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RESEARCH ARTICLE

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Participatory approaches and Social Network Analysis to analyse the emergence of collective action for rural development: a case study in the Spanish Pyrenees

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ABSTRACT

This paper explores the social capital of an emergent beef quality brand in two valleys (Ansó and Hecho) in the Spanish Pyrenees through a combination of participatory approaches (focus groups) and Social Network Analysis. We organised three focus groups with stakeholders from the administration, tourism and commerce, and farming sectors to evaluate the interest for the initiative. In the Social Network Analysis, we surveyed 32 local stakeholders to construct an advisory network, including the surveyed actors and non-surveyed actors that they mentioned, and a trust network, including only the surveyed actors and their trust level in each other. The trust network was analysed using the Louvain's algorithm to identify potential internal communities and the exponential random graph model (ERGM) to infer the shaping effects of actors' attributes on the network's structure. Our results revealed a general interest of the stakeholders in the beef quality brand and a sparse network characterised by a propensity to mutual and open interactions with four clusters based on employment sectors/educational levels and connected by two prominent actors. Therefore, the social capital of the initiative showed both risks because a loss of these few prominent actors could inhibit the network, and opportunities, because their presence, along with the mutual and open interactions, would ensure efficient information exchange. The investigation revealed also two possible limiting factors: the absence of a coordinator and the actors' unwillingness to assume this role. The results confirmed the efficacy of the methodology used to investigate the social capital of emergent initiatives, but further research should be carried out including stakeholders' concerns on its economic implications.

HIGHLIGHTS

- Focus groups and Social Network Analysis allowed to explore the social capital of a beef production quality brand initiative.
- A sparse network with mutual interactions but few central actors emerged.
- The absence of a coordinator and unwillingness to cover the role are possible limiting factors.

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Beef production; mountain area; participatory approach; Social Network Analysis; rural development

Introduction

Cooperation has permitted human societies to deal with complex challenges throughout history (Henrich and Henrich 2007; Österblom and Paasche 2021). Collective action is a voluntary process of cooperation involving different stakeholders with shared interests (Scott and Marshall 2009; Barnaud et al. 2018) pursuing common objectives. Cooperation and collaboration between different stakeholders enable the exchange of knowledge and resources to find common solutions (Lazega 2006; Ostrom 2009; Tengö et al. 2014) and develop common initiatives (Díez-Vial and Montoro-Sánchez 2014). The results regarding the interactions, cooperation, trust, and exchange of

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knowledge between stakeholders, and the networks generated by these interrelationships is known as social capital (Ostrom 1990; Inkpen and Tsang 2005). Solid social capital means strong relationships between stakeholders, which is fundamental for collective action, while trust and mutual understanding are essential for a cooperative project to succeed (Stern and Coleman 2015; Young et al. 2016; Zaga-Mendez et al. 2021). Stakeholders are more likely to participate in common initiatives if they trust each other (Ostrom 2010) and are willing to adopt the norms of reciprocity leading to a higher level of cooperation (Baland and Platteau 1998; Jagers et al. 2020). Different backgrounds and interests may give rise to conflict (Ostrom 2010), which can limit the chances of a project succeeding. However, these differences can also mean different ideas and contributions being brought to the table, improving the chances of success (Meinzen-Dick et al. 2004).

Collective action and social capital in mountain regions are essential to protect natural areas, promote rural development (Ernstson et al. 2008; Koutsou et al. 2014), and maintain ecosystem services, such as cultural landscapes and the production of quality products (European Commission 2008; Vialatte et al. 2019; Rac et al. 2020). Mountain regions are disadvantaged because their relative isolation hampers the creation of broader markets. At the same time, they still must compete with big industrial producers and intensive farming systems located in the more privileged lowland areas. The disadvantaged position of mountain regions can lead to population decline, with weakened social capital, poor access to public services, and an ageing population, making it difficult to escape what then becomes a depopulation trap (Camarero and Oliva 2019; Muñoz-Ulecia et al. 2022). These processes compromise the long-term maintenance of the ecosystem services delivered by mountain agroecosystems, which are highly valued by society (Bernués et al. 2005; Faccioni et al. 2019). Most ecosystem services from mountain agroecosystems are delivered by grazing livestock farming systems (Schirpke et al. 2021) using pastures and meadows for animal feed, with low off-farm inputs.

In this context, collaboration between local stakeholders (e.g. farmers, tourism operators, local government, rural development agencies, etc.) can improve the provision of ecosystem services (Schirpke et al. 2021). We use a case study to explore the usefulness and complementariness of participatory methods and social network analysis (SNA) to analyse the emergence of collective action and social capital to create a beef quality brand to strengthen rural development in the Spanish Pyrenees.

Qualitative and quantitative methods are valuable tools for analysing collective actions and social capital (Grootaert and Van Bastelar 2002; Meinzen-Dick et al. 2004). The former can provide a more comprehensive perspective on different issues, whereas the latter are more reliable as they are based on numerical, hence more accurate, data (Choy 2014). Qualitative data may lack objectivity, whereas quantitative data lack human perceptions and beliefs (Choy 2014). Yet, they offer researchers useful tools to develop their investigations more detailed, e.g. by including different case studies (Meinzen-Dick et al. 2004). Combining both methods can provide more consistent results (Shaffer 2013).

Focus groups are a useful means of collecting qualitative data since they involve a small number of participants (Wilkinson 2004), allowing them to share their opinions, ideas, perceptions, and doubts (Krueger and Casey 2000) on a specific topic. The researcher facilitating the group should play a marginal role (Nyumba et al. 2018) and enable the participants to freely express their ideas (Acocella 2012). The discussion generated by a focus group on a specific topic is fundamental for collective action (Wibeck 2011) since the exchange of information between stakeholders with different backgrounds allows finding solutions and achieving common objectives (García-Nieto et al. 2019; Jungsberg et al. 2020).

SNA is a valuable tool for understanding the relationships between stakeholders in a collaborative process (Connick and Innes 2003; Mandarano and Meenar 2015). It provides a quantitative measure of the exchange of information and resources among stakeholders and institutions, revealing the level of collaboration (Lazega 1998; Bodin and Crona 2009). It also allows investigating the link between collective action and the structural elements comprising the social capital (Siegel 2009; Bodin and Prell 2011). According to Schröter et al. (2018), SNA could also support inclusive processes to create cooperation to develop new projects.

Using a participatory approach methodology and SNA, this study aims to assess the feasibility of an emergent initiative, i.e. developing a beef quality brand in the Ansó and Hecho valleys (Aragonese Pyrenees, Spain). Local and regional rural development agencies and public institutions promoted the initiative. The use of participatory approaches and SNA is still relatively unexplored (but see Pachoud et al. 2020) to assess and analyse the interest of stakeholders and the exchange of information among them

regarding an emergent initiative in mountain regions. The specific objectives were:

i. To assess interest in the development of the beef quality brand by collecting local stakeholders' opinions and perceptions;
ii. To construct an advisory social network that included all the local stakeholders involved or potentially interested in the development of the beef quality brand and to analyse the relationships between them and their roles in the initiative;
iii. To construct a trust social network that included only the local stakeholders surveyed and to analyse the level of trust between them and their roles in the initiative;
iv. To identify whether local stakeholders could be split into different groups according to how and why they contributed to developing the quality brand.

Material and methods

Study area

The study was conducted in the Hecho and Ansó valleys located in Jacetania *comarca* (county) on the western side of the Aragonese Pyrenees (province of Huesca, Northern Spain, 42° 58′ 10′′ – 42° 44′ 20′′ N/ 02° 45′ 40′′ – 03° 06′ 00′′ E) (Figure 1). The two valleys cover an area of 435.9 km^2 at an average altitude of 1244 m a.s.l. (ranging approximately between 500 m a.s.l. and 2,500 m a.s.l.) and are drained by the Aragón Subordan Fiver (Hecho Valley) and the Veral River (Ansó Valley). The land is covered mostly by forest (53.5%), followed by pasture (36%), unproductive land (9%), arable land (1.3%), and urban areas (0.2%) (Gómez et al. 2020). Currently, communal pastures cover an area of around 27,520 ha, split almost equally between the two valleys. Communal pastures occupy more than 50% of the total area of the Ansó valley. The last century saw large population abandonment of the valleys due to rural-urban migration. This depopulation resulted in a sharp decrease in the number of farms and an increase in the size of herds, which has continued to the present day. According to the Instituto Aragonés de Estadistica (IAEST), between 2010 and 2021 the number of heads of cattle in the two valleys increased by 29% (from 2080 in 2010 to 3949 in 2021). In contrast, the number of farms remained almost the same (42 in 2010, 41 in 2021).

Unlike neighbouring valleys, such as Broto and Benasque, Hecho and Ansó have seen only modest tourism development. Less competition from other economic activities and a lack of alternative work has allowed the valleys to maintain their agricultural and livestock activities. Currently, 18% of the local population still works in the primary sector. In 2006, law 51/ 2006 created the *Valles Occidentales* Nature Park, an

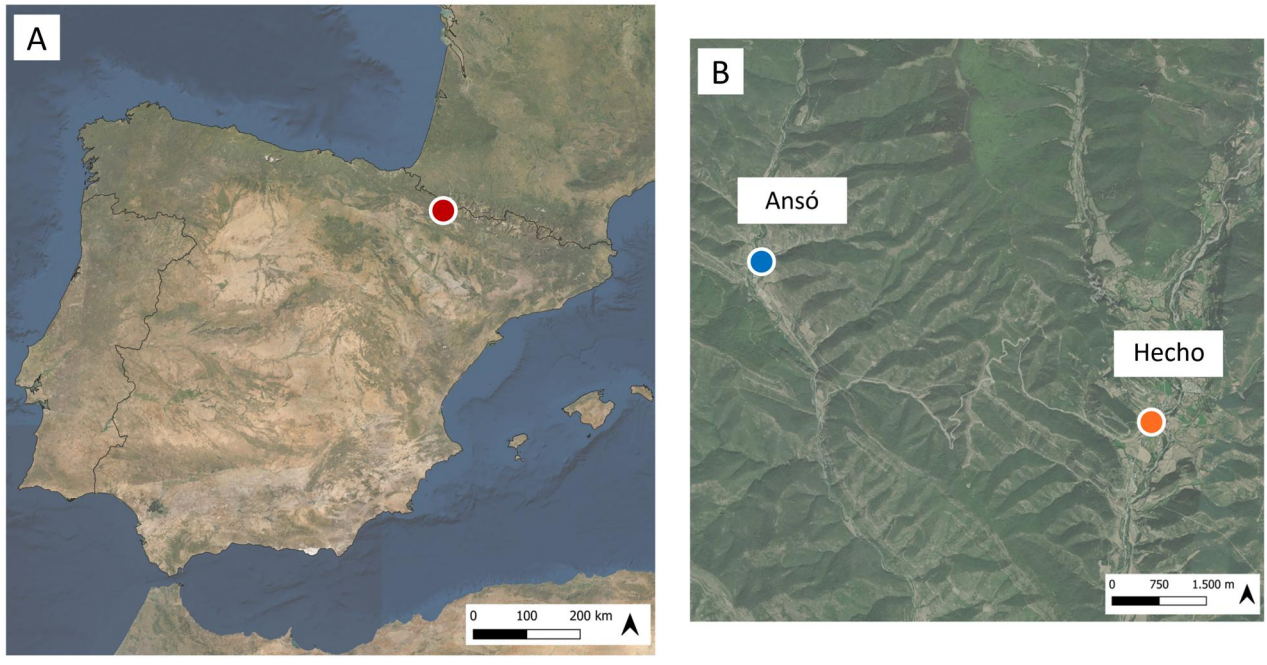

Figure 1. The panel a represents the *Jacetania comarca* (red dot) on the Western side of the Aragonese Pyrenees where the two study areas are located, which are represented in Panel B (villages of Ansó – blue dot – and Hecho – orange dot).

area of 27,073 ha, which included the Hecho and Ansó, and other neighbouring valleys, with the specific aim of recognising the important natural value of these territories.

The quality brand initiative and participant selection

Local and regional rural development agencies and public institutions are evaluating whether to develop a beef quality brand in the Hecho and Ansó valleys, where demand has been growing for local, high-quality products from tourists and residents. The idea is to launch a bottom-up initiative involving local stakeholders with different profiles and from three different employment sectors: (i) administration, comprising local and regional government, rural development agencies, and veterinarians; (ii) commerce and tourism, comprising restaurateurs, accommodation providers, local shops, tourism associations; (iii) livestock, comprising farmers managing livestock in the study area. Local stakeholders are the main actors who would contribute to the development and success of the beef quality brand. The initiative's first step was to investigate the feasibility of creating a quality brand to add value to local beef products through focus groups. The study presented here was carried out in parallel with the initiative's development process, which began with the local and regional rural development agencies and public institutions promoting the beef quality brand. As the beef quality brand has yet to be developed, our study represents only an initial stage in the investigation of the initiative and the related social capital to verify its feasibility.

Data collection and analysis

Data were collected using two complementary participatory methodologies, i.e. focus groups and surveys. We wanted to use the focus group methodology to analyse the local stakeholders' opinions and perceptions about the feasibility of developing the beef quality brand and the opportunities it might hold. We wanted also to assess their level of interest in the initiative. Our aim regarding the surveys was to collect data for constructing both the advisory and the trust networks, analysing the relationships among local stakeholders and the roles they play in the development of the beef quality brand. Through the trust network, we analysed the levels of trust among the local stakeholders surveyed.

Ethics statement

All data collection and treatments were approved by the Ethics Committee of the Agrifood Research and Technology Centre of Aragón, Spain (no. CEISCH_20212_4). Concerning the focus groups, participants expressed their oral consent to record the discussion and to take notes, granting their anonymity; regarding the surveys, at the beginning of all sessions, we asked each participant to sign a data privacy and consent form, which specified that their data would not be associated with their identity.

Focus group

The focus group methodology involves a researcher moderating a discussion of a specific topic by a group of 4–12 people (Nyumba et al. 2018). The participants aim to share their knowledge, opinions, and ideas. At the same time, the researcher pays attention to the interactions between them and the course of the discussion (Stewart and Shamdasani 2014), and ensures that everyone can participate and express their opinions (Elliott et al. 2006).

The focus groups, organised in collaboration with the local and regional rural development agencies and public institutions, took place in October 2021 with the aims of: (i) assessing the feasibility of developing the beef quality brand and the opportunities it would present; (ii) assessing the willingness of local stakeholders to take part in the initiative; (iii) identifying the synergies among local stakeholders belonging to different employment sectors. A total of three focus groups' repetitions were organised according to common interests and employment sectors of local stakeholders: (i) administration (8 participants); (ii) tourism and commerce (4 participants); and farming (6 participants).

The focus group discussions lasted, on average, an hour and a half. They started with a short introduction to the initiative and an explanation of the reasons for inviting the participants. The three focus groups had a common design, but some aspects were specific to each (supplemental Table S1). With the participants' permission, the discussions were recorded and two assistants took notes. The three focus groups were scheduled to maximise the number of participants considering the logistic difficulties due to the mountain context (i.e. local movement). The focus groups were analysed through inductive content analysis to extract the opinions and the perceptions of the actors involved (Elo and Kyngäs 2008).

Social network analysis

Social network analysis (SNA) is based on the graph theory (Otte and Rousseau 2002) and allows for the study of the patterns of relationships among local stakeholders (network structure) and their interactions (Stokman 2001; Vaughan 2005). It allows understanding each stakeholder's role in the network and their position within the social structure (Crona et al. 2012; Pachoud et al. 2019). Therefore, SNA allows considering the individual along with the social context, defining the structural regularities able to change the actors' behaviour and relations (Otte and Rousseau 2002). Social networks are commonly represented by graphs, in which nodes represent actors while links or edges between the nodes represent the relationships or interactions between them (Bodin and Crona 2009).

To collect data and build the social network, we used the roster method (Butts 2008), which consists in asking participants to indicate from a list the names of the persons with whom they have discussed the initiative (i.e. '*with which of the people on the list have you discussed the initiative concerning the development of a beef quality brand in the Ansó and Hecho valleys?*').

From an initial list of 47 local stakeholders, only 32 were available to take part in the survey: 18 farmers and 14 other stakeholders (3 tourism operators, 3 restaurateurs, 1 veterinarian, 2 rural development agents, 2 town council administrators, 1 shop owner and 1 retail assistant (butchers), 1 employee of a multi-sectoral association that also deals with marketing). All actors of the focus groups, except one, were involved in the SNA.

The survey design (see supplemental Table S2 for details) first collected general information concerning the participant's name, age, employment sector and place of residence and his interest in the quality brand (number of meetings regarding this initiative that each participant attended, from whom they first heard about the initiative, whether they thought it would create added value in the Hecho and Ansó valleys). Then, to construct the advisory network, we presented to each participant a list of the people involved in developing the beef quality brand and asked them to state with whom they had discussed the development of the beef quality brand and exchanged opinions and information on it. Finally, to assess the level of trust among them and to build the trust network, we asked each respondent to indicate on a scale from 0 (very low) to 10 (very high) how much they thought that the opinions and ideas of those people on the list with whom they had discussed the initiative could contribute to developing the brand. The question concerning trust was formulated based on methods adopted in other published studies (Hahn et al. 2006; Crespo et al. 2014; Pachoud et al. 2020). To assess the initiative's potential for success, we adopted a participatory approach and SNA methodologies, as they are valuable tools for investigating the exchange of ideas and opinions among local stakeholders and their interest levels. We analysed two networks: the advisory network, which represented the relationships among both the surveyed and non-surveyed actors, and the trust network, which represented only the surveyed actors, i.e. those for whom we had complete data, in order to avoid biased results. The advisory network, therefore, represented the exchange of information between the local stakeholders potentially interested in the initiative and their relative contributions to developing the beef quality brand. The trust network, instead, represented the level of trust among the actors, a critical factor in developing new initiatives, and the contribution of each actor to the network.

We took two approaches to analysing the advisory and the trust networks: structural and positional. We reported the indices estimated through the two approaches in Table 1. For the trust network, we also used a third approach, namely the exponential random graph model (ERGM). The analyses were carried out in R 4.1.3 (R Core Team 2013) using the packages igraph (Csardi 2006), qgraph (Epskamp et al. 2012), ergm (Hunter et al. 2008) and btergm (Leifeld et al. 2018).

Table 1. Description of the indices used in the structural and positional approaches within SNA (Social Network Analysis).

Variable	Igraph function	Approach	Description
Density	Edge_density	Structural	Ratio between the number of edges in the network and the total number of possible edges. It is an indicator of the level of connectedness among actors. It is expressed as a percentage between 0 and 100, where a high value indicates a high connectedness.
Reciprocity	Reciprocity	Structural	Reciprocity is the tendency of dyads (pair nodes) to have a mutual interaction in a direct network. It is expressed as percentage between 0 and 100, where a high value indicates a high probability of mutual interaction.
Modularity	Modularity	Structural	Propensity of a network to divide into sub-networks or communities. It ranges between −1 and 1, where the maximum value indicates a high propensity to divide into communities.
In-degree	Degree(mode='in')	Positional	Number of edges (links) that point to a node (in-going edges)
Betweenness	Betweenness	Positional	Number of geodesics (shortest paths) going through a node. A high value identifies a node with brokerage position (i.e. strong contribute to manage information exchange within the network)

With the structural approach, we analysed the relationships between the local stakeholders, e.g. how much they were interconnected or whether specific individuals were isolated. From this approach, we estimated structural indicators to assess the sharing of knowledge and the exchange of information. Specifically, we estimated the density and reciprocity of relationships and identified Louvain communities for the trust network. Density is the ratio between the number of edges in the network and the total number of possible edges, and it is an indicator of the level of interaction or connectedness among actors (Otte and Rousseau 2002; Huang et al. 2014). Density is expressed as a percentage between 0 and 100, where values near 0 indicate a sparse network, while values close to 1 suggest a well-interconnected network with direct interactions among the actors (Otte and Rousseau 2002; Huang et al. 2014). Density was estimated using the function 'edge_density' from the library 'igraph'. Reciprocity is the number of members mutually cited and determines the level of advice exchanges, i.e. reciprocal help between the local stakeholders in the network (Jana et al. 2013). Reciprocity is expressed as a percentage between 0 and 100, where high values indicate high probabilities of mutual interaction. It was estimated using the function 'reciprocity' from the library 'igraph'. Louvain's algorithm uses modularity parameters to identify communities of actors based on mutual characteristics (Blondel et al. 2008). Modularity ranges between −1 and 1 and measures the propensity of a network to split into sub-networks, which can be interpreted as communities (Clauset et al. 2004). The computation of Louvain's algorithm is only available for undirect networks in 'igraph' due to its complexity in the case of direct networks (Blondel et al. 2008; Malliaros and Vazirgiannis 2013). Thus, we converted the trust network from direct to undirect to estimate the Louvain communities. First, we estimated the modularity using the function 'modularity' from 'igraph' library. Then, we estimated the Louvain communities using the function 'cluster_louvain' from the library 'igraph' and extracted each node's community membership attribute. We also performed two multinomial models to analyse separately the community effect on the distributions of each 'employment sector' (four categories: 'Farmers'; 'Tourism and commerce stakeholders'; 'Administration stakeholders'; 'Other stakeholders') and 'educational level' (five categories: 'Primary school'; 'Middle school'; 'High school'; 'Professional training'; 'University'). We ran the multinomial models with the function 'multinomial' from the library 'nnet' (Venables and Ripley 2002).

With the positional approach, we identified the actors playing a central role in the network by estimating the in-degree and the betweenness centrality. In-degree centrality is a measure of the number of edges (links) that point to a node (Hansen et al. 2020) and therefore identifies the prominent or support actors since it is a count of the number of advice requests received by an individual from others (Wasserman and Faust 1994; Tabassum et al. 2018; Baek et al. 2022). The in-degree centrality was estimated using the function 'degree' from 'igraph' library, specifying the mode as 'in'. Betweenness centrality measures '*the extent to which a certain vertex lies on the shortest paths between other vertices*' (Hansen et al. 2020), and identifies the actor in the brokerage position, i.e. the person who contributes to information flow and network cohesion (Everett and Valente 2016). Betweenness was estimated using the function 'betweenness' from 'igraph'.

Finally, we used the ERGM (Exponential Random Graph Modeling) to test whether the trust network was randomly shaped and to discover which factors contributed to defining it. The ERGM is a relevant tool to infer the structural configuration of a network from the presence or absence of its edges and reveal tendencies within the analysed system (Lusher et al. 2013). Specifically, the ERGM infers the significant presence of a specific network structure by comparing the sampled network with all its possible arrangements (Lusher et al. 2013). This approach does not require independence among network edges, an assumption of conventional statistical methods (Lusher et al. 2013). Additionally, the ERGM allows to test the effects of node attributes (e.g. covariates) on the network's endogenous structure and exogenous patterns. In our case, we investigated which internal and/or external attributes most influenced the exchange of advice, identifying which factors contributed to forming the social networks. We applied the ERGM only to the trust network since its computation requires no missing values, using the function 'ergm' from 'statnet' library (Hunter et al. 2008). Table 1 reports the ERGM metrics used in the analysis, according to Handcock et al. (2008). We investigated whether the relationships among members were established randomly or by the nodes' internal (endogenous) or external (exogenous) attributes. We analysed three internal attributes: i) density of the edges ('edges'); ii) reciprocity, i.e. mutual advice relationships between two nodes ('mutual'); iii) the probability of two nodes *i* and

r to share a connection with a third node *k*, constructing a triad within the network ('*Geometrically-Weighted Edgewise Shared Partnerships*' – 'GWESP'). The external attributes considered in the ERGM were 'employment sector' and 'educational level'. We tested both the homophily and the effect on edge formation for each attribute, using 'nodematch' and 'nodefactor' terms respectively (Table 1). To test the homophily for each attribute category with set the condition 'diff' of 'nodematch' as 'true'. Then, the ROC (receiver operating characteristic) curve was estimated to assess the goodness of prediction, expressed as R^2, with the 'gof' function in the 'btergm' package (Leifeld et al. 2018). A model with a higher ROC value has a better predictive power (Cranmer and Desmarais 2011) (Table 2).

Results

Focus groups

Figure 2 reports a summary of the opinions and perceptions of the actors participating in the beef quality brand focus group. All participants were interested in the initiative since they perceived an increasing demand for local products, including beef. Nevertheless, the three focus groups exposed a lack of leadership, the need to build a formal social organisation, and the lack of someone willing to fill the intermediary role in the production chain (manufacturing, packaging, marketing, etc.). The participants identified the rural development agency as playing a central role in coordinating or leading this initiative.

Table 2. Description of the network and ERGM metrics used in the analysis.

Variable	Statnet term	Attribute type	Description
Edge	Edges	Endogenous	A number of network edges. Its estimate provides information about connection density in the network, where negative values indicate low density. A significant value indicates no random edge formation.
Reciprocity	Mutual	Endogenous	Reciprocity is the tendency of dyads (pair nodes) to have a mutual interaction in a direct network. Positive and significant estimates indicate edge propensity to be mutual (reciprocity presence)
GWESP	GWESP	Endogenous	'*Geometrically-Weighted Edgewise Shared Partnerships*', the propensity to construct a triad interaction among three nodes. Positive and significant estimates indicate the propensity of constructing close triangles or close interactions among nodes. Negative and significant estimates indicate the propensity of constructing open triangles so open interactions among nodes.
Effect of Node attribute	Nodefactor	Exogenous	Effect of node attribute on edge development (in-going and out-going edges); positive and significant estimates indicate a high probability of constructing both in-going and out-going edges
Homophily node attribute	Nodematch	Exogenous	Node propensity to be tied of others of the same category. Positive and significant estimates indicate high node homophily.

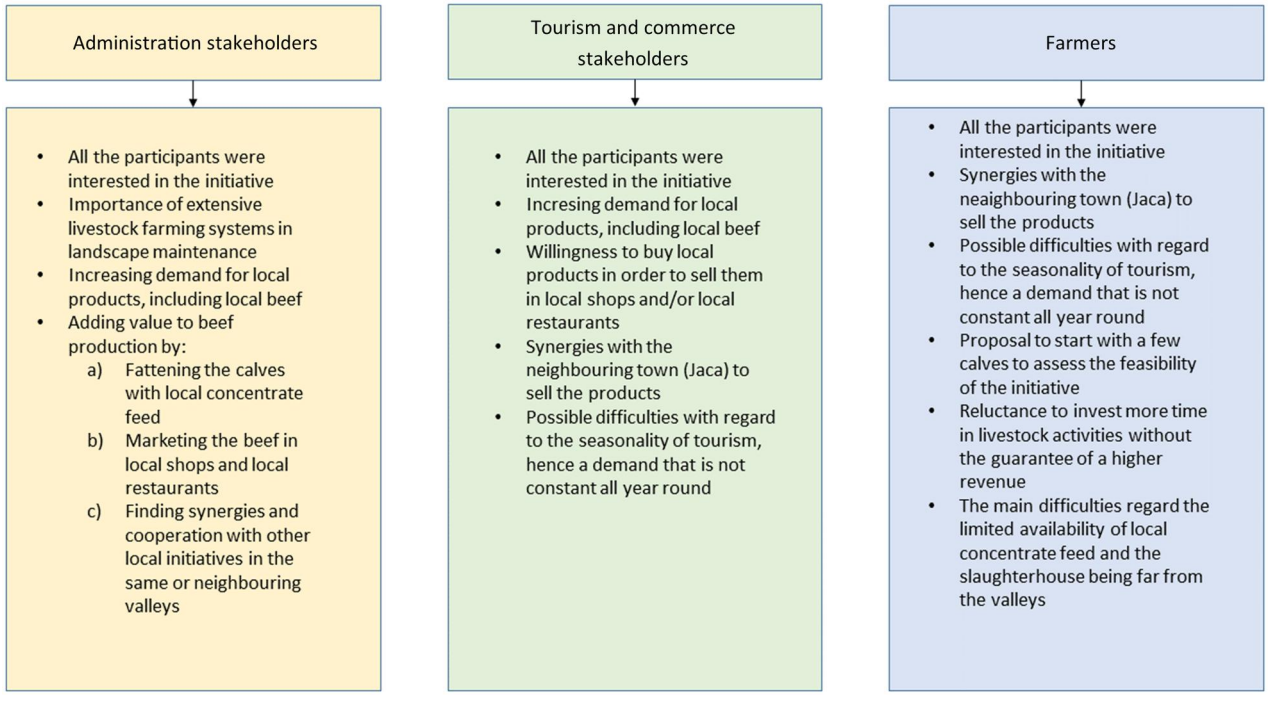

Figure 2. The main results emerged from the three focus groups and inductive content analysis.

Table 3. The main characteristics of the actors surveyed. The figures refer to numbers of actors.

Variable	All actors	Farmers	Tourism and commerce stakeholders	Administration stakeholders	Other stakeholders
Actor surveyed	32	18	7	5	2
Age	44 ± 13	44 ± 13	48 ± 11	44 ± 13	34 ± 10
Educational level					
Primary school[a]	7	7	0	0	0
Middle school[b]	4	3	1	0	0
High school[c]	5	3	2	0	0
Professional training	8	5	2	1	0
University	8	0	2	4	2

[a]6–12 years of age; [b]12–16 years of age; [c]16–18 years of age.

Unlike the other focus groups, the farmers did not recognise the importance of livestock activity in maintaining a high-value landscape in terms of both its natural and cultural assets. Furthermore, they were reluctant to invest time in additional activities without the guarantee of higher revenue and therefore proposed starting with a few calves to assess the feasibility of the initiative. Participants in the three focus groups agreed with finding synergies and cooperation with other initiatives, either in the same valleys or in other neighbouring valleys or villages, e.g. Jaca (the largest neighbouring town).

Main characteristics of the actors surveyed and of the farms and farmers involved in the study

Table 3 shows the main characteristics of the actors who participated in the interviews. The average age was 44 ± 13 years. The educational level of the Administration stakeholders, and of the other stakeholders was higher than that of the farmers, most of whom ($n = 10$) completed only compulsory school education (up to age 16), with only 3 going on to high school (age 16-18) and 5 taking a professional training course. Four of the tourism and commerce stakeholders had either a university degree or a professional training diploma, 2 attended high school, and 1 completed only compulsory school education.

Table 4 provides general information on the farmers and their livestock activities. Most declared themselves to be employed full-time on their farms. A small but relevant group of them (22%) had other employment in addition to farming.

The average herd size was 146 ± 88 LU/farm. The number of calves sold in the two valleys corresponded to 30 ± 17 LU/year/farm. The grazing period (of the whole study area) was 8 ± 2 months. Most of the land used consisted of communal pastures with an average area of 356 ± 629 ha/farm, followed by rented lands (including pastures, meadows, and cropland) with an average area of 79 ± 239/farm. There was considerable variability because: i) some farmers have access to a large area as they share the pastures with other farmers; ii) the farmers keep the herds on pasture all year round. Finally, the results showed that farmers owned very few hectares (9 ± 8/farm).

Table 4. General information on the farmers and their livestock activities.

Variable	Unit	All farms
Famers, total	*N*	18
Employed full-time in farming activities	%	78
Other employment	%	22
Farmers, mean age	years	43 ± 13
LU[a,b]/farm	LU/farm	146 ± 88
LU[a] of calves sold/year	N	30 ± 17
Grazing length, months	months	8 ± 2
Owned land, mean	ha/farm	9 ± 8
Rented land, mean	ha/farm	79 ± 239
Communal pastures, mean	ha/farm	356 ± 629

[a]LU: Livestock Unit; [b]LU includes cattle and calves.

Advisory network and trust network

Figure 3 represents the advisory network of the stakeholders involved in the initiative, including the non-surveyed actors, while Figure 4(A,B) represent the trust network. Table 5 reports the positional and structural indicators, as well as the number of nodes and links. The advisory network comprised 44 actors (nodes) and 196 links, whereas the trust network comprised 26 actors (nodes) and 131 links. The trust among stakeholders ranged between 0.2 and 1, with an average of 0.7 and a standard deviation of 0.15. The density of the advisory network was 10%, lower than that of the trust network, which had a density of 20%. Both density values indicate networks with general sparse connectedness. Reciprocity was 53% for the advisory network and 58% for the trust network. These values show that more than half of the stakeholders were mutually linked.

Regarding the structural indicators, the most mentioned actor in the advisory network was actor 8, an administrator in the Hecho town council, with 17 advice requests (the highest in-degree centrality – Figure 3). During the survey, we discovered that this

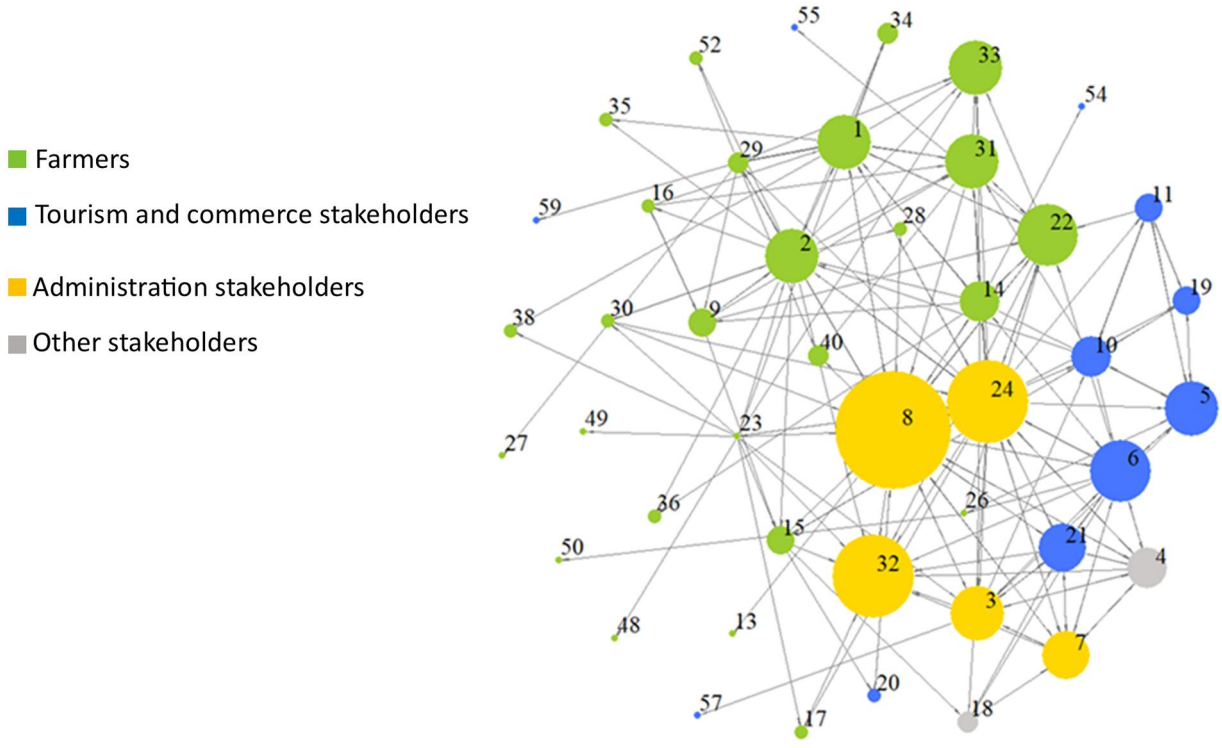

Figure 3. SNA of the advisory network including all the actors (surveyed and non-surveyed) involved in developing the quality brand. The graph represents the exchange of advice between the actors: nodes represent actors, and links (edges) represent the connections between them (44 nodes, 196 links). The node's size indicates the in-degree value of the actor (Central actors have the largest values). The network is directional with arrows indicating the direction of advice requests; bi-directional arrows indicate mutual relationships/requests. The colours of the nodes represent the different employment sectors as reported in the legend.

actor was the initiative's promoter. The next most frequently mentioned actors, with 12 advice requests each, were actor 24 (a rural development agent and organiser of the first meeting and the focus groups), and actor 32 (the veterinarian). Actor 6 (an employee in the tourism sector) and actor 22 (a farmer) received 9 advice requests. In the trust network, actor 8 had the highest in-degree centrality (Figure 4(A)) with 12 advice requests, followed by actor 24 with 8, and actor 6 and 22 with 8. Finally, concerning the betweenness centrality, the advisory network revealed actor 24 to be in the brokerage position with a betweenness centrality value of 283.5, followed by actor 8 with a value of 268.6. As shown in Table 5, actors 2, 6 and 22 had lower betweenness centrality values. In the trust network, it was again actor 24 who contributed the most to the information flow and network cohesion with a betweenness centrality value of 112.5, followed by actor 2 (president of the Hecho Valley Farmers' Association) with a value of 88.7. Actors 8, 6 and 22 had lower values, 77.7, 60.5 and 50.8, respectively. There was wide variation between actors in terms of their betweenness centrality values for both the advisory and trust networks.

Louvain communities within the trust network

The trust networks had a modularity of 0.27, revealing a propensity to be clustered. Figure 5(A) shows the four Louvain communities within the trust network. Their characteristics in terms of employment sector and educational level are represented in Figure 5(B,C), respectively. Supplementary Table S3 reports the detailed characteristics of the communities. The number of members in each community ranged between 4 and 8. Community A was formed only of farmers with an average age of 30 ± 8.7 years, mostly from the Hecho Valley and holding a professional training diploma. Community B had 8 members, mostly non-farmers, with an average age of 46 ± 13.5 years; most have a university degree and are employed in the tourism, commercial, technical or administration sectors. Community C comprised mainly stakeholders in the tourism and commercial sectors, most of them from the Ansó valley, with an average age of 46.0 ± 10.8 years. Finally, community D had 4 members, mostly farmers in the Hecho valley, with an average age of 44 ± 9.9 years. The educational level of community A was higher than that of community D, although

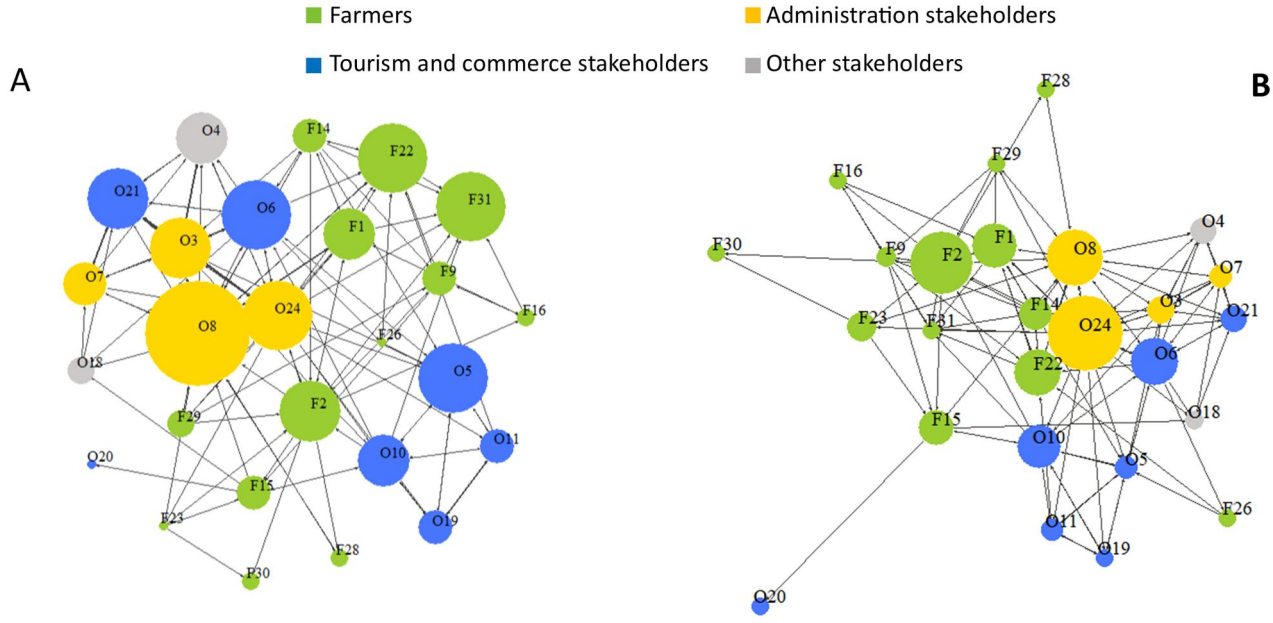

Figure 4. SNA of the trust network of the actors surveyed. F preceding the number indicates a farmer, and O a non-farmer. The size of the nodes in Figure 4(A) indicates the in-degree value of the actor, whereas in Figure 4(B) it indicates the betweenness value given by the other actors in the network (Central actors have the largest values). The colours of the nodes represent the different employment sectors, as reported in the legend. The edges are thicker or thinner according to the average value of trust given by the actors during the survey (26 nodes; 131 links).

Table 5. Nodes, links, structural and positional indicators for the advisory SNA and the trust SNA.

Advisory SNA		Trust SNA	
Variable	Results	Variable	Results
Nodes	44	Nodes	26
Links	196	Links	131
Structural indicators		*Structural indicators*	
Density	10%	Density	20%
Reciprocity	53%	Reciprocity	58%
Positional indicators		*Positional indicators*	
In-degree centrality		In-degree centrality	
Actor 8, administrator stakeholder	17	Actor 8, administrator stakeholder	12
Actor 24, rural development stakeholder	12	Actor 24, rural development stakeholder	8
Actor 32, veterinarian	12	Actor 6, tourism sector stakeholder	8
Actor 6, tourism sector stakeholder	9	Actor 22, farmer	8
Actor 22, farmer	9	Actor 2, farmer	7
Betweenness centrality		Betweenness centrality	
Actor 24, rural development stakeholder	283.5	Actor 24, rural development stakeholder	112.5
Actor 8, administrator stakeholder	268.6	Actor 2, farmer	88.7
Actor 2, farmer	127.6	Actor 8, administrator stakeholder	77.7
Actor 6, tourism sector stakeholder	115.4	Actor 6, tourism sector stakeholder	60.5
Actor 22, farmer	96.2	Actor 22, farmer	58.2

Nodes indicate the number of actors in the network, while links correspond to the number of edges or interactions. Density indicates the connectedness of a network, ranging from 0 to 100. Reciprocity indicates the propensity of mutual interactions between pairs of nodes, ranging from 0 to 100. In-degree centrality indicates the number of in-going links to the node. Betweenness centrality indicates the bridge function of a node. Higher values correspond to stronger contribution to information exchange within the network (dimensionless unit).

both were comprised mostly of farmers, and this may be due to the younger average age of community A.

Table 6 reports the results of the multinomial models from the Louvain communities. The factor with the strongest effect on shaping the communities was the employment sector, although the educational level was also significant since it is partly associated with the employment sector. Previous results show that most of non-farmers had a university degree, whereas most of farmers finished their education after middle school or attended a professional training course.

Trust network: results of the exponential random graph model (ERGM)

Table 7 reports the results of the trust network's final Exponential Random Graph Model (ERGM). The statistical analysis showed that all the endogenous

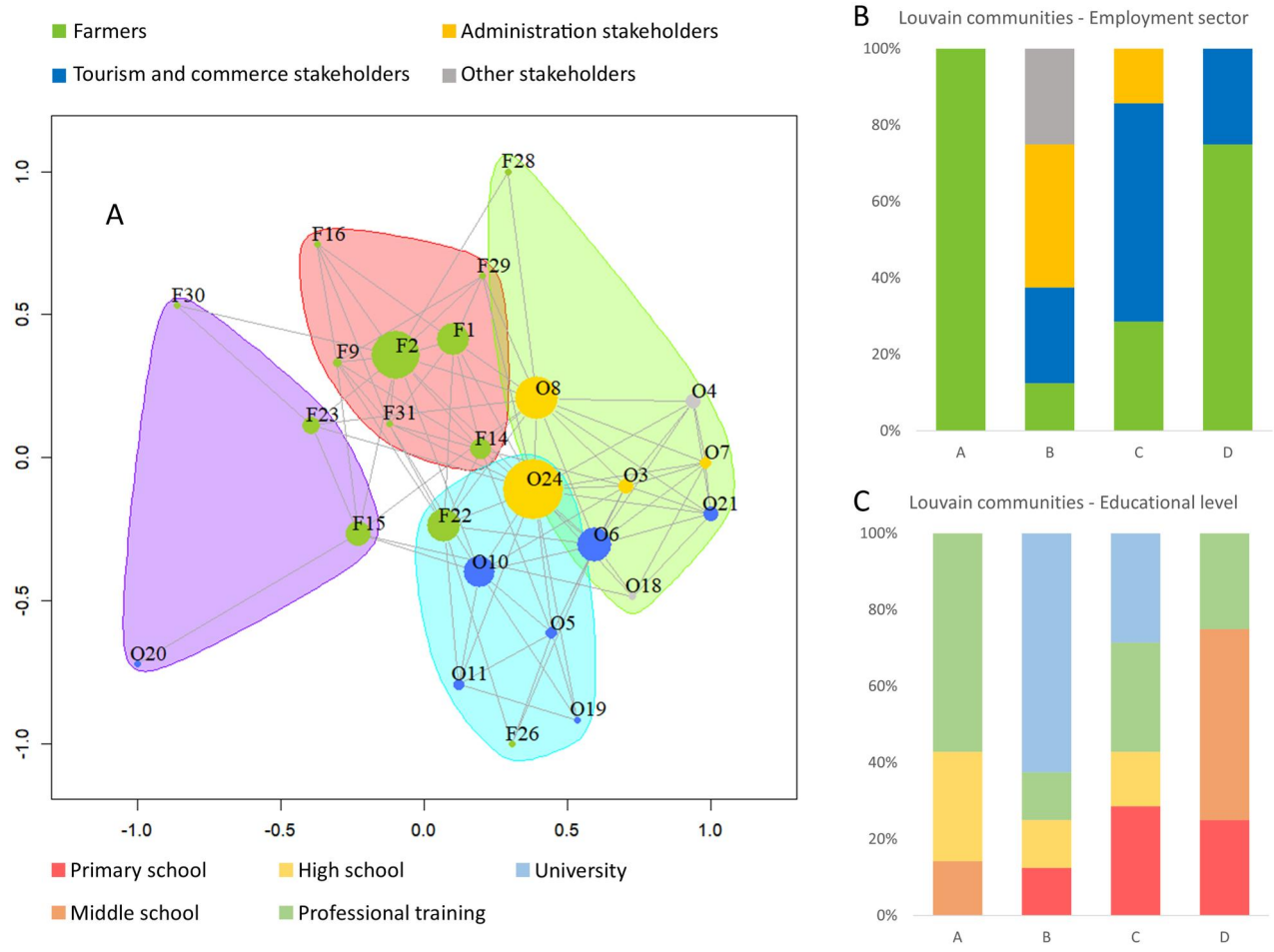

Figure 5. Panel A, communities in the trust network identified by the Louvain's algorithm. Each is indicated by a different colour: community A-red; community B-green; community C-blue; community D-purple. The colours of the nodes represent the different employment sectors while their size corresponds to the betweenness values, according to Figure 4(B); panel B, barplot of employment sectors' distribution among the communities identified by Louvain's algorithm; panel C, barplot of educational levels' distribution among the communities identified by Louvain's algorithm.

Table 6. Results of the multinomial models to test the variability of the employment sector and educational level categories in function of the Louvain communities.

	Df	Chi Sq	Pr(Chi Sq)	Significance	R^2
Employment sector					
Louvain communities	9	22.61	0.007	**	0.37
Educational level					
Louvain communities	12	22.34	0.03	*	0.28

Significance is marked by *, corresponding to p-value $<$ 0.05. Pairwise comparisons are reported in table S3.

attributes shaped its structure. Reciprocity and GWESP had positive, significant values as trust influences the network's structure and the presence of common exchange partners. Among the exogenous attributes possibly influencing the network's structure, there were positive and significant effects for the employment sector 'Administration stakeholders', the educational levels 'High school' and 'Professional training' and, regarding homophily, the employment sectors 'Farmers' and 'Tourism and commerce stakeholders', and the educational level 'Secondary school'. Thus, the ERGM revealed a sectorial propensity towards homophily within the network. If we compare the endogenous and exogenous attributes, we can see that all the external attributes influenced the exchange of advice between local stakeholders. The goodness of fit parameters for both the endogenous and exogenous attributes are reported in Supplementary Material (Figures S1 and S2).

Discussion

Our study aimed to assess the feasibility of developing a beef quality brand in Hecho and Ansó valleys (Aragonese Pyrenees, Spain) and its potential interest through a participatory approach (focus group) and SNA. The results showed that stakeholders were interested in the initiative as it could give added value to

Table 7. Estimates, standard errors, and *z*-values for the endogenous and exogenous attributes of the exponential random graph model (ERGM).

	Estimate	S.E.	z-value	Pr(>|z|)	Significance
Endogenous attributes					
Edges	−3.7948	0.2736	−13.87	<1e-04	***
Reciprocity	2.4215	0.3049	7.942	<1e-04	***
GWESP[a]	1.2231	0.2303	5.31	<1e-04	***
Exogenous attributes					
Edges	−4.651	0.525	−8.859	<1e-04	***
Reciprocity	2.175	0.325	6.702	<1e-05	***
Employment sector – Tourism and commerce stakeholders	0.342	0.276	1.242	0.214	
Employment sector – Administration stakeholders	1.716	0.352	4.870	0.000	***
Employment sector – Other stakeholders	0.641	0.390	1.641	0.101	
Educational level – Secondary school	0.113	0.320	0.355	0.723	
Educational level – High school	0.909	0.276	3.289	0.001	**
Educational level – Professional training	0.820	0.280	2.930	0.003	**
Educational level – University	0.352	0.334	1.053	0.292	
Homophily Employment sector – Farmers	1.497	0.419	3.574	0.000	***
Homophily Employment sector – Tourism and commerce stakeholders	1.414	0.453	3.126	0.002	**
Homophily Employment sector – Administration stakeholders	−0.282	0.598	−0.472	0.637	
Homophily Employment sector – Other stakeholders					
Homophily Educational level – Primary school	−0.385	1.009	−0.382	0.703	
Homophily Educational level – Secondary school	2.118	0.916	2.312	0.021	*
Homophily Educational level – High school	−1.533	0.973	−1.575	0.115	
Homophily Educational level – Professional training	−0.111	0.389	−0.285	0.776	
Homophily Educational level – University	0.724	0.427	1.694	0.090	.
ROC[b]			0.794		

[a]GWESP: geometrically-weighted edgewise shared partnerships; [b]ROC: receiver operating characteristic curve.
The homophily of 'OTHER stakeholders' was not estimated as it had only two nodes. The description of the model terms is reported in table 1 while the pairwise comparisons are reported in table S4. The goodness of fit is reported in Supplementary Figure S1.

the region and foster local and rural development. The SNA revealed a sparse interaction and knowledge exchange among the stakeholders, supported predominantly by five actors. Stakeholders were mutually linked and trusted each other, which can strengthen the social capital, a key element for achieving collective action, such as developing a quality brand.

The focus groups revealed that all local stakeholders were interested in the initiative, with some agreements and disagreements between farmers, administrator and technician actors, and tourism and commerce actors. Administration stakeholders had a strong positive perception of the role of livestock activity in maintaining the landscape in terms of its natural, environmental, and cultural assets. Studies analysing people's perceptions of ecosystem services provided by mountain livestock activities have shown that residents and non-residents in mountain regions consider landscape maintenance to be very important (Rodríguez-Ortega et al. 2016; Leroy et al. 2018; Zoderer et al. 2019; Pachoud et al. 2020). However, farmers did not mention landscape maintenance as a benefit of livestock activities, nor did they consider their beef to have a higher quality than beef from livestock enterprises with a weaker regional attachment. They also did not think that beef production in the Hecho and Ansó Valleys had a higher added value than that of neighbouring valleys or lowland areas. This opinion was due to: (i) their use of concentrate feeds to fatten calves raised elsewhere, which makes it difficult to guarantee a local supply chain and to differentiate their beef production from other livestock systems, e.g. those located in the lowland areas; and (ii) slaughterhouses being located far from the valleys and usually in other regions, i.e. Navarra. The indistinctive finishing process, where calves from different farms are fattened together and sold at big national markets, i.e. Zaragoza and Madrid, meant that farmers perceived their livestock production to be no different from others. This contrasts with the scientific literature, which views mountain livestock grazing systems as highly self-sufficient due to few off-farm inputs, their links to the territory through short, local supply chains, and their provision of ES and high-quality products (Ryschawy et al. 2019; Horrillo et al. 2020; Barron et al. 2021). These characteristics increase the market value of the products, and several studies have shown consumers' willingness to pay more for high-quality, healthy products (Meemken and Qaim 2018; Profeta and Hamm 2019; Ali and Ali 2020; Mazzocchi et al. 2021). The positive externalities provided by mountain livestock farming systems increase consumer interest in sustainable products (Mazzocchi and Sali 2022), and the product labelling framework is a fundamental means of providing consumers with information on quality and traceability (Stampa et al. 2020). The recent Farm to Fork Strategy (European Commission 2020), established by the EU, is moving towards

consumer awareness of high-quality, healthy products. Furthermore, a food labelling framework gives added value to local products and contributes to local development (McMorran et al. 2015; Bentivoglio et al. 2019). A collective brand should be considered since the initiative involved local stakeholders willing to collaborate with neighbouring valleys. However, to accomplish this goal, it is important to proceed in stages, for example: (i) analysing consumer preferences and their consumption behaviour (Moran and Blair 2021; Tabacco et al. 2021); (ii) focusing on the close relationships between livestock farming systems and mountain agroecosystems, and on the environmental and cultural benefits they provide (Santini et al. 2013; Sarti et al. 2018). Finally, collaboration and cooperation among local stakeholders, which is highly dependent on trust, is fundamental (Perlik and Membretti 2018; Pagliacci et al. 2022), which is why the development of a quality brand to differentiate beef production in the Ansó and Hecho valleys should be accompanied by a structured labelling framework that increases consumer awareness.

The average age of the farmers in our study was younger than that recorded in other studies conducted in neighbouring valleys (García-Martínez et al. 2009; Muñoz-Ulecia et al. 2021). Within the Louvain communities (Figure 5 – see below for a detailed discussion), the 7 farmers in community A were younger again than the average age and presented high educational levels (Fig %C). The presence of this community can be due to generational turnover or relocation of farmers from lowland areas (i.e. the towns and cities) and their decision to undertake livestock activities. Teston et al. (2022) and Cocca et al. (2012) found that farmers frequently had second employment in other sectors, such as services or industry, as livestock activity did not provide enough income. This dependence on second employment has increased in the region over the last decades (Muñoz-Ulecia et al. 2021). Herds were larger than in other studies conducted in the Spanish Pyrenees, e.g. the Aragonese and Catalan Pyrenees (Teston et al. 2020; Muñoz-Ulecia et al. 2021), but the length of grazing period was similar. This result reflects a herd management system characterised by extensive use of natural communal pastures, where several farmers share large public pasture areas in nearby valleys, forests, and mountain meadows and move their herds according to the availability of natural resources. Communal pastures are a (free or cheap) feed source throughout long periods of the year, and their use is supported by the Common Agricultural Policy (Bernués et al. 2011; Liechti and Biber 2016).

The results of the SNA show higher levels of reciprocity than found in other studies about mountain context (Pachoud et al. 2019; 2020), and neither network had isolated nodes, revealing the propensity of stakeholders to trust each other and be mutually connected. This propensity was also confirmed by the average trust level and its standard deviation. The density values of both networks were comparable to those observed in other mountain contexts (Pachoud et al. 2020; Filippini et al. 2020). The morphology of mountain areas can hamper connectivity among local communities due to a sparse presence of local infrastructures, such as roads (ESPON 2018; Bertram and Chilla 2023). Thus, the mountain context may contribute to the isolation of local communities, according to the network density estimated. In the context of this study, the community extended over two valleys, making it challenging to connect the actors, thus explaining the low density of both advisory and trust networks. However, the trust network's density was twice that of the advisory one, revealing a higher connectedness for the former and consequent better exchange of information among actors. This result happened probably because: i) stakeholders who participated in the survey had a clearer idea of the initiative since they took part in the focus groups and/or other meetings concerning the initiative and considered the beef quality brand to be an opportunity for local development and to generate added value to local beef; ii) the trust network revealed not only the exchange of information on the beef quality brand among the stakeholders but also the level of trust among them.

Concerning the positional indicators, both the advisory network and trust network revealed the same two prominent actors, Actor 24 and 8, characterised by higher values in their in-degree centrality (prominent actor or support actor – Tabassum et al. 2018), and betweenness centrality (brokerage position or gatekeeper – Tabassum et al. 2018). Interestingly, the prominent actors presented different values of in-degree centrality and betweenness between the two networks. This difference was probably because: (i) the advisory network revealed only the exchange of information on the initiative among the surveyed and non-surveyed actors; (ii) the trust network was based not only on the exchange of information but also on trust levels. Actor 24, a rural development agent and organiser of the focus groups, was the most relevant in both networks according to the highest values of in-

degree and betweenness centrality. Therefore, this actor was recognised as the main broker, with an important role in managing the information among stakeholders. Interestingly, during the surveys, actor 24 was not considered the idea's owner, recognised instead as actor 8. Actor 8 was a local administrator and proponent of the initiative, probably in connection with her, with a familiar tie to a farmer. Both actors 24 and 8 had high educational level and awareness of the role of the local livestock system in the maintenance of ecosystem services, as revealed by the focus group. This awareness and their administrative roles helped them to be familiar with the farmers and other employment sectors, explaining their central role in the networks as supporters of information exchange. Despite their central role in managing the information flow in the network, these actors had trust levels (0.69 ± 0.02) similar to the general average. This similarity may reveal a generally high trust level among all actors, which could benefit the information exchange.

Regarding the positional indicators, Louvain's algorithm identified four communities within the trust network, where stakeholders tended to cluster concerning similar employment and educational profiles. Specifically, the Louvain's algorithm identified four communities within the network: the first consisted of young farmers with a generally high educational level, the second consisted of individuals with a high educational level and mixed employment sectors, the third consisted of Tourism and commerce stakeholders with mixed educational level, and the fourth consisted of farmers with a generally low educational level. People with similar interests and characteristics tend to form groups and/or to belong to the same community (Wang et al. 2013; Little 2016). Only the fourth community appeared less connected than the others, which had numerous connections to the two central actors. However, the levels of interaction among individuals, even of different communities, appeared favourable to developing the quality brand as no isolation was detected. Indeed, some studies have shown that interactions among stakeholders with different profiles can foster knowledge sharing, which is fundamental for building trust and for the success of collective action (García-Nieto et al. 2019; Jungsberg et al. 2020).

Finally, concerning the ERGM, endogenous attributes had significant effects, revealing relevant roles of the information exchange and the trust among stakeholders in shaping the trust network. According to Cvetkovich and Winter (2003), sharing values and knowledge builds relationships, and therefore trust, among stakeholders. Young et al. (2016) found that trust is fundamental to actors' participation in collective action. The ERGM confirmed the sparse connectedness characterised by a propensity to mutual interaction among actors, according to the effects of the edges and mutual terms. Moreover, the significant and negative effect of GWESP revealed the propensity of actors to have open interactions among them, supporting the results found with the structural and positional approaches. Instead, the employment sector and educational level influenced the exchange of information between stakeholders. These two factors are closely tied, as the descriptive data show that actors in similar employment sectors also tend to have a similar education level. Despite the relation between these two factors, the ERGM revealed distinct effects in terms of homophily. The educational level was a relevant driver for the edge development, but its categories did not have homophily, except for Secondary school. Instead, the employment sector was a relevant driver for edge development and significantly contributed to the network homophily. Specifically, the categories of Farmers and Tourism and commerce stakeholders significantly and positively affected the homophily. This result was in accordance with those of Louvain's algorithms and the multinomial analysis of its communities. Thus, the employment sector appeared to be a potential limit for the initiative's development as it tended to cluster actors and induce exclusive interactions within the sub-groups. However, the ERMG homophily analysis revealed a negative propensity to exclusive interactions for the Administration stakeholders. This result was coherent with the prominent actors detected through the betweenness and in-degree indices. Thus, the ERGM also confirmed the positive role of the Administration stakeholders in the information exchange. The results show a likely interaction among stakeholders of different communities thanks to the presence of prominent actors. The interaction among different communities is crucial for the success of an emergent initiative, especially in mountain regions (Gretter et al. 2019). Endogenous attributes may be a good instrument for exchanging knowledge and ideas between stakeholders, who could also promote the initiative among non-surveyed actors.

The SNA revealed a sparse network clustered by similarity in employment sectors and educational levels, where individuals tended to interact mutually. Administration stakeholders emerged as prominent actors who could support the initiative thanks to their

capacity to connect people from different employment sectors and educational levels. This aspect can represent both a risk and an opportunity for an initiative such as the beef brand quality. A sparse network, characterised by a limited information exchange managed by a few prominent actors (Hua et al. 2022), tends to be less resilient and can collapse due to the loss of its central actors with a negative implication for the initiative. The loss of prominent actors can be crucial in the context of the beef quality brand due to the propensity of multiple categories to have exclusive interactions among their individuals, according to the homophily detected. However, the presence of few prominent actors can minimise the redundancy of information exchange, improving its efficiency with potentially positive implications for the initiative's development (Burt 2003; Nerkar and Parachuri 2005, Zhang et al. 2018). In the case of the beef quality initiative, an efficient information exchange appeared probable thanks to the Administration stakeholders, who tended to connect different groups and had a general propensity for mutual trust and open interactions.

However, an important missing figure was a stakeholder who would be able to coordinate the actors involved in the initiative. Another important limitation is the farmers' concern about the labour effort and the investment of limited economic resources necessary to start and sustain the initiative without a secure income return. One possible solution to this concern would be appointing a coordinator to support access to European and/or national funding within the rural development framework and sustain the local stakeholders. However, despite the roles of actors 24 and 8, no one was willing to cover the coordinator role. This absence can be a limiting factor, either inhibiting the initiative's implementation or making it unsustainable in the long term.

Limitations of the study

Since not all stakeholders were willing to participate in the survey, we focused the SNA only on those local stakeholders interested in the initiative. From a methodological perspective, some studies consider that a lack of data should not be ignored as the results could be affected by bias (Huisman 2009; Huang et al. 2018). However, since our objective was to explore the possibility of cooperation among local stakeholders in the study area, the results from the SNA should be considered a preliminary step to analysing the exchange of information and opinions among local stakeholders. We carried out this analysis only with those local stakeholders interested in the initiative and, therefore, took part in the survey. Some studies have shown that missing data due to no response to all or part of a survey could be balanced out by reciprocal nominations or by including common exchange partners (Robins et al. 2004; Kossinets 2006; Jorgensen et al. 2018).

Conclusion

Our study shows that a methodology based on a participatory approach and SNA is useful in investigating the feasibility of an emergent initiative, such as a beef product quality brand, by characterising the social context. The focus groups allowed us to investigate and define the stakeholders' interest in the initiative along with the opinions and ideas to improve the whole supply chain, which supports the characterisation of social context. The SNA allowed us to investigate the information exchange and the level of trust among the local stakeholders involved in the initiative development, defining the effect of internal and external factors. The initiative's social context showed strengths, such as the inclination towards mutual and open interactions and an information exchange well regulated by administrators and technicians, and weaknesses, such as a potential dependency on prominent actors. No of the two prominent actors, recognised by multiple stakeholders, were willing to take on the coordinator role. These results indicate that the success or failure of initiatives of small networks highly depends on the attitudes and willingness of very few individuals, which may be a limit for local development and policies. Finally, we did not address economic issues, but the stakeholders expressed concern over the labour effort and economic investments associated with the initiative. Social analyses, such as the one conducted here, should be complemented with appropriate assessments of the economic implications of collective initiatives.

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Disclosure statement

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