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## Mixed crop-livestock systems across scales: toward new agroecological models?

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### Introduction

Integrated crop-livestock systems (ICLS) are recognized worldwide as a way to improve farming sustainability (Hendrickson et al., 2008; Ryschawy et al., 2014). Interactions between crops, livestock and grasslands potentially provide multiple ecosystem services. Soil quality improvement would result from organic fertilization from livestock waste and crop-grassland rotations; increased landscape heterogeneity through the integration of grasslands within diversified crop rotations would enhance biological regulation. According to these assumptions, ICLS would be a key agroecological model for rethinking agriculture (Bonaudo et al., 2014). However, ICL farms are decreasing due to workforce and skills constraints and the strong specialization trend linked to the economic and politic contexts. A new opportunity would be to develop ICLS at local scale based on exchanges between specialized farmers (Moraine et al., 2014). We present here some case-studies considering these different scales of interest: from the ICL farm to the local level integration.

### Opportunities and limits of conceiving sustainable ICLS at the farm scale

Ryschawy et al. (2014) studied 56 ICL farms in a south-western France less-favored region. ICLS at the farm scale allowed farmers to benefit of economies of scope and limit inputs through combining crops and livestock enterprises. High level of spatiotemporal coordination required thus implementing diversified crop rotations, integrating grasslands, and adapted fertilization or feeding practices. These results highly depended on farmers' management of interactions between crop, grassland and livestock activities (Bonaudo et al., 2014). However integration required a high level of technical skills and additional labor (Hendrickson et al., 2008). Despite low labor availability and work conditions, some farmers maintained their ICL farms (Ryschawy et al., 2014).

### Opportunities of up-scaling: conceiving between-farm exchanges at the regional scale.

Conceiving ICLS at the local scale goes beyond farm-scale workforce constraints while providing comparable benefits. Spatial and temporal coordination would provide landscape heterogeneity and soil quality improvement. Collective organization allows farmers to combine and share their technical skills while limiting qualitative and quantitative workforce constraints. Crop farmers could diversify their rotations while integrating grasslands and obtaining manure. Livestock producers could benefit from local traceable and lower-cost feed production. Moraine et al. (2014) and further studies were based on between-farmers exchanges in the French Tarn-Aveyron Basin. Exchanges were studied at three scales: i) between 6 neighboring farmers including collective technical changes, ii) between 24 local farmers including investment in collective equipment, iii) wider exchanges involving local cooperatives and supply chains. ICLS at the local scale would require new research effort to design relevant technical and social practices and evaluation indicators. Design and assessment tools should integrate local knowledge and be easily out-scaled.

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