

# Promoting crop diversification for more sustainable agri-food systems

Antoine Messéan, Loïc Viguier, Lise Paresys and Didier Stilmant

- Crop diversification can support a transition towards more sustainable agri-food systems, mitigate climate change and help achieve the Sustainable Development Goals;
- Current national and European agri-food systems are still very much centred on dominant crops and associated long value chains;
- Crop diversification is hindered by barriers throughout the agri-food system. Such barriers should be removed through systems approaches, which take the whole system into account;
- Collaboration, innovation and learning among actors are key factors to scale out crop diversification;
- It is necessary to combine various diversification strategies that are adapted to local conditions and needs, and which evolve over time;
- Systems approaches and decision-support tools are needed to support actors along crop diversification pathways.

## What is crop diversification?

Crop diversification means increasing the diversity of crops in space and time using diversification practices such as rotation extension, multiple cropping, intercropping, and/or a combination of these practices (Figure 1).

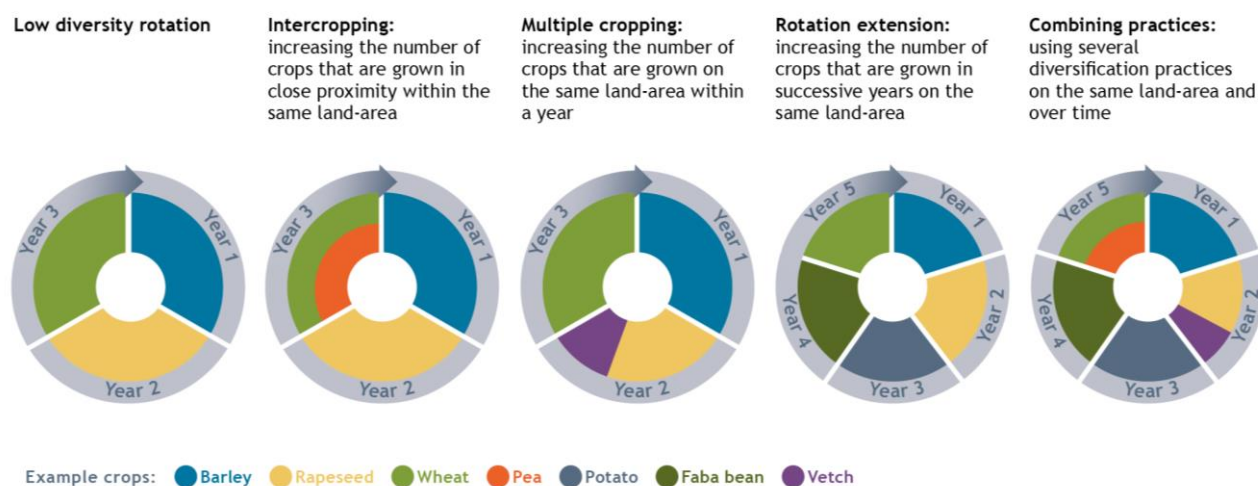
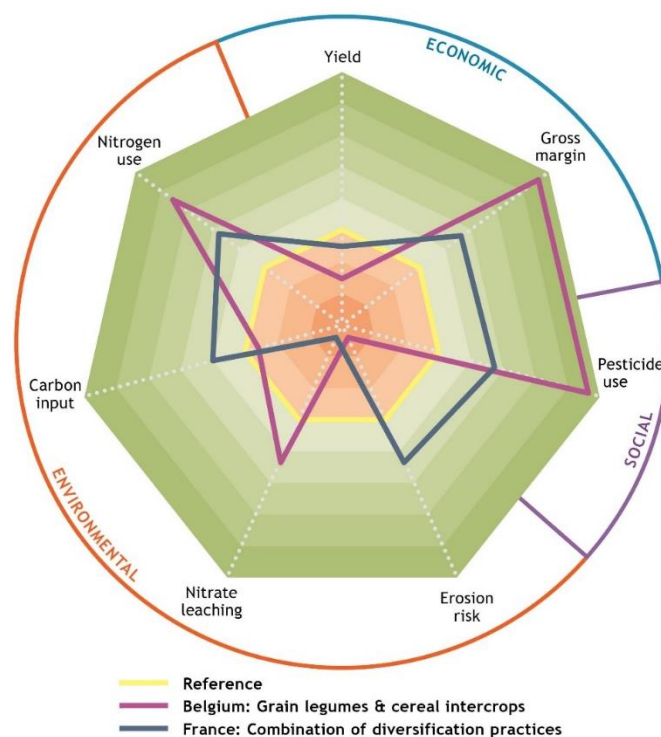


Figure 1: Crop diversification strategies

Crop diversification can support agroecological transitions towards sustainable agri-food systems, mitigate climate change and help achieve the Sustainable Development Goals.<sup>1</sup> Research has shown that crop diversification significantly enhances crop yields, biodiversity, and several ecosystem services including water quality, pest and disease control and soil quality, compared to low diversity rotations.<sup>2</sup> Regardless of the context, a combination of several diversification practices outperforms any individual diversification practice.<sup>3</sup> This suggests that incentives to promote crop diversification should favour the adoption and maintenance of a combination of diversification practices by farmers for greater performance.

However, the benefits of crop diversification are sometimes coupled with less desirable impacts (Trade-offs)<sup>4,5</sup> (Figure 2). For instance, the introduction of cover crops in hillside areas may prevent soil erosion but this may require using chemical destruction (pesticides) or mechanical destruction (soil tillage), which may increase global pesticide use or greenhouse gas emissions respectively. Also, if a newly introduced crop fails, it may result in reduced ecosystem services and economic performance compared to well-mastered low-diversity rotations. Because such trade-offs are highly context specific, it is necessary to continuously adapt crop diversification strategies, crops and crop management practices to local contexts in order to fully benefit from crop diversification.

*Collaboration among actors involved in agri-food systems and their empowerment to innovate, learn and adapt are key factors to scale out crop diversification*

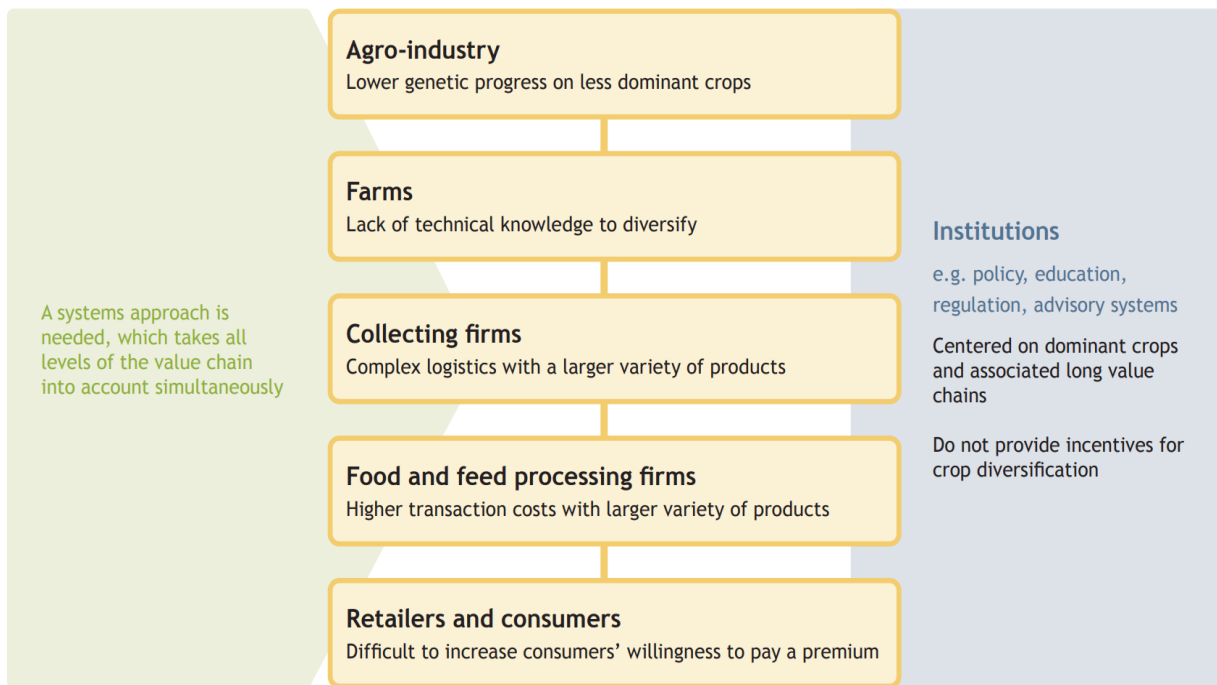


**Figure 2:** Performance of two diversified cropping systems compared to their low diversity references. Where the line is in the green area, the diversified system performs better than its reference (yellow line); where it is in the orange area, it performs worse than the reference. Performances of diversified cropping systems are variable and trade-offs exist.

## What are the barriers and how can the potential of crop diversification be unlocked?

### Consider the agri-food system as a whole

For the past 50 years, institutional systems have co-evolved towards specialised and highly simplified agricultural systems and long and integrated value chains resulting in a major technological lock-in of the agri-food systems and a strong inter-dependency between its actors.<sup>6,7</sup> In this context, diversification is hindered by various barriers concerning all actors in the value chain.<sup>6,8,9</sup> Overall, this unfavourable socio-economic context often renders



**Figure 3: Barriers to crop diversification in agri-value chains in Europe (adapted from Meynard et al., 2018)**

minor crops less competitive than major crops (e.g., wheat or rapeseed), especially in a globalized commodity market, which hampers crop diversification.<sup>7,10</sup>

Collaboration among actors involved in agri-food systems and their empowerment to innovate, learn and adapt are key factors to scale out crop diversification.<sup>11</sup> Incentives should foster the creation and maintenance of local and short value chains when possible and global and long value chains when necessary.<sup>6</sup>

*Farmers attempting to diversify their cropping systems face farm-level and socio-economic factors, requiring continuous adaptive management in terms of configuration and management of their cropping systems.*

### **Develop accompanying tools and infrastructure to support learning processes**

Crop diversification is a complex process: actors need to continuously adapt in order to account for farm-level and socio-economic factors and identify new paths forward (Figure 4). Consequently, there is no one-size-fits-all diversification strategy. Indeed, not only does each farm have specific pedoclimatic conditions, market opportunities and preferences but drivers such as climate change and societal demands call for adaptive management.

This non-linear pathway to crop diversification requires high flexibility as well as new knowledge, attitudes, roles and arrangements from all actors. The benefits of diversification must be acknowledged and trade-offs dealt with creatively.

In DiverIMPACTS, special attention has been paid to:

- Fostering mutual learning and helping multiple actors construct and share their vision of crop diversification and sustainable agri-food systems, enlarging their perspectives, and coordinating their actions over time;<sup>12</sup> and
- Assessing the actual sustainability of crop diversification strategies at different levels of agri-food systems (cropping systems, farm systems, value chains and territory), understanding their economic, social and environmental outputs and supporting their design in diverse and continuously evolving contexts.



**Figure 4: Cropping systems diversification toward sustainability is a non-linear pathway requiring a continuous adaptive management. Low-diversity systems comprise a small range of major crops belonging to the dominant system. Farmers attempting to diversify their cropping systems face numerous farm-level and socio-economic factors, requiring continuous adaptive management in terms of configuration and management of their cropping systems. This results in a series of diversified cropping systems closely adapted to their farm and socio-economic contexts. Diversified cropping systems produce a large range of crops, requiring *ad hoc* value chains and coordination and flexibility from all actors.**

## Policy recommendations to promote crop diversification

DiverIMPACTS is elaborating practical recommendations that will be further detailed in upcoming policy briefs. General recommendations include:

1

Expand the scope of CAP and enrich CAP instruments to support both farmers and other value chain actors in diversification:

- Integrate an indicator capturing the actual effects of crop diversification to implement the Good Agri-Environmental Conditions standards and facilitate the implementation and monitoring of eco-schemes;
- Include risk insurance mechanisms or multi-annual eco-schemes to cover costs of increasing diversification until the full benefits of crop diversification take effect

2

Sustain the development of infrastructure:

- Develop an EU farm sustainability data network including crop management practices at the field level, thus enabling a multi-criteria and dynamic assessment and monitoring of the sustainability of crop diversification;
- Developing a platform gathering resources to support crop diversification (e.g., field experiments, on-farm case studies, databases, decision tools);

3

Adapt research funding instruments to sustain systems approaches:

- Secure research investments over time to allow long-term experiments that are crucial for diversified cropping systems and develop mechanisms to build on past experiences and share outputs in dedicated databases;
- Foster multi-actor involvement and farmer-led approaches: increase flexibility in Research Innovation Action projects to allow them to adapt over time according to actors' needs and new insights.

4

In national and regional education and advisory systems, promote systems approaches and favour the integration of skills and knowledge to (i) understand the functioning of agri-food systems beyond the field level; (ii) explore and assess crop diversification options and alternative agri-food systems, and (iii) support farmers and other actors' decision making on crop diversification in continuously evolving situations.

## References

- HLPE. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. (2019).
- Beillouin, D., Malézieux, E., Seufert, V. & Makowski, D. Benefits of crop diversification for biodiversity and ecosystem services. (2020). doi: <https://doi.org/10.1101/2020.09.30.320309>
- Beillouin, D., Ben-ari, T. & Makowski, D. Evidence map of crop diversification strategies at the global scale. *Environ. Res. Lett.* (2019). doi:10.1088/1748-9326/ab4449
- Hellou, G. & Jensen, E. S. Deliverable 3.4 Second annual report on main findings of each field experiment. (2020).
- Viguié, L. et al. Combining diversification practices to enhance the sustainability of conventional cropping systems. *Eur. J. Agron.* (2021). doi:10.1016/j.eja.2021.126279
- Meynard, J. et al. Socio-technical lock-in hinders crop diversification in France. *Agron. Sustain. Dev.* 38:54 (2018). doi:10.1007/s13593-018-0535-1
- Magrini, M. B. et al. Why are grain-legumes rarely present in cropping systems despite their environmental and nutritional benefits? Analyzing lock-in in the French agrifood system. *Ecol. Econ.* 126, 152-162 (2016).
- Messéan, A. et al. First European Conference on Crop Diversification. In First European Conference on Crop Diversification, September 18-21, 2019 Budapest (INRAE and ÖMKI, 2019).
- Morel, K., Revoyron, E., Cristobal, M. S. & Baret, P. V. Innovating within or outside dominant food systems? Different challenges for contrasting crop diversification strategies in Europe. *PLoS One* 15, 1-24 (2020).
- Preissel, S., Reckling, M., Schläfke, N. & Zander, P. Magnitude and farm-economic value of grain legume pre-crop benefits in Europe: A review. *F. Crop. Res.* 175, 64-79 (2015).
- Makowski, D., Carpentier, A., Sadjahin, R. I., Vanwindekens, F. & Legein, L. Deliverable 1.4 Critical review of published evidence on the benefits and main drivers of crop diversification. (2020).
- Rossing, W. A. H. et al. Crafting actionable knowledge on ecological intensification: Lessons from co-innovation approaches in Uruguay and Europe. *Agric. Syst.* 190, 103103 (2021)

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