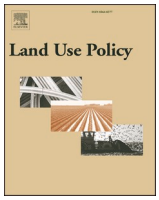
Land Use Policy 144 (2024) 107240

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol



# Democratic participatory networks and governance processes in Sicily

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ARTICLE INFO

*Keywords:*
Democratic Participatory Network
Governance
Innovation Helix Models
SNA
Community Detection
Sicily

ABSTRACT

Democratic participation improves the chances of success of local development policies. New governance processes that directly involve the actors who inhabit the territories are necessary for the challenges that sustainable growth requires. Therefore, the feedback on the pre-existing conditions of cooperation and coexistence is essential for carrying out actions with a place-based logic of development. The Innovation Helix Model allows us to understand the relational dynamics and support territorial strategies in enhancing innovation processes that contemplate the relationship between civil society, public and private institutions, and the natural environment from the perspective of a democratic approach. In this way, ecosystemic innovation is a dynamic network of territorial actors interconnected within a delimited geographical space. This study proposes an innovative way of investigating territorial relationship networks. It examines and describes the network deriving from the policies implemented in an internal area of Sicily. The governance processes implemented through partnership agreements between local actors over ten years have created relationships measured and described through Social Network Analysis (SNA), specifically with Affiliation Networks and Community Detection with a bipartite structure. The study moves towards an innovative territory analysis, looking for the relational links and providing references for building bottom-up policies with greater awareness.

## 1. Introduction

In Europe, in recent years, a negative perception has developed in a few Member States of the European institutions, seen as too distant and incapable of responding to the needs of citizens. Various populisms have been born, and the "Age of Discontent" summarizes this perspective. The extensive literature on "geographies of discontent" (Larsson et al., 2021) has increased recently. A central theme in research on this topic is that lagging places cultivate a sense of being left behind, ultimately leading to the election of populist parties. Europeanization has unevenly impacted the geographical and territorial levels (Marques et al., 2018). The European Cohesion Policy aims to reduce socioeconomic disparities within Europe and has only marginally contributed to the growth of institutional autonomy, which should have initiated development paths for the European Regions (European Commission, 2022a). The same concept of the "*regional development trap*" (Diemer et al., 2022) indicates regions that face significant structural challenges in retrieving past dynamism or improving prosperity for their inhabitants.

Furthermore, the shock of COVID-19 has highlighted unresolved structural problems, especially for the less developed regions. Growth gaps are at the center of the ongoing European debate. The processes of economic convergence desired are not reflected in the growing increase in inequalities within the European regions. In the last decade, an increasingly popular framework for place-based policies has emerged (Barca et al., 2012). The geographical context, consisting of social, cultural, and institutional elements, forms the basis for a policy intervention involving a broad group of stakeholders (Hassink and Gong, 2019), triggering processes of democratic participation in development strategies. In the new programming period 2021–27, Europe reinforces and envisages a place-based approach to programming, which requires building development paths that truly address local needs (European Union, 2018a; 2018b). The European Union adopted new criteria for resource allocation that privilege areas with high youth unemployment, low educational attainment, and actions on climate change and the integration of migrants. Significant attention is focused on less developed and peripheral regions (Rauhut and Humer, 2020). In addition, there will be a further focus on innovation strategies, where the local level is the protagonist for social-economic and sustainability outcomes.

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https://doi.org/10.1016/j.landusepol.2024.107240
Received 21 December 2021; Received in revised form 14 September 2023; Accepted 7 June 2024
Available online 14 June 2024

Therefore, the comprehension of relational evolution in the territories becomes fundamental, where institutions, collective action, governance, social capital, and creativity converge as essential mechanisms for territorial development. It also means investigating the innovative space in a systemic vision of innovation and democratization of knowledge. Local development requires the cooperation of different subsystems with a diversified intensity during the stages of the overall activity. The role of each subsystem becomes decisive in the innovation system, reflecting a synergistic process with non-linearity characteristics. In this direction, the innovation approach through the Helix Models (Etzkowitz and Leydesdorff, 1995; Carayannis and Campbell, 2009, 2010) appraises the innovation in an ecosystem where territorial actors play an essential role. According to Carayannis and Campbell (2022), the framework of Helix Innovation Models is the basis for building modern societies and economies. In fact, with a participatory approach, they include territorial stakeholders in a democratic, inclusive, and sustainable vision. The dimension of democratic participation is expressed in the Innovation Helix Framework through the relationships, such as those between Government, University, and Industry (the three basic Helices), the Civil Society (the fourth Helix), and, finally, the natural environment (the fifth Helix). Therefore, identifying innovation as a process involving different actors requires the knowledge of the most relevant factors influencing each element of the helices.

A research question examines the democratic participation in promoting local development and whether the change of discovering current examples of democratic processes towards new patterns of local, sustainable growth is a real option to follow. Therefore, it is necessary to investigate the relational characteristics of the territories capable of triggering innovation processes.

The work fits in the Institutional Collective Action (ICA) framework (Feiock, 2013), where local governing units are considered to achieve better outcomes collectively than acting individually by reducing barriers to mutually advantageous collaborative action, as represented by the transaction costs required for achieving joint projects. In a few cases, some interest groups are better positioned for collective action and equipped to promote their preferences, allowing them to participate in decision-making more effectively (Ramírez et al., 2023). Collective action is particularly relevant for ecosystem emergence (Thomas and Ritala,2022), as ecosystems arise from the interactions between different participants in pursuing the shared value proposition, similar to Olson's classic theory of collective action (Olson, 1965).

To better understand the process of ICA, we mapped the structure of intergovernmental institutions, organizations, agreements, and networks across a subregional area (Feiock, 2013).

To do this, we analyze the operational scenario in Sicily, particularly in the Madonie, a local area included in Italy's National Strategy for "Inner Areas" (SNAI). This strategy is a territorial program for development cohesion to counteract marginalization and demographic decline in the inner Italian territories (Cotella and Brovarone, 2020).

This work describes the relational network created in the Madonie local area in ten years, identifying the actors and communities who mainly play a central role in democratic local development strategies. Furthermore, it tries to take the first step in identifying non-random subgroups or specific democratic communities within the network to give more helpful information for a long-term strategic vision and the growing (if any) process of institutional thickness (Busetti and Pacchi, 2014). Social network analysis (Wasserman and Faust, 1994) is the methodology indicated in this paper to describe and understand the existing relational dynamics in this case study. In addition, through Community Detection, we try to individuate the presence of stable subgroups of the networks. The rest of the article is organized as follows. Section 2 summarizes some aspects of innovation knowledge and democratic participation. The Social Network Analysis and the Community Detection are presented in Section 3. Section 4 shows the main results; conclusions are drawn in the final paragraph.

## 2. The democratic, participatory networks for territorial development strategies and the Helices of innovation knowledge

The territories result from constant socioeconomic construction, and the peculiarities of the places imply development strategies adapted to the local context. The joint action of several players in public, private, and non-profit sectors can create relationships capable of strengthening the identity of a territory. It is necessary to open to new forms of participatory and democratic governance that directly involve the protagonists who inhabit the territory and represent the interests of a given context. By expanding the number of subjects involved in defining a local growth strategy, it is possible to exploit synergies between institutions and civil society, as confirmed by sociological and economic theories (Rodríguez-Pose and Garcilazo, 2015; Farole et al., 2011). New forms of participatory governance can make territorial development processes innovative and dynamic by adding value at the local level and strengthening regional emancipation (Borges, 2017). From this perspective, the outcome generated is an ecosystem based on resources where relational networks become central elements. Social relations in each context led to collaboration and favored knowledge development, allowing for new ideas and the availability of more information (Bodin and Crona, 2009). The local development paradigm assumes that each territory has a set of goods and values that local actors should recognize and use (Bevilacqua and Pizzimenti, 2016). Thus, territorial development may depend on the existence and strength of social ties between actors. In this context, the local reference to new ideas of regional development (Barca, 2009) opens distinctive aspects of analysis. A place-based strategy identifies positive elements for territorial development by deciphering the territory's main configurations of social and relational structures. Therefore, the involvement of local actors in development strategies is essential to enhance their territory. Especially in lagging areas, the ability to set in motion processes that simultaneously aim at creating economic, social, and environmental value through innovative and democratic organizational formulas is crucial. In this way, an ecosystem innovation approach becomes a key factor for developing peripheral areas, diversification, and increased competitiveness (Provenzano and Seminara, 2014). The concept of systemic innovation shifts the attention from an innovation-oriented idea toward economic competitiveness to another notion of sustainable territorial development (Solis-Navarrete, 2021). The key factors become resources, activities, and skills, inseparable elements of the territorial context. Therefore, in this perspective, territorial relations play a crucial role. Triple, Quadruple, and Quintuple Helix (Etzkowitz and Leydesdorff, 1995; Carayannis and Campbell, 2009, 2010) models investigate and explain systemic innovation processes, interactions, contributions, and collaborations among critical stakeholders.

The focus and the success of the Triple Helix (TH) model of university-industry-government relations lie in its continued pertinence and aptitude to stimulate new ideas in research and policy agendas (Cai and Etzkowitz, 2020). As Stiglitz et al. (2006) suggest, markets, government, and individuals are three pillars of a successful development strategy. Nevertheless, societies require additional dimensions. The Quadruple Helix (QH) extends the Triple Helix by adding the Helix of the media-based and culture-based public. In particular, the Quadruple Helix promotes the perspective of the knowledge society and knowledge democracy for knowledge production and innovation (Carayannis et al., 2012).

Finally, the Quintuple Helix (Q2H) contextualizes the Triple and Quadruple by adding the Helix of the natural environment. It assumes the formation of a constructive state that encompasses ecology, knowledge, and innovation and creates comprehensive synergies between economy, society, and democracy. The individual components in all helix models contribute synergistically to the systemic innovation processes. Knowledge and know-how are shared through a continuous interaction where the relationship among the actors of the Helixes is crucial. The Quintuple Innovation Helix Framework represents the most

comprehensive and significant construct and modality, encompassing the five key core dimensions of modern, sustainable, and democratic knowledge economies and societies (Carayannis and Campbell, 2022). The interactive participation of all territorial actors, including researchers and decision-makers, aims to increase the confidence of those concerned and allow them to define, express, and analyze their reality without adopting the opinion of the more assertive and more dominant voices (Patel et al., 2007, Sisto, et al., 2018, Wilson, 2013) facilitating a democratic approach. Therefore, recognizing territorial networks can be a prerequisite for building local development strategies. In this regard, it is essential to acknowledge the presence of existing relationships that can determine and reinforce the dynamics of innovation places. Considering the arguments expressed above, it is of fundamental importance to analyze and know the relationships already present in a given geographical context to check the existence of a network and the most important players for disseminating knowledge and innovation. Once the significant stakeholders have been identified and categorized based on freedom, equality, control, and sustainable development (Campbell et al., 2019), a participative democracy of innovation contributes to new change directions. Therefore, it is necessary to find methodologies to understand these relationships present in the territories, and this work seeks to support research in this direction. The following paragraph illustrates the methods chosen to analyze a marginal area, the Madonie, which has shown over time a dynamism in the democratic approach to policies with the involvement of various territorial stakeholders.

## 3. Social network analysis, community detection, and territorial bonds

The Social Network Analysis allows for examining a network system. The value of social networks for the diffusion of innovation and social change processes is widely recognized in many areas of scientific practice and disciplines. Social networks have the strength to influence learning processes, furnish opportunities for problem-solving, and set up new ideas. Therefore, they can promote synergy effects, pool essential resources such as the know-how of the participating actors, and so forward the diffusion of innovation (Kolleck, 2013). A relational context is studied through techniques to measure the social relationships that arise from bonds of different natures between and from a group of subjects (knots). Hanneman and Riddle (2005) highlight the basic idea of a social network: a set of actors (points, nodes, vertices) that can have relationships (edges, bonds, arcs) between them. Networks can have few or many actors and one or more types of relationships between pairs of actors. The use of network analysis depends on the availability of relational data rather than attributes, unlike the sample survey that responds to identify relationships between characteristics or variables. Thus, while a classical survey approach treats individuals as a subject isolated from their social context, the network approach reverses the perspective, gathering data on some concrete relationship between individuals and their characteristics based on the form of relationships (Chiesi, 1999). Thus, in our case study, we analyze the relational network of the Sicilian area of Madonie, a specific geographical context, self-delimited by socioeconomic proximity, cultural identity, and similar territorial characteristics.

In particular, the Affiliation Network (Faust, 1997) method in the bimodal form is used to examine the links between a set of actors and events and the individual relationships of each group component with members of the other set. Thus, the events considered are the partnership agreements implemented to implement territorial policies, and the actors are the stakeholders involved. Affiliation networks are composed of two modes. The first mode is the set of agents *N*; in our case, the territorial actors of Local Authorities, Public-private partnerships, Credit institutions, Trade associations, Cultural, sporting, environmental, tourist associations, Consortia, Cooperatives Unions, Foundations, Educational, training, and study centers, and SMe.

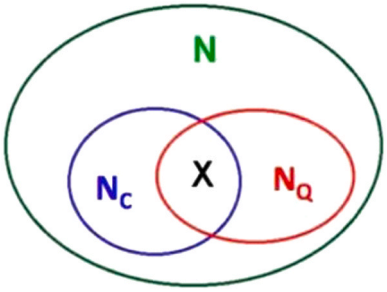


**Fig. 1.** Equation illustrative Diagram. Source: Tumminello et al#, (2011).

The second mode is the set of events *M*. The events considered have been the territorial policies in the Madonie implemented in a decennial period from 2000 to 2011, which provided for partnership agreements between different actors. The number of agents in the network is *n*, and the number of events is *m*. An agent can take part in one or more events. We can represent an affiliation network by an affiliation matrix *A* of size $n \times m$. We define an element of *A* by *aij*, with $i = 1, \ldots, n$ and $j = 1, \ldots, m$.

The coefficient *aij* takes the value 1 if the agent *i* participates in the event *j* and 0 otherwise.

$$a_{ij} = \begin{cases} 1 \text{ if } i \text{ particitates in } j \\ 0 \text{ otherwise} \end{cases}$$

Each row of the affiliation matrix *A* gives all the events in which an agent participates. The sum of a row of the affiliation matrix shows the events in which an agent is involved. Each column gives all the participants in an event. The sum of a column provides the number of participants in this event.

Affiliation networks are "two-mode networks," the two modes being the set of events and the group of agents. To build the adjacency matrix $X^{NM}$ of the "two-mode network," we can use the matrix affiliation A. This matrix is equal to the following:

$$X^{NM} = \begin{pmatrix} 0_{(n\times n)} & A_{(n\times n)} \\ A'_{(m\times n)} & 0_{(m\times m)} \end{pmatrix}$$

With A as the affiliation matrix, A' as its transposed, and 0 as the zero matrix. We can see the matrix size in brackets composed of $X^{NM}$.

We use a bipartite graph to represent the two modes within the same network (Section 3, Fig. 2). The purpose is to observe the events which make the links between agents and conversely. In the bipartite graph, there are no direct links between two agents or between two events. Links exist only between agents and events. The Affiliation network is characterized by properties that allow the exploration of some characteristics of the networks analytically. The difference in how actors are connected can be a crucial indicator of a population's social organization's cohesion, solidarity, or complexity. The stakeholders in the territories can assume different relevance and be bearers of links and unions, information intermediaries, or peripheral but not central players. The number and type of links the actors have are a basis for the similarity or dissimilarity between actors and, therefore, the result of possible differentiation and stratification. Furthermore, they determine their rooting in the network that can limit their behavior; otherwise, it can foster opportunities, influence, and exercise power in the network.

In the analysis carried out in the case study, we used some indicators such as density, reachability, and distance. Density is one of the most relevant indices for the degree of cohesion of the network (Cordaz, 2005). The index range varies from zero (absence of cohesion) to one (maximum cohesion).

Another indicator that allows us to measure how the actors are incorporated into the network and, therefore, try to grasp the complexity inherent in relationships is distance. By measuring the links' distance, the differences concerning the position of the actors in the network are analyzed. The concept of shorter distance is crucial in the

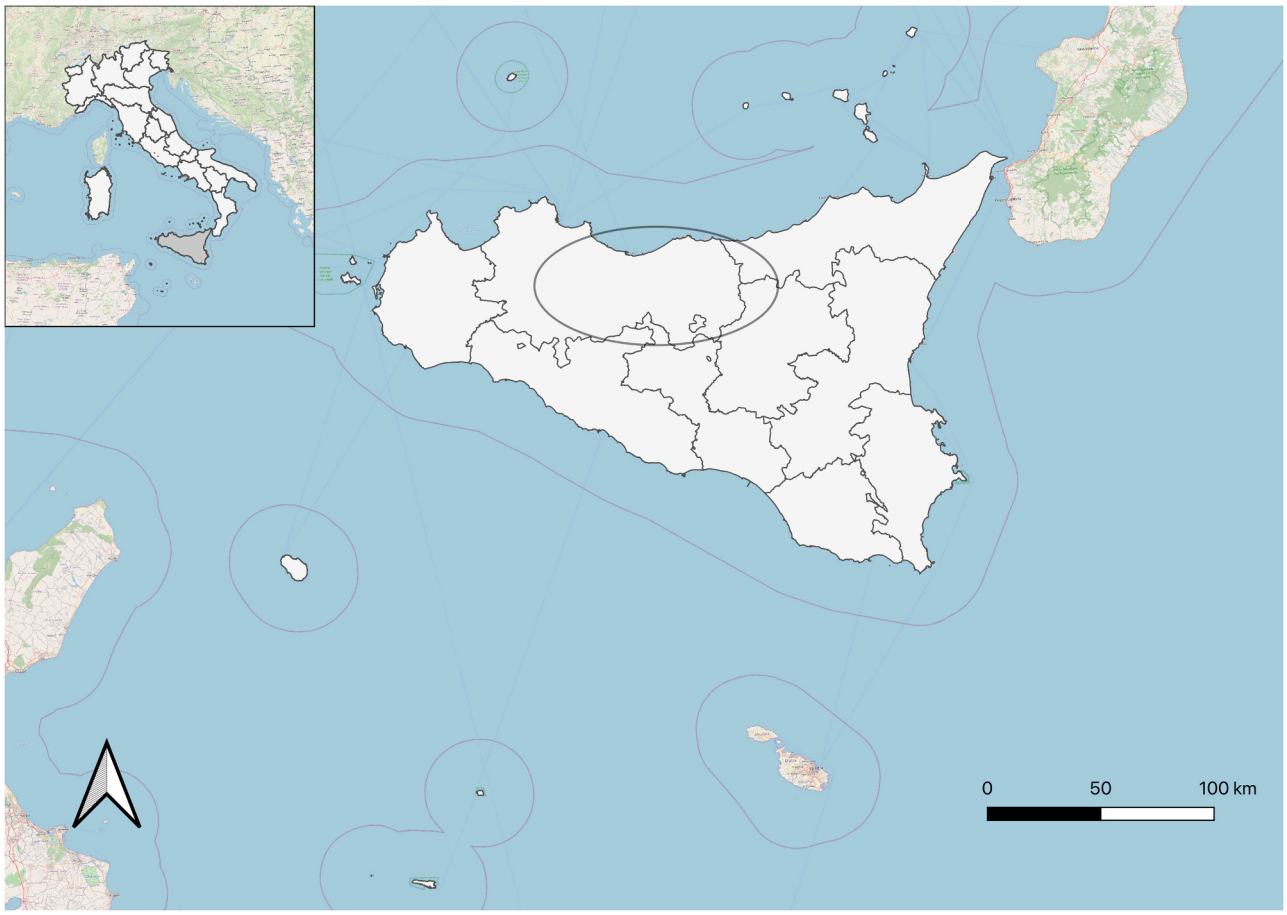


**Fig. 2.** The territory of the Madonie, Sicily.

case of information transmission and resource exchange. However, even closer actors can exercise greater power in the network than those positioned further away (Hanneman and Riddle, 2005). Specifically, the geodetic distance is a measure that indicates the shortest distance between two players in the network.

Centrality evaluates the visibility within the network as a measure of the importance or power of an actor. It indicates the number of bonds each actor holds and the ability to influence other stakeholders to obtain information.

In the affiliation matrix, the degree of centrality (Freeman, 1978) measures the number of events in which actors participate and the number of actors affiliated.

The indicators analyzed in the work that describe the network's cohesion and the actors' centrality are listed in Table 1:

Source: own elaboration

### 3.1. *Community detection and territorial applications*

Social models are real problems that can be mathematically represented and topologically studied to reveal unexpected structural features (Newman, 2006). In the context of relational data, community detection deals with complex networks. They have been applied to natural systems, such as the wide world web, epidemiological studies, networks of bibliographic citations and scientific collaborations, and biological, ecological, and neuronal networks. Since 2006, starting with Newman's analysis (2006) and subsequently, with the works of Leicht and Newman (2008), Karrer et al. (2008), and Blondel et al. (2008), there has been a boost in research and studies based on the theory of community analysis. One way to efficiently analyze complex systems is to break them down into simpler parts, understand how they work, and then try to

**Table 1**
Structural network measures.

| **Affiliation Networks Analysis Measure** | **Definition** |
|---|---|
| **Cohesion** | Cohesion describes the interconnectedness of actors in a network. There are three standard measures of cohesion:<br>• Density<br>• Reachability<br>• Distance |
| Density | The fraction of edges relative to the higher possible number of edges given the set of nodes. |
| Reachability | Reachability measures whether actors within a network are directly or indirectly related to all other actors. Actors not connected to any other actors are "isolated." |
| Distance | Distance between two actors in a network (or nodes in a graph) is calculated by summing the number of distinct ties (lines) that exist along the shortest route between them. |
| Geodetic distance | The Geodetic distance between two vertices in a graph is the shortest path between the vertices. The geodesic distance between two vertices is the length of the number of edges of the shortest path between the vertices. |
| **Centrality measures** | Centrality measures are numbers used to quantify the degree of interconnectedness of nodes in a network. |
| Degree Centrality | The most straightforward measure is Degree Centrality (DC), which counts the number of ties a node has with other nodes in the network. It measures a node's immediate connectivity or popularity and vulnerability to catching whatever flows through the network. |

recompose the original design.

Community analysis examines the network and its structure together with the possibility of dividing it into subnets (communities or clusters), groups of nodes characterized by a density of internal links more significant than the link density of the rest of the network. The thickness of connections suggests that the network has certain specific divisions. By verifying the network structure, we can infer its topology and functioning. The network itself determines the number and size of the groups. The dynamics of a network pass through the structure of the communities that compose it. Thus, for example, tightly connected social communities will have a faster information or knowledge transmission rate than loosely connected communities.

The community's positions and communication flow within the governance network strongly influence the adaptive capacity ( Hirschi, 2010).

The development of increasingly suitable algorithms for the study of network partition has divided the methods adopted by community detection into various strands, such as Graph partitioning (Buluc and Madduri, 2011), Hierarchical clustering (Girvan and Newman, 2002), and Modularity Optimization (Newman, 2006).

Modularity is a measure that leads to the emergence of communities in each network. Modularity is a scalar quantity that measures the density of the arcs that fall within the assigned groups minus the expected density of the arcs if they have been randomly distributed. The Modularity of a partition is a scalar value between −1 and 1. The positive values indicate that a statistically surprising fraction of arcs in a network falls within the communities identified by the partition. Experience shows that positive values greater than 0.5 indicate the actual presence of a structure in the community (Newman, 2006).

In contrast, values close to zero indicate that the distribution of the arches between intra- and inter-community does not differ from uncertainty, thus denoting the absence of an effective community structure. Significant progress has been made in addressing the problem of detecting communities in complex networks, and several methods have been studied to achieve this outcome (Fortunato, 2010). The identification of communities, however, remains only a first step in understanding the structure of a complex system. The next step is interpreting the representation of communities in terms of the attributes and characteristics that compose them.

In addition, the work takes a further step using a method (Tumminello et al., 2011) to statistically validate each link of a projected network against a null hypothesis that considers system heterogeneity. It applied to the bipartite system of our case study in which different relationships might have different qualitative natures, generating statistically validated networks in which such difference is preserved. It has identified communities based on their characteristics or attributes. In our case study, the identifying features are the belonging of the actors to the various categories: local authorities, public-private partnerships, credit institutions, trade associations, cultural, sporting, environmental, tourist associations, consortia, cooperatives, unions, foundations, educational, training, and study centers, and Small and Medium Enterprises.

It is possible to validate the communities that emerged from the analysis statistically. The attributes sought are not necessarily the most frequent in the community but rather are those characteristics that present significantly higher than the frequency observed in the community starting network. The attributes sought are statistically inconsistent with the null hypothesis of a random event. It considers a system of *N* elements and a specific community *C* characterized by *NC* elements. Each component of the network has an attribute close to a particular class. By indicating the total number of different attributes on all network elements with *NA*, for each attribute *Q* of the network, it is verified whether *Q* is over-expressed in community *C*. The method tests whether the number *NC, Q* of elements in cluster *C* that has the *Q* attribute is significantly greater than that obtained by randomly selecting the *NC* elements of the cluster from the total N elements of the network. The probability that *X* elements in cluster *C* possess the attribute *Q*, under the null hypothesis of randomly selected elements, is given by the hypergeometric distribution:

$$H(X|N,NC,NQ) = \frac{\binom{NC}{X}\left(N_Q^{N-N_C} - X\right)}{N_Q^{N}}$$

*NQ* is the total number of elements in the network with attribute *Q*.

Using this distribution, we can associate a *p-value* for the number of elements *NC*, *Q* observed in cluster *C* classified with the *Q* attribute according to the equation:

$$p\left(N_{C,Q}\right) = 1 - \sum_{X=0}^{N_{C,Q}-1} H(X|N,N_C,N_Q)$$

If *p* (*NC, Q*) is smaller than a specific statistical threshold $p_t$, attribute *Q* is over-expressed in cluster *C*; therefore, attribute *Q* characterizes community *C*. The method tests all possible *NA* attributes separately for each cluster *C* detected.

Analyzing an extensive network of N nodes with E edges requires a multiple hypothesis test correction to avoid a significant increase of false positives. The Bonferroni correction is the most robust multiple hypothesis test correction, with the False Discovery Rate (FDR).

## 4. The Madonie: a participatory democratic network?

The study of a territorial network through the SNA provides essential information on how new forms of governance among stakeholders may support local development. Our study focused on Madonie (Fig. 2), Sicily's peripheral lagging territorial area configured as a dynamic territorial system.

The Region of Sicily is in a phase of substantial stagnation, and the post-pandemic crisis will further accentuate its position of weakness. The medium-long term analyses of the Region (European Commission, 2022a) show weak regional economic performance in the European comparison, caused by a worse dynamic of productivity and employment. Following the Quintuple Helix framework, the Madonie area, with the public, private, research, people, and environment, is suitable for implementing place-based policies. To analyze governance processes and their dimension over time, SNA allows for examining the structural properties of the network. The SNA determines the blueprint for these relations created in the territory, and the Affiliation Network (Wasserman and Faust, 1994) selects actors and events in the Region. Specifically, the empirical exercise identifies a set of circumstances as planning measures and local stakeholders as actors. The Affiliation Network studies the links between a group of actors and a set of events and their relations. The empirical exercise identifies a set of events in the programming measures negotiated on the territory and local stakeholders as a set of actors. Specifically, the events examined are five chosen for the data availability and typology of intervention. The events concerned during the period 2000–2011 are the local District Pact of Agriculture, the District Pact of the Beef Supply Chain of the areas, the Madonie-Termini Network City, the Local Action Group (Lags) I.S.C. Madonie, and the Tourist Consortium Cefalù - Madonie - Himera. The measures (see Table 2) distinguish all stakeholders divided into 11 different categories. The categories have been identified on the activities carried out by the stakeholders, from local authorities to small and medium enterprises. The total number of actors involved in the network is 428 units (see Table 3).

Source: own elaboration

Source: own elaboration

The first partnership is the Territorial Pact for the Agriculture of Madonie, which involves 36 stakeholders with a more significant presence of Public Authorities and the absence of private and voluntary institutions. Established in 2006, the District Pact of Beef and Veal Supply

**Table 2**
Stakeholders and Local Projects.

| | District Pact of Agriculture 2000 | District Pact of the Beef Supply Chain 2006 | PIST 22 Network City 2009 | LAGs Madonie 2010 | Tourist Consortium Madonie – Himera 2011 |
|---|---|---|---|---|---|
| **Local Authorities** | 22 | 28 | 30 | 35 | 31 |
| **Public-private partnership** | 1 | 4 | 4 | 3 | 4 |
| **Credit institutions** | 1 | 1 | 2 | 2 | 1 |
| **Trade associations** | 4 | 1 | 3 | 8 | 1 |
| **Cultural, sporting, environmental, and tourist associations** | 0 | 1 | 0 | 14 | 27 |
| **Consortia** | 0 | 2 | 0 | 6 | 4 |
| **Cooperatives** | 0 | 5 | 0 | 7 | 10 |
| **Unions** | 3 | 1 | 0 | 2 | 0 |
| **Foundations** | 0 | 0 | 0 | 1 | 1 |
| **Educational, training, and study centers** | 5 | 7 | 0 | 3 | 6 |
| **SMe** | 0 | 218 | 0 | 1 | 50 |
| **Total Stakeholders** | 36 | 268 | 39 | 82 | 135 |

**Table 3**
Stakeholders involved in the network.

| | Numbers of Actors | % |
|---|---|---|
| **Local Authorities** | 40 | 9,35 % |
| **Public-private partnership** | 7 | 2 % |
| **Credit institutions** | 3 | 1 % |
| **Trade Association** | 13 | 3 % |
| **Cultural, sporting, environmental, and tourist associations** | 41 | 10 % |
| **Consortia** | 10 | 2 % |
| **Cooperatives** | 21 | 5 % |
| **Unions** | 6 | 1 % |
| **Foundations** | 2 | 0,1 % |
| **Educational, training, and study centers** | 17 | 4 % |
| **SMe** | 268 | 63 % |
| **Total Stakeholders** | **428** | 100 % |

Chain of inner areas of Sicily indicates the second event where private stakeholders prevail: 218 out of 268 are private SMEs. The third democratic dialogue concerns the Local Action Group (LAG) I.S.C. Madonie, established in 2010, with 82 participants. The Integrated Territorial Development Plan (PIST 22) is the fourth measure, which extends the territory to the municipalities of neighboring provinces: 39 stakeholders are involved, of which 30 are the municipalities part of the City Network. The last event is the Tourism Consortium, with 135 stakeholders, many associations, local authorities, and small and medium enterprises. The most significant percentage of all five events examined are private stakeholders, such as small enterprises (63 %), related to conspicuous participation in the District Pact of the Beef Chain and the Tourist Consortium Cefalù-Madonie.

### *4.1. Affiliation network empirical results*

The Affiliation matrix represents the information and characteristics relating to an Affiliation Network. It is based on a dichotomous matrix consisting of rows (the actors) and columns (the events), highlighting the participation of any single actor in each (five) event. The affiliation matrix is rectangular since the rows and columns refer to objects of a different nature, and the incidence matrix is used to analyze social networks. By elaborating the bipartite graph (Fig. 3), we determine that the affiliation matrix allows us to detect a path between all the pairs of actors. All stakeholders participate in at least one event, and all events count at least one actor, so the graph is connected, and isolated nodes are not present.

Density indicates the degree of cohesion of the network. The index range varies from zero (absence of cohesion) to one (maximum cohesion). The calculated density of our network is 0.26. The density does not consider the intensity of the ties but the actor's participation, which is how far from the network is from its maximum potential, expressed by the sum of the existing relations concerning all possible ties. The value found shows that 26 % of all likely bonds are present, i.e., 560 out of 2140 potentially viable bonds. The low-density value results from the participation of 428 actors in only five events, i.e., a low cohesion of the network as a whole; on the other hand, it reflects the broad participation of actors existing in the territory of at different events. In short, the result shows a flexible network with an extensive probability of disseminating ideas and opportunities. According to Granovetter (1985), most social and economic behaviors are strictly rooted in networks of interpersonal relationships.

Manipulating the incidence matrix, we derive two square matrices, indicated as adjacency matrices. The incidence matrix transformation leads to the modification from the bimodal to the unimodal network, reflecting the intensity or frequency of the link. The adjacency matrices, derived from the Affiliation matrix, are the Co-Membership matrix and the Overlap events. In the actor's participation matrix, the rows and the columns represent the actors, and the single cells show the number of events each pair of actors shares. Therefore, whether actors are linked by common association highlights the actual relationships or links between the actors. The event overlap matrix reports affiliations in both rows and columns. The individual boxes show whether the corresponding pairs of associations are linked using common actors, i.e., records the number of actors each couple of events has in common.

Table 4 summarizes our findings. The Co-Membership density matrix may vary between 0 and 5, and the Overlap Event Matrix falls between 0 and 428. The density index in the Co-membership matrix expresses the participation in the events of any two actors in the network. The value of 0.542 (11 %) indicates the average percentage of involvement in a pair of stakeholders' events (5). The Overlap Events Matrix density index, equals 28.7, which shows the average number of actors each pair of events shares (table4).

Source: own elaboration with Ucinet 6 and igraph software package

The Affiliation Matrix is dichotomous and non-directional. Therefore, the reachability, which detects the direct and indirect links between the nodes, is reciprocal. Thus, the information can spread throughout the network since there are no divisions. The joint participation in an event creates a link between the actors who participate in it, and the involvement of the actors in several events establishes a connection between the various events, thus creating potential information channels. The average metric of geodesics for each actor is 1.5, indicating the average proximity of each actor to all the others. The value shows that despite the large number of actors participating in the network, there are short paths for each pair of actors. The low value indicates that the network can directly convey information without intermediaries. The actors' Degree Centrality (Table 5) varies from a

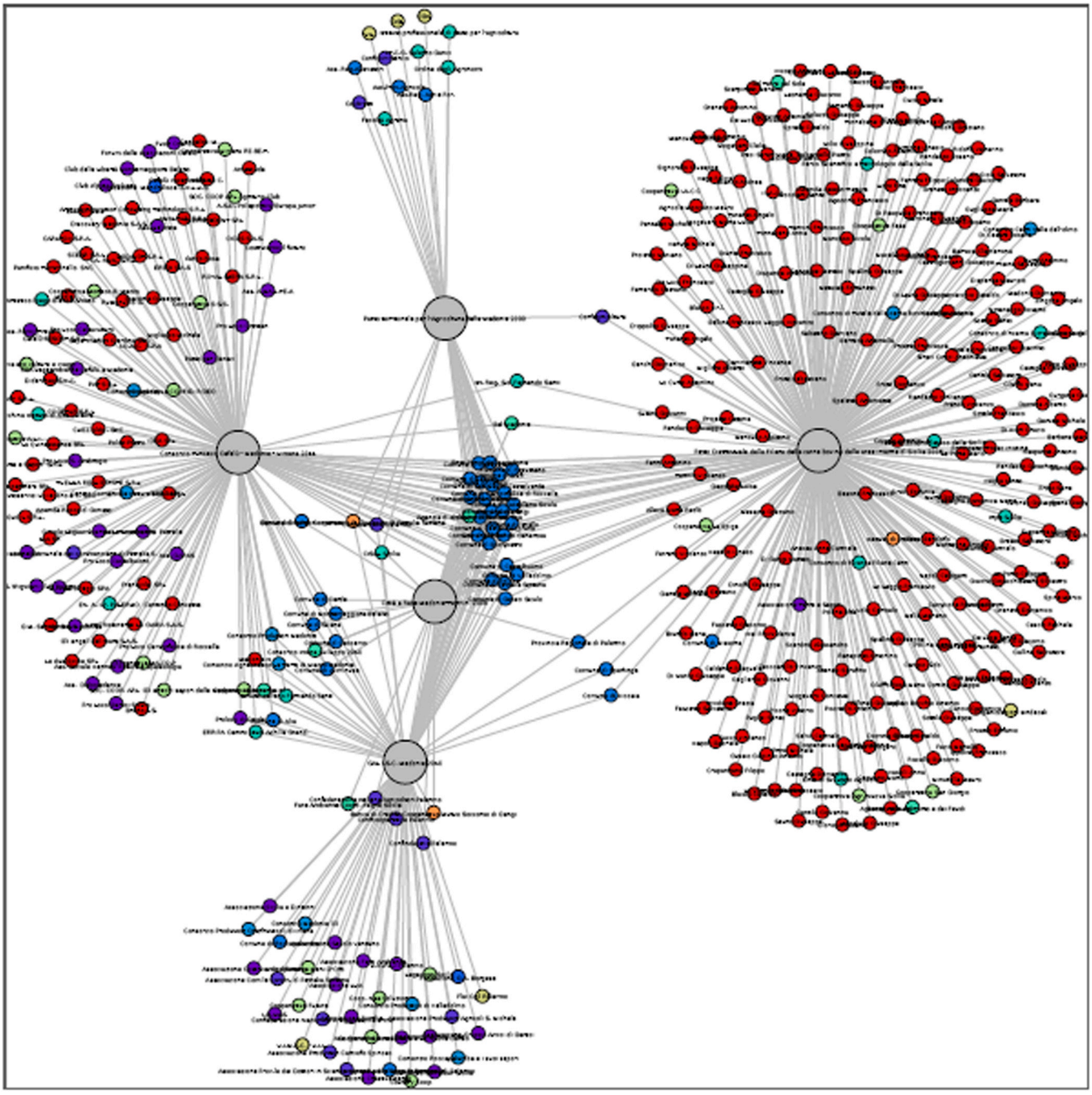

**Fig. 3.** A Bipartite Graph of Madonie Events. Source: own elaboration with igraph software package. In the graph, the larger circles in gray indicate the five measures-events implemented in the territory. The smaller circles indicate the stakeholders who participated in the five events. The colors of the smaller circles distinguish the various categories of stakeholders.

**Table 4**
Statistics of the network - Density index.

| | | Density | |
|---|---|---|---|
| | **Nodes** | Valued | Dichotomy |
| Affiliation Network | 433 | | 0.261682 |
| Co-membership matrix | 428 | 0.542 | |
| Overlap events matrix | 5 | 28.7 | |

**Table 5**
Statistics of the network - Centrality index.

| | | Centrality | |
|---|---|---|---|
| | **Nodes** | Degree | |
| | | Min. | max |
| Affiliation Network | 433 | | |
| Actors | 428 | 1 | 5 |
| Events | 5 | 36 | 268 |
| Co-membership matrix | 428 | 35 | 555 |
| Overlap events matrix | 5 | 97 | 130 |

Source: own elaboration with Ucinet 6 and igraph software package

minimum of 1 (one event) to a maximum of 5 (all events in our case). The stakeholders with a higher degree of centrality equal to five are the 20 municipalities, the Madonie Park Authority (MPA), and the Local

Development Agency SoSviMa (Development Agency of Madonie). The participation of stakeholders in all events confirms their constant presence in the territorial network. The SoSviMa Local Development Agency and the MPA are local public authorities, reflecting their role in the planning and managing local activities. The agency SoSviMa played a crucial role in the territory, managing most of the measures implemented in the area. The high degree of centrality of the Madonie Park Authority demonstrates its mission to identify and attract the local stakeholders in the area. The Park holds a prominent position, especially for environmental issues so important in the current transition period of COVID-19.

Moreover, the critical role of MPA and the Agency SoSviMa highlights the value given to sustainable development strategies for the Madonie area. The democratic process and environmental sustainability are, therefore, well connected. The centrality index of events varies from a minimum of 36 to a maximum of 268 actors affiliated with an event. The event with the highest degree of centrality is the District Pact of the Chain of Beef of the internal areas of Sicily, which involved a considerable number of enterprises, equal to 81.3 % of the total. From the analysis of the unimodal networks, the Centrality values confirm the results of the Affiliation matrix. The Co-Membership Matrix's highest centrality value (555 links) is assigned to the Local Authorities, SosviMa, and the Park Authority, confirming their essential position within the network. In the matrix of events, the minimum number of links activated is associated with the Territorial Pact for Agriculture of Madonie (97), while the main event is the LAG with 130 ties.

### 4.2. Community detection, empirical results

Studying topological properties becomes fundamental for better understanding complex systems in the real world. To this end, it was interesting to break down the complex governance relations system into simpler granular parts of the Madonie marginal area.

The social network of the Madonie area is divided into communities, searching for densely interconnected nodes. Identifying communities means identifying subgroups with different properties concerning the network. In the Madonie, we identified two Communities: community defined as 0, which includes 240 network actors, and community defined as 1, which comprises 188 actors. According to the attributes detected, the communities registered specific elements. In this second step, the actors are different for belonging to particular reference categories such as businesses and private companies, cultural, sports, environmental, tourist associations, public entities, trade associations, and cooperatives.

Community 0 is significantly represented by 218 private companies (out of 268 total actors in the network). It comprises 90 % of firms interacting more with each other than the rest of the network.

Community 1, on the other hand, indicated 188 cultural, sporting, environmental, and tourist associations, public bodies, trade associations, and cooperative actors. The metric obtained is of 40 cultural, sports, environmental, and tourism associations out of 41, 37 public bodies out of 40, 12 trade associations out of 13, and 16 Cooperatives on 21.

The statistical validation of the groups made it possible to verify the validity of the two communities found. Indeed, the *p-values* indicate that it is impossible to assign a random event null hypothesis and that the elements/actors grouped in the two communities identified by a different category of belonging are over-expressed in the two communities.

Table 6 shows the number of elements with the attributes present in the identified communities, the total number of features/actors who possess this attribute within the network, and the p-value associated with each result (Bonferroni test and False Discovery Rate, FDR test are indicated).

Source: own elaboration with Ucinet 6 and igraph software package

Therefore, the two communities indicate that the policies implemented in the area have facilitated the formation of specific subgroups in the network. Identifying and knowing subgroups that interact differently from the rest of the network can be particularly interesting in developing policies more suited to the territorial context of reference to strengthen agreements and consolidate latent ties. The two communities identified indicate the importance of ad-hoc financial measures implemented at the local levels. For community 0, the grouping of companies within the same group typology demonstrates how the same category is more involved in closer ties than other categories. This result is the consequence of the measures adopted within the territorial context, which leads to more significant interaction between companies. The configuration of the business community indicates the link with the current structure of small and medium enterprises that need to collaborate to have a more significant influence and impact on the markets. On the other hand, Community 1 demonstrates how different interest groups (cultural, sports, environmental and tourism associations, trade associations, and cooperatives) have a greater relational intensity with institutions, following a clear example of the Quintuple Helix at work and inside a specific natural environmental context. Community detection helps in the more detailed understanding of the network structure that various planned concentration measures produce. It also makes it easy to implement targeted strategies toward the relational subgroups that emerge from the network of relationships in each territory.

## 5. Discussion and conclusions

The EU Cohesion Policy places ever greater emphasis on promoting the development of territories, encouraging them to look at their specific characteristics and strengths and exploit them. The territorial dimension is proposed to achieve a tailored efficiency of European investment in local areas. So, strengthening an integrated place-based approach into policies of less developed European regions requires shifting local actors' perspectives. The Sicilian Madonie area analyzed in the case study shows how democratic participation may change the inevitable negative trend of inner areas. Therefore, policy formulation and planning must define tailor-made strategies considering the effective local resources.

The main objective of this article is to provide a discussion on the importance of democratic networks for the reinvention of local economic, territorial strategies, and innovation processes. The role of governance networks in influencing the emergence of technical, civic,

**Table 6**
Community analysis results.

| ID cluster | Name | p-value | Attributes in the community | Elements in Cluster | Number of Elements with attribute | Number of elements total | Type of test |
|---|---|---|---|---|---|---|---|
| 0 | Businesses and private companies | 3,53E-42 | 218 | 240 | 268 | 428 | bonf |
| 1 | Cultural, sports, Environmental and tourist associations | 9,84E-12 | 40 | 188 | 41 | 428 | bonf |
| 1 | Public entities | 1,61E-08 | 37 | 188 | 40 | 428 | bonf |
| 1 | Trade associations | 3,34E-01 | 12 | 188 | 13 | 428 | bonf |
| 1 | Cooperatives | 2,22E+00 | 16 | 188 | 21 | 428 | FDR |

and governance innovation is a critical but understudied topic. The importance of new territorial governance processes that trigger systemic innovation mechanisms contemplating a green transaction is challenging for European regions. The Helix Architectures (EUTOHA) (Carayannis and Campbell,2022), particularly the Quintuple Innovation Helix framework, presuppose democratic approaches to innovation, including the involvement of all stakeholders in environmental sustainability processes. Therefore, it is necessary to analyze the complexity of a given territory to identify the relational forces capable of triggering innovation mechanisms. This way, the paper has advanced an innovative data approach to analyzing relationships in a specific geographical context. In the study, we developed a case of governance processes in the Madonie, an internal area of Sicily, which has shown mechanisms thickening relations, more democracy, and valuable links with the local economic structure and the natural environment. The social network analysis methodology has identified the network of relationships created over time by territorial policies. All network metrics, such as cohesion, density, reachability, and centrality, make it possible to analyze stakeholders and their involvement following the various planning initiatives.

Furthermore, community detection has made it possible to detect the presence of groups of nodes characterized by a density of internal connections greater than the density of links in the rest of the network. Therefore, the methodology reveals some of the latent links for a dynamic comprehension of the network, and the statistical validation confirms the strength of specific action groups. The study attempts to take a step towards an innovative territory analysis, looking for the links and providing references for building bottom-up policies with greater awareness. Interpreting governance as a network process for adding value implies a new territory management model. Understanding how the networks form and evolve in response to external stimuli is crucial for designing, implementing, and evaluating new development strategies. The political challenge for marginal regions is to find a way to replace the traditional hierarchy and dependency governance structure with mutual links among economic agents, organizations, and institutions in a democratic vision and setting. A model of "associative democracy" (Hirst, 2013) in which the State and civil society are part of a single regulatory model that transforms their functions.

## CRediT authorship contribution statement

**Maria Rosaria Seminara:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. **Vincenzo Provenzano:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that no financial/personal interest or belief affects their objectivity.

## Data Availability

Data will be made available on request.

## Acknowledgments

Acknowledgements. This research work is the result of the synergetic activity of the TREnD (Transition with Resilience for Evolutionary Development) Project, which has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreements No. 823952 (TREND) and the SOUND (Smart Open Urban-rural iNnovation Data) Project that has received funding from the Italian Minister of University and Research (MIUR) under the PRIN—Progetti di Ricerca di Rilevante Interesse Nazionale Bando 2017 grant no. 2017JMHK4F.

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