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METHOD ARTICLE

REVISED Advancing relational methods in agri-food governance research and beyond: Introducing the Socio-Material Actor-Network Analysis (SMANA) methodology

[version 2; peer review: 1 approved, 2 approved with reservations]

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Abstract

To better grasp the messiness of agri-food governance, recent scholarship has called for approaches that foreground its relational, territorial and power-laden character. This paper contributes to this agenda by presenting the Socio-Material Actor-Network Analysis (SMANA) methodology developed in the context of the research project AETERAKIS – A territorialised Agricultural Knowledge and Innovation Systems (AKIS) framework for agroecological transitions.

Building on a hybrid theoretical foundation based on Actor-Network Theory (ANT) and Social Network Analysis (SNA), the SMANA methodology centres its attention on unpacking the agencies, formal and informal interactions, and capacities of different actors in agri-food governance processes, focusing on what infrastructures – physical and non-physical – hold actor relationships together.

Based on its implementation during the AETERAKIS project, the paper proposes the operationalisation of the SMANA methodology through an adaptation of the Net-Map toolkit – a visual-based method for participatory network mapping. This approach enables collective reflection throughout its application and subsequent analysis, supporting local transformation processes. Beyond the immediate purpose of guiding data collection and analysis within the AETERAKIS project, the proposed methodology can assist researchers working on other components or relational aspects of complex, territorial and multi-actor governance processes.

Plain Language summary

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This paper presents a new methodology to better understand how agri-food governance works in practice. Agri-food governance is often complex and messy, shaped by relationships, territories, and power dynamics between different actors. To make sense of this complexity, the paper introduces the Socio-Material Actor-Network Analysis (SMANA) methodology, developed within the AETERAKIS research project.

SMANA combines ideas from Actor-Network Theory and Social Network Analysis. It focuses on how different actors interact, both formally and informally, and on the infrastructures - physical and non-physical - that connect them. These infrastructures help explain how relationships are formed, maintained, and shaped within governance processes.

The paper also explains how SMANA can be applied in practice through an adapted version of the Net-Map tool, a participatory mapping method. This approach allows participants to collectively reflect on their own networks while also generating data for research. Beyond the AETERAKIS project, the methodology can support researchers studying other complex, multi-actor governance processes at the territorial level.

Keywords
agri-food governance, social network analysis, participatory network mapping, actor-network theory



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REVISED **Amendments from Version 1**

This revised version further develops the conceptual and methodological framing of SMANA. It provides a more explicit account of the relationship between ANT and SNA, positioning SNA as a methodological and analytical resource for supporting an ANT-informed relational and socio-material reading of governance networks. It also develops the performative use of SNA and clarifies how participatory mapping, quantitative network analysis, thematic analysis, and collective interpretation interact within the methodology.

Particular attention is given to the distinction between actors and infrastructures, which are approached as contingent, functional, and relational categories rather than fixed or mutually exclusive ones. The revised version also provides a more detailed discussion of how different infrastructures mediate interactions and governance dynamics, and of the importance of qualitative research principles when applying participatory and interpretive network methodologies.

The methodological discussion has also been extended to reflect more explicitly on the limitations, possible adaptations, and further development of SMANA. Together, these additions aim to provide a clearer and more systematic account of how the methodology can be applied, interpreted, and further developed in the study of relational and socio-material governance dynamics.

Any further responses from the reviewers can be found at the end of the article

1. Introduction

Agri-food governance is a concept of multiple interpretations and uses. As Yap (2023) rightfully points out, a body of literature focuses on specific tools and mechanisms to improve fragmented policymaking, such as policy integration (Candel, 2014; Parsons, 2022), while others focus on the networks of state and non-state actors for effective participatory policy development and implementation (Levkoe et al., 2021; Reina-Usuga et al., 2022). However, such focuses have been argued to sideline relevant dynamics of agri-food governance processes, including their historical trajectories, territorial embeddedness, and the unpredictability arising from influences outside the formal boundaries of governance mechanisms (Moragues-Faus & Battersby, 2021).

Seeking to problematise this understanding, increasing work is bringing forward more relational, territorial, and power-sensitive approaches to the study of agri-food governance. In this view, agri-food governance encompasses the diverse decision-making processes that shape food systems – both what they do and how they work (Yap, 2023). This conceptualisation directs attention to the decisions and activities of state and non-state actors, each with distinct resources and capacities, that guide, steer, control, or manage food system processes and outcomes through complex, overlapping networks (Moragues-Faus et al., 2017, 2024).

Following this rationale, Social Network Analysis (SNA) is a promising methodology for advancing relational approaches to agri-food governance research. It offers a systematic and quantitative approach to studying relational data, focusing on the positions of actors within networks *(nodes)* and their interconnections *(ties)* (Borgatti et al., 2022). As a methodological tool, SNA supports the visualisation and measurement of social connections, revealing patterns related to actor interactions that are often difficult to detect (Light and Moody, 2021). For example, it can shed light on forms of relational power associated with actors' centrality in multi-actor networks (Borgatti et al., 2022), as well as on network structures that underpin different modes of governing agri-food systems (Levkoe et al., 2021).

Nevertheless, SNA presents several challenges for researchers in its implementation. Network data is commonly collected through surveys using either *name generators* – open-ended questions that ask respondents to list the actors with whom they interact – or a *roster format* – a predefined list of actors for respondents to select from. Both approaches, however, involve trade-offs (Agneessens & Labianca, 2022). Roster-based surveys can be burdensome for participants, particularly when the list is long, and researchers risk overlooking relevant actors who fall outside the predefined boundaries. Name generators, by contrast, rely on participants' memory and are therefore susceptible to poor recall, which can lead to incomplete network data. More broadly, both methods raise the fundamental issue of network boundary specification – determining which actors should be included and how to ensure that the resulting network adequately reflects the complexity of the system under study (Laumann et al., 1989).

Alternatively, a performative approach has been proposed to the use of SNA. Drawing from Actor-Network Theory (ANT)'s understanding of social scientific methods (Latour, 2005), Scott (2015) argues that SNA, similar to other social methods, can be performative: rather than merely describing social realities, it may also contribute to enacting particular realities and rendering them open to reflection and transformation. From this perspective, the performative turn in SNA is not just to provide a complete or exhaustive representation of a social phenomenon. Rather, it emerges as a tool for social learning by visibilising the cultural, social and institutional bonds that underpin complex governance structures, enabled

by collective reflection activated around visual depictions of that complexity (Mancilla García & Bodin, 2020). This approach is usually operationalised through participatory mapping methods using visual, collectively generated data, which is subsequently analysed using SNA metrics and collectively interpreted (Boyle et al., 2021; Hauck et al., 2015; Schröter et al., 2018b).

Governance dynamics are, however, messy, evolving within shifting actor constellations, uneven power relations, and context-dependent interactions over time (Boyle et al., 2021; Forney et al., 2025). Simplified SNA visuals do not necessarily depict this complexity (Rosas & Knight, 2019). Greater analytical attention has therefore been directed towards adopting relational approaches that move beyond social dynamics alone to include socio-material elements, thereby providing entry points for understanding complex governance systems (Forney et al., 2025), such as that proposed by ANT (Latour, 2005) or assemblage theory (DeLanda, 2016). This focus emphasises the instruments, artefacts, and procedures through which governance is enacted, as well as the diverse interactions between human and non-human actors that hold it together. Nevertheless, the operationalisation of such an approach remains challenging in empirical research, with specific methodologies and methods not necessarily outlined. At the same time, relational approaches, such as ANT, have been argued to pay insufficient attention to power asymmetries and social inequalities within networks (Elder-Vass, 2008), while also suffering issues of boundary-setting (Spies & Alff, 2020), and, thus, operationalisation.

This paper seeks to advance the implementation of a relational approach to analysing governance dynamics by leveraging the analytical strength of SNA to operationalise ANT's relational and socio-material theoretical perspective. For this purpose, it proposes a hybrid methodology that mobilises a performative approach to SNA: the Socio-Material Actor-Network Analysis (SMANA) methodology. Developed within the AETERAKIS project – *A territorialised Agricultural Knowledge and Innovation Systems (AKIS) framework for agroecological transitions*, this innovative methodology seeks to produce collective reflection and social learning by making visible – and thus, actionable – relationship patterns, actors' relative centrality, and the socio-material mediations through which specific network structures and power asymmetries emerge in agri-food governance processes.

1.1 Overview of the AETERAKIS project

The proposed methodology is part of the AETERAKIS project, conducted between January 2025 and July 2027 and funded as a Marie Skłodowska-Curie Postdoctoral Fellowship 2023. The project focuses on the territorial organisation and the role of AKIS in supporting agroecological transitions, with the aim of developing the AETERAKIS framework[1] (https://cordis.europa.eu/project/id/101146631). It combines participatory network mapping methods under the hybrid SMANA methodology across four provincial Spanish case studies – Barcelona, València, Araba, and Madrid. The project explores how formal AKIS infrastructures and governance for organic farming interact with agroecology-oriented farmers' personal knowledge networks, and how these interactions shape the orientation, circulation, and use of knowledge and innovation for agroecological transitions.

The focus on formal AKIS infrastructures for organic farming stems from the assumption that, as an institutionalised production model (Moschitz et al., 2021; Ewert et al., 2023), organic farming might have already established AKIS infrastructures that could support deeper agroecological transitions. While we acknowledge the tensions and limitations associated with this assumption (see, for example, Migliorini and Wezel 2017; Lampkin et al. 2020), discussing them falls beyond the scope of this paper, which primarily concerns the proposal of the SMANA methodology and its operationalisation.

In this paper, AKIS are used as an exemplary empirical case to illustrate how the proposed methodology provides a structured entry point for tracing actors, socio-material interactions, and power-laden relations in complex and hard-to-bound governance systems. AKIS are particularly suitable for this purpose as they constitute dynamic, multi-actor, and multi-level systems in which knowledge and innovation emerge through interaction among farmers, advisors, researchers, public authorities, educational institutions, consumers, and other agrifood actors, such as input suppliers (Charatsari et al., 2023; EU SCAR, 2019). AKIS are also influenced by their broader socio-institutional landscape, including the norms, values, arrangements, and decision-making processes that influence what is prioritised and thus legitimised and rendered feasible (Charatsari et al., 2024; Fieldsend, 2020; Knierim et al., 2017; Klerkx et al., 2012).

[1]The AETERAKIS framework will introduce a conceptualisation of territorialised AKIS and identify key characteristics and relational dynamics through which AKIS can be reconfigured to better support agroecological transitions, including patterns of actor diversity, knowledge circulation, governance arrangements, and cross-scale linkages.

2. Combining ANT with SNA: Introducing the SMANA methodology

SNA and ANT approaches are among the most prominent frameworks for analysing networks, yet they stem from distinct epistemological and ontological traditions (Vicsek et al., 2016). ANT advances a flat ontology within a realist and (new) materialist paradigm. It rejects a-priori hierarchies of interactions and binary distinctions, allowing *both human and non-human actors* to conform networks, with agency, understood as relational and emerging from the interrelations in which actors are enrolled (Latour, 2005; Gamble et al., 2019). By contrast, SNA is commonly situated within a broader positivist paradigm (Vicsek et al., 2016). It emphasises the measurement and representation of social relations and interaction patterns within an observed system or community composed mainly of *human* actors. Although these approaches are often considered incompatible, the SMANA methodology aims to bring ANT and SNA into productive dialogue by leveraging the analytical potential of SNA to advance ANT's relational and socio-material perspective.

A key premise of ANT is its focus on how heterogeneous associations between human and non-human actors are formed, and how these associations are stabilised and maintained over time. It poses particular attention to the practices and devices through which collectives of actor-networks are provisionally assembled (Vicsek et al., 2016). In Latour's (2005) words *"we have to take non-humans into account only as long as they are rendered commensurable with social ties and also to accept, an instant later, their fundamental incommensurability"* (p. 78). This means that non-human actors are analytically considered insofar as they become relevant within the associations that constitute actor-networks. They are rendered commensurable only in terms of the roles they play in mediating these associations – through which they are also transformed or even conformed, not because they are necessarily equivalent to social actors or social ties. Such commensurability is therefore situational and ever-changing; not finished nor characterised by any essence beyond such situated interrelations.

In this line, a key role in actor-networks is that of non-humans in the form of *mediators*. Mediators do not simply transmit action or information without modification. Instead, they transform, translate, redirect or amplify relations as associations are formed. Their effects cannot be inferred from their inputs alone, as they actively shape how actors relate to one another and have a crucial role in stabilising actor-networks, thus having, in terms of Latour (2005), their own agency. The concept of mediators is particularly helpful in providing a starting point to trace the social structures of governance systems. Durable social connections and structures are not only based on human means. They are fragile and ephemeral if they do not have something that sustains them across time and space (Latour 2005; Forney et al. 2025). By shifting action onto material, technical or organisational elements, mediators give relations durability and inertia, allowing power, coordination and governance arrangements to extend beyond transient interactions (DeLanda, 2016). Looking at the role of non-humans in this way is also the key in bringing ANT and SNA into productive methodological dialogue.

Similar to ANT, the underpinning theoretical assumption of SNA is that, to explain social phenomena, attention must be given to their inherent relationality. Indeed, networks in SNA need to be understood by including dyadic variables (attributes of pairs of actors and characteristics of relations among actors) (Borgatti et al., 2022; Vicsek et al., 2016). Although in SNA those considered actors are predominantly individuals or social groups, such as institutions or organisations, the notion of *two-mode networks* can set a bridge with ANT's idea of mediators in actor-networks. Two-mode networks (also known as affiliation networks) are composed of two distinct sets of nodes (actors of mode I and actors of mode II) – commonly individuals and the events, organisations, or institutions to which they are connected (Borgatti et al., 2022). Here, the focus is on how nodes of mode I are connected to one another through their affiliation with or participation in nodes of mode II. Direct connections among actors within the same mode are not represented, unless the network is transformed into a one-mode projection derived from these shared affiliations (ibid.). In this sense, mode II nodes can be understood as playing a mediating role within the network, as they enable and structure relations among mode I nodes, thereby providing a conceptual bridge between both theories.

Building on this insight, the proposed hybrid SMANA methodology analyses two-mode affiliation networks within the context of complex agri-food governance; in this paper exemplified through AKIS. Rather than treating organisations, events or institutions as mode II nodes, as is common in conventional SNA, the SMANA methodology foregrounds socio-material infrastructures as heterogeneous mediators of governance systems. These infrastructures are understood as the *means* – particularly concerning physical or non-physical spaces, such as marketing spaces, test farms, platforms, research or R + D projects, online platforms, dissemination events, through which AKIS actors develop, exchange, transfer and implement knowledge and innovation. To maintain coherence with ANT while avoiding a strictly positivist interpretation of network data, the SMANA methodology adopts a performative approach to SNA, as explained in the introduction. This approach retains formalised network representations and quantitative analyses, while using them as tools to trace associations and elicit collective reflection rather than as definitive descriptions of a given system. In doing so, it leverages the strengths of both ANT and SNA, combining selected elements of both. The following section illustrates how the SMANA methodology has been implemented in the context of AETERAKIS project.

3. Methods: Operationalising the SMANA methodology through visual data collection and analysis methods

The SMANA methodology is operationalised by using an adaptation of the Net-Map method (Schiffer & Hauck, 2010; Schiffer & Waale, 2008). The Net-Map method aims to understand complex actor-networks, power relations, and influence dynamics within a governance or decision-making context using SNA and a visual, interactive data collection approach. Originally developed for individual interviews, Net-Map has been increasingly applied in group settings and collaborative planning, allowing for the visualisation of shared knowledge and the co-construction of system representations (Hauck et al., 2015; Boyle et al., 2021). Through visual and participatory network mapping, Net-Map supports participants in identifying leverage points and limitations in navigating complex systems to achieve common goals. In the case of AETERAKIS project, the Net-Map method was deployed through one-day workshops using collective, consensus-based assessment. The resulting maps therefore show shared co-constructed interpretations and deliberations, consistent with a performative use of SNA in which actors, relations, and mediating arrangements are collectively negotiated and opened to reflection.

The implementation of the Net-Map method is usually guided by a specific research question, such as "Who influences XY policy development or XY system achievement of sustainability goals" (Hauck et al., 2015). This question is put into practice via either workshops or interviews through the following objectives: (1) determining what actors are relevant in achieving/influencing system goals; (2) eliciting their level of influence and alignment with these goals, and (3) identifying the linkages that are currently present to determine whether increased strategic networking can improve in the achievement on these goals (Schiffer & Hauck, 2010). As a visual-based method, it draws heavily on material objects for eliciting answers and facilitating discussion. Small figurines and actor cards are utilised to represent actors that are positioned by participants on large sheets of paper, checker pieces or similar round disks that are stacked to build influence towers below or next to the actors, and color pens to draw actor links. As this requires active participation, the method prompts participants to stay focused on the objectives of the workshop (Gava et al., 2025; Hauck et al., 2015; Schröter et al., 2018b).

We adapted this method to include the identification of the mediators of actor interactions, following the proposed SMANA methodology. To do so, besides figurines for actors (people, organisations), figures for mediating socio-material infrastructures are also utilised, with links then drawn between actors-infrastructures. Besides this adaptation, the elicitation of influence was removed from the exercise. As Boyle et al. (2021) indicate, this step could lead to power conflicts when performing workshop activities, particularly related to state and non-state actors. Although this is a relevant aspect, the use of the SMANA methodology during the AETERAKIS project prioritised facilitating local transformation processes through an improved understanding of AKIS governance. The potential for generating conflicts was therefore carefully planned, both within and beyond the workshops. Moreover, influence and power relations can be measured using quantitative SNA metrics (Borgatti et al., 2022). Conversely, actors' alignment with agroecological transitions was indeed assessed, following the original Net-Map approach of eliciting alignment with a system's desired goals. Figure 1 provides a step-by-step guide to implement the SMANA methodology through the adapted Net-Map method. The next sections develop this step-by-step guide further and discuss the different stages of the implementation of the SMANA methodology, including which SNA metrics to use for this purpose as deployed within the AETERAKIS project.

4. Use cases: Implementation of the SMANA methodology in the AETERAKIS project

4.1 Preparation, pretesting and sampling

Despite the performative use of SNA, such as through the Net-Map method, partly reducing the need to define strict network boundaries, clear guiding parameters are still required (Schiffer & Hauck, 2010). These include specifying what is being studied and identifying the actors or actor categories likely to be present in the system, drawing on prior experience or existing literature. It also requires careful consideration of participant selection, as the resulting network reflects the perspectives, positions, and degrees of engagement of those invited (Hauck et al., 2015). In this regard, selection should explicitly aim to capture a diversity of perspectives, based on actors' roles in the system and their viewpoints on the system under analysis. Moreover, the number of workshop participants needs to also be considered. As in the case of other group-based data collection methods (Stewart et al., 2007), 6–8 participants was considered an appropriate number to facilitate fluid group discussion and reflection.

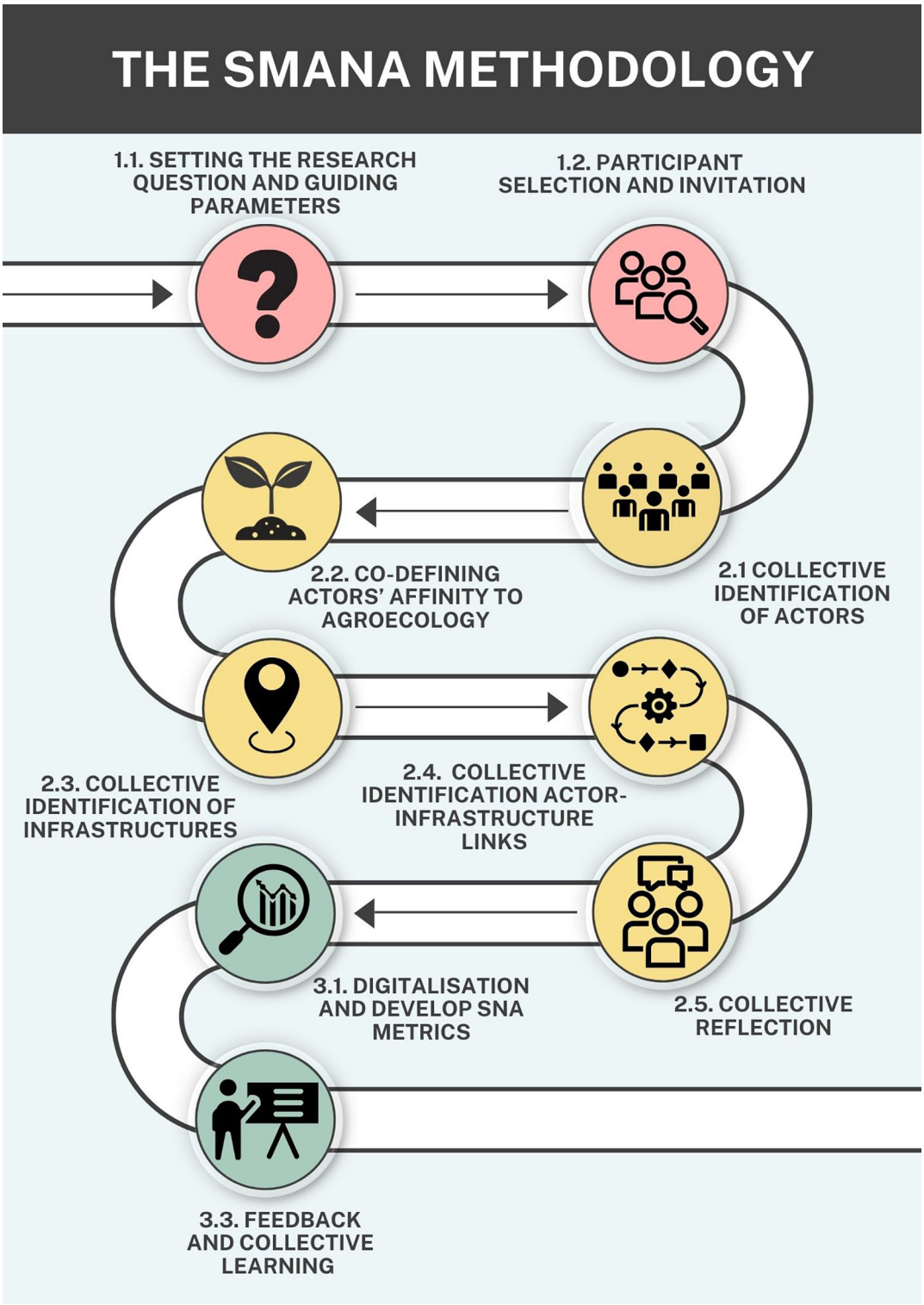

Figure 1. Step-by-step guide SMANA methodology. Pink circles refer to steps of Phase 1 (Preparation, pretesting and sampling), yellow circles to steps of Phase 2 (Conducting the workshops), and green circles to steps of Phase 3 (Analysis).

Given the action-oriented approach of the AETERAKIS project, participant selection was guided by their relevance to agroecological transitions in the territory. Moreover, the selection followed the 8 recommendations for the design of participatory processes in environmental management developed by Del Vente et al. (2016), since its accuracy allowed it to adapt it to the research context. We took into account, number of participants, gender, age, ways of knowing, and power asymmetries to align participation with inclusiveness and equity principles. Specifically, participants were selected based on their in-depth knowledge of the AKIS infrastructure for organic agriculture and related models and/or their active involvement in agroecological initiatives in each province's context. The aim was to ensure a balance between critical reflection and grounded insight into existing systems of knowledge exchange, transfer, and co-production for organic farming from an agroecological perspective. Moreover, participant selection also focused on including perspectives of a variety of fields of expertise (following Wyborn et al. (2019) conceptualisation of ways of knowing) within the different AKIS-subsystems, including public administrations, farming advisory services, education and research, farmers, and the agri-food supply chain sector and civil society. The intention was to include at least one representative from each sub-system.

With the starting hypothesis that AKIS for organic farming could serve as a stepping-stone toward agroecological transitions, the one-day workshops in each case study sought to achieve three core objectives: (1) to map the formal AKIS infrastructure in the territory, including actors and infrastructures, for organic farming as perceived by participants; (2) to identify its limitations and potential leverage points of this system in supporting agroecological transitions; and (3) to generate recommendations for policy, action, and intervention based on collective reflection of the resulting map.

As noted above, clarifying terminology is essential to ensure the robustness of the method, particularly with regards to meeting its objectives. Accordingly, the workshop protocol was reviewed by the authors several times and tested in a simulation of a workshop between two authors. The last version of the workshop protocol utilised in the AETERAKIS project after this process is available in the official DIGITAL.CSIC repository (see http://hdl.handle.net/10261/419174 - Zerbian, 2026). During the testing phase, it was identified that clear working definitions of the concepts knowledge, innovation, actors, and infrastructures were needed, particularly regarding the differentiation between an actor and an infrastructure. The following working definitions were proposed:

- *Knowledge* as a learned, experiential, or evidence-based understanding of a topic used for decision-making;
- *Innovation* as a collective process of improving practices, organisation, or commercialisation through knowledge exchange, not limited to technology;
- *Actors* as organisations or entities involved in generating, exchanging, or applying knowledge and innovation within the territory including the categories of: advisory services, research, farmers and farmer-based organisations (FBOs), education, public authorities, the food supply chain (upstream and downstream, including consumers and input suppliers), and non-governmental organisations (NGOs) (Charatsari et al., 2023; EU SCAR, 2012; Fieldsend, 2020; Knierim et al., 2015, 2017);
- *Infrastructures* as physical (commercialisation spaces, demonstration farms, training centres) or non-physical spaces (research projects, governance platforms, local networks) that enable - and thus intermediate - diverse interactions and connectivity among actors.

Moreover, actor-infrastructure-actor links were distinguished between information flows, resource/material flows, and planning, following previous SNA studies analysing agri-food governance dynamics (Levkoe et al., 2021; Zerbian et al., 2022). Similar to the original Net-Map method, the materials utilised, and thus prepared beforehand, included (with exceptions of the exclusion of the checker pieces and inclusion of figures for infrastructures):

1. Large sheets of paper to draw the resulting AKIS maps.
2. Post-its to write down actor and infrastructures' names.
3. Coloured 3D cylinders representing different actors based on previously defined actor AKIS categories.
4. Coloured 3D cubes representing the infrastructures, differentiating between physical and non-physical ones based on colour.
5. Different coloured felt pens to draw different types of links.

The testing phase also made clear the need for more than one facilitator and the need for close collaboration between facilitators while conducting workshops. Given their complexity, joint facilitation was essential to set an environment of collaboration among actors that have diverging backgrounds, experiences and knowledge types. During implementation, collaborative facilitation helped participants stay focused on the task, manage the different dynamics unfolding in parallel, and ensure the smooth progression of the sessions and achievement of expected outcomes. At the same time, it was considered that working collaboratively allowed the facilitators to support one another, distribute attention and responsibilities, and maintain the quality and consistency of the process throughout the workshop. Following the five pillars proposed by Albert-Fonseca et al. (2025) for transformative research allowed the research team to generate caring spaces for themselves and the participants during workshops for knowledge co-production.

4.2 Conducting the workshops

The participatory workshops followed a sequenced structure combining individual and collective reflection that integrated four steps. Guiding questions were prepared for each step, as exemplified in the workshop protocol (Zerbian, 2026). These questions were designed to support participants' continuous interpretation of the emerging maps as they were being co-constructed, allowing lessons to be drawn throughout the mapping process.

The first step involved participants identifying relevant actors of the AKIS for organic farming within the territory of each case-study and assessing their alignment with agroecological principles. Actors were represented using coloured figurines (cylinders) - see Figure 2 - based on each of the actor categories developed in the preparatory phase. While these categories served as a guide, previous research highlights that the boundaries within and between AKIS subsystems are often blurry, and hybrid profiles and overlapping mandates are common. For instance, advisory services may be delivered by actors embedded within commercial firms, cooperatives, or NGOs, sometimes combining public and private funding streams (Knierim et al., 2015). Therefore, actor categories were not treated as rigid, with the main function of the actor within AKIS as its categorisation but recognising the hybridity of actors and overlapping mandates during workshop discussions. At the same time, actors outside the administrative boundaries of the territories could also be considered as long as they have an active role in the AKIS dynamics of the analysed territory. In line with the AKIS definition explained before, the key inclusion criterion was that actors be engaged – directly or indirectly – in generating, sharing, or using knowledge and innovation for organic farming and related fields of the selected territories. This served as the main criterion for delimiting the boundary of the network during the workshops. While identifying relevant actors, participants were also asked to elicit **whether these actors were aligned with agroecology** – yes (+), no (−) or having a neutral stance (=), which was indicated in the post-its with actor names.

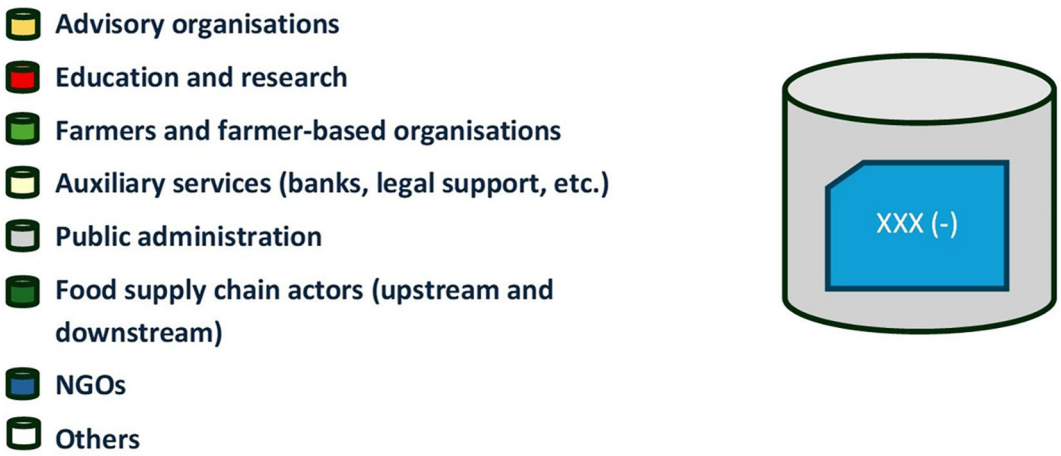

Figure 2. Colour-based actor categorisation and example of an identified AKIS actor. Post-it note colours were used randomly and did not convey any analytical meaning. Within the post-its participants wrote the name of the actor, agroecology alignment (+/=/−), and indicated whether there were individuals within each actor that either facilitated or limited agroecology-related actions.

In **step 2**, participants subsequently mapped mediation infrastructures – physical or non-physical – where knowledge exchange, coordination, and co-production occur among the identified actors (Figure 3). These included training events, working groups, collaborative projects, online platforms, among others. Participants were explicitly prompted to discuss the nature and purpose of each infrastructure, including whether it served to transfer information, coordinate activities, support decision-making, or foster experimentation. This dialogue helped to clarify the functional roles of these spaces in current AKIS dynamics and their relevance to agroecological transitions.

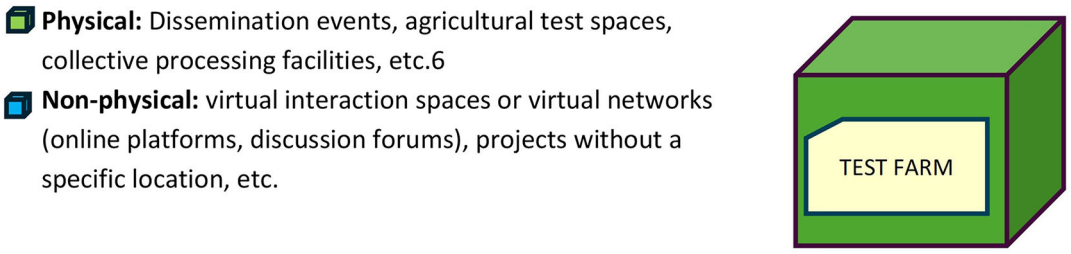

Figure 3. Colour-based infrastructure categorisation and example. Post-it note colours were used randomly and did not convey any analytical meaning.

Next, for **step 3**, participants collectively identified which actors were involved in which infrastructures. Actors were then physically positioned close to the infrastructures in which they actively participated in the large sheets of paper. This exercise helped to make actor–infrastructure relationships immediately visible. Finally, links were drawn between actors and infrastructures, and between actors who shared the same infrastructures, utilising colour-coded markers and indicating the direction of the links, distinguishing between information flows, resource/material flows, and planning, as explained earlier (see Figure 4).

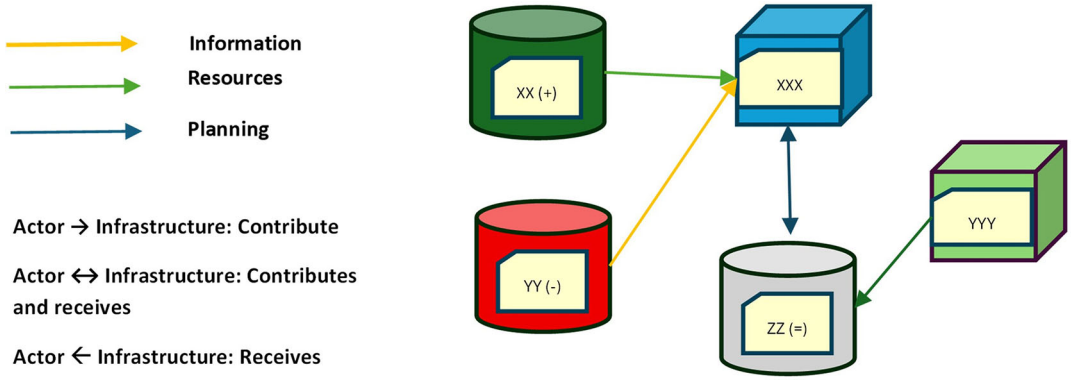

Figure 4. Example of link tracing between actors-infrastructures-actors with directionality and link categorisation. Each colour represents a different link – yellow for information, green for resources, and blue for planning. Links also had three different options for directionality – receiving, contributing, and contributing and receiving.

The **final step** of the workshop focused on group discussion, interpretation, and strategic reflection. Specific guiding questions were devised to support collective analysis (see workshop protocol by Zerbian (2026), particularly to draw out what the identified relational dynamics revealed about AKIS governance. Participants analysed the mapped AKIS network structure, identifying central or missing actors, underused or critical infrastructures, and potential barriers to agroecological transitions such as silos, asymmetries of power based on resource or planning flows, weak cross-sectoral collaboration, and misalignment of relevant actors with agroecological principles. The sessions closed with collective identification of actionable leverage points – actors, relationships, and infrastructures that could be strengthened or reoriented to better support agroecological transitions, along with discussion of funding flows, policy and institutional support needed to do so.

4.3 Analysis

As explained by Hauck et al. (2015), analysing Net-Map data can take many forms depending on the research objectives. A common practice, beyond collectively analysing the network visually during the workshop (as in the final stage of the SMANA methodology), is to translate the information generated into SNA metrics and share these results with participants for a further round of collective reflection. This process was also conducted in the AETERAKIS case studies, with the digitised networks fed back to the participants through an online meeting for further discussion and reflection.

As an initial step, hand-drawn network maps were converted into an edgelist, a standard data structure for SNA in which each row represents a tie between two nodes and can include link attributes (Borgatti et al., 2022), such as link type or directionality in this case. Ties connected actors to the identified AKIS knowledge and support infrastructures. As

suggested by Mihăilă et al. (2026), this process was complemented by documentary triangulation, including the review of websites, policy documents, project materials, and organisational information to cross-check actors, ambiguous links, and further identify or substantiate mediating infrastructures and relations that were only partially captured during the workshops.

Two-mode networks require analytical approaches that differ from those used for one-mode networks. Available options include analysing each mode independently using metrics specifically developed for two-mode networks, projecting the two-mode network into one-mode networks and applying conventional SNA measures, or analysing the two-mode structure directly (Murphy & Knapp, 2017). The SMANA methodology focuses on the third approach, given the relevance of identifying the role of infrastructures as mediators between actor interactions.

Metrics specialised for two-mode networks were calculated using xUCINET (V. 0.0.2.0020) in RStudio. Network visualisations were produced using the *sna* (V. 2.7–2) and *igraph* (V. 2.0.1.1), packages. For SNA analyses, all data were treated as undirected to allow for better two-mode data analysis (Borgatti et al., 2022). To analyse the relational dynamics of the AKIS governance of the cases, including the role of infrastructures in mediating interactions among actors, we focused on a set of complementary SNA measures addressing both node relevance and overall network structure. Specifically, we examined degree centrality, network density, community detection, and core–periphery structure.

- Degree centrality was used to assess the relevance of both actors and infrastructures within the AKIS. In two-mode networks, degree centrality corresponds to the number of connections a node has to nodes in the opposite mode. For actors, this reflects engagement with knowledge and support infrastructures; for infrastructures, it indicates the number of actors connected to them and their functional reach within the AKIS.

- Network density was used as an indicator of overall structural cohesion and was calculated as the proportion of observed actor–infrastructure ties relative to the maximum number of possible ties between the two modes.

- To identify substructures within the governance network, community detection and core–periphery analysis were applied using a dual-projection approach (Everett & Borgatti, 2013). The Dual-projection approach projects the information of both one-mode projections (actor–actor and infrastructure–infrastructure), losing less information when used in algorithms and models (Borgatti et al., 2022).

    - Community detection identified clusters of actors engaging with similar infrastructures and groups of infrastructures mobilised by similar sets of actors, capturing patterns of coordination and functional differentiation.

    - Core–periphery analysis identifies highly popular and densely interconnected actors and infrastructures. Actors can be part of the core given their active participation in infrastructures, and infrastructures given the amount of actors that participate in them, indicating the concentration of governance and coordination functions.

The digitised network and SNA analysis were then presented to workshop participants through an online meeting in each case for validation to systematically review and flag any discrepancies or ambiguity. Feedback meetings also included a final reflection section to draw lessons from the analysis for transforming AKIS towards agroecological transitions, identifying possible joint actions, policy changes, and institutional support needs.

After incorporating participants' feedback, final versions of the digitised maps and SNA analyses were produced for each case. This analysis was then accompanied by a qualitative thematic analysis (Braun & Clarke, 2006) conducted in Atlas.ti, using the transcriptions of the workshops and feedback meetings to gain more insights into the *why* and *how* of the observed network structures and metrics, as well as methodological insights. The analysis used categories derived from the project's evolving conceptual framework of AKIS for agroecological transitions (see Zerbian et al. (2026) for the initial conceptual foundation). The analysis focused on identifying patterns of actors' roles, mediating infrastructures, knowledge and support flows, perceived barriers and enablers, and participants' interpretations of emerging network properties such as cohesion, fragmentation, centrality, and dependency across and within each case. These qualitative findings were then compared with the SNA metrics and visualisations to support collective reflection of the observed network structures and its elements, including similarities and differences, and to better understand the governance dynamics behind them.

5. Discussion: Lessons learned from the application of the SMANA methodology

The implementation of the SMANA methodology in the case studies of the AETERAKIS project, as described before, offers relevant insights into its strengths and limitations. We describe next the lessons learned from this process, pointing to relevant aspects to be further developed in future implementations or adaptations of the methodology.

5.1 Reflecting on actors and infrastructures

First, implementing the methodology through participatory network mapping offered multiple points of discussion of the quality and stability of AKIS actor relationships. Significantly, approaching networks through infrastructures helped reveal contrasts between stable, institutionalised patterns of interaction and more informal dynamics, where coordination relied on ad hoc arrangements and personal ties. For instance, physical spaces functioned as recurrent points of coordination and planning, whereas time-bound projects were primarily understood as funding channels with constrained deliberative capacity, shaped by their limited duration and predefined objectives. Moreover, being able to lay out the different types of interactions – information, resources, and planning, as well as their directionality, elicited discussions regarding who exchanges information with whom, who provides funding, and what kinds of participation are promoted and whether these are mutual or one-sided.

One limitation was the difficulty to differentiate clearly between actors and infrastructures for participants. Projects, platforms, and organisations frequently overlapped, raising the question of what constitutes an "infrastructure": whether it should be understood as an actor in its own right, as a mediator among actors, or as a temporary assemblage tied to specific funding or objectives. This ambiguity became particularly evident where long-running projects or shared platforms, such as territorial agroecological networks, were described both as places of interaction and as collective actors with agency. On the one hand, they function as infrastructures because they connect actors across the territory and enable coordination, exchange, and collaboration. On the other hand, they also operate as actors when they participate in specific projects, mobilise resources, take decisions, or represent shared agendas within AKIS dynamics. Similarly, FBOs were mapped as actors when participants referred to them as organisations involved in AKIS dynamics by creating and sustaining collective structures for farmer coordination (López-García & Carrascosa-García, 2023; Rani et al., 2023), but they were also discussed as infrastructures when they sustained specific spaces, services, or arrangements, such as a regular agroecology farmers' market, that connect farmers with consumers, advisors, public administrations, and other territorial actors.

These discussions highlight the importance of attending to participants' meanings and perspectives on the realities under study, in line with Small and Calarco's (2022) principle of cognitive empathy as a criterion of qualitative research quality. It encourages researchers to account for the ambiguities arising from the interaction between theoretical and methodological categories and participants' own understandings of the realities under study. Rather than resolving such ambiguities only through predefined, immutable categories, a crucial aspect in the workshops was thus to allow these categories to be tested, discussed, and interpreted iteratively and openly with participants. Based on this reflection, a revised operational distinction between actors and infrastructures was deployed, informed by ANT's understanding of action. An entity is understood as an actor when it is described as taking part in action, for example by mobilising resources, participating in projects, or shaping decisions by setting or influencing specific policy priorities. Infrastructure, by contrast, refers to the connective function that an entity, including one also identified as an actor, may perform when it enables, sustains, or mediates relations among other actors. As Vicsek et al. (2016) rightly note, ANT promotes attending to this complexity by treating actors as fluid entities that are themselves actor-networks, composed of heterogeneous elements and able to perform different functions depending on the relations in which they are embedded.

5.2 Reflecting on infrastructures' function and temporality

Differentiating between types of infrastructures was also relevant to support in-depth discussion on their role in configuring AKIS governance dynamics. However, this proved difficult to fully capture during workshops. Projects, online platforms, advisory initiatives, and physical meeting spaces, such as test and training farms, community buildings and assets, farmers' markets, were all mapped. Yet, the limited workshop time available constrained a more detailed examination of how different infrastructures mediate and condition interactions in distinct ways, beyond the types and directionality of the ties represented in the maps. The collective analysis of the digitised networks during the feedback online meeting provided a crucial opportunity to deepen this analysis, particularly for clarifying the role of infrastructures identified as central through SNA. Participants emphasised that the mediating function of central infrastructures is not uniform but dependent on the quality of the interactions they facilitate. For example, one-off technical communication events may temporarily bring numerous actors together without necessarily fostering sustained relationships or deeper collaboration. Regular agroecology farmers' markets, food policy councils, and other regular spaces, by contrast, can support continued engagement, strengthen connections among actors, and create opportunities for mutual support and collective action.

To further examine the different mediating roles of infrastructures, the proposed SNA metrics could thus be complemented by an additional analytical layer exploring how particular interaction patterns intersect with specific infrastructures. As noted above, physical spaces frequently emerged as recurrent sites of coordination and planning. Analysing these overlaps would provide a deeper understanding of how infrastructures enable or channel specific relational dynamics. This focus is consistent with ANT's attention to materiality, suggesting that places, objects, and spatial arrangements do not merely provide a backdrop for interaction but actively participate in shaping what actors do and how relations unfold (Latour, 2005). In this sense, physical spaces can be understood as socio-material settings in which recurring activities, roles, objects, and norms become stabilised. A further analytical layer of this kind could therefore examine which types of ties, such as information flows, material or resource flows, and planning relations, are most frequently associated with particular spaces, platforms, or initiatives due to their specific materiality.

The challenges faced during the SMANA implementation also raised questions about whether it requires more than just punctual workshops to reach its full potential. In particular, the technique provides largely static network representations, leaving temporal and historical dimensions underexplored. This was reflected in participants' difficulty in refraining from drawing direct linkages between actors, as discussions repeatedly gravitated towards actor–actor exchanges configurations, rather than actor-to-infrastructure relations. Participants noted that relations currently represented as direct exchanges were often shaped by earlier periods in which interaction was mediated by specific projects or spaces. What appears as a stable tie in the present drawn networks frequently rested on a shared historicity of collaboration. Small and Calarco's (2022) discussion of exposure in qualitative research was particularly relevant for attending to these findings, highlighting that researchers' closeness with the case under study is crucial for understanding this complexity. The co-authors' prior involvement in the case-study territories provided situated knowledge of their historical, institutional, and relational contexts, supporting a deeper contextual understanding and a more nuanced reflection of the mapped networks.

5.3 Reflecting on facilitation and the potential of the SMANA methodology

It is important to note that, in practical terms, the successful implementation of the methodology depends on facilitators having specific training in facilitation and participatory methods, as recommended more broadly for participatory research (Scher et al., 2023). Such training is essential for navigating conflict and unequal influence, guiding participants towards active and respectful engagement in group discussions and the mapping process, given the workload and intensity of the workshops. This is particularly relevant when feeding back results to participants. In one of the cases of the AETERAKIS project, the presentation of the SNA metrics, identifying who occupies central positions and who does not, generated discomfort and critical reactions among some participants, particularly as actors they considered central to the governance dynamics did not appear as such in the resulting map. As emphasised by Small and Calarco's (2022), self-awareness is imperative in qualitative research, more so if knowledge co-production is intended (Albert-Fonseca et al., 2025). Attention should therefore be paid to how results are conveyed and communicated, since the analytical frame through which they are interpreted shapes how network data are received and may influence the direction and tone of subsequent participant discussions.

Careful consideration of participant recruitment is also required to ensure a coherent diversity of perspectives – heterogeneity as expressed by Small & Calarco (2022) – in the mapping process, including adaptation of time schedule to enhance participation. For example, in the case of Araba, participation barriers were especially evident for women facing work overload, a challenge rooted less in the technique itself than in the broader context of women's role in agroecological transitions (Vizuete et al., 2024). Simultaneously, it is also extremely important to make clear to participants that the primary aim of the methodology is not to produce a complete or objective representation, but rather to elicit collective reflection through the process of mapping and its later analysis through SNA. As Boyle et al. (2021) explain, performative SNA through Net-Map requires sensitivity to processes of information exclusion, balanced against the objectives and scope of the research, with the question of 'who participates' and 'who is missing' then also becoming a central analytical concern in the collective reflection of the resulting maps. Such an approach also brings SMANA closer to what is understood as 'performative' new materialisms (Gamble et al., 2019). For example, in the case studies of the ATERAKIS project, participants stressed the importance of explicitly asking who is not included as a reflexive practice.

Despite the challenges outlined here, participants identified several advantages of the SMANA methodology. The participatory workshops prompted reflection on how to improve collaboration among actors who rarely work together due to institutional, sectoral, or resource constraints, such as farmers and researchers. As noted by Schröter et al. (2018a), network maps serve as boundary objects that facilitate multi-actor collaboration through iterative learing and collective reflection. This learning capacity was also particularly evident during feedback meetings, where SNA metrics, analyses, and multiple visualisations of the digitised networks were presented, allowing for the identification of relational patterns of AKIS governance. Indeed, participants were able to identify infrastructures and actors that function either as enablers

or as sinks for agroecological transition, while also identifying the need for new connections that may support future collaboration and innovation.

At the same time, these advantages should not be read as implying a full epistemological convergence between ANT and SNA. SMANA's contribution is primarily methodological: it uses SNA as an analytical device to make visible, discussable, and comparable the socio-material configurations of governance dynamics. Several steps could further extend this methodological approach. Applications could repeat mapping exercises to analyse how relations evolve, incorporate additional comparative measures such as fragmentation or the number of components, and, where appropriate, explore formal modelling approaches such as Exponential Random Graph Models (ERGMs) or stochastic actor-oriented models (SAOMs), as also noted by Mihăilă et al. (2026). Such extensions would nevertheless require particular attention to the situated and partly subjective character of the networks produced. In these cases, participant selection, together with validation and triangulation, remain especially important for robust applications and extensions of SMANA.

6. Conclusion

This paper set out to advance relational approaches to the study of agri-food governance by proposing and empirically testing SMANA, a hybrid methodology integrating ANT with a performative use of SNA developed under the AETERAKIS project for the case of AKIS. Grounded in participatory network mapping and collective reflection, SMANA was developed to better capture the messiness, territorial embeddedness, and socio-material mediation that characterise complex governance dynamics, while also supporting social learning and knowledge co-production. Its main contribution lies in using SNA's analytical potential to operationalise an ANT-informed understanding of governance as a socio-material and relational process through the use of infrastructures as mediators.

The application of SMANA in the context of AKIS demonstrated its value in bridging ANT's sensitivity to the role of mediation of non-human actors to surface relational complexity, leveraging SNA's capacity for systematic analysis and visualisation of relational patterns. At the same time, its application highlights methodological challenges related to temporality, facilitation skills, participant selection, and the limits of static representations. These challenges should not be understood as shortcoming, but as inherent tensions in operationalising relational methodologies in complex governance contexts. Rather than seeking exhaustive or objective representations, SMANA is best understood as a flexible framework for operationalising relational approaches to complex, multi-actor governance processes, fostering collective reflection, knowledge co-production, and social learning. Accordingly, its relevance could lie not only in the specific context of agri-food systems or AKIS, but also in its applicability to complex governance processes more broadly.

Ethics and consent

This study was reviewed and approved by the Ethics Committee of the Spanish National Research Council (Comité de Ética del Consejo Superior de Investigaciones Científicas, CSIC) (Reference No. [166/2025]). All procedures involving human participants were conducted in accordance with the ethical standards of the CSIC.

Following these standards, written informed consent was obtained from all participants prior to their participation in the study. No identifiable personal details or images of participants are included in this publication.

Use of Generative AI tools

The authors used ChatGPT (OpenAI) version 5.2 to improve the clarity, grammar, and overall readability of the manuscript. The tool was used exclusively for language editing and stylistic refinement. All conceptual development, methodological design, analysis, and interpretation of results are the authors' own.

Data and software availability

DIGITAL.CSIC repository. AETERAKIS workshop protocol. URI: http://hdl.handle.net/10261/419174 DOI: https://doi.org/10.20350/digitalCSIC/18110 (Zerbian, 2026).

Data is available under the terms of the CC BY 4.0 license.

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The authors have responded to the reviewers' comments by incorporating appropriate changes.

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I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

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The manuscript presents the SMANA methodology, a hybrid approach that combines ANT and SNA to study complex agri-food governance systems, particularly the Agricultural Knowledge

Innovation System (AKIS). The objective of this methodology is to overcome limitations of both approaches by integrating ANT´s attention to socio-material mediation and non -human actors with SNA´s capacity for structural and quantitative network analysis. SMANA uses an adapted version of the Net-Map method, where participants collaboratively map actors, infrastructure, and their relationships during participatory workshops.

The study applies the methodology within the AETERAKIS project to analyse governance dynamics related to agroecological transitions. The findings show that focusing on infrastructure as mediators helped participants identify how knowledge exchange, coordination, funding and planning processes are organised within AKIS. The integration of participatory mapping promoted social learning and identification of leverage points for improved collaboration.

The study identified methodological challenges and limitations.
The manuscript presents a valuable methodological contribution and is well structured overall. SMANA provides a flexible framework for analysing socio-material governance networks, and the study case is clearly presented. The manuscript requires only minor revisions.

Areas where the manuscript could be strengthened include:

1.- Clarifying whether the main innovation lies in the use of infrastructures as mediators, the performative interpretation of SNA, the adaptation of Net-Map, or if it is the integration of all these elements.
2.- The manuscript acknowledges the ambiguity between mediators and infrastructure. Readers would benefit from clearer criteria to help understand when something is treated as an infrastructure, as an actor or as both.
3.- Clearly defining the concept of performative SNA, as it remains somewhat underdefined in this context.
4.- Thematic Analysis is mentioned; however, no details are provided. It would be helpful to explain how the information from this analysis was integrated with the SNA results and how it contributed to the interpretation of findings.

Is the rationale for developing the new method (or application) clearly explained

Yes

Is the description of the method technically sound?

Yes

Are sufficient details provided to allow replication of the method development and its use by others?

Yes

If any results are presented, are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions about the method and its performance adequately supported by the findings presented in the article?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Food system sustainability and governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 13 Aug 2026

Tanya Zerbian

Thank you for the positive feedback and identifying the manuscript as a relevant contribution. Below please find our responses to your comments and the changes made in the manuscript.

We have clarified that the innovation of the paper lies in the integration of the three elements identified. The central contribution is the use of an SNA analytical approach to operationalise an ANT-informed understanding of agri-food governance particularly through the use of infrastructures as mediators. This is enabled by a performative interpretation of SNA, understood not only as a tool for representing networks, but also as a way of making actors, relations, and mediating infrastructures visible and open to collective discussion. The adaptation of Net-Map serves this purpose methodologically, providing a participatory procedure through which relational data can be generated, visualised, and analysed. Thus, the innovation lies in combining ANT, a participatory – and thus – performative use of SNA, and an adapted Net-Map approach into a coherent methodological strategy for analysing infrastructures as relational mediators.
We have included this in the first paragraph of the conclusion. We have addressed the point regarding the ambiguity of actors and infrastructures further in the discussion (Section 5), where we now reflect on how this distinction has been refined after the discussions raised during the workshop and bringing this in closer conversation with ANT. We also indicate these categories should be seen as contingent, functional and relational rather than fixed or mutually exclusive ones, complying with the theoretical underpinning of the methodology. We have better explained the performative use of SNA in the Introduction. In the revised manuscript, we have reorganised the section where it was explained and provided a clearer definition of performative SNA, specifying that its performative role lies not in producing a complete representation of a network, but in making certain actors, relations, and governance problems visible, discussable, and actionable through collective reflexivity. We have also refined Section 4.3 to clarify our analytical strategy and have added a final paragraph to explain how thematic analysis contributed to the interpretation of findings.

Competing Interests: No competing interests were disclosed.

Reviewer Report 14 May 2026

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A Amarender Reddy
ICAR-National Institute of Biotic Stress Management (NIBSM), Raipur, India

The manuscript presents an innovative and timely methodological contribution by integrating Actor-Network Theory and Social Network Analysis into the proposed SMANA framework. The paper is conceptually strong, well-structured, and highly relevant for analysing complex agri-food governance systems and AKIS dynamics. The participatory adaptation of the Net-Map approach and the emphasis on socio-material mediation are particularly valuable.
However, the paper would benefit from greater clarity on the operational distinction between “actors” and “infrastructures,” as this ambiguity appears repeatedly during implementation. The paper is too lengthy, but relevant sub-sections are missing. Like what are the specific characteristics of “actor” and “infrastructure”. The graphical presentation is well, but the ultimate illustration of integrating and depicting all in one graphical form is missing, it may be incorporated. Authors also should explicitly mention how one can draw lessons, while preparing the maps. Further discussion on handling temporality, power asymmetries, and validation of network representations would strengthen the methodology, although they have mentioned it in the limitations Some sections are overly detailed and could be condensed for readability. Minor language editing (See “elements that hold these relations togethe.”) is also recommended to improve flow and remove repetition.
Authors may take some real examples to explain like Farmers Producer companies (FPCs) etc. Rani, C. R., Reddy, A. A., & Mohan, G. (2023). From formation to transformation of FPOs. Econ Polit Wkly, 58(36), 15.
Overall, this is a significant methodological contribution with strong potential applicability beyond agri-food governance, but minor revisions are needed to improve conceptual clarity and presentation.
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Is the rationale for developing the new method (or application) clearly explained
Yes

Is the description of the method technically sound?
Yes

Are sufficient details provided to allow replication of the method development and its use by others?
Yes

If any results are presented, are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions about the method and its performance adequately supported by the findings presented in the article?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: agricultural economics, institutional economics, governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 13 Aug 2026

Tanya Zerbian

We thank the reviewer for the positive feedback and view of the article as a significant contribution, as well as for the points for improvement. Below please find our responses and the changes we have made in the revised version.
We have included more information on the operational distinction between "actors" and "infrastructures" in Section 4.1. However, as rightfully pointed out by the reviewer, the operational distinction between “actors” and “infrastructures” became especially relevant during the implementation of the mapping process. We have therefore addressed this point in the discussion (Section 5), where we now reflect on how this distinction builds from the theoretical underpinning of the methodology, particularly the performative understanding of SNA as a process that does not simply represent networks, but also supports knowledge co-production, collective interpretation, and reflection on how relations are configured.
Drawing on the discussions raised during the workshops, we use these insights to refine the

definitions of actors and infrastructures, while clarifying that they should be understood as functional and relational categories rather than fixed or mutually exclusive ones, complying with the ANT approach. Regarding adding a graphical representation depicting all in one, we believe that Figure 4 already depicts how a potential mapped network could look, bringing together the different elements discussed in the manuscript in a single graphical form. We have clarified this more explicitly in the revised text and are willing to revise the figure if needed. In response to the comments, we have further explained in the methodology how lessons can be drawn during the map-making process through guiding questions. Further discussion on handling temporality, power asymmetries, and validation of network representations would strengthen the methodology, although they have mentioned it in the limitations. *We have also included more detail on handling temporality, power asymmetries, and validation of network representations in* Section 4 and Section 5, also responding to Reviewer 1. Where possible, sections have been reduced. Language editing has also been conducted. We have also included real examples, such as that suggested, to discuss the role of infrastructures.

Competing Interests: No competing interests were disclosed.

Reviewer Report 16 April 2026

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The text proposes a methodology for analyzing agri-food governance networks. It is clear and well-structured, reviewing relevant and current literature. Network analysis can contribute to a relational and territorial understanding of agri-food governance, particularly regarding the relative centrality (and power) of different actors and the identification of relevant subgroups in decision-making.

The text suggests integrating Actor-Network Theory with network analysis. In theory, networks that combine actors and objects (that is, "human and non-human actors") can be operationalized as Mode 2 networks and are therefore amenable to empirical analysis. However, it is worth noting that network analysis and actor-network theory often stem from different epistemological foundations. Although two theories can be integrated methodologically, this does not necessarily imply that such integration is possible or coherent at the epistemological level, where irreconcilable ontological assumptions and validity criteria may persist. It would be worthwhile to reflect on the limitations of the methodological proposal suggested here. It is noted that "these approaches are often considered incompatible", but that a "productive dialogue" between them is proposed. As presented, it appears that the analytical potential of network analysis (e.g., obtaining

indicators of actors' intermediation capacity) is actually being used to serve actor-network theory. In other words, one approach takes precedence over the other.

The case study is relevant and well-presented. Furthermore, the implications of relational processes for the governance of the agri-food sector are adequately justified.

Some of the challenges involved in using name generators, name lists, or the network boundary specification problem are identified. Reference is made to the "performative use" of network analysis, although the source of this term is not indicated, among the different uses of networks in intervention. It should be noted that the use of the term "performative" in the network interventions literature may have a different meaning or implications than its use in the context of actor-network theory.

Methodologically, it would also be useful to distinguish between data collection through strictly analytical procedures (for example, asking each independent actor to systematically evaluate their relationships with each of the other identified actors) and through consensus-based evaluation procedures (for example, the qualitative assessment of a group of actors gathered in a focus group). The second approach is likely better suited to what the authors intend to do regarding agri-food governance. In this second case, the proposal could benefit from applying the principles of validity in qualitative research (see, for example, Small and Calarco, 2022). (Ref 1)

To illustrate the methodology, the case study is presented in sufficient detail, with a focus on the lessons learned, which may be useful for other researchers who wish to use the same approach. It may be of interest to compare this with other studies that have also been inspired by the Net-Map technique, such as Mihăilă et al. (2026). (Ref 2)

The combination of centrality indicators (e.g., degree), structural cohesion (e.g., density), and subgroups (e.g., community detection) covers some of the key dimensions of network variability. For comparative purposes, it would possibly be useful to incorporate an assessment of fragmentation or the number of components in the analyzed networks.

It is noted that "physical spaces functioned as recurrent points of coordination and planning." This is an interesting observation. However, it should be noted that interaction patterns sometimes overlap with common places or settings. This is the case with the concept of "behavior settings," where it is not possible to separate interactions from the places where they occur. One version of this analytical strategy would be to identify relationship patterns associated with specific places or community contexts.

I find the observation that the application of this technique, with its strong qualitative basis, depends heavily on the facilitators' skills particularly pertinent.

Overall, the text provides valuable insights into the experience of applying participatory-relational techniques to describe agri-food governance. I believe the section on the technique's limitations could be expanded, explicitly outlining the cautionary notes regarding what it cannot contribute.

Minor corrections: visibilitsing = visibilising.

References

1. Small M, Calarco J: Qualitative Literacy. 2022. Publisher Full Text
2. Mihăilă B, Hâncean M, Geantă M, Cioroboiu C, et al.: From stakeholder mapping to statistical modeling: an illustrative demonstration of end-to-end Net-Map methodology for health governance analysis. *Archives of Public Health*. 2026. Publisher Full Text
3. Maya-Jariego I: Types of network-based interventions: a conceptual clarification. *Connections*. 2025; **46** (1): 15-24 Publisher Full Text

Is the rationale for developing the new method (or application) clearly explained
Yes

Is the description of the method technically sound?
Yes

Are sufficient details provided to allow replication of the method development and its use by others?
Partly

If any results are presented, are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions about the method and its performance adequately supported by the findings presented in the article?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Social psychology; Network analysis; Community intervention.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 13 Aug 2026

Tanya Zerbian

We thank the reviewer for the careful revision of the manuscript and the extremely relevant methodolgical and conceptually relevant comments. Below are our responses: We agree that the manuscript needed to more explicitly address the methodological and epistemological tensions involved in combining ANT and SNA. We have therefore clarified this issue in the Introduction and in Section 2, specifying that our proposal does not aim to fully reconcile ANT and SNA at the epistemological level. Rather, we use SNA as a methodological support for an ANT-informed, relational, and performative reading of networks. We have also added a final paragraph to make this contribution explicit. Regarding the claritifcation of the performative use of SNA, we had already included a description of this idea in the Introduction, but we recognise that the paragraph was not

sufficiently clear or well structured. In the revised manuscript, we have reorganised this section and provided a clearer definition of performative SNA, specifying that its performative role lies not in producing a complete representation of a network, but as a tool for making certain actors, relations, and governance problems visible, discussable, and actionable.

We have also clarified in the introduction to Section 3 that our proposal is based on a consensus-based evaluation procedure, as implemented in the workshops, rather than on independent actor-by-actor assessments of all possible relationships. We particularly thank the reviewer for pointing us to Small and Calarco (2022). Rather than incorporating their principles as a formal checklist in the manuscript, we have used them throughout Section 5 to discuss the lessons learned from the application of SMANA and its limitations, as they helped us engage more critically with the methodology's application. Regarding comparing the lessons learnt of the application of the proposed methodology, we had already compared our approach with other Net-Map-inspired studies, particularly in the limitations section through the discussion of Boyle et al. (2021) and Schröter et al. (2018a/b). In response to the reviewer's comment, we have expanded this comparison by incorporating Mihăilă et al.'s (2026) recent study. *To respond to comments regarding extensions or including more analytical layers to the methodology, we have included these acomments in now Section 5.3 as potential adaptations of the methodology, such as including other metrics (fragmentation or the number of components). With regards to the point that interaction patterns may overlap with common places or settings is highly relevant for mobilising an ANT-informed perspective to analyse agri-food governance dynamics. Indeed, similar to the concept of "behaviour settings", ANT explicitly advances the notion that the materiality of the spaces in which relations occur are part of an 'assemblage' of what makes social relations. However, this implication had not been explicitly developed in the discussion or in relation to potential analytical extensions. We have therefore added this point to the revised manuscript (Section 5.2), noting that the proposed set of SNA metrics could be complemented by an analytical layer examining how specific relationship patterns are associated with particular physical spaces given their materiality.*

Competing Interests: No competing interests were disclosed.