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Diverging and Converging Pathways

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Workshop 1.7: Scaling up and scaling out transformative farming practices: critical assessment of tools, methods and skills

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Over the past years, many initiatives have been taken to design and develop transformative farming systems, i.e. new farming systems that contribute to sustainability on a variety of dimensions. They cover a range of farming subsectors (e.g. arable farming, horticulture, fruit production, animal production) and may start from various backgrounds, e.g. research, co-creation between research and practice, or practice directly. Rather than offering "off the shelf" sustainable farming systems, such initiatives boost 'transformative farming practices', in which the term 'practice' covers new hardware or software, as well as orgware. To enable farming as a whole to contribute to sustainability transitions, it is crucial to scale up and/or scale out such new practices. Across Europe, numerous initiatives (whether bottom-up or policy driven) have been taken to achieve this for various subsectors, but the results to date have been meagre. To make this more effective, it is important to critically evaluate such attempts and to try and learn across a variety of cases what works best under which circumstances. At conferences like IFSA, the emphasis is usually on presentation and discussion of individual papers, which makes the cross-comparison needed in this case problematic. To tackle this, this workshop was organised somewhat differently, to get the required coherence. The workshop was built around examples of concrete attempts to scale up and scale out new, transformative farming systems. Attention was paid to the methods and tools used, and the skills required to apply these in the specific circumstances where such scaling up and out processes are at stake. Furthermore, it appears that scaling up and scaling out is not a matter of simply transferring a new practice from one location to another, but typically involves further development and learning in a new location to tune the new practice to the needs of that location. Hence, scaling up and scaling out is an active learning and development process, involving a range of stakeholders. The contributions to this workshop discussed which tools and methods were used to shape this process, what skills were required, and what the experiences were in applying these. Although the focus in this workshop was on 'scaling up and scaling out' transformative new practices, we knew from experience that this is often closely connected to how the new practice was created and who was involved in its initial design and development process. Hence, contributions were also expected to address this design process, insofar as it co-determines the approaches for scaling up and scaling out. To get as close as possible to how this works in practice, we sought examples presented by people who are or have been involved themselves in such scaling up and scaling out attempts (who could be researchers), rather than researchers who study such attempts made by others. To satisfy the overall objective to learn across various experiences, the workshop consisted of four sessions, the first three for presentation of cases and the final one for cross-comparison and general discussion and learning. To facilitate the cross-comparison, the convenors made a list of topics that each presenter of a case was asked to address. It was felt that such a cross-comparison would be most fruitful if the cases were presented and discussed in considerable depth. To achieve this, only two cases were presented per session (hence, six in total), a discussant directly after each presentation highlighted key issues, and there was plenty of time for discussion. After the three sessions the convenors assessed these and made an agenda of the most important items to discuss at the final, cross-comparison session. These were introduced at the final session by the convenors and/or the commentators to the three other sessions, as a starting point for the general discussion.

Upscaling of integrally sustainable animal production systems: the dynamic of anchoring processes

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Abstract : This paper analyses the combination of a method to design new sustainable animal husbandry systems by the name of RIO with efforts to stimulate the uptake of these new designs in practice. Over the past 15 years, this approach has been applied in a variety of animal production sectors in the Netherlands, two of which will be analysed here, one for broilers (chickens for meat) and one for pigs. To analyse the uptake process we build on the concept of anchoring that describes how a novelty becomes newly connected, connected in a new way, or connected more firmly to a niche or a regime. In the literature, three forms of anchoring are distinguished, notably technological, network and institutional anchoring. In this paper we seek to develop this general conceptualisation further to understand the dynamics of anchoring processes. On the basis of the cases analysed we conclude that to make technological anchoring more robust, a process takes place that we have called the 'specification of technology'. Furthermore, we distinguish two patterns in institutional anchoring, one in which the technology adapts to existing institutions and one in which new institutions are adapted to fit the developing novelty. This latter process seems to be key in transition processes to develop 'integrally sustainable' solutions.

Keywords: Anchoring, niche-regime interaction, system innovation, sustainable agriculture, animal production, reflexive interactive design

Introduction

In traditional innovation studies, the issue of *upscaling* (which is the central topic at this workshop of the 2016 IFSA symposium) is conceptualised as the 'diffusion of innovations' (Rogers, 1962). More recent work on transitions has shown, however, that innovation is a much more complex process, especially when looking at 'radical' innovations or 'system innovations' (Geels, 2002; 2004, Elzen & Wieczorek, 2006). The widely used multi-level perspective (MLP; Geels, 2002) sees innovation as the interplay between the three levels of niches, regimes and landscapes. A regime denotes an existing socio-technical system which may be under external pressure from a socio-technical landscape to change. Thus, the agricultural regime is under large landscape pressure to become more sustainable. The reaction of regimes to such pressures typically is to transform via a path of incremental innovation.

Alongside that, various actors may be tinkering with radical alternatives in 'technological niches'. In a niche, these alternatives (novelties) are protected from market forces via a variety of protection mechanisms and the niches thus provide a space for the actors involved to develop the novelty further and learn about how to make it work in practice. A novelty not only concerns technical aspects, but also social aspects like how it is to be used, a network of actors to sustain it, etc.

One key issue in transition studies is how niches can link up to regimes and start a process that may lead to a transformation of the regime (Smith, 2007). This linking is a first key step in a process of upscaling. In this paper we will address this linking issue by building on the concept of 'anchoring'. We will apply this to two cases from the RIO projects that the authors have been involved in over the past decade. The next section will describe the general RIO approach and the anchoring concept. Subsequently we describe the two cases and end with some conclusions.

Reflexive Interactive Design and Anchoring

Around the year 2000, Wageningen UR Livestock Research (WLR),[1] was assigned the task of tackling the sustainability challenges associated with large scale animal production in the Netherlands. This led to the development of the RIO approach, a Dutch acronym for "Reflexive Interactive Design". The authors of this paper have applied this approach in several projects targeting various animal sectors and developed it further, taking into account what was learned in previous applications

Details of the RIO approach have been described elsewhere (Bos et al., 2011; Bos & Groot Koerkamp, 2009; Bos et al., 2009). Here we only describe its main features. RIO starts with a design phase that builds on the approach of *Structured Design* (Cross, 2008; Siers, 2004; Van den Kroonenberg & Siers, 1998), in an interactive fashion. The design groups consisted of various types of agricultural stakeholders (including farmers, farming equipment suppliers, policy representatives, NGOs) to ensure the incorporation of practical and tacit knowledge, and prevent a research bias with respect to the values underlying the design.

To study the uptake of the results from the RIO design sessions, we build on the concept of anchoring, which was developed in the context of system innovation programmes (Loeber, 2003; Grin & Van Staveren, 2007). In a study of the uptake of radical energy novelties in glasshouse horticulture, the concept was defined more specifically as follows:

"*Anchoring is the process in which a novelty becomes newly connected, connected in a new way, or connected more firmly to a niche or a regime. The further the process of anchoring progresses, meaning that more new connections supporting the novelty develop, the larger the chances are that anchoring will eventually develop* into durable links." (Elzen et al., 2012a, p.3)

Building on a distinction between three constituent components of a regime, notably technical, network and institutional components (Geels, 2004), the authors distinguish three forms of anchoring. These are technological anchoring, network anchoring and institutional anchoring (Elzen et al., 2012a, p.4-6). *Technological anchoring* takes place when the technical characteristics of a novelty (e.g. new technical concepts) become defined by the actors involved and, hence, become more specific to them. *Network anchoring* means that the network of actors that support the novelty changes, e.g. by enrolling new producers, users or developers. *Institutional anchoring* relates to the institutional characteristics of the novelty, i.e. the new rules that govern its further development and uptake. Institutional anchoring implies

[1] In 2000, WLR had a different name (ID Lelystad) but for simplicity we use the name WLR for the whole period.

that developments within a niche or regime become translated into adapted or new rules that govern, at least temporarily, the activities of both niche and regime actors.

Elzen et al. (2012a) have described anchoring in rather general terms, providing evidence that the distinction of three forms of anchoring can help to understand how novelties are picked up in niches and regimes and can start a transformation process. The next step is to analyse in further detail how the dynamic of anchoring progresses. In this paper, we will analyse how the results of two RIO projects, one on broilers (chickens for meat) and one on pigs, were taken up and what we can learn from these on the dynamics of anchoring processes.

Concerning the research methodology, all authors have been involved to some extent in the projects described. Most of the empirical material is based on our own presence in various meetings and interactions with relevant actors. A secondary analysis of this material allowed us to give a detailed account of the anchoring of the core radical concepts in the two RIO cases. We use them in this paper (i) to illustrate and refine the concept of three forms of anchoring; (ii) to show the dynamic of these forms of anchoring; and (iii) to answer the question whether we can deliberately anticipate and stimulate anchoring.

Windstreek case

Introduction

The formal origin of the Windstreek henhouse can be traced back to a government funded RIO project that started in 2009. Farmer Robert Nijkamp (together with two other farmers) became involved in the second half of 2010, during the first round of interactive design sessions.

One of the authors of this paper (Bram Bos) was involved as project leader in 2010 and played an active role in the follow-up of the *Broilers with Taste*-project, after its end in 2011 (Janssen et al., 2011). The follow-up was spurred by a special policy instrument (*Small Business Innovation Research* or SBIR) used to elicit societally desired innovations from private enterprise by means of a tender, in which competition is firstly based on quality and business prospects, and only secondarily on price. Eventually, a consortium of five private parties around the concept of *Windstreek* was the big winner of the SBIR-tender “Sustainable barns in the landscape” that ran from 2011-2015. Helped by the considerable amount of financial support from SBIR (about 500k€), the consortium was able to further develop and establish the first pilot barn of Windstreek, at the Nijkamp farm.

The consortium consisted of a poultry slaughterhouse (Interchicken), a climate technology firm (Sommen), a landscape architectural bureau (Vista), farmer Nijkamp himself and Wageningen UR Livestock Research. Engineering MSc-student Hendrik Kemp was firmly associated. Later, Interchicken was substituted by the largest Dutch slaughterhouse Plukon after a takeover, while Vista was replaced by the bureau Circular Landscapes.

This led to the development of Windstreek, opened late 2015, a henhouse very unlike the traditional ones in the Netherlands. Its iconic, asymmetrical form (cf. Figure 1) is noticed from almost a kilometre away. Its 11 meter high transparent front on the north side can be opened across the full 95 meters of its length, both in the upper as well as the lower 2 meters. As a result, the animals live by the natural rhythm of day and night. The air inside is refreshed by natural ventilation. The very young chickens (that enter the barn as one-day old chickens or as eggs) are kept warm in a special isolated ‘mini-barn’ - the brooding hood - that captures their own warmth and can be heated additionally by PV powered infrared panels. The higher parts of Windstreek are used as living space, both on the ground, as well as on long stretching tables that can be reached via straw bales. Special mats under the brooding hoods can be used to remove the litter (with manure) from the barn, to prevent the emission of ammonia and fine dust. Trees on the outside, facing the high open front, capture part of the remaining fine dust before it is emitted to the environment. As a result, the Windstreek housing system is claimed to be very animal friendly, to have a very low energy consumption that can be renewably supplied by solar panels, and to have low emissions, while the working environment is healthier than in regular systems.

As the system differs in so many respects from traditional housing systems, and is under a much bigger influence from weather conditions, testing of these and other claims will take at least a year. The economic prospects of the system, and thus its ability to scale up to a larger number of barns without subsidies, still have to be established.

Figure 1 presents a timeline of the history of Windstreek since the start of Broilers with Taste in 2009. Below the timeline, the visual and technical evolution of three central concepts are depicted, notably the barn system as a whole, the concept of the brooding hood and the concept of regular litter removal.

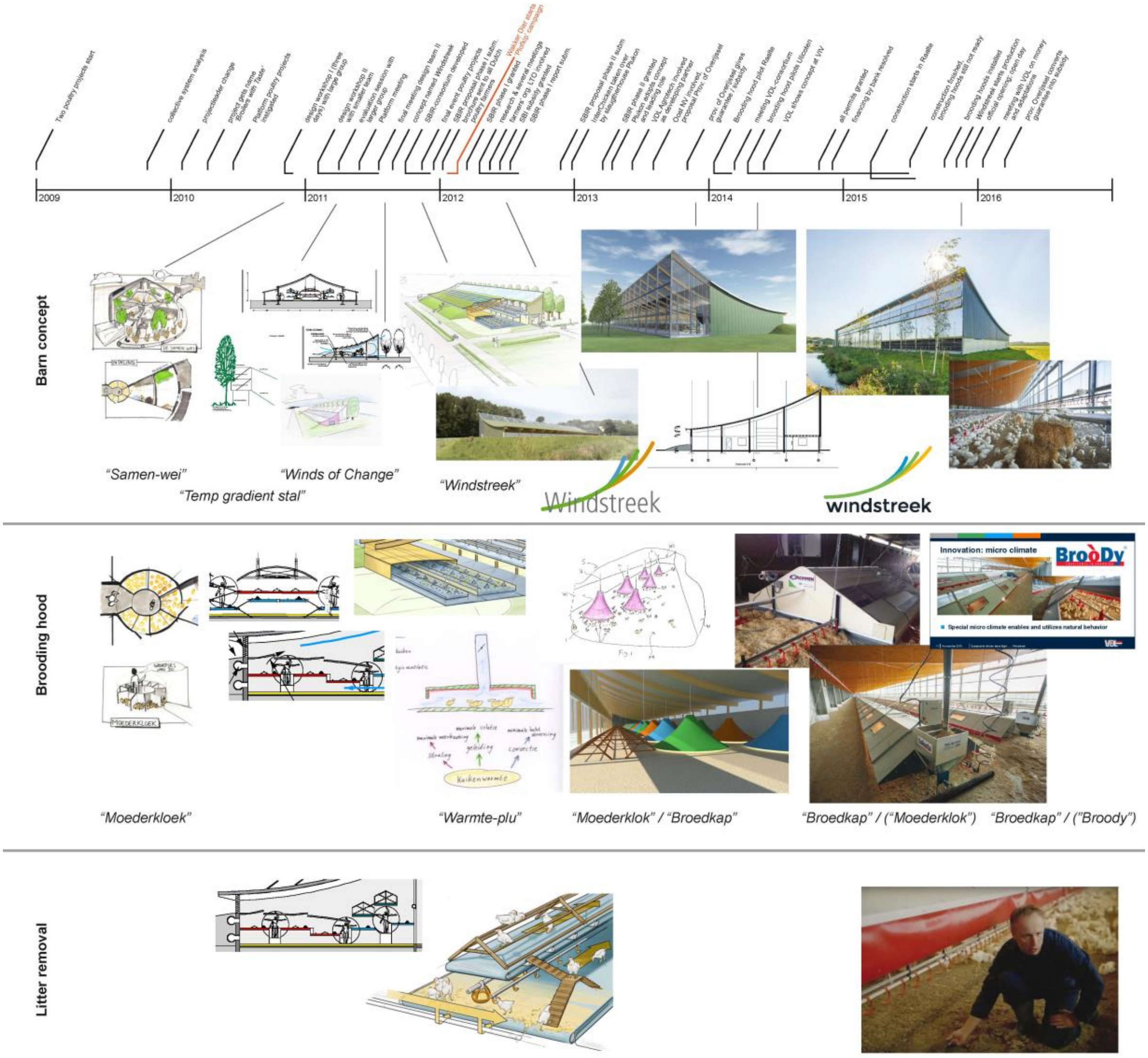

Figure 1. Timeline of Windstreek development for the overall concept and two 'partial innovations'

Anchoring of the Windstreek concept as a whole

As can be seen from Figure 1 (Barn concept), these features were already present in one of the designs (the 'Samen-wei') from the first interactive design session. During the second, extended design round, these ideas got different shapes, but were maintained as core elements. The use of the third dimension to enlarge the living area and the radical 'halving' of the architectural form and curving of the remaining slope were added. This curved slope was originally conceived as (technically) functional to natural ventilation, but appeared not to be critical to achieve this. But it was kept, even though it increased building costs, to become part of the Windstreek 'logo', and it was registered by the consortium as a trademark together with the name itself. Thus, although the technical reasons for the curved slope weakened, it became firmly anchored in the network for aesthetical reasons. This was the distinctive feature that made immediately clear to an outsider that this broiler barn was very different from any other in the country.

Landscape quality was an important provision under the SBIR-tender and a landscape architecture firm (Vista) developed the initial shape of a 'barn' into a concept that moulded with the landscape. This helped the local government to bypass institutional barriers (building aesthetics regulations) that initially prohibited both the height and form of Windstreek. These and other distinctive features helped to get Windstreek through the local and regional regulative systems. Early visuals by Vista from 2012 were not only used in the SBIR tender phase II, but also in an NGO publication on sustainable food.

The application of natural ventilation throughout the system became technologically anchored in the existing network via the involvement of a climate systems enterprise (by the name of Sommen), with whom Nijkamp had worked before. Contrary to many similar firms, their specific business model turned out to fit working with natural ventilation, since Sommen did not primarily depend on the sales of mechanical ventilation systems, but on the sales of computer systems and software for climate regulation in livestock production. Part of the SBIR-grant was used by Sommen to completely redesign its climate software.

Anchoring of the brooding hood

Enlarging the living space for broilers as they grow older was originally meant to decrease costs. This was combined with the concept of a 'mini-barn' to save energy and create a special climate for very young broiler chickens, as well as brooded eggs. Important institutional barriers were Dutch and EU-regulations that prohibited limiting the space per chicken, even very small ones. Thus, the 2011 Windstreek-concept, that featured a smaller inner barn for young chickens, faced an important hurdle that was unlikely to change.[2] It was one of the reasons that the concept of a mini-barn morphed into the brooding hood.

Regular broiler chickens live for approximately 42 days, while slower growing varieties in more animal-friendly market-concepts live two weeks longer. In the first two weeks of their life, broiler chickens cannot maintain their own body temperature. For this reason, traditional barns are heated during these weeks to a temperature of about 32-38 degrees celcius, which consumes much (fossil) energy in the Dutch climate. The mini-barn in the original Windstreek design of 2011 was intended to solve this, by reducing the volume to be heated.

In the first phase of SBIR tender (spring 2012), the technical people from the Windstreek consortium developed an alternative to this mini-barn: they calculated that the warmth emitted by a large group of very young broiler chickens might be enough to keep an insulated enclosure warm, provided ventilation is reduced a minimum. The concept was called "warmte-plu" (heat umbrella) and was developed further into a churchbell shaped device. On the basis of this it was renamed 'moederklok' (mother bell), a word play with 'moederkloek' (a broody hen in Dutch) and its churchbell form ('klok' in Dutch). Later it was renamed 'brooding hood'. In a subsequent visualisation by Vista, the whole Windstreek barn was equipped with over sixty bells with different bright colours, each to be used by about 500 young chickens. Since these brooding hoods hover 10-20 cm above the floor, the young chickens can move freely throughout the whole barn, thus circumventing EU and Dutch regulations. But chickens are

[2] Parallel to the first phase of the SBIR-tender, project leader BB was involved in a similar case of a farmer who invented an inflatable wall to decrease the volume of his traditional barn in the first weeks of a round to save on energy. This farmer approached BB after the publication of the brochure of Broilers with Taste that was sent to all poultry meat farmers in the Netherlands. After some backing and forthing with, among others, the Dutch Animal Protection Society (Dierenbescherming), it became clear that there was a short term view on institutional changes, that forbade this temporary decrease in living surface, despite the fact that there was evidently no animal welfare issue per se.

likely to stay underneath the warm hoods most of the time because it fits their thermal requirements and natural behaviour.

Shortly after the consortium won the second phase of the SBIR tender,[3] climate systems firm Sommen got in touch with VDL Agrotech, an industrial supplier of agricultural equipment, and part of one of the largest Dutch industrial conglomerates (VDL). Sommen saw a chance to enrol a partner that could develop and mass produce the brooding hood, a vital part of Windstreek that would be needed in considerable numbers. Furthermore, the director of Sommen saw an important general business opportunity to collaborate with VDL Agrotech.

The new partner was reluctantly welcomed by the consortium. Initial contacts suggested a lukewarm and sceptical reception of the brooding hood concept by VDL. Especially the non-manufacturing partners in the consortium (Nijkamp, WLR, Vista) feared that a distinctive feature of Windstreek, with the most commercial potential, would be gradually appropriated by an outside partner and sold to anyone, as the brooding hood would also be applicable in standard broiler barns. Without exclusivity, the upscaling potential of the Windstreek concept as a whole might be in danger. Partners Plukon and Sommen, however, stressed the inevitability: the consortium would not be able to develop the brooding hood by itself and, more importantly, lacked the capabilities needed to produce them in large numbers at an affordable price.

Sommen and VDL started a series of small scale pilot experiments with the brooding hood. First in Nijkamp's open cow barn during winter, later in a covered alley way between two poultry barns of a farmer near Sommen headquarters in Ulicoten. These pilots involved a few hundred chickens and hand-made constructions of metal and plastic. Both mechanical and natural ventilation were tested. Heating was supplied by a warm water heating device.

After a few months of experimenting, VDL Agrotech decided to prominently present the brooding hood, as well as Windstreek, at the VIV-fair 2014 in Utrecht, an annual fair for the global equipment industry for intensive livestock production. This again sparked the doubts of the non-manufacturing partners on concept ownership.

At this point in time, for ease of construction reasons, VDL played with the idea of connecting a number of brooding hoods to a large tunnel, but farmer Nijkamp objected to this. Furthermore, Sommen and VDL were about to conclude that, for control reasons, the brooding hood should be mechanically ventilated. Nijkamp opposed this vehemently, since he wanted a robust system that would be as independent as possible from fallible technology. Additionally, he wanted to experiment with infrared heating, instead of warm water heating, since this could be powered by solar panels which would save the costs of a separate gas connection to the new barn.

Infrared heating and natural ventilation were implemented reluctantly by Sommen and VDL in the subsequent pilot experiments. Both features reduced the controllability of the brooding hood with traditional sensors, and required new ways of thinking. As they proceeded, however, they became more and more convinced that these features were possible and an important characteristic of the brooding hood concept.

[3] *The first phase is a feasibility study; the second phase a pilot, proof of concept or full scale implementation, aiming to show the commercial relevance.*

While the construction of the Windstreek barn commenced in March 2015, pilot experiments in Ulicoten were still under way. VDL had a contract with Nijkamp to deliver and install *sixty* brooding hoods in Windstreek. When the construction of Windstreek was almost finished, VDL told Nijkamp that, for construction reasons, the sixty brooding hoods would be fused into six large tunnel-like brooding hoods. Since Nijkamp planned to start production in July 2015, he had no option but to agree. Production in Windstreek eventually started in November 2015.

Anchoring of the regular litter removal

The concept of regular litter removal (by means of belts) was a central idea from the start of the design process. Yet, the actual implementation in Windstreek has been half-hearted. An important reason seems to be that it is a solution for a problem that is not perceived to be urgent by anyone except the researchers of WLR and the former project leader: the emission of fine dust. Since Windstreek is naturally ventilated with large volumes of air, fine dust is not seen as a problem inside the barn, nor in the rural surroundings of the village of Raalte. Additionally, some partners believe emissions will be low *because* of the slow air velocities associated with natural ventilation. On this basis, expensive dust reducing belts were replaced by cheap composting mats. Attempts to get a machine for removing and cleaning these mats failed because of high costs and lack of motivation from third-party enterprises to innovate on this. Thus, the network anchoring of this concept was limited to WLR people only and it never took off.

The risk, however, is that emissions of fine dust may be higher than desired. This will pose institutional obstacles (regulations on fine dust emissions) that limit the applicability of the Windstreek concept elsewhere in the Netherlands. Moreover, since regular litter removal is also meant to limit the emission of ammonia, Windstreek also might not be able to comply with the regulations in this respect, especially if the barn were used with higher stocking densities.

Vair Varkenshuis case

In 2009, pig farmer Marijke Koenen joined a multi-day interactive design session that was part of a WLR-led RIO project by the name of Porc Opportunities. She fattened pigs on an outdated pig farm in the south of the Netherlands and wanted to renew her business. But she did not want to proceed with fattening pigs as she had done before as she was dissatisfied with the current production system and had been looking for alternatives for several years. Most important to her was to become an autonomous entrepreneur and disentangle from the straitjacket of production efficiency. She wanted to be proud of her farm again, and to be able to show the general public how she kept pigs without having to be afraid of disgust. As possible alternatives, she had looked into systems by the name of "ecological production" and "Canadian bedding", but in her view these limited the autonomy of the farmer too much.

By joining Porc Opportunities, Koenen hoped to find an alternative that would satisfy her objectives. She took part in a design workshop in which the participants designed new pig production systems on the basis of the requirements and functions that this production system should fulfil. By thinking in terms of requirements and functions, without directly jumping to solutions, the solution space was enlarged, so that problems in the current production system could be solved in new ways via radically different designs.

In Porc Opportunities there were several design sessions. In the first session only pig farmers and researchers participated. They worked together on three designs for radically new ways of keeping pigs. In the second design session, researchers only acted as facilitators. The actual design process was carried out by participating pig farmers, builders of housing systems, agricultural advisors and a municipal and a provincial policy maker. Another difference between the first and the second design session was that in the first session participants worked on generic designs, while the second design session put the needs of pig farmers in the centre of the design process. They designed their own potential future farm. To further stimulate the practice-orientation, the participants were informed of the possibility of participation in an SBIR tender with their new design to finance realisation of their plans. Here the foundation was laid for “Vair Varkenshuis” (meaning Fair Pig Home).

One of the core elements of Vair Varkenshuis is the ‘pig toilet’ that uses the rather clean excretory behaviour of the pigs to improve animal welfare, reduce ammonia emissions and raise the quality of manure. Following the second design session, not only Koenen started working with it, but also a national pig innovation centre, VIC-Sterksel, applied it in a pilot farm.

Her involvement in Porc Opportunities did not only provide Koenen with a draft design for her farm, but also with a small network of parties who were enthusiastic about various concepts that were embedded in the Vair Varkenshuis, and who were willing to join her in developing an SBIR proposal. She was joined by another pig farmer and three service suppliers/system builders.

On the basis of the promising results from the SBIR feasibility study, the consortium wrote a proposal for the second phase of SBIR (to build a pilot barn), which was granted. Supported by a 500k€ grant, a first pilot barn was built and several experiments were carried out. At the end of the SBIR trajectory this pilot barn was improved and expanded to finally form Vair Varkenshuis.

This was not a smooth process, however. Although all parties were eager to make it a success, they clearly had differing interests and objectives. Koenen’s ultimate aim was to create a new market concept for pork while the service suppliers/system builders were only interested in the technical aspects. This resulted in several discussions on what to put on the agenda and how to spend the SBIR grant. This resulted in a process of continuous negotiation within the network to specify the various technological details.

The SBIR grant was an important resource to make this process possible. The provisions of the grant determined to a considerable extent what could happen, in terms of content as well as in terms of the network. On content, SBIR specified that the concept should be integrally sustainable, i.e. combine several sustainability aspects. Furthermore, the concept should be scalable and have a good market perspective. On the network, SBIR provided specifications for the participating consortium. To be eligible the consortium should consist (at the very least) of farmers and service suppliers/system builders. SBIR ensured a certain commitment and continuity by not only providing money, but also a ‘project’ infrastructure with outsiders monitoring the process and the outcomes. Without SBIR, the network would possibly have split up at an earlier moment in time.

Thus SBIR also offered a degree of robustness. For Koenen this meant that the SBIR trajectory gained a rather technological focus. The system builders focused on perfecting the technical features and developing them in such a way that pig farmers could implement them in their existing barn. Although this was not very successful in the end, it meant that there was very little attention paid to the marketing and communication aspects of Vair Varkenshuis.

Thus Koenen had to work on these aspects separately from the SBIR consortium and largely after the realisation of the barn.

In terms of anchoring, due to the provisions of SBIR and the objectives of the majority of the consortium, there was a focus on technological anchoring. By contrast institutional anchoring (economic, but also influencing and connected to world views/problem definitions of other farmers or consumers) received minimal attention.

To pay attention to these aspects as well, Koenen teamed up with a marketer, who supported her in building the story of Vair for the consumer. Furthermore, she involved product developers and advisors to work on the meat products and worked on developing sales channels. She first entered into a dialogue with supermarkets, but when they refused to satisfy her requirements, i.e. give compensation for improved sustainable production, she turned towards a combination of house selling, internet marketing, market sales and other regional marketing solutions.

Although Koenen reached her goal - she created a radically different pig farm that provided her with autonomy and pride - anchoring to prelude upscaling is ongoing and continuing along two routes. Firstly, Koenen is constantly trying to find new ways to consolidate what she obtained and pursue new opportunities. She started her own crowdfunding initiative (*institutional and network anchoring*), continues to explore new sales channels (*institutional anchoring*) and tries to encourage colleague pig farmers to adopt Vair Varkenshuis (*network, technological and institutional anchoring*). Secondly, other innovation trajectories have started: system builders try to sell the technology they developed in the SBIR trajectory, various farmers appear to be inspired by the technological features of Vair Varkenshuis, and various stakeholders see potential in the way product development and marketing of Vair is being shaped.

Concerning upscaling, several pig farmers built a variation of the farrowing pen from Vair Varkenshuis, and various pig farmers started to consider adopting the pig toilet or other elements of Vair Varkenshuis. This offers an interesting dilemma from the perspective of system innovation. Adoption of a sustainable farrowing pen, without changes in the rest of the production system, could enable farmers to satisfy important sustainability conditions imposed by the market and public society. With this (relatively easy) modification they might realise more sustainable production circumstances, but at the same time they would hold back from a more radical shift towards sustainable pig production, as is realised in Vair Varkenshuis. This is different for the pig toilet that can be considered an integrally sustainable partial innovation, by offering advantages for animal welfare, reducing emissions of ammonia and odour, and improving manure quality.

Conclusion

In this paper we used the three forms of anchoring distinguished by Elzen et al. (2012a), i.e. technological anchoring, network anchoring and institutional anchoring. Our main interest is to shed more light on the dynamic of these anchoring processes as a stepping stone towards understanding the linking between niches and regimes (Smith, 2007) or, in terms of the theme for this workshop, the upscaling of the application of novelties.

It appears that the various forms of anchoring do not neatly follow one another in a specific order but show a process of continuous leapfrogging. Moreover, two or three or these may be occurring at the same time and become visible depending on the perspective taken. For technological anchoring, the reasoning starts from the perspective of an actor or a network. Technological anchoring takes place when a radical concept (which can either be a rather abstract technological concept or a concrete material manifestation of a concept) takes on meaning as something they support (as user, maker, or outsider). When we reason from the perspective of the technology, however, network anchoring takes place, i.e. the network of actors for whom the technology becomes meaningful grows.

Does this mean, then, that all forms of anchoring are really describing the same process? This is certainly not the case if we acknowledge that technological anchoring is not just a quantitative phenomenon (i.e. more or less, or weaker or stronger technological anchoring) but also has qualitative characteristics. In both cases, technological anchoring started on the basis of a rather abstract concept of a novelty. Gradually, the concept became more specific without changes in the network (e.g. in a design meeting). We see this as an important characteristic of technological anchoring which we call the *specification of the technology*. It describes a process in which anchoring progresses by way of certain technological characteristics becoming seen as an essential aspect of the novelty while this specification is shared among the actors in the network.

Our cases suggest that this process of specification has the effect that anchoring becomes more robust. In our cases, both of which started as a design process, initial anchoring took place on the basis of rather abstract concepts. In this phase, the networks related to it frequently changed composition, showing that anchoring was not very robust. With the further specification of the technology, however, for the actors that remained part of the network their links with the more specific technology appeared to be stronger than with the initial more abstract concept. This process is clearly recognisable in connection with the "brooding hood" but also with the "pig toilet".

Concerning institutional anchoring, the cases show two opposing processes. One is that the technology was modified to fit existing institutions. When the 'mini barn' appeared not to fit national and EU regulations, this concept was modified to eventually become the "brooding hood" that enabled the 'bypassing' of these regulations. The alternative process was that existing institutions are modified or 'bent' to fit the new technology. An example is the bypass of local building aesthetics regulations to allow the construction of the curved shape of the Windstreek. Other examples can be found in the cases for both processes.

From the very beginning, the RIO projects had the ambition to radically change the current animal husbandry system in the Netherlands, i.e. to contribute to a system innovation or a sustainability transition. In both cases, this was quite successful at the local scale, i.e. the development of a first production farm with far better sustainability performance on a range of issues. Whether this marks the beginning of a wider change to the sector, however, remains to be seen.

One striking phenomenon in both cases is that there were repeated attempts to downgrade the ambition to better fit the existing system, i.e. to realise institutional anchoring by adapting the technology to existing institutions. Even if these were not successful eventually for the pilot barns, they may well be successful in terms of the uptake of various 'partial innovations' in conventional husbandry systems. The interest in doing so is already emerging in connection with the "brooding hood" and the "pig toilet". This would increase the sustainability performance of such conventional systems somewhat but the ‘integrally sustainable’ ambition from the initial RIO project would be lost.

This raises the question of how such a high ambition can be upheld against the forces to downgrade the ambition. Key to this is to understand in further detail the issue raised before, i.e. how institutional anchoring is shaped: by adapting technology to the existing institutions or by adapting the existing institutions to the emerging technology. To answer that question is beyond the scope of the present paper and will have to be the topic of further research.

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Practical lessons for successful long-term cropping systems experiments

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Abstract: Many lessons in long-term cropping systems experiments are learned from practical experience. The senior author has conducted large-scale, long-term, multidisciplinary dryland and irrigated cropping systems experiments with numerous colleagues (mostly with the coauthors of this paper) at university and government research stations and in farmers' fields in the United States and in developing countries for 30 years. Stakeholder input is critically important for designing these experiments. Several practical lessons learned through the years are outlined in this conference proceedings paper. While some of these lessons learned may be intrinsically obvious, results of many cropping systems experiments have not been published in scientific journals due to fatal flaws in experimental design, improper transitioning between phases of the experiment, and many other reasons. Ongoing active support by stakeholders is critical to maintain funding for long-term cropping systems studies. Problems and unexpected challenges will occur, but scientists can often parlay these into opportunities for discovery and testing of new hypotheses. Better understanding and advancement of stable, profitable, and sustainable cropping systems will be critical for feeding the world's projected 10 billion people by the mid 21st century.

Key words: Long-term cropping systems experiments, crop rotations, world food needs, adoption of new systems by farmers

Introduction

Long-term cropping systems experiments are widely recognised as an ideal mechanism to encourage scientists of different academic disciplines to work towards a common goal (Johnston, 1997). There is a wealth of information on long-term cropping systems experiments related to agronomy, sustainability, environmental concerns, weeds and diseases, soil quality, fertility, economics, and other factors (Peterson et al., 1993; Tanaka et al., 2002). There is also a vast quantity of information in the scientific literature and in textbooks on how to design and interpret data from long-term experiments. However, the "practical" and "everyday" aspects of successful long-term cropping systems endeavors have received much less attention.

The senior author has spent the majority of his professional career as a cropping systems research agronomist in developing countries and in the Pacific Northwest region of the United States. The junior authors have collaborated widely in these experiments. There are some basic principles or "lessons learned" from this experience with successful long-term cropping systems experiments that have not been adequately emphasised in the scientific literature and in university classrooms. The principles outlined below apply across diverse cultures and environments, whether: (i) average farm size is 0.2 or 2000 hectares, (ii) implements are pulled by bullocks or 450 hp tractors, or (iii) grain is threshed by hand or with a fleet of modern combines.

Lessons learned

1. Form a farmer advisory group of progressive individuals who have a strong vested interest in the research. Allow farmers an active role in designing crop rotation treatments. When farmers feel ownership in a project they will likely remain strong supporters throughout the life of the project (Lawrence et al., 2007)
2. Set term limits for farmer advisors (e.g., 3 to 6 years). Some advisors will make numerous valuable contributions and maintain a high level of interest whereas others will not. The most valuable advisors will likely agree to serve an additional term. Term limits provide a diplomatic means to end the service of the less energetic advisors and open opportunities for new members.
3. Your collaborating scientists will largely determine the success of the study. Put a great deal of thought into what academic disciplines will best contribute to the cropping systems team. Look closely at the publication record of experienced scientists. If an individual has an excellent track record, they will likely continue to publish regularly. Certainly seek out and mentor enthusiastic new-career scientists and encourage their participation.
4. Involve a statistician from the very first to ensure that the experimental design is valid and the most appropriate for the study (Cady, 1991).
5. Plan to conduct the cropping system experiment for at least six years or through two complete cycles of the crop rotations. Each crop in all rotations must appear each year for valid statistical analysis.
6. Ideally, systems experiments should have a staggered start to account for temporal entry into the rotation, but this is seldom imposed because it is not practical.
7. For valid statistical interpretation of results, all crop rotation treatment combinations must have a common year denominator. For example, if you have 2-year, 3-year, and 4-year crop rotations, the experiment needs to be conducted for 12 years.
8. Obtain and archive baseline soil samples at the beginning of the experiment so that changes over time in carbon, microbial activity, and other soil quality indicators can be documented.
9. If possible, conduct long-term experiments at a university or government research station where land and facilities are guaranteed to be available (Drinkwater, 2002). Mistakes are less likely to occur at a research station than in a cooperating farmer's field. Labour and equipment resources are most efficiently utilised when travel and equipment hauling is kept to a minimum. It generally costs much less to conduct a cropping systems experiment at a research station than in a farmer's field. In addition, personnel at research stations are available to check the experiment daily, if needed.
10. If the long-term experiments are located on farmers' fields, do not expect cooperating farmers to use and operate their own equipment to conduct field operations (e.g., planting, harvesting, herbicide application). This may be feasible for the first few years when the experiment is new and novel, but the farmers need to manage their own field operations during the same time period and the experiment will likely not receive high priority. Plan to provide your own personnel and preferably your own equipment to ensure that field operations are conducted in a timely manner.

11. Become a trusted friend of your cooperating farmer. Do not become a burden. Pay an annual rental fee for the land. List the cooperating farmer as a coauthor on all popular and extension publications from the experiment.
12. Consider purchase or fabrication of smaller customised implements, such as no-till drills to facilitate transport of equipment to and from sites and to reduce tractor size requirements.
13. Equipment may need to be customised for cropping systems experiments. For example, many cropping systems experiments involve conservation-till or no-till management. A small-plot combine is accurate for grain yield determination, but most machines lack proper chaff and residue spreading capability. Residue and chaff spreaders can be fabricated for small-plot combines (Schillinger et al., 2008).
14. Many cropping systems experiments do not contain enough treatments and/or replicates to provide adequate degrees of freedom for error to statistically detect treatment differences (Gomez & Gomez, 1984). Try to maximise the degrees of freedom for error. Remember that degrees of freedom for error is based on the number of treatments and replications.
15. When field operations or data collection cannot be completed in one day, always stop work for the day at the end of a replicate. This ensures that all treatments within a replicate are exposed to the same environmental factors (e.g., rain, heat, shattering) that may occur from one day to the next.
16. Funding for long-term cropping systems research is often difficult to obtain (and maintain) because answers cannot be obtained within the typical 3-year grant cycle (Soane & Ball, 1998). Even modest set-aside funds from the university experiment station (e.g., Hatch funds) or other sources can go a long way in sustaining long-term experiments.
17. Long-term cropping systems experiments provide critically important data on soil quality (Blanco-Canqui et al., 2011), soil biology (Kirkegaard et al., 2008), carbon sequestration (Wienhold et al., 2016), nitrous oxide emissions (DeAngelo et al., 2006), nutrient cycling (Ritcher et al., 2007), and weed ecology (Anderson, 2004). Such information is of interest to a worldwide audience.
18. If feasible, include a production economist on the team as economic returns of cropping systems are of foremost concern to farmers (Young et al., 1994).
19. Be open to new ideas and view problems and surprises as potential opportunities. As an example, Rhizoctonia bare patch (*Rhizoctonia solani* AG-8) appeared in year three of a long-term no-till dryland cropping systems experiment in eastern Washington. The fungal root pathogen stunted all cereal and broadleaf crops in the experiment. Rhizoctonia bare patch at these high levels had not previously been encountered in the United States. Scientists decided to map the distribution of bare patches from year to year with a backpack-mounted global positioning system. The severe expression of Rhizoctonia bare patch was unexpected, but led to a unique opportunity to publish journal articles about the epidemiology of this pathogen under long-term no-till management (Cook et al., 2002).
20. Although scientists need to "lock in" and stay with the crops and crop rotations throughout each phase of the long-term experiment, there is often opportunity to superimpose new experiments, especially with wide plots. If plots are narrow to begin with, options for future additional treatments are limited. Long-term cropping systems experiments continually generate new hypotheses to be tested. Embedding sub-experiments within a long-term study can be a good way to obtain grant funding to support the long-term effort without comprising the integrity of the treatments already in place.

21. Hold field days at your research site. Scientists, graduate students, farmers, and others involved in the experiment will welcome the opportunity to share their data, expertise, and insights. Hands-on demonstrations, such as soil quality changes with different management practices, are popular and can carry an excellent take-home message. For field days at off-station cropping systems research sites, always feature the cooperating farmers as key speakers as they will have important insights into what does and does not work on their farms.
22. Publish results in peer-reviewed journals at regular intervals. Decide beforehand which scientist(s) will take the lead on articles and the time frame for when the articles will be written.
23. Do not stop with the publication of your research in a scientific journal article. Publish your research as an Extension Bulletin, Extension Video, or other popular format. Convert units of measurement to those used by farmers. For example, farmers in the US use English, not metric, units. Delete unneeded verbiage (e.g., scientific names for plants and herbicides), and include interesting and relevant photos. Remember that you must obtain permission from the scientific journal in which the research was published before making the information available to stakeholders in an alternative format. We have never been refused permission by a journal to make information available in an alternative format for stakeholders. Many universities and government agencies have extension publication units that publish Extension Bulletins at no cost to the authors.

Conclusions

Following basic common-sense principles will help scientists achieve success in long-term cropping system experiments. As a research agronomist, the senior author has collaborated most closely with a soil microbiologist, production economist, plant pathologist, and soil scientists in cropping systems research endeavors. The specialty areas of scientists needed to address key issues will, of course, vary depending on the experiment. A major goal of the United Nations and other organisations is wide spread adoption of conservation agriculture (Hobbs, 2007). To achieve this goal, more long-term systems experiments need to be conducted throughout the world. Long-term experiments provide the best and foremost scientific information for understanding the sustainability and stability of cropping systems and for successful adoption of tested systems by farmers.

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Upscaling of more sustainable cropping systems: a framework to analyse and support intermediation processes

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Abstract: The Ecophyto Plan 1 was devised to achieve a 50% decrease of pesticide use in France between 2008 and 2018. Based on available agronomic knowledge, collective expertise showed that reaching such a target at farm level implied in-depth redesigning of the current cropping systems. The DEPHY Network is one of the main policy instruments to support such a redesign process and to contribute to inviting more and more farmers to take up this challenge. To analyse the ways in which intermediation is organised in this network, we developed a framework which we also applied to two farmer-led networks that support farmers in redesigning their cropping systems and that seek to increase farmers' participation in such processes. Grounded in former studies on transition pathways at farm level and in participatory design processes in work system design projects, or in open source communities, our framework distinguishes three levels (strategic, experiential and collaborative) to analyse the organisation of intermediation. We apply it to the DEPHY Network and then point out the differences that we identify between the 3 networks analysed. Based on this, we make recommendations about the way each level should be addressed in order to support on-farm redesign processes in a large and inclusive network. We finally conclude by highlighting the limits of our framework and the need to test our recommendations.

Key words: Intermediary objects, pesticide reduction, sustainable agriculture, cropping systems, participatory redesign, peripheral participation.

Introduction

Since the year 2000, various expert reports in France (CPP, 2002; Momas et al., 2004; ESCo Pesticides, 2005) have pointed out the noxious effects of pesticides on workers' health and on the environment. In 2006 a European Directive[1] invited all the EU Member States to draft National Action Plans for a sustainable use of pesticides. In France the "Ecophyto 2018" plan was launched in 2009. It targeted a 50% decrease of pesticide use "if possible" within 10 years (starting point 2008). The first phase, the Ecophyto 1 Plan (2009-2015), was led by the French Ministry of Agriculture. It was funded by the "tax on indirect pollution" paid mainly by farmers[2]. The plan was divided into 9 themes[3] and 114 actions. During the 2009-2014 period, it cost M€361, of which M€194 came directly from taxes (Potier, 2014).

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[1] *The final Directive (2009/128/CE), along with the (CE) n° 1107/2009 regulation, the Directive 2009/127/CE, and the (CE) n°1185/2009 regulation, are together called the "pesticide package", adopted in 2009.*

[2] *Pesticides sellers and State programs also contributed to the funding of the Plan*

[3] *The 9th theme only appeared in 2011, to address workers' health issues.*

The objective was ambitious, as the Ecophyto R&D expert report pointed out (Butault et al., 2010). The experts noted that such a reduction in pesticides would require in-depth redesign[4] of cropping systems, and would certainly reduce the total amount of agricultural production. This objective was nevertheless supported by environmental and citizen associations and by networks of farmers who had already developed new practices contributing to limited use of pesticides (Organic Farming associations, Sustainable and Autonomous Farming Network, among others). Representatives of the incumbent players argued however that such an objective would not be achievable and would make French Agriculture less competitive. Many controversies erupted on the targeted reduction, on the best practices to significantly decrease the use of pesticides, and even on the way to promote large-scale adoption of such practices.

While some experts pointed out that this redesigning would require changes to the supply chains, to the input providers' strategies and in the advisory work, such shifts were hardly taken into account in the Ecophyto Plan which mainly targeted changes at farm level. In fact, the DEPHY network was one of the major thrusts of the Plan in terms of ambition (190 groups of about 10 farmers to be involved in a national network, each group being supported by an advisor working half-time) and of funds allocated (around M€18 per year). A mid-term evaluation of the Ecophyto Plan pointed out poor achievement in terms of reduction of pesticide use at national level since 2008. A second plan, the Ecophyto Plan 2 (2015-2025), was launched in 2015 under the aegis of both the Ministry of Agriculture and the Ministry of Ecology. This plan still targets the farmers: the network is supposed to involve 3000 farmers and a new goal is agreed for the Plan: it will be accountable for supporting upscaling of the best practices from the DEPHY farms to 30,000 farmers.

It is difficult to know the extent to which the lack of achievement of the first Plan should be attributed to a lack of consideration of systemic barriers. In this paper we chose to pay attention to another issue: how intermediation is organised in the Dephy Network. Various studies (Coquil, 2014; Chantre et al., 2015) have shown that transition pathways at farm level imply in-depth change in farmers' jobs and activity. How is such transformation supported within the network? How is the network organised to support up-scaling processes and such transformation outside of itself? More precisely, how does it support in-depth redesign of cropping systems and create opportunities for large-scale involvement of farmers in such a redesign process? To examine these questions, we developed a specific framework which we present in the next section. We apply it to the Dephy Network and briefly point out the differences that we found between this network and two other farmer-led networks, in the way up-scaling processes are organised. We then discuss its limits and the ways in which it can usefully support intermediation work in transitions towards a more sustainable agriculture.

A framework for analysing intermediation in sustainability transitions

Approaches to and studies of up-scaling processes have often considered them as a dissemination and adoption process (e.g. Rogers, 1983). They have tended to focus mainly on the attributes of the technologies and adopters that determine adoption likelihood. Adoption thinking also pays attention to social networks and increasingly looks at how the configuration

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[4] Hill & Mac Rae (1995) distinguish different strategies to change farming practices: efficiency, substitution of inputs, and redesign. In addition, some farmers adopt an efficiency or a substitution strategy, we chose to focus on the network which claimed to support redesign processes.

of social networks influences adoption behaviour (Compagnone, 2014). In contrast, innovation system scholars[5] working on sustainability transitions propose a more systemic approach and point out technological and organisational lock-in and/or system failures within a socio-technical system. Such approaches give a "big picture" of the processes that take place and suggest some relevant levers for policy makers. They often take as a starting point a new technology. They do not really consider the process by which the technology and its use in practice are co-developed at farm level (Béguin & Cerf, 2004; Klerkx et al., 2010; Béguin et al., 2012), but the reduction of pesticide use is rather a withdrawal of a technology. The cropping system redesign does not necessarily rest on new technologies. It rather rests on new insights on the ecological processes and on developing new practices in order to cope with their unpredictability and with the complex dynamics within the cropping system.

Nevertheless, these studies emphasise the role of brokers or intermediation workers (Klerkx & Leeuwis, 2009) who create new links between a network of players and technological artefacts in order to stabilise a technological niche and to support scaling up and out processes (Hermans et al., 2013) or anchoring processes (Elzen et al., 2012). Following Meyer and Kearnes (2013), we consider that intermediation is a specific type of practice in processes of change. Intermediation not only creates links to overcome systemic barriers or to develop anchoring processes, it also contributes to shaping understandings, new practices and new interaction rules among participants involved in a process of change (Steyeart et al., 2007). We therefore chose to understand the ways in which intermediation is organised to support: (i) the co-evolution of the designed cropping systems and of the activity required to manage them; and (ii) the participation of more and more farmers or other stakeholders (experts and knowledge providers, farm implement manufacturers, input providers, supply chain actors, policy makers, researchers, etc.) in the design process[6] in which farmers re-create both the technology and their work activity. But how can we identify the key conditions to be created?

To answer this question, we built a framework which is grounded on existing results on intermediation found in work systems redesign studies (Barcellini et al., 2014) and in studies on participative and collective design in Online Epistemic Communities[7] (Detienne et al., 2012). According to these results we considered that intermediation means: (i) to identify or create a space in which discussions can take place among various stakeholders (where *who* is invited to join the discussion is key!), whether about the transformation intention or the data needed to analyse the work situations (farming systems) to be transformed; (ii) to support the test of innovative farming practices (implementation and analysis) in order to support the co-evolution of the artefact (the cropping system) and the farmers' activity; and (iii) to support the emergence of specific socio-cognitive roles that contribute to discussions about design and use of new cropping systems, and to proposals for rules and mechanisms that can create peripheral participation in a constantly on-going design process.

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[5] Innovation systems studies is a research field grounded in STS and evolutionary economics. The multi-level perspective is a heuristic framework focusing on the interplay of niches, regime, and landscape in a transition process (see Geels & Schot, 2010 for details).

[6] The latter point has however not been adequately documented in our analysis and further data need to be collected in order to fully identify the way these players are interested or enrolled to support the shift in farming practices.

[7] E.g. communities involved in producing an Open Source Software or an encyclopaedic article, for instance in Wikipedia.

In our framework we therefore considered three intertwined levels of intermediation in the up-scaling process: a strategic one which is meant to grasp the way the transformative intention is set and discussed over time; an experiential one that addresses the way work activity is represented and supported so that farmers can participate in tests and simulation loops; and an interactive one that specifies the rules and roles which are at work to create inclusiveness and participation of various stakeholders in the design process. We now describe how we chose to acknowledge each level:

1. **Strategic level:** we identified the transformative intention which serves as a seed to the building of the network, and analysed how discussions are organised around it (Who takes part in it? Where does it take place? What makes it change over time?).

2. **Collaborative level**: we focused on the roles and rules that are built during the up-scaling process or created from scratch within the network in order to perform this process. We also paid attention to the way the collective production (whether it be knowledge or cropping systems) is capitalised on by participants, and to the way peripheral participation (inclusion of newcomers) is organised.

3. **Experiential level:** we paid attention to the way intermediation supports relations between design and use in the up-scaling process through the development of intermediary objects or tools (Vinck, 1999). We also identified the discussion spaces that were created to support design-use exchanges. More specifically, we analysed the way scientific knowledge and farmers' experience were translated and shaped in order to support the co-evolution of both the designed cropping systems and ways of managing them. We also identified the way intermediary objects took on board a given representation of farmers' activity**.**

We applied this framework to various networks to identify how they differ in their way of supporting the up-scaling process while also supporting in-depth redesign of cropping systems that contribute to reducing pesticide use. Box 1 below gives a quick overview of the three networks. We develop a full analysis only of the DEPHY Ecophyto Network, but then point out the differences we found between the three different networks.

Box 1. Three different networks supporting the redesign of cropping systems

The Dephy Ecophyto Network was initiated in 2010 and gradually (from 2010 to 2012) came to involve 190 groups of about 10 farmers. The initiator was the Ministry of Agriculture. The Network was devised as a new policy instrument to support farmers in redesigning their cropping systems in order to reach a 50% reduction of pesticide use. A common indicator, the frequency treatment indicator (FTI) was defined to measure the reduction. The organisation of the network was created from scratch. More details can be found in the next section.

The BASE Network was initiated by a farmer who encouraged other farmers to explore farming practices with a view to restoring and enhancing biological dynamics in the soil (no tillage, direct sowing and conservation agriculture). The network was initiated in the 1990's and now involves about 2000 farmers. It is a loose organisation which holds an annual assembly of the participants. A core team proposes some training sessions and expertise for the participants and supports a journal (TCS) and a website (Agricool). Local associations (farmer groups) can emerge but this is not encouraged by the core team even though it does not reject such associations. The reduction of pesticide use is controversial both within the network and outside (opponents are mainly other farmers or agronomists) as no tillage and direct sowing practices are often related to intensive use of glyphosate. The pros and cons of this are discussed mainly in the journal or on the website but also at local levels. Since 2006, participants have been invited to seek practices (mechanical destruction, covering crops, etc.) that target both the enhancement of soil biological dynamics and the reduction of pesticide use.

The RAD-CIVAM Network is part of a national organisation that coordinates local associations of farmers who explore new farming systems mainly oriented towards a high level of decisional and technical autonomy (from input sellers and supply chain buyers). Each local association is supported by a facilitator and has to find its own financial support. Local groups as well as R&D projects can contribute to the funding of the national coordination. Originally the main driver for designing new farming systems was the quest for autonomy and economic efficiency but since 1994 attention was paid to pesticide use. In 2006, they address a document to the Ministry of Agriculture in which farmers stated their experiences in reducing pesticides use. The network was invited to take part to the round tables organised on the issue of pesticide reduction during the Grenelle de l'Environnement. In the follow-up to this involvement, the RAD-CIVAM chose to design cropping systems that could also meet certain environmental challenges (e.g. less use of pesticides and nitrogen, sustaining of functional biodiversity through landscape infrastructures). They chose to put this to discussion in two different arenas: within farmers' groups that were connected through a dedicated government-funded R&D project; and within the Ministry of Agriculture with the policy makers in charge of the agrienvironmental measures (AEM) and more specifically of the ones called AEM "system". The starting point was the establishment of a list of requirements drawn up by farmers and their group facilitators during the R&D project. Facilitation tools were also developed during this phase and used later by other facilitators within the DEPHY Network. The RAD-CIVAM encouraged some farmers' groups to participate in the latter network with the intention to upscale their own way of coping with the reduction of pesticide use. The RAD-CIVAM also proposed a new AEM "system"" which it viewed as a way to support farmers in developing less input-dependant and more environment-friendly cropping systems.

Intermediation to support up-scaling processes in the DEPHY Network

The DEPHY Network has three main arenas in which the transformative intention is discussed: the national strategic committee in which representatives of various farmers' associations, co-operatives, advisory and R&D organisations are invited to participate, along with representatives of the State and research organisations or environmental associations; the

National Core Team (NCT) which defines the procedures (roles and rules, intermediary objects) to be developed within the network; and a third arena with looser boundaries, the farmers' group at local level which can develop interactions with other local farmers and stakeholders.

The collaboration is driven at national level. In 2010 a classical call for projects was launched. Applicants (farmer groups and their facilitators) were required to fill out an application form in which details about the current cropping systems, the levers to reduce pesticides use and the targeted systems had to be described. A scientific committee composed of experts designated by the Ministry of Agriculture assessed the proposals. After that, the strategic committee decided which groups to support financially[8].

Each farmer group then entered into a contract with the national board and had to commit: (i) to developing the testing phase (i.e. putting the proposal into practice), (ii) to feeding the national database, and (iii) to opening their farms to show their results. Such contracts were under the responsibility of the national core team which was also responsible for developing procedures, tools and knowledge to feed the network, to collect and analyse data, and to report annually to the Ministry of Agriculture and the strategic committee about the way the network intended to meet its target (Ecophyto 1: 50% reduction of pesticide use in 2018; Ecophyto 2: 50% reduction of pesticide use and reaching 30,000 farmers in 2025). In 2016 new contracts are being negotiated with the groups already involved and newcomers are invited to submit their proposals following a new call (to expand the network from 2000 to 3000 farmers). From scratch, in 2010, specific roles were assigned to the group facilitators (NE) within the network: they have to support the design-implementation process in their group, to collect data to feed the data base, to communicate on the SCEP, and to organise farm visits. To this end they have a 50% part-time job paid through a contract between their employer and the NCT. After two years a specific role has emerged called territorial engineer (TE). Some NE and some of the NCT experts have become TE. All have a part-time contract between their employer and the NCT. Their role is to support the NE in facilitating design and implementation processes in their groups, and to check and aggregate the data collected in each group in order to feed the data base. They also discuss with the NCT how to analyse the data and, more generally, they discuss the shape and content of the mediation tools.

Five main tools are currently operational in the network and give some consistency to the experiential level of intermediation. Two of these are primarily dedicated to group facilitators (called network engineers NE) in order to support their interaction with farmer groups for designing and implementing new cropping systems: (i) the "STEPHY guide" which proposes a procedure to diagnose the current cropping system and to support its redesign in order to achieve a certain reduction of pesticide use; and (ii) the "Ishikawa graph" which enables a farmer to visualise the main levers to be activated for each crop in order to reach the target. Three other tools support interaction among all the participants within the network and with other audiences outside:

- A 4-page leaflet which is meant to disseminate information on "SCEP" (SCEP is an abbreviation for a cropping system which is seen as a good example for a 50%

[8] It combines scientific evaluation criteria and other criteria such as the types of cropping systems, in order to cover the diversity of criteria or the types of advisory organisations involved in supporting the farmers.

reduction of pesticide use). Such SCEP are sorted out statistically from the various cropping systems designed and implemented by farmers within the network. The expertise of NE can also be used to point out which cropping systems they consider to be a SCEP;

- On-farm visits that NE have to organise to present what was achieved in the farm network, especially to farmers who are not yet engaged in reducing pesticide use;
- A national database on cropping systems tested in the network (data on crop sequence and crop management of each crop) can include data from experiments conducted on experimental plots or farms. Data are collected on-farm with a shared protocol and are accumulated in the data base. Statistical analysis is applied to identify the SCEPs. The database can also be used for research purposes.

Discussion: what lessons can be drawn?

As the scope of this paper does not allow us to make an in-depth comparison between the three networks that we studied, we would like here to point out some differences that the framework enables us to highlight. In doing so, we will also make some recommendations about the way intermediation can be organised to support redesign of cropping systems in order to reduce pesticide use, with an increasing number of farmers involved in the process.

We first wish to acknowledge that the intermediation work is differently shaped in the networks. The DEPHY network was developed as a policy instrument to encourage farmers to commit to the Ecophyto Plan, and intermediation work is covered by massive public funding. The other two networks are made up of farmers who are willing to change their cropping systems according to a transformative intention they all share, and who have to seek funds in order to support the intermediation work. But such differences should not play down other issues that our framework enables us to point out.

The first issue is about the way the transformative intention is settled and the way discussions are organised around it. ***We suggest that volunteer farmers' participation can be increased if they share a common motive to change rather than just a quantified target to reach***. Targeting only the reduction of pesticide use does not clearly identify the motive for which a redesign of the cropping system is required (pesticides are only a means within a cropping system). Such motives are much clearer in the other two networks, and discussions within these networks are not about the transformative intention as such but about the means to achieve it. In the DEPHY network many discussions are about the target as such. For example, the NCT is an operational team but the experts who take part in it sometimes endorsed institutional positions[9] to discuss the legitimacy of the target while their role was to discuss the available means to reach it. At local level, the target was discussed less from an institutional point of view than in relation to the room to manoeuvre that existed at farm or

[9] The core team is composed of various crop production experts who mainly belong to technical institutes, cooperatives, and Chambers of Agriculture, i.e. incumbent players whose leaders often contest the targeted objective. In order to limit political discussions on the target and to focus the debates on the knowledge uncertainties or on the facilitation and data-base tools to be developed, the Ministry of Agriculture took the lead after an initial period during which it delegated it to the National Assembly of the Chambers of Agriculture (NACA). Nevertheless, as the leader of the team is hired by the State, he works within the NACA which still has responsibility to develop the network.

supply chain levels (in terms of the required quality for international markets, for example in fruit production systems, in terms of crop diversification and work organisation or available market opportunities in arable cropping systems, etc.). As a result, the participants of the DEPHY network share neither a transformative intention nor the means to achieve it.

The second issue is about the way intermediation supports the experiential level. ***We suggest that the development of intermediary objects and experiential spaces needs to support both constructive and productive dimensions of farming activity.*** Constructive refers here to the farmers' ability to explore new ideas and new practices and to be engaged in redesign processes and through trial and error a new cropping system. Productive refers to the way farmers manage the cropping system efficiently in order to reach their productive goals (yield, quality of work, etc.). In the BASE network the intention is clearly to support the constructive dimension. This is achieved by giving a lot of space, in the TCS journal and on the website, to farmers' narratives about successes and failures in experiencing new cropping practices and systems. The core team also creates "experiential platforms" so that farmers can share their experiences regarding a given new practice and assess it jointly (but without necessarily sharing a common experimental protocol). In the RAD-CIVAM network we noticed that they develop tools which can support both productive and constructive dimensions.

While farmers' narratives and experiential platforms are key ways to support the constructive dimension, tools are also built to support facilitators in collecting data on such experiences and in supporting the monitoring of the change process in the cropping system. In both cases such tools not only target the farmers already taking part in the network, but are also built to involve newcomers. In the RAD-CIVAM network the development of an AEM "system" was also seen as a means to support farmers in joining the network. This type of tool can however obscure the motive which initially drives the farmers who developed such an AEM and cannot sufficiently support the constructive dimension of the activity. The list of requirements in the AEM "system" mainly defines means or thresholds to commit to, and does not mention all the experiences and the monitoring that enable the farmers to develop new cropping systems in line with these requirements. The same can be said about the SCEP in the DEPHY Network. Moreover, in this network the tools developed are mainly based on available agronomic knowledge. Finally, they give little room to farmers' experiences and the way the constructive and productive dimensions of their farming activity were developed during the redesign process. In fact, in most of the intermediary tools developed in the DEPHY Network (except perhaps for the on-farm visit), farmers' activity was represented mainly through a management scheme rather than as a constructive and productive process in which the farmers experienced new ways of coping with the uncertain system dynamics.

Last but not least, the third issue is about farmers' participation within the networks. ***We suggest that collaborative roles should also be taken on by farmers who are experimenting with a new cropping system. Farmers should contribute to shaping the intermediary tools as these are crucial in supporting the co-development of the cropping system and of their activity. We also suggest that new participants need to be enabled to develop both constructive and productive dimensions of their activity while redesigning their cropping systems.*** In the BASE network, the collaborative level is organised by the core team (mainly farmers) to let other participants (mainly farmers) take different roles or to be recognised by the other participants as assuming such roles (experts, boundary spanners between the network and other ones, project leader for promoting a new experiential platform, etc.). Farmers can take part in defining the transformative intention, proposing new practices, testing and implementing them, sharing experiences and building shared designing principles. In the RAD-CIVAM network, the collaboration takes place within a public funded project in which farmers have a key role in defining the brief of requirements, in designing and implementing new cropping systems that comply with the brief of requirements, and in contributing to a reassessment of the practices and thresholds indicated in the brief. But facilitators also have a key role in collecting and analysing data that can support this assessment process and can be used to plead with the Ministry of Agriculture for an AEM "system". The collaboration is organised at project level: the project core team draft a contract and the farmers and the facilitators involved in the project have roles assigned in the design process. The way to support the inclusiveness of newcomers is subject to discussions within the network mainly to identify which intermediary tools (such as an AEM "system" but also videos, on-farm visits, facilitation toolkit, etc.) could support the redesign process for these newcomers. The DEPHY network does not really give farmers much latitude in the way collaboration is organised. For example, during the inclusion-selection process no attention is paid to the way farmers participate in the design of the proposal[10]. Although farmers' group discussions are encouraged to support farmers in their transition pathways towards less pesticide use in their cropping systems, they have no real influence on the way data are collected and analysed within the network in order to produce useful knowledge either for themselves or for newcomers. While they have discussions within their own group about how to implement their new cropping systems, few opportunities are given to groups to meet together, even if there is room for the NE or TE to organise such meetings. Formal roles are assigned to the NE, TE and NCT, but our analysis shows that these roles are assumed differently. More informal roles have emerged, mainly for two purposes: the first is to involve more farmers and other stakeholders locally in discussions about the targeted objective and the means to reach it; the second is to open discussions on the advisory practices that can support on-farm design and implementation of new cropping systems. Finally, such informal roles try to take on board ways of involving newcomers in an open and inclusive process rather than just by SCEP production or on-farm visits. But inclusiveness might have been hindered by the fact that in this network the participants receive funds as soon as they are considered as part of the network (indirectly, whether by funding advice for farmers or by funding the advisory and expert organisations for the other network participants), and the total amount of funds do not allow for the network to expand.

Conclusion

The framework we developed looks at intermediation in sustainability transitions mainly through its ability to support large-scale transformation of cropping practices at farm level. It points to the need to take on board the normative dimension underlying redesign processes (strategic level), the productive and constructive dimensions of the activity developed to redesign and implement new cropping systems (experiential level) and the interactive

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[10] Most of the proposals were directly written by the advisor with little participation of farmers at this stage of the process. As recommended in the call, the proposals included a diagnosis of each farm's situation at the beginning of the process, and some levers to be combined for achieving a given level of reduction. But most of the time the way farmers participate in the choice of these levers, their analysis of the way they could change their practices and the meaning they gave to change was not addressed in the proposal. Inclusion was therefore based mainly on an evaluation by the scientific committee experts of the credibility of what was written on the proposal regarding the proposed targets and their consistency with the proposed levers and time schedule.

dimension thereof (collaborative level). By contrasting different networks involved in such intermediation processes, some key attributes for organising an effective intermediation were established. None of the networks really combine all the attributes we identified.

Our recommendations need to be strengthened by testing them within existing networks if possible. The way we analysed intermediation did not however pay attention to the way it addresses some of the lock-in processes that various studies have pointed out (Cowan & Gunby, 1996 for the United States; Vanloqueren & Baret 2009 for Belgium; Lamine, 2011 or Fares et al,. 2012 for France). We did not identify intermediation work directed towards supply chain actors who are concerned by the potential reduction not only of pesticide sales, but also of production levels, and who are key actors for the development of new crops (for which they do not have markets and conservation silos), or of cultivar mixtures or intercrops (which are used as an efficient lever to reduce pesticide use). Even the Ecophyto Plan which has the largest spectrum of actions does not really address this. Also, we did not identify the intermediation work directed towards the exploration of collective solutions (for example by designing collective agro-ecological infrastructures and by organising crops among farmers). Indeed, the networks we studied address change mainly at an individual level. A question is then how they might adopt a broader approach such as this, and how it might challenge their way of organising farmers' participation in the whole change process.

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Competing socio-technical transition pathways towards implementation of conservation policy aimed at enhancing hedgerow and grassland networks

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Abstract: Rural landscapes containing hedgerow networks and permanent grassland have diminished in France and current legislation aims to conserve and restore such habitats and their wildlife. Our multidisciplinary study aimed to identify how livestock farm viability could be reconciled with biodiversity conservation planning policy, in three regions with hedgerow networks. The implementation of the green network policy is legally imposed, though local parties must determine the methods for achieving it at local level. Therefore, the state puts local authorities in charge of organising spatial, ecological planning, from farm scale up to the scale of a small region, a process involving a diversity of local stakeholders. We consider this process as a test case for upscaling and outscaling. The results of sociological analysis of interviews show that local stakeholders tend to envisage three different possible pathways to attaining the policy's requirements: (i) ecological knowledge-driven network design which promotes minority forms of agriculture (niche innovation); (ii) protection of the dominant socio-technical regime, as it is considered to have produced the hedgerow networks and their biodiversity; (iii) Agro-ecological innovation and reconfiguration of the socio-technical regime in order to better integrate biodiversity. Results from ecology and animal science / agronomy approaches shed additional light on the pathways envisaged. It emerged from this work that (i) ecological results do not necessarily provide clear recommendations about the optimal approach for land planning; (ii) the diversity of farming situations is such that one cannot consider that the contribution of each farmer to ecological continuities will be equal; (iii) increasing natural elements within livestock farms may be possible but must be achieved without neglecting the up-scaling dimension of ecological networks.

Keywords: Biodiversity conservation, ecological connectivity, crop-livestock farms, agriculture, governance, "Trame Verte et Bleue"

Introduction

Currently nature conservation policy is evolving as society searches for ways to stop biodiversity decline. This international, shared objective should have been achieved by 2010, but failure to do so has called into question traditional conservation methods, which have been largely based on the preservation of protected areas that occupy a limited proportion of the land area. Now it is generally believed that limiting conservation action to such protected areas will not suffice and that a scaling-up of conservation efforts, to include the wider landscape, is needed (Jongman, Külvik, & Kristiansen, 2004). This approach implies a better integration of biodiversity conservation with regard to a diversity of land-users and human activities (Jongman & Kristiansen, 2001). One step in this direction is the introduction, in many European countries, of legislation to support the definition of ecological networks which should help to increase habitat availability and more particularly enhance connectivity, and thereby plant and animal dispersal, in the vast areas that are not subject to strict nature conservation laws (Bonnin *et al.*, 2007).

Agriculture is one of the major human activities to be concerned by this shift in policy; in France, farming occupies two thirds of the land and is associated with a considerable and partly highly specialised flora and fauna. It is also an activity known to have had major impacts on biodiversity over the past few decades. In Europe, agricultural intensification and homogenisation have led to declines in many groups of species and this is best illustrated by major losses in common farmland birds (Jiguet, 2010, Inger *et al.* 2015). These declines do not relate to rare or endangered species but to the common species that form the bulk of our ecosystems and that play key roles in the provision of ecosystem services. The focus of our conservation efforts therefore also has to shift to take into account this “common biodiversity”. In this context, attempts are being made to preserve and enhance farmland habitats of high ecological value. Among these, hedgerow networks and permanent grasslands represent two key types. At national scale, these habitats have generally diminished, but in north-western regions of France they are still present and are the focus of some considerable attention in the context of nature conservation in farming areas.

Since 2009, national legislation in France has required that ecological networks called “Trame verte et bleue” (TVB) be established at national, regional and local levels. Each level of organisation must define its own method for implementing the policy, using national guidelines. These guidelines explain the ecological basis for the legislation and the general methods to be used for defining and delimiting the areas of ecological continuity to be protected using appropriate planning laws; the precise form of implementation is open to regional and local interpretation. At the scale of each French “commune”, the smallest planning sub-unit, the network must be translated into the local land use planning document known as the “PLU” (Plan Local d’Urbanisme) and for larger rural and peri-urban areas these sub-units may be jointly administered by a cohesive planning document known as a “SCoT” (Schéma de Cohérence Territoriale). Hence this policy, by its very nature, cannot be limited to ecological considerations but must be directly reasoned in terms of the multiple landscape functions (farming, urban, industrial, recreational…) considered by planning documents. Therefore, at SCoT level, the negotiations involve a wide diversity of organisations of which farmers and their representatives constitute just one contributor (Allag-Dhuisme et al., 2010).

In the context of rural landscapes dominated by agriculture, the policy will require stakeholders to think beyond the possible actions of individual farms in order to scale up to the minimum scale for TVB implementation which is the “commune” or group of “communes”. Only if this process of upscaling is successful will it be possible to preserve and enhance the ecological elements forming the desired, and hopefully ecologically functional, network. Hence, the success of this new policy will also depend on outscaling processes: on the involvement of a significant proportion of the farming community, on efficient coordination and on the capacity of local and farming communities to work together.

We are therefore concerned with the classical question of how agricultural change is operated and can be guided. Pioneered in France by (Mendras & Forsé, 1983), this field of research has in particular shown the importance of social configurations within peer groups and their influence on transformations to the ways we see and think (Darré, Le Guen, & Lémery, 1989). When considering current environmental policies, such approaches to the study of changes in standard practice meet with three limits. Firstly, changes to standard practice made in this context depend on objectives that are imposed by public policy. Secondly, these policies are declined regionally such that negotiation between local stakeholders must be arranged, posing the question of how farmers and farming groups interact with each other as well as with other types of stakeholder. Finally, the urgency of environmental problems leads us to explore radical forms of change to current farming systems (Turnheim et al., 2015). Geels (2004) proposed a framework for the analysis of transitions, defined as changes from one sociotechnical regime to another. Geels & Schot (2007) extended this work by suggesting different forms of transition pathway (transformation, de-alignment re-alignment, technological substitution and reconfiguration). These pathways involve varying degrees of reconfiguration of technologies, supporting infrastructures, business models and production systems as well as of consumer preferences and behaviour and they combine different levels of organisation (socio-technical landscape or regime, technological niche) in contrasting ways. This multi-level perspective (MLP) is interesting because it provides a framework for analysing the interactions between the institutional sphere and cultural dynamics within socio-professional groups, or in our case for considering the socio-technical processes that could enable a shift from a situation where some farmers preserve good quality habitats for wildlife, but in a fragmented configuration, to more coordinated and widespread nature protection. Although the MLP was originally based on an analysis of major technological revolutions of the past, we feel that it may also be useful for the study of transitions to come.

In this paper, our aim is to examine how various stakeholders involve themselves in setting up ecological networks in their locality. While our study does not go as far as examining the process of policy implementation, it does shed light on the specific question of how the farming sector's view may be fully taken into account during local negotiations. We describe and discuss the different views of stakeholders in relation to the possible transition pathways for achieving ecological network implementation. Ultimately we aimed to detect the pathways with the most potential to achieve the upscaling objectives of the nature conservation policy. In order to assess this, we will drew upon ecological and farm survey results from our multidisciplinary study.

Methods

Our work was carried out in three study areas close to the urban centres of Angers, Nantes and La Roche-sur-Yon (with between 50 000 and 300 000 inhabitants) in north-western France, with different histories of collaboration between local stakeholders. These areas corresponded to three different "SCoT" planning documents and all contained relatively well-preserved hedgerow networks and permanent grasslands, with a dominance of livestock farming. In all three areas, the process of integrating ecological network policy (TVB) into the SCoT was in progress during the study period (2012-2015). We interviewed 26 stakeholders who had in the past or were at the time collaborating for TVB policy implementation in a variety of ways (consultancy or expertise, local consultation participant for planning document construction, persons employed in ecological network implementation). These stakeholders were local elected representatives, employees or representatives of professional farming organisations or wildlife conservation organisations, or environmental consultants. Based on each respondent's account of their contribution to TVB policy implementation, semi-structured interviews were used to more thoroughly examine their view of the relationships between agriculture and biodiversity, and then more specifically in relation to ecological network policy. In parallel to these interviews, grey literature produced locally by nature conservationists and other professionals was analysed and 11 SCoT construction meetings were observed at one of the study sites (La Roche-sur-Yon). This qualitative material was analysed through a cross-analysis based on four main themes: representation of biodiversity, its links with agriculture, representations and judgements of the ways TVB policy is negotiated locally in order to enhance biodiversity, links made to related issues. We paid particular attention to the ways in which knowledge was used and presented and to the manner in which the diversity of farming situations was described. Based on this analysis we were able to give detailed descriptions of the different representations of the desired transition pathways for enhancing biodiversity, from farm to regional scale, using three Weberian ideal-types (Weber, 1992). The described viewpoints were subsequently linked to the three transition pathways proposed by Geels and Schot (2007), which they closely resembled.

We also drew upon results of farmer interviews conducted by a team of agronomists, animal scientists and sociologists, as well as the results of observations of the avifauna of the hedgerows and grasslands made by ecologists. Farmer interviews were carried out exclusively in the La Roche-sur-Yon study area in order to determine, using a number of approaches, how local farming systems might adapt to implementation of TVB policy. A first survey of 68 farms was used to describe the diversity of bovine mixed farming systems to include hedgerows and grassland and to classify these systems into groups on the basis of their animal production types, levels of intensification and of the spatial and temporal organisation of their cropping systems. Secondly, a sub-sample of 22 of these farms were questioned in more detail to assess the extent to which farmers had the possibility to modify the spatial and temporal organisation of hedges and grasslands, without changing their overall farm strategy. Thirdly, 20 mixed farms belonging to a single landscape unit were questioned individually and then in a group, about their willingness to adopt scenarios involving large increases in hedgerow length and grassland area. The ecological surveys aimed to determine the differences in bird communities of well-connected as opposed to isolated grasslands and hedgerows. In the Angers and La Roche-sur-Yon study areas, we identified two types of survey site: large areas of continuous permanent grassland and small remnants of permanent grassland surrounded by other land-uses, mainly crops. In one field within each of these areas we carried out bird surveys in two breeding seasons using standard territory mapping methodology and the total area surveyed was approximately 85 ha. These grasslands were always associated with well-preserved multi-tier hedgerows. The results from these three disciplines were used together to discuss the viewpoints and pathways and their possible impact, in ecological and agricultural terms, on future policy implementation and success.

Results

Our interviews revealed that stakeholder viewpoints depended mainly on socio-professional category, and were not influenced by the specific contexts of each study site. The viewpoints regarding the best transition pathways for achieving the objectives of TVB policy were varied and this diversity could be structured around three ideal-types:

(i) Ecological knowledge-driven network design which promotes minority forms of agriculture (niche innovation);

A proportion of the stakeholders that we questioned, mainly employees and managers of nature protection organisations, tended to view the development of ecological continuities as a project which should be based upon scientific ecological knowledge. They attached a great importance to landscape ecology and its concepts. Network construction should involve the acquisition of better knowledge of local ecology, based on ecological surveys and/or landscape analyses. This type of knowledge keeps farmers at a distance: at best they may be consulted to give permission to access to their land or information about their farm, but the data collected is analysed without their participation (in order to ensure objectivity) using analytical tools and spatial scales that tend to exclude them, such as spatial modelling of landscapes and aerial photography.

This posture leads them to an assessment of the relationships between different uses of rural areas and the maintenance of biodiversity. They distinguish two types of farming. On the one hand, most farmers have intensive, modernised practices, with short rotations, conventional farming methods and increasing areas devoted to cash crops. In some areas of France these farmers have seriously degraded local biodiversity. On the other hand there are farmers that contribute to biodiversity preservation. One survey respondent describes them, *"They have farming systems and practices that are ecologically compatible. This means that they are people already involved in alternative techniques, selling methods, farming practices. They are at the margins of conventional systems, and their installations rely on as little investment as possible; they are mostly organic farmers, who sell their produce locally."*

Therefore these stakeholders perceive the fact that local authorities are now required by law to propose an ecological network as a window of opportunity which might allow groups of farmers considered virtuous to replace today's conventional farmers. This situation also provides an opportunity for nature protection organisations themselves to display their expert knowledge (and sometimes to sell it to local authorities). This view corresponds to Geels and Schots' "technological substitution", whereby a network of stakeholders that represent a minority, composed of alternative farmers, militant organisations and groups of consumers, develop a niche innovation that matures and could come to substitute the dominant farming regime if a modification to the legislative framework favours its development.

(ii) Protection of the socio-technical regime, as it is considered to have produced the hedgerow networks and their biodiversity;

This second view mostly belongs to elected representatives or project managers from professional farming organisations concerned with representation of farming interests (farmer's unions, extension services). For this group, the link between farming and ecological networks is limited to the view that maintaining livestock farmers leads to the maintenance of hedgerow networks. The knowledge they use is of a sociological nature. They consider that the livestock farmers they represent are relatively homogeneous, with generally similar practices and a belief in the preservation of hedgerow networks and biodiversity. From their perspective, biodiversity declines are above all related to the difficulties facing the farming profession such as devalued food prices, the economic crisis (in particular for the meat industry), the unattractiveness of farming careers, urbanisation, political uncertainty relating to CAP reforms, etc. If adaptations to current practices are to be accepted, they must be compatible with farmers' everyday concerns. From these stakeholders' viewpoint, biodiversity preservation is also professional farming matter and they demand that a special delegation be put in charge of the design of the ecological network in rural and agricultural areas. Moreover, these stakeholders ask that the ecological objective be integrated into land planning documents along with the broader aim of maintenance of farmland in peri-urban areas. This leads them to defend the ecological functions of farming areas, but also to demand that space for nature conservation be limited to allow room for agricultural production.

This posture corresponds to the socio-technical regime transformation pathway (Geels & Schot, 2007). As the socio-technical environment exerts pressure on farming, incremental innovations may be undertaken by the current farming majority. This pathway is characterised by adaptations resulting from a tension between niche stakeholders who defiantly point the way forward and socio-technical stakeholders who demand the right to transform their regime from the inside.

(iii) Agro-ecological innovation and reconfiguration of the socio-technical regime in order to better integrate biodiversity

This is a view that is common among advisors and technicians from rural and farming development organisations. They see the relationships between agriculture and biodiversity in terms of techniques, citing, in no particular order of importance, a great diversity of beneficial methods: tractor-mounted flushing bars, planting hedgerow networks, woodland and grassland management, ecological infrastructure management (field margins, grassy strips, hedges, ponds, trees), etc. They quite accurately perceive a wide diversity of farming systems, but rarely judge them in terms of their impacts on biodiversity. When accompanying farmers they are more interested in identifying possibilities for improvement.

While these respondents have a clear vision of the types of innovation that are relevant for farmers and for biodiversity, the ways in which agricultural biodiversity can be defined and observed are of lesser importance than the fact that farmers are engaged in agro-ecological and innovative approaches. To achieve this aim, it is necessary to increase awareness, by experimenting, to produce reference results that will convince farmers of the merits of agroecology, and through training. For this group, the farm scale and farmer involvement are the key aims while local and regional approaches, and therefore ecological continuities, are only secondary concerns. Nonetheless, implementation of TVB policy is seen by some as an opportunity to increase farmer awareness, or to improve knowledge of the notion of ecological continuity, or indeed to develop training activities with financial input from local authorities.

This view corresponds to a socio-technical regime reconfiguration pathway (Geels & Schot, 2007). The socio-technical regime encounters pressure that encourages the development of agro-ecological innovations. This pressure may take the form of technological dead-ends, such as problems with the control of green cover as authorised chemical products are progressively banned, economic pressures, legal or political influences, development of environmental labelling schemes... In this context, the diversity of farming systems constitutes a resource, allowing stakeholders to pick from a whole repertoire of innovations that can be integrated into the socio-technical regime. In this way, the regime will be subject to both technological and sociological adjustments which could, over time, lead to a better coordination between farmers contributing to the construction of ecological continuities. These stakeholders envisage these reconfigurations as occurring within an agricultural sphere, in which they themselves play a coordinating role based on technical knowledge.

Discussion

Hedgerow or grasslands networks: a diversity of types, uses and ecological values

The farm survey results revealed a real diversity of livestock farming systems, that related to both structural criteria (Utilised Agricultural Area, land parcel fragmentation, local soil and climate, workforce) and to conceptions of farming (specialisation versus diversification, intensification versus extensification, workforce or animals, ecological farming practices). Hence the areas and functions of grasslands within these systems vary greatly; we classified a number of types of grassland (short temporary, long temporary, long multi-species temporary, permanent) whose place in the farm depended on a number of important factors. Four archetypal production logics, with different degrees of flexibility, were identified. For each, with no change to production strategy, we found that it would be very difficult to modify the surface area and spatial arrangement of grasslands to improve their connectivity. In a few cases a reduction in the areas cultivated with maize could be envisaged, leading to a reduction in the security of the forage system and a change to the animal feeding strategy. It should be added that recent meat production crises have led a small number of farmers to rethink their production methods and to see grasslands as a means of reducing production costs; some are redesigning their farming systems to include more grassland.

Secondly, the farm surveys made it clear that to consider hedgerow-grassland continuity as a whole, was not practical from a farming perspective. These two habitat types were viewed in different ways by farmers and integrated in different ways into their farming systems. Development of grassland continuities represents a radical change for a majority of farmers. As far as hedgerows are concerned, farmers are more inclined to plant, as they view these landscape elements as positive and multi-functional. Hedgerows are usually replanted around permanent grasslands, much more rarely in field interiors. This does not significantly interfere with production strategy and can be considered as an incremental innovation.

From an ecological viewpoint, also, the characteristics and value of each habitat type need to be examined both separately as well as jointly. Landscape ecological research has tended to focus on the spatial configuration of wooded habitats and its effects on forest specialist species, often considering open farmland habitats to be less favourable for biodiversity. Semi-natural open habitats support different forms of biodiversity and more knowledge is needed about the value of increased connectivity of open habitats like grasslands. Our results focus on birds, though this taxonomic group cannot alone provide a full assessment of the value of hedgerow and grassland habitats for biodiversity. What is can do is provide an illustration of the complexity of ecological knowledge in relation to TVB policy. The bird surveys at our study sites showed that the majority of the nesting community utilised hedgerows while only two species of lark (Skylark *Alauda arvensis* and Woodlark *Lulula arborea*) used grasslands for ground-nesting. The majority of observations of feeding behaviour were also in shrubs or trees at the field margin. There was no positive effect of increasing grassland connectivity on overall species richness and abundance or on the presence of any functional group. A closer analysis of the species using hedgerows revealed that the community was dominated by generalist species that are able to adapt to most environments, along with several forest specialists. The levels of bird abundance observed in the Pays-de-la-Loire Region hedgerows were higher than average when compared with around 40 other studies in similar farming contexts. The value of wooded habitats was therefore clear for these species groups. However, farmland specialist species do not seem to benefit from the maintenance of these continuous areas of permanent grassland and their hedgerows. With one or two exceptions, farmland specialists were less abundant in our samples; hedgerow density was perhaps too high for true open specialists like Skylark, but we no doubt observed, at local scale, the results of recent steep declines in farmland bird populations measured at regional or national scales. Other authors have alerted conservationists to the need for appropriate protection strategies for open farmland specialist groups that are of greatest conservation concern (Filippi-Codaccioni et al., 2010).

The relative merits of the three pathways for TVB implementation

We will now discuss the transition pathways envisaged during TVB construction with a view to highlighting the differences between the knowledge presented by stakeholders and that obtained by researchers at the Roche-sur-Yon study site.

(i) ecological knowledge-driven network design which promotes minority forms of agriculture

This pathway is founded on a simplistic view of how hedgerows and grasslands are considered in agricultural systems that does not reflect the local situation. There are "good" and "bad" farming systems and not much in between; this dichotomy is particularly untrue as regards grasslands. In reality, a gradient of grassland use exists, ranging from grassland-based systems to total absence of this land-use type. Moreover, it relies upon a rather vague definition of grasslands, although a great diversity of grassland types can be found on farms. Even in the minority of farms that include a large proportion of grass (23% of farms are grassland-based), and that may therefore be considered desirable for this pathway, the grasslands present are of different types and the areas and spatial configuration of these are not necessarily optimal for conservation purposes.

Although this is the only pathway to base its views and actions upon ecological objectives and a clear attempt to implement policy to accentuate ecological connectivity and functions, it relies on a rather utopic view of ecological knowledge. It should be stressed that the results we obtained in our study cannot be generalised for all taxonomic groups, but they illustrate the complexity of ecological knowledge and the difficulty of guiding action based on this type of knowledge. What we and others have shown, is that increasing hedgerow density will have both positive and negative effects depending on the species considered. One of the TVB policy "target species" for the Pays-de-la-Loire Region is the Little Owl *Athene noctua*, a species that thrives in areas with grassland and *loose* hedgerow networks. For this species a degree of hedgerow maintenance is desirable, but not too much. However, for many farmland specialists of conservation concern, modifications to hedgerow networks will not suffice as their ecological needs depend on actions within the areas used for production. The broad ecological principles guiding TVB policy need to be accompanied by an analysis of context-specific ecological knowledge, which is sometimes lacking, to establish clear and shared objectives for biodiversity, and this represents a major challenge, also for the future assessment of policy success.

However, this pathway is the only one that recognises the major changes that up-scaling of grassland networks would require, and as such is likely to meet with various structural obstacles. For example, certain farms may not have enough suitable land for growing grassland or may not be in a position to evolve for economic reasons. In addition, this pathway's view of the spatial arrangement of grasslands is at odds with the way in which farmers view these areas, i.e. above all in terms of their functions in relation to agricultural production. This is why this group aims to transform the dominant socio-technical system by aiding the installation of farmers possessing what they would term agro-ecological principles. It seems unlikely, at this stage, and without any other major disruption of socio-technical landscape, that the debates surrounding the implementation of TVB policy will allow this technological substitution to occur.

(ii) protection of the dominant socio-technical regime, as it is considered to have produce the hedgerow networks and their biodiversity

Like the previous pathway, the major limit of this pathway is the fact that it is based on a caricatured view of the local farming situation that considers the farming community as one homogeneous block. By protecting the dominant socio-technical regime while ignoring its internal diversity, this posture does not correspond to the local situation. In ecological terms, no objectives are defined and the diversity of environmental situations to be found locally is glossed over. Lastly, by demanding that TVB design be delegated to the farming sector, this approach prohibits out-scaling and cross-learning processes. This attitude reveals the many pressures to which farmers are subjected such as drops in milk and meat prices due to high costs associated with imported inputs or the effects of decreasing land availability due to urbanisation, and which farm sector representatives hope to address in the context of land planning negotiations.

(iii) agro-ecological innovation and reconfiguration of the socio-technical regime in order to better integrate biodiversity

This pathway is the one that best considers the diversity of farming situations observed locally, but it does not pose clear ecological objectives. Its main limit, as regards the implementation of landscape-level policy, is its focus on farm scale operations, therefore minimising the changes needed to achieve effective ecological grassland continuity. At landscape level, coordinated increases in grassland continuity are unlikely in the medium term, without more profound changes to farm production strategies. Through a process of incremental innovation, this pathway is more likely to achieve up-scaling of wooded habitat continuities.

A first major obstacle for TVB implementation seems therefore to be the definition of clear regional objectives from a diversity of stakeholder viewpoints. The way in which different types of knowledge, either ecological or socio-technical, are used to define objectives as well as the definition of the role of the farming sector in achieving these objectives are particular challenges.

Coping with diversity: a test for the transition pathways

Here we will suggest ways to overcome this difficulty basing our analysis on i) what can be learned from a discussion of ecological objectives with a group of farmers and ii) an analysis of what local authorities make of this diversity of stakeholder viewpoints.

The farmer workshop involved livestock farmers with differing production methods. It confirmed that livestock farmers found it difficult to imagine making changes to areas of grassland (quantity, type or localisation) without also changing production logic (animal productivity, income, workforce organisation). For this reason, they were not able to agree upon a scenario for a future grassland network. Conversely, they were able to spontaneously imagine collective scenarios for creating hedgerow connectivity. This result confirms the importance of considering hedgerow and grassland continuities separately. The second clear result was the farmers' view that the most important factors limiting hedgerow development are the time needed for hedge maintenance and the risks of conflicts with adjacent landowners. Putting in place hedgerow networks would depend on the collaboration of local authorities, farmers and owners to plan planting, determine management methods in such a way as to minimise conflictual situations and promote and finance new hedgerows and maintenance initiatives. The workshop results seem to support a view of transition achieved by organising the combined inputs of a diversity of stakeholders (close to view iii).

Among the different stakeholders involved in local implementation of TVB policy, a final group plays a very specific role: they are the local authorities required by the state to put the legislation into practice. As such they organise the working methods between all the local stakeholders.

Elected representatives and civil servants of local authorities, or the consultants they mandate, coordinate the work of constructing an ecological network. Their view of the most suitable method for writing the ecological plan is situated between the ecological knowledge-driven network design viewpoint (i) and the socio-technical regime protection viewpoint (ii). The similarity with the naturalists is due to the importance often attached to the need for better local knowledge for policy implementation, resulting in ecological surveys being funded during network construction, to complement existing data. However, their vision differs from the first because they also give weight to majority social groups in the locality, therefore allowing agricultural extension services to make a significant contribution or even delegating certain forms of expertise to such services. It also differs from all visions in the importance accorded to pre-existing protected areas (for nature or other purposes in urban areas), which for this group constitutes a base upon which the ecological network must be constructed.

As they conduct the project, they seek to organise a form of compromise between an ecological planning approach, strongly influenced by local ecological knowledge, and a more negotiated, political approach linking, in as much as local stakeholders are prepared to allow, areas already identified or protected by previous documents and legislation. In our study areas, this led to different levels of importance being accorded to nature protection organisations (local ecological expertise) or to agricultural organisations as work progressed. We can therefore see, as regards the three pathways previously described, that this group in charge of policy implementation see their role as attempting to conciliate the opposite views of the socio-technical regime and niche stakeholders but not at all as facilitators of agro-ecological innovation or reconfiguration of the socio-technical system.

Conclusion

We showed that stakeholders involved in ecological network implementation had contrasting views of the possible pathways for TVB policy implementation. The three archetypal views we distinguished closely resembled the three transition pathways described by Geels and Schot (2007). This framework therefore provided a useful tool for explaining the divergent views of stakeholders involved in putting local policy into practice. A primary difficulty in the implementation of this conservation policy is the coordination of a local, political project involving stakeholders with contrasting viewpoints and methods. These viewpoints are above all related to the positions different stakeholders occupy in the process; they participate as nature protectors, farming representatives or farming or development advisors. Each position is associated with a particular form of experience and knowledge as well as a set of interests for each stakeholder. The writing of the planning document is partially an opportunity to reinforce his/her influence in a context of increasingly regionalised farming and environmental policy.

Our analysis of the local approach to the TVB legislation, combined with research results from ecological surveys and a study of livestock farming in one of the study areas, show that this policy has to deal with high levels of uncertainty. The ecological knowledge used is incomplete and the sociological and technological knowledge is imprecise. In particular, in the context of spatial planning it seems to be difficult to integrate the diverse ways in which individual farms function. Therefore the goal of writing a fixed plan based on a negotiated balance between the interests of professionals and wildlife is unrealistic.

From the discussion it also appears important that ecological continuities of open and wooded habitats be considered independently in both ecological and farming terms, as well as in terms of their linkages and interactions. However, the work carried out by local authorities tends to focus on the wooded network, hardly considering grassland continuity, except as being generally associated with areas of dense hedgerow networks. This is partly due to the choice of legal instrument for policy implementation; it is easier to protect isolated woodland features in a planning document than areas used for production. It may also reflect the difficulties anticipated if farmer actions need to be coordinated in such a way as to increase grassland continuity. Finally, the role of local authorities in enhancing hedgerow networks may be decisive; the upscaling and outscaling processes may rely on the actions of this type of stakeholder, for example through active promotion of hedgerow creation and coordination of the involvement of farmers, landowners and their neighbours for the definition of management methods. As we have seen, currently stakeholders in charge of writing planning documents seem to opt for a compromise born out of the conflict between nature protection interests on the one hand and defence of the agricultural profession on the other (pathways i and ii in our analysis). This leads, via alternating contributions from each party, to a form of moderation of the initial ecological proposals. This method excludes the possible contribution of those stakeholders who defend agro-ecological innovation.

Could the way in which local stakeholders involved in agricultural development, so far generally excluded from the process, envisage reconfiguration pathways be a model for the development of wooded and grassland continuities? We think not, in as much as, at our study sites, these stakeholders tend to limit their actions to the professional farming sector and the farm scale, neglecting the need for a coordinated spatial organisation of farms if landscape-level policies are to be implemented. Additionally, these stakeholders belong to professional organisations and they risk being limited in their contribution by the need to defend certain groups of farmers who may feel unable to conform to the increases in grassland area and connectivity called for by the ecological network. It also clearly appears that, to succeed in ecological terms, the reconfiguration pathway would need to better integrate ecological propositions during the adaptive process.

This confrontation of the views of stakeholders with the different transition pathways opens up new questions about the interactions between local authorities and stakeholders involved in rural development and farming innovation. Perhaps the goal should no longer be the search for compromises between social groups but rather the reconfiguration of ecological, political and agricultural knowledge.

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