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Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions

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ABSTRACT

Well-designed and supported innovation niches may facilitate transitions towards sustainable agricultural futures, which may follow different approaches and paradigms such as agroecology, local place-based food systems, vertical farming, bioeconomy, urban agriculture, and smart farming or digital farming. In this paper we consider how the existing agricultural innovation systems (AIS) approach might be opened up to better support the creation of innovation niches. We engage with Innovation Ecosystems thinking to consider the ways in which it might enhance efforts to create multi-actor, cross-sectoral innovation niches that are capable of supporting transitions to sustainable agricultural systems across multiple scales. While sharing many similarities with AIS thinking, Innovation Ecosystems thinking has the potential to broaden AIS by: emphasizing the role of power in shaping directionality in innovation platforms or innovation communities that are connected to niches and their interaction with regimes; highlighting the plurality of actors and actants and the integral role of ecological actants in innovation; and offering an umbrella concept through which to cross scalar and paradigmatic or sector boundaries in order to engage with a variety of innovation systems affecting multifunctional agricultural landscapes and systems. To this end, an *Agricultural Innovation Ecosystems* approach may help design and support development of transboundary, inter-sectoral innovation niches that can realize more collective and integrated innovation in support of sustainability transitions, and help enact mission oriented agricultural innovation policy.

1. Introduction

To sustainably meet the increasing demand for food (FAO, 2014, 2016), agricultural systems will need to transition away from the dominant industrial agriculture paradigm designed for production, self-sufficiency, efficiency and affordability (Prost et al., 2017) to one of sustainable agriculture that "conserves land, water, and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable" (FAO, 1989). Recent efforts have included co-existing and co-evolving but also competing approaches that aim to develop and enact alternative forms of agriculture such as permaculture, aquaponics, vertical farming, urban agriculture, precision agriculture, social and care farming, agroecology and 'smart' or digital farming (Dell'Olio et al., 2017; Hassink et al., 2013, 2018; Ingram, 2018; Junge, 2017; Muller et al., 2017; Orsini et al., 2013; Wolfert et al., 2017; Wezel et al., 2011). Along with these alternative forms of agriculture comes the potential for creating bioeconomies and circular economies, or local place-based food systems (Borrello et al., 2016; Hermans, 2018; Rossi, 2017).

The diverse and complex challenges facing a transition to more sustainable agricultural systems are often related to resource competition (e.g. water, energy, biodiversity, land), socio-economic concerns (e.g. rural livelihoods, community development, emerging markets), human health and environmental integrity (e.g. ecosystem health, environmental justice, climate change) (Bennett et al., 2014; Elzen et al., 2012; FAO, 2014, 2016). These challenges inherently span multiple natural resource management systems (e.g. agriculture, fisheries, forestry, water, conservation, energy) and linked ecosystem services (i.e., regulating, provisioning, cultural and supporting services) (Bommarco et al., 2013; Tittonell, 2014; Saint Ville et al., 2015). Agriculture-related fields (e.g. agroecology and socio-ecological systems) recognize the need to better foster linkages across scales and sectors to address

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complex sustainability challenges (Berthet et al., 2016; Foran et al., 2014). Therefore more networked approaches to innovation governance are required in order to facilitate the boundary crossing (e.g. cross sector/cross-scale/cross-domain/cross-property) and co-ordination across scales necessary to support transitions towards sustainable agriculture (Elzen et al., 2012; Hermans et al., 2016). Similarly, landscape approaches (i.e. place-based frameworks that consider ecosystems and politics of scale) (Arts et al., 2017) have the potential to develop more integrated strategies for sustainable agriculture and to facilitate the required linkages between the systems, services and sectors affecting agricultural landscapes (Sayer et al., 2013).

Agricultural innovation systems (AIS) thinking has become increasingly applied to analyze the organization of combined technological, social and institutional innovations in agriculture (Kilelu et al., 2013; Turner et al., 2016). AIS thinking is broadly focused on understanding the governance of actor interactions in innovation, the role of innovation policies and of innovation support structures such as research and extension (Hall et al., 2003; Klerkx et al., 2012; World Bank, 2006, 2012) and is often applied to the level of a country, a sector, or a particular technology (Klerkx et al., 2012). However, when competing normative directions for alternative forms of agriculture emerge (competing with the dominant industrial agriculture paradigm, or competing with each other) an AIS may be in support of some of those directions, but exclude other directions, which may contribute to lock-in and stagnation in unsustainable systems (Stirling, 2011; Ingram, 2018; Plumecocq et al., 2018; Vanloqueren and Baret, 2009; Schlaile et al., 2017; Touzard et al., 2015). This may be reinforced by early AIS thinking that emphasized economic contributions and private sector engagement as opposed to sustainability transitions ambitions (Hall et al., 2016; Hall, 2017; Schlaile et al., 2017; Schot and Steinmueller, 2016). To date, AIS remains rather focused on innovation in the agricultural sector alone and often on the industrial agriculture paradigm, having yet to take a multifunctional approach to agriculture or explicitly focus on ecological aspects (Foran et al., 2014; Wigboldus et al., 2016).

In order to capture and support a variety of alternative agricultural transition pathways, this paper considers how AIS might be opened up or expanded by engaging Innovation Ecosystems thinking, which has been previously identified as well suited for supporting transitions towards sustainability (Oksanen and Hautamäki, 2015). The goal of the paper is therefore to compare AIS and Innovation Ecosystems thinking to see where Innovation Ecosystem thinking may assist in conceptualizing and strengthening the creation and support of innovation niches in which alternative forms of agriculture are being developed, and to identify where Innovation Ecosystems thinking itself may be strengthened. The paper continues as follows. After defining innovation niches, we identify conceptual overlap and divergence between Innovation Ecosystems and AIS thinking in order to assess their potential contributions to sustainable agricultural systems. The paper then contemplates how Innovation Ecosystems thinking may complement AIS and assist with the creation and support of new multi-actor, multi-scale and multi-sectoral innovation niches. We conclude by reflecting on how an *Agricultural Innovation Ecosystems* approach may encourage collective and integrated innovation to better address the complex challenges facing transitions to sustainable agriculture.

2. Innovation niches, agricultural innovation systems (AIS) and innovation ecosystems

2.1. Fostering innovation niches in pursuit of transitions

Transitions to more sustainable agriculture require the formation of innovation niches (Elzen et al., 2012; Meynard et al., 2017). Innovation niches are defined as the spaces that allow actors to experiment, co-innovate and create new technologies, practices and institutions that can support transitions to sustainable agriculture by enabling interactions across boundaries (e.g. sectoral, organizational, professional, disciplinary, cultural, etc.) in agricultural systems (Elzen et al., 2012; Meynard et al., 2017; Schot and Geels, 2008). They can facilitate the collective action of diverse actors (often in new combinations) for developing new modes of production, new institutional arrangements and new organizational systems to better support systemic learning, adjusting and adapting (Elzen et al., 2012; Meynard et al., 2012; Meynard et al., 2017). In practice, innovation niches can be identified as spaces (i.e. physical, ecological, technological and virtual) where stakeholders come together to define shared objectives and engage in social learning to support an innovation process (Meynard et al., 2017).

Innovation niches are nested within larger regimes (the status quo of dominant systems they aim to change) and socio-technical landscapes (exogenous developments that influence niche development) (Grin et al., 2010; Schot and Geels, 2008; Elzen et al., 2012), but these levels should be seen as analytical constructs because in reality there is no dichotomous struggle between niche and regime, instead transition processes run across multiple scales (e.g. geographic, ecological, technological, etc.) (Ingram, 2015, 2018; Hermans et al., 2016; Svensson and Nikoleris, 2018; de Haan and Rotmans, 2018). Transitions occur when the creation and broader scaling of innovations established at the innovation niche level interact with current regimes, ideally leading to the opening of existing regimes and transforming them (Hinrichs, 2014; Wigboldus et al., 2016; Ingram, 2018). This perspective implies that agricultural innovation is a process in which co-evolution of technology, practices and institutions takes place at multiple and sometimes overlapping scales (e.g. farm, supply chain, policy system, sector, region, country) (Hermans et al., 2016; Wigboldus et al., 2016). Yet, innovation is not guaranteed, and the mere existence of a niche does not automatically transform a regime, drawing attention to the complex and heterogeneous factors that contribute to entrenched agricultural regimes and lock-in (Ingram, 2015; Wigboldus et al., 2016; Vanloqueren and Baret, 2009). Nonetheless, proponents of sustainability transitions argue that innovation niches can be built to facilitate linkages to support opportunities to innovate in radical ways to help solve complex issues (Geels, 2002; Schot and Geels, 2008), which may also take place through purposeful design (Elzen and Bos, 2016). Thus, there are ongoing questions about the architecture required to support the design and further development of successful agricultural innovation niches (Elzen et al., 2012; Meynard et al., 2017; Prost et al., 2017). We now consider how Innovation Ecosystems thinking may complement AIS and assist with conceptualizing design and support development of innovation niches.

2.2. Expanding AIS thinking to better understand and support innovation niches for sustainable agriculture

Both AIS and Innovation Ecosystems thinking emerged in parallel from national systems of innovation thinking in the 2000s. While Innovation Ecosystems thinking has largely been applied to business contexts, it has been applied to the agri-food industry (van Lohuizen, 2016). Table 1 contrasts the key characteristics of AIS (Hall, 2007; Klerkx et al., 2012; World Bank, 2012) and Innovation Ecosystems (de Vasconcelos Gomes et al., 2016; Jackson, 2011; Oksanen and Hautamäki, 2015). This table shows they share some theoretical foundations and converge on the notion that there is a need to foster innovation environments where scientists, policymakers, producers, end-users and entrepreneurs can mobilize their collective knowledge to innovate (Klerkx et al., 2010; Oksanen and Hautamäki, 2015). For example, a well-functioning AIS supports the construction of multi-actor innovation networks, often referred to as innovation platforms (Kilelu et al., 2013; Schut et al., 2016), with the aim of fostering interactions between actors for jointly solving agriculture-related challenges (Hall, 2007; Klerkx et al., 2012). Constructing innovation platforms generally involves attracting entrepreneurial members that act as champions, fostering linkages and cooperation, stimulating learning and mobilizing