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Governance networks for agroecology transitions in rural Europe

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ABSTRACT

Governance networks, made of diversified and multidisciplinary actors, have a prominent role in the development and implementation of actions for agri-food system transformation that foster both farm-level and societal change, as in the case of agroecology transitions. This article aims at delivering a typology of governance networks, building on evidence from across Europe. By adopting a governance network theory perspective, a multiple case study is developed through participatory research, by characterising the emerging governance networks from transition actions at different levels in the pathway towards agroecological redesign. Three types of governance networks are identified. Adoption networks develop from early-stage actions in the agroecology transition pathway, to facilitate the shift from conventional to more sustainable farming practices. Positioning networks emerge from actions to create a demand for agroecologically produced food, through the development of marketing strategies and the creation of market channels. Amplification networks are the closest to agroecological redesign, originating from actions structured towards participatory planning and the development and reinforcement of diversity and trans-disciplinarity. Advisory services play a key role in all three types, by fostering knowledge diffusion and exchange, as well as by developing trust among farmers and encouraging cooperation, including conflict management. The role of advisory services for agroecology could be strengthened further through targeted policy. Measures to sustain multi-actor cooperation have the potential to create these conditions by developing and exploiting synergies between and within value chains, and with other relevant actors, including consumers.

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1. Introduction

1.1. Background

It has long been recognised that agri-food system redesign is needed to achieve the intertwined objectives of managing wide ecosystem outcomes, ensuring food and nutrition security, making food systems more equitable and providing livelihoods and economic opportunities in rural areas (FAO, 2019; Hill and MacRae, 1996; OECD, 2021). However, agri-food systems worldwide are still facing the immense challenge of providing safe and nutritious food, while meeting planetary boundaries (Gerten et al., 2020; Richardson et al., 2023). The challenge involves the Global South, where the population is estimated to grow, and the Global North, where substantial inequalities exist in the access to nutritious food and there are high rates of food waste (Nature Communications, 2024). This article focuses on Europe. Europe is a relevant context due to the ample diversity of landscapes, farming systems, food cultures, and histories, as well as to the high level of industrialisation and global economic importance (Levers et al., 2018; Schimmelfennig et al., 2015).

Agri-food system redesign implies realising systemic changes in the supply and demand sides (Pretty et al., 2018). This requires a greater diffusion of holistic approaches that create knowledge and capacity of farmers and communities, especially through the promotion of networks of collaborating actors (e.g., farmers, policy makers, food industry, advisors) able to stimulate exchange and trust, also across different disciplines (e.g. alternative food networks, agroecology, innovation platforms for the co-production of technologies) (Boix-Fayos and de Vente, 2023; Pretty et al., 2020). This research concentrates on agroecology transitions, due to their prominence in the scientific and policy debates (Altieri et al., 2017; Bezner Kerr et al., 2023; van der Ploeg, 2021), thereby acknowledging the existence of closely related approaches to redesign (e.g., organic agriculture, agroforestry, permaculture, food sovereignty) (HLPE, 2019). Agroecology transitions are actor-centred, context-dependent and multi-scalar processes that realise agri-food systems' shift from a dynamic equilibrium (conventional production and consumption) to another (more sustainable modes of production and consumption), through long-term and pervasive changes in values, norms, rules, institutions, and practices (Loorbach et al., 2017; Markard et al., 2012). A multiplicity of actors are critical agents in these processes, by making decisions on the type and level of change to achieve collective expectations, following action plans (hereinafter actions) (Gliessman and De Wit Montenegro, 2021; Meynard et al., 2023). Actors' coordination and collaboration to develop and implement one or multiple actions generate a social network, which builds the structure of the governance for agroecology transition, a form of governance network (Loorbach et al., 2017; Torfing, 2005).

1.2. Contribution to scholarship

Governance networks are central to agroecology transition frameworks (Ollivier et al., 2018a)[2]. However, improved and targeted research is required to provide an understanding of meaningful models, with relevance for the science and policy communities in Europe (Anderson et al., 2019; Slimi et al., 2021; Utter et al., 2021). The published literature is bounded, focusing on specific locations, actors, and/or farming systems, or the emphasis on the farm level (Weber et al., 2020). These gaps may prevent the delivery of recommendations to bring agroecology to praxis that are attuned to the inherent diversity and similarities of European rural areas (Walthall et al., 2024; Williams et al., 2023).

The aim of this article is to propose a typology of governance networks that may emerge along agroecology transition pathways. To achieve this objective, a multiple case study is developed through multi-method research, building on governance network theory (Torfing, 2005). In-depth analysis at the case study level is enabled by the integration of information about transition actions (content analysis) and social networks (social network analysis). A participatory research approach is applied in 15 case studies across Europe, within the frame of the UNISECO project (Schwarz et al., 2022). The methodological workflow involves three steps, each being conceived to achieve more specific research aims that bridge relevant research gaps (McKendrick, 1999), as follows.

(i) Content analysis (Weber, 1990) of agroecology transition strategies developed and implemented in the case studies to characterise transition actions and support the creation of governance network types. This will contribute to address the lack of studies grounded in real-world initiatives at different levels of maturity, in diverse contexts and scales (López-García et al., 2021; Sachet et al., 2021), and driven by groups of diverse actors (Gascuel-Odoux et al., 2022; Ollivier et al., 2018b).

(ii) Social network analysis (Wasserman and Faust, 1994), to map and characterise actors and networks that emerge from action development and implementation, and to contribute to the iterative adjustment of the typology. This will contribute: (i) to address the lack of actor mapping and categorisation based on the diversity of interests they represent, by highlighting positions and roles, by identifying (missing) actors, who may enhance the transition if included in the networks, and by unravelling agency (Darmaun et al., 2023; López-García et al., 2021); (ii) to bridge the knowledge gap about emerging patterns of interaction, considering economic relationships and the mobilisation of knowledge and know-how, including co-creation (Coquil et al., 2018);

(iii) Triangulation, to present and discuss the governance network typology by integrating findings from previous methodological steps and generating lessons learnt with relevance beyond the case study level. This will contribute to advance the understanding of conditions and mechanisms of governance networks contributing to agroecology transitions in Europe beyond the case study perspective, thereby providing useful insights for agri-food systems in other regions worldwide (Williams et al., 2023).

The proposed typology reflects the dynamics of change that underlie agroecology transitions, by identifying three types of governance networks that may emerge at different stages along the pathways, i.e. adoption, positioning, amplification. Findings suggest that structure, roles and decision-making patterns within governance networks adapt to fit the evolution of actions along the transition pathway, i.e. from incremental change through efficiency/input substitution in predominantly conventional systems (adoption networks) and/or through the creation and stabilisation of a demand for agroecological products (positioning networks), towards transformational change through the increase of the size and effect of agroecological practices (amplification networks). Along transition pathways, governance network types evolve by increasing actor diversity and shifting from individual to collective agency, while gradually building capacity of farmers and other actors, creating the market conditions for the viability of agroecological farms, and improving policy targeting and coordination.

Research insights might be useful for the (co-)design of targeted public and private measures to address power imbalances and remove lock-ins (Anderson et al., 2020; Giraldo and McCune, 2019; Oteros-Rozas et al., 2019). This is of utmost importance for creating an enabling environment for transition actions, by facilitating actor engagement within a coherent institutional framework and generating stronger actor-actor relationships (Aguilera et al., 2020; Migliorini et al., 2018; Wezel et al., 2018)

[2] This article is rooted in a wider research project, where agroecology transitions were framed within Ostrom's socio-ecological systems framework (McGinnis and Ostrom, 2014; Ostrom, 2009).

The rest of the article defines the theoretical and analytical approach to the analysis of governance networks for agroecology transitions (Section 2), details the research design and the participatory data collection process in the case studies (Section 3), show findings (Section 4) and discuss them by emphasising lessons learnt and recommendations (Section 5), and concludes by highlighting the key message of the research, critically reviewing its strengths and limitations, and delivering recommendations for further research.

2. Governance network theory in agroecology transitions

Agroecology incorporates ecological principles into farming practices (favouring natural processes, limiting purchased inputs, promoting closed cycles with minimal negative externalities), while not prescribing sets of practices (Wezel et al., 2020). The uptake of agroecology involves a series of changes in agri-food systems (Laforge et al., 2021), in a process known as agroecology transition (López-García et al., 2019; Méndez et al., 2016). Agroecology transitions are stepwise processes of transformational change, developed towards the combination and co-creation of traditional, technical and scientific knowledge, through cooperation and iterative learning among transdisciplinary actors, who, in turn, are committed to apply that knowledge to enable agri-food system's redesign (Gliessman, 2015). Agroecology transition is a dynamic concept, underlying the need for a pathway where gradual changes in both the technological and governance components of agri-food systems meet, to move from conventional modes of food production and consumption to redesigned agri-food systems (Gliessman, 2020). That pathway can be described as an open-ended and not-necessarily linear succession of stages, where incremental change evolves into transformational change (Tittonell, 2014; Wezel et al., 2020).

Along transition pathways, actors (individuals or organisations) create collaboration spaces to develop and implement strategies to achieve the shared goal of transitioning to agroecology. In this context, actors' agency and mutual interaction generate social networks that define the governance for transition (Newig et al., 2010). Governance is an umbrella concept used in a variety of disciplines (e.g., political science, law, public administration, economics, business administration, sociology, geography, history), including rural studies. As such, the concept has different meanings and builds on different theoretical traditions, and still lacks a shared definition. In the frame of this research, governance is the set of structures, institutions, and processes that drive decision making (who makes decisions, how decisions are made, how actions are taken) to find solution to social and environmental problems (Bennett, 2016).

Agroecology transition governance is a form of governance network, i.e. one that uses social mechanisms for coordinating public and private interests, actions and resources (Jones et al., 1997; Loorbach et al., 2017). Governance network theory provides understanding on the structure, management, and development of governance networks (Torfing, 2005). The networks originate from the interaction of all the relevant actors who have a stake in an issue of public and private interest and who hold recognised ability to provide resources and/or competencies to find a solution to the issue. Governance is defined by the forms of actors' agency, collaboration and coordination among each other (Newig et al., 2010). In the frame of agroecology transitions, governance networks are groups of multi-disciplinary and coordinated actors, who articulate a diversity of viewpoints, by stimulating change to enable agri-food system redesign (Loorbach et al., 2017). Key characteristics of these governance networks are the ability to consider diversity of opinions and solve conflicts, through reduced power asymmetries and hierarchy in the decision-making process, and the encouragement of learning and knowledge exchange to reduce the resistance to action implementation (Loorbach et al., 2017; Triboulet et al., 2019). The expectations for those networks to foster agroecology transitions are relatively ambitious, involving (i) the generation of social spaces that promote private-public collaboration and synergies among different competencies and resources, while empowering the local communities; and (ii) the support to and participation in the design and implementation of enabling policies and market instruments, to manage the trade-offs among the dimensions of sustainability and to align the objectives of supply and demand-side actors (FAO, 2018; IPES-Food, 2016).

Governance networks are cross-cutting and fundamental elements of the processes of change at the basis of sustainability transitions (Agrawal et al., 2022; De Schutter et al., 2020). This is well acknowledged by the multiple frameworks for the analysis of sustainability transitions (e.g., multi-level perspective, strategic niche management, transition management, innovation systems, socio-ecological systems, social practice approach) (El Bilali, 2020; Lachman, 2013; Loorbach et al., 2017; Ollivier et al., 2018a).

3. Analytical framework

In this study, an action is defined as the key element of transformational change, upon which case study actors have agreed to base the agroecology transition strategy to address context-specific environmental-economic challenges. Actions offer an approach to generalisation in the analysis of governance networks through the identification of driving themes of agroecology transition strategies, subject to the observation of common network features and of their contribution to action themes (Mayring, 2014).

3.1. Actions

The successful development and implementation of different transition actions may require governance networks with different structure and where agency is in the hands of different stakeholder groups (Barnes et al., 2017). Actor agency is related to the overall structure of the network, which depends on actor engagement with each other (their reciprocal position in the network) (Newman and Dale, 2007) and is subject to change as interaction evolves to actualize transition actions, especially through time (Emirbayer and Mische, 1998). This is due to different motivation and patterns of actor engagement (Borgatti et al., 2018).

Along a transition pathway, early-stage actions focus on the promotion of incremental change, to foster efficiency increase or input substitution (Tittonell, 2014; Wezel et al., 2020). Those actions are expected to occur in agri-food systems characterised by a large share of conventional farms that are approaching the transition pathway though the gradual adoption of sustainable farming practices. To provide the basis for transformational change, the level of implementation of transition actions is expected to shift from the farm-level to the agri-food system level, through the mobilisation of other stakeholders, to create the economic conditions for the viability of value chains for agroecological products (e.g., sustainability certifications, marketing cooperatives). This can occur through the co-evolution of incremental change with social mobilisation. The importance of the technological component of the pathway decreases, as the development of these actions draws on the need to create market channels for raw or processed agricultural products of farms that have already adopted sustainable farming practices (Garnett, 2014; Wezel et al., 2020). To enable agroecological redesign, multi-disciplinary actors should cooperate and create alliances towards an agreed target, with the aim of amplifying the level of implementation of agroecology (i.e. to increase its size and effect), especially at the territorial level (Lam et al., 2020).

Different actions underlie different types of actor agency, i.e. their capacity to make decisions and to establish (formal or informal) relationships amongst each other as individuals (individual agency) or groups of individuals (collective agency) (Pelenc et al., 2015; Pereira et al., 2015). Getting closer to the agroecological redesign of the agri-food system requires the participation of different stakeholder

groups to the decision-making process, e.g. through the development of fairer and more just marketing arrangements and by enabling closer relationships between farmers and consumers (e.g., community supported agriculture) (Wezel et al., 2020). However, collaboration is not something that just happens and different actors are likely to hold competing interests that bring relationship frictions (Cursęu and Schruijer, 2017). Then, enabling policies might be required to support specific actions, especially by removing the barriers to change related to different aspects of decision-making, such as technology, knowledge, financial resources, social environment, institutional arrangements, bio-physical elements (Gruère and Wreford, 2017).

Against that background, the following propositions are formulated.

Proposition 1. *Agroecology transitions are expected to require a shift from individual to collective agency*.

Proposition 2. *Policy needs are expected to differ based on transition action characteristics*.

3.2. Network structure and role of actors

The empirical study of governance networks of agroecology transitions draws on the extensive literature about social networks in natural resource management and sustainable agriculture (Bodin and Crona, 2009; Isaac, 2012; Manson et al., 2016), which has used formal and/or qualitative Social Network Analysis (SNA) to explore network structure and network elements, to understand how they affect decision-making, and to shed light on the processes behind network formation (Bodin, 2017; Halbe et al., 2020). SNA enables the characterisation of whole networks and of their constituting actors through indexes, thereby supporting the identification of patterns.

3.2.1. Networks

The interaction pattern of actors within social networks is associated with networks' cohesion. Empirically, cohesion can be evaluated through the coupled analysis of the density and degree centralisation (Gava et al., 2017; Sutherland et al., 2017). Density is the share of observed actor-actor edges out of the maximum possible number of edges in the network; degree centralisation is a measure of the extent to which the observed edges are evenly distributed among network actors (Wasserman and Faust, 1994). Cohesion affects the ease of collective decision-making: density is positively correlated with the speed of the exchanges of knowledge, goods and services, and the level of trust, but is negatively correlated with the openness to novelties, including new knowledge and newcomers, and with knowledge diffusion outside the network (Bodin and Crona, 2009; Bodin and Norberg, 2005). While excess cohesion can contribute to network's closure, low levels of cohesion suggest a potential for growth of actor-actor relationships, including the ability to improve network structure by letting important missing actors in (McGinnis, 2011; Reed et al., 2009). The distribution of actor-actor links (degree centralisation) suggests the extent to which one of few "focal" actors have control on the exchange flows across the networks, i.e. those displaying the greatest number of connections (Freeman, 1978; Scott, 1991).

There are at least three structural patterns of networks, characterised by different cohesion (Borgatti et al., 2009; Sutherland et al., 2017). Centralised networks have a low density as most flows through one or very few "central" nodes channel most flows. Those networks are subject to falling apart if the central node(s) leaves the network, thereby suggesting a relatively low stability (Borgatti et al., 2009). In decentralised networks, actor connections are denser than in centralized networks and shared among a larger number of actors. Among the three structural patterns, the density and distribution of links of decentralised networks allows a better allocation of power and quicker exchanges among actors, which suggest greater network stability (Bodin and Crona, 2009; Newig et al., 2010). Distributed networks display the highest density, with no "central" node having control on a large share of flows (Sutherland et al., 2017). Distributed networks can facilitate the creation of social capital especially via the creation of informal peer-to-peer linkages; however, link redundancy might generate closure that can prevent network expansion to new actors and negatively affect the success of transition actions (Gava et al., 2017; Sutherland et al., 2017). In terms of stability, the great number of actor-actor connections makes distributed networks less likely to break, compared to the other network patterns (Borgatti et al., 2009).

This leads to the following proposition.

Proposition 3. *Start and end points of the transition pathway are expected to show the most stable network structures* (*decentralised*); *intermediate stages are expected to show relatively unstable network structures* (*distributed*, *centralised*).

3.2.2. Actors

At the actor level, the analysis of connections enables the identification of structurally relevant actors, i.e. those displaying the greatest engagement (major sources/targets of actor-actor connections) and those that are able to bridge actor groups (gatekeepers) (Barzilai-Nahon, 2008). Structurally relevant actors are generally well connected throughout the network, e.g. due to their past relationship with network actors, and support action success by meeting the efforts of different interest groups (Castella and Kibler, 2015). The distribution of connections around source/target actors is linked to network dynamism and can be described at the actor level via degree centrality measures (Freeman, 1978). Major sources and major targets display, respectively, high out-degree (high number of outgoing edges) and high in-degree (high number of incoming edges) centrality (Hanneman and Riddle, 2005). Out-degree centrality supports the identification of opinion leaders, who actively generate exchange relationships. Out-degree and in-degree centrality show, respectively, the extent to which nodes can generate (givers) or receive (takers) flows. When out-degree exceeds in-degree, nodes act predominantly as givers rather than takers, and the other way around (Hanneman and Riddle, 2005). The ability of network nodes to act as gatekeepers can be evaluated via the calculation of betweenness centrality, i.e. the extent to which a node enables shortest paths between other network nodes (Freeman, 1978). Often, gatekeepers play the role of network brokers by displaying boundary-spanning relations, due to their ability to create linkages between different actor categories and to channel multiple relationships (e.g. exchange of knowledge, goods and services) (Lubell et al., 2014). Then brokers can be identified based on the combination of betweenness centrality and boundary-spanning relations (Gava et al., 2017).

Beyond structural analysis, the viewpoint of people with context-specific knowledge should be considered, as they might have a clear understanding of actor influence on the action and of the existence of missing actors. Influence is the ability of specific network actors to initiate the process of action development and implementation, e.g. by exerting formal power, generating issue-specific information flows, building trust through their capacities and expertise (Castella and Kibler, 2015; Hauck et al., 2015). Influence can be elicited qualitatively through specific participatory methods (Schiffer and Hauck, 2010). Missing actors are categories of actors that are not (yet) part of the network or that are currently under-represented, but are expected to contribute significantly to action success, also by affecting network structure (Schröter et al., 2018a, 2018b). The analysis of missing actors has a diagnostic purpose, by placing emphasis on currently under-represented (or not represented at all) actor categories (McGinnis, 2011; Reed et al., 2009). Additionally, it might shed light on the structural needs of the networks to progress along the transition pathway, without making any assumption about the potential links of missing actors within the network.

Then the following propositions are formulated.

Proposition 4. *Key actors in agroecology transitions are expected to cover wider interests, i.e. from just supply side to demand side, knowledge*

professionals, local and national public institutions.

Proposition 5. *Along the transition pathway, missing actors are expected to improve network structure to move towards agroecological redesign.*

4. Methods, data and case studies

Multiple case study research is an inductive approach that enables theory building based on lessons learnt from several empirical evidence (Yin, 2014). Theoretical propositions support analytic generalisation and the delivery of lessons learnt with broad applicability, beyond the individual case studies (Eisenhardt and Graebner, 2007).

Empirical research tools are applied at the individual case study level. Then, the challenge with multiple case studies is to bridge in-depth meanings extracted from individual cases (within case analysis) with cross-case analysis. The development of typologies is a widespread approach in exploratory research to face this challenge, involving the creation of types from case subgroups (Stapley et al., 2022). Typology building is the result of an iterative process that considers similarity within cases and differences across cases based on a hierarchy of attributes (Kluge, 2000). In this study, evidence on the different levels of attributes is generated through staged multi-method research design, due to the multifaceted research objective at stake (McKendrick, 1999).

(i) Content analysis: identification of first tier attributes and (preliminary) definition of types;
(ii) Social network analysis: internal validation and characterisation of the network typology based on second tier attributes;
(iii) Triangulation: interpretation and discussion of results through the lens of the typology.

4.1. Content analysis

In this study, content analysis is used to condensate information about actions, through the identification of transition patterns and the development of types from analytical categories that represent similar action foci (Elo and Kyngäs, 2008; Weber, 1990). Content analysis a widespread method in qualitative research, to condensate wide-ranging information about a phenomenon through classification into categories that represent similar meanings, intentions, consequences or context (Weber, 1990). The categories are abstractions created using words that represent common meanings and intentions across case studies (Elo and Kyngäs, 2008), here the "actions" to foster agroecology transitions. The approach can be deductive (from the general to the specific), i.e. by using existing theory to generate a system of categories that reflect the objective of study, or inductive (from the specific to the general), i.e. by combining observed patterns in the analysed texts into general categories (Elo and Kyngäs, 2008). This study adopts an inductive approach as existing knowledge about the phenomenon is not developed enough. The created system of categories is the analytical coding framework (Saldaña, 2009) and here represents the typology.

Content analysis is applied to a text that details the co-created strategies for agroecology transitions at the case study level (Schwarz et al., 2021). The strategies identify major required changes in food production and consumption, and in the supporting policy framework, to guide technological and governance change in the mid-term. Each case study strategy is analysed to pinpoint the key change that it aims to implement, i.e. the action, and the main focus of it. The following attributes are used to characterise actions: (i) action's focus (how to achieve the transition); (ii) type of change (incremental, transformational); (iii) starting point of the case study (level of adoption of sustainable farming practices); (iv) time of action development and implementation (before or during the project lifetime); (v) policy needs (enabling policy instruments for action development and implementation).

4.2. Social network analysis

Social network analysis (SNA) is used (i) to map governance networks, i.e. actors (and missing actors) and their connections that originate from the relationships of exchange of knowledge (formal and know-how) and/or goods and services (Allee, 2008; Heath et al., 2009; Schiffer and Hauck, 2010); (ii) to provide a qualitative description of the dynamics behind network formation and actor roles (including the potential role of missing actors); (iii) to identify key actors (structurally relevant and influent); (iv) to characterise the network structures (cohesion patterns).

SNA is a well-established research tool for studying relational data, i.e. those describing the graphs (visualised via sociograms) made of finite sets of nodes (actors) connected through directed (edges) or undirected (ties) linkages (Scott, 1991; Wasserman and Faust, 1994). SNA supports purposive sampling to focus on group-level data and allows to generate evidence from the study of the relationships that originate from actor-driven processes (Prell, 2012). This research uses mixed-methods variant of SNA (Crossley, 2010; Froehlich et al., 2020; Hollstein, 2014), which has received increasing interest in rural studies (Chen et al., 2020; Jiren et al., 2018; Rudnick et al., 2019). Mixed-methods SNA enables the generation of evidence grounded in data that represent multiple contextual conditions by complementing the strengths of formal and qualitative SNA and thus strengthening the validity and usefulness of research findings (Froehlich et al., 2019; Hollstein, 2011; Provan and Milward, 1995). Analysis follows three common steps of mixed-methods research, i.e. qualitative SNA, formal SNA, and integration (Creswell, 2014), under an exploratory sequential design, where (i) qualitative SNA occurs first and informs formal SNA, which in turn complements and supports qualitative findings; (ii) data collection and analysis are connected by using the same sample; (iii) results are reported by merging the findings of both analytical steps (Fetters et al., 2013; Froehlich et al., 2019).

Qualitative SNA draws on the Net-Map tool box (Hauck et al., 2015; Schiffer and Hauck, 2010) and was used for participatory network mapping, through face-to-face interviews and/or workshops, as follows.

(i) Reflection on the sustainability challenges and on the proposed agroecology transition strategy, to recall background information, especially about actors and their mutual relationships;
(ii) Paper-based network mapping (iterative process to reach consensus), including missing actors and elicitation of influence (ranking of mapped actors on a 0 to 5 scale). This task helps participants to stay focused on the objective of the exercise (Hauck et al., 2015; Jasny et al., 2021; Schröter et al., 2018a) (Fig. 1);
(iii) Qualitative description of the network and their elements, including contextual information.

Formal SNA is used to generate the sociograms, to characterise network's cohesion patterns and to identify structurally relevant actors through the following metrics, by means of the UCINET® software (Borgatti et al., 2002), as follows (Scott, 1991; Wasserman and Faust, 1994).

- A network's density is the proportion of pairs of actors that have ties (edges when direction matters) out of the maximum possible number ties in the network;
- A network's degree centralisation is the extent to which edges are evenly distributed among actors, i.e. the extent to which density is organized around focal actors;
- An actor's degree centrality is the ratio between the number of edges and the maximum possible number of edges displayed by an actor in the network and can consider the direction of the mapped exchange relationships, i.e. out-degree centrality (outgoing edges) and in-degree centrality (incoming edges);

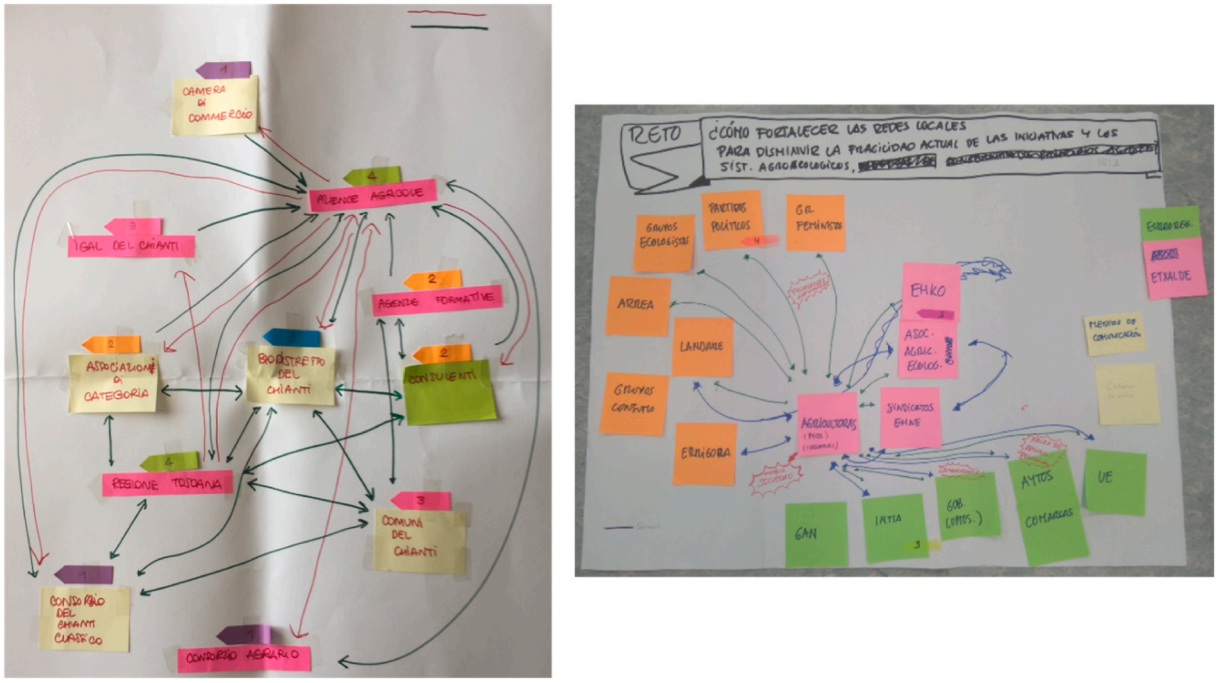

Fig. 1. Two examples of network mapping exercises: left Italian case study; right Spanish case study. Colours of Post-it notes represent actor categories, numbers are influence scores; arrows of different colours represent different relationships and their direction (source to target). Source: Authors' own elaboration. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

- An actor's betweenness centrality is the number of times an actor allows shortest paths among network actors.
- An actor's boundary-spanning relations are connection with network actors that play different roles, i.e. that own to different fields of expertise (here actor categories) (Lubell et al., 2014).

Within mixed-methods SNA, integration involves the creation of actor categories, the identification of key actors, and the combined reporting of findings.

The mapped (and missing) actors are classified under seven categories of relevant agents in agri-food contexts, similar to those adopted in related research (Hauck et al., 2016; Schröter et al., 2018a) (Table 1).

Following relevant literature (Freeman et al., 2018; Fuhse, 2015), actor categories are constructed based on actor similarity or difference, to represent the activities and outcomes of the agri-food systems and their criticality to achieve the goals of the transition actions, with the overarching aim of improving the identification of patterns and their contribution to action themes. To better frame and compare roles and agency, category definitions highlight the rationale behind actor contribution to the network for the purpose of the development and implementation of transition action, i.e. by representing or giving voice to specific interests, by providing knowledge resources, or by orienting people's perceptions and preferences.

Actor level metrics from qualitative and formal SNA are aggregated and used to identify key actor categories (hereinafter "key actors"). Key actors display simultaneously high influence, high brokerage potential (boundary spanning relations and high betweenness centrality), and high out-degree or in-degree centrality; a metric is interpreted as "high" when its actor-level value exceeds at least that of the majority (60%) of other actors.

Expert knowledge gathered through qualitative discussions is combined with the findings about key actors at the case study level.

The findings of mixed-methods SNA generate second tier attributes for use in the iterative adjustment of the typology.

Table 1
Actor categories. Source: Authors' own elaboration.

Code	Definition	Actors
AKISpro	Professionals in the creation and diffusion of formal knowledge through sustainable innovation. They are part of the Agricultural Knowledge and Innovation System (AKIS).	Formal and vocational education, certification bodies, research, advisory services
Civic	Non-state, not-for-profit, voluntary entities representing a wide range of interests (e.g. environmental protection). They are separate from the State and the market.	Associations (excluding consumers), civil society groups
Consumers	Actors representing the voice of consumers, aiming at their own protection, especially through informed decisions.	Consumers, consumer associations
Farm	Actors representing the interests of farmers	Farmers and farmer unions
Value chain	Actors representing the voice of breeders, processors, distributors, and retail companies	Upstream and downstream actors (excluding consumers)
Media	Citizens are exposed to content from social media mass media, which can affect their perception and preference towards food production and consumption	Mass media, social media
Public	Actors representing the welfare or well-being of the general public, through policy design and implementation, including the delivery of financial support	Governmental and administrative organisations (excluding research and education)

4.3. Case studies and participatory data collection

The empirical work was carried out in Summer (2019) in 15 case studies (Fig. 2; Table 2).

The case studies are selected to meet the criteria of typicality (agri-

food systems) and diversity (contextual specificity) with respect to a series of relevant sustainability aspects for rural development (Gong and Tan, 2021; Sovacool, 2011). Overall, the 15 case studies provide an overview of the diversity of European rural contexts, their typical farming systems and relevant environmental problems (e.g., nutrient runoff, toxicity from pesticides, soil degradation, reduction of biodiversity). To better frame agroecology transitions as a phenomenon under development, case studies identify two different situations for the development of transition actions (Yin, 2014): (i) initiating case studies enable understanding of actions for the introduction of agroecology in predominantly conventional systems; (ii) enhancing case studies provide insights about the upgrade of agri-food systems where some agroecological practices are already established (Gava et al., 2022).

In each case study, participatory data collection activities are developed through the engagement of actors drawn from those of most relevance for the different case study characteristics. Actor selection aimed at including a variety of fields of expertise. All the engaged actors were identified from Multi-Actor Platforms, created at the case study level. These are forums for exchanging ideas for co-learning and knowledge co-creation that bring together a multiplicity of actors

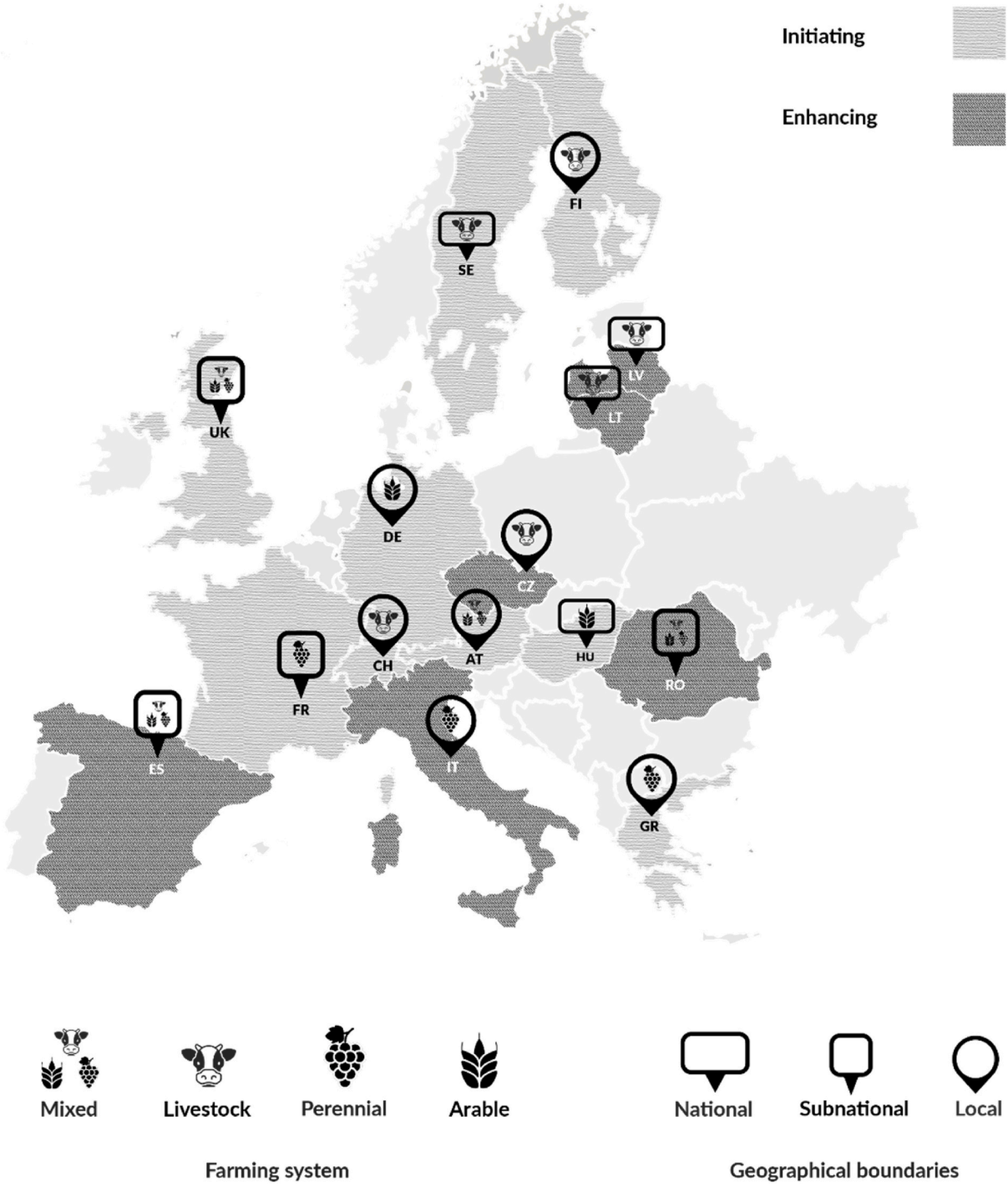

Fig. 2. The 15 case studies are indicated with the ISO Alpha 2 international codes of the country in which they are located. The geographical boundaries of the case studies are defined inductively, based on the areas of influence of the social networks that were mapped during the research process. Case studies are either initiating (AT, CH, DE, FI, FR, GR, HU, SE, UK) or enhancing (CZ, ES, IT, LT, LV, RO) the agroecology transition process. Source: Authors' own elaboration.

Table 2
The 15 case studies, relative transition actions and themes, and information about data collection. Source: Authors' own elaboration.

Action theme	Case study	Specific action's focus	Participants (interviews, workshops)	Field of expertise of participants
Adoption	Lake Lucerne (Switzerland)	Increasing agricultural diversification	10 (10, -)	Advisory services, Agricultural chamber, Environmental associations, Local administrations, Policy makers (agriculture, environment), Researchers
	Nienburg (Germany)	Diffusion of conservation agriculture practices	12 (4, 8)	Agricultural chamber, Environmental associations, Farmers, Local administrations, Policy makers (agriculture, environment), Researchers
	Nivala (Finland)	Installation of a collective biogas plant	8 (8, -)	Bioenergy distribution, Bioenergy production, Farmer associations, Farmers, Food processing,
	Imathia (Greece)	Diffusion of integrated pest management practices	11 (3, 8)	Advisory services, Local administrations, Farmer cooperatives, Farmers, Food processing, Policy makers (agriculture), Researchers, Retail
	Hungary	Diffusion of conservation agriculture practices	11 (11, -)	Advisory services, Farmers, Policy makers (agriculture), Researchers, Sustainable agriculture associations
Positioning	Lithuania	Creating a producer cooperative	13 (3, 11)	Advisory Services, Chamber of agriculture, Farmer associations, Farmers, Food processing, Policy makers (agriculture, environment), Researchers
	Latvia	Sustainability labelling and creating a marketing cooperative	3 (3, -)	Farmer association, Organic agriculture associations, Policy makers (agriculture)
	Transylvania (Romania)	Promotion and awareness campaigns about traditional food and farming	9 (2, 7)	Environmental associations, Farmers, Local administrations, Policy makers (agriculture)
	Sweden	Marketing for plant-based food for direct human consumption	18 (4, 14)	Advisory services, Farmer associations, Farmers, Food processing, Local administrations, Researchers, Retail
	Scotland (United Kingdom)	Promotion and awareness campaigns about sustainable food produced locally	7 (3, 4)	Advisory services, Farmers, Farmer associations, Landowner associations, Researchers
Amplification	Kaindorf (Austria)	Developing a territory of sustainable arable farming	8 (8, -)	Advisory services, Environmental associations, Farmers, Retail, Voluntary certifications
	Vysočina (Czech Republic)	Scaling out organic dairy farming	4 (4, -)	Agricultural chamber, Farmer cooperatives, Policy makers (agriculture), Sustainable agriculture associations
	Basque Autonomous Community and Navarra (Spain)	Scaling out agroecological arable farming	7 (7, -)	Advisory services, Farmer associations, Farmers, Local administrations, Policy makers (agriculture), Retail, Sustainable agriculture associations
	Auvergne and Rhône-Alpes (France)	Developing a territory of sustainable viticulture	17 (7, 10)	Agricultural chamber, Farmer cooperatives, Policy makers (agriculture)
	Chianti (Italy)	Developing an agroecology territory	12 (4, 8)	Advisory services, Consortia for the protection of quality food, Environmental associations, Farmers, Food processing, Local administrations, Voluntary certifications,

(researchers, policy-makers and civil society) (Zawalińska et al., 2022).

5. Results

Typology building is the result of a qualitative research process, and differences exist between individual case study results, in terms of action-related and network-related attributes. A reference case study is selected to keep the focus on the characterisation of types, by showing how in-depth information from the case studies is used and by offering at the same time a varied perspective on farming systems (arable, livestock, perennial) and European regions (south, centre, east), while avoiding an overflow of information about case-by-case specificities. This section presents the characterisation of the network typology of governance networks, through the support of in-depth information about one case study per each of the three developed types (adoption, positioning, amplification).

5.1. Adoption networks

5.1.1. Actions

Adoption actions aim at fostering the introduction of agroecological practices in predominantly conventional farming systems. These are early-stage actions in an agroecology transition pathway and are co-developed during participatory research activities. The focus is fostering efficiency increase or input substitution (incremental change) in conventional farms.

Adoption actions occur in case studies that are initiating the agroecology transition pathway. Actions focus on the promotion of incremental change (sustainable agronomic practices) on conventional farms, to foster efficiency increase or input substitution (Tittonell, 2014; Wezel et al., 2020). For example, the case of the diffusion of conservation agriculture practices in Nienburg, Lower Saxony (Germany), frames the context of an intensive arable farming area that experiences sustainability issues regarding biodiversity loss and water quality. Conventional and strongly market-oriented production systems dominate the area, as farmers face a series of economic pressures. The proximity to high-livestock densities regions led to high land prices and legal restrictions on farm development options. Also, conflicts emerged among local actors about property rights and the related implications in terms of the provision of public goods. Farmers receive payments from EU's Common Agricultural Policy (CAP) for voluntary environmental measures (e.g., flowering strips and protection strips for amphibians, extensive field margins, cover crops). However, the uptake of the most farther-reaching measures (e.g., intercropping, agroforestry, integrated biodiversity management) is very limited. Some forms of cooperation exist (e.g., producer cooperatives, machinery rings, locally based environmental associations). However, there is no ongoing concrete cooperation experience that explicitly aims at fostering a transition of the agri-food system to sustainable farming. This is mainly due to conflicting opinions between farmers and other actors about the potential negative implications for the economic performance of farms and land value. Despite that, farmers acknowledge the potential threats of current (conventional) farming methods for future land productivity and recognised the need for change in their attitude towards nature protection measures and their relationship with farm business aspects. The uptake of conservation farming practices by individual farms has been

identified as a first concrete step to move along a transition pathway.

5.1.2. Structural properties and agency

Adoption networks tend to be decentralised, with few central actors. This suggests the existence of a good flow of information and tangible goods across the actors, as well as a general agreement towards the leading sources for both flows (focal actors). For example, in the Nienburg case studies Farm (farmers) and AKISpro (Chamber of Agriculture) are focal actors (Table 3).

In adoption networks, focal actors can channel multiple relationships and may be able to attract actors from outside of the network. However, stronger trust is needed across actors. This may be related to the short duration of actor relationships at the time of analysis.

Farm actors are key decision makers and key actors in adoption networks, being concerned about future land productivity, though more actors are involved in creating the conditions for farm-level change, especially by stimulating knowledge flows. They are active seekers of information and tangible goods to reduce uncertainty in the decision-making process about action implementation. AKISpro and Farm actors are the key sources of knowledge and tangible goods across the network. Public and Value chain are additional key actors. Public actors meet the call for environmental protection intervention by Civic, Consumers and Media. This requires accurate information about real-world situations from Farm and AKISpro actors to improve the policy framework. Value chain actors are interested in the development of additional partnerships with network actors for benefiting from public funding opportunities (e.g., Operational Groups projects (EU CAP Network, 2024a)).

For example, the Nienburg network (Fig. 3) shows that farmers are key actors.

In the case study, knowledge flows are largely directed towards Farm actors (individual farmers; takers) and address the following topics: requirements for the adoption of conservation farming practices and their potential environmental-economic returns (AKISpro); opportunities for public policy incentives (Public); campaigns to promote the environmental benefits of conservation farming (Civic) (Table 4).

In the Nienburg network, the flows of goods and services mainly involve contractual agreements with Value chain actors for production inputs and the outputs, including machinery rings. Farm actors agree on the gradual adoption of conservation farming practices, starting from selected areas in their holdings, to enable the provision of environmental benefits and ecosystem services that would support an internalisation of biodiversity benefits into farm business plans. Their decisions are largely driven by economic interest and are affected by the relationships with all other actor categories, which makes farmers the networks' brokers. AKISpro actors (Chamber of Agriculture) are opinion leaders (givers) by initiating the process of promoting and developing ideas and concepts for sustainability transitions and foster capacity building. Advisors pay particular attention to farmers' voice, thereby considering not only environmental aspects but also trying to find cost-effective solutions to keep the profitability of the sector.

In Nienburg, Public actors have high influence on farm-level adoption of conservation farming, by setting rules and criteria for public support. Especially, the Ministry of Agriculture of Lower Saxony can design policy measures promoting agroecological practices and adjust rules and criteria of their implementation, within the national and European policy framework and regulations. Value chain actors can drive some knowledge flows as well, by providing farmers with extensive information about seed characteristics or food requirement to meet retail's sustainability standards. In the case study, Consumers display high influence. They would need for more direct contacts with food producers (e.g., direct sales, farmers' markets), and more information about farming methods and the efforts made by farmers to provide ecosystem services from arable cropping. Retailers diversify to meet Consumers' demand for locally grown food and with sustainability attributes, also in response to information disseminated by Media (the local radio and press) about contributions of agriculture to water pollution and biodiversity loss.

Table 3
Network-level measures in the case of Nienburg, Lower Saxony (Germany). Source: Authors' own elaboration.

Network characteristics	Value
Actor categories	7
Actors	19
Edges	84
Density	0.25
Degree centralisation	0.66
Cohesion pattern	Decentralised

5.1.3. Missing actors and policy needs

Action development and implementation require public support to sustainable practices, especially to encourage change by conventional farmers. However, farmers doubt the positive environmental outcomes of CAP's measures that do not correspond to the central aspects of their understanding of nature protection (Stupak et al., 2019). In this study, a need emerged for farmers' involvement in the design of agri-environmental measures, aiming at less rigid prescriptions, more flexible controls and a stronger focus on results. For example, in Nienburg farmers' willingness to adopt CAP's agri-environmental and greening measures has been negatively affected by their experience with the payment system, mainly due to bureaucracy, detailed monitoring, and financial penalties.

Improved practice-specific knowledge of farmers is needed, alongside the development of trusted and skilled agroecology advisors. AKISpro actors are crucial by supporting farmers and advisors that lack specific knowledge and previous experience with agroecological practices. Targeted policy is required to support the provision of technical training to farmers and advisors about agroecological practices. For example, the Nienburg case study provides evidence about the urgent need for policy support to the continuing education of advisors (including intermediary, advisory styles and facilitatory skills) and the development of specific curricula for biodiversity management in secondary and tertiary education.

Additional AKISpro actors with skills in biodiversity management are needed that take on the roles of trusted intermediaries, with the objective of fostering cooperation and conflict management among different actor categories, by generating new understanding of the multidisciplinary information (know-how, scientific evidence) that is required by farmers to enable the diffusion of more far-reaching farming practices and solve the most urgent environmental problems. This would support trust-building amongst farmers. For example, in the Nienburg case study mediation by representatives of the agricultural chamber could stimulate landowners' awareness about environmental problems, while considering their perspective and needs.

Enabling policy should aim at creating networking opportunities for farmers, including their involvement in policy design and the creation of public-private partnerships with value chain and other actors. This might support the formulation of income stabilisation measures for farmers, such as production contracts or premium prices, e.g. the initiative "Favourite Farm" (*Lieblingshof*) in the example case study that enabled successful farm-value chain cooperation by setting up a shop for around 50 local producers.

Public procurement and school programmes are additional enabling market instruments, by developing a societal demand and recognition for agroecologically produced food.

5.2. Positioning networks

5.2.1. Actions

Positioning actions aim at creating and stabilising a demand for agroecological products that are already available from the farms in the

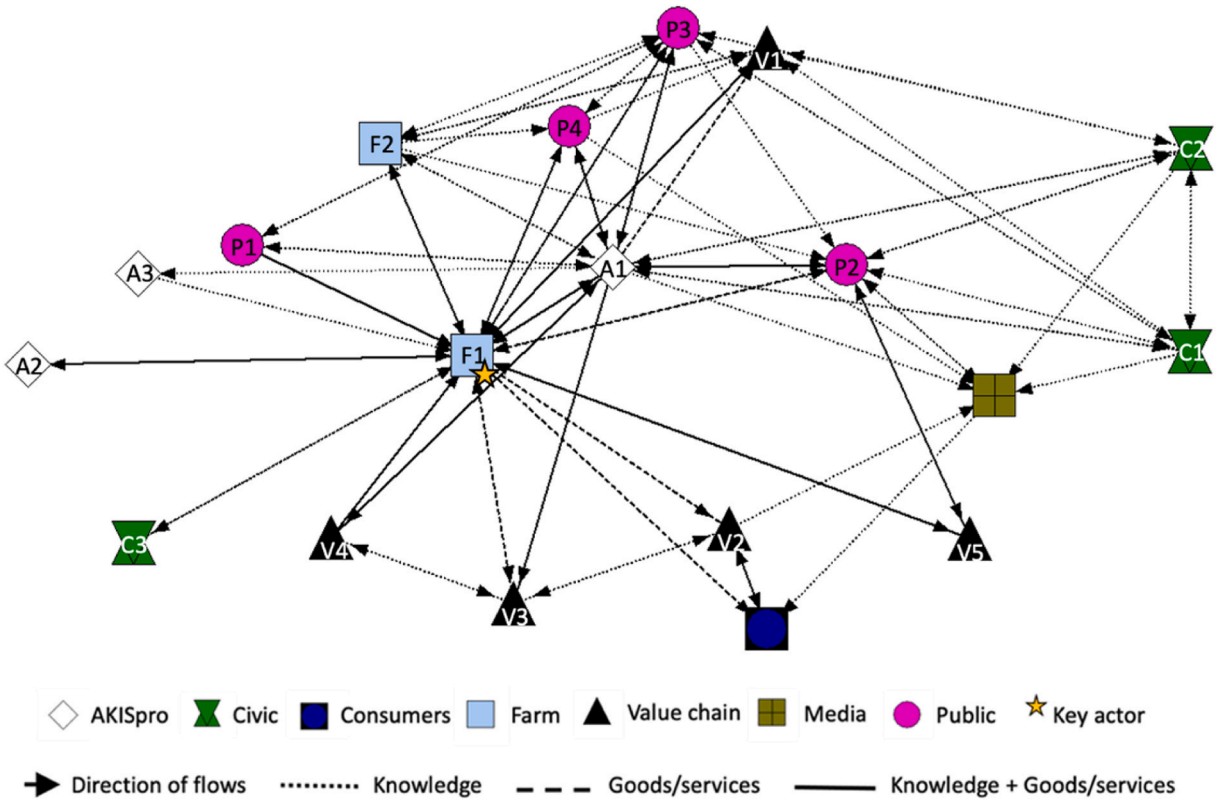

Fig. 3. Example sociogram generated through actor relationships for an adoption action in Nienburg, Lower Saxony (Germany). See Table 3 for actors' codes. Source: Authors' own elaboration.

Table 4
Actors and missing actors in the Nienburg case study (Lower Saxony, Germany). Source: Authors' own elaboration.

Category	Actor	Influence	OutDegree	InDegree	Betweenness
AKISpro	A1: Chamber of agriculture	0.8	1	0.69	0.46
	A2: Private advisory services	0.6	0.08	0.08	0
	A3: Agricultural secondary school	0.8	0.08	0.08	0
	Missing actor: advisor for biodiversity management				
Civic	C1: Nature and Biodiversity Conservation Union	0.6	0.46	0.31	0.01
	C2: Friends of the Earth Germany	0.6	0.46	0.31	0.01
	C3: Hunter organisation	0.4	0.08	0.08	0
Consumers	Local citizens	1	0.08	0.23	0.01
Farm	F1: Farmers	1	0.92	1	1
	F2: Farmers union	0.8	0.46	0.31	0.03
Value chain	V1: Landowners	1	0.15	0.46	0.02
	V2: Retailers	1	0.23	0.23	0.13
	V3: Agricultural traders	0.4	0.23	0.31	0.17
	V4: Seed producers and suppliers	0.2	0.23	0.15	0.02
	V5: Machinery ring	0.6	0.15	0.15	0
Media	Local press and radio	0.2	0.15	0.46	0.09
Public	P1: Ministry of agriculture of Lower Saxony	1	0.23	0.15	0
	P2: Local administration	0.8	0.46	0.62	0.25
	P3: Nature protection authority of Lower Saxony	0.6	0.62	0.54	0.12
	P4: Local water management authority	0.8	0.38	0.31	0.01

agri-food system. Positioning actions still promote incremental change. Compared to adoption actions, they are at a relatively more advanced stage in a transition pathway, occurring in case studies that have already adopted a series of sustainable farming practices. These actions are co-developed during participatory research activities.

Positioning actions draw on the need to create market channels for raw or processed agricultural products of farms that have already adopted agroecological practices (Garnett, 2014). Creating and stabilising a demand for agroecological products is the key driver to initiate or enhance the transition process. This might require multiple complementary initiatives targeting the supply and the demand sides. For example, the Latvia case study is centred on the creation of marketing cooperatives and the diffusion of sustainability labelling in smallholder dairy farming across the country. In Latvia, traditional animal husbandry methods are widespread. However, certified organic dairy farms account for just 10% of all dairy farms and struggle to increase, mainly for economic reasons. The productivity gap between conventional and organic dairy farms is still marked. Organic farms have lower economies of scale, due to fragmentation and the small scale (generally below 30 cattle). They are dispersed across Latvia, with high costs for milk collection and delivery to certified organic dairies. The value chain is dominated by large retail chains and 50 large conventional dairies.

There are just 7 certified organic dairies. Then, organic farmers and processors have a weak position in the value chain, which prevents organic milk from getting a premium price. To move along a transition pathway towards system redesign, local actors identified two complementary actions for the organic dairy sector, i.e. large cooperatives and effective organic labelling. Mixed producer-marketing cooperatives for the collection, processing, and sale of organic milk can increase farmers' bargaining power and facilitate market access.

5.2.2. Structural properties and agency

Network structures are predominantly distributed. This might be explained by the recent formation of actor relationships for developing positioning actions. Time is needed for emerging connections to become stable, to enable trust building, and long-lasting collaboration among peers and across fields of expertise, based on actor identification of their preferred sources of knowledge and tangible goods. This pattern is exemplified by the Latvia example (Table 5).

In the Latvia network, the observed cohesion pattern suggests that roles in the network still need to be defined, which might require further actor commitment to build trust.

In positioning networks, the decision-making process is driven by individual agency of Farm actors, who aim at achieving fair revenues for sustainably produced food. For small farms, additional aims are increasing product visibility and value added (e.g., farmers markets), and/or achieving economies of scale while improving bargaining power (e.g., marketing cooperatives). However, agency is not necessarily mirrored by findings about key actors. Ties to Value chain actors aim at ensuring adequate processing (e.g., compliance with sustainability criteria and standards), securing appropriate distribution and marketing, as well as agreements with the retail sector. Retailers can support specific standards for agroecologically produced food e.g. through their private labels, or can promote initiatives to sustain locally grown food by small-scale producers. The active search for information and funding opportunities from across actor categories is also motivated by the willingness to create public-private partnerships (e.g. Local Action Groups (EU CAP Network, 2024b)). Ties to Public actors are related to national agricultural sustainability policies, including eligibility for funding opportunities dedicated to agroecology and the rules for national sustainability standards (e.g. organic farming). Ties from Public actors are motivated by consultation processes for better consideration of agroecology in policy design and implementation, including local and national food strategies. Civic actors are committed to raise the awareness of Consumers actors about agroecologically-produced food, through public events or farmers markets. Civic actors can create bridges across the network by looking for knowledge and tangible goods from multiple actor categories.

For example, in the Latvia case study, Farm actors (Organic farmers) were observed to be the most active takers of knowledge and goods/services flows, and Public emerge as key actor to shaping network structure (Fig. 4).

However, in the Latvia network Public actors had not much leverage on the decision of individual farmers, with respect to their participation into a cooperative. While all actors are active seekers of information and know-how (all takers), the flows of goods and services are less dense, and mainly involve the design of contractual agreements to increase the volume of organic milk that is processed into organic dairy products. A large share of actor-actor connections is controlled by a Public actor (Department of rural development of the Ministry of Agriculture). However, the relatively high density suggests that one or few focal actors have not been identified yet for the purpose of fostering the action. The Department of rural development of the Ministry of agriculture is the opinion leader and most influent actor, together with the Rural support service, a public advisory service providing training about good agricultural practices, including agroecology (Table 6).

In the example of the Latvia network, the high influence of Public actors is related to their institutional role in the implementation of agricultural and rural development policy at the national level, including CAP. A Public actor is also the network's broker (The Ministry of the Environment). The environmental issues caused by conventional livestock husbandry (water pollution, soil erosion) have recently become severe, thereby driving the emerging collaboration between the Ministry of Agriculture and of the Environment for developing agro-environmental measures. The Ministry of the Environment organises consultations, together with the Ministry of Agriculture, with Value chain, Civic, AKISpro, and Farm actors.

5.2.3. Missing actors and policy needs

Value chain emerge as a missing actor. Value chain actors are required to re-configure value chain relationships to allow a fairer redistribution of value added to farmers (e.g., through cooperatives in the example case study). Consumers are generally not part of the networks. This might depend on the lack of a strong demand and interest for agroecologically produced food, which often is not easy to identify due to the lack of a dedicated certification and labelling scheme, different e.g. from organic farming. The stimulation of Consumer participation requires coordination between Value chain, Civic and Media actors (e.g. promotion of awareness campaigns co-delivered by retailer companies and environmental associations).

For example, the Latvia network well represents the dairy supply chain up to the distribution stage, but misses representatives of major retail companies and consumer groups that could be supportive of organic farming and organic dairy product production. Both actors could improve the performance of the network with respect to the action by driving a demand for domestic and organic dairy products. To enable a transition to agroecology in Latvia, the involvement of diversified actors should be coupled with interventions to change the mindset of farmers and consumers, including facing the social trauma left by the collective agricultural system imposed by the socialist regime. Continued support through CAP payments plays a major role to encourage supply-side change. More targeted training for advisors and farmers might also require policy support to remove cultural barriers towards cooperation that are still affecting people's behaviour in post-socialist countries. However, change depends not only on farmers' behaviour, but also on consumers' price for organic food and their purchasing power, which remains low.

There is a need for certification and labelling schemes linked or specific to agroecology, which may also pave the way to the development of public procurement programmes in canteens, targeting agroecologically-produced food. For example, the Latvia network call for intervention to support consumers recognition of the link between environmental and health attributes of sustainably produced food, and to increase their confidence in food labels. The Latvian food policy framework requires improvement, building on past and ongoing experience with national food quality labels, such as, e.g., the Green Spoon (*Zaļā karotīte*) and Bordeaux Spoon (*Bordo karotīte*), as well as with the EU funded "School Milk and Fruit" programme.

To enable a progression of positioning networks along the transition pathway, policy and market instruments would be needed aimed at developing of demand-driven approaches to encourage farmers to keep farming in a sustainable way while strengthening public-private partnerships. Awareness raising campaigns might be needed addressing

Table 5
Characterisation of the network in Latvia. Source: Authors' own elaboration.

Network characteristics	Value
Actors	19
Edges	105
Density	0.31
Degree centralisation	0.51
Cohesion pattern	Distributed

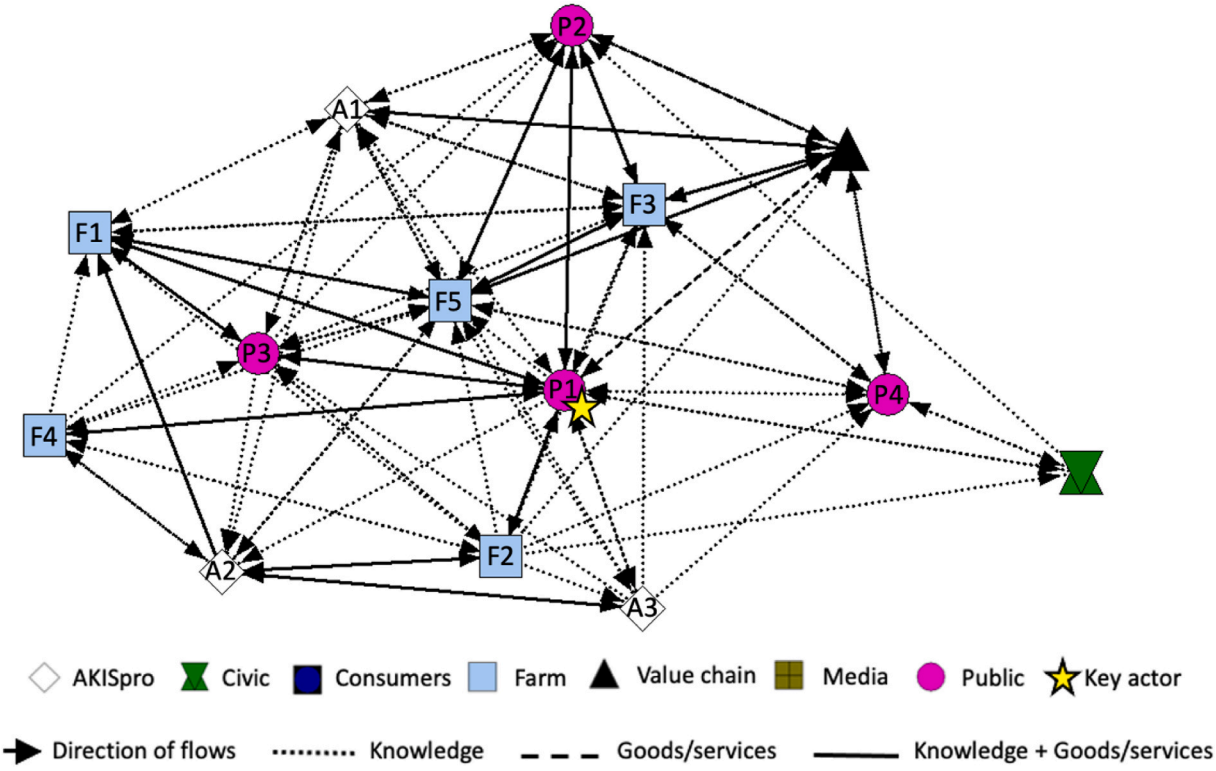

Fig. 4. Sociogram of the network in Latvia, generated by a positioning action. See Table 5 for actors' codes. Source: Authors' own elaboration.

Table 6
Actors and missing actors in the Latvia case study. Source: Authors' own elaboration.

Category	Actor	Influence	OutDegree	InDegree	Betweenness
AKISpro	A1: Certification body (organic farming)	0.2	0.67	0.67	0.6
	A2: Private advisory and training service	0.6	0.42	0.58	0.4
	A3: Agricultural University of Latvia	0.6	0.58	0.33	0.6
Civic	Environmental association	0.6	0.25	0.25	0.4
Farm	F1: Farmers council (farmer association)	0.8	0.58	0.33	0.4
	F2: Farmers parliament (farmer association)	0.8	0.92	0.33	0.8
	F3: Association of Latvian Organic Farming	0.8	0.42	0.67	0.6
	F4: Dairy farmer association	0.6	0.67	0.83	0.6
	F5: Organic farmers	0.4	0.83	1	0.6
Public	P1: Department of rural development - Ministry of agriculture	1	1	0.92	0.8
	P2: Rural support service	1	0.42	0.67	0.8
	P3: Department of food, biotechnology and quality - Ministry of agriculture	0.8	0.67	0.67	0.6
	P4: Ministry of environment	0.6	0.42	0.58	1
Value chain	Milk logistics company	0.6	0.5	0.5	0.6
	Missing actor: Retailers				
Consumers	Missing actor: Consumer organisation				

Consumers, through the active involvement of environmental associations (Civic) and retailers (Value chain), aiming at providing information about sustainably produced and locally grown food, including environmental and/or ethical performance, and certification and labelling schemes. For example, in the Latvia case study, a need emerged for a strong label for domestic organic milk, alternative to the current national label for organic food that displays low brand recognition and lacks national policy support.

5.3. Amplification networks

5.3.1. Actions

Amplification actions aim at increasing the size and effect of agroecological farming, by fostering changes with transformative potential, especially based on a collective approach (agreements, collaboration). Amplification actions build on collaboration projects that were already in place before participatory research activities. Amplification actions are characterised by a collective approach to agroecology transitions, with the overarching aim of expanding the size or effects of agroecological farming.

Amplification actions are characterised by a collective approach to agroecology transitions, with the overarching aim of expanding the size or effects of agroecological farming, building on previous collaboration projects. The creation of agroecology territories, i.e. "ecoregions" or "biodistricts"[3] projects, is an example of amplification action, involving formal agreements among multiple actors, under the guide of a

[3] The term biodistrict is specific of Italy and translates the Italian *biodistretto*, a portmanteau word formed from "*biologico*", meaning "organic" in the sense of organic farming, and "*distretto*" (district), borrowed from the concept of Marshallian industrial districts. The biodistrict model has spread internationally with the name "Ecoregion" (IN.N.E.R., 2021).

Table 7
Characterisation of the network in Chianti (Tuscany, Italy). Source: Authors' own elaboration.

Network characteristics	Value
Actors	14
Edges	47
Density	0.26
Degree centralisation	0.42
Cohesion pattern	Centralised

coordinator (Wezel et al., 2016). The agreement includes a strategic document that defines the aims and scope of the partnership, including geographic boundaries, general farming methods, collective implementation of practices and collective advisory services, educational programs, awareness campaigns, food labelling, among others.

The case of Chianti, Tuscany (Italy), provides an example of amplification actions. Chianti is a specialised winegrowing area in central Italy. Since the 1970s, the high profitability of winemaking had driven the expansion of vineyard areas through new plantations and the levelling of terraces and hill slopes. However, the dramatic decrease of farm diversification and the abandonment of less productive agricultural land led to severe multidimensional issues, e.g. soil erosion, crop vulnerability to climate change and pest outbreaks, weakening of value chains other than wine and exposure to market fluctuations, increased fire risk due to woody encroachment into abandoned land. In the last thirty years, concerned farmers have originated grassroots initiatives, acknowledging that farm-level change was not enough to face such complex environmental-economic problems. Territorial approaches to sustainable farming were proposed that included the involvement of social actors through participatory governance in Local Action Groups. Building on that, continuing collective action led to the creation of the Chianti Biodistrict (*Biodistretto del Chianti*) that pursue the following strategic objectives: (i) expanding the organic viticulture area; (ii) supporting the diffusion of the most advanced agronomic practices; (iii) increasing crop diversification; (iv) creating a local market for locally grown food, other than wine; (v) reducing the rate of land abandonment.

5.3.2. *Structural properties and agency*

Amplification networks display centralised structures, generally with very few focal actors. This cohesion pattern suggests the existence of trusted actors, to whom anyone with interest in the action may refer, including newcomers. Actors have clearly identified who, and how, can trigger (new) transition actions.

For example, in the Chianti case study Civic (Chianti Biodistrict association) and Public (Tuscany Region) are focal actors (Table 7).

In the Chianti case study, network actors had been previously involved in collective action initiatives. However, the network is still under development, with its structure and composition being subject to change as the strategic biodistrict plan evolves and consensus reached.

In amplification networks, decision-making is a collective process, with multiple actor categories contributing to the development and implementation of the action. Key actors are representatives of associations (Civic), who actively collect information and search for support for developing agreements at the territorial level. AKISpro display high influence, give the high interest of network actors into the integration of the most recent scientific evidence with knowledge about traditional farming methods. Public are structurally relevant actors (brokers), as the creation of agroecology territories may depend on the regulatory framework and on public funds for organic farming and territorial development projects.

In the example of Chianti, collective action was guided by AKISpro (advisors, including the Experimental station for viticulture) services), Farm (organic farmers), and Civic (Chianti Biodistrict association) actors, through the stimulation of knowledge exchanges (Fig. 5).

The association is a group of multidisciplinary of private and public actors (including local administrations), sharing long-lasting experience with organic farming methods and grassroots movements, including pioneering territories of organic viticulture in the Chianti area in early 2000s. The association is the key actor as well (Table 8).

In the example of Chianti, the association promotes events and initiatives around a variety of topics, to spread knowledge about agroecology territories and the Biodistrict model, local organic canteens in schools and small and medium sized enterprises, campaigns to ban pesticides in public green areas, and conscious waste management. In this example network, AKISpro shows the highest influence. An individual advisor and the Experimental station for viticulture have jointly contributed to the diffusion of organic farming practices and to their continuous improvement and adaptation at the field level in Chianti. The broker and opinion leader of the network is Tuscany Region (Public), one of the 20 Italian regions, i.e. the highest tier of subnational division and management authorities of CAP Rural Development Programme at the time of analysis.

5.3.3. *Missing actors and policy needs*

Missing actors may prevent the advancement of amplification networks towards agroecological redesign. Especially, the lack Value chain and Consumers may hinder the ability to develop more effective interventions to meet the supply with the demand of agroecological products, which is key to achieve system re-design (Garnett, 2014). More variety in the Farm category is needed as well to ensure that the diverse interests of farmers are represented. Agroecology is often linked to small farms; however, representatives of large agricultural organisations should be included in the networks to bring agroecology at scale. For example, in Chianti, conflicts emerged due to the involvement of a large conventional farmers. The mediation of an influent advisor enabled the alignment of the perspectives of organic and conventional farmers, enabled conflict management through. Large conventional farmers, supported by the Chianti Classico Wine Consortium (Value chain), are well positioned on the export market and need to guarantee stable wine supply in terms of quantity and quality. The Chianti Classico Wine Consortium has its own quality label and the EU Protected Denomination of Origin label, both of which are well established on the domestic and export markets. The Consortium is active in lobbying activities at both national and regional levels Winegrowers are concerned about the potential negative effects on their competitiveness due to changes in farming methods. The involvement of conventional farmers and the Chianti Classico Wine Consortium enabled the representation of a variety of perspectives that were considered during action development. Conflicting opinions were solved by prioritising interventions to the shared goal of preventing environmental degradation. The worldwide popular landscape of Chianti is a key element of the rural economy, with hundreds of thousands of tourists visiting the area every year and the development of multifunctionality. Conflict solving was facilitated by skilled advisors, including the presentation of data about the lack of negative effects on yield and fruit quality of specific practices, e.g. inter row soil cover, and the proposal by the Experimental station for viticulture to expand pest monitoring infrastructures, to prevent pest outbreaks through more accurate decision support systems.

Consumers is an important category of missing actors. These actors are called to play a role in the design of strategies to match supply with demand priorities, while meeting societal expectations. This is related to the still poor involvement of Value chain actors (missing). For example, in the Chianti case study the tourism sector is not represented at all. Given the contribution of tourism to all citizens' income (including farmers), these actors should take part in the decision-making process about the biodistrict.

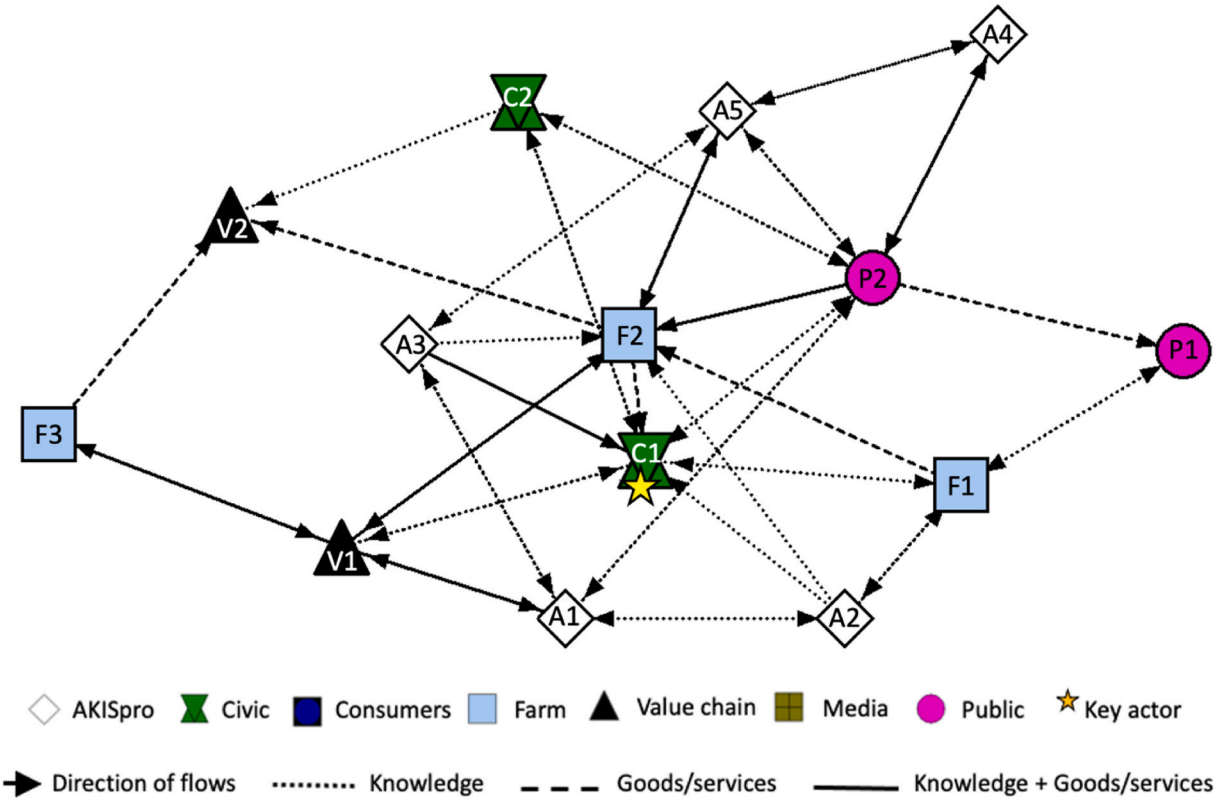

Fig. 5. Sociogram of the network in Chianti (Tuscany, Italy), generated by an amplification action. See Table 7 for actors' codes. Source: Authors' own elaboration.

Table 8
Actors and missing actors in Chianti (Tuscany, Italy). Source: Authors' own elaboration.

Category	Actor	Influence	OutDegree	InDegree	Betweenness
AKISpro	A1: University of Florence	0.4	0.57	0.57	0.57
	A2: Experimental station for viticulture	1	0.57	0.29	0.14
	A3: Individual advisor 1	1	0.57	0.29	0.08
	A4: Individual advisor 2	0.2	0.29	0.29	0
	A5: Organic farming certification body	0.4	0.57	0.57	0.34
Civic	C1: Chianti Biodistrict association	0.8	0.57	1	0.91
	C2: WWF (local branch)	0.6	0.43	0.29	0.06
Farm	F1: Winegrowing Union	0.6	0.57	0.43	0.52
	F2: Organic farmers	0.8	0.57	0.86	0.69
	F3: Conventional farmers	0.4	0.29	0.14	0.02
	Missing actor: Agricultural organisation				
Public	P1: Local administration	0.4	0.14	0.29	0.04
	P2: Tuscany Region	0.4	1	0.71	1
Value chain	V1: Chianti Classico Wine Consortium	0.2	0.57	0.57	0.77
	V2: Local retail stores and restaurants	0.2	0	0.43	0
	Missing actor: Tourism				
Consumers	Missing actor: Local citizens				

6. Discussion

6.1. Lessons learnt

The agroecological redesign of agri-food systems is a complex and staged process, where incremental and transformational change occur in an open-ended and not-necessarily linear transition pathway (Tittonell, 2014; Wezel et al., 2020). An enabling condition for the transition pathway is the creation of governance networks that can drive transdisciplinarity and collective decision-making (Newig et al., 2010; Runhaar, 2021). The typology of governance networks developed in this study highlights the potential for change developed by actor agency along agroecology transition pathways and pinpoints relevant needs to move towards system redesign (Fig. 6).

Adoption networks emerge from actions elaborated in predominantly conventional farming contexts, where farms are initiating their pathway, aiming at improving the environmental performance through efficiency increase or input substitution. Positioning networks result from actions that mirror more advanced stages in the pathway. They are proposed in areas where sustainable agronomic practices are in place, but struggle to get a wider diffusion. The focus is on market or marketing aspects, to develop a demand for sustainably produced food. Amplification networks are generated by actions developed and implemented in sustainable farming areas by actors, who were involved in previous collaboration. The stage in the transition pathway is more advanced, though not representing an end state. The focus is on formalising agreements among a multiplicity of supply and demand-side actors, to increase the size and multidimensional effects of sustainable farming

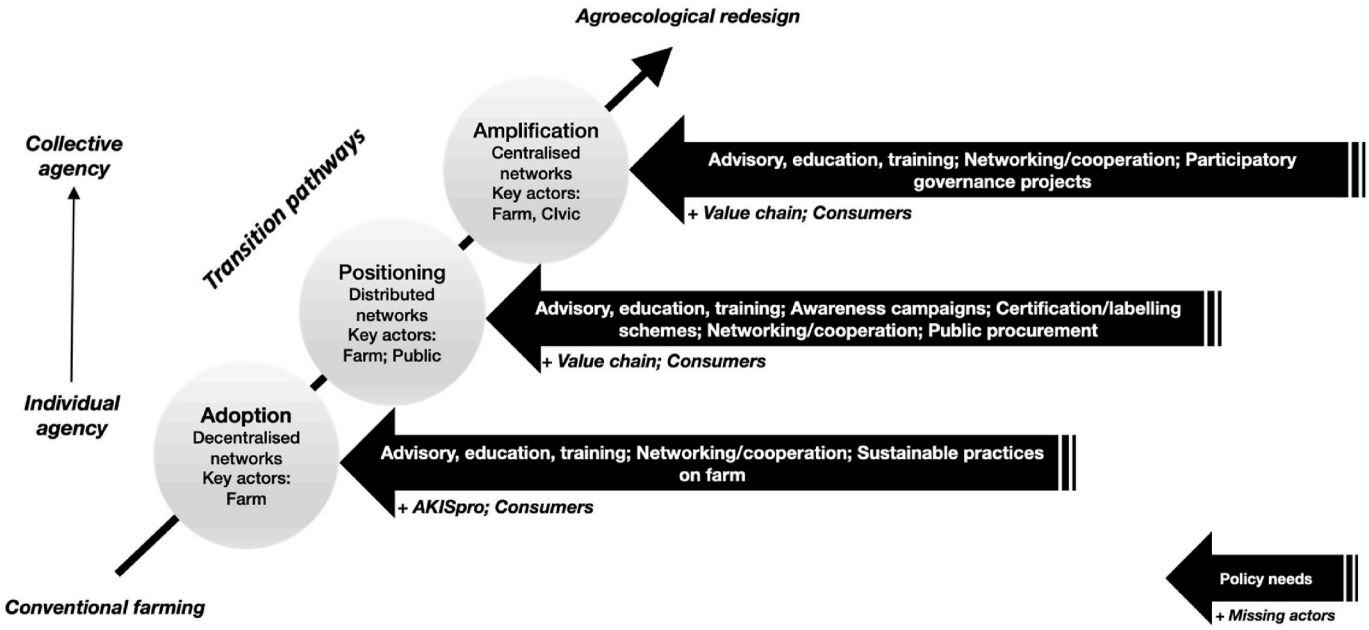

Fig. 6. Governance networks framed within action themes on the open-ended and not necessarily linear agroecology transition pathway. Source: Authors' own elaboration.

through agroecology territories.

Along the pathway, networks' cohesion evolves from decentralised (adoption), to distributed (positioning) and to centralised (amplification). Adoption networks have the most stable structure. Some trusted focal actors hold the majority of ties and show a potential to attract newcomers from outside of the network. This suggests that the governance networks are not likely to fragment into subgroups and that they are open to incremental or transformational change (Gava et al., 2017; Rudnick et al., 2019), to evolve into positioning amplification networks, respectively. However, progression along the pathway may not happen or regression may even take place, if (new) conflicts emerge that hinder actor collaboration on the action. Positioning networks have the least stable structure. Positioning actions could fail, and the networks could break, if networking actors do not pinpoint focal actors and increase the level of mutual trust. Actors being still in the process of understanding with whom to engage to create feasible, profitable, and acceptable marketing strategies and market channels for agroecological food. The consequence is the creation of multiple actor-actor links during the development of the transition action, and general lack of previous relationships, with increased network density and low levels of trust (Sutherland et al., 2017). The identification of one or few focal actors, possibly opinion leaders, could reduce network density and facilitate progression towards amplification models. Amplification networks tend to rely one or very few focal actors, with a relatively low number of ties, thus displaying moderate stability. If central actors leave the network, most links would break and the network would fracture (Borgatti et al., 2009). The centralised structure may be due to the legacy of previous collaboration and enables quick exchanges of knowledge and tangible goods among actors, as well as openness to newcomers (especially missing actors). A greater number of focal actors (and ties) are needed in those networks to get to a more stable coalition (i.e. decentralised structure) towards redesign. Noteworthily, all governance network types, and underlying actions, may fail or not change at all, due to the shrinking or collapsing of the collaboration, depending on external (e.g., deep changes in the political context and in the agricultural and food policy framework) and/or internal (e.g., a key actor or a broker leaves the network) factors. Then, agri-food systems may not necessarily evolve towards redesign and can even regress, regardless of their initial stage in the pathway.

Agency evolves from individual (adoption, positioning) to collective (amplification) as the creation of real-life alliances become the driver of an agreed project to increase the size and effect of agroecology, especially at the territorial level (Lam et al., 2020). This involves promoting and extending the collaboration outside the current network configuration, to define a plan for implementing transformational change through transdisciplinarity. However, the identified types of governance networks models mirror the supply side better than the demand side and lack effective education and advisory services, especially to sustain farmers at the beginning of the pathway by reducing risk aversion. More knowledge is needed by farmers as well as by advisors. Advisors are expected to mediate between different actors to solve conflicts and create more varied transition networks (Laforge et al., 2021). Farm actors are at the core of all governance network types, though with decreasing dominance from adoption to amplification. This is likely due to the object of analysis, closely related to farm level decision-making. Civic actors emerge in amplification networks, especially where grassroots movements drive societal change, as transition actions get more complex and embedded in geographical territories (Hossain, 2016). Even in that case greater involvement of a broad range of private actors is needed to support the transition (López-García, 2020). More actors along the value chain are required to create viable markets for agroecological food. Consumers should be more involved as well (Wezel et al., 2020), which may require deeper understanding of how to create the conditions for change in mindsets in different contexts, including geographical area, social and economic conditions (Soini Coe and Coe, 2023).

6.2. *Recommendations for the science-policy-society interface*

Findings from typology development suggest that policy and science do not influence agency within governance networks for agroecology transitions in rural Europe. As transition actions in farming systems evolve towards redesign, scientific evidence gets more importance within collective decision-making, especially when by providing new knowledge about agronomic practices. Scientific findings about real-world interaction patterns in governance network types may contribute to the development of strategies for agroecology transitions, by highlighting who is currently part of the actions and who should be

there to improve action's successfulness, and by recommending targeted policy improvements to remove the barriers to change along the transition pathway (McGinnis, 2011; Reed et al., 2009).

There are at least three types of barriers to agroecology transitions, actor capacity, value chain and policy-related (Gava et al., 2022). The actor capacity barrier can be removed through policy, largely related to the delivery of information and training to all the actors involved in the agri-food system (including those participating into governance networks), for developing agroecology-related and entrepreneurial skills. Another building block of future policy is expected to be the creation of partnerships and collective projects, including cooperation measures along the value chain. The importance of cooperation among a broad range of actors for co-designing actions to solve complex problems has been supported by a growing body of research (Cronin et al., 2021; Dumont et al., 2021; Feo et al., 2022; Kansanga et al., 2020; Kernecker et al., 2021; Labeyrie et al., 2021; Matt et al., 2017; Schiller et al., 2020; Šūmane et al., 2018). The EU is increasingly promoting the establishment of networks of farmers, throughout the value chain and beyond. Operational Groups within European Innovation Partnership for Agricultural Productivity and Sustainability are an example of multi-actor approach, where a variety of actors with complementary types of knowledge (e.g., scientific, practical) collaborate throughout the project lifetime to develop innovative solutions for real-world agri-food systems (EU CAP Network, 2024a). Additionally, agroecological living labs are the focus of the European Partnership on "Accelerating farming systems transition: agroecology living labs and research infrastructures". The aim is creating collaborative on-farm experimentation, between farmers and researchers, and multi-actor involvement to foster the adoption and diffusion of agroecological practices throughout the value chain (SCAR, 2023).

These policy developments might also help to remove value chain barriers, alongside more targeted measures, especially to enable greater consumer involvement (e.g., awareness and educational campaigns in schools and through media), the stimulation of demand-side change (e.g. new voluntary agroecology certification and labelling schemes), including environmental and health-sensitive public procurement, which is expected to have a great potential for sustaining markets for sustainably produced food (Swensson et al., 2021). However, the success of public procurement programmes with respect to fostering agroecology transitions depends upon the creation of an enabling environment for farmers (especially smallholders), who should cope with possible difficulties with the continuous supply of food in the required quantities by contracts (Simón-Rojo et al., 2020). Another success factor might be changing consumers' mindsets, which may require dedicated awareness raising campaigns based on behavioural research findings (Soini Coe and Coe, 2023).

Policy barriers are cross-cutting, being related to the need for more flexible mechanisms with less rigid prescriptions (in line e.g. with the EU's 'Farm to Fork Strategy'), especially for measures targeting small and medium farms, for more efficient policy delivery and coordination, especially through greater integration in the CAP framework (e.g., among the support for investments, for the adoption of sustainable practices, and for cooperation), and for improved targeting to agroecological objectives.

7. Conclusions

This research proposes a typology of governance networks for agroecology transitions, grounded in the European region. Empirical evidence is generated through a staged multiple case study research design, covering the diversity of European farming-systems in 15 countries.

Adoption networks are at an earlier stage in the agroecology transition pathway and can facilitate the shift from conventional to more sustainable farming practices. The agency of farm-level actors is action driver. However, to move along the pathway more skilled farm advisors are needed. Positioning networks focus on the development of marketing strategies and the creation of market channels for sustainably produced food, to create a demand for agroecologically produced food. The public sector is expected to play a major role in the promotion of cooperation along the value chain, as well as in the creation of consumer awareness and markets for food with ecological and health attributes, e.g. through school programmes and public procurement initiatives. Amplification networks get closer to agroecological redesign, by focusing on participatory planning and the development and reinforcement of diversity and transdisciplinarity. Amplification networks implement transformational change through collective agency, with a major role being played by civil society groups.

To enable agroecology transitions, all governance network types require more active involvement of advisory services and value chain actors to: i) reduce farmer aversion towards risk when deciding about the uptake of agroecological practices; ii) reduce farmer uncertainty about the income generating potential of their agroecological food; iii) support the creation of transdisciplinary partnerships and collective projects to increase the size and effect of agroecology, especially at the territorial level. Enabling policy is needed, as well, to provide: (i) support to advisory services, education and training, with measures targeting Farm actors and AKISpro actors, to improve the integration and concrete application of scientific knowledge and know-how at the territorial level and to develop facilitating skills of advisors; (ii) support for the development of new food chains and recovery of marginal land, to sustain farm diversification and reduce land abandonment; (iii) development plans to strengthen participatory governance and collective agency through the formalisation of multi-actor/participatory governance projects as agroecology territories (e.g. biodistricts as in the example case study), with dedicated streams of public funds.

The research and policy interest in agroecology transitions has supported the growth of governance network studies. The findings of this research suggest that multifaceted research designs grounded in real world contexts are an appropriate tool to study and characterise governance networks, by generating a wealth of information on driving mechanisms (strategies, actions) and practical arrangements (network structure, actor roles), as well as to pinpoint policy needs. This approach enables the creation of a typology through the construction of a hierarchical set of attributes based on multilevel characterisation of governance networks, and to advocate changes in the mapped relationships to promote improvements. However, research findings offer a static picture on the range of actions and networks across European farming systems, and postulates a trajectory based on the literature and on the perspectives of actors involved into participatory activities. Further participatory research may focus on the development of desired futures by local actors, to understand the required changes in the institutional and policy frameworks, e.g., through participatory backcasting. This would support strategic planning towards a step-by-step agroecology transition across Europe. Additionally, more empirical research is needed to validate the typologies in different contexts, and to embed governance networks for agroecology transitions in middle-range theories and frameworks of governance network studies.

This study relies on an exploratory approach. Those findings could be used to design further research into cause-effect relationships between observed network features and environmental/economic achievements over a given time horizon. Given the diversity of European contexts, explanatory research might be carried out across countries to support the findings presented here, by identifying rules to classify case studies while not losing information about their diversity (e.g., farming system, geographical scale, economic size, governance of the farming system). This would be of significance to inform decision making about future rural development policies, and to improve private certification and labelling schemes to reduce business-to-consumer information asymmetry.

Agroecology transitions entail switching from an input-intensive to a knowledge-intensive food production and consumption. To achieve that ambitious outcome, advisory services play a key role, not only by

fostering knowledge diffusion and exchange, but also by developing trust among farmers and encouraging cooperation, including conflict management. While policy support to advisory services is the backbone of agroecological transitions, measures to sustain multi-actor cooperation have the potential to create synergies between and within value chains, to promote capacity building and the change of consumer purchasing patterns.

CRediT authorship contribution statement

Oriana Gava: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francesco Vanni:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Gerald Schwarz:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Funding acquisition. **Emmanuel Guisepelli:** Writing – review & editing, Investigation, Data curation. **Audrey Vincent:** Writing – review & editing, Investigation, Data curation. **Jaroslav Prazan:** Writing – review & editing, Investigation, Data curation. **Rainer Weisshaidinger:** Writing – review & editing, Investigation, Data curation. **Rebekka Frick:** Writing – review & editing, Investigation, Data curation. **Andrea Hrabalová:** Writing – review & editing, Investigation, Data curation. **Johannes Carolus:** Writing – review & editing, Investigation, Data curation. **Uxue Iragui Yoldi:** Writing – review & editing, Investigation, Data curation. **Jarkko Pyysiäinen:** Writing – review & editing, Investigation, Data curation. **Alexandra Smyrniotopoulou:** Writing – review & editing, Investigation, Data curation. **George Vlahos:** Writing – review & editing, Investigation, Data curation. **Katalin Balázs:** Writing – review & editing, Investigation, Data curation. **Alfréd János Szilágyi:** Writing – review & editing, Investigation, Data curation. **Gražvydas Jegelevičius:** Writing – review & editing, Investigation, Data curation. **Elvyra Mikšytė:** Writing – review & editing, Investigation, Data curation. **Andis Zilans:** Writing – review & editing, Investigation, Data curation. **Mihaela Frățilă:** Writing – review & editing, Investigation, Data curation. **Elin Röös:** Writing – review & editing, Investigation, Data curation. **David Miller:** Writing – review & editing, Investigation, Data curation. **Andrea Povellato:** Writing – review & editing, Writing – original draft, Supervision, Resources, Funding acquisition.

Declarations of competing interest

none.

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Data availability

Data will be made available on request.

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