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Review of livestock farmer adaptations to increase forages in crop rotations in western France

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ABSTRACT

Since the 1960s there has been a global trend toward specializing and intensifying farming systems in order to produce more food. However, harmful environmental consequences have been recognized. Integrated crop–livestock systems (ICLS) are now being reconsidered as a means of improving farm and land sustainability. We suggest that understanding interrelations of ICLS to achieve sustainability requires scrutinizing the way farmers exploit them to adapt their farming system. We used six different case studies covering maritime and semi-maritime regions of France (beef and dairy + crop systems) to describe factors influencing production, environmental, and socio-economic considerations for change in farming practices. Farm surveys and analysis of farmers' practices and farm time-course of change were framed within the European farming system approach. Transition in the medium-term pointed out new interactions at stake between crops and livestock when farmers developed adaptation to climate changes, introduced grassland in contrast to the general trend of specialization and enhanced feed self-sufficiency. In the medium- and short-term, multifunctionality of crops and crop rotation adjustments, as well as regulation of cropping systems by livestock classes are the main levers of system flexibility. We showed how ICLS increased sustainability and began to notice the positive effects of farm collaboration. Further research is needed in partnership with additional stakeholders to support sustainable development of agriculture at the landscape level.

1. Introduction

Since the 1960s there has been a global trend toward specializing and intensifying farming systems in order to produce more. However, several authors (Russelle et al., 2007; Wilkins, 2008; Hendrickson et al., 2008; Griffon, 2009) have highlighted negative environmental and social consequences, such as excessive accumulation of nutrients in soil and water, increased economic dependence on product prices, vulnerability to market changes and hazards, and decrease in biodiversity. Conversely, integrated crop–livestock systems (ICLS), which combine crop production with animal husbandry (Russelle et al., 2007; Hendrickson et al., 2008), are now being reconsidered as a means of improving farm and land sustainability (Herrero et al., 2010; Lemaire et al., 2014). Such systems may improve nutrient cycles via exchanges of manure and straw (Schiere et al., 2002) and are a source of economy of scope (Vermersch, 2007). They have the potential to bring about diversification in farm plans, crop rotations, and crop and grassland locations on the landscape (Bonny, 2011).

Schiere and Kater (2001) viewed the benefit of ICLS as follows: the best known type of integrated mixed farming is probably the case of mixed crop–livestock systems. Cropping in this case provides animals with fodder from grass and nitrogen-binding legumes, leys (improved fallow with sown legumes, grasses or trees), weeds and crop residues. Animals graze under trees or on stubble, they provide draught and manure for crops, while they also serve as a savings account. Van Keulen and Schiere (2004) extended the concept of mixed farming to the regional level, considering that ICLS should be assessed not only at the farm level, but also

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at the regional scale. A wide range of ICLS can be involved in such a definition (Ewing and Flugge, 2004).

The potential value of crop–livestock interrelations need to be assessed at different spatial and temporal scales. We considered six case studies in western France using various time scales to investigate a wide range of crop and livestock interrelations. We explored ICLS interrelations to achieve sustainability through an adaptive capacities framework (Dedieu and Ingrand, 2010; Darnhofer et al., 2010; Milestadt et al., 2012). To survive in an increasingly perturbed, changing and uncertain environment, farmers must strengthen the ability to adequately respond to changes, rather than reacting to the adverse impacts of those changes. They must take into consideration the uncertainty and unpredictability of future developments of technical innovation, product quality and markets, and landscape, and they must become capable of buffering the effects of unexpected developments (Milestadt et al., 2012). Within a 1–10-year time period, adaptive capacity can be framed as transition and flexibility.

1.1. Transition

In the medium-term, innovation may be required because of a need or an opportunity to face changes in the environment or because of a disparity between a farmer's values and practices (Lamine and Bellon, 2009; Coquil et al., 2013). Transition is thus a concept (Elzen et al., 2012), helping to analyze the process of change leading to an innovative (i.e. radically new) situation. Moving toward ICLS requires farmers to change practices, rules and knowledge. We wanted to study transitions to ICLS to understand how to strengthen adaptive capacities. We framed this by asking what interrelations between crop and livestock are at stake when farmers (a) continue with self-sufficient systems, or (b) introduce temporary or permanent grassland in contrast to the general trend of specialization and crop development. An outcome would be to widen farmers' medium-term choice of farm plan (area of crops and grassland), spatial allocation of crops and grasslands within the farm (Havet et al., 2010b; Coquil et al., 2011; Schaller, 2011), and evaluate the influence of economic levers and environmental politics (Havet et al., 2010a; Ryschawy et al., 2012a,b; Schaller et al., 2012).

1.2. Flexibility

In the medium- and short-term, farming systems face hazards and perturbations that are more or less predictable, notably price volatility and weather fluctuations. The flexibility concept from management science (Tarondeau, 1999) analyzes how the system adapts to these perturbations and what kinds of adaptation are useful. The literature (e.g. Chia and Marchenay, 2008) distinguishes between reactive and proactive levers, internal and external (e.g. social networks) levers. Livestock scientists have shown how certain features of a system can, in operation, provide buffer capacity or the ability to easily adjust practice sequences (Astigarraga and Ingrand, 2011; Nozieres et al., 2011). Farmers have to maintain various sources of flexibility over the short-term and avoid technical solutions that are irreversible (Darnhofer et al., 2010). The combination of several agricultural activities and various resources for production with ICLS can be a source of farming system flexibility. To cope with perturbations, we need to understand how crop and livestock management practices and forms of integration can act as levers of flexibility. We wanted to explore the contribution of medium- and short-term multifunctionality of crops and crop rotation adjustments to system flexibility (Havet et al., 2010a; Roche et al., 2010; Schaller et al., 2011), and the contribution of specific livestock classes to the regulation of cropping systems (Coquil et al., 2011).

Our adaptive capacities framework was developed as a part of a farming systems approach (Darhnofer et al., 2012). It refers to a view of farms as a result of human and biotechnical components linking farmers' values and decision-making to achieve production and various types of performance, such as environmental improvement or product quality.

Our objective was to understand at the farm level the development of crop–livestock interrelations in transition processes and as sources of flexibility. Practices and rules were main concerns. Our inquiry of transitions focused on three main topics:

(1) What are the different factors that modify crop–livestock interrelations and how does this work?
(2) What is the influence of socio-economic levers or environmental policies?
(3) How are rules to build cropping plans modified with shift to temporary grasslands?

2. Materials and methods

Data were collected for six case studies of beef and dairy cattle farms in maritime and semi-maritime regions of western France. Self-sufficiency and environmental considerations (erosion, biodiversity) were the main foci.

2.1. Mixed crop–livestock farming in a rural area with natural handicaps (Case Study 1)

Coteaux de Gascogne (Pyrenean Piedmont in south-western France) is an upland area where agriculture specialization has until now been limited. In this hilly region, half of the farms maintained cattle and cash crops, while others specialized in either crops or cattle production. We carried out spatially explicit surveys of all 56 farms located in four municipalities to assess diversity in farm characteristics and changes undergone since 1950 (Choisis et al., 2010).

2.2. Intensive farming systems with some integration (Case Studies 2–5)

Forage systems of these farms, which are located in intensive arable or crop–livestock production regions, are undergoing changes. For various environmental reasons, grassland conservation or development has recently become an important issue in livestock farming systems in western France, especially on dairy farms. We studied many dairy farms with different levels of self-sufficiency in terms of inputs, particularly straw and animal feed.

Crop specialization in the Pays de Caux (north-western France, Case Study 2) has resulted in erosive runoff. Grasslands are increasingly being recognized as a way of mitigating this phenomenon. We surveyed eight dairy farms and conducted an economic assessment of different farm management options (Faure et al., 2010).

In the Plaine de Niort (western France, Case Study 3), conversion of grasslands into intensive annual crops led to a huge decline in population of little bustards (*Tetrax tetrax*, a heritage bird species). This trend was reversed in 2004 thanks to agro-environment schemes. To assess the role of grasslands in production systems, we analyzed: (i) farmers' management choices (24 farms) (Havet et al., 2010b) and (ii) farmers' decisions and adaptation regarding crop choices, crop rotations and spatial arrangement of fields (5 farms) (Schaller, 2011).

In Brittany (western France), intensification of farming systems has led to farm enlargement and specialization in animal production (dairy or beef cattle, pigs and poultry). Land use simplification at the regional level has resulted in three main categories of land