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Abstract:

Whilst interactions between crop and livestock productions can contribute to the agroecological transition, crop-livestock farms are in decline in favour of specialized farms. Interactions between farms can be an alternative through exchanges of fodder, grain, straw, and manure. However, these interactions are rarely documented. We aimed to better understand farmers' perceptions and decision factors when involving in-between farm interactions.

We worked with a group of about 17 farmers in south-western France (Ariège, 2017-2022). The group included crop, livestock and crop-livestock farmers aiming to increase local interactions. We conducted two sets of semi-structured interviews with the participants to understand their perceptions on interactions and study interactions they had.

We highlighted heterogeneous perceptions of the benefits of interactions. Crop farmers were interested in agro-environmental benefits and focused on decreasing logistical costs. Livestock farmers aimed for feed self-sufficiency and self-sufficiency in decision making when involved with cooperatives. Logistics, neighbouring and social dimensions were important decision factors.

We provided an initial insight into interactions between farms. We highlighted the importance to further study farmers' situation in dynamic, over time (e.g. evolving situations, possible positive gradation of interactions) and space, as well as asymmetries in farmers' situations (e.g. offer or demand).

Keywords: crop-livestock system; agroecological transition; motivations; landscape level

Purpose

Interactions between crop and livestock productions and especially circulation of biomass between them can contribute to agroecological transitions. They can help closing nutrient cycles (e.g. carbon, nitrogen) to reduce environmental impacts and improve the use of resources (e.g. co-products); promoting cropping system diversification (e.g. pasture or fodder legume introduction in crop rotations); and promoting resilience of farms to address unpredictable climate and market events (Bonaudo et al., 2014; Martin et al., 2016; Schut et al., 2021). In Europe, crop-livestock farms are declining in favour of specialized farms, partly due to the limited availability of a workforce and the lack of appropriate skills. Interactions between farms seem a relevant option to address these limiting factors (Martin et al., 2016). These interactions involve exchanges of a diversity of biomasses (grain, fodder, crop by-products, manure, or even live animal). However, whilst these interactions do occur between farms, they remain scarce due to transaction costs (Asai et al., 2018) and implicit

aversion to risk and lack of trust between crop and livestock farmers (Garrett et al., 2020). Overall, how and why these interactions occur is rarely documented.

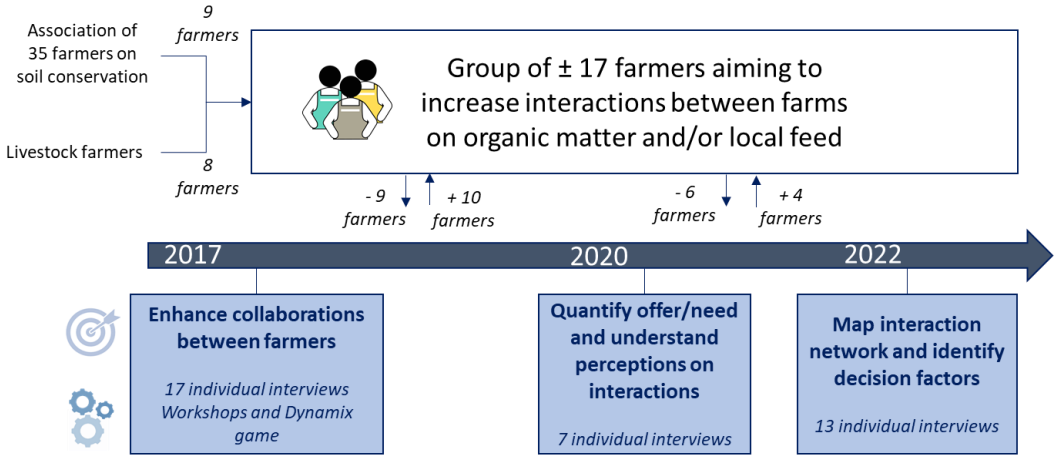
We aimed to better understand farmers' perceptions and decision factors when involving in-between farm interactions. This implied: i) identifying levers and barriers leading to interactions between farms as expressed by farmers; ii) understanding how and why these were translated in practice.

Methodology

In 2017, we started a participative process with extension advisors from the local "Chambre d'agriculture" and a group of 17 farmers aiming to increase local interactions on organic matter (e.g. manure) and/or local feed (Ryschawy et al., 2022). Crop farmers were particularly engaged in soil conservation practices. This group is located in Ariège, a French NUTS 3 region from Southern France. In the region, farms tend to be specialized depending on the geography: specialized crop farms in the northern plains (seed maize production and wheat-sunflower rotations) and specialized livestock farms oriented toward grazing and transhumant systems (beef cattle, sheep) in the southern mountains. Both systems are highly reliant on inputs (fertilizers for the first and feed and straw for the latter). On foothills at the border of plains and mountains, mixed farmers are engaged in both crop and livestock productions, with heterogeneous situations regarding input self-sufficiency.

Throughout the years, we conducted two sets of face-to-face interviews with the participants (Fig. 1). The first set (2017-2020) focused on the farm, agricultural practices and farmers' perception on interactions (i.e. motivations, barriers, and levers). The second set (2022) aimed at mapping with the farmers all the interactions they had for season 2021-2022. We considered one interaction as one triptych including i) two partners, ii) one biomass and iii) one flow type, i.e. sale-purchase, exchange against another type of matter, barter. We considered four types of biomasses: fodder (standing for grazing/mowing, or conditioned), grain related to livestock feed, straw (standing or conditioned) and manure. We asked farmers to describe each interaction with the name of the partner, the type of relationship, the biomass involved, the flow type, and occurrence frequency of the interaction. These interactions occurred within an open network of farmers and were not limited to the farmers interviewed. Farmers were invited to comment on the history of each interaction, particularly on why i) they were involved in these interactions, ii) had stopped previous interactions and iii) had started new interactions. We performed inductive content analysis and open-coded the interviews into key themes that emerged from the interviews (Elo and Kyngäs, 2008) and are highlighted in italic in the findings section. We also performed a descriptive analysis of farm interactions.

Fig. 1. General approach with aims, methods and group constitution over time (2017-2022)



Findings

Expressed levers and barriers for interactions between farms

All farmers mentioned a common desire for *local cohesion and solidarity* which matched, according to them, with interactions between farms. However, we highlighted different perceptions on the levers and barriers of these interactions according to their productions. Crop farmers were looking for *agro-environmental benefits* such as i) cropping system diversification through introduction of crops to feed livestock, or ii) the improvement of soil organic matter content thanks to manure inputs. Growing alfalfa seemed an opportunity to them to improve soil nitrogen content, limit erosion, and for some even a step to organic conversion. However, crop farmers emphasized the *logistical costs* were a barrier to local interactions. Due to geographical segregation and steep roads to collect manure in the mountains, costs were too high. They mentioned how easy it was to deliver grain to local cooperatives compared to a coordination with a livestock farmer ("It's easier than coordinating ourselves with livestock farmers […] I need things to be simple"). At the cooperative there was always an employee available to take care of their merchandise, they did not have to make an appointment in advance.

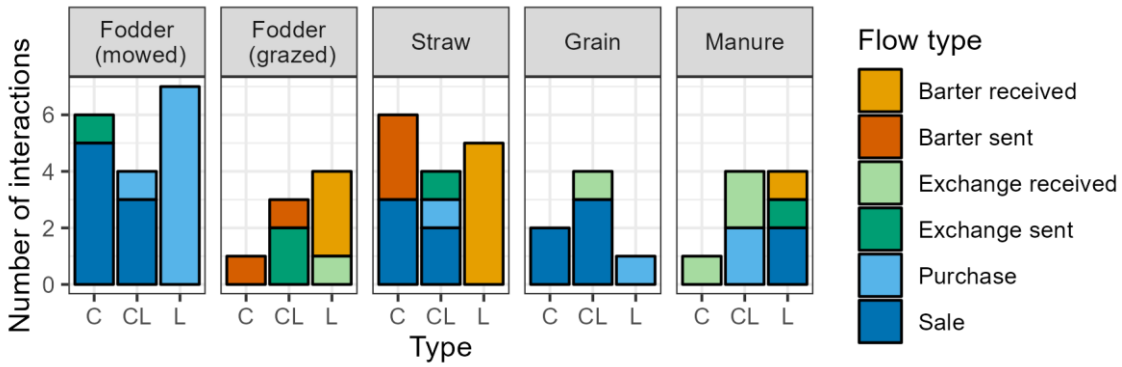
Crop-livestock and livestock farmers aimed for *local feed self-sufficiency* for their animals in order to be less reliant on the global market and large cooperatives (regarding prices and product quality). Indeed, those who bought feed to the cooperative were dubious regarding its quality and composition ("we don't know what's inside [depending on global crop market] […] and this quality is directly impacting manure quality that goes back to our fields"). Farmers' wish to be *autonomous from cooperatives* in their decision-making was strong. Some farmers mentioned situations where cooperatives invested and provided buildings, livestock and feed and farmer had to apply recipe-like recommendations (systems highly embedded in the value chain) as opposite as their view of their profession ("you are not livestock breeder anymore", "you are not the manager in your house"). Most of these interviewees showed such a profound mistrust in cooperatives that they were producing their feed on-farm or were planning to. This facilitated interactions between farmers. Livestock farmers with few land to produce their fodder and grain interacted with livestock farmers to get it. However, they mentioned they could not work with any crop farmer: as they were looking for *quality feed*, they needed to work with technical crop farmers with "clean fields", or farmers who let them handle grain/fodder production from seeding to harvesting. For those who were buying ready-to-eat feed from the cooperative, the technical cost of changing their system to produce their own feed were a strong barrier hindering interactions. Indeed, it required sourcing the crop products (access to production, sorting, and storage), as well as equipment and knowledge to formulate rations. They perceived high risks to decrease the herd productivity if quality of the feed and ration formulation were not handled properly. In addition, uncertainty on price volatility was an important barrier for some farmers with livestock production who were still unsure whether sourcing local products would really be an economic advantage in the long run. Others were less hesitating ("when we limit intermediaries there is always less cost [economically].").

Interactions between farms in practice

For season 2021-2022, over 13 farms, two farms were not involved into any interaction: a crop farmer sold all his grain to the cooperative and kept his straw as mulch and a mixed farmer was fully autonomous. For the 11 other farms, we recorded 51 interactions in total. On average, there were four interactions per farm (range: 1 to 8 interactions) and three different partners per farm (range: 1 to 6 partners). Nine pairs of farms interacted for more than one type of biomass. Most of the interactions occurred between farmers with a spatial proximity (45% with neighbours), or social

proximity (31% with friends or family), while 23% occurred with an acquaintance from the professional network. Farmers sealed an oral contract in 75%, none in 23% and a formal contract in 2% (1 case) of the interactions. The formal contract concerned a crop farmer and a livestock farmer who met through their professional network. They mainly established it to cover for insurance as the interaction involved sheep grazing within the crop farmer's farm. Oral contracts varied in substance but specific terms could be agreed upon, such as date of removal (e.g. take away the straw from the field as soon as it is packed and ready).

Fig 2. Interactions from 2021 to 2022 by biomass, flow type and type of farmer (C = crop farmer, CL = crop-livestock farmer, L = livestock farmer). Exchange flows were recorded twice (received and sent)



Interactions involving fodder were the most common (25 interactions, or 44%, Fig. 2). They involved both crop farmers who supplied the biomass and livestock farmers who sought it. Mixed farmers were buyers when their own production was insufficient and sellers when they produced surplus. Overall, 64% of fodder-related interactions involved buying and selling. Over the years, new interactions with cover crop and cereal grazing were tested and adopted. Fifteen interactions involved straw (27%, Fig. 2). They were mainly bartering (53%), followed by buying and selling (40%) and exchange for manure (7%). As with fodder, mixed farmers were both buyers and sellers. Nine interactions involved manure (17%, Fig. 2). There was as much buying and selling (45%) as exchanges for straw or grazing (45%) and one donation (10%). Seven interactions involved grain (12%), of which 86% were buying and selling, and 14% were exchanged (Fig. 2). In terms of quantity, these interactions represented a small amount of crop total production, most of the grain was sold to cooperatives.

We highlighted tensions around straw and manure. Most farmers had stopped straw-manure exchanges due to high logistic costs and straw sales without manure in return left a feeling to downgrade from a win-win to a loose-win situation (in favour for the livestock owner). Crop farmers tended to keep straw in the fields to improve or maintain soil quality ("if I sell my straw [without manure in return], I need mineral fertilizer to compensate and this is not my wish"). Main factor to maintain straw-manure exchanges was solidarity, related to trust and friendship. This was the same for straw sales ("In solidarity with a livestock farmer, I give him straw. Actually I don't give it, I sell it but at a reasonable price").

As a confirmation to what the farmers had expressed when mentioning important barriers to interactions between farms, logistics and costs were important decision factors for all biomasses. However, their perceived level of importance on the choice to whether or not involve into interaction depended on whom was in charge of it. Most of the straw and mowed fodder were handled by the receiver (livestock owner) and did not affect the crop farmers, as long as it was

collected right after the harvest to let them time to prepare for the next crop. It was more heterogeneous for interactions involving grain (even though even availability of storage was important factor in the arrangement).

Even though farmers did not seal written contracts with each other, they agreed upon modalities and rules for their collaboration. They wanted to keep these collaborations based on trust and flexibility through the years. Infinite debates came at hand when mentioning the possibility to prepare a contract with fixed prices in order to cope with price volatility. One crop farmer even mentioned the need for a neutral institution to help set up mechanisms to decide prices with a fair adjustment through years.

Practical implications

This study started from a need from this group of farmers and their adviser. Farmers explicitly aimed to increase local interactions between farms. Far from representing the dominant regime in the study region, they remained within a niche with a high propensity to take risks and implement innovative farming systems. Understanding these farmers' perceptions and decision factors to get involved into interactions was and remains a necessary first step in supporting the development of those interactions. Despite an expressed mistrust towards cooperatives, further research could be undertaken on their role as innovation intermediaries; e.g. as conducted in China by Yang et al. (2014). We confirmed the importance to emphasize on trust and social capital, as highlighted by King et al. (2019).

The group composition evolved throughout the years. The number of farmers remained quite stable but only six farmers were involved during the whole process. The most spatially isolated livestock farmers left the group and more farmers located in the piedmont joined it. This evolution highlighted how difficult it is to maintain a group which is too spatially spread in the long run. Also, some participants changed priorities (e.g. investments) or faced personal issues and paused their involvement for a time. Overall, independently of the case study, we highlighted the importance to work in the long run with farmers. It allows to take a step back from focusing on specific practices, and to recontextualize them regarding farmers' objectives. Those objectives may be reached through many paths depending on hindering factors, and lead to innovative change of practices (e.g. here, focus progressively switched from straw-manure exchanges to cover crop grazing in interactions leading to crop fertilization and livestock feeding).

Theoretical Implications

In the study region, but most likely also in most other European regions, farms do interact with other farms (through biomass, workers, machinery, etc.). However whilst they often benefit from local coexistence, they are more rarely involved in a stronger level of integration leading to more spatial, temporal and organization coordination (Martin et al., 2016). We showed that interactions between farms is not only a question of offer and demand, there is more at hand. Bouttes et al. (2019) emphasised that farmers do not only focus on profit maximization and/or optimized productivity. Each farmer has his own objectives depending not only on farm structure but also on individual values. We showed that his perceptions and decision factors for being involved into interactions may even differ according to the biomass considered and farmers' position (i.e. offer or demand). We showed the importance of trust, solidarity, and spatial and social proximity in involving into interactions. Many interactions with neighbours relied on informal help, which is key element but rarely documented in studies. Also, there was a gradation in the interactions, as after many interactions with acquaintances from the professional network, friendships developed. They could also lead to more subsequent changes in the cropping systems (e.g. choice of the crop composition

for fodder) and to more integration, contributing then more to the agroecological transition. These dynamic and individual elements should be thought through when developing models on farmers' decision-making, especially regarding farm interactions.

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