Barriers and levers for greater crop-livestock integration at regional level

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The specialization of agriculture and livestock, coupled with the concentration of production in specific regions and the resulting environmental impacts call for a paradigm shift. To meet the sustainability challenges, reconnecting crops and livestock on a local scale would enable exploiting the benefits of integrating livestock into cropping systems, and vice versa. Crop-livestock integration allows making use of biological synergies between animal and plant production through nutrient exchange (fertilisation and feeding) and natural complementarities between species (biological control). However, these practices are not yet mainstream in the current dominant agricultural model. Their development will require removing several obstacles to expand their scope effectively.

Keywords: diversity, multifunctionality, agroecology, mixed farming system

1. The benefits of crop-livestock integration

Crop-livestock integration can be defined as a set of agricultural practices based on synergies between crops and livestock, which contribute to the agroecological transition. Several studies (Asai et al., 2018; Garrett et al., 2020; Martin et al., 2016; Moraine et al., 2017; Moraine et al., 2019; Moraine et al., 2020; Thenard et al., 2021) have extensively described the benefits of this coupling, at the farm and regional scales.

The implementation of crop-livestock integration practices at these scales can increase the supply of ecosystem goods and services (Martin et al., 2016). These practices also have an impact on closing nutrient cycles by enhancing nutrients recycling, thereby limiting the use of external resources and the associated losses.

When considering the economic dimension, closing cycles by integrating livestock into agrosystems can lead to increased autonomy and therefore savings on purchasing inputs (Moraine et al., 2017). Farmers are therefore less exposed to the ups and downs of the feed market, while cereal growers can find stable outlets for their diversification crops (Moraine et al., 2020) and reduce their purchases of synthetic fertilisers. This integration of animals also has an economic interest in terms of the diversification of production that it enables. On a regional scale, this diversification creates local markets, securing outlets and stabilising the incomes of the farms concerned (Martin et al., 2016). By controlling costs more effectively and developing a range-based economy to enhance the value of production, it is possible to encourage the local development of crop-livestock interactions.

At a local scale, the integration of livestock farming can also be the result of collective dynamics that enable exchanges and knowledge sharing between different categories of stakeholders, creating a network between farmers and local stakeholders such as consumers, local authorities, and environmental organisations. These synergies can result in establishing shared governance and values, and contributing to local food supply chains through the diversification of activities and the development of short distribution

channels. At the farm scale, this complementarity reflected in a collective organisation can have positive repercussions on the economy and working hours. This complementarity and diversification of agriculture can also make farming systems more acceptable to society, particularly through the greater attractiveness of landscapes with grazing systems, incorporating hedges or local breeds, for example (Martin et al., 2016).

2. Barriers to the development of crop-livestock integration

Despite the numerous advantages of crop-livestock integration, there are still many obstacles preventing these initiatives from taking root in local areas.

2.1 Agronomic barriers

Some obstacles are agronomic: the area's potential such as topography, water resources availability, and soil and climate conditions can limit the opportunities for integrating crop and livestock farming. Additionally, stakeholders do not necessarily have the same expectations. Therefore, a mismatch between supply and demand may arise (Martin et al., 2016). This can be the case for livestock keepers and winegrowers for grazing services in vineyards,i.e.: livestock farmers require forage resources throughout the year, whereas winegrowers may only need grazing services during a specific period.

The highly specialised nature of research institutions and support organisations also hinders introducing such systems. This specialisation, in either crops or animals, results in a lack of knowledge, skills, and references on integrated crop-livestock systems. This lack of interdisciplinarity is also an obstacle to innovation and the development of this type of agroecological approach.

2.2 Logistical obstacles

Logistical obstacles also present significant challenges. The diversification of production entails additional costs, whether in terms of availability and capacity to acquire infrastructure and equipment, or transportation between complementary areas that are often far apart. Furthermore, the long working hours required for production, harvesting, packaging, and processing due to a lack of labor can also be a real obstacle for farmers considering projects involving animals at both farm and regional scales (Asai et al., 2018, Moraine et al., 2020). These constraints can lead to higher costs: production costs due to high feed prices energy or logistics costs of individual and collective investments, human resources, transportation, and coordination. The increase in these costs is an obstruction to the development of integration practices (Moraine et al., 2017). As previously mentioned, commodity chains tend to be highly specialised, thus reducing market opportunities for a system integrating both animal and crop production. Moreover, products from diversified systems can be challenging to market, which prevents farmers from promoting their approach to consumers who may not beaware of this type of initiative.

2.3 Administrative and legal obstacles

Besides logistical obstacles, there are also administrative and legal ones. Most exchanges, such as livestock keepers grazing their sheep in vineyards or cultivated plots, are not regulated. Currently, there is no formal contractual framework for these services, which are often carried out informally and based on verbal mutual agreements on friendly basis. In addition, certain legal tools can hinder the development of these integration projects such as regulations on transporting by-products or the fact that crops can be exchanged without the intervention of a storage organisation (Moraine et al., 2020). As the sectors are specialised, this also has repercussions on aid and insurance, which typically focus on specific products and can be detrimental to integrated crop-livestock systems.

2.4 Cultural barriers

Finally, cultural barriers can also be a hindrance. Integrated crop-livestock systems are often perceived as less profitable and more labour-intensive compared to specialised systems. Moreover, certain farming practices or their consequences can give rise to controversy. This is the case, for example, of the transportation of livestock effluents, intensive livestock farming, the establishment of methanisation units (Moraine et al., 2020), and induced pollution (eutrophication of water and GHG emissions, etc.) (Asai et al., 2018). Conflicts and rivalries between stakeholders such as farmers, local residents, and hunters can also hamper the introduction of these systems. Coordinating these stakeholders can thus be complicated, as they do not all have the same issues and expectations when it comes to implementing these practices.

3. Levers identified during the workshops

A 1.5-hour workshop was organised to collectively think on the question of "Agricultural specialisation or diversity in the regions: issues, benefits and limits, conditions for transition". Around thirty participants took part in two sessions.

The first part of the presentation was devoted to a concrete example; the Sagiterres project (Collective Strategies for Territorial Agroecology). This participatory research project, led by both INRAE and BioCivam de l'Aude, focuses on the issue of maintaining and reintroducing livestock farming in wine-growing areas (Aude). This project aims to strengthen collective strategies for reintroducing livestock farming by supporting them and designing models that will enable them to plan and implement initiatives that are more complex effectively. At the same time, in order to provide better support, work has been carried out to better understand the obstacles and levers involved in these projects to . Five different case studies, that already existed during the project, were chosenfor this purpose. The main results of the project were then presented i.e. 1) identification of the region-specific obstacles, 2) design of collective strategies, 3) modelling of the region's potential, 4) evaluation of the benefits, and finally, 5) implementation of strategies for integrating local crop and livestock farming. These elements provided participants with an initial overview of the issues involved and the complexity of reintegrating livestock farming on a regional scale through a concrete example.

Secondly, the participants (students, researchers, teacher-researchers, and livestock farmers) were divided into sub-groups. All had varying degrees of knowledge on the subject. The objective of this exercise was to collectively reflect more specifically on the levers to be mobilised. The previously mentioned list of obstacles was presented in the form of posters as a basis for reflection. Numerous agronomic and economic levers were highlighted in the various sub-groups. However, in the end, the organisational and social levers came up most often in the discussions. Several points raised and discussed by the participants aligned with levers already mentioned in other studies.

3.1 Agricultural levers

Regarding agronomic levers, the focus was on identifying available resources to improve their distribution and sustainability. The example of integrating sheep into vineyards was given, with reference to the choice of suitable grape varieties and the trellising of vines to prevent damage from passing animals. Choosing appropriate breeds would also facilitate the establishment of these systems. To offset the complexity of managing such systems and the amount of work required, grouping plots into blocks, making it easier to set them up, was identified as a potential lever to streamline their implementation.

One of the agronomic barriers to crop-livestock integration, previously discussed in this article, was the lack of knowledge and references. Although no levers relating to this obstacle were discussed during the workshop, several are discussed in the literature. Demonstrations, trials, system experiments, farm visits, and the development of participatory research forms involving the various stakeholders can help identify

effective farm types, models, and initiatives that would enhance knowledge and understanding of crop-livestock integration projects (Garrett et al., 2020).

In connection with this challenge of producing new knowledge, the promotion and implementation of cross-disciplinary and interdisciplinary approaches within research and development institutions were mentioned, with the aim of 1) providing better support for integrated crop-livestock farming systems and 2) overcoming the high degree of specialisation in agricultural sectors, which can hinder the successful development of such initiative. Rethinking the role of research by despecialising it, same along with support organisations, advisers and public policies were reported as possible levers in several groups. This emphasises the importance of forming multi-disciplinary teams to support projects and facilitate the decompartmentalisation of skills. There is therefore a need for cross-functionality at all levels.

Moraine et al (2020) also mentioned this importance of local support. ilt has been observed that, without local support, farmers are more likely to withdraw from projects. This support and facilitation must therefore be maintained until the new practices and coordination tools are fully acquired to ensure that the changes take root and the projects are sustainable. The multi-skilling of facilitators and support staff is necessary for such projects to provide the necessary knowledge, engage the right people, and ensure appropriate facilitation and monitoring (Moraine et al., 2019).

3.2 Economic and administrative levers

To overcome economic and administrative obstacles, it has been proposed to rethink and adapt the aid system, prioritising localised aid tailored to specific conditions. Simplifying administrative procedures would also be an important lever. Regarding these administrative levers, Garrett et al (2020) emphasised the need for better technical support and knowledge for financial backers to encourage them to assess the projects submitted over a longer period and to propose collective subsidies to encourage crop-livestock integration. Insurance companies would also benefit from this kind of technical support, allowing them to redefine risk profiles by taking into account the diversity of farms rather than just focusing on the farm specific products. Furthermore, adapting and simplifying legislation on the circular economy, particularly regarding the transportation of animal co-products such as effluents or animal feed, would be an important administrative lever (Garrett et al., 2020).

From an economic standpoint, the participants identified promoting products resulting from these projects integrating crops and livestock, within a specific area, as a lever. This effective communication, whether through the organisation of events or the promotion of these crop-livestock complementarities, can help to change attitudes and raise consumer awareness. Garrett et al (2020) also highlighted the crucial role of communication and marketing in engaging consumers. This would enable the establishment of territorial identities supported by labels, thereby creating a value chain ensuring higher value for products derived from these agroecological practices. Another economic lever would be to market these products through short circuits within a group of farmers, thereby capitalising on the complementary nature of the products produced by the group (Moraine et al., 2019).

3.3 Social and organisational levers

Regarding social and organisational levers, several aspects were discussed. A first set of levers aimed at facilitating connections between crop and livestock farmers, with solutions mobilising various stakeholders and resources. The role of supply chains, public policies, support, and promotion to design these systems, not only on a farm-by-farm basis but also on a regional scale, was highlighted.

Indeed, involving these different stakeholders in the exchanges would be beneficial for supporting these initiatives and therefore ensuring their long-term sustainability. Projects that have f political support also seem to be the most developed. Therefore, support structures play a decisive role in the creation of these projects and their feasibility (Moraine et al., 2019).

Public policies could be used to define the status of exchanges and formalise partnerships, while cooperatives could provide logistical support and back up the sector by identifying local markets. Support from local stakeholders in marketing would also be a significant lever, as would the involvement of CUMAs (Coopératives d'Utilisation de Matériel Agricole; farm machinery cooperatives), which could initiate collective dynamics (Moraine et al., 2017; Garrett et al., 2020).

Public stakeholders also have a role to play by integrating these initiatives into their territorial projects in order to support them and enable them to benefit from local dynamics (Moraine et al., 2017). All these stakeholders (cooperatives, policymakers, consumers) have a role to play in changing public policy in a more favourable direction to the integration of farming and livestock production (Garrett et al., 2020).

In addition to their roles in providing logistical and technical support for the development of these projects, all these stakeholders contribute to the sharing and dissemination of information, which are essential elements for project success. For instance, cooperatives disseminate resources and cost-benefit analyses; experts and researchers analyse available resources available in a specific area and provide knowledge on existing systems; CUMAs, farmers' associations, and Chambers of agriculture facilitate exchanges and cooperation (Moraine et al., 2020).

The importance of jointly defining constraints and needs to facilitate understanding between stakeholders was also discussed. In fact, the collective design and conception of these coupling projects on a regional scale, involving both farmers and livestock keepers, makes it possible to define common objectives and exchange methods together, which facilitates exchanges by initiating a collective dynamic (Moraine et al., 2017). This is particularly enabled by the creation of farmer networks (Garrett et al., 2020). Moraine et al. (2020) also highlighted the importance of having farmer leaders when building projects to organise, harmonise collective action, and facilitate dialogue between stakeholders. Similarly, players with the capacity to invest, such as cooperatives and large farms, are considered major assets (Moraine et al., 2020).

Finally, the introduction of platforms or tools (meeting sites, shared CUMAs for processing, mobile slaughterhouse) to facilitate networking and meet the needs and demands of each group was mentioned in several groups. Various tools could be implemented such as GIEEs bringing together cereal growers and livestock farmers to facilitate the creation of collectives, project management tools to reduce organisational costs (with monitoring of time invested, compensation, and adjustment rules), and collective rules establishment (Moraine et al., 2020).

4. Conclusion

This reflection on the obstacles and levers to crop-livestock integration has provided a re-contextualisation of the challenges related to crop-livestock complementarity in a specific area, considering the characteristics of agricultural and natural landscapes, as well as the involved stakeholders. Given the systemic nature of these territorial dynamics, the identified obstacles span across agronomic, economic, administrative, social, and organisational dimensions. These challenges, while are not insurmountable, require a joint commitment from the concerned local stakeholders and supportive public policies to facilitate and sustain their implementation.

Ethics

The authors declare that the experiments were carried out in compliance with the applicable national regulations.

Declaration on the availability of data and models

The data supporting the results presented in this article are available on request from the author of the article.

Declaration on Generative Artificial Intelligence and Artificial Intelligence Assisted Technologies in the Drafting Process.
The authors have used artificial intelligence-assisted technologies to translate from French to English.

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Declaration of interest
The authors declare that they have no known financial interests or personal relationships that could have influenced the work presented in this article.

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