Agricultural networks across EU: What are the key features to enhance farmers' ability to learn and to innovate in cooperation with other actors?

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Abstract

Multi-actors networks are increasingly used by farmers to link between them and to be interactively connected with other partners, such as advisory organizations, local governments, universities, and non-farm organizations. Given the importance assigned to the agricultural innovation by EU resorting to the networking between the research chain actors and the farmers, a strong focus on enhancing the creation of learning and innovation networks is expected. In this context is relevant to have information about the features of such networks enhance farmers' ability to learn and to innovate in cooperation with other actors. The main goal of the paper is to contribute to the understanding of which are the features of agricultural or rural networks showing determinant to enhance the farmers' ability to learn and to innovate in cooperation with other actors, namely by identifying the influencing factors encouraging the farmers' enrolment and the influence of network stability. The additional goal of the paper is to provide insights on the way these networks link to R&D infrastructures and advisory services. Five case studies were conducted in Italy, Germany, Portugal, and UK comprising heterogeneous networks. The results highlight aspects that show decisive for the networks ability to provide effective learning and innovation platforms, including bottom-up functioning, informality, leadership and power balance, along with the participation of facilitators when networks are large and heterogeneous. These networks focus on innovation exploitation and depend on the existence of a support subsystem, namely a functioning R&D and advisory services infrastructure. They can fill in gaps in this infrastructure, but they cannot replace it.

Keywords: agriculture, knowledge and innovation networks, agricultural knowledge and innovation systems (AKIS), multi-actors networks, EIP-AGRI

1. Introduction

The role of 'horizontal' multi-actors networks for the rural development has been emphasised by Murdoch (2000). This type of networks enhances farmer's learning and innovation behaviour through social interaction and collaboration by joining heterogeneous actors (Hartwich and Scheidegger, 2010; Saether, 2010; Murdoch, 2000) and by enabling their link with formal external entities sourcing knowledge and information (Isaac, 2012; Klerkx et al., 2010; Prell et al., 2010).

On the other hand, the regional innovation systems approach (RIS) that envisages innovation as being the outcome of interaction and collective learning processes, which are systemic by nature and that take place in specific spatial contexts (Lundval, 1992; Cooke et al., 1997; Audretsch, 1998; Asheim, 1999), are now

acknowledged, namely by the European Innovation Partnership on agricultural sustainability and productivity (EIP-AGRI), as the new paradigm to promote innovation in the agricultural sector. The European Innovation Partnerships (EIPs) are a novel framework launched by the European Union (EU), in the context of Europe 2020 strategy for growth and jobs (CEC, 2013), to tackle major societal challenges, such as the sustainable increase in food production, putting together the researchers and the innovation exploiting actors. The EIP-AGRI states that the multi-actors knowledge networks are the ground for innovation processes which take place at the territorial level. Hence, the EIP-AGRI activities focus on enhancing the networking of producers and users of knowledge, comprising farmers, researchers, advisors, business and other individual and collective actors whose interaction generates 'new insights and ideas, and mobilise existing tacit knowledge into focused solutions' (EU SCAR, 2013, p. 25).

The approach adopted by the EIP-AGRI emphasises the role of farmers as knowledge co-creators by creating and mobilising tacit knowledge. This approach is an alternative to the model of innovation-diffusion established by Rogers (1962). This model is based on a clear dichotomy of functions between researchers and farmers: Researchers are the producers of scientific knowledge and technologies and farmers are the adopters of these technologies (e.g. new seeds, fertilizers, machines and equipment's) which incorporate the scientific knowledge. Within this linear model of transferring knowledge, the advisors or extension technicians play a key function: the knowledge transfer between researchers and farmers, mainly in the form of new technologies (Schneider et al., 2012; Saether, 2010; Scoones and Thompson, 1994).

The EIP-AGRI approach, built on the interaction of heterogeneous actors and on the ability of different actor's to co-create knowledge by mobilising tacit knowledge along with scientific and other forms of codified knowledge, is supported by the agricultural innovation systems theoretical perspective. The innovation systems and related research defines innovation as an outcome of open-ended interactions among heterogeneous actors combining knowledge from many different sources (Wood et al., 2014; Klerkx et al., 2010; Conroy, 2008; Klerkx and Leeuwis, 2008). In addition, other authors emphasize the importance of incremental innovation focused on problem solving (e.g. Kroma, 2006) or on the constant minor adjustments and improvements (e.g. Hall, 2009) that farmers make to be succeeded.

In rural areas networks are increasingly being used by farmers to link between them and to be interactively connected with other partners, such as advisory organizations, local governments, universities, and non-farm organizations. Information and Communication Technologies (ICT) facilitate networking, namely when it is used to share and exchange knowledge. Given the importance assigned to innovation by the EIP-AGRI and by the recent new wave of rural development programmes (RDP) a strong focus on supporting the creation of agricultural/rural learning and innovation networks is expected in the next years.

However, there is little knowledge on the features and configuration of the best performing innovation networks (by enhancing farmer's innovation behaviour) accounting for different problem-solving (e.g. adapting to climate changes, introducing novel crops or how to obtain incremental gains of productivity in mature sectors) and for different farming systems and farming styles across Europe. An additional, and relevant, research gap respects to the lack of knowledge regarding the interface between the networks that exploit innovation and the knowledge support subsystems that underpin it (Saether, 2010; Edquist, 2005), which comprise the R&D, education and training and the advisory / extension regional infrastructures.

The FP7 EU project PRO AKIS encompassed among their goals exploring and identifying the possibilities, conditions and requirements of agricultural and rural innovation networks that might constitute examples for the EIP-AGRI. A set of five case studies, for in-depth analysis, was selected across different European countries. Diverse networks were studied, addressing different problems with quite different configurations,

reflecting the heterogeneity of problems and the regional contexts, namely the quality of R&D and advisory infrastructures where the network embeds on (Knierim et al., 2015).

A common methodological approach was followed in the different countries relying on semi-structured interviews to the network members, or a sample of it depending on the networks size, complemented with interviewing actors from the R&D infrastructures and advisory services found relevant in the different cases, as well as participant observation by attend meetings and events organised by the networks.

The main goal of the paper is to contribute to the understanding of which are the features of agricultural or rural networks showing determinant to enhance the farmers' ability to learn and to innovate in cooperation with other actors, namely by identifying the influencing factors encouraging the farmers' enrolment and the influence of network stability. The additional goal of the paper is to provide insights about the way these networks link to R&D infrastructures and advisory services.

The paper is organised as follow: Section 2 introduces the criteria for the selection of the case studies and the methods used for the data collection; Section 3 offers an overview of the case studies; Section 4 presents and discusses the results, including a cross-country comparison of the various case studies. Finally the Section 5 offers some concluding remarks.

2. Selection of the case studies and methods for data collection

The case studies were selected in each country based on an inventory at country or regional level (depending on the type of AKIS, centralised or decentralised) of the existing agricultural or rural knowledge and learning network which showed innovative network models by themselves and appear to have the features to enhance collaborative innovation.

The networks investigated included a (see Figure 1): (a) policy-induced agricultural innovation network in Brandenburg, Germany ('Adapting seeds to climate change'); (b) the 'Anti-Mafia innovation network: from land to fork' (abbreviated as 'Anti-Mafia'), a rural network situated in the Northern part of the Campania region in Southern Italy; (c) the 'Cluster of Small Fruits' (CSF), a sectoral and nationwide Portuguese network; (d) a berry pest-monitoring local network, situated in the Central-North of Portugal; and (e) the 'Monitor Farms' which are farmer-driven networks set-up by the Scottish Monitor Programme implemented by the Scottish government with delivery partners including levy bodies such as Quality Meat Scotland (Madureira et al., 2015).

An exploratory-descriptive approach was chosen to gather information about the structure, content and dynamics of each network. Two different interview guides were constructed, and applied through questionnaires: one for the network actors and the other for the facilitators. The interview guides were translated to involved country languages and applied through personal interviews. The number of interviews were around 30 for farmers and 15-20 to the advisors and actors from the advisory and knowledge infrastructure.

Figure 1*:* Location of cases studies by country
Source: Madureira et al., 2015

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3. The case studies

3.1 Policy-induced agricultural innovation network in Brandenburg, Germany

This network was situated in Brandenburg and involved researchers, farmers, associations and a public authority. It was set up in the context of a project, funded by the German Ministry of Education and Research, and focussed on developing innovative strategies for adoption of practices to counter climate change. Concretely, the studied project and network aimed to test and evaluate crop seed varieties under different climatic conditions. The planned activities were carried out on time, and the project can be considered successful in terms of its realised activities and goals. After a stable working phase of five years, despite an interest in its continuation by a majority of its members, the network dissolved in 2014 due to a lack of available funds for any follow-up network. It was established and ran within a period of public service downsizing in related fields and with a complete lack of public advisory services.

In terms of agricultural production, a structure of big farms is characteristic for Brandenburg, as a result of the history of collectivised farming. In 2010, the average farm size in Brandenburg was 240 ha (compared to an average of 56 ha in Germany as a whole). The four participating farms collectively operate over 1000 ha, with the largest farm operating over approximately 500 ha. With this, they all fall into the biggest 6.4% of farms in Brandenburg. The four farms have professional management and are strongly market-oriented. More detailed information on this case study can be obtained in Boenning and Knierim (2014).

3.2 Anti-Mafia Innovation network: from land to fork! Italy

The Italian case study focusses on the emerging rural innovation network in the so-called *Land of Fires*, an area in the Northern Campania region (Southern Italy) that is infamous for the socio-economic and environmental impacts of more than two decades of waste crisis. The network involves cooperatives who work on land which has been confiscated from the Mafia, environmental activists, associations, public and private actors (citizens and companies) fighting against dispossession and contamination of territories, and against Mafia culture. The study analysed the "economic heart" of this emerging network which is also a smaller formal network: the consortium of five social agricultural cooperatives called NCO (Nuova Cooperazione Organizzata) that was founded in 2012. They practice mostly organic agriculture, avoiding pesticides and inorganic fertilisers, adopting crop rotation systems to replace nutrients in the soil. They minimize and recycle the farm waste making compost for fertiliser. The cooperative also tries to regenerate and use local seeds and plants, sometimes in cooperation with a regional research institute, becoming both users and custodians of biodiversity in connection with local knowledge and the farming communities. The NCO cooperatives advance social inclusion, through the agricultural work of disadvantaged people (mentally ill people, former prisoners, immigrants and unemployed people), with the ambition of becoming sources of "ethic economic wealth". In addition, they base on direct selling by getting closer to consumers build on short food supply chain. The innovative *land use* of NCO involves a cognitive and cultural re-orientation that assumes a purely non-instrumental relationship with the environmental and territorial resources, the labour force and with consumers.

In spite of the existing regional agricultural advisory services, which are still publicly funded, the network lacks specialised technical advice and extension services for organic farms, which the cooperatives mainly access through external sources and informal channels (other cooperative and farmers). Other relevant sources for knowledge and information are downstream firms and organisations, such as plant and seed suppliers and private control bodies for organic certification. More detailed information on this case study can be obtained in Caggiano (2014).

3.3 The berry networks in Portugal

The Portuguese case studies included: the *Cluster of Small Fruit* (CSF) and the *Drosophila Suzukii Monitoring* (DSM) network. The first is a horizontal nationwide sectoral network established in 2013; its coordination structure comprises the main facilitators of knowledge sharing and diffusion processes. It is composed of both experienced and inexperienced producers and a diversified set of other actors, such as: private agricultural advice companies, independent consultants, several FBOs (cooperatives, farmers' groups and associations) and up and downstream industry firms, amongst others.

The DSM network established in 2014 is a regionally located, hierarchical but informal network led by a coordinating body (Regional agency of the Ministry of Agriculture) which also involves farmers and facilitators.

The CSF network involves the full range of actors in the berry production sector and is itself instrumental in organising the sector, specifically the knowledge and information supply to meet to the current heavy demands of farmers and their organisations. It may be considered a relevant case study in the Portuguese AKIS context, not only because of its national and sectoral importance, but also due to its unique position: on the one hand it shows how farm-based organisations (FBOs) and private advice can organise themselves in order to meet farmers' needs and demands and, on the other hand, it identifies these organisations' limitations in providing quality support to a novel and knowledge-intensive sector.

The second network, DSM, presents a model designed to create and store local-specific knowledge that is fundamental both at the regional and sectoral levels, when dealing with crop pest-monitoring, and one that engages farmers in the process of co-creating knowledge. The DSM is geographically a well-defined network, located in the central-northern region of Portugal. The network is co-ordinated by a public regional agency of the Agriculture Ministry and the members are farmers, mostly inexperienced berry producers, who were selected by the FBOs and private firms that they (the producers) are linked to. As regards to these organisations, the private firms act as facilitators, identifying the farms which are suitably located for field experiments and the farmers who are actively exchanging knowledge as well as having the ability to implement and maintain the scientific experimental tests designed to detect the Drosophila Suzukii, the insect pest responsible for devastating this crop and to store and report the data collected. More detailed information on this case study can be obtained in Madureira et al. (2014).

3.4 Monitor Farms in Scotland, UK

In the Scottish case study 'monitor farms' were investigated as an example of agricultural innovation network. The Scottish Monitor Farms Programme is delivered by Scottish Government in collaboration with delivery partners. Delivery partners include levy bodies (Quality Meat Scotland, DairyCo, Home Grown Cereal Authority), National Farmers Unions Scotland and the Scottish Organic Producers Association. Between 2009 and 2013, 18 Monitor Farms were established by the Scottish Government and the Delivery Partners. To date a total of 40 monitor farms have been initiated in Scotland, funded mainly through the Scottish Government's Rural Development Programme Skills Development Scheme.The Monitor Farm strategy stated that improvements to knowledge transfer to the Scottish agricultural industry lay at the heart of the Programme.

Different farmer types participate in the monitor farm network, representing the range of enterprises in the geographical area of the monitor farm, as well as young farmers and new-entrant farmers. Many participants were known to each other prior to the initiation of the network, from other groups or memberships, or from farming in the same area. The selection of topics covered in the Monitor farm meetings is relatively farmer-led as they are determined by the management group made up of 5-8 participating farmers that want to become more involved.

There are many links between the monitor farm programme and existing knowledge and advisory services, not least due to the role of the programme facilitators, many of whom are agricultural advisors, and through the wider network including invited specialists, industry representatives and student/researcher attendees. The network provides an opportunity to bridge gaps in advisory services, for example, providing practical on-farm demonstrations. As the objective of the monitor farm network is to develop best practice through on-farm changes, the processes and dynamics developed to generate and exchange knowledge for co-innovation focus on communication, knowledge exchange and co-creation, for example through the informal discussion and sharing of ideas and experience between monitor farm participants. More detailed information on this case study can be obtained in Creaney et al. (2014).

4. Results

4.1 The networks configuration: structure, goals, actors and their interaction

Table 1 presents a comparative description regarding the main features defining the structure of the five studied networks. It illustrates their diversity with regard to the contexts of their origins and its establishment.

It is noteworthy that even in those cases where the initiative for the network creation was top-down these tend to function through a bottom-up approach with a prevalence of horizontal and a mix of formal and informal interactions (as shown in Table 2).

Table 1: Networks structure

	'Adapting to climate change', DE	'Anti-Mafia', IT	'Cluster of Small Fruits', PT	'Berry pest monitoring', PT	'Monitor Farms', Scotland
Context for establishment	Research Programme	Collective action	Sectoral initiative	Institutional but 'ad hoc' initiative	National Programme
Initiator	National research	Local care cooperatives	Local authority	Government department	Government
Geographical scope	Regional	Local	National	Local	Local
Temporal scale	2009-2014	Established 2012	Established 2013	2013 - 2015	2011 - 2014
Scope/field	Specific problem oriented – agricultural	Territorial oriented- multi-sectoral	Novel sector oriented – agricultural	Specific problem oriented – agricultural	Sector oriented – agricultural
Leadership	Science-led network	Cooperative-led network	Farmers-led network	Facilitator-led network	Farmer and facilitator-led network
Funding	Public funding	Self-funded	Public	Self-funded	Public with industry contributions

Source: adapted from Madureira et al., 2015

Most of the networks are individual, one-off or even ad hoc initiatives, with the exception of the Monitor Farms programme in Scotland. This suggests that networks are still not regarded as essential collective learning, advisory and co-innovation tools for agriculture and rural development, or, that the official frames within which they sit do not fit the needs of the actors in the ground.

Figure 2 depicts, in a simplified way, the respective interaction of the main actors in the knowledge flows, underpinning the various networks.

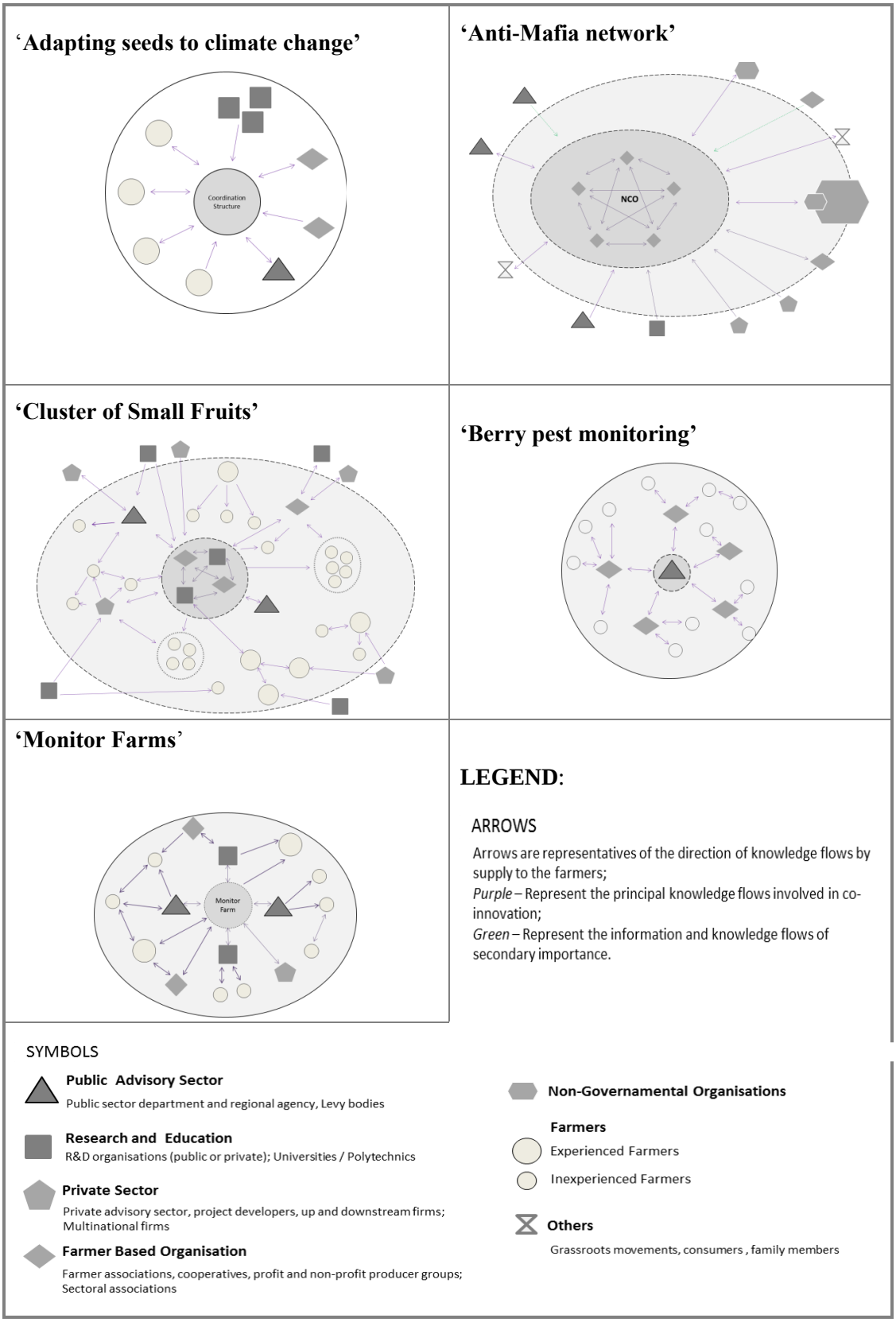

Figure 2: Actors and their main interactions
Source: Madureira et al., 2015

Figure 2 illustrates the configuration of each of the studied network, highlighting its boundaries, type and diversity of actors involved and their main interactions in terms of knowledge flows. The policy-induced innovation agricultural network in Brandenburg ('Adapting seeds to climate change') has well-defined boundaries due to its formality as a result of being a research-project based network, led by scientists and involving a lower number of participants. In contrast, the 'Anti-Mafia innovation network' is not a clearly bounded network, involving a multitude of actors, both in type and number that interact in a multi-directional way through formal and informal communication channels. The stability of the network is assured by the well-defined leadership structure defined by the cooperatives consortium that acts as the turntable of the multiple and diverse knowledge flows underlying the broader network. The main knowledge flows in the Cluster of Small Fruits underline the presence and role of small-scale and inexperienced farmers. These farmers demand knowledge and information from the interaction opportunities provided by the network, either in an isolated manner or jointly with private and farmer-based producer groups, both formally and informally. This is not a bounded network but involves knowledge flows into and out of the network, namely involving pioneer innovation-led farmers that demand knowledge from outside the cluster, e.g. from R&D institutions with ICT resources. In this case, a core structure is fundamental to ensure the functioning and stability of the network, composed of four diverse but complementary actors: a sectoral farmer-based organisation, two R&D entities, and an internationalisation facilitator organisation. The knowledge flows underlying the Berry pest monitoring shape clearly this network. This is not surprising giving that the main goal of this network is the co-creation and storage of explicit knowledge. The overall picture of knowledge flows in the 'Monitor Farm' networks relies on a diverse group of farmers and other actors gathering around the 'monitor farm/farmer'.

4.2 Influencing factors of the farmers enrolment and of the network stability

The absence of fees as well as the informal nature of the enrolment into the network appears to be key aspects to the farmer's enrolment in the networks. We noted that farmers are generally willing to bear travelling expenses and time opportunity costs, and appear to be satisfied with the gains of their participation, namely in the cases of Monitor Farms and the Portuguese berry networks. An additional factor showing relevant to the farmer's enrolment is the existence of previous informal relational capital and trust (social capital), which also shows determinant to the network stability (Madureira et al., 2015).

The previous inter-personal and professional relationships and mutual understanding between the farmers and the scientists involved within the 'Adapting seeds to climate change' network was decisive for the enrolment and stability of the network (Boenning and Knierim, 2014). In the case of the 'Anti-Mafia' network, previous contacts, interactions and inter-personal relationships between the founder cooperatives have also shown to be helpful in building the trust needed to establish the consortium. In the broader network, led by the consortium, stability comes from shared values derived from anti-mafia attitudes and belief in a social alternative economic model to the sustainable development of the region of the 'Land of Fires' (Caggiano, 2014). The inter-personal and trust amongst the pioneers berry producers and strong ties with researchers and other actors, such as advisors and traders, has shown a critical feature to cope with tensions and imbalances present in this network due to the participation of a large number of inexperienced farmers, with knowledge needs and demands very much dependent on the pioneers and their informal networks support. The 'Monitor Farm' networks in Scotland also provide evidence regarding how farmers value informal and neighbourhood connections. Previous personal and professional relationships and contacts enhance the adherence of farmers to the Monitor Farm (and respective farmer). The social aspects of participation appear to be of special value

in this case, where the 'free meal' and opportunity to socialise with friends and acquaintances, as well as to enhance personal social networks, act as a determining enrolment factor (Creaney et al, 2014).

The value that farmers assign to previous informal relationships and to the opportunity of socialising with peers and other professionals experienced provided by the networks should to be highlighted given that it can show a determinant feature to the success and effectiveness of learning and innovation within agricultural and rural networks.

A further important aspect related to the networks' dynamics in terms of their social cohesiveness is how they address tensions, namely respecting cooperation versus competition, when the members (i.e. farmers) are competitors. In this case, previous relational and trust capital showed to be a decisive factor, although this tension can be surmounted by identifying and focussing on shared goals (Madureira et al., 2015).

4.3 Network linkages with the R&D and advisory services infrastructure

The linkages between the different studied networks and the respective national and/or regional R&D and advisory services infrastructure is summarised in Table 2.

Table 2: Links between networks and knowledge and advisory infrastructure

Networks	Knowledge and advisory infrastructure				
	Public Advisory Sector	Research and Education	Private Advisory sector	FBOs	NGO
'Adapting seeds to climate change', DE	○	◉		○	
'Anti-Mafia', IT	○	◉	◉	○	◉
'Cluster of Small Fruits', PT	○	○	○	◉	
'Berry pest monitoring', PT	◉	○	○	◉	
'Monitor Farms', Scotland	◉	○	◉	○	

Legend:
○ Links
◉ Main links

Source: Madureira et al., 2015

The links identified in Table 2 underline the networks ability to mobilise and to integrate this infrastructure (R&D and advisory sector) in two alternative directions: (a) benefiting from it in situation where advisory services are present, as is the case with the Monitor Farms in Scotland, and (b) benefiting advisory services by filling gaps resulting from the weakness or even absence of advisory infrastructures due to public services downsizing policies, such is the case of the Portuguese berry networks and the Adapting seeds to climate change' network in Brandenburg region.

The role of place-based innovation networks for the creation of local knowledge (scientific and synthesised) is underlined by the cases of 'Adapting seeds to climate change' in Brandenburg region, the 'Berry pest monitoring' in the Centre-North of Portugal and the 'Monitor Farms' in Scotland.

4.4. Cross-country comparison of the cases studies

All the networks involved the cooperation of a varied range of actor's, providing examples of multi-actor networks which enhance the farmer's innovation capacity in cooperation with other rural (and non-rural)

actors through social interaction and collective learning. The studied networks were all, with the exception of the Italian case, focused on the agricultural sector. The 'Anti-Mafia' was a rural network involving and integrating a diversity of sectors, including social and health care, agriculture and ecological restoration.

None of the selected networks has received support from the respective country's Rural Development Programmes (RDPs). The innovation network for developing climate change adapted seeds (in Germany) and the Monitor Farms in Scotland were funded through national funds. The Portuguese 'Cluster of Small Fruits' (CSF) network was funded by EU structural funds. The NCO cooperatives that constitute the core of the Anti-Mafia innovation network decided to invest in agriculture as way to give economic sustainability to the network, by reducing its dependency on public funds for health and social services that are often delayed and discontinued. The *Drosophila Suzukii Monitoring* (DSM) network case in Portugal was not funded, not by public or private funds, and depended on the voluntary time and work contributions of the involved actors (researchers, technicians, facilitators and farmers).

A common denominator across the networks studied, with the exception of the Italian case study, is that they all filled gaps in Agricultural Knowledge, Information and Innovation System (AKIS) in the regions and/or sectors in which they are situated. The network studied in the Italian case also filled a gap in the regional/local AKIS (advice for organic farms), although the reasons for the establishment of this network were rather different and broader in comparison with the other case studies. The four cases illustrated quite diverse network models reflecting the agricultural/rural diversity across Europe, the different AKIS at regional/national level, and as well as the diversity of problems and potential solutions that the innovation agricultural/rural networks can address.

The comparison of case studies highlighted that multi-actors networks are actually able to deliver advisory services within innovative formats that overcome some of the limitations of the conventional advisory systems. They enable multi-topical advice, enhance the farmers' role as creators, co-creators and converters of knowledge, and reduce the distances (geographical and cognitive) between farmers and other actors, such as researchers and experts. It also showed that somewhat different network arrangements are possible to address similar problems/solutions. This diversity is due to contextual differences and the available options (e.g. with regards to funding).

5. Concluding remarks

The set of selected case studies illustrates a diversity of knowledge and innovation networks regarding their goals, structure, and the number of actors and the type of their interactions. However, they all show that multi-actors networks are in fact an effective tool enabling to bridge the actors from the research chain with the farmers, advisors and other rural stakeholders, by reducing cognitive distances between these heterogeneous actors and valuing tacit and local-based knowledge. How these ties and interactions might be reinforced? The evidence gathered suggests that there are aspects in the network's configuration which show influential to enhance the farmer's to enrol and to develop the ability to learn and innovate in cooperation with other actors. These factors include the following:

- Bottom-up functioning, in spite of the more or less hierarchical structure os the network; Bottom-up functioning has shown to be a 'natural' feature of these networks, explained by the wat they work, with little degree of formalised ties and interactions, but focused on a well-defined and shared goal.

- The informality of the ties and the interactions is very much valued by their members and allow linking the network with a number of knowledge and information flows related to other formal and informal networks where the actors participated too, increasing the network performance in terms of farmers capacity building for learning and innovating.
- Networks need good leadership power balance and this tend to rely on previous relational capital amongst the core members of the network, inter-personal and institutional trust, along with personal leadership abilities.
- The networks comprising a high number of actors, in particular when they are heterogeneous (e.g. farming styles, cognitive abilities related with learning and innovation, or farming structures) need good facilitators, persons or entities represented by persons, able to facilitate actors involvement and their interaction.

The linkage between these knowledge and innovation multi-actor networks and the R&D and advisory service infrastructure, has shown they are often filling the gaps on the regional AKIS, derived from the disinvestment in many of the EU countries on applied research (e.g. the seed trial or the demonstration fields) and on the public advisory services (Knierim et al., 2015). However, they cannot replace these infrastructures and they actually depend on them. Networks filling these gaps, such as the 'Adapting seeds to climate change' in Brandenburg region or the Portuguese berries networks, depend on key actors linked to these infrastructures, evidencing that these are their underpinning support subsystem. The flexibility and informality demanded by the innovation networks is not compatible with using them to replace structures needing regular funding and continuity in their activities.

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References

Asheim, B. (1999). Interactive learning and localised knowledge in globalising learning economies. Geo Journal, 49, 345-352.

Audretsch, D. (1998). Agglomeration and the Location of Innovative Activity. Oxford Review of Economic Policy, 14, 18-29.

Boenning, K., Knierim, A. (2014): Designing, implementing and maintaining (rural) innovation networks to enhance farmers' ability to innovate in cooperation with other rural actors. Case study report on a policy-induced agricultural innovation network in Brandenburg. Report for AKIS on the ground: focusing knowledge flow systems (WP4) of the PRO AKIS project. November 2014. Online resource: www.proakis.eu/publicationsandevents/pubs

Caggiano, M. (2014): Designing, implementing and maintaining (rural) innovation networks to enhance farmers' ability to innovate in cooperation with other rural actors. Anti-Mafia Innovation network: from land to fork! Report for AKIS on the ground: focusing knowledge flow systems (WP4) of the PRO AKIS project. November 2014. Online resource: www.proakis.eu/publicationsandevents/pubs

Commission of the European Communities (CEC) (2013). State of the Innovation Union 2012 - Accelerating change. Brussels: Commission of the European Communities, COM (2013), 149 final.

Conroy, C. (2008). The nature of agricultural innovation. In Snapp, S. and Pound, B. (Eds.), Agricultural Systems: Agroecology and Rural Innovation for Development. San Diego, California, Academic Press.

Cooke, P., Uranga, M., and Etxebarria, G. (1997). Regional Innovation Systems: Institutional and Organisational Dimension. Research Policy, 26, 475-491.

Creaney, R.; McKee, A.; Prager, K. (2014): Designing, implementing and maintaining (rural) innovation networks to enhance farmers' ability to innovate in cooperation with other rural actors. Monitor Farms in Scotland, UK. Report for AKIS on the ground: focusing knowledge flow systems (WP4) of the PRO AKIS project. November 2014. Online resource: www.proakis.eu/publicationsandevents/pubs

Edquist, C. (2005). Systems of innovation: Perspectives and challenges. In Fagerberg, J., Moery, D. C. and Nelson, R. R. (Eds.), The Oxford Handbook of Innovation, 181-208. Oxford University Press, Oxford.

EU SCAR (2013). Agricultural knowledge and innovation systems towards 2020 – an orientation paper on linking innovation and research. Brussels.

Hall, A. (2009). Challenges to strengthening agricultural innovation systems: Where do we go from here? In I. Scoones and J. Thompson (Eds.), Farmer first revisited: Innovation for agricultural research and development. Rugby: Practical Action Publishing.

Hartwich, F., Scheidegger, U. (2010). Fostering innovation networks: the missing piece in rural development. Rural Development News, 1/2010, 70–75.

Isaac, M. E. (2012). Agricultural information exchange and organizational ties: The effect of network topology on managing agrodiversity. Agricultural Systems, 109, 9–15

Klerkx, L., Aarts, N., Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. Agricultural Systems, 103, 390–400.

Klerkx, L., Leeuwis, C. (2008). Matching demand and supply in the agricultural knowledge infrastructure: Experiences with innovation intermediaries. Food Policy, 33, 260–276.

Knierim, A., Boenning, K., Caggiano, M., Cristóvão, A., Dirimanova, V., Koehnen, T., Labarthe, P., Prager, K. (2015). The AKIS concept and its relevance in selected EU member states. Outlook on Agriculture, 44, 29–36.

Kroma, M. M. (2006). Organic Farmer Networks: Facilitating Learning and Innovation for Sustainable Agriculture. Journal of Sustainable Agriculture, 28, 5-28.

Lundvall, B. (1992). National Innovation Systems: A Comparative Analysis. Oxford: Oxford University Press.

Madureira, L., Ferreira, D., Pires, M. (2014): Designing, implementing and maintaining (rural) innovation networks to enhance farmers' ability to innovate in cooperation with other rural actors. The berry networks in Portugal. Report for AKIS on the ground: focusing knowledge flow systems (WP4) of the PRO AKIS project. December 2014. Online resource: www.proakis.eu/publicationsandevents/pubs.

Madureira, L., Koehnen, T., Ferreira, D., Pires, M., Cristovão, A., Baptista, A. (2015). Designing, implementing and maintaining agricultural/rural networks to enhance farmers' ability to innovate in cooperation with other rural actors. Final Synthesis Report for AKIS on the ground: focusing knowledge flow systems (WP4) of the PRO AKIS. May 2015. Online resource: www.proakis.eu/publicationsandevents/pubs

Murdoch, J. (2000). Networks – a new paradigm of rural development? Journal of Rural Studies, 16, 407-419.

Prell, C., Reed, M., Racin, L., Hubacek, K. (2010). Competing structure, competing views: the role of formal and informal social structures in shaping stakeholder perceptions. Ecology and Society. 15, 34, http://www.ecologyandsociety.org/vol15/iss4/.

Rogers, E. M. (1962). Diffusion of Innovations. Free Press: New York, NY.

Sæther, B. (2010). Agricultural extension services and rural innovation in inner Scandinavia. Norwegian Journal of Geography, 64, 1-8.

Schneider, F., Steiger, D., Ledermann, T., Fry, P., Rist, S. (2012). No-tillage farming: Co-creation of innovation through network building. Land Degradation & Development 23: 242–255.

Scoones I, Thompson J. (1994). Knowledge, power and agriculture: Towards a theoretical understanding. In Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice. In Scoones I., Thompson, J. (Eds), Intermediate Technology Publications: London; 16–32.

Wood, B. A., Blair, H. T., Gray, D. I., Kemp, P. D., Kenyon P. R., Morris, S. T., Sewell, A. M. (2014). Agricultural Science in the Wild: A Social Network Analysis of Farmer Knowledge. PLoS ONE 9(8): e105203. doi:10.1371/journal.pone.0105203.