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Agricultural transition: niche and regime knowledge systems' boundary dynamics

Julie Ingram

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Abstract

This paper examines how knowledge systems within alternative agricultural niche develop and interact with the regime's Agricultural Knowledge Systems (AKS). It frames the analysis around transition, knowledge systems and boundaries literatures. Specifically it explores the extent to which niche knowledge systems confront and, or enhance the regime's AKS. The paper draws on empirical data from a study of the Permaculture community in England. The analysis describes the boundary between the knowledge systems of the Permaculture niche and the mainstream agricultural regime. Rather than a simple notion of PKS confronting or enhancing the AKS there are multiple knowledge processes operating which both maintain and permeate boundaries between the two knowledge systems.

Keywords

Permaculture; Knowledge systems; Niche; Regime; Boundaries; Innovation

Highlights

- Examines how knowledge systems within alternative agricultural niche (Permaculture) develop and interact with the mainstream regime's AKS.
- Distinctive knowledge systems emerge to support learning in niche.
- A boundary between the Permaculture niche and the mainstream regime knowledge system exists.
- The boundary is characterised by tension between strong internal processes in the niche and weaker external links across knowledge system boundaries.

1. Introduction

Scholars agree that a transition towards sustainable agriculture is needed if we are to meet the future challenges in the agri-food system (Hargreaves et al., 2013, Hinrichs, 2014). This entails a shift from a system characterised as having the goal of increasing productivity, to one built around the wider principles of sustainable production and rural development and resilience (Brunori et al., 2013); social justice and food security (Goodman, 2004, Marsden, 2004). Innovative forms of agriculture are emerging which can potentially contribute to such a transition, often associated with groups and networks of actors advocating alternatives to mainstream agri-food systems (Wiskerke and van der Ploeg, 2004). Transition theory considers such innovative forms of production and organisation as niches (a space where new ideas and practices can develop)¹ and conceptualises transition as the outcome of interactions between these niches and socio-technical regimes (the incumbent system of dominant technologies, practices and institutions) (Kemp et al., 1998), particularly in terms of the niches' potential to influence the wider system (Elzen et al., 2012). The aim of this paper is to examine such an interaction from the perspective of knowledge by means of a Permaculture case study.

Niches defend radical innovations such as alternative agricultural production methods or particular ideologies and operate outside established structures, cultures and practices. They are important sources of ideas and practices which can seed a transformation in the socio-technical regime, if processes at niche, regime and landscape² levels of the system are supportive (Kemp et al., 1998, Schot and Geels, 2008). However, regimes are resilient and resist change. In the agricultural context the dominant agri-food regime exhibits technological, organisational and institutional lock-in that ensures its persistence (Seyfang and Smith, 2007) and results in only incremental improvements in sustainability performance (Seyfang et al., 2014 p14). Influences in the broad political and economic, socio-cultural 'landscapes' (Elzen et al., 2004) operate to different extents, for example, changing consumer culture, but, as yet, have not radically changed institutional structures and conventions within the agri-food system.

As such niches advocating more radical innovations such as sustainable agriculture alternatives often struggle to find and maintain a viable space within the regime due to limited funding and support, and experience difficulty in making effective links and diffusing oppositional ideas (Seyfang and Smith, 2007, Smith, 2006b). Consequently they are often consigned to operating on the fringes of conventional agricultural contexts. This is demonstrated in numerous examples of sustainable solutions and grassroots innovation movements that deviate from mainstream agricultural practices that encounter difficulties in achieving widespread transformative change (Hermans et al., 2015). Scholars, for example, note that the current agricultural science and technology agricultural landscape does not sufficiently support holistic and agroecological approaches, while other more

¹Niches are variously defined in the transition literature, for example as protected spaces where new socio technical practices can develop, or the outcome of a process of consolidation of paradigms different from those prevailing in the dominant socio-technical systems; and as places or communities such as grassroots innovation movements where novelties are developed.

²This refers to the three levels niche, regimes and landscape, heuristic analytical concepts within the multi-level perspective, used to conceptualise transition.

technical agricultural innovations, are able to flourish (Duru and Therond, 2015, Vanloqueren and Baret, 2009, Lamine, 2011). This interplay between the entrenched regime and innovative niche has been examined and conceptualised within different strands of the transitions literature (Diaz et al., 2013, Smith, 2007, Bui et al., 2016), and widely explored with respect to the agri-food system and innovation (Knickel et al., 2009, van der Ploeg et al., 2004, Ingram, 2015). However the role knowledge plays in this interaction has yet to be fully explored.

Knowledge has been described as one of the most relevant resources circulating in niches (Ingram et al., 2014, Morgan, 2011, Smith, 2007). Actors in niches typically share common goals and interests; they learn together to experiment and create new ideas and innovative practices (Knickel et al., 2009). In doing this they develop their own distinctive knowledge systems, often with limited support from the formal Agricultural Knowledge System (AKS). Arguably niche knowledge systems potentially confront and destabilise the regime's AKS, which is charged with fostering innovation but is locked into old approaches or trajectories of the incumbent regime (Brunori et al., 2013). Equally, however, this learning and experimentation in niches may enhance the regime's AKS, contributing to its diversity and adaptive capacity, and creating opportunities for mutual learning and boundary work which are critical to transition (Cash et al., 2003, Tisenkopfs et al., 2015).

Understanding this dynamic across the boundaries between the knowledge systems of niches and the established mainstream AKS is therefore important particularly with respect to the role of knowledge in the overall system innovation that transitions require (Grin et al., 2010). Despite the centrality of knowledge to innovation and transition, there is little understanding of the interplay between knowledge systems of emerging innovative niches and the incumbent regime. This paper addresses this gap. It frames the analysis around transition, knowledge systems and boundaries literatures and draws on empirical data from a study of the Permaculture community in England, a niche advocating agricultural transition through community development and food production based on agroecological principles. It examines how the Permaculture community links with, and influences, the conventional agri-food regime through the lens of knowledge and learning, specifically examining the potential of the Permaculture niche's knowledge system to confront or enhance the AKS of the mainstream regime. Specifically the paper aims to make theoretical and empirical contributions to understanding the role of knowledge and knowledge processes in niche-regime dynamics.

Understanding these processes can contribute to the body of work which seeks to explain why some niches and indeed the agricultural sector as a whole have made limited progress on sustainability transition pathways (Diaz et al., 2013, Vanloqueren and Baret, 2009). Using Permaculture as a case study allows analysis of a niche with radically different from the incumbent regime with clear ambitions to transform the agri-food system, a community and membership organisation with identifiable knowledge structures and mechanisms in place. Increasingly, analysts and policy makers are seeing the need for steering radical system innovations in more sustainable directions in the agricultural domain (Seyfang and Smith, 2007), insights from this study can contribute towards this endeavour.

2. Niche and regime knowledge systems' boundary dynamics

2.1 Knowledge Systems

In agriculture the notion of the Agricultural Knowledge System (AKS) describes the formal set of institutes and actors (researchers, advisory services, supply chain industries, education and engaged farmers) charged with fostering innovation. The AKS framework captures the stable actor networks which support agricultural innovation and learning (Roling and Engel, 1991). Beyond these formal entities Roling and Jiggins (1998) argue that knowledge systems can also be coherent set of cognitions, cosmologies and practices; while other scholars equate knowledge systems to social systems (van de Kerkhof and Wieczorek, 2005). According to Roling and Jiggins (1998) knowledge systems are made up of the key elements which can occur in unique, internally coherent combinations and can be characterised and distinguished on the basis of the following elements: an epistemology: a belief about the way people interact with their environment; a set of practices for managing agro-ecosystems; ways of learning about agroecosystems; ways of facilitating and supporting such learning; supportive institutional frameworks and actor networks; conducive policy context.

2.2 The Regime Agricultural Knowledge System (AKS)

The incumbent socio-technical agri-food regime built around industrialised agriculture exhibits the mutually entrenching cognitive, material, economic and social phenomena that characterise a regime (Smith, 2006a). In western agriculture this is manifested through regulation, prescribed farming practices, a specific trajectory for research and development and established supply chains; and in institutions, such as the AKS, that are locked-into generating incremental innovations and segmented knowledge (Knickel et al., 2009). The AKS encompasses powerful actor networks (comprising agricultural scientists, extension officials, and agro-chemical suppliers and technologically innovative farmers), and can be thought of as one of the key apparatus of the mainstream agricultural regime (Roling and Jiggins, 1998). Co-evolving within the regime, the AKS institution confers legitimacy and scientific authority, and reinforces existing trajectories (Leeuwis et al., 2004). As a core element of the knowledge dimension, the AKS institution is central to the conventions, rules, and norms that guide the uses of particular technologies and the everyday practices of agri-food regime actors (Geels, 2004, Seyfang and Smith, 2007, Smith, 2007). AKS typically include research, education, innovations support services (e.g. public and private advisory systems), supply chain actors and practice subsystems where knowledge is developed (learning), codified, stored and exchanged.

Guiding principles and socio-cognitive processes in the established AKS knowledge base are geared towards first-order knowledge development which sustains the same technological paradigm and dominant designs (and keep higher level rules, actors and artifacts largely unchallenged with incremental innovation), rather than second-order paradigmatic shifts (radical innovation which changes higher level rules, actors and artifacts). Radical innovations are often rejected because insufficient resources are directed to new knowledge development, or research and development to support them (Bock and Fieldsend, 2012). For example, Vanloqueren and Baret (2009) describe determinants of innovation (the factors that influence research choices) within agricultural research systems

that construct a technological regime, where conditions prevent competition and hinder the development of agroecology compared to genetic engineering.

2.3 Niche knowledge systems

Knowledge is one of the key resources devoted to alternative socio-technical processes and practices of technical and social innovation (Geels, 2004). Indeed knowledge development and the mechanisms of learning are at the heart of any innovation process (Hekkert et al., 2007). As Smith (2006b p441) notes “Niches allow time, knowledge, capabilities, and resources to be devoted to the alternative sociotechnical practice. Lessons are generated and disseminated”. The transition literature identifies learning processes and the experimental nature of the niches as critical for successful growth and emergence (and potentially regime transformation), and consequently in need of support and nurturing (Geels and Schot, 2007, Hoogma, 2002, Smith and Raven, 2012). This learning, together with building social networks, leads to niches developing their own distinctive learning or knowledge systems. Brunori et al. (2013), for example, describe the niche-like learning and innovation networks for sustainable agriculture as alternative knowledge systems which develop patterns and infrastructures for communication, memories, access to and retrieval of information, intellectual property rules, validation of information and framing functions. Such knowledge systems, characterised by collaborative modes of learning, have been revealed in the analysis of transition towns (Seyfang and Haxeltine, 2012); organic farming (Smith, 2007, Morgan, 2011); agri-environmental action (Lockie, 2006), and Permaculture (Ingram et al., 2014, Maye, 2016, Veteto and Lockyer, 2008). In agriculture these niches are part of a wider ecological knowledge system which exhibits fundamentally different characteristics to those of the AKS (Roling and Jiggins, 1998).

2.4 Niche knowledge systems confronting or enhancing the AKS?

Emerging groups of actors in niches advocating more sustainable approaches are said to challenge the assumptions and rules of the AKS. These groups demonstrate the explicit endeavour to foster innovation for sustainability and they look actively for alternatives to productivism. They tend to operate outside, and often conflict with, official research and extension programmes, and enjoy little or no public support (Brunori et al., 2013). Significantly their knowledge or learning systems are distinct from those of the regime (Duru and Therond, 2015). Through collaborative learning and the development of raised levels of awareness, empowerment and capacity building they tend to follow a ‘second-order’ learning; this questions and confronts the fixed rule set (or paradigm) of first-order learning of the mainstream AKS which is dependent on technical efficiency and innovations from science and technology (Kemp et al., 1998, Seyfang and Smith, 2007). This second-order learning is considered to be important in overcoming stable and difficult-to-change socio-technical systems. By taking a different innovation and learning direction, niches, through the actions of their knowledge systems, challenge the dominance of the AKS, and seek to change it through diffusion of more radical ideas and practices. Successful niches facilitate the diffusion of innovative sociotechnical practices and systems. This diffusion, however, is inevitably a contested and difficult process where niches are radical and are grounded in assumptions and values that are incompatible with those of the regime, as described for organic and agroecological approaches (Meek, 2016, Smith, 2007). Social movements, which can correspond to a niche situation (Rip and Kemp, 1998), have also been shown to mobilise knowledge and resources with the aim of generating tipping points in political values,

actions and behaviours. However, their knowledge is characterised by experience, culture and emotion and is often rejected by institutions founded on reductionist epistemologies, which reproduce themselves by denying validity of alternative knowledge (Chesters, 2012, Williams, 2004). Thus the term ‘confronting’ is used here to describe a complex set of processes and tensions across the niche and regime knowledge systems interface, characterised by contestation and diffusion of radical ideas.

However, the knowledge systems of niches and regime are rarely coherent, described by bounded single models of learning and innovation which confront each other. This is especially so in the context of transition towards a more sustainable agriculture. Niches integrate various knowledge actors, sources, types, and intermediaries. They do not always cohere around a common goal or mode of learning; first- and second-order learning can co-exist. Niches will potentially comprise an ecology of knowledge, resulting in diverse knowledge systems that interact with AKS in different ways (Santos et al., 2007). A similar observation has been made about social movements which comprise diverse actors and beliefs and diffuse networks (Chesters, 2012).

Equally the AKS is not a uniform entity. Criticisms of the perceived homogeneity of the regime are common and these are equally pertinent to its knowledge system (Diaz et al., 2013, Elzen et al., 2012, Geels, 2002). As a central element of the knowledge dimension of the regime, the AKS arguably reflects the heterogeneity of the regime it serves. Rather than a coherent system it comprises multiple social and technical components (including actors, networks and rules and routines) and is characterised by internal tensions, by different actor experiences and motivations, and by a dynamic adaptive capacity (Ingram, 2015). It is possible that some AKS and niche actors may share the same perceptions and motivations (Smith, 2007).

This view is consistent with how agricultural innovation is increasingly being framed, shifting from a strongly hierarchical pattern premised on adoption as a top-down linear process to a more network-like structure (Biggs and Smith, 1998, Klerkx et al., 2010). Commentators, for example, have described self-organising networks coordinated by rural actors (traditional and non-traditional) and coalition networks with regime actors, or emanating from within the regime itself (Aarts, 2007). Indeed it is argued that single community homogenous knowledge can coexist with multiple heterogeneous communities of knowledge producers which are both inside or outside networks (Clark et al., 2011, Tisenkopfs et al., 2015), demonstrating that AKS boundaries are diffuse (Klerkx et al., 2012). This concurs with descriptions of AKS becoming creative and flexible spaces as they become accessible to outside initiatives (Garforth et al., 2003). Furthermore according to perspectives that regard AKS as innovation support systems, the overall performance of AKS can be improved by networking (as a pre-condition to learning) for innovation through shared visions, well-established linkages and information flows amongst different sorts of actors (Klerkx et al., 2012). Thus, rather than confronting or contesting the AKS with a view to transformation or destabilisation, alternative niche knowledge systems can interact with, bring innovation and diversity to, and potentially enhance and invigorate the AKS. This interpretation corresponds with descriptions of a transformation from AKS to AKIS (Agriculture Knowledge

and Innovation System)³ where alternative actors and networks strengthen the system and arguably support transition (EU, 2012, EU, 2013, Hermans et al., 2015). Scholars suggest that the AKS, which is geared towards conventional farming contexts, needs to adapt to create new spaces and capacity for such innovative groups by working across boundaries (Leeuwis et al., 2004). Fostering such changes by reforming the AKS towards a more diverse and adaptive AKIS has been the focus of attention in academic and policy circles and is at the core of the EU's EIP AGRI programme (Brunori et al., 2013, EU, 2012, Knickel et al., 2009, OECD, 2010).

This view also concurs with more nuanced view of transition processes at the niche-regime interface which is described as a complex and messy process (Elzen et al., 2012), characterised by fluidity in both niches and regime (Diaz et al., 2013). Here linkage processes, which involve networking actors from regime and niche entities (Klerkx et al., 2010); translation (Smith, 2007); re-invention and adaptation (Ingram, 2015); mixtures of niche experiments and regime practices established in hybrid forums (Elzen et al., 2012); and intermediate projects, are described as active across diffuse boundaries. Some of these correspond to different diffusion processes which include: the replication of projects, by constituent project growing scale, or (most significantly for knowledge) the translation of niche ideas into mainstream settings (Seyfang and Haxeltine, 2012), outscaling (widespread adoption) and upscaling (embedding) (Hermans et al., 2015).

Thus the analysis above suggests that from one viewpoint, knowledge systems of niches and the mainstream regime are disconnected, and that the niche knowledge systems confront and contest the incumbent AKS. While, from another viewpoint, the niche knowledge systems can potentially strengthen and invigorate the AKS by networking and bringing in new knowledge, innovation, and opportunities for shared learning (Figure 1).

[INSERT FIG 1. Title: Niche knowledge systems: potentially confronting or enhancing the AKS]

2.5 Boundaries - conceptualising niche knowledge systems and AKS dynamics

Boundaries provides a useful frame for conceptualising this posited dialectic interaction between knowledge systems of niches and regimes. Boundaries demarcate the socially constructed and negotiated borders between disciplines, sectors and communities and they delimit functions such as knowledge generation as well as different knowledges (e.g., western scientific, traditional, situated, or local) (Cash et al., 2002). Structural and cognitive barriers can restrict bridging between different knowledge systems (Berkes, 2009, Roling and Jiggins, 1998) and where they become impermeable, boundaries at the interface between knowledge domains prevent any meaningful communication taking place across them (Clark et al., 2011, Robinson and Wallington, 2012), or any innovation emerging (Carlile, 2004).

Boundaries are maintained by groups (niche networks) which share certain sorts of knowledge, learning and practice. Social bonds are strengthened in these groups by sharing the same knowledge, language, practice, values, culture and repertoires (Wenger, 2000,

³ The AKIS concept has become an established framework to analyse innovation processes in the domain of agriculture from a system perspective.

Williams, 2004). As Castree (2005 p12) notes “typically, knowledge exists as more or less established bodies of knowledge that distinct groups of people share in common.” The social nature of knowledge in niches has been highlighted in studies of social or grassroots innovations which are applied to a goal of sustainability (Seyfang and Smith, 2007). In these innovations knowledge systems cohere around social systems, they are “. . .a network of actors connected by social relationships, formal or informal, that dynamically combine knowing, doing, and learning to bring about specific actions for sustainable development” (van Kerkhoff and Szlezák, 2010 p1).

These groups, however, can be so tightly knit that they become, closed in, and boundaries around them can be a source of misunderstanding, constraining knowledge flows (Tagliaventi and Mattarelli, 2006). Strong internal learning and networking within radical niches has, for example, been observed as preventing them from communicating effectively with wider audiences and constraining their development (Ingram et al., 2014, Maye, 2016, Seyfang and Haxeltine, 2012). Absence of common knowledge is a defining feature at the boundary between different knowledge domains (Carlile, 2004).

As well as boundaries marking spaces of disconnect, commentators have argued that boundaries can become spaces of unusual learning, where fresh perspectives meet and new opportunities arise (Wenger, 2000). Exposure to new information “creates an environment in which ‘creative abrasion’, the synthesis that is developed from multiple points of view, is more likely to occur” (Powell and Grodal, 2005 p59). Thus, according to Carlile (2004) knowledge is seen, both as a source of, and a barrier to, innovation. In support of this, research by Dolinska and d'Aquino (2016) suggests that innovation is stimulated the most at the intersection of horizontal interaction both inside farmers' communities of practices and external interactions of the community's members with other actors. This also corresponds to the notion of ‘edges’ as providing opportunities for interaction, learning and dialogue across boundaries and for stimulating ideas and knowledge development (Turner et al., 2003).

Furthermore finding common knowledge at boundaries can promote effective exchange and this is often the basis of boundary processes (Roberts, 2006). Tisenkopfs et al. (2015) provides examples of boundary work in a number of sustainable agriculture networks where individual knowledge stocks are translated into collectively shared knowledge and innovations for sustainable agriculture. Thus boundaries can be places of knowledge combination and in this respect can contribute to the linkage processes described in niche-regime interaction (Elzen et al., 2012, Klerkx et al., 2010, Smith, 2007).

The paper draws on these different perspectives on boundaries to inform and examine the hypothesised disjuncture or connection between the knowledge systems of the Permaculture niche and the regime. Specifically it examines the extent to which the niche knowledge system confronts or enhances the AKS. The complementary theoretical contributions to this framing are set out in Table 1 which shows through the linking arrows that the divide between confrontation and enhancement is not a distinct one, in accordance with views about a diffuse niche-regime interface. Taken together these constructs provide a framework for the methodology described in Section 4.

Table 1 Theoretical contributions framing the interaction between niche and regime (AKS) knowledge systems

Theoretical Concepts	Niche knowledge system confronts (challenges and contests) the AKS	Niche knowledge system enhances (diversifies and invigorates) the AKS
Transition	<p>Niches develop to overcome stable and difficult-to-change socio-technical systems</p> <p>Limited diffusion of radical ideas into regime; incompatibility (Smith, 2007)</p> <p>Niche KS confront and destabilise regime AKS (Knickel et al., 2009)</p> <p>Insider learning restricts external linkage (Seyfang and Haxeltine, 2012)</p>	<p>Niche-regime linkage processes enable learning and knowledge exchange (networking, translation, boundary processes) (Smith, 2007)</p> <p>Niche (KS) contribute to regime adaptive capacity (Ingram, 2015)</p> <p>Learning, networking, shared expectations develop the niche (Kemp et al., 1998)</p>
AKS	<p>2nd order niche learning confronts 1st order AKS learning (Brunori et al., 2013, Knickel et al., 2009)</p> <p>Conventional and ecological KS differ according to key elements (Roling and Jiggins, 1998)</p>	<p>AKS 1st and 2nd order learning combined in diverse AKIS (Leeuwis et al., 2004)</p>
Boundaries	<p>Bounded knowledge in niches (Wenger, 2000, Carlile, 2004)</p> <p>Lack of common knowledge as a barrier to innovation (Cash et al., 2002)</p>	<p>Boundary processes (Cash et al., 2002)</p> <p>Collectively produced knowledge (Tisenkopfs et al., 2015)</p> <p>As a space for unusual learning and a source for innovation (Carlile, 2004)</p>

(KS=knowledge system)

3. The context - Permaculture in England

Permaculture, a global movement which emerged in the late 1970s, is an approach to the design of community and agricultural systems according to the principles that mimic ecological systems (Holmgren, 2002, Mollison, 1988, Veteto and Lockyer, 2008). Permaculture is primarily associated with multilayered perennial polyculture agricultural practices, however, its wider goals are transformative in that it reframes agri-food systems. The Permaculture community in England is an emerging niche⁴ that questions the operations of the mainstream agricultural regime. It advocates a radical shift in patterns of thinking and action towards new agri-food systems framed around agro-ecological principles and social development, as this statement from the Permaculture Association's strategic plan demonstrates:

⁴ The term niche is used here to describe the Permaculture community in England, it might also be thought of as a niche entity developing in the value space of a wider agroecological niche.

"Many researchers, including myself, believe that Permaculture should form the basis of agricultural and social development. The establishment of a large number of small, Permaculture type farms serving local communities and adapted to local conditions, would create tremendous cultural as well as biological diversity, because farming would no longer be geared to uniform global production. Permaculture based mini-farms could be the key to agricultural and community regeneration." Dr. John Zarb, Newcastle University (Permaculture-Association, 2011)

This broad vision is shared by a diffuse network of diverse individuals, communities or projects comprising an estimated 500 community level projects, farms and smallholdings and many thousands of individual practitioners. The community in England is supported by the Permaculture Association (PA) a membership organisation (over 1200 individual, 67 group, and 18 business) (Permaculture-Association, 2011). These figures together with the 5000 UK circulation of the Permaculture Magazine indicate an established community.

However, Permaculture is associated with a lifestyle movement, described as an eclectic and adaptive approach founded on traditional ecological knowledge and broadly concerned with sustainable human habitats (Veteto and Lockyer, 2008). For this reason it is seen to lack a good evidence base and not accepted nor supported by the AKS. Holgrem (2011, p 23) noted the challenge being addressed "there is a perception of lack of intellectual rigour, which has continued to inhibit the concept being taken seriously in academia". Equally data is seen as an important resource for influencing farmers as a Permaculture magazine article notes "Without the collection of precise statistics - and in particular financial information - Permaculturists will continue to struggle to persuade mainstream farmers to implement their ideas" (Perkins, 2012). Permaculture therefore represents a useful case study in which to examine the paper's main premise, as it is a radical niche which potentially encounters some challenges at the interface with the ASK.

It is not the intention to describe the agri-food regime or the AKS in England in detail here. The regime's dominant narrative is largely techno-centric with technical innovation, efficiency and competitiveness at the core of government and industry strategies, with the mainstream concept of sustainable intensification capturing this together with the recognised need to limit environmental damage (Defra, 2013). The AKS in England (Curry et al., 2012, Garforth et al., 2003, Prager and Thomson, 2014) is described as fragmented, complex (public-private) and open with some 22 key diverse actor organisations providing a range of support for private and public goods. It is characterised by heterogeneity as described in Section 2.4.

4. Methodology

The Permaculture community in England was a case study within the three year EU funded project SOLINSA (Support of Learning and Innovation in Sustainable Agriculture). This project aimed to understand the processes that enable niche to develop and grow, and specifically how they could be supported by the AKS. Following the project's analytical framework and criteria, the Permaculture case study was selected to represent a radical innovation (Ingram, 2015). In line with the transdisciplinary approach of the project (Home and Rump, 2015) the researchers took an action-research approach; the research team and

the Permaculture actors met regularly over the three year project period to encourage mutual learning and to co-plan research activities. Key themes and questions related to confrontation and enhancement, as derived from the literature and summarised in Table 1, are presented in Table 2. Data collection activities and their timings are listed in Table 3.

Table 2 Framing the analysis: themes and questions underpinning data collection

Confronts (challenges and contests): combined characteristics from Table 1	Questions used in all data collection methods
<p>Niches develop to overcome established socio-technical systems.</p> <p>Niches KS confront and destabilise regime AKS</p> <p>Different knowledge systems exist</p> <p>Limited diffusion of radical ideas into regime</p> <p>Insider learning restricts external linkage</p>	<ul style="list-style-type: none"> • What are the ambitions of the niche with respect to transforming the regime? • What processes are in place to achieve ambitions and how successful are they? • Are there different knowledge systems and if so what are their characteristics? Do they have different value systems? Absence of common means of validating knowledge claims? Strong internal ties? Is the knowledge in each (un)familiar, (ir)relevant, (in)accessible? • How do Permaculture and AKS actors value, perceive and judge each others knowledge with respect to scientific credibility, inspiration, validation of their own knowledge and beliefs? • What are the barriers for connection and diffusion of ideas between niches and the AKS?
Enhances (diversifies and invigorates): combined characteristics from Table 1	
<p>Niche-regime linkage processes enable learning and knowledge exchange (networking, translation) and boundary processes allow collectively produced knowledge</p>	<ul style="list-style-type: none"> • What are the connections between Permaculture actors and the AKS? Formal or informal connections at individual or institutional level? Do Permaculture and AKS interact at the level of research, advice, education or training? • What are the opportunities for connection between Permaculture and AKS actors? Do they engage in any joint activities/ partnerships? Are there boundary organisations? Brokers? Spanners?
<p>AKS 1st and 2nd order learning combined in a more diverse and adaptive AKIS</p>	<ul style="list-style-type: none"> • How effectively does the conventional AKS meet the information needs of Permaculture actors? And vice versa. • Is there any creative combination of knowledges or innovation at the boundary?

Data collection methods

Data collection was primarily through a series of participatory workshops supplemented by interviews, participant observation, document analysis and informal meetings, all facilitated by the Permaculture Association. This is in line with typical strategies for data collection to understand transition processes (Smith et al., 2010). Overall these activities focused on understanding the niche knowledge systems and its interaction with the AKS as well as wider aspects of agroecological knowledge system connections with the AKS. More specifically mechanisms for learning and sources of information were evaluated, as were the structural and cognitive elements of knowledge systems referred to in Section 2.1. Table 2 lists the specific themes and questions which shaped the interviews and the workshop discussions and exercises.

Table 3 Data collection activities (PKS=Permaculture Knowledge System)

Activity and Date	Respondents, participants	Workshop methods and focus of questions	Knowledge system - main elements studied
AKS participatory scoping workshop 2nd June, 2011 (Workshop 1)	6 individuals from farmers' union, government agriculture department, research organisations, NGOs and National Rural Knowledge Exchange Initiative	Systems analysis: What is enabling or hindering effective support of learning networks?	AKS research, training and support of learning, dissemination, networking support for niche
Four Permaculture participatory workshops (2-5) November 29, 2011 March 19, 2012 November 11, 2012 July 10, 2013	Permaculture stakeholders (practitioners, Permaculture Association representatives)	2. Visions and values; Permaculture knowledge system operation, Permaculture Association development and governance; group timeline construction; 3. Knowledge networks, sources of information, learning, and inspiration (mapping of key influencers) 4. Individual learning (story-telling to ascertain personal experiences and learning journeys) 5. Integrating with mainstream agriculture (FarmLAND); reflecting on project experiences, opportunities for interaction with AKS, visions for Permaculture's future	Learning (individual and shared) Dissemination Training Networking and working at the edge
AKS and the agroecological knowledge system participatory workshop 24 April 2013 (Workshop 6)	Participants from the AKS and the agroecological knowledge system at a national level.	Personal experiences with knowledge exchange initiatives (rich pictures methods): Boundaries and connections between the conventional AKS and the agroecological knowledge system Forces (Force field analysis) enabling and constraining connections between the agroecological knowledge system (s) and the mainstream knowledge system	Networking, mutual learning, boundaries
PKS face-to-face and telephone semi-structured interviews 2011-2013	14 individuals from the Permaculture community Permaculture Association CEO;	Learning and networking processes Opportunities to interact with the AKS Mainstreaming Permaculture	PKS Individual learning Networking and working at the edge

	Research Coordinator; Research Advisory Board x 6; Communications Officer; LAND coordinator; tutors Practitioners (including dairy and organic farmers)		
AKS face-to-face and telephone semi-structured interviews 2011-2013 (after workshop2)	13 individuals from AKS	Approach to providing information and opportunities to interact with agroecological niche Perspectives on alternative niche	AKS Research Training and support of learning Dissemination Networking
PKS document analysis, FarmLAND and LAND documents 2011-2014	Strategic Plan (Permaculture-Association, 2011) Research Strategy (Permaculture-Association, 2014 p4) Permaculture knowledge platform (website)	Visions and goals; membership Structure and governance of learning Training Research	PKS Research Training and support of learning Dissemination Networking
<p>PKS participatory observation at events: Permaculture Association Research Advisory Board: Work Plan meetings , Academic Development Sub-Group Meeting (December 2012 and May 2013)</p> <p>Workshop: Linking Permaculture and academia: new directions for research and practice Feb 10, 2012</p> <p>Workshop: Polyface Farming Systems April 28, 2013</p>	<p>Research Advisory Board</p> <p>Permaculture practitioners, Permaculture Association actors and UK academics (ecologists, systems scientists, anthropologists)</p> <p>Multiple stakeholders (researchers, practitioners, farmers, intermediaries) active in agroecological and conventional systems</p>	Research plans and activities, joint research with AKS actors	Research and practice

Three sets of participatory workshops were held. Firstly a scoping workshop (1) with AKS actors at a national level was held to conduct a knowledge and innovation systems analysis identifying factors which enable or hinder effective support of learning networks (niches). This provided an overview of the operation of the AKS with respect to fostering alternative networks and niches, and helped to consolidate the themes and questions for the data collection that followed. Secondly four participatory workshops (2-5) were co-convened with the Permaculture Association and held at approximately six-month intervals over three years. These were co-designed with the Permaculture Association staff and run by the project researchers. Invitations were advertised through Permaculture Association newsletters (>1000 membership) and website accessible to all practitioners. Some 15-20 different participants attended each workshop, these represented the diverse range of actors who engage with Permaculture in England including: practitioners with land holdings of different sorts and sizes; tutors who teach Permaculture design and Permaculture Association staff and representatives. Each workshop was held in a different region and were designed to progressively cover all the themes in Table 2. Any strong or new themes that emerged were used to inform the following workshops or interviews. Thirdly a workshop was held to bring together participants from the AKS and the wider agroecological knowledge system at a national level. There are no official datasets for this population so participants were invited from a sampling frame of advisers, project officers, policy makers, researchers farmer organisations, NGOs who provide knowledge and advice within mainstream and agroecological agriculture (including organic farming, regenerative agriculture, agroforestry, agri-environment management, conservation).

Face-to-face and telephone semi-structured interviews were also carried out with 14 individuals from the Permaculture niche. Purposive (based on lists suggested by the Permaculture Association) and snowball sampling was used to select respondents involved in some way with knowledge generation, utilization and coordination. Practitioners, tutors, Permaculture Association staff and advisory board members who had a long history of involvement and could provide a board range of views and experiences. The questions on the interview schedule were derived from the main themes (Table 2).

These were complemented by 13 face-to-face and telephone semi-structured interviews with AKS actors representing research, advice, intermediaries and policy and decision makers. Again these key informants were selected purposely using personal contacts and website searches, and through a snowballing technique to capture those who are engaged in providing or coordinating knowledge. They took place as part of the wider project research and were used to provide insights into the activities of the AKS and the linkages with emerging niche. Overall workshop and interview selection methods aimed to capture a range of Permaculture and AKS actors, with respect to age, gender, background, training, experience, location and type of site.

Document analysis included the key strategic documents produced by the Permaculture Association, focusing on their knowledge system, i.e. the provision, structure, function and governance of research, education and training. Participant observation data were collected over the project period. This consisted of the project researchers attending and contributing to a number of Permaculture community events and discussions concerning

research strategy and collaboration (Table 3). This allowed observation of interactions between Permaculture and AKS actors.

Workshop group discussions and interviews were recorded and transcribed and analysis of transcripts was undertaken manually based on repeated reading of transcripts and notes (Table 2). The data from all the sources was triangulated, thus ensuring a greater degree of validity and coherence. Data were interpreted according to the key themes and questions identified above and analysis is presented in the next section according to the main knowledge system structures and processes. The analysis sums up all the structural and cognitive elements that together define the Permaculture Knowledge System (PKS) and its linkages with the AKS, and in doing this aims to address the paper's key question, to what extent does the PKS confront or enhance the AKS?

The results refer to 'the AKS' or 'AKS actors' or 'niche knowledge system' as shorthand for the multiple system components and interactions. It is not the intention to suggest that knowledge systems act as homogenous entities with agency, since they are mental constructs or framework for understanding knowledge actors, structures, networks and processes and innovation support services.

4. Results

The results section starts with an overview description of the PKS drawn from a synthesis of data from all the sources. This identifies the key subsystems and processes active in the PKS (research, training and support of learning, dissemination, learning and networking, boundary crossing and working at the edge) which are used to structure the analysis that follows. This analysis draws on all data sources to build a picture of the knowledge processes operating within the niche and across the boundary with the AKS.

4.1 The Permaculture Knowledge System (PKS)

The analysis reveals a distinctive Permaculture Knowledge System (PKS) which has emerged around the Permaculture niche. This is characterised by a broad community of individuals and groups who learn experientially, and share and validate their knowledge through multiple social networks, supported by codified design principles and a formal set of structures and activities run by the membership body, the Permaculture Association. Here the term 'PKS actors' is used to refer to all those involved in this system.

Knowledge and learning are at the centre of the Permaculture niche. This learning is intimately connected to participating in a community of Permaculture practice. The process is guided by a belief in the Permaculture principles, self-reliance and a trust in the system of production. The ethos is one of mutual support through shared learning, both in terms of the core ethics, and with respect to practical knowledge about design tools and techniques. Permaculture is underpinned by a certain set of values and understandings of what constitutes valid and relevant knowledge. However, there are multiple personal understandings of what Permaculture means and, as such, approaches to learning vary: for some it is a scientific process, for some practical, for others it is a philosophical or even a spiritual one.

To support this a more formal set of structure and processes have been established. The community globally and locally draws on codified resources, mainly the Designers Manual (Mollison, 1988), that all respondents tend to refer to as “the bible”. In England the Permaculture Association formalizes, coordinates and aggregates knowledge. It aims to promote the understanding of the theory and practice of Permaculture in England through education, training, advice, support, information and research for members and a wider audience; also to legitimise the design principles, provide accredited training courses, disseminate information and coordinate research. The strategic plan describes two phases of ambition, firstly to develop the capacity of the Permaculture Association and wider networks, create a vision of what is possible, and develop new systems to support practitioners; secondly to reach out to new groups and sectors, scale up the scope and ambition of the work and facilitate a step change (Permaculture-Association, 2011). Implicit in these aims is the confrontation of the conventional regime through the development and effective functioning of a PKS. It is apparent that in each of main subsystems and processes of the PKS there is a tension between internal facing activities which create and reinforce boundaries around the knowledge systems, and external facing activities that attempt to cross these boundaries.

4.2 Research

According to the strategy document the Permaculture Association aims “to research and share tools for ecological farming and land use, that create working models of resilient, productive and low-carbon land stewardship” (Permaculture-Association, 2016). Research is regarded as important, both in terms of improving Permaculture practice, and creating a robust evidence base to gain credibility within the AKS’s organisations. Perceptions of poor academic rigour from those outside the niche were apparent in the AKS interviews and workshop (1) and these drive the ambition to provide evidence. The Association’s Research Advisory Board (RAB) is in the early stages of developing and implementing a research strategy which states:

“Well-documented research [also] raises the profile and standing of Permaculture in civil society.... .. By providing an interface with academic research, our own research efforts also enable us to feed into policy-forming scientific debates, and improve access to relevant academic research for non-academics”. (Permaculture-Association, 2014 p4)

The Permaculture principles underpin the systems research approach with participatory methodologies and co-production of knowledge at the core. The Association views its network of practitioners as a ready-made research resource, this Practitioner Research Network (PRN) are seen to have the potential to carry out small scale, technologically simple research into a wide range of topics, as an interview respondent from the Research Advisory Board explained:

“One characteristic of Permaculture is large number of amateur practitioners in the field, in terms of practice the knowledge lives with the practitioners, so the structures we’ve created around research are intended to gather momentum, not reinvent the wheel, just do a few case studies... we have started some participatory

trials, so people can try things at home and report in a format that we can aggregate”.

Permaculture is also seen to provide a novel approach and to offer freedom for all researchers. The ambition is to bring together the data available from a number of plots and to produce a published research evidence base. This interview respondent explained:

“So a few years down the line we will put out paper to prove that Permaculture works and draw on evidence of applying principles to a plot from all continents, we will have 10-20 examples from the main ecosystems on the planet, we will go granular. We can offer evidence that Permaculture design works, the approach is working.” Research Advisory Board member

In this sense the Association wants to prove that Permaculture works, by seeking credibility with AKS researchers, and looking for validation according to the AKS rules of peer-reviewed publications. However, they are aiming to do this on their own terms, using non-conventional methodologies (e.g. small scale participatory trials of wheat and poly vegetable production) which they acknowledge may not be “scientific enough”, for mainstream research actors. Furthermore the Practitioner Research Network lacks research skills and equipment and there are inadequate systems for measuring and recording, since they have not historically carried out research in the conventional sense. They anticipate problems in communicating their findings to AKS research actors due to their approach and different views about what constitutes valid knowledge. The interview respondent from the Research Advisory Board described the “difficulty of sticking your head above the parapet when you don’t fit with the norm”. These barriers are fully acknowledged in the Permaculture Association Research Strategy (Permaculture-Association, 2014).

There are, however, areas of common understanding and knowledge between PKS and AKS research approaches. Some interview respondents and workshop participants pointed to fundamental agroecological principles, such as nutrient cycling and nutrient use efficiency, which were described as ‘value-neutral knowledge’ that researchers in both knowledge systems draw on in framing their research. Furthermore, it was evident in the agroecological workshop (6) and in the interviews that both communities recognise that a systems research approach has more potential to understand interconnected sustainability issues compared to discipline based research. Permaculture Association actors observed in research planning meetings explained how they are planning to exploit this potential commonality to access new streams of research and project funding.

4.3 Training and support of learning

A well-developed training programme exists delivering the Permaculture Design Course, viewed by many as an essential route into Permaculture, and the higher level Diploma in Applied Permaculture Design. In the community overall there are over 100 trainers, over 3500 design course graduates and 90 Diploma holders (Permaculture-Association, 2011). According to workshop participants the training style emphasises participatory approaches and co-learning, reflecting the Permaculture sharing ethos. One course tutor interviewee commented:

“If you think of Permaculture design as a culture, everyone who does a design course goes through a similar sort of processit is quite inspiring and transformative to be working with a group of like-minded people”. Permaculture course tutor

It became clear from the interviews and workshops with Permaculture Association staff, and tutors and practitioners in the community, that attaining the qualifications confers some level of cognitive authority on the participants and builds a critical competence. It also represents a level of investment in knowledge, time and money, both by tutor and trainee, since the courses can be demanding. These aspects, together with the style of mutual learning tend to build and strengthen internal connections, reinforced by a shared outlook. This is evidenced by comments from Permaculture practitioners, for example, one said: “I found the meeting point [at the training course] is the Permaculture principles and the ethics...I’ve always felt this is good because people are speaking a similar language”. However this language is not always accessible to those outside the community.

This limits the transferability of courses to outside the niche. Reconciling the training with mainstream learning systems is problematic since it is difficult to standardise curricula, and to monitor, evaluate and certificate the courses. However the Permaculture Association has negotiated the accreditation of some design course modules by a leading adult education awarding body. This marks the first stage in making the course content accessible to a wider audience and partly fulfils one of the Association’s strategic goals which is to mainstream Permaculture education. Thus, although training tends to reinforce a closed knowledge systems, there is an element of boundary crossing into the AKS with more conventional educational institutions. According to workshop (2) respondents however some “purists” in the niche argue that, by dividing courses into practice modules, the holistic nature of Permaculture is lost.

4.4 Dissemination

Dissemination activities are aimed both at informing and connecting existing Permaculture practitioners, and reaching out to the public, new groups and sectors. The main mechanisms used by the Permaculture Association are newsletters, events, the website, advice and support by phone and email and demonstration networks. The independent Permaculture Magazine also provides an important role in this respect. The Association’s ‘Learning And Network Demonstration’ (LAND) and Farming (FarmLAND) initiatives in particular represent opportunities for diffusion of Permaculture knowledge to AKS practitioners operating in the field. LAND is a network of some 80 small scale demonstration sites. Although largely intended to link existing practitioners, some demonstration site managers interact with their local community, as one LAND network interview said “We have contacts on many fronts, farmers, local government, architects, urban food growers, we’re reaching out to a lot of people”. However, both (Permaculture) interview respondents and workshop (3, 4) participants remarked on the difficulties in communicating Permaculture principles to these people saying, for example, “Permaculture is easy to understand but not easy to explain”. As a consequence most success in LAND has been in enhancing learning amongst those already practicing Permaculture, that is, reinforcing the PKS boundaries.

The FarmLAND initiative aims to support and promote Permaculture design at the farm scale by working with farmers and AKS partners and training organisations using demonstration sites, group visit scheme, events. It is ambitious and largely aspirational. So far it has attracted interest mainly from already interested smallholders. The difficulties of attracting AKS actors to the events is captured in this comment by a Permaculture practitioner interviewee involved in the initiative who described attempts to communicate with local farming union representatives: “We have been trying to knock on door of the NFU [National Farmers Union] for ages without success...NFU is a hard nut to crack”. FarmLAND events have however been used to disseminate agroecological ideas to a wider farming community and conventional farmers and advisers have attended these, although there has been some scepticism. One practitioner, a dairy farmer, interviewee, who is implementing Permaculture design at a farm scale, described an organised farm walk led by a well-known expert in mob grazing:

“The meeting attracted some local farmers. All the people for Permaculture design course also came. Some of the farmers thought they were a bit weird and one described them as ‘fanatical’. I thought I can see what you’re saying. But you’re looking at it purely from a farming point of view and not listening to what they are saying. Sometimes we can come over as quite fanatical”.

A lack of mutual understanding appears to be the main barrier to communication, one problem being that Permaculture is frequently misunderstood by AKS actors, as one organic farmer interviewee applying Permaculture principles explained:

“Even to the closest farmers that we work with, if you said do you know what Permaculture means? If they do, it will be nothing to do with us. They know that we’re organic, and they know that we’re grass fed”.

According to Permaculture Association representatives and workshop (1-4) participants a few larger scale ‘mainstream’ farms have engaged, some attracted by the notion of Permaculture design, but most by single practices which can be implemented on conventional farms (e.g. mob grazing, sustainable soil management). Some Permaculturist interviewees however describe such uptake as “piecemeal” and accuse farmers of “cherry picking”. This extraction of selected practices is an anathema to many who regard the Permaculture approach as indivisible and holistic. Interestingly from the perspective of those in the AKS, many of these practices are not uniquely Permaculture but are already in use in conventional and agroecological systems. Arguably AKS actors are claiming and rebranding these to find entry points for diffusion into conventional farms. Despite this, the initiative is providing some new encounters and learning experiences for both mainstream and Permaculture practitioners. Workshop 6 participants reinforced this view pointing out that some agroecology practices and approaches are becoming more acceptable than before.

As well as showing that Permaculture concepts are difficult to communicate to those outside the community, interviews and workshop exercises with AKS actors also reveal AKS actors’ resistance to new ideas. Workshop (1, 6) participants described mainstream farmer groups as “inward looking”, conditioned by their background with a common “shared food

production narrative". One AKS representative (an agricultural adviser) at workshop 6 commented on the insularity of conventional farmer groups saying "you get the 'group-think' where people reinforce knowledge and values but not bring in new stuff". The workshop (6) discussions identified entrenched views, different value systems and the dominant discourses of the AKS actors perpetuated by, according to participants, the agricultural education system, the dominant food production and techno-centric discourses. This limits communication across the boundaries between the AKS and the wider agroecological niche. Workshop (6) participants suggest that there is an agroecological knowledge system but that "it is not singular; there are many knowledge systems". The nature of these was described as "a loose collection of interested people and organisations but with no particular structure". Some participants also described boundaries within boundaries which reveal different degrees of division and entrenchment.

4.5 Learning and networking

It is apparent from conversations in the interviews and workshops that Permaculture practitioners have a considerable personal investment in experimental learning and have built up a significant level of individual, context-specific knowledge. Learning is also part of active participation in a community and sharing information freely is a central element of the PKS, as one workshop (2) participant (practitioner) said "Permaculture is about connections and the sharing we are not holding 'my bit of information' but we give it away to as many people as possible".

At the individual level practitioner respondents (interviews and workshops) described the need to enhance their discovery driven learning by absorbing knowledge from others. They welcome the chance to interact (virtually or at events) with others implementing Permaculture design and to share and validate their learning. This sharing is enabled by people having the same worldview, according to one workshop (2) participant.

You go somewhere and you are all on the same page straight away. You don't have to explain what your methodology is. For example, when we're here together I know that you have the same sort of ethical mindset that I have. So I don't have to prove to you or explain my reasoning. Permaculture practitioner

The significance given to this tacit or 'unspoken' knowledge generated and circulated within the community, and the allegiance to those who share the same identify, beliefs and values, serves to strengthen internal ties and networks but also creates boundaries, restricting external communication. Knowledge also tends to be personified, there is a lot of knowledge embedded in inspirational and charismatic individuals who act as advocates for Permaculture. These people were frequently referred to in interviews and workshops.

Permaculture actors who were interviewed or attended workshops expressed reluctance to engage with AKS knowledge or actors. This was explained both in terms of their strong belief and conviction in Permaculture, and their ideological opposition to the conventional agri-food system. AKS information is regarded as irrelevant to the local contexts in which Permaculture actors operate, and as not addressing the more complex problems they face as they attempt to implement Permaculture design at a holistic or systems level. Furthermore knowledge from conventional agriculture sources is perceived as privatised

and inaccessible, and in this respect contrasted to the freely available shared knowledge of Permaculturists.

The Permaculture niche constituency of practitioners however is diverse, and they hold different views and demonstrate variable learning and information seeking modes. Not all look exclusively inwards to the Permaculture community for support. Some are exploring new interpretations and new ways of operationalising Permaculture, tapping into networks outside of the PKS. Workshop participants, for example, identified a number of individuals and organisations they look to for information and inspiration, although they do tend to be in the wider agroecological niche or with similarly marginal networks who share the same transformative ambition for the agri-food system (e.g. local transition groups, agroforestry community), and rarely the established AKS organisations (public and private research, advice and education), progressive farmers or sectoral support.

4.6 Boundary crossing and working at the edge

Although most of the data collected characterises the PKS as bounded and reinforced by practitioners' shared learning, practice and values, some respondents conversely argue that Permaculturists by their very nature outward looking, as one interviewee (Permaculture plot owner and tutor) explained:

"In Permaculture design we often say everyone is working on an edge and the edge is the most productive part of the system, where two environments meet or mix or intermingle, so there is greater species diversity and greater interaction between the two systems. We've got Permaculture designers living 'ordinary lives' with jobs and stuff like that but they are looking from a different perspective and the perspective is shared, which is fantastic.... The association is continually breaking new edge, making new connections and as an organisation is forming partnerships. They are very much outward looking.... There is room for many different perspectives. It is a design system that is adaptable to different people, different places, and different environments".

Others support this view arguing that Permaculture, in that it integrates many different perspectives, is externally facing. Indeed it is described by some as being 'magpie-like', collecting and drawing on a wide range of ideas and practices. For example practices such as mob grazing, low-carbon farming, agroforestry, which have emerged within a number of 'alternative' and conventional farming arenas are claimed and re-interpreted by the Permaculture actors. This is in accordance with the many different interpretations of Permaculture held by those in the community.

Furthermore interview respondents from the Permaculture Association staff who take a more strategic view in particular argue that as the niche and regime actors ultimately share the same ambitions for a more sustainable agriculture, more synergies and partnership opportunities will emerge. The need for integrated approaches to tackle complex problems of the modern food system can also be seen as an opportunity for the Permaculture systems approach, as one interviewee (Research Advisory Board representative) remarked Permaculture's "time has come". In support of this Workshop 6 participants from AKS and agro ecological knowledge systems remarked that they want the same outcomes but have

different ways of getting there, applying common principles (soil biology or ecology) in different ways.

In this respect the Permaculture Association strategic plan articulates their intentions “We have worked hard over the last ten years to move Permaculture from being seen as a ‘fringe’ or ‘alternative’ concept, to one at the heart of sustainability thinking” (Permaculture-Association, 2011 p6). In enacting this, regime concepts such as sustainable agriculture, sustainable intensification, mitigation and catchment based approaches are re-interpreted through a Permaculture lens. Furthermore it was also considered by workshop 6 participants that the AKS needs to adapt and absorb agroecological knowledge to respond to new challenges in agriculture but that they “do not know this”. Also it was generally felt that the AKS cannot meet the needs of those in the agroecological knowledge niche without some modification, due to the different underlying belief systems.

To operationalise the plan to penetrate the AKS, Permaculture Association staff are active in forming external connections with a range of organisations (largely in the wider agroecological niche), they also seek out and look for support from sympathetic regime actors. Although the Permaculture Association sees itself as a “connector, facilitator and enabler, and keeps network wide administrative and communication systems in good working order” (Permaculture-Association, 2011 p6), most interactions are informal often enacted at the individual level by key networking intermediaries. These actors are important in terms of their leadership role in the Permaculture community, however many interview respondents pointed to a lack of structures and funding for boundary work, and to the absence of any recognised boundary organisations, which they argue limits their attempts at networking.

5. Discussion

As observed in other niche contexts, knowledge is an important resource circulating in the Permaculture niche, and a discernable PKS has emerged. Boundaries are demarcated between this PKS and the established AKS, however these knowledge systems are diffuse and heterogeneous and the boundaries are characterised by differing levels of permeability to different sorts of knowledge. The knowledge processes in operation contribute to shared learning and the circulation (and aggregation) of knowledge within, and the flow across, boundaries. The interaction between these coincident internal and external knowledge flos is characterised by tension. Thus, instead of a simple notion of PKS confronting or enhancing the AKS, there are complex processes which both maintain and permeate boundaries between the two knowledge systems. Figure 2 illustrates the PKS and AKS boundary dynamics and the characteristics of permeable and impermeable boundaries.

The term knowledge flow is used to encapsulate the multiple diffusion processes observed; primarily the translation of ideas and practices; the translation of disassociated Permaculture and AKS knowledge which involves adaptation, negotiation and re-interpretation, as well as boundary processes (networking, intermediation). These have been described as active at the niche-regime interface in previous studies but not explicitly as knowledge processes (Seyfang and Haxeltine, 2012).

[insert Fig 2 title: PKS and AKS boundary dynamics: characteristics of permeable and impermeable boundaries]

5.1: Impermeable boundaries between knowledge systems: shared internal learning and limited knowledge flows

Knowledge flows between the knowledge systems are often constrained by boundaries around the PKS and the AKS which coincide with different sorts of values, knowledge, epistemological language, or epistemic divide, and different views of what constitutes reliable or useful knowledge (O'Kane et al., 2008). The absence of a common sort of knowledge is a defining feature that creates and maintains these boundaries. This results in a set of cognitive barriers which limit boundary permeability.

Shared internal learning

Learning through experimentation at the local level contributes to expertise and everyday skills concerning 'how to do Permaculture' (aligned to first-order learning). At the same time learning about Permaculture ethos and principles, through shared activities and learning with others, leads many to adopt new systemic approaches to and understandings of land management to question and challenge the assumptions of mainstream agriculture, these alternative cognitive frames and different ways of valuing and supporting the niche are aligned to second-order learning.

Knowledge in every element of the PKS is centred around values, beliefs and co-produced through experience and mutual support. This creates a common repertoire, a range of communal resources, routines and ways of doing things that have become part of the niche's knowledge system over time. Such cultural resources such as tacit knowledge, tactical repertoires, organisational templates, technical or strategic know-how are linked to cultural competencies and collective identities are described in studies of social movements which share characteristics with niche (Williams, 2004).

Aligned to this the PKS knowledge has a tendency to circulate internally with boundaries maintained by these shared internal understandings, a common epistemological language, invested knowledge, and the cognitive authority attached to personified knowledge and to Permaculture training and qualifications. This internal learning creates an insular community and an inclination towards being self-referential, engaged only in reproduction of Permaculture practices and knowledge supporting the niche's own development but not translating it beyond its boundaries. This situation where actors are locked into their relationships, which blocks new ideas from outside and prohibits other potentially fruitful collaborations has been referred to as 'insider learning' (Seyfang and Haxeltine, 2012) with respect to grassroots innovations, as strong network failure in business contexts (Håkansson and Ford, 2002), and seen as limiting innovation system function overall (Hekkert et al., 2007).

Limited knowledge flows

Such knowledge is hard to standardise and codify and lacks a means of validating it according to the rules and assumptions of the AKS where science and farming generate their authorised knowledge and associated values; and where shared entrenched views ('group think') in support of conventional agriculture are also evident. These distinctive learning

processes, tacit understandings and language make external communication with AKS actors not only difficult (Curry and Kirwan, 2014) but also unnecessary since Permaculture actors are well served by their own PKS while the universal, sector and discipline-oriented knowledge of the AKS is regarded as irrelevant. Diffusion, specifically the translation of Permaculture knowledge associated with concepts and values outside the community is therefore limited. Dissemination activities are hindered as niche actors find concepts hard to convey, while for the AKS actors they are difficult to comprehend especially when they are “looking at it [Permaculture] purely from a farming point of view”. This is further hampered by the AKS actors’ perception that knowledge generated in the PKS, and associated claims, lacks rigour. By denying validity of Permaculturists’ knowledge, they inevitably reinforce their own knowledge systems.

All these experiences reveal a fundamental reluctance in both the PKS and AKS to relinquish or compromise their existing knowledge, acquired through experience, training or research. As Carlile (2004 p556) points out, where knowledge is invested within a given practice—it should be seen as “at stake,” indicating the significant costs associated with giving it up and acquiring different knowledge. He describes the difficulty actors have in abandoning previous knowledge as the “curse of knowledge”, as a common property of knowledge at a boundary (Carlile, 2004 p557). Furthermore strong internal actor identity formation in both knowledge systems can inhibit knowledge exchange. This corresponds to observations in social movements where boundary work entails constructing both a collective self and a collective other, an “us” and a “them” (Williams, 2004).

Thus shared internal learning reinforced by strong values and beliefs in Permaculture consolidates the niche and reinforces the PKS boundary, while absence of common understanding limits the translation of Permaculture concepts and ideas beyond the respective knowledge systems boundaries. Boundaries are maintained by actors in each knowledge system stewarding and protecting their own critical competence (Cash et al., 2003).

5.2 Permeable boundaries between knowledge systems: disassociated knowledge flows and boundary processes

Knowledge flows

While the translation of Permaculture knowledge attached to concepts is constrained, there is some boundary permeability to disassociated Permaculture knowledge, and where some commonality in knowledge occurs. As noted by others, the translation of ideas is more difficult where there is a fundamental clash of values, ideas, and practices and needs additional diffusion pathways and adaptation (Seyfang and Haxeltine, 2012). There is evidence of such pathways being forged and some boundary permeability enabled by mutual interests.

At a strategic level arenas of common interest are opening up whereby sustainable agriculture concepts emerging from both knowledge systems can be shared. Interest in multiple and overlapping interpretations of sustainable agriculture (e.g. agroecology, diversified farming systems sustainable intensification, ecological intensification, multifunctional, organic or eco-agriculture); and in regional and local systems of ecological, economic and community development as ‘solutions’ to unsustainable approaches (Kremen

and Miles, 2012, Marsden, 2012, Wezel et al., 2015) offer spaces for finding a common understanding between the Permaculture and regime knowledge systems, and for PKS actors to adapt, negotiate and re-interpret it. The niche is exploiting these openings or windows of opportunity by interpreting the niche's knowledge in a way that is compatible with the AKS actors' framing of sustainability challenges, as described by Smith and Raven (2012). In research 'value-neutral knowledge' (e.g. nutrient cycling, soil biology) and systems approaches also provide opportunities for mutual learning between the knowledge systems. Thus the boundary can be a place of knowledge combination and potentially mutual reinforcement as described in other niche-regime interaction contexts (Elzen et al., 2012, Klerkx et al., 2010, Smith, 2007).

At the same time this underlying common purpose has led to the accreditation of Permaculture training modules by national education bodies, bringing PKS and AKS courses together under a common curricula. A shared desire to farm more sustainably has also brought tentative connections between PKS and the AKS actors at the field level, with the translation of selected Permaculture knowledge and practices into mainstream farming. This is through individual networking or more formal dissemination activities fostered by structures and intermediary activities of the Permaculture Association. Together these provide entry points to link Permaculture to the relevant actors and institutions of the AKS.

However, this brings its own set of tensions. The flow of this disassociated knowledge is criticised by some Permaculturists as 'piecemeal', extracting the knowledge and practice from its value setting and failing to embrace the full concept, achieving only a partial transformation. Such division and appropriation, as described for organic farming, and other social movements, is resented and seen as a threat (Darnhofer et al., 2008, Morgan, 2011, Williams, 2004). This is also part of a more general concern for Permaculture founders like Holmgren (2005) who lament the slow shift of Permaculture away for its true values whereby its scope and objectives are significantly understated. This tension has been described elsewhere, where niche actors engaged in 'oppositional' social movements wish to grow their movements, but not at the cost of 'selling out' and incorporation into mainstream contexts, and leads to conflict among niche actors (Hielscher et al., 2011). From the perspective of the regime, although some discrete practices might be appropriated, there is still fundamental resistance to Permaculture's holistic ideology. Thus the regime tends to accommodate distinct divisible knowledge and practice according to the notion of first-order learning familiar to the AKS rather than the more systemic second-order learning of the PKS.

There is also a suggestion that selected knowledge from the AKS flows into the Permaculture community (and often claiming it as their own), which is described as "very much outward looking".... with room for "many different perspectives". The 'magpie-like' collecting tendencies of PKS actors and the 'cherry picking' by some regime farmers represents a translating back and forth within the context of events, meetings, networking, research consortia and partnerships in which PKS and AKS actors negotiate and reframe agroecological, conventional agriculture and other concepts. Some in the niche describe Permaculture as "a design system that is adaptable" and open to such processes. This adaptive translation process, in which the niche and regime adapt to accommodate each other's ideas is a diffusion process described elsewhere (Smith, 2006a).

Activities in the research subsystem provide another example of boundary permeability where knowledge can potentially flow between knowledge systems. Providing evidence from research about Permaculture efficacy compared to mainstream agriculture is seen as one of the most important strategies to confront and challenge the AKS. However in doing this, the Permaculture Association face an interesting paradox as the data is derived from unorthodox participatory research methods and as such challenging the methodological rules of the AKS. On the other hand, they consider that complying with the rules of the regime and seeking legitimacy through peer review publication will be the most effective way to convince AKS actors. They recognise they will face opposition, as described for the organic movement who encountered problems establishing scientific proof due to the ecological philosophy held by activists and the need to understand the full system (Smith, 2007); and for the agroecology more generally whose credentials as a scientific discipline are critiqued by mainstream actors (Dalgaard et al., 2003). However the Permaculture Association, together with interested AKS researchers, are optimistic that there is now an appetite for this evidence and that it will provide innovative solutions to emerging problems and so mutually reinforce and enhance mainstream research.

Boundary processes

Finding common knowledge at boundaries can promote effective exchange and provide the basis of boundary processes (Roberts, 2006). However to fully exploit such openings requires boundary work to negotiate interactions between different knowledge systems while maintaining the integrity of each. Such boundary work is needed to manage the demarcations between and within different actors and align their different motivations, perceptions and expectations into common cognitive frames and concerted actions (Clark et al., 2011, Klerkx et al., 2010). In the Permaculture niche these boundary processes are enacted by actors at many levels. Individuals are active in informal external networking while Permaculture Association representatives take on the key intermediary role of enablers or community leaders as described elsewhere (Martiskainen, 2016). They connect with similar organisations in the wider agroecological niche and seek out supportive AKS actors in research, training and practice subsystems. They possess bridge building qualities and competences. Although not 'innovation brokers' or 'boundary spanners' (Swan et al., 2002) in the strictest sense, as their motivations and intentions are not value-free, they nevertheless are starting a dialogue with selected actors across the AKS. At the same time sympathetic AKS actors link with the PKS actors using mechanisms familiar to them such as the Research Advisory Board, research proposals, dissemination events (workshops and farm walks). These intermediation activities might be furthered as part of a concerted and managed upscaling diffusion process in which opportunities within institutional structures are identified to enabling embedding of the innovation (Hermans et al., 2015).

5.3 Confronting and enhancing the AKS

There is clearly a complex set of dialectic activities operating at the knowledge systems boundary. Thus the idea of confronting or enhancing the AKS should be re-envisioned as a blend of overlapping and contradictory processes. Typically these are a variety of internal and external forces and practices associated with boundary demarcation and crossing.

Firstly, with respect to confronting the AKS, PKS challenges to the AKS are articulated by the Permaculture Association through its strategy and operationalised through active dissemination and research programmes that aim to demonstrate that Permaculture represents a credible alternative to conventional agriculture. Permaculture goals are visionary and transformative and actors share expectations about innovation performance, they have strong networks and shared learning processes, all activities which contribute to effective niche building (Kemp et al., 1998; Hoogma et al., 2001). The role of informal learning processes in these niche building activities is significant. In support of this, there are formalised learning processes which draw on standardised rules and codified knowledge (manual of design principles). Furthermore the Permaculture Association has created a knowledge infrastructure to facilitate communication and provide a framework for stewarding and circulating knowledge from the field to provide evidence, and to deliver and share information amongst members. The membership organisation (Permaculture Association) nurtures a sense of community to facilitate information-sharing and social networking and beyond this acts as an intermediary actor who can ‘speak for the field’, and do the ‘socio-cognitive work of knowledge aggregation’, all aspects of what Seyfang et al. (2014) call the ‘hidden work’ of niche-building.

Together these processes should allow the niche to develop and build up momentum to challenge and confront the regime, furthermore the second-order learning in the PKS arguably helps in overcoming stable and difficult-to-change socio-technical systems. However, it would appear that, at least with respect to the PKS, the Permaculture niche is not yet robust enough to influence the AKS institutions or contribute to AKS reconfiguration. Boundaries constrain PKS actors’ effectiveness in confronting the AKS in terms of enabling diffusion of transformative principles and design into the AKS. Although there is evidence of connections being forged and some boundary permeability, most knowledge processes are consolidating internal learning or are incremental and related to the translation of dissociated knowledge and practices, adaptation and seeking legitimacy in the regime, not confronting or transforming the rules. Thus instead of seeking to change the institutional AKS structures and functions the PKS tends to either co-evolve with or adjust to the existing one (Smith and Raven, 2012). Accordingly, many in the AKS have yet to be convinced that Permaculture’s “time has come”, as some Permaculturists claim.

Permaculture is one of many niches in the wider agroecological niche, part of a loose collection of interested people and organisations sharing similar transformative goals. Arguably the Permaculture niche’s potential to confront and transform lies in its ability to consolidate, and aggregate learning and knowledge resources from multiple constituent projects, and to share learning ‘upwards’ by networking with a range of intermediary organisations in this wider niche. The power of such aggregation of cultural knowledge resources is described for social movements (Williams, 2004) and other niche contexts (Seyfang et al., 2014). This could build on and consolidate the shared learning, self-reliance, self-organisation and determination of the niche, characteristics that have enabled and sustained the niche’s development so far, and could become key components in future transformational potential.

Secondly with respect to the PKS’s potential to enhance the AKS, there is evidence of boundary crossing and opportunities for the PKS to bring innovation and diversity into the

AKS. Arguably the AKS can incorporate this novel knowledge and draw on fresh perspectives, for example, in new research methodologies, innovative field practices, and training. PKS actors claim that Permaculture offers new solutions for contemporary challenges, this is in line with views on social movements which are seen to be at the forefront of knowledge generation about crises in socio-ecological systems and as having the potential to generate alternative models needed to provide solutions (Chesters, 2012). However inevitably there is some resistance from AKS actors. Although many in the PKS and the wider agroecological niche are convinced that the AKS needs new knowledge to respond to new challenges in agriculture, AKS actors are described as failing to appreciate this. Additionally the translation of dissociated knowledge compromises the innovative aspects of Permaculture knowledge to such an extent that it loses its ability to enhance the AKS.

Diversifying the AKS can also be achieved through the boundary work and mutual learning opportunities described, and, in particular, through creative boundary processes or “continually breaking new edge”. The ‘edge effect’, an ecological concept that describes how there is a greater diversity of life at the boundary or interface between two biological communities (Holmgren, 2002, Turner et al., 2003), corresponds to the notion that radical innovation emerges following negotiation and reinterpretation of knowledge at boundaries (Powell and Grodal, 2005, Swan et al., 2002). Whilst there is no evidence from this research of new innovations being created at the AKS-PKS interface, there are opportunities appearing and conditions developing for nurturing these.

6. Conclusion

Transition is conceptualised as the outcome of interactions between niches and socio-technical regimes particularly in terms of the niches’ potential to influence the wider system (Kemp et al., 1998). Providing in-depth case study analysis of these interactions from a knowledge systems perspective advances understanding of niche-regime dynamics, it also highlights the important role of knowledge in sustainability transition pathways.

Sustainable transitions, in which niche advocate radical transformations, are inevitably disputed and controversial because they lead to confrontations of systems of knowledge, interest and value. This is revealed in this research which describes the boundary between the knowledge systems of the Permaculture niche and the mainstream regime as a space where differing sets of beliefs and values, epistemologies, ways of facilitating and supporting learning, practices and approaches to research confront and negotiate with each other. The interaction between the knowledge systems is characterised by the tension between the strong internal learning processes which reinforce the PKS boundaries and the tentative external links being forged across PKS-AKS boundaries. This dynamic is being played out at all levels of the PKS as actors endeavor to maintain a cohesive PKS true to Permaculture values and ethos, cross boundaries to confront and diffuse radical ideas into the regime, but at the same time negotiate, adapt and exploit entry points and seek legitimacy from the AKS institutions. In broad terms these boundaries are impermeable to the translation of Permaculture knowledge associated with holistic concepts but more permeable to knowledge, which has become dissociated from these concepts, or which shares some commonality with AKS knowledge. Tensions within the regime and multiple

interpretations of sustainable agriculture are opening up spaces for exploring common knowledge between such niche and regime knowledge systems. These provide opportunities for knowledge exchange, mutual learning and boundary processes, which have been shown to be critical to transition.

Rather than a simple notion of PKS confronting or enhancing the AKS there are multiple processes which both maintain and permeate boundaries between the two knowledge systems. The interconnected knowledge processes active at the boundary comprise shared learning, (limited) translation of ideas and practices; translation of disassociated knowledge which involves adaptation, negotiation and re-interpretation; and boundary processes (networking, intermediation, creative boundary 'edge' work). The balance between these processes will steer the future trajectory of the niche, that is, whether the emphasis is more on facilitation of adaptation and boundary working or whether on consolidation and aggregation of knowledge development within the niche and the wider agroecological niche. The outcome will be determined by both PKS and AKS actors and how their perspectives and sympathies shift with time and the changing political and economic, socio-cultural landscape. In terms of policy support, although the emphasis has been on provision of a protected space for niche development (Hoogma, 2002) these results suggest that fostering an adaptive and more open AKS is equally important.

This research, with its focus on boundaries and knowledge processes, was not able to analyse all the dimensions, actors and processes of the AKS or PKS. As such there are some limitations which should be recognised, although they do not detract from the results presented. The comparative scale of PKS and AKS is clearly important when considering the potential for a minor niche knowledge system to influence the established AKS. The temporal scale also requires analysis since niche and regime knowledge systems are dynamic with evolving actors, institutions and processes. Furthermore the results might suggest some symmetry between PKS and AKS in terms of structures (research, education, dissemination etc.) whereas in reality the AKS includes dimensions such as innovation support services, entrepreneurs and supply chain organisations and actors which are not present in the PKS. These are important AKS dimensions with powerful actors who influence transition towards sustainability. Finally restricting discussions to analytical constructs such as niche and regime, or knowledge systems suggests some uniformity in actors within them, whereas multiple interpretations, interests and values are expressed which need to be represented. Future research could be strengthened by addressing these gaps to provide a more comprehensive picture of niche and regime boundary dynamics from a knowledge perspective.

Figures:

Figure 1 Niche knowledge systems: potentially confronting or enhancing the AKS

Figure 2 PKS and AKS boundary dynamics: characteristics of permeable and impermeable boundaries

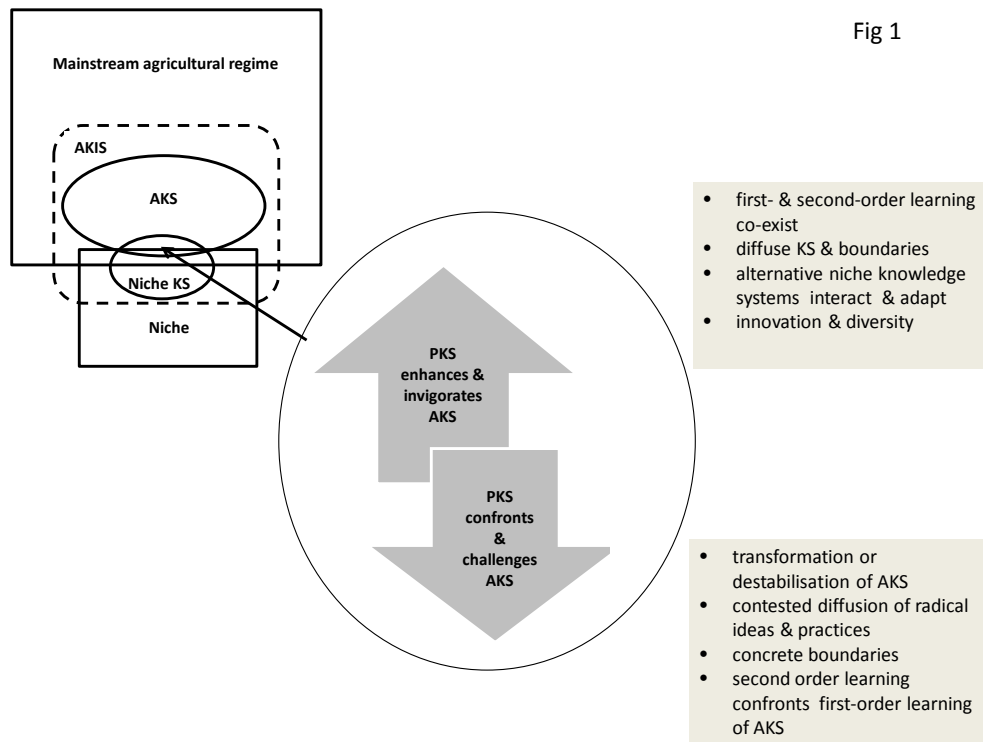


Fig 1 Niche knowledge systems: potentially confronting or enhancing the AKS

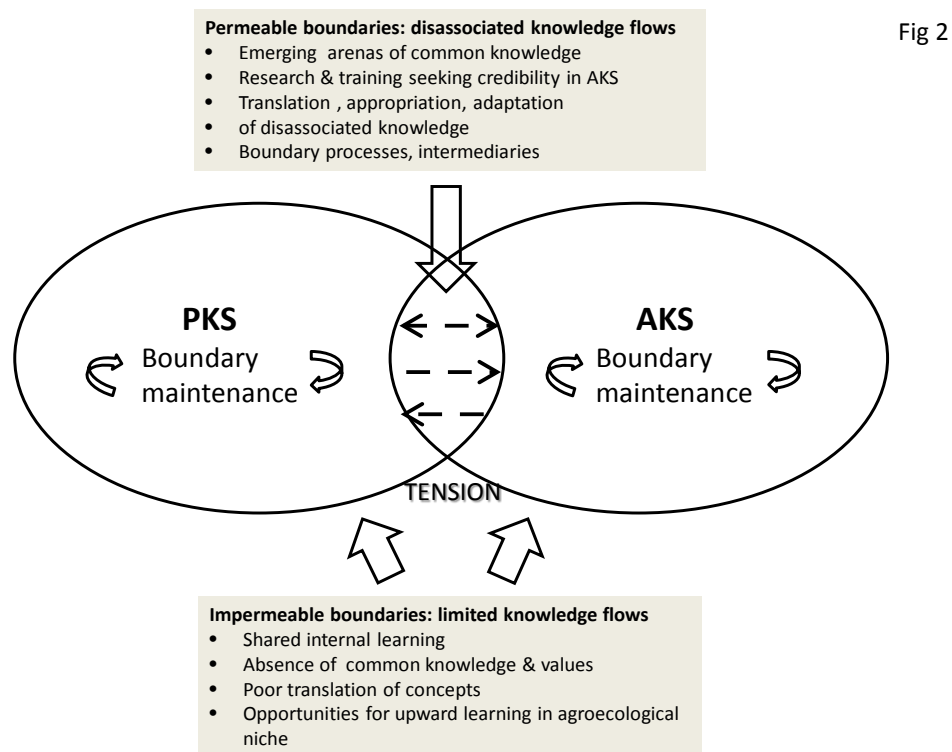


Fig 2 PKS and AKS boundary dynamics: characteristics of permeable and impermeable boundaries

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