that can be monitored and suggested that accepting lower production levels can be one way to reduce costs. In comparison, sheep farmers most frequently related the word “production” to the word “milk” (itself strongly connected to the word “price”). Indeed, some sheep farmers recommended increasing production in the current positive context of high milk prices.

3. Regarding the resilience factor “Diversification,” cattle farmers mentioned processing milk on the farm and direct marketing as a way to improve financial viability and secure outlets: “On-farm processing of dairy products was implemented in 2017 to avoid market failures with the cooperative” (F6). Ten farmers, mostly cattle farmers, suggested diversifying farm activities by producing energy by installing photovoltaic panels on the roofs of stalls.

DISCUSSION

Similarities and differences between farmers’ and academics’ resilience framework

Definitions of farm resilience

The synonyms that farmers used to define farm resilience as the ability to continue when encountering disturbances corresponds with the literature on farm resilience. Resistance is similar to "passive robustness" (Urruty et al. 2016), and farmers used both resistance and robustness to define farm resilience (Table 2), confirming earlier suggestions in the SES resilience literature (Anderies et al. 2013) that they are equivalent terms for describing short-term challenges, like those that farmers mentioned, e.g., droughts or decrease in milk prices.

Robustness is a farm's ability to cope with a defined range of uncertainty (Anderies et al. 2013). It describes its ability to respond to a disturbance without changing in structure or function and corresponds to "buffer" capacity, one of three capacities required for farm resilience (Darnhofer 2014). Buffer capacity supports conservation within the adaptive cycle: "during the exploitation and conservation phase, a farm needs to be able to buffer a shock, such as a sudden price increase or the unavailability of a family member, without substantial changes on the farm" (Darnhofer et al. 2016:113).

Adaptive capacity is necessary for flexible farm organization and management (Darnhofer et al. 2010*a*). Farm adaptive capacity depends greatly on individual farmers' skills, such as the ability to anticipate or to react, which provides flexibility and increases options in response to disturbances (Darnhofer et al. 2010*a*). In agreement with previous studies on SES, livelihood, and farm resilience (Folke et al. 2002, Kummer et al. 2012, Darnhofer 2014), farmers highlighted the importance of learning processes, e.g., observing and experimenting, in building farm resilience. Learning is at the root of the capacity to anticipate, self-organize, and adapt and these are major contributors to SES resilience (Anderies et al. 2013).

Transformative capacity (Darnhofer 2014) seemed less important to farmers in the definition of farm resilience. This may have been because the farms in our sample had already transformed their farms before or during their conversion to organic farming, had developed a routine set of practices, and did not believe that further transformation was needed at the time of the interview. That may also relate to the lack of research on the topic, which limits dissemination of relevant knowledge.

The resist-adapt approach that farmers mentioned is similar to the persistence-adaptation approach developed by Darnhofer et al. (2010*b*). Farmers' definitions of resilience did not correspond completely with the scientific definition, but they tended to indicate that the concept is percolating outside of research fields.

Indicators of farm resilience

Autonomy:

Autonomy is an important value for many farmers (Darnhofer 2014). Assessing farm resilience based on the level of autonomy in feed, finances, and decision making agrees with the (Cabell and Oelofse 2012) resilience indicator "globally autonomous and locally interdependent" for agroecosystems. The latter indicator suggests, for example, that less reliance on commodity markets and external inputs should be included in assessments of agroecosystem resilience. Decision-making autonomy is strongly connected to the above-mentioned learning processes because acquiring knowledge is crucial for making one's own decisions (Darnhofer 2014). Autonomy was the main category cited by both sectors combined, and no farmer considered that too much autonomy was a potential risk. Recent droughts in France, however, showed that less autonomous farms, i.e., those that depended less on local resources, that routinely purchased from fodder suppliers could sometimes manage droughts better than farms with a higher level of autonomy. Farmers' pre-existing contacts and networks made it easier to buy feed. Farmers did not mention that overdependence on local resources decreased a farm's resilience to climate disturbances, as mentioned by Sundkvist et al. (2005). Autonomy can also be applied to the territory scale. Moraine et al. (2017) and Ryschawy et al. (2017) highlighted the potential of farmer networks exchanging grain, fodder, and manure for enhancing autonomy and resilience at the territory level. Reliable exchanges and connectivity between farms enable not only material exchanges but strengthen information networks and participation in polycentric governance of rural areas, as recommended in (Biggs et al. 2015) for SES.

Financial viability:

Farm financial viability was of great importance to farmers, which agrees with (Meuwissen et al. 2020), who claimed that the financial health of farms and available financial liquidity are suitable indicators for assessing farm robustness and resilience. Financial viability can be considered as a slow variable (González-Quintero and Avila-Foucat 2019) of the farm as an SES: farmers' management strategies for enhancing farm financial viability require a medium to long-term view and, and as farmers themselves pointed out, good financial management capacities. The financial viability of farms enables farmers and farm workers to earn a living wage without relying too much on subsidies (as farmers mentioned). The "reasonable profitability" of farms adds buffering capacity and flexibility, and allows farmers to invest to prepare for the future (Cabell and Oelofse 2012). In relation to investments, previous studies in Eastern Europe showed that limiting loans and even choosing modest technological upgrades were ways to strengthen farm resilience (Knickel et al. 2018).

Overall consistency of the farming plan:

Acknowledging that a farm, as an SES, is composed of complex connections and interdependencies within the farm and between the farm and its environment is the first step toward adopting management practices that foster resilience (Biggs et al. 2015). It should allow reconsidering the farming plan toward improved consistency by managing the connectivity among the farm components. The need to manage a farm as a whole by taking advantage of the connectivity of its components echoes the resilience indicator "appropriately connected" (Cabell and Oelofse 2012). The connectivity among crops, animals, and the farmer determines the farm's capacity to adapt and transform in response to disturbances and influences its degree of resilience. Farmers' networks, which are becoming increasingly dense and experienced in organic farming, also enable connectivity as already observed in SES: these problem-solving networks facilitate the exchange of both knowledge and inputs, e.g., fodder, creating opportunities for self-organization and local interdependencies (Berkes 2007). Self-organization, cooperation, and interaction between actors contributes to autonomy and thus to resilience (Ifejika Speranza et al. 2014).

A farm that can be transferred:

Transferability is one of the four pillars of farm sustainability (Landais 1999). As resilience focuses on the persistence of the farm over the long term, transferability seems highly compatible with the overall goal pursued by family farms, which is to ensure farm continuity and intergenerational succession (Darnhofer 2014). Transferability partly echoes Cabell and Oelofse's (2012) resilience indicator "honors legacy," as legacy can include biophysical resources, farming knowledge, and know-how inherited from predecessors. Transferability of the farm joins the definition of livelihood resilience in the need to sustain or improve well-being over time. This emphasizes the dynamic dimension of resilience and the long-term vision needed. Well-being and resilience are closely related concepts (Armitage et al. 2012). A farm that provides a satisfying living condition in a healthy environment is easier to take over. Such a farm keeps on producing food, ecosystem services, and broadly maintains its core structures and functions over long periods despite the disturbances met.

Farm resilience factors

Organic farming:

Previous work highlighted the potential of organic farming for increasing farm (Milestad and Darnhofer 2003) and farm community (Milestad and Hadatsch 2003) resilience. Farmers often highlighted the potential of organic farming for increasing soil health, which is a slow variable (Carpenter et al. 2001) at the core of organic farmers' management. Getting or keeping a productive and healthy soil with proper soil organic matter content is a long lasting process and soil health depends on the connectivity among farm components, e.g., via manure transfers from the stable to the field. This importance of soil and of animal health illustrates that farmers already internally shifted from a focus on productivity to a focus on long-term health of the whole farm system (Carlisle 2014). As previously shown (Mzoughi 2014, Bouttes et al. 2019), surveyed farmers often reported an increase in their motivations and satisfaction at work directly related to organic farming. They expressed their satisfaction to contribute to the maintenance of healthy soil and to lesser use of chemicals. Organic farmers also expressed satisfaction with their financial situation in relation with organic farming that provides higher and more stable milk prices. The organic market's favorable context brings more financial flexibility and helps building the financial viability of the farm. Financial serenity, motivation, and satisfaction at work highlight farmers' well-being and well-being is a factor of livelihood and SES resilience (Armitage et al. 2012). Thus, organic farming was perceived as a resilience factor for farms and beyond: it brings well-being, a wide range of ecosystem services, contributes to environmental integrity, and improves citizens' quality of life.

Low pressure on resources and autonomy:

Autonomy was identified as an indicator of resilience and farmers strive for relying as far as possible on their own resources (Darnhofer 2010). An adapted management of these resources is thus needed to keep the farm functions productive over time. The need to balance the land and the herd properly appeared as a major management aspect to farmers, and agrees with literature. Results from Beukes et al. (2019) showed that pasture-based dairy systems with high stocking rates that were not adapted to the land's potential were exposed to more climatic and economic disturbances because of their inability to buffer these disturbances. According to organic farming regulations, 60% of dry matter in the diet must come from coarse, fresh, dried, or silage fodder (FranceAgriMer 2016). Autonomous farms often rely greatly on pastures to feed livestock (Coquil 2014), and cattle farmers appeared particularly concerned with the need to build autonomous pasture-based grazing systems. Besides fodder intake, pastures influence cow health by decreasing mastitis and lameness (Washburn et al. 2002, Hernandez-Mendo et al. 2007) and contribute to sustainable management of animals.

Regarding water resources, the long-term sustainability of systems relying on hillside reservoirs and irrigation systems proposed by farmers is uncertain. The focus on maintaining crop and pasture productivity sometimes prevented farmers from considering larger changes in their crop rotations, which have already demonstrated their long-term environmental potential (Allain et al. 2018). Moreover, irrigation systems introduce risks of inequalities in access to water resources that can possibly lead to conflicts between farmers although those risks have not been stated.

Regarding our findings for human resources management, they echoed Gosetti (2017) who developed a framework to assess the quality of working life from the perspective of farm sustainability. This framework included an "ergonomic dimension," e.g., well-being of workers, work hours, work intensity, tools and instruments available, health and safety of the work place, which corresponds to farmers' perceptions. Good working conditions are necessary over the long term to ensure farm resilience. In agreement with Kummer et al. (2012), farmers mentioned that sharing knowledge and experimenting on farms helps build farm resilience.

Diversification:

Diversity is a major attribute for SES (Carlisle 2014), livelihood (Ifejika Speranza et al. 2014), and farm resilience (Darnhofer et al. 2010*a*). On a livestock farm, diversity applies to all the components of the farm, e.g., pastures, crops, animals, and products sold, and is crucial for absorption and reorganization (González-Quintero and Avila-Foucat 2019). Diversification is thus one way to spread risks and create buffers (Darnhofer et al. 2010*a*). On this point, farmers' perception of resilience were similar to the literature on diversification, regardless of the scale considered, e.g., cropping system (Lin 2011, Gaudin et al. 2015), crop-livestock system (Frison et al. 2011), and farm (David et al. 2010). As far as farm products are concerned, promoting economic diversification through an expansion of farmers' activities enhances resilience and this is also the case of off-farm activities providing a stable source of income (Ashkenazy et al. 2018). However, diversifying activities and income sources changes both the workload and the work organization (Darnhofer and Strauss 2014) on the farm. Farmers who mentioned this type of diversification were sometimes reluctant to begin a new activity because of potential work overload. Installing photovoltaic panels on the roofs of stalls could increase farm energy autonomy. Darnhofer et al. (2010*b*) identified developing on-farm energy production as an adaptation approach to transform farming.

Similarities and differences between sectors, regions, and farmers' experience

Indicators of farm resilience

The perception of (1) autonomy, (2) financial viability, and (3) transferability as indicators of farm resilience differed between cow and sheep farmers.

1. Autonomy appeared more important to cattle than to sheep farmers. This difference was also reflected in a quantitative assessment of farmers' resilience and practices (Perrin et al. 2020). The latter study highlighted that on the one hand, practices that focused on autonomous pasture-based grazing systems improved subjective resilience of organic dairy cattle farms. On the other hand and in relation to the sector contexts, autonomy was less relevant for sheep farmers. The improvement of subjective resilience of organic dairy sheep farms was primarily driven by an increase in sheep productivity. High milk prices allowed sheep farmers to buy expensive inputs more easily.

2. French farms generally have a high debt ratio. In 2017, the indebtedness of dairy cattle farms equaled ~45% of their gross surplus, and it was ~38% for sheep farms (Ambiaud et al. 2019). This difference could explain why financial viability was particularly important for cattle farmers.

3. "A farm that can be transferred" was a category more cited by cattle farmers than by sheep farmers because cattle farms in our sample were mainly family farms contrary to surveyed sheep farms.

Farm resilience factors

The perception and the importance of (1) organic farming, (2) a low pressure on resources, and (3) diversity as farm resilience factors also differed between farmers.

1. Both cattle and sheep farmers perceived organic farming as a resilience factor. However, we observed differences in their perception of hindrances to resilience directly related to organic farming. Sheep farms in Aveyron have a limited autonomy for feed (Vial 2017), and the difficulty in finding concentrates on the local market at affordable prices may explain why sheep farmers tended to cite the category "input availability and prices" more often. Farmers in Austria noted similar hindrances: Darnhofer et al.' (2005) "pragmatic conventional" type of farmer highlighted the technical challenges of organic farming as one reason not to convert. Besides these technical challenges, overreliance on external organic inputs purchased from specialist suppliers threatens organic farm resilience (Milestad and Darnhofer 2003), as do practices that require large amounts of external inputs (Darnhofer et al. 2010*c*).

2. MC farmers cited more frequently the need to balance land and herd in farm management. Topographical and climatic constraints faced by farms from this region result in lower potential pasture and crop productivity than in the NW. Adapting the size of the herd to the potential of the land is even more important in MC.

3. Farm-scale diversification seemed less important to sheep farmers, likely because of the currently high and stable organic milk prices, which are increased by the well-known Roquefort PDO.

Cognitive biases

The current positive context for organic dairy production, e.g., high and stable milk prices, growing advisory networks, positive and future-facing image to consumers, may have resulted in an optimistic bias. Despite the mention of some hindrances to resilience caused by organic farming, farmers were mostly satisfied with the current state of their farm and perceived little need for transformative capacity (except certain farmers who mentioned installing milk-processing or energy-production units). The definition of resilience that we provided to farmers who had no idea of the concept missed this transformative capacity, which could have influenced the farmers' lack of reference to this capacity. Organic farmers also trended to perceive their situation as generally more comfortable, e.g., regarding income or the working conditions with no use of chemicals, and less risky (Klein and Helweg-Larsen 2002) than that of conventional farmers. Organic farming in itself appeared as a resilience factor. This may have resulted in part from confirmation bias: some farmers could seek evidence that organic farming is by definition resilient partially because of their own beliefs and expectations (Nickerson 1998), thereby rejecting resilience factors that could also exist on nonorganic farms. Moreover, the interviews used "resilience," which farmers may not have known as well as other terms such as "sustainability." This could have decreased the importance assigned to the environmental impacts of their farms and placed more emphasis on the dynamics and adaptations needed to reach each farmer's "desired state" (Milestad and Hadatsch 2003).

FARMS AS COMPLEX ADAPTIVE SYSTEMS AND FUTURE FOR ORGANIC DAIRY FARM RESILIENCE

Farm resilience is complex to define and to assess (Quinlan et al. 2016). Farmers play a central role in farms as complex adaptive systems; thus, their subjectivity is relevant. Our study highlighted the relevance of assessing subjective resilience (Jones and Tanner 2017) to complement resilience assessment methods that focus on quantitative performance indicators (Groot et al. 2016). We position it on Jones's (2019) objectivity-subjectivity continuum as a study in which resilience is subjectively defined and evaluated by farmers, with the resulting judgment and personality biases. Beyond their understanding of resilience, farmers provided their own metrics for farm resilience, i.e., the ideas they use to assess it: indicators (Fig. 5) and farm management practices that increase farm resilience, i.e., factors. Researchers can use content analysis to test theoretical issues (Elo and Kyngäs 2008), and although not all farmers interviewed knew the concept of resilience, this conceptual framework corresponds in many ways to the literature for defining, measuring, and improving the resilience of SES, livelihood, and agro-ecosystems (Table 2). This study once again reveals resilience as a multidisciplinary bridging concept and thus as a useful tool to the study of the disturbed systems at the interface between humans and nature that farms are. Many of farmers' conceptualizations were similar with the academics' framework, but some differed. Among the differences, managing water resources by digging hillside reservoirs or installing new irrigation systems raises questions about the long-term resilience for farms and broadly for rural areas on which conflicts for water resources may arise in a context of more and more frequent and pervasive droughts. Some of farmers' perceptions appear oriented toward the short term, which could be described as "coerced resilience," i.e., "resilience in the context of production that is created as a result of anthropogenic inputs ... rather than supplied by the ecological system itself" (Rist et al. 2014:3). During a drought, irrigation-dependent farms can still be pushed into an undesirable state and lose a considerable amount of yield (Peterson et al. 2018). The major difference between the conceptual frameworks of farmers and researchers is that farmers did not mention transformative capacity directly. The example of irrigation illustrates the resistance to transform farming systems by radically changing cropping systems to better cope with droughts. Regarding milk prices and health problems, sheep farmers seemed less preoccupied by autonomy than cattle farmers. Buying fodder and ensuring ewe productivity in the context of high milk prices appeared to be the preferred strategy, which could challenge farm resilience in the long term. The decrease in feed autonomy could become risky if milk prices decrease or feed shortages occur.

Despite the optimistic bias, farmers' perceptions in a positive context highlighted concrete ways to improve the resilience of organic dairy farms in France. Although the context for the dairy sheep sector is specific to the Roquefort DPO, the results for the dairy cattle sector are relevant to farms outside of France. In agreement with (Šūmane et al. 2018), farmers' informal but accurate knowledge of their farming systems provided considerable insights and a step toward rendering the concept of resilience operational. The results can help other farmers (or future farmers) to assess the resilience of their farms (or desired farms), which is crucial for their daily management choices and for achieving their goals. Advisors and teachers in agricultural schools can also use these results but they need to be made easier to work with. Developing a pedagogical teaching tool based on these operational results and considering contextual differences (cattle, sheep, and other sectors) would be useful for expanding systems thinking in education programs as Blackmore et al. (2018) recently advised and supporting the design of resilient and sustainable agricultural systems.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/11897

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Data Availability:

The data that support the findings of this study are available on request from the corresponding author, A.P. The data is not publicly available because they contain information that could compromise the privacy of research participants. The authors certify that the work was done with prior approval for human subjects research by the institutional review board (IRB) of INRAE.

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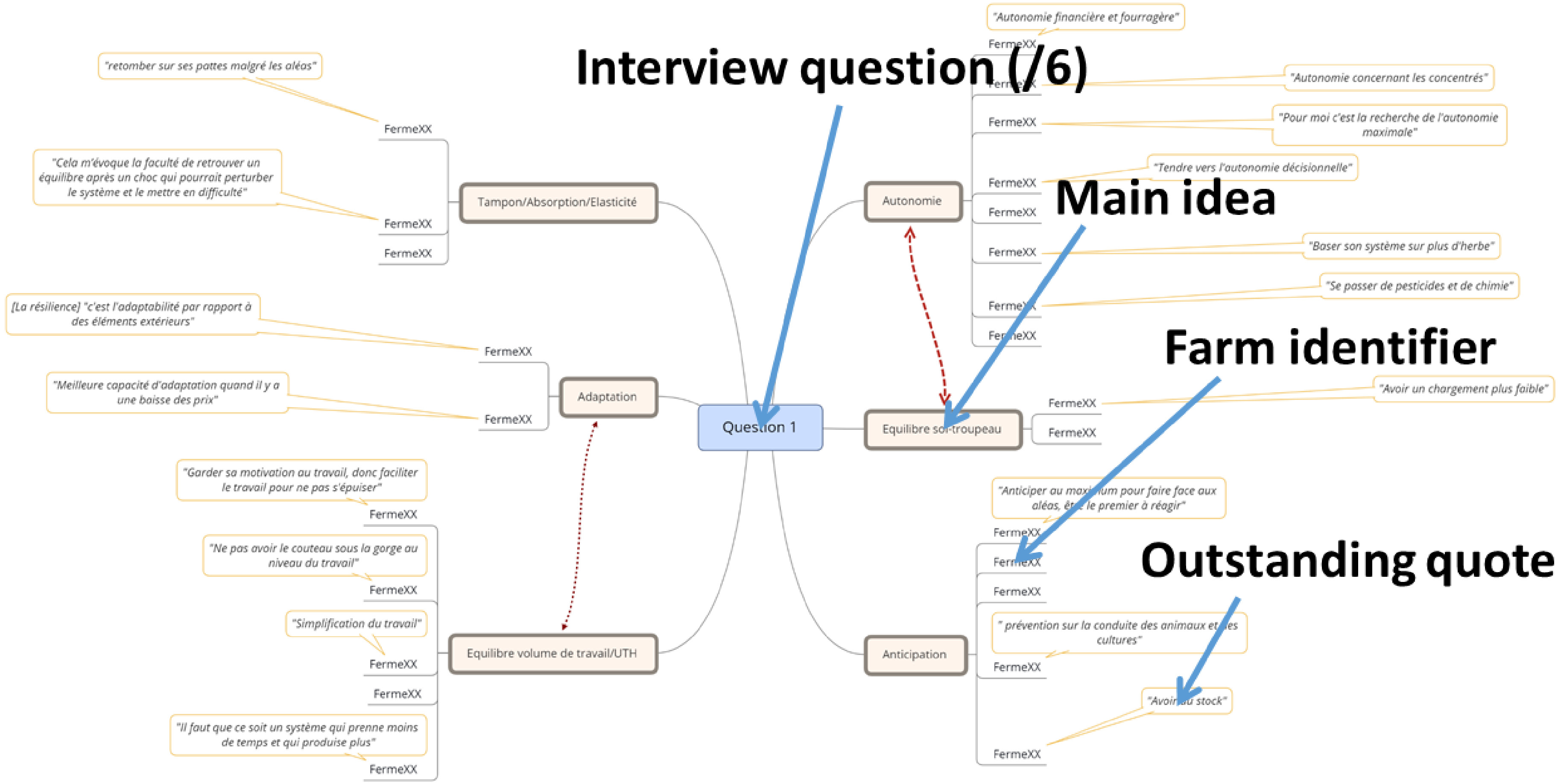

This kind of mind map (this is a simplified version for a better readability), drawn for each of the six questions, provided a useful initial overview of the main perspectives. The same person made the mind maps and decided how to organize the main ideas from transcripts of the interviews. The main ideas grouped farmers' discourses based on nearby lexical fields, and the outstanding quotes were selected for their ability to summarise the main ideas well. As some farmer responses during the interview corresponded to a previous question or were redundant, the entire corpus was encoded after this mind-mapping step using the categories that resulted from the pre-analysis phase.