Bucking the trend: Crop farmers' motivations for reintegrating livestock

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Abstract

Context

European farms and regions follow the trend of agricultural specialisation, which results in a disconnection between crop and livestock production. High-input specialised farming systems are continuing to be developed even though they generate negative environmental impacts. Despite these trends, a few pioneering farmers have intentionally reintegrated livestock onto crop farms in several regions. To date, research has rarely examined farmers' motivations to develop such systems.

Objective

We aimed to identify French farmers' motivations for reintegrating livestock onto specialised crop farms and into crop-producing regions.

Methods

Following innovation-tracking principles, we identified 18 crop farmers who had reintegrated livestock in two regions where crop farming predominates: Occitanie and the Parisian Basin. The farmers' profiles varied in production mode, farm size, the crops and livestock produced, and the type and duration of livestock reintegration. Semi-directed interviews focused on the farmers' motivations for having reintegrated livestock. At the end of the interviews, we asked them to select and rank 10 of 36 cards that represented their main agronomic, economic, social and environmental motivations for crop-livestock farming. We transcribed the interviews and performed inductive content analysis, which was then triangulated with the farmers' rankings of the cards.

Results and Conclusions

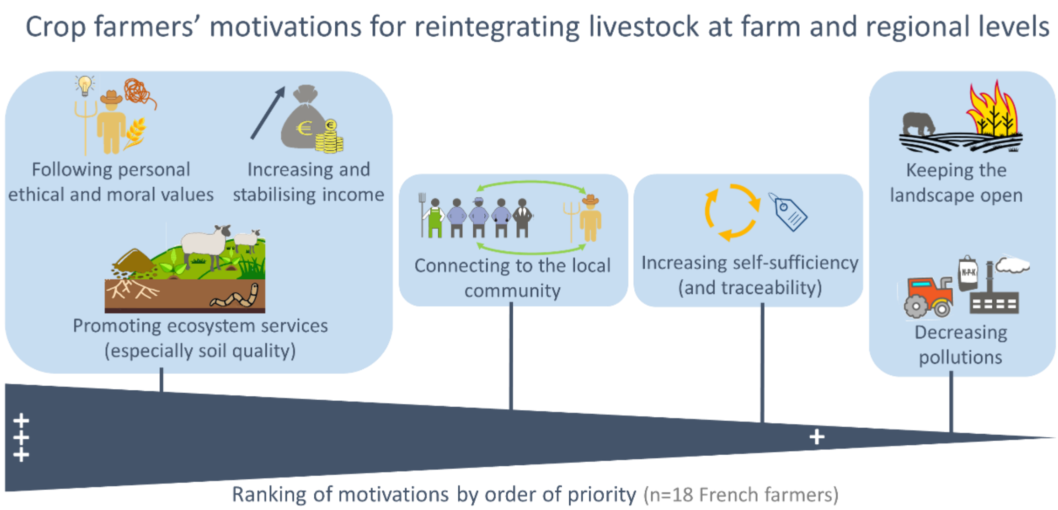
Seven categories of motivations for reintegrating livestock emerged from the interviews: following personal ethical and moral values, increasing and stabilising income, promoting ecosystem services, increasing self-sufficiency and traceability, connecting to the local community, decreasing pollution and keeping the landscape open.

In both discourse analysis and motivation card rankings, agronomic motivations (including promoting ecosystem services) were predominant, especially improving soil life and fertility. Farmers ranked economic and social categories nearly equally. Improving and stabilising income was cited by 17/18 farmers in their discourse, consistently with the two most-selected economic motivation cards. Strengthening social connections was the most-selected social motivation in card rankings and was mentioned by 14/18 farmers in their discourse, particularly for connections among farmers. Environmental motivation cards were selected less often, except for environmental stewardship, which was consistent with the desire to build an environmentally friendly farming system to follow personal ethical and moral values mentioned by 10 farmers in their discourse.

Significance

This study is the first to provide a ranked summary of crop farmers' motivations for reintegrating livestock. Understanding this diversity is an initial step in incentivising, promoting and/or supporting the development of this innovative sustainable practice under favourable conditions and can encourage public actions that promote it.

Graphical abstract



Highlights

- Specialisation of crop or livestock production has negative environmental impacts.
- A few pioneering farmers have reintegrated livestock onto crop farms and into crop regions.
- We identified seven categories of motivations for reintegrating livestock.
- Promoting ecosystem services and following personal values were the main motivations.
- Strengthening social connections and improving income were other major motivations.

1. Introduction

Over the past few decades, the trend towards agricultural specialisation in Europe, and in France in particular, has disconnected crop and livestock farming at farm and regional levels, which has contributed to environmental externalities (Garrett et al., 2020). This regional specialisation raises many issues for crop and livestock regions. Specialised crop regions are productive, but depend greatly on nutrient inputs (Peterson et al., 2020) and consume large amounts of direct and indirect energy (Harchaoui and Chatzimpiros, 2018). In comparison, specialised livestock regions are not self-sufficient in animal feed and generate excessive amounts of manure, leading to storage, disposal and pollution problems (Peterson et al., 2020). Begun in the 1950s, specialisation still occurs in France, with livestock production concentrating in a few regions and livestock and mixed (i.e. crop-livestock) farms decreasing elsewhere. In 1988, livestock farms were the most common type of farm in France (44% of all farms), followed by crop farms (37%) and mixed farms (19%) (AGRESTE, 2020). From 1988-2020, the number of each type of farm decreased, especially mixed farms (-75%), followed by livestock farms (-66%) and crop farms (-42%). Consequently, in 2020, crop farms were the most common type of farm (52%), followed by livestock farms (36%) and mixed farms (12%) (AGRESTE, 2020).

As explained extensively by Garrett et al. (2020), this specialisation results from several major structural changes that occurred during the second half of the 20th century. Liberalisation of trade forced farmers to become competitive on the global market (Ryschawy et al., 2013). To gain global market shares and protect farmers from international competition, the European Union's Common Agricultural Policy developed subsidies that focused on commodity crops and were tied to production, thereby increasing the profitability of specialised systems (Garrett et al., 2020; Schut et al., 2021). The development of labour-saving equipment and the increased cost of labour promoted the industrialisation of farming to reduce production costs, as well as its specialisation to favour economies of scale. The low prices of nitrogen fertilisers reduced farmers' reliance on livestock manure. To benefit from an agglomeration economy (i.e. clusters of related agribusinesses), specialisation also occurred at the regional level. Research agencies, advisor services and subsidy programs specialised towards crop or livestock systems, which led to path dependencies toward specialisation (Garrett et al., 2020;

Gil et al., 2016). In regions where mixed farms and livestock farms have been decreasing for decades, the livestock socio-technical system has decreased, with a fragmenting supply chain (e.g. few slaughterhouses, veterinarians or technical advisors) and a general lack of knowledge. These facts challenge the practice of mixed farming and livestock farming in several French regions.

Despite these trends, in the current context of increasing prices for energy and fertilisers (fuel and nitrogen fertilizer prices have been multiplied by 2.6 and 4.2 respectively between 2020 and 2022 in France (EUROSTAT, 2023), including a 1.6 and 1.9 multiplication between 2021 and 2022), a few pioneering farmers in France have reintegrated (i.e. intentionally organised the return of) livestock onto crop farms and into crop regions. These systems may help reduce environmental impacts of specialised agricultural production by reconnecting crop and livestock production (Lemaire et al., 2014) at the farm level (e.g. rearing livestock on the farm) or regional level (e.g. partnership between a crop farmer and livestock farmer, with the former hosting the latter's livestock for a specific period, for example to graze a winter cover crop). While crop-livestock integration has been studied widely in recent years (Baker et al., 2023; Paut et al., 2021; Sekaran et al., 2021), livestock reintegration has not received much attention to date. Understanding the motivations that drive farmers to reintegrate livestock in such a challenging context is a necessary first step to assess performances of these systems in light of farmers' objectives and to incentivise, promote and/or support adoption of this sustainable practice (Cortner et al., 2019; Paut et al., 2021; Ryschawy et al., 2021).

Farmers' adoption of a practice relies on i) their behavioural control (which corresponds to the question: "Can I do this?"), i.e. how elements of the socio-economic context (e.g. policies, market) and farm characteristics (e.g. climate, ecology, economic and physical ability to access technology) will make it easier or more difficult to adopt a practice and ii) their attitude ("Do I want to do this?") (Ajzen, 1991; Cortner et al., 2019; Ryschawy et al., 2021), both influencing each other. Farmers' attitude towards adopting a practice is influenced by i) their beliefs about the practice ("What benefits do I expect from this practice?) (Ajzen, 1991); ii) their objectives for the farm (Ryschawy et al., 2021); iii) their values (Raymond et al., 2016; Stern and Dietz, 1994); iv) their risk preference (i.e. how willing they are to adopt practices that are considered risky) (Flaten et al., 2005; Greiner et al., 2009), which is strongly related to their perception of their ability to adopt this practice and v) subjective norms (Ajzen, 1991) that they have internalised ("How much do I think people want me to adopt this practice?").

To date, no study has specifically sought in-depth understanding of the attitude (hereafter, "motivation") toward reintegrating livestock onto specialised crop farms and into crop-producing regions. Few studies have focused on the conditions (including both behavioural control and attitude) that support persistence of mixed systems or reconnection of crops and livestock due to farmer cooperation beyond the farm level in regions where both types of farms still exist. They emphasised research on self-sufficiency, mitigation of market and climate risks through diversification, increased nutrient and land-use efficiency, strong cultural norms of environmental stewardship or connections to traditions as factors that support the persistence or re-emergence of mixed systems, provided that a sufficient workforce is available (Bell and Moore, 2012; Coquil et al., 2014; Garrett et al., 2020; Peterson et al., 2020; Ryschawy et al., 2013). Studies also highlighted multiple lock-ins of reconnecting crop and livestock systems through farmer cooperation beyond the farm level (Garrett et al., 2020; Martin et al., 2016; Moraine et al., 2017), especially the high costs of creating and maintaining long-term cooperation due to i) collecting information, due to the overall lack of knowledge; ii) collective decision-making when crop and livestock farmers have strongly diverging viewpoints and iii) monitoring partnerships (Asai et al., 2018).

The objective of this study was to identify and analyse French farmers' motivations for reintegrating livestock onto crop farms and into regions. We used the term "livestock <u>re</u>integration" as we considered that nearly all farms in France used to include both crops and livestock until the 1950s (Harchaoui and Chatzimpiros, 2018). We used the term "crops" in its broadest sense, including grain crops, orchards, vineyards and vegetables.

2. Materials and methods

2.1. Case study

2.1.1. Case study regions

We conducted 18 semi-directed interviews with crop farmers who had reintegrated livestock in order to analyse their motivations for having done so. We selected two regions where crops currently predominate but which differed in their history of livestock production: Occitanie and the Parisian Basin.

<u>Occitanie</u>

In Occitanie (a French region composed of the departments of Gers, Haute-Garonne and Ariège) (Fig. 1), farming was traditionally dominated by self-sufficient diversified crop and mixed farms that produced mainly grain crops, followed by vineyards and orchards (Luxembourg, 1934; Perez, 1944). The dynamics of livestock and mixed farms in the Gers department represents those of the Occitanie region relatively well. In 1988, 39% of the farms were mixed (vs. a mean of 20% in France) (AGRESTE, 2020). Livestock production has strongly decreased and has been replaced with specialised crop production. From 2010-2020, 95% of the farms that disappeared were either livestock (48%) or mixed (47%) farms (AGRESTE, 2020). By 2020, the number of mixed farms had decreased to 16% of the farms (vs. a mean of 12% in France). Currently, the main type of livestock produced in Gers are poultry, beef cattle and meat sheep. Due to the department's long history of livestock production, services and elements of the supply chain (e.g. slaughterhouses, technical advisors) have remained, but they have been reduced greatly (e.g. several slaughterhouses have closed). Farms in Gers have a mean utilised agricultural area (UAA) of 70 ha. Gers is one of the French departments with the largest area of certified organic farms (30% of the farms, representing over 120 000 ha) (Agence Bio, 2020). In addition, 10% of farms in Gers process some of their production on the farm, and 20% of the farms sell some of their production directly to consumers (AGRESTE, 2020).

The Parisian Basin

In the Parisian Basin (Fig. 1), specialised cash crop farms have dominated for decades, especially due to its rich, deep and silty soils (Bryant, 1973; Rolland and Brun, 1966). In 1988, 73% of the farms in Seine-et-Marne (the main agricultural department in this region) were specialised in crop production (mainly grain crops and beets), whereas 17% were livestock or mixed farms. By 2020, specialised crop farms had increased to 83% of the farms, whereas livestock and mixed farms had decreased to 12% (AGRESTE, 2020). Currently, the few remaining livestock farms produce mainly meat sheep (AGRESTE, 2020). The remaining services and elements of the supply chain for livestock production are even scarcer than those in Occitanie. Farms in Seine-et-Marne are large, with a mean UAA of 140 ha. Due to its proximity to Paris, this region benefits from a vast consumption basin, but it also experiences strong urban pressure that results in the disappearance of agricultural land. Overall, 11% of the farms are certified organic (representing 21 000 ha) (Agence Bio, 2020). In addition, 7% of the farms process some of their production on the farm (mostly fruits, vegetables or livestock), and 22% of the farms sell some of their production directly to consumers (AGRESTE, 2020).

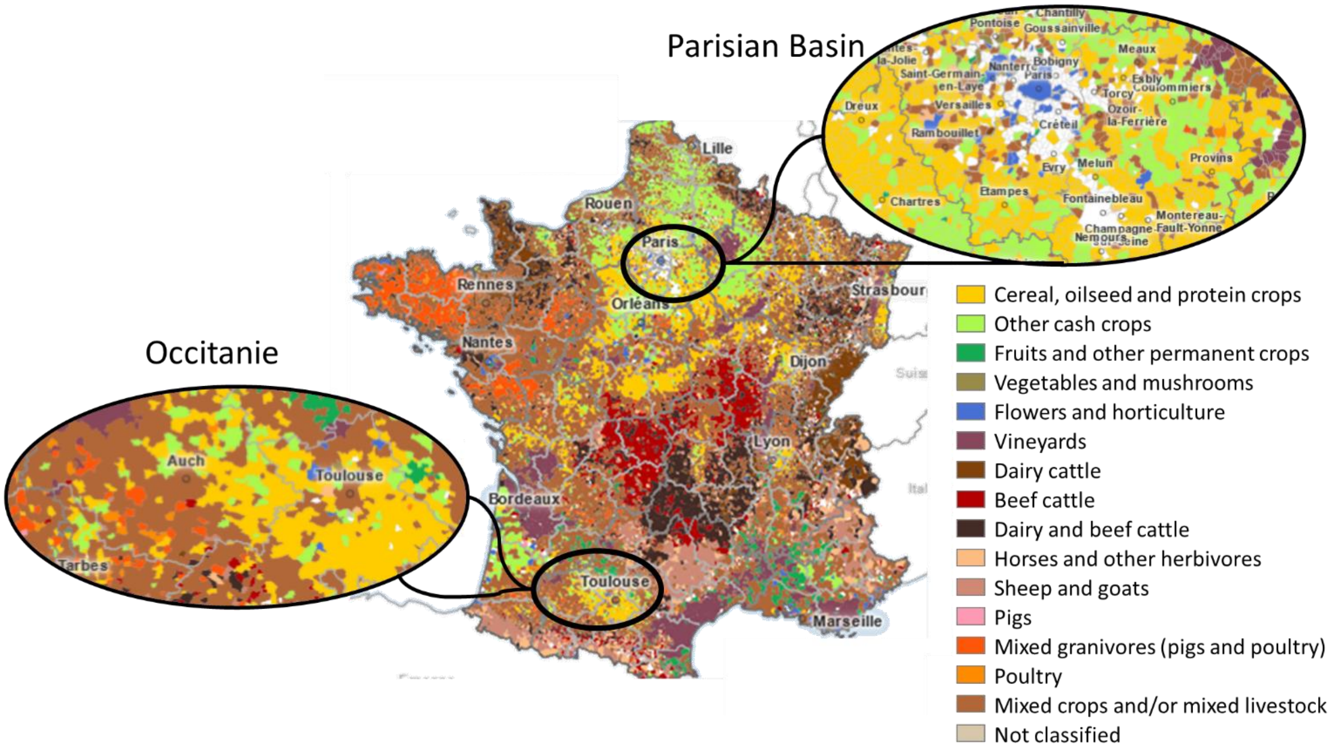


Figure 1. Main production orientation of French farms in 2020, with a focus on the two case study regions: Occitanie and the Parisian Basin (AGRESTE, 2020)

2.1.2. Case study farmers

Profiles of targeted farmers

We followed the principles of innovation tracking defined by Salembier et al. (2021), considering livestock reintegration as an innovation, as the farmers who practice it are "bucking the trend" of the decrease in the number of livestock and mixed farms. In France, few crop farmers have reintegrated livestock, and it is difficult to identify them. Because reintegrating livestock is uncommon, to identify the variety of crop farmers' motivations for having done so, we included all crop farmers we could identify in the two regions, regardless of the production orientation or farming system. Thus, we targeted organic or conventional farmers who produced any type of crop and had reintegrated any type of livestock at the farm level or regional level. As in the case-study research approach (Eisenhardt, 1989), our objective was to identify a wide variety of motivations for reintegrating livestock rather than to obtain statistical representativeness.

Identifying the targeted farmers and initial contact

To identify innovations, like most cases of innovation tracking studied by Salembier et al. (2021), we first identified farmers who had reintegrated livestock onto crop farms and into regions by contacting farm advisors in our network, as no available database exists for this type of system. We relied on diverse organisations such as the Chamber of Agriculture and Organic Farmer Group (GAB) in both regions, as well as the organisation Agrof'Ile (which promotes living soils and agroforestry around Paris) in the Parisian Basin. We telephoned the identified farmers to verify they met the criteria for involvement in the study (i.e., they had reintegrated livestock on a crop farm and were willing to participate), collected general information about the farm and organised a meeting on the farm to conduct the interview. The first farmers interviewed helped us identify farmers who had reintegrated livestock outside our initial networks, which allowed us to increase the sample size using the snowball approach.

Farmer profiles

We interviewed 10 farmers in Occitanie and 8 farmers in the Parisian Basin (total: 18) (Table 1) who had diverse profiles in production mode, UAA, crop and livestock production, as well as the type and duration of livestock reintegration. Most farms in the sample were certified organic (12, plus 3 in conversion), especially in Occitanie, where all farms were either organic or in conversion. The farmers had a wide range of farm sizes (UAA of 5-2000 ha) and number of animals (e.g. from 200 laying hens to 1200 ewes plus 15 000 fattening lambs).

The sample included four types of crops: grain crops, fruits, vineyards and vegetables. The crops varied more in Occitanie, with production of cash crops (6 farms), vineyards (3) and fruit (2), whereas nearly all farmers in the Parisian Basin grew only cash crops (7, with only 1 producing vegetables), consistent with the region orientation. Farmers had reintegrated four types of livestock (i.e. sheep, beef cattle, pigs, broilers or laying hens), resulting in eight combinations of crops and livestock on the farms. Most of the reintegrated animals were reared at least partly outdoors. Livestock reintegration occurred at the farm level (10 farms), the regional level (3) or both (5). In the Parisian Basin, reintegration at the farm level was the most common, with only 1 farmer who had been involved in a partnership for a few years but then stopped to reintegrate livestock on his own farm. Sheep had been reintegrated at the farm and regional levels, whereas broilers and laying hens had been reintegrated only at the farm level. The duration of livestock reintegration varied greatly (1-24 years), but most farmers had reintegrated livestock recently (mean of 5.6 years and median of 4 years).

Table 1. Profiles of the 18 farmers interviewed in the Occitanie (O) or Parisian Basin (PB) regions. Younger : less than 35 years old; Middle : between 35 and 55 years old, Senior : over 55 years old. School : high school or university.

Farmer	Region	Production mode	Crops	Livestock	Level of reintegration	Years reintegrated	UAA in 2022 (ha)	Type and no. of animals in 2022	Outdoors/ indoors	Age	Prior connection to livestock farming
F1	O	Conversion	Vineyard	Meat sheep	Regional	2	30 (+ 30 in grain crops)	120 ewes	Outdoors + field with shelter	Younger	No
F2	O	Organic	Vineyard	Meat sheep	Farm and Regional	1	70 (+ 30 in nuts)	35 owned sheep + 130 hosted sheep in winter	Outdoors	Senior	Family
F3	O	Organic	Vineyard, Grain crops	Meat sheep	Farm and Regional	4	2000, of which 80 in vineyards and 100 in pasture	1000 ewes	Outdoors (+ fold)	Younger	School
F4	O	Organic	Orchard	Meat sheep	Regional	2	45 in plums (+ 230 in grain crops)	Hosted ewes	Outdoors	Middle	No
F5	O	Organic	Orchard	Meat sheep	Farm	4	80	12 ewes + 1 ram	Outdoors	Middle	Family

F6	O	Organic	Grain crops	Meat sheep	Farm and Regional	4	200 (of which 40 in pasture) + mountain pasture	200 ewes + 45 other sheep	Outdoors	Middle	No
F7	O	Conversion/ Conventional	Grain crops	Meat sheep	Regional	2	500 (+20 in vineyards)	Hosted ewes	Outdoors	Younger	No
F8	O	Organic	Grain crops	Broilers	Farm (+Regional)	9	130 (of which 10 in pasture)	2 × 8000 broilers (+ renting a field to a neighbour to graze cattle)	Free range	Middle	Family
F9	O	Organic	Grain crops	Laying hens	Farm	14	350	10 000 laying hens	Free range	Senior	Family
F10	O	Organic	Grain crops	Laying hens	Farm	2	29 (of which 5 in permanent pasture)	6000 laying hens	Free range	Middle	Family
F11	PB	Conventional	Grain crops	Meat sheep	Farm (+Regional)	10	650	550 ewes	Mixed indoors/ou tdoors	Middle	Family
F12	PB	Organic	Grain crops	Sheep for wool	Farm	5	165	30 ewes and castrated males	Outdoors + field with shelter	Younger	Family
F13	PB	Organic	Grain crops	Meat sheep	Farm	3	190	18 ewes + other sheep	Outdoors	Middle	Family

F14	PB	Conventional	Grain crops	Meat sheep	Farm	24	500	1200 ewes + 15 000 fattening lambs	Mainly indoors, partly outdoors	Senior	No
F15	PB	Organic	Grain crops	Laying hens, beef cattle	Farm	5	230 (of which 30 in pasture)	9000 laying hens + 20 beef cattle	Free range for hens, mixed indoors/ outdoors for cattle	Younger	Family
F16	PB	Conventional	Grain crops	Laying hens	Farm	2	160	8000 laying hens	Free range	Younger	Family
F17	PB	Organic	Vegetable s	Laying hens	Farm	4	5	200 laying hens	Free range	Younger	No
F18	PB	Conversion	Grain crops	Pigs	Farm	5	140	1 boar + 6 sows	Free range	Middle	Family

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2.2. Data collection

The interviews were conducted from fall 2021 to spring 2022 by one researcher (C.M.). They lasted 1.0-3.5 hours (mean of 2.0 hours) depending on the complexity of the system and availability of the farmer. All interviews were conducted on the farm, except for one farmer whose schedule allowed only a telephone interview. When the farmer had enough time, the interview was supplemented by a visit to the farm.

We designed two interview guides to interview crop farmers who had reintegrated livestock at the farm or regional level, respectively. The two guides were similar, differing only in the inclusion of certain questions that targeted specific characteristics of the systems: on-farm livestock production for the former, and opportunities and difficulties of establishing a partnership with a livestock farmer for the latter. The guides included questions aimed at helping farmers mention all the factors that motivated them to reintegrate livestock (Ajzen, 1991) (Table 2). Questions focused on the farmers' i) beliefs about livestock reintegration, ii) overall objectives for the farm, iii) values and their influence on livestock reintegration, iv) perception of the risks involved in reintegrating livestock and v) internalised subjective norms and how the farmer's relatives reacted to his/her idea to reintegrate livestock. Other topics were also mentioned, as the variety of questions helped us understand the overall functioning of the farm and identify some of the farmer's motivations for reintegrating livestock, even when the farmer might not have mentioned them when specifically asked.

Table 2. Interview questions asked to understand farmers' motivations for reintegrating livestock

Targeted factor	Questions
Beliefs about the behaviour	Which elements influenced you to consider livestock reintegration? Why did you decide to reintegrate livestock? What motivated you to do so? Were you surprised by the results of livestock reintegration, or did you expect them? How is livestock reintegration consistent with your overall approach to the farm and its history?
Objectives	In your opinion, what are the objectives of a farmer? What are your objectives for the farm and for each type of production? Try to imagine your farm in 5 or 10 years: what does it look like?
Values	Why did you decide to reintegrate livestock? What motivated you to do so? + Follow-up questions: Was [the element mentioned, such as building an environmentally friendly system, connecting to traditions] important/relevant to you?
Risk preference	What were your concerns when you first considered reintegrating livestock? Did you think it was risky back then? And now?
(Internalised) subjective norms	How did your relatives react when you mentioned your decision to reintegrate livestock? Did you feel isolated/supported?

To conclude the interview, verify whether we had identified all the motivations for livestock reintegration and rank them, we gave farmers 36 cards that listed the main benefits of mixed farming and livestock reintegration found in the literature and supplemented by us with some benefits for farmers of adopting sustainable practices (Table 3). The cards were divided into four categories: agronomic (13: 5 for soils and 8 for other aspects), environmental (4), economic (12) and social (7). We asked farmers to select and rank approximately 10 cards (from any category) that were consistent with their own motivations for reintegrating livestock onto their crop farm. Farmers could also add cards if they believed that a major motivation was missing. We briefly discussed their rankings, related them to the motivations identified during the interview and added missing points, if necessary.

Our study procedure followed the guidelines provided by INRAE's Charter of deontology, scientific integrity and ethics (INRAE, 2020). Farmers did not belong to particularly vulnerable groups. They were explained the purpose of the interview and provided informed oral consent before beginning the interview. They were also informed that they could skip questions. The data were pseudonymised before processing (European Commission, 2020).

Table 3. Motivation cards given to the farmers during the interview

Category		Motivation card	Abbreviation	Reference(s)
Agronomic	Soils	Improving soil fertility/organic matter content	Soil Fertility	(Brewer and Gaudin, 2020; Franzluebbers and Stuedemann, 2014; Veysset et al., 2014)
		Improving soil structure	Soil Structure	(Brewer and Gaudin, 2020; Garrett et al., 2020)
		Promoting carbon storage in the soil	Soil Carbon Storage	(Brewer and Gaudin, 2020; Franzluebbers, 2005; Veysset et al., 2014)
		Promoting erosion control	Erosion	(Franzluebbers et al., 2014; Garrett et al., 2020; Martin et al., 2016)
		Improving soil life (biomass and microbial activity)	Soil Life	(Brewer and Gaudin, 2020)
	Others	Reducing all types of pesticides/mechanical weeding	Pesticide	(dos Reis et al., 2021; Hendrickson et al., 2008; Niles et al., 2018)
		Reducing weed pressure	Weed Pressure	(Brewer and Gaudin, 2020; Hendrickson et al., 2008; Niles et al., 2018)
		Breaking pest, weed and disease cycles	Pest Cycle	(Brewer and Gaudin, 2020; Hendrickson et al., 2008)
		Promoting biodiversity	Biodiversity	(Ryschawy et al., 2012)

		Increasing productivity per ha	Productivity	(Niles et al., 2018; Peterson et al., 2020)
		Optimising forage resources	Forage Resources	(Hendrickson et al., 2008)
		Diversifying and extending crop rotations	Crop Rotations	(Ryschawy et al., 2017)
		Maintaining the landscape of the region	Landscape	(Davies et al., 2016; Rouet-Leduc et al., 2021)
Environmental		Decreasing greenhouse gas emissions	Greenhouse Gas	(dos Reis et al., 2021; Gil et al., 2018; Lazcano et al., 2022)
		Closing nutrient cycles (nitrogen, phosphorus, potassium)	Nutrient Cycles	(Lazcano et al., 2022; Ryschawy et al., 2012; Veysset et al., 2014)
		Decreasing nitrogen loss/water pollution	Nitrogen Loss	(Ryschawy et al., 2012; Veysset et al., 2014)
		Improving environmental stewardship	Environmental Stewardship	(Parker, 2013)
Economic		Ensuring a market for specific products	Market	(Bell and Moore, 2012)
		Sharing equipment	Equipment	(Lemaire et al., 2014)
		Reducing production costs	Production Costs	(dos Reis et al., 2021; Niles et al., 2018; Ryschawy et al., 2012)
		Mitigating risks of climate and market uncertainties	Risk Mitigation	(Gil et al., 2018; Veysset et al., 2014)

	Stabilising income by diversifying production	Production Diversification	(Bell and Moore, 2012; Ryschawy et al., 2012)
	Becoming more self-sufficient	Self-Sufficiency	(dos Reis et al., 2021; Regan et al., 2017; Ryschawy et al., 2012)
	Increasing income	Income increase	(dos Reis et al., 2021; Hendrickson et al., 2008; Peterson et al., 2020)
	Sourcing inputs locally	Sourcing Locally	[Added by us]
	Ensuring a more flexible marketing method	Marketing Flexibility	[Added by us]
	Ensuring better control of the products	Product Control	[Added by us]
	Improving the traceability of purchased products	Traceability	[Added by us]
	Promoting agri-tourism	Agri-tourism	[Added by us]
Social	Improving the image of the production system	System Image	(Franzluebbers et al., 2014; Martin et al., 2016)
	Creating social connections, solidarity and mutual aid	Connections	(Ryschawy et al., 2017)
	Acquiring and sharing new knowledge	Knowledge	(Ryschawy et al., 2017)
	Developing networks	Networks	(Ryschawy et al., 2017)
	Connecting to family history/traditions	Traditions	(Parker, 2013)
	Responding to a desire/preference/belief	Desire	(Cortner et al., 2019; Parker, 2013)

	Responding to the desire for a technical challenge	Technical Challenge	[Added by us]

2.3. Data analysis

2.3.1. Discourse analysis

To identify farmers' motivations for reintegrating livestock, we transcribed the 18 interviews completely and performed inductive content analysis (Elo and Kyngäs, 2008), which is an effective method for identifying key points during an interview and highlighting themes related to a topic. Following Perrin et al. (2020), we first performed free-floating reading of farmers' responses and identified six main topics that they had mentioned during the interview: description of the system, motivations, practices, impacts, enabling conditions, disenabling conditions and perspectives. For each topic, we systematically collated all farmers' responses (i.e. the corresponding idea(s) mentioned), their identifiers (e.g. F1) and a related quote extracted from the transcription. We coded the responses by grouping them into categories and subcategories of similar ideas that emerged during the process. For instance, "Because [the sheep] provide organic matter" (F5) and "[Sheep] are above all an agronomic tool…that can provide fertility" (F6) were grouped into the category "Agronomy", subcategory "Soil" and sub-subcategory "Soil fertility". We adjusted and redefined categories to consider all the ideas that emerged from farmers' responses and formulated them as motivations (e.g. the category "Agronomy" was redefined as "Promoting ecosystem services"). The coding was double-checked separately by two researchers (G.M. and J.R.) to increase the robustness of the motivations. Results for each category and, when necessary, subcategory identified were associated with the number of farmers who mentioned it, and illustrated by anonymised quotes extracted from the interviews and translated by the authors.

2.3.2. Analysis of motivation cards

To rank crop farmers' motivations, we analysed their 18 rankings of the motivation cards using two indicators:

- the number of times each card had been selected, considering all the cards that farmers had selected (range: 9-18, with a mean and standard deviation of 11 ± 2).
- the weighted sum of points attributed to each card. We allocated points to the 10 highest-ranked cards (from 10 points for rank 1 to 1 point for rank 10) and then summed all the points for each card.

We performed multivariate analysis to characterise farmers' motivation rankings and then related them to farming system features or farmers' profiles. We used principal component analysis (PCA) to explain farmers' motivation card choices, including the sum of points attributed to each category (i.e. agronomic (soils and other), environmental, economic and social).

We analysed the projection of the farmers' rankings on the factorial map according to 9 qualitative variables that described the farming system (i.e. Region, Crops, Livestock, Level of reintegration, Years reintegrated, UAA, Outdoor/Indoor system) and the farmer's profile (Age and Prior connection to livestock farming). We tested the significance of the graphic structures revealed by the PCA using the Monte Carlo method (1 000 iterations). All tests were performed using R software version 4.3.1 (R Core Team, 2018), with significance set at $p<0.05$.

2.3.3. Triangulating the results: comparing interview responses and motivation cards

To increase the robustness of the results, for each farmer, we compared the motivations identified through discourse analysis to the ranking of each motivation card and classified the comparison into four classes:

i) the same
ii) nearly the same (the card could be related easily to something the farmer mentioned, but using different words)
iii) ambiguous or unclear (i.e. the motivation was mentioned by the farmer only after he/she saw it on the card, it was more general than specific to livestock reintegration, or it was mentioned as an impact of livestock reintegration rather than a motivation for it)
iv) different (the motivation was identified through discourse analysis but not selected in the cards, or vice versa)

When a selected card did not refer to an interview response, we rechecked the transcription to ensure that we had not missed the information, which increased the robustness of the discourse analysis. We then calculated the percentage of motivations in each class for all 18 farmers combined.

3. Results

3.1. Inductive analysis

Seven categories of motivations for reintegrating livestock emerged from the inductive analysis of the interviews: promoting ecosystem services (especially improving soil quality), decreasing pollution, increasing self-sufficiency and traceability, increasing and stabilising income, connecting to the local community (among farmers, by improving image of the system towards customers and citizens), keeping the landscape open (i.e. keeping agricultural land in production) and following personal ethical and moral values (e.g. passing down a satisfying farming system, building an environmentally friendly farming system or undertaking a technical challenge) (Fig. 2).

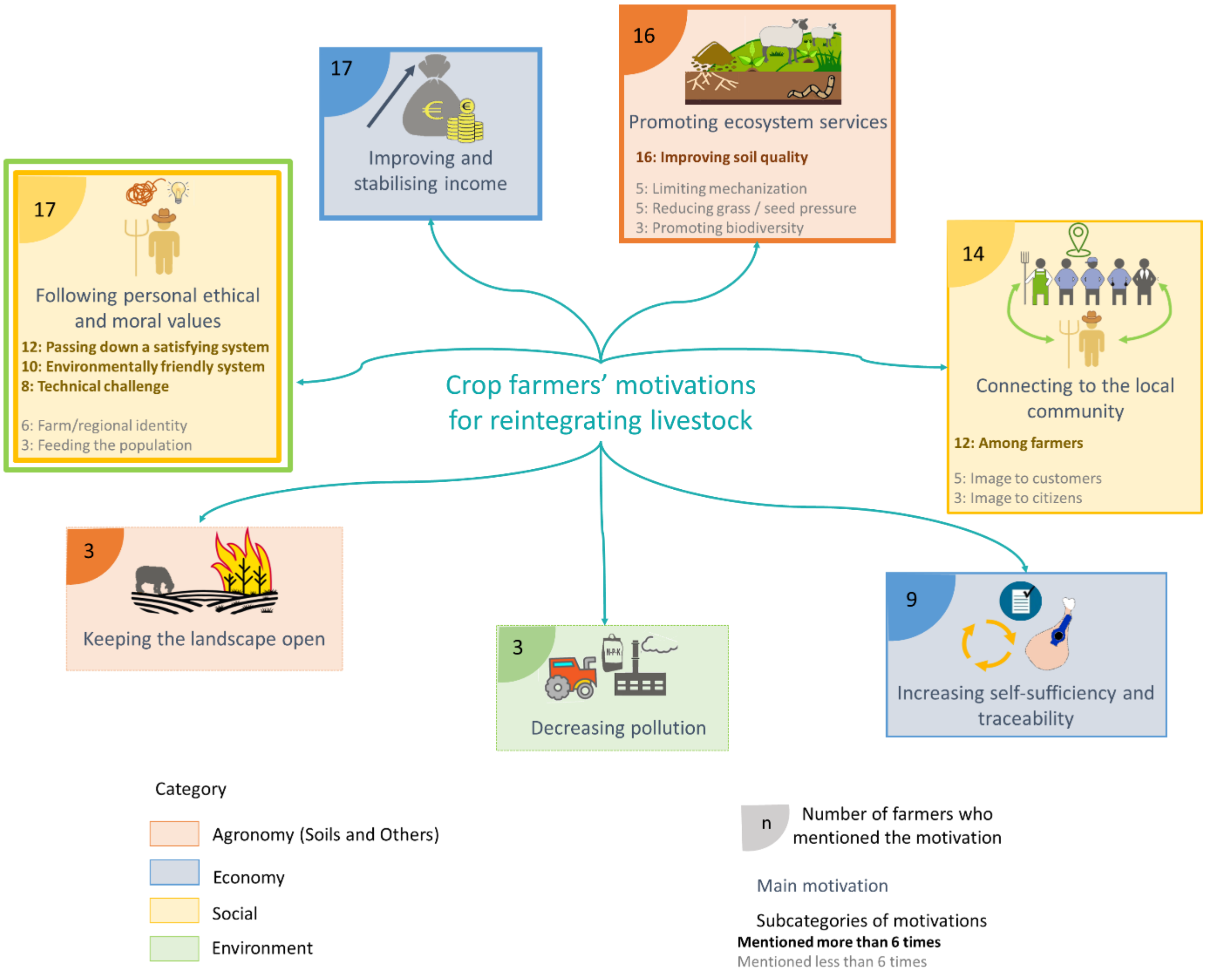


Figure 2. Overview of crop farmers' motivations for reintegrating livestock identified through discourse analysis

Livestock reintegration to follow personal ethical and moral values

Almost all farmers (17) identified livestock reintegration as a way to increase their overall well-being because it matched their many and diverse personal objectives, beliefs and values better (F3: "I get up in the morning with pleasure. I do the things I like.").

From a personal viewpoint, 3 farmers identified livestock reintegration as a way to respond to their desire to have a meaningful job by feeding the population, using the animals as a way to derive value from crops that were difficult to sell (F14: "I thought 'I am 30 years old; I spend my life growing wheat that nobody needs. My job is meaningless; nobody wants my wheat'.").

Another motivation for farmers to reintegrate livestock was that having animals on the farm helped them produce food in a way that matched their value of environmental stewardship (Stern and Dietz, 1994) (10 farmers, e.g. F18: "I want to be able to save the Earth [and] produce things without polluting."). Farmers also wanted to be more consistent with types of sustainable farming (e.g. agroecology, biodynamics, mixed farming, the farm as an ecosystem) (F5: "For agroecology, I feel that having animals in a production system helps close the loop, especially in organic farming.").

For 8 farmers, reintegrating livestock onto a crop farm without knowing exactly how to do it was one way to break the routine and undertake a technical challenge (F13: "I like to say that I am experimenting, and then when it begins to work well, I am no longer interested.").

From a heritage perspective, 6 farmers mentioned livestock reintegration as a way to connect to family history (F13: "I remember my aunt…, who brought her sheep along the paths to graze. It was amazing. I was there; I lived it.") or regional identity (F18: "[A few years ago, in the region] we did not use hectares to describe farm size; we used the number of ewes. We said 'it's a farm with 300 ewes'. I am going to bring them back…. Go back to what they did before.").

Livestock reintegration reassured 6 farmers about the transmission of their farm, as it increased its financial value, thereby echoing their desire to provide the best for future generations (F10: "It is because I have two sons; I am planning for their future."). More concretely, having livestock on the farm helped some farmers reduce their workload (5 farmers, e.g. F3: "We avoid two stubble ploughings thanks to grazing."), thus improving the balance between personal and professional life. Reintegrating livestock was also seen as a way to improve farmers' satisfaction in their work, especially due to the presence of animals (11 farmers, e.g. F13: "It is really a pleasure to see animals out there.").

Livestock reintegration to increase and stabilise income

Fourteen farmers reintegrated livestock to increase their income (F10: "It is simply for the money. If I could earn a living with crops, I probably would not have [reintegrated livestock]; it is easier to work in the fields."). This increase can be related to the following:

i) selling new products (6 farmers, e.g. F17: "In direct selling, customers ask for eggs…produced in the region, on a farm.")

ii) using “lost” crops or land, such as between orchard or vineyard rows or growing pasture on land where crop production would be too expensive (7 farmers, e.g. F15: “Lucerne is like medicine for the soil, so it is great that we can make the good use of it with the cows.”)
iii) decreasing production costs by promoting ecosystem services and increasing self-sufficiency, as mentioned (6 farmers made a direct connection, e.g. F7: "And also saving money on mechanisation costs to produce lucerne hay [thanks to the sheep]").

Another motivation for reintegrating livestock mentioned by 10 farmers was to stabilise income, in the following ways:

i) increasing farm self-sufficiency and diversifying production, thereby depending less on fluctuating global market prices and climate events (10 farmers, e.g. F18: “I was finished with not being able to make ends meet [by] producing grain and selling it on the global market. I needed to find a ready-to-sell product, so now…all my grain will feed my sheep, pigs and chickens.”; F14: “We have four jobs, and there is always one that does not go well. […] This year, it is a pleasure to work with the sheep. It is going to be a good year for grain, but last year was not great. It is fairly balanced; it helps to be a bit more resilient.”).
ii) using livestock to derive value from crops that did not grow well (1 farmer, F18: “I can mess up with one crop because I can mow it to feed my livestock; they provide flexibility.”)

Livestock reintegration to promote ecosystem services

One motivation for reintegrating livestock was to promote ecosystem services, mentioned by 16/18 farmers. All of these farmers emphasised motivations regarding soils, especially soil life (i.e. biomass and microbial activity) (9/18, e.g. F13: “The main idea of having sheep was…to revitalise the soil.”) and fertility (14/18, e.g. F16: “It was a way to have livestock on the farm and produce our own organic matter for the fields.”), and thus soil structure (3/18). Four farmers also mentioned the expected role of reintegrating ruminants in promoting carbon storage in soils (as part of soil quality improvement) due to the decrease in greenhouse gas emissions caused by replacing mechanisation with grazing and reintroducing pasture into crop rotations. Five farmers also mentioned the expected role of ruminants in consuming grass or weeds, which was directly related using them to manage cover crops, thereby reducing mechanization (F1: “I think that my first objective was to stop mowing the cover crops.”) or weeds (F2: “[Sheep] are eating tall fescue a lot … I am really happy I found this way; it’s really hard to get rid of it [without sheep]”), especially between orchard or vineyard rows, where mechanical weeding is difficult. One farmer also mentioned adding pasture to feed animals, which helps to decrease weed pressure by extending the crop rotation and breaking pest cycles (F3: “If we have sheep, we can extend the crop rotation up to 10 years. We are going to sow lucerne and pasture; this is truly long-term thinking.”). Three farmers mentioned the role of livestock in increasing biodiversity in fields, especially for fauna such as birds (F1: “I found sheep wool in titmouse nest boxes…, so it is useful for biodiversity; birds can use it.”) and auxiliary insects (F4: “When sheep arrive in the field, we see insects climbing the trees, so we have ladybugs and many other auxiliary insects that…help us deal with the aphids and [other pests].”).

Livestock reintegration to strengthen connections with the local community

Farmers’ motivations for reintegrating livestock were also influenced by a strong desire to strengthen their connections to the local community and decrease isolation (12/18 farmers). This can be related, for instance, to having other people work on the farm throughout the year to tend to the livestock (F12: “Livestock farming is a social support.”; F11: “Currently, on a cash crop farm, from November 15th to December 15th, nothing happens…. […] [With livestock], you can see people on the farm every day, even during winter; there is always something happening. It is not restful, but [I like it]”). Reintegrating livestock can also be an opportunity to work with someone else, either by helping a shepherd become established (F2: “I think we can create a win-win partnership with young shepherds who do not have enough money to become established, as we want [to have livestock] but do not have the time to do all of it correctly.”) or by partnering with a livestock farmer (F6: “Integrating livestock without being a livestock farmer [means] hosting [the livestock of] someone who has problems because he does not have enough land.”).

Some farmers reintegrated livestock to strengthen their relationships with others, as having livestock can be seen as a way to improve the image of livestock farming to citizens (3 farmers, e.g. F11: “When I walk across the village with my sheep, people like that.”). It can also help them improve the image of their products to their customers and maintaining a “licence to operate”, especially when selling directly to consumers (5 farmers, e.g. F3: “Some time ago, [the organic shop] advertised our products to show people we were practising agro-pastoralism. Clients like it, everybody likes it.”).

Livestock reintegration to increase self-sufficiency and traceability

Eight farmers reintegrated livestock to improve farm self-sufficiency, especially in nitrogen, by producing livestock manure (F17: “There is also the idea of reaching…self-sufficiency in nitrogen.”). Reintegrating livestock onto a farm could also provide farmers an outlet for grain or fodder legumes introduced into crop rotations, which would increase nitrogen fixation and decrease input costs.

One farmer considered self-sufficiency as a way to improve the quality of farm inputs, such as manure (F8: “Last year…I spread 5 tons of [imported] chicken manure per hectare; it was as if I had done nothing at all.”). Four farmers emphasised the increased traceability of farm products when selling directly to consumers or locally with few intermediaries (F15: “The eggs, once you collect them, …are ready to be packed in boxes and sold. We can manage the entire supply chain on the farm and get back in touch with our customers.”).

Livestock reintegration to decrease pollution

Three farmers stated that they decided to reintegrate livestock to decrease pollution, especially by promoting ecosystem services, which helps to decrease the use of inputs (e.g. nitrogen fertilisers, pesticides, fuel) (F1: “I think I use my tractor less often and [use fewer nitrogen] inputs, which are hard to quantify.”). These farmers considered reintegrating grazing animals as a way to produce food or fibre with lower environmental impacts (F6: “Livestock farming is criticised for its impact on the climate, and this is true. However, I believe that we can perform wholesome actions. […] The idea is to have animals grazing to…decrease mechanisation to make hay.”; F12: “When you wash [wool clothes], it doesn’t release dyes or plastic residues into water treatment plants or the sea.”).

Livestock reintegration to keep the landscape open

Another motivation for reintegrating livestock was to help restore and maintain the landscape, for instance by renovating an abandoned orchard (3 farmers, e.g. F2: “We do not have sheep only to produce meat. We also have sheep to maintain the land.”). One farmer also perceived having grazing livestock as an opportunity to stop spending large amounts of money to produce crops on land marginal for cultivation, without letting it turn into abandoned rangeland (F12: “It means having the chance to stop cultivating small parts of fields without feeling that we are abandoning them.”).

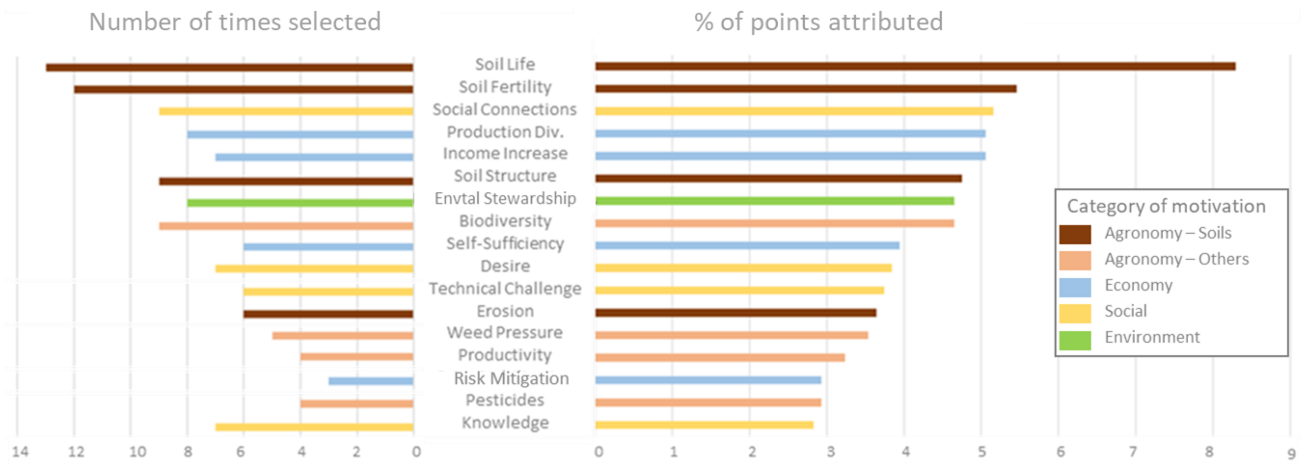
3.2. Analysis of farmers’ selection and ranking of motivation cards

3.2.1. Farmers’ motivations for reintegrating livestock: agronomy first

Analysis of farmers’ selection and ranking of motivation cards helped us rank their motivations for reintegrating livestock. Each card was selected at least once. One card was added by a farmer for a specific motivation (i.e. decrease the amount of strenuous work) and was not used again. The points attributed to each card and the number of times it was selected yielded similar results overall (Fig.3, Supplementary Material 1).

Farmers attributed the most points and selected the most cards from the agronomy category (Fig. 3) (43% of the points and 41% of the cards selected). Among these cards, farmers’ main concern was the soil (25% of the points), especially improving soil life and fertility, which were the first and second motivations, respectively, in points (8% and 6%, respectively) and the number of times selected (by 13 and 12 farmers, respectively) (Fig. 3). Soil motivations were often selected by the same farmers (9 farmers selected soil life and soil fertility; 8 farmers selected soil life and soil structure). Promoting biodiversity was another agronomic motivation (5% of the points, selected by 9 farmers).

After agronomic motivations, economic and social categories were selected nearly equally by farmers (25% and 22% of the points, respectively, and 24% of the cards selected each). Economic motivations included mainly increasing and stabilising income by diversifying production (5% of the points each, and selected by 8 and 7 farmers, respectively, with 5 farmers selecting both). Increasing self-sufficiency was attributed 4% of the points and was selected by 6 farmers. The social motivations selected regarded creating social connections (5% of the points, selected by 12 farmers), responding to a desire/preference/belief (4% of the points, selected by 7 farmers) and acquiring and sharing new knowledge (only 3% of the points, because although selected by 8 farmers, it was ranked low, with a mean of 4.0 points). Farmers attributed the fewest points and selected the fewest cards in the environmental category (9% of the points and 10% of the cards), in which the motivation selected most was the desire to improve environmental stewardship and to close nutrient cycles (5% and 3% of the points, respectively, selected by 8 farmers each).



<u>Figure 3. Number of times selected and percentage of points allocated by farmers when ranking the cards for the most-selected motivations, by category. To increase readability, the graph shows only motivations selected by more than 6 farmers, or allocated more than 2.5% of the points. See Supplementary Material 1 for details. Div.: Diversification, Envtal: Environmental</u>

3.2.2. Differences in motivations for reintegrating livestock among farmers' systems

The PCA distributed categories of motivations according to farmers' rankings. On the factorial map, axis 1 (53.6% of the variance explained) distinguished agronomic and soil from economic motivations, whereas axis 2 (24.9% of the variance explained) clearly distinguished social from environmental motivations (Fig. 4A).

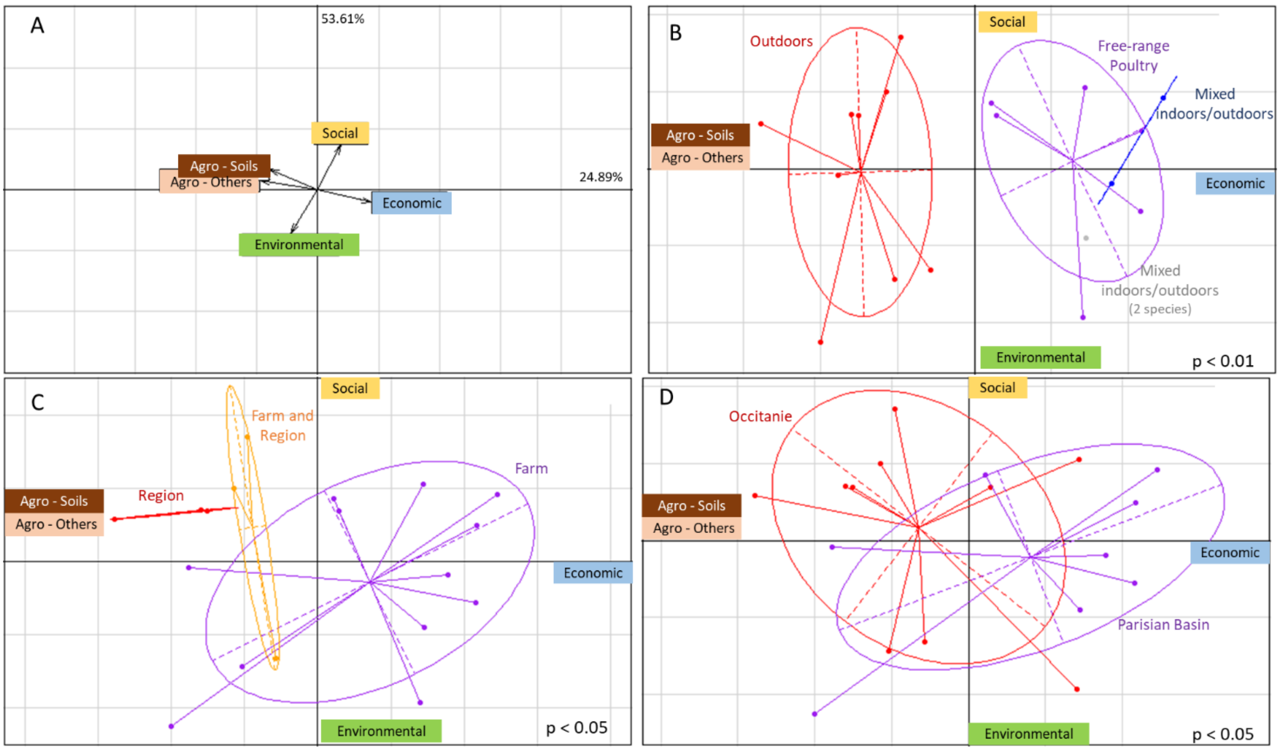


Figure 4. (A) Factorial map of the motivations for reintegrating livestock, by category, with projections of farmers' rankings as a function of (B) livestock housing, (C) the main level of livestock reintegration and (D) the region (D). Agro: Agronomic

The projection of farmers' rankings on the factorial map showed that, in our sample, farmers with outdoor livestock systems (n=7) favoured mostly agronomic (soils and others) motivations, whereas farmers with at least partly indoor systems (e.g. free-range poultry, mixed indoors/outdoors for other livestock) (n=11) tended to select more economic motivations (Monte Carlo method, p<0.01) (Fig. 4B, Supplementary Material 2). The type of housing seemed to determine motivations more than the species of livestock reintegrated (Supplementary Material 2). Farmers with outdoor livestock systems selected soil life as their first motivation (1.5 times as many points attributed and selected by 6/7 farmers compared to 7/11 with other systems), followed by other agronomic, environmental and social motivations. Self-sufficiency was the economic motivation that these farmers selected most (2/7 farmers). Farmers with at least partly indoor livestock systems selected income stabilisation by diversifying production as their first motivation (8/11 farmers vs. 0 with outdoor systems). Improving soil life was the first non-economic motivation that these farmers selected (7/11 farmers).

Farmers who reintegrated livestock at the regional level (n=3) had perennial systems (i.e. orchard, vineyard) or grain crops, and favoured mostly agronomic and social motivations (Fig. 4C, Supplementary Material 2). Farmers who reintegrated livestock at the farm level (n=12, including 10 with grain crop systems, 1 with vegetables and 1 with an orchard) prioritised a wider variety of motivations. The farmer with vegetables (F17) reintegrated laying hens on his farm for mostly economic motivations, whereas the farmer with an orchard (F5) reintegrated sheep for social and agronomic motivations. Farmers who reintegrated livestock at both farm and regional levels (n=3) had grain crops, a vineyard or both, and did it more for agronomic motivations, with either a strong social dimension or a strong environmental dimension.

Farmers in Occitanie (n=10) favoured agronomic motivations (soils and others) in their rankings more than did farmers in the Parisian Basin (n=8), who favoured economic motivations (Monte Carlo method, $p<0.05$) (Fi. 4D, Supplementary Material 2). In both regions, the main motivation for reintegrating livestock was to improve soil life, but farmers in Occitanie selected more motivations regarding soils than did those in the Parisian Basin, with 2.1 times as many points attributed and 1.8 times as many cards selected (e.g. soil fertility was cited 8 out of 10 times in Occitanie vs. 4 out of 8 times in the Parisian Basin). In the Parisian Basin, economic motivations were most common, being represented 1.7 times more than in Occitanie. They included increasing and stabilising income by diversifying production, mentioned by 4 and 5 out of 8 farmers, respectively (vs. 3 out of 10 each in Occitanie). This difference between regions may have been related to the larger percentage of outdoor systems in Occitanie (80% of the systems vs. 25% in the Parisian Basin) and to other reasons (e.g. greater vulnerability of soils in Occitanie, proximity to a vast wealthy consumption basin in the Parisian Basin, which may provide the opportunity to sell high-quality products at higher prices). For the other factors (i.e. UAA, farmers' age and prior connection to livestock farming), we found no clear evidence of differences in motivation ranking (Supplementary Material 2).

3.3. Similar motivations between inductive analysis and motivation card rankings

Overall, 64.1% of the motivations were the same (46.0%) or nearly the same (18.1%) in the discourse analysis and selection of motivation cards. The motivation farmers ranked first was always the same (72.2%) or nearly the same (27.8%) as one of the motivations identified through discourse analysis, which indicates that the two methods were consistent and increased the robustness of the results. For the motivations classified as ambiguous or unclear (14.5%), the mismatch appeared low in farmers' rankings (mean rank was 8.3 ± 4.0 considering all of the cards selected) and did not seem to challenge the robustness of the results. The motivations classified as different (21.4%) were mainly those identified through discourse analysis but not selected in the cards (83%). These motivations included ensuring the farm transmission and increasing personal satisfaction with work, which were not explicitly listed on the cards even though they could have been included with the card "Responding to a desire/preference/belief". Farmers rarely mentioned a motivation without selecting the corresponding card, which could have been due to the instruction to select approximately 10 cards.

In both discourse analysis and motivation card rankings, agronomic motivations (in which we included promoting ecosystem services, as they support production), especially those regarding soils, predominated, as soils were mentioned by 16/18 farmers in their discourse, and at least 1 soil card was selected by all but 1 farmer. Improving and stabilising income was cited by 17/18 farmers in their discourse, consistent with the two most-selected economic motivation cards (7 and 8 farmers, respectively). Similarly, self-sufficiency was mentioned by 9 farmers in their discourse and selected by 6 of them in their card rankings. Strengthening social connections was the most-selected social motivation in card rankings and was mentioned by 14/18 farmers in their discourse, particularly for connections among farmers. Personal ethical and moral values were mentioned as a motivation by 17/18 farmers and may have corresponded to a wide variety of motivation cards (e.g. desire, technical challenge, environmental stewardship, connection to family/traditions), as well as to broad values not included in the cards (e.g. farm transmission, feeding the population). In both discourse analysis and card rankings, keeping the landscape open and decreasing pollution were rarely selected. Farmers did select some environmental cards, but sometimes only because they felt that they needed to select at least one card from each category, despite the instructions to the contrary. The most-selected environmental card was environmental stewardship (8/18), which was consistent with the desire to build an environmentally friendly farming system mentioned by 10 farmers.

4. Discussion

4.1. Farmers' motivations for reintegrating livestock compared to expected benefits

The farmers' diverse motivations for reintegrating livestock are consistent with the benefits of crop-livestock integration in the literature. Crop farmers' main motivation was to promote ecosystem services, especially by improving soil life and fertility. Improving soil quality is one of the main benefits of mixed systems, especially those based on grazing, due to organic fertilisation from livestock waste and the diversification of crop-pasture rotations to feed the animals (Brewer and Gaudin, 2020; Franzluebbers, 2005; Soussana and Lemaire, 2014). Crop farmers' economic motivations included increasing and stabilising income by diversifying production and increasing self-sufficiency. The literature highlights that mixed systems increase economic efficiency and decrease dependence on external inputs, which increases resilience to climate and market events (Bell and Moore, 2012; dos Reis et al., 2021; Ryschawy et al., 2021). Social motivations were also a main motivation for reintegrating livestock, including strengthening connections with the local community or following personal ethical and moral values. The literature has not documented social benefits of mixed systems in detail. The few studies that mention them focus on the difficulty in identifying and maintaining a partnership between crop and livestock farms (Asai et al., 2018; Ryschawy et al., 2017).

Farmers rarely mentioned motivations linked to energy consumption or pollution, whereas these impacts are documented in the literature. Mixed systems help to close carbon and nitrogen cycles, which can decrease nitrate leaching and water pollution (dos Reis et al., 2021; Ryschawy et al., 2021; Veysset et al., 2014). The ranking of motivation cards in the environmental category need to be considered carefully given the potential selection bias previously mentioned. Similarly, the farmers rarely mentioned maintaining the landscape as a motivation, whereas the literature indicates that grazing helps keep the landscape open and prevent wildfires (Davies et al., 2016; Rouet-Leduc et al., 2021). This result may have been related to the absence of fallow or communal land that the farmers in our sample could use, or because landscape management is a service that society expects from farmers rather than one that farmers expect (Guillaumin et al., 2008).

4.2. Similarities with farmers' motivations for adopting other sustainable practices

Farmers' motivations for reintegrating livestock varied, but most were consistent with those mentioned in studies of the adoption of sustainable practices. The main motivation in the present study of promoting ecosystem services, especially improving soil quality, was consistent with Casagrande et al. (2016), who studied organic farmers' motivations for adopting conservation agriculture practices. Pergner and Lippert (2023) showed that protecting biodiversity (in the soil and elsewhere) was a motivation for reducing pesticide use, and Paut et al. (2021) mentioned biological control as one motivation for grazing orchards. Increasing biodiversity was ranked highly in the present study, but was associated instead with the overall idea of diversifying the farming system to be consistent with farmers' values (Stern and Dietz, 1994), rather than to protect auxiliary insects. Paut et al. (2021) emphasised grass management as one of the main motivations for grazing orchards, and Casagrande et al. (2016) highlighted that farmers were motivated to adopt conservation agriculture practices to improve weed, pest and disease control, which several farmers also mentioned in the present study, although it was not the main motivation for reintegrating livestock.

Farmers mentioned economic motivations, such as increasing and stabilising income or decreasing production costs, which is consistent with motivations for adopting other sustainable practices, such as converting to organic farming, adopting conservation agriculture practices in organic farming, reducing pesticide use or grazing orchards (Bouttes et al., 2019; Casagrande et al., 2016; Paut et al., 2021; Pergner and Lippert, 2023). Farmers' motivations for reintegrating livestock to increase self-sufficiency and resilience to volatile market prices were also mentioned by Bouttes et al. (2019) at a time when organic product prices were high and stable. Bouttes et al. (2019) mentioned social motivations as a main influence for farmers to convert to organic farming, as farmers were looking to stimulate learning, which can be related to the desire to undertake a technical challenge, which was identified as a motivation for livestock reintegration in the present study. Bouttes et al. (2019) also mentioned developing group dynamics and an open exchange of experiences, which is consistent with the desire to strengthen connections with the local community and create social connections in the present study. Bouttes et al. (2019) and Duval et al. (2021) highlighted that farmers adopted sustainable practices to increase work satisfaction, which was related to farmers' personal ethical and moral values in the present study. Maintaining or increasing the value of the farm in a perspective of heritage and transmission was also a motivation for livestock reintegration, which was related to other motivations in a long-term strategy, such as improving soil quality. Caring about future generations, both within the farmers' families and beyond, was also a motivation for reducing pesticide use (Pergner and Lippert, 2023) or adopting other sustainable practices (Greiner and Gregg, 2011; Ingram et al., 2013; Schoonhoven and Runhaar, 2018).

Protecting the environment and being a good steward of the land (Stern and Dietz, 1994) are often strong motivations for adopting sustainable practices, such as soil conservation techniques, reducing pesticide use or grazing orchards, which increases nutrient cycling (Bakker et al., 2021; Chèze et al., 2020; Paut et al., 2021; Reimer and Prokopy, 2012). As mentioned, farmers in the present study mentioned few motivations related to water and air pollution or energy consumption. However, farmers mentioned environmental values, either directly during the interview, through the environmental card "Environmental stewardship" or to explain their selection of the social card "Responding to a desire/preference/belief", or indirectly by referring to sustainable practices that they wanted to uphold. Reducing health risks for farmers and consumers is a main motivation for reducing pesticide use (Chèze et al., 2020; Pergner and Lippert, 2023). None of the farmers we interviewed mentioned health concerns, likely because given the current state of knowledge, the relationship between livestock reintegration and farmer health and food safety is more difficult to make.

Recent studies focused on mapping farmers' motivations and clustering them into farmers' profiles for adopting sustainable practices (e.g. investment-minded farmers, farmers focused on their quality of life) (Lalani et al., 2021; Tessier et al., 2021). In our work, farmers mentioned several motivations in their discourse, but they always belonged to at least three dimensions (among agronomy, economy, social and environment) and farmers almost never mentioned feedback loops between them. Identifying farmers' profiles of motivations for reintegrating livestock by studying those interlinkages could be a future research question. Many studies of farmers' motivations focused on elements that facilitate or hinder farmers' adoption of sustainable practices, such as a farmer's profile (e.g. age, level of education, experience with the practices) (Damalas, 2021; Prokopy et al., 2015; Yoder et al., 2019); economic and social costs of implementing changes on the farm (Chèze et al., 2020); or the lack of inspiring examples (Bakker et al., 2021; Hammond et al., 2017), knowledge or an adapted socio-technical system (Gaitán-Cremaschi et al., 2022; Mamine and Farès, 2020; Spangler et al., 2022). These elements were not considered in depth in the present study, as they influence farmers' motivations for reintegrating livestock in relation to their behavioural control rather than to their attitudes towards the practice. We found no clear influence of farmers' profile age or prior connection to livestock farming on their motivations for reintegrating livestock, perhaps due to the small sample size and the fact that these elements would influence the adoption of a practice rather than the motivations for performing it. As it is important to consider motivations for, but also obstacles to and mechanisms for developing crop-livestock integration, these elements will be analysed in future studies. Similarly, given our small sample size, the influence of farms' characteristics (organic or conventional, type of crop or livestock reintegrated) on farmers' motivations for reintegrating livestock could be further analysed.

4.3. A mixed method for completeness and robustness of the results

We developed a mixed method to summarise motivations for reintegrating livestock by combining qualitative inductive discourse analysis with quantitative analysis of farmers' rankings of motivation cards (DeCuir-Gunby, 2008; Greene et al., 2005). Inductive content analysis is a powerful tool for identifying emerging themes in farmers' responses (i.e. motivations anchored in farmers' realities) (Elo and Kyngäs, 2008). However, farmers' motivations cannot be ranked based on discourse analysis alone because i) it is difficult to determine which motivation is the most important to a farmer, and ii) farmers may not mention the same motivations. Although we counted the number of farmers who mentioned each motivation in their discourse, it is difficult to distinguish whether a farmer did not mention a motivation because it was irrelevant to him/her or because it did not occur to him/her at the time. Offering farmers the same panel of cards and asking them to select and rank those they found relevant was one way to rank their motivations. The selection and ranking phase can enrich the responses by recalling forgotten motivations or deepening subjects that had been mentioned briefly (i.e. triangulation for completeness (Hussein, 2009)). It also allowed differences in the motivations that farmers prioritised to be identified as a function of their farming system, although the small sample size only allowed trends to be identified (Salembier et al., 2021). In addition to expanding the variety of motivations and ranking them, combining these two methods increased the robustness of the results by comparing the motivations identified through discourse analysis and the number of farmers who mentioned them to the ranks of cards (i.e. triangulation for confirmation (Hussein, 2009)).

Discussing differences between results of the two methods with the farmers and asking them to explain their choices in more detail (e.g. economic motivations mentioned in the discourse but selected rarely in card rankings) would further increase the completeness and robustness of our results.

Conclusion

Following innovation-tracking principles, we identified and ranked a wide variety of crop farmers' motivations for reintegrating livestock in two region of France. To do so, we developed an original mixed method to combine inductive discourse analysis of farmers' motivations for adopting a sustainable practice with their selection and ranking of predefined cards based on the benefits of this practice found in the literature. In the current context of increasing prices for energy, feed and nitrogen fertilisers, livestock reintegration seems an appropriate lifeline for crop farmers. Understanding the diversity of crop farmers' motivations for reintegrating livestock is the first step in developing this innovative sustainable practice under favourable conditions. It could help decision-makers provide recommendations that encourage it, by communicating the benefits of these systems in relation to farmers' objectives and/or by developing payments for the ecosystem services provided by livestock reintegration. Elements other than farmers' motivations should be considered, such as the conditions that facilitate or hinder livestock reintegration.

Acknowledgements

The authors acknowledge funding from the European Union Horizon 2020 Programme for Research and Innovation under grant agreement no. 862357 (project MIXED: Multi-actor and transdisciplinary development of efficient and resilient MIXED farming and agroforestry-systems) and from the ERA-NET project Mi Bicycle (Mitigation and adaptation through better biomass cycling in crop livestock systems of North and Western Europe) funded under the joint call ERA-NET Cofund SusAn, FACCE ERA-GAS, ICT-AGRI-FOOD and SusCrop. They thank M. Corson for English proofreading, and offer special thanks to the farmers who provided their precious time to make this study possible.

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