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The contribution of the meat value chain to inclusive sustainable development in the highlands: a systems thinking approach

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Highland regions support multiple essential services and activities worldwide but face harsh ecological conditions. To mitigate these challenges, the need for specific development policies arises, like inclusive sustainable development in highlands (ISDH). Mountain farming involves a variety of traditional livestock systems adapted to local conditions, resulting in strong interrelations with the regional culture and representing key economic drivers contributing to ISDH. Transdisciplinary teams interviewed 23 cases related to the meat value chain (MVC) from Argentina (11) and Europe (12). Actors interviewed were farmers, cooperatives, retailers, and associations. A systems thinking approach was applied to develop two conceptual maps (Causal Loop Diagram, CLD) for the Argentinian and European highlands, describing the contribution of the MVC to ISDH, through the interpretation of the viewpoints of interviewed actors. The results relate to the cases, not the regions. In each CLD, subsystems and leverage points were identified. The key challenges faced by each initiative were identified and clustered into themes for both territorial contexts. For the Argentinian highlands, three interconnected subsystems were identified (environment, diversification, and local development) together with three leverage points (sustainable resources management, traditional production, and own farm investment). For the European highlands, an additional subsystem was identified (community), together with two leverage points (public subsidies, diversification of products, and services). Both Argentinian and European initiatives share common challenge themes: natural resources, people, and lack of finance. The Insecure Land Tenure theme is specific to Argentina, whereas compliance and competition are specific to Europe. Argentina's system depends more on family farms and self-financing to keep the activity going, with limited government help. European MVC relies more on subsidies to support its environmental sustainability and local development. The interplay between the challenges and the leverage points was explored, showing that more than one lever needs to be activated to address the impact of challenges. Taking a systems approach has revealed insights not available when breaking the system into its components. Limitations of this study consist of interpreting the actors' view, lack of data triangulation, and validation of CLDs with actors, which means that caution is required to extrapolate results to the wider geographical context.

KEYWORDS

Argentina, causal loop diagram, challenges, European Union, inclusive sustainable development, leverage points, mountain livestock systems

1 Introduction

Highland regions cover approximately 25% of the Earth's land surface (Kapos et al., 2000). These areas play a vital role for humanity, constituting a specific ecological backbone and providing multiple essential services (Schickhoff et al., 2022) that support a wide range of activities. Highland regions, home to 13% of the global population, provide essential ecosystem services but are simultaneously characterized by altitude-driven fragility that demands tailored development and management approaches (FAO, 2015; Payne et al., 2020; Yu et al., 2021). Highlands require the implementation of specific development policies (Dobremez and Borg, 2015; Rueff et al., 2015). In recognition of this, there have been calls for models of inclusive sustainable development in the highlands (ISDH) (Price, 2016). Inclusive sustainable development can be defined as the integration and promotion of wellbeing, the reduction of inequalities, and the long-term viability of economic, social, and environmental systems (United Nations, 2015).

Mountain livestock systems, shaped by local traditions and climates, convert grassland resources into high-quality food products (Dufey et al., 2009; Hoffmann et al., 2014; Bernués et al., 2019) while supporting cultural heritage, biodiversity conservation, carbon sequestration, and landscape management, thereby contributing to inclusive sustainable development (Bernués et al., 2011; Romeo et al., 2021; Benedetti del Rio et al., 2024; Pauler et al., 2025). Being a grassland-based system, mountain livestock farming and its associated value chain are therefore activities that can contribute to ISDH (Ronchi and Ramanzin, 2024). Based on these positive contributions, these systems also favor their integration with agrotourism (Mazzocchi and Sali, 2019). However, mountain farming faces environmental, social, and economic constraints that lead to lower productivity and higher costs than lowland systems, often resulting in land abandonment, land-use change, and rural depopulation (Baldock et al., 1996; Cooper et al., 2006; Tasser et al., 2007; Battaglini et al., 2014; Pagliacci et al., 2022).

This study, conducted within the HIGHLANDS.3 project (2020–2025) funded by the European Union (EU), adopts a systems-thinking approach to explore the meat value chain (MVC) in the case studies of Argentina and Europe. This study explores the causal relationships within the MVC system and its relationship to ISDH, as perceived by interpreting interview transcripts from participating actors and adopting a systemic lens. Both MVCs and their associated challenges are described. Leverage points are identified to point out where it is best to intervene to enhance the virtuous behavior of the system and to reduce the negative impact of challenges.

2 Method

2.1 Data collection

This research has been conducted under the framework of the HIGHLANDS.3 project, which aims to contribute to and promote

ISDH worldwide. Focusing on Argentinian and European highlands, four Research and Innovation Sessions (R&IS) were conducted in six highland regions between 2021 and 2023: Alps (Italy and Slovenia), Andes (Argentina), Balkans (Greece), Carpathians (Romania), Massif Central (France), and Pyrenees (Spain). For each R&IS, 20 to 30 initiatives, related to territorial development, were selected by local research teams, in partnership with local stakeholders, based on local knowledge and contextual relevance, rather than a uniform set of criteria. These initiatives were local entities, such as farms, cooperatives, associations of producers, retailers (Table 1), pursuing a variety of activities to achieve individual and community goals, such as tourism, agriculture, natural resource protection, and industry.

Data from each initiative were obtained through semi-structured interviews conducted by transdisciplinary teams of up to five people from different disciplines (i.e., nature conservation, farming, social science, agricultural science, and extension). Individual participants of the R&IS self-selected the initiatives they wanted to interview, and only when numbers were too high, or there was no diversity of discipline or interview experience, people were allocated by the organizers of the session. In many interviews, local researchers had to play the role of translator between the interviewee and the research team. A guideline for conducting interviews was developed and aligned to a standardized database spreadsheet template to be populated with information obtained from the interview. Information collected in the spreadsheet was related to the following different dimensions of Inclusive Sustainable Development: geographical location, types of employees (youth, gender, disability), governance model, financial viability, relationship with local community, interaction with local natural resources, relationship with mountains and impact on the environment, history and main objectives and activities, challenges and solutions, and future opportunities and challenges. During each interview, an audio recording was made, but these were not used in this study as there were no translations to English, and after the interview, a report was compiled and the spreadsheet populated. All this material was then stored on a data platform. While a semi-structured interview guide was provided to ensure some consistency, interviewers adapted their approach based on the dynamics of each conversation and their interpretation of key issues. We cannot be sure that some nuance was not lost in translation, as often the local research team had to translate the responses of those being interviewed for the benefit of the other participants in the R&IS. Consequently, the depth and focus of responses varied. Interview notes and summaries were recorded by the team of interviewers and thus reflect their perceptions and interpretations of participant responses. Although this introduces a degree of subjectivity and methodological variation, the data, nonetheless, offer valuable insight into local perspectives, practices, and contextual dynamics. Findings are presented as indicative of themes emerging from within these diverse settings, rather than as generalizable conclusions.

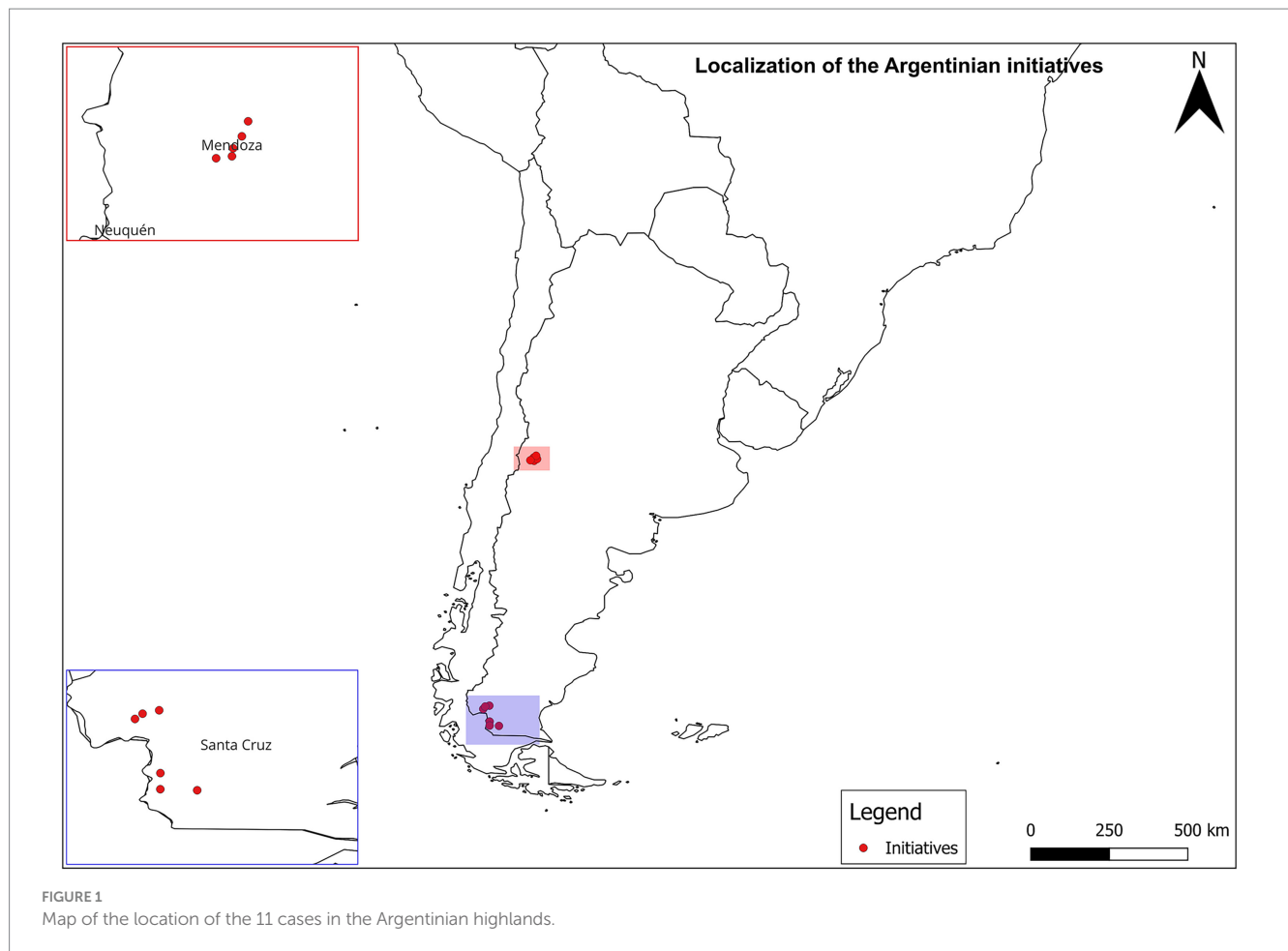
TABLE 1 Meat value chain initiatives interviewed.

Region	Initiative	Brief description
Andes	Family livestock farm	Family activity dedicated to raising goats and cattle; secondary activities such as textile manufacturing. They receive financial support from governmental programs.
Andes	Family livestock and agritourism activity	Family business with diversified activities, including sheep and cattle breeding, and agritourism. They are committed to local development. Initially, they received private financing, but now self-financing.
Andes	Ranch	Ranch rearing cattle and sheep, wool production, and supply to local and international markets. Provisioning of permanent and seasonal employment for local workers. Collaboration with public institutions, self-financing.
Andes	Family ranch	Family ranch, rearing beef cattle and sheep for meat and wool production. Local and international marketing of animal products, self-financing.
Andes	Family ranch	Family business rearing cattle and sheep for meat production. Collaboration with research institutions, benefiting from technical support. They receive public subsidies from the State, but also own financing.
Andes	Family ranch and agritourism activity	Family ranch rearing cattle and sheep, with also diversified agritourism activities. Self-financed investments.
Andes	Family farm and agritourism activity	Family business dedicated to raising sheep, with a traditional agritourism activity. Offering a variety of products marketed within the agritourism services. Self-financing.
Andes	Family goat farm	Family business dedicated to raising goats and cattle, adopting transhumance practices. Selling of live animals to intermediaries. Absence of external financial assistance.
Andes	Family livestock farm	Family-run business dedicated to cattle and goat farming, adopting transhumance activities. Selling live animals to intermediaries. Absence of external financial support.
Andes	Meat processing cooperative	Cooperative focused on the processing and marketing of goat meat, playing a key role in local development. Recipient of technical assistance and governmental funding.
Andes	Livestock farm and agritourism activity	Family business dedicated to traditional goat breeding with agritourism activity. Local marketing of products and services. Own financing.
Alps	Family-run farm and agritourism activity	Family farm with diversified activities, producing sheep meat sold through its own facilities. Additional agritourism activity. Recipient of public subsidies.
Alps	Agritourism farm	Family farm adopting traditional practices, with complementary agritourism activities based on on-farm products. Rearing of local goat and cow breeds. Additional public funding.
Balkans	Family farm	Family farm certified organic for beef cattle breeding. Public subsidies as financial support.
Carpathian	Family farm and agritourism activity	Family business focused on multi-species breeding, integrated with agritourism. Own capital investments.
Carpathian	Family farm and agritourism activity	Family farm focusing on sheep farming. Additional ecotourism activities for product selling. Recipient of governmental subsidies
Massif Central	Cattle breed association	Conservation and promotion of endangered local breeds for meat production, supporting sustainable agricultural practices, local food chains, and research. Public and private funding.
Massif Central	Farm shop	Store managed by a cooperative of local producers, with self-management and collaboration. Public financial support.
Massif Central	Cooperative for sheep meat production	The cooperative brings together sheep farmers who jointly manage mountain pastures. Intensive production to sell young lambs. Recipient of technical and public financial support.
Massif Central	Slaughterhouse	Municipal slaughterhouse managed by the town council, renovated through public and private funding. Promotion of organic meat production, with occasional on-farm slaughtering and supplying to local markets.
Pyrenees	Family livestock company	Family business based on organic beef, marginally pork, lamb, and chicken. It operates the entire production chain (production, processing, and distribution). Supply to various markets, private and public financing.
Pyrenees	Pig meat factory	Family business processing and selling pork meat, based on a specific breed, traditional recipes, and regional product selling. Recipient of public funding.
Pyrenees	Family company	Family farm for traditional animal-based products. Own store for selling and supplying to local markets.

2.2 Systems thinking analysis

The data platform holding all the initiative interviews from across the R&IS was interrogated by an interdisciplinary team composed of

six participants with expertise in animal science (four scientists and two stakeholders) to identify those that were related to the MVC. Twenty-three initiatives, 11 from Argentina and 12 from Europe (Table 1; Figures 1, 2), were identified. They all had in common



the production of meat products (such as live animals), albeit at different scales from individual farms to associations of farmers and processing factories.

The data were interrogated to answer the question that guided the systemic analysis, using a Systems Thinking approach (Maani and Cavana, 2007): “What are the factors and relationships that describe the meat value chain’s contribution to ISDH?” The challenges facing each of the Argentinian and European initiatives were also identified from the data. To address this question, the participants adopted the methodology proposed by Ceppatelli et al. (2024). The 23 initiatives were randomly allocated to the six members of the research team; each initiative was interrogated by three different members. Each participant read the report and spreadsheet generated from each interview, applied the question, and concisely described the factors of each initiative, writing one factor per sticky note. For each initiative, the three members placed their sticky notes randomly on a wall and discussed the factors they had identified. Any differences were discussed and checked to ensure that no new assumptions were being introduced beyond those of the original interview team’s perceptions. New assumptions, when identified, were discarded.

For each initiative, the interdisciplinary team clustered the similar factors, giving them a common title (Figure 3), using an inductive process: observations were made from interview material, comparisons between the various initiatives, and general discussions, all reported in concise thematic titles used as variables to construct the two CLDs (Argentinian and European). The factors underlying the

variables were always available to refer to if clarification was required in the constructing process of the CLDs. The titles coming from the clustered factors of each initiative were then compared with the ones coming from the other initiatives to avoid considering the same title more than once. Construction was framed in a positive manner, and the narrative results follow these virtuous cycles. The challenges identified from the interviews are noted in the results section, and the interplay between these and the tensions that they bring to the systems is explored in the discussion.

Within the CLDs, variables are connected through arrows that, at their head, will have either an “S” or “O” symbol representing directionality (“S” moving in the same direction and “O” moving in an opposite direction). A feedback loop occurs when the arrows leave and return to the same variable. The loop is defined as a reinforcing loop (R) or positive feedback, and a balancing loop (B) or negative feedback. Reinforcing loops are feedback systems that amplify change in a single direction, accelerating growth or decline, and are classified as vicious or virtuous depending on the context. Balancing loops seek stability through resisting change, returning to control or aiming for a specified target (i.e., a thermostat). System behavior results from the interplay between these two opposing feedback mechanisms. Each CLD provided a visualization of the system dynamics underlying the contribution of the meat value chain system to ISDH. The software VENSIM (Version 10.1.5 Ventana System UK Ltd) was used to graphically present the CLDs. Feedback loops were checked, and subsystems identified and named.

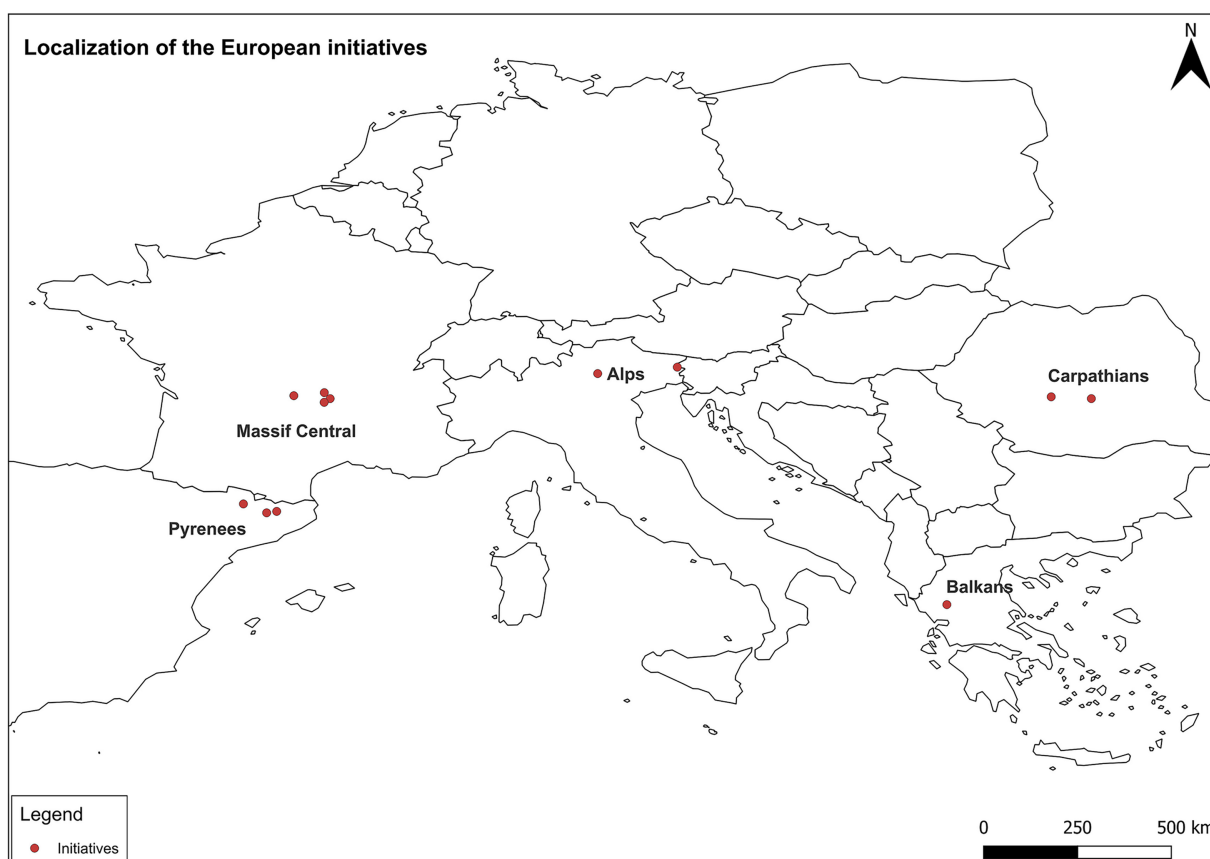


FIGURE 2
Map of the location of the 12 cases in the European highlands.

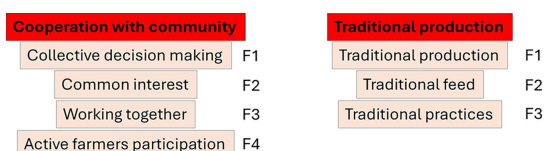


FIGURE 3
Schematic example illustrating the flow of factor identification (F) from interview materials, clustered under common theme titles (in red) that were used as variables to construct the CLDs. "Cooperation with community" refers to Figure 5—R8. "Traditional production" refers to Figure 4—R2.

Combining information about the challenges facing the MVC, as noted by actors in the interviews, and exploring the CLD, allowed the identification of points of leverage in each CLD. The decision about which leverage points to include was reached by team consensus. The team focused on the variables that may cause large system changes. Two types of variables were considered: those able to influence the whole system across subsystems, and those that strongly influence the behavior of a single subsystem. As the CLDs were constructed using a positive, virtuous lens, the cycles can also be viewed as vicious, and leverage points were selected when they had the potential to reverse negative impacts. This process ensured that all team members applied the same criteria consistently.

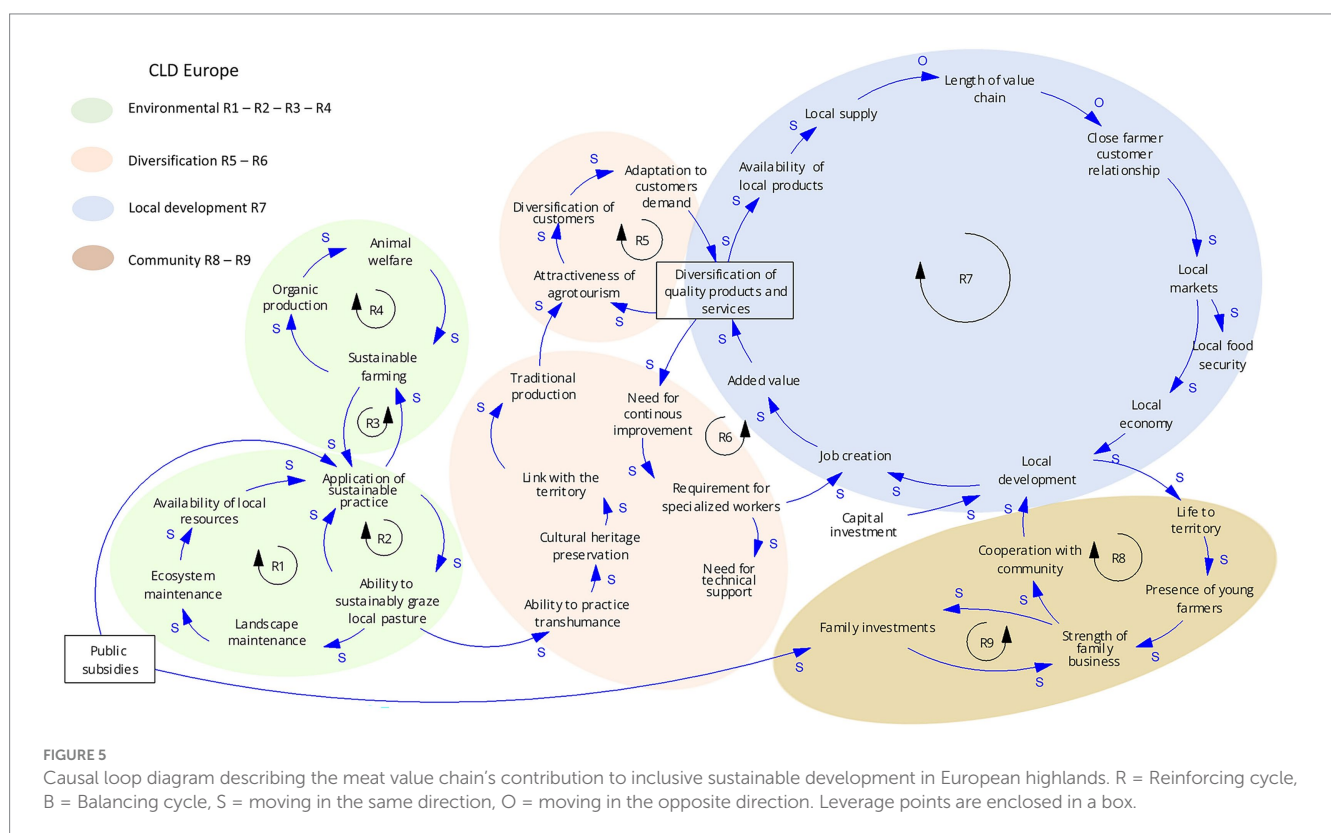
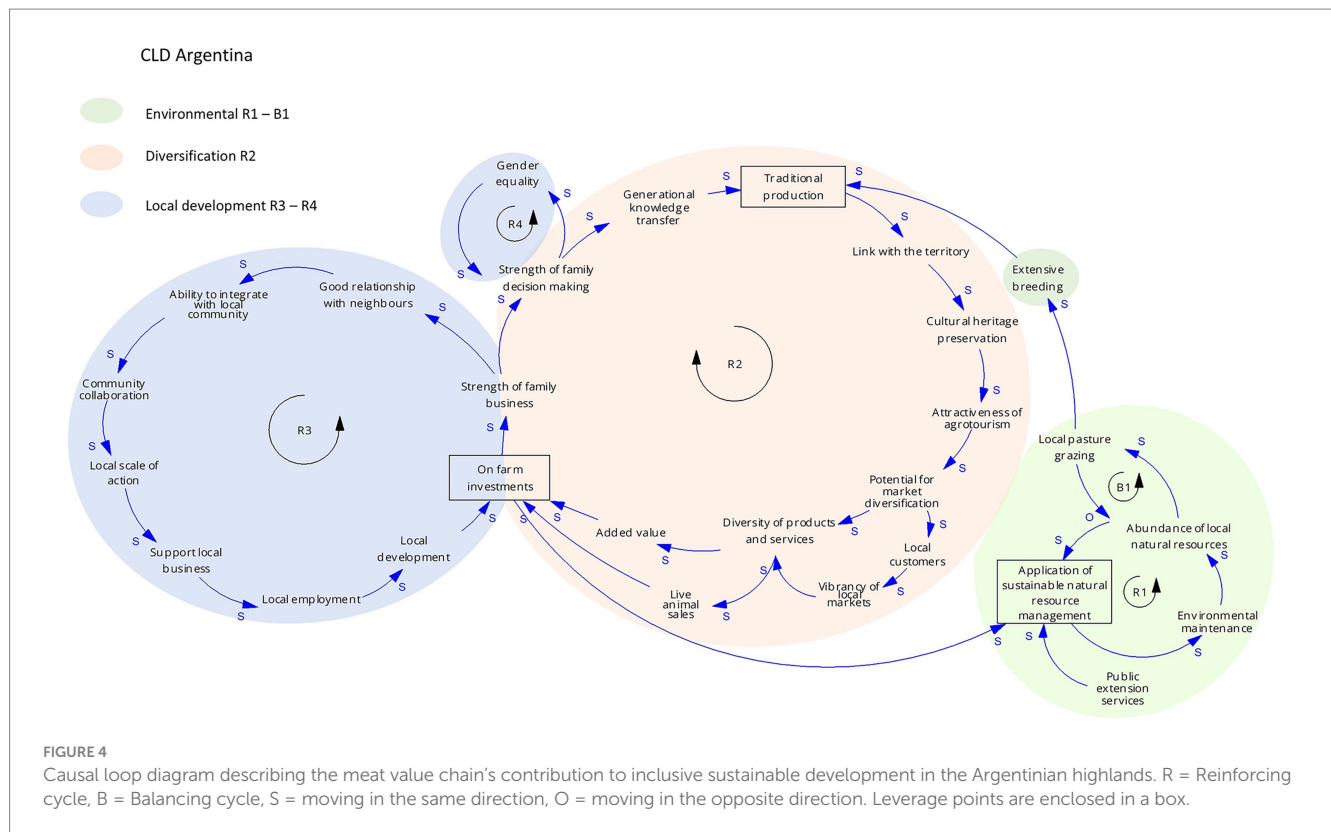
3 Results

3.1 Meat value chain description in Argentinian highlands

The CLD describing the system of Argentina's meat value chain contribution to ISDH consisted of three interconnected subsystems (Figure 4): environment, diversification, and local development.

In the environmental subsystem, the abundance of local natural resources (as reported by an initiative interviewed, "the rivers and streams are plentiful and allow easy access to water resources for cattle raising"), particularly local pasture grazing and own-produced feed, combined with the use of public extension services, promotes the application of sustainable natural resource management. This benefits the maintenance of the local environment, increasing the use of local resources, thus creating a reinforcing cycle (R1 - Figure 4). However, the continuous growth cycle of natural resources is countered by a balancing loop (B1 - Figure 4) driven by the limited availability of local pasture for grazing.

In the diversification subsystem, the use of local pasture for extensive breeding supports a traditional way of production, strengthening the link with the territory and reinforcing the preservation of cultural heritage. This results in a higher attraction of tourists in the territory, providing opportunities for additional activities such as agrotourism that diversify the farmers' income, as



reported “key characteristic is the diversification of products and services sold and provided, all related to tourism.” The resulting market diversification can attract a higher number of local customers,

enhancing the vibrancy of the local markets and stimulating the diversification of products and services (as stated, “expansion of the farm is not desired, but the diversification is”), thereby adding value

to the local meat value chain. Multiple services and value-added products, together with the direct selling of live animals, increase farm revenue and thus enable greater economic reinvestment, strengthening the family business. A strong family business enables solid family decision-making (as evidenced, “solidarity between the family members is the main key of success”), enabling the promotion of gender equality (R4 - [Figure 4](#)) and reinforcing an inclusive model of on-farm governance (“all decisions are discussed between the family members, they look for internal agreement”). The family scale of action encourages the transfer of knowledge to new generations, favoring the preservation of traditional production, leading to the reinforcement of the subsystem (R2 - [Figure 4](#)).

In the local development subsystem, strong family businesses facilitate relationships with neighbors and enhance the capacity of the actors to be better integrated and to further collaborate with the local community (“he can count on the family’s support since they are all living and working in the same place, and also on the help of neighboring producers”). Collaboration at the local level supports local businesses, contributing to local development and therefore leading to job creation, as reported by an initiative, “taxi drivers and other workers get more work because tourists have to travel to the farm.” A more dynamic local economy can contribute to increasing the farm income, enhancing the farmers’ capacity for self-financing and reinvestment of revenues, leading to the reinforcement of the subsystem (R3 - [Figure 4](#)).

For the Argentinian highlands, three leverage points were identified. Application of sustainable resource management influences the success of the whole system based on enhancing natural resources that underpin traditional production, which is used to build added value and strengthen local development. In the absence of this lever, the three subsystems have the potential to behave as a vicious cycle. Use of traditional forms of production is a lever that influences the integration with agrotourism and the related possibility to diversify products and services. Without this lever, added value may be compromised, reducing the third potential lever, own farm investment. Own farm investment supports the family business, influencing both the local development and the diversification subsystems.

3.2 Meat value chain description in European highlands

The CLD describing the system of the European meat value chain’s contribution to ISDH consisted of four interconnected subsystems ([Figure 5](#)): Environment, Diversification, Local Development, and Community.

In the Environmental subsystem, the availability of natural resources combined with public subsidies promotes the application of sustainable grazing practices on local pastures. This, in turn, increases the ability to sustainably graze local pastures, forming a reinforcing cycle (R2 - [Figure 5](#)) while enhancing landscape maintenance (as reported, “the cooperative maintains the area that would otherwise be wooded” and “the landscape is maintained through sheep grazing that prevents the total domination by forest”) that, in turn, favors the maintenance of the ecosystem and results in a higher availability of local resources, forming a reinforcing cycle (R1 - [Figure 5](#)). The application of sustainable practices leads to more sustainable

production (and creates a reinforcing cycle: R3 - [Figure 5](#)), such as organic farming, paying more attention to animal welfare in accordance with organic farming standards, increasing sustainable farming, thus resulting in a reinforcing cycle (R4 - [Figure 5](#)).

In the Diversification subsystem, a greater capacity to sustainably graze local pastures enables the practice of transhumance, contributing to the preservation of cultural heritage and strengthening the connection with the territory. The maintenance of traditional production systems is therefore supported, and the attractiveness of agrotourism is enhanced. The development of agrotourism attracts a more diversified customer base, highlighting the need to adapt products and services to customer demand. This leads to the diversification of offerings, such as the production of quality products. This, in turn, enhances the attractiveness of agrotourism, creating a reinforcing cycle (R5 - [Figure 5](#)), as reported by an interviewee, “I do not want to grow, but be faithful to my customers, the ones who supported me during all these years and gave me stability.” Furthermore, the diversification of products and services increases the need for continuous improvement, requiring the need for technical support and specialized workers, and contributes to job creation. This supports further product diversification, creating a reinforcing cycle (R6 - [Figure 5](#)).

In the Local Development subsystem, the diversification of products increases the availability of local products, enhancing the local supply, shortening the value chain, and strengthening the close relationship between customers and farmers. A closer relationship between customers and farmers also enhances the presence of local markets, contributing to local food security, as stated by an initiative interviewed, “the farmer chose to directly sell to consumers, a way for him to achieve a higher price and for the consumer to buy at a lower price.” An enhanced presence of local markets also supports the local economy from the increased added value of meat products, contributing to local development. Increased local development allows more opportunities for job creation and for the diversification of products and services, forming a reinforcing loop (R7 - [Figure 5](#)).

In the Community subsystem, the capital investment injected into local development contributes to giving life to the territory, encouraging the younger generation to be involved in farming and therefore increasing the presence of youth in the territory. This helps to strengthen the family business and the cooperation within the community, as reported by a cooperative of farmers, “the cooperative improves relations between people, who could not carry out these activities on their own.” Finally, this further supports the local development, creating a reinforcing cycle (R8—[Figure 5](#)). The profit derived from the increased added value of meat products can increase the household revenues, which are reinvested in the farming activity, strengthening the family business, and creating a reinforcing cycle (R9 - [Figure 5](#)).

For the European highlands, two leverage points were identified. Public subsidies exert a direct influence on farmers applying sustainable management practices, enabling traditional livestock production on local pasture, and supporting direct investment in the family business, with flow-on positive influences across the whole system. In the absence of this lever, the cycles would be vicious, as quoted by multiple initiatives interviewed, “without subsidies, the cooperative would not be able to carry out its pastoral activities” and “the summer pastures will only last if there is enough financial support.” As a lever, diversification of products and services adds a

need for specialized roles and continuous improvement, which influences the local development subsystem through job creation and added value that flows into meeting customer needs.

3.3 Challenges facing the meat value chain in both Argentinian and European highlands

A total of 28 challenges facing the meat value chain were identified from the Argentinian initiatives, each appearing with varying frequency, although this does not equate with severity of impact (Table 2). These challenges were clustered into four themes and ranked

TABLE 2 Challenges mentioned by interviewed initiatives in the Argentinian highlands clustered by the topics (in bold).

Challenges by clusters	Number of initiatives
Natural resources	11
Climate change	11
Predators	7
Summer drought/dry conditions	6
Limited water resource	4
Invasive weeds	2
Competition for grazing by wild animals	1
Harsh winter conditions	1
Poor forage quality	1
Lack of finance	8
Lack of government financial support	8
Economic instability	4
Lack of public investment and activities	4
Lack of infrastructures	3
Transport costs	2
Buyer sets price	1
Currency fluctuations	1
Decrease in wool price	1
High taxation	1
Increase cost of energy	1
Lack of value from certification	1
People	5
Lack of cooperation between producers	3
Distance from cities	2
Lack of workforce	2
Low succession rates	2
Lack of families' presence	1
Weak external connections	1
Insecure land tenure	4
Lack of land ownership	4

according to the number of initiatives in which they were mentioned: natural resources (11 initiatives), lack of finance (8 initiatives), people (5 initiatives), and insecure land tenure (4 initiatives).

In the case of the European initiatives, 27 challenges facing the meat value chain were identified, each appearing with a different frequency (Table 3). These challenges were clustered into five themes and ranked based on how often they were mentioned across initiatives: people (11 initiatives), lack of finance (5 initiatives), compliance (5 initiatives), natural resources (4 initiatives), and competition (3 initiatives).

3.4 Comparative analysis of meat value chain systems and challenges in the Argentinian and European highlands

Comparing the meat value chain between Argentinian and European highlands revealed three subsystems in common: local development, diversification, and environment. An additional subsystem was identified in the European Highlands, Community.

Both models pursue the diversification of products and services as a strategy to add value. The main difference is that in Argentina, the sale of low-value-added products (i.e., live animal sales) is part of the system. In Argentina, value addition is linked to traditional production systems complemented by agrotourism, whereas in Europe, added value is associated with these two factors and further reinforced by the supply of high-quality products. The source of funding is another distinction between the two models. In Argentina, initiatives largely depend on self-financing, whereas in Europe they are highly reliant on public subsidies. The support from public extension services is found in both models. The initiatives related to the meat value chain in Argentina are mainly family-based, whereas in Europe, a more diverse composition of initiative types is reported, such as family farms, associations, and cooperatives.

Both Argentina and European initiatives share common challenge themes: natural resources, people, and lack of finance. The Insecure Land Tenure theme is specific to Argentina, whereas compliance and competition are specific challenge themes for Europe.

Within the Natural Resources theme, both Argentina and Europe mention predators as a common challenge, such as in Argentina Competition for Grazing by Wild Animals. Only in Argentina did all the initiatives name climate change, detailing summer drought, limited water resources, and harsh winter conditions. The impact of these challenges results in invasive weeds and poor forage quality. In comparison, European initiatives highlight environmental degradation, dry summers, low soil fertility, and pressure from tourism.

Within the people theme, both Argentina and Europe share concerns about low succession rates and workforce availability due to the lack of attractiveness of the farm in Europe and isolation from cities and families in Argentina. In Europe, meat cooperatives are lacking new members, whereas in Argentina, they have a lack of cooperation between producers.

Both Argentina and Europe have in common the lack of a finance theme, despite the specific challenges differing between regions. In Argentina, lack of government and public financial support, and national economic instability contrasts with Europe's lack of access to

TABLE 3 Challenges mentioned by interviewed initiatives in the European highlands clustered by the topics (in bold).

Challenges by clusters	Number of initiatives
People	11
Lack of attractiveness of the farm	4
Low succession rates	3
Lack of skilled people	3
High demand for time and energy	2
Difficulty in finding new members of the cooperative	1
Increasing rural exodus	1
Isolation in winter	1
Lack of finance	5
Access to funding	3
Difficulty to expand	2
Lack of financial capital	1
Lack of investment	1
Low income	1
Low profit margins	1
Old infrastructure	1
Compliance	5
Complex bureaucracy	5
Complying with EU norms	5
Animal welfare practices, e.g., dehorning cows	1
Lack of certification	1
Link with PDO production	1
Natural resources	4
Predators	4
Dry summers	1
Environmental degradation	1
Low soil fertility	1
Pressure from tourism	1
Competition	3
Competition from international markets	3
Competition from supermarkets	1
Feed price fluctuations	1

capital investment to allow for expansion. Additionally, Argentina highlights challenges such as transport costs, currency fluctuations, and high taxation, which are not mentioned in Europe.

Specifically for the two contexts, only in Argentina, the lack of land ownership was noted as a challenge, whereas only in Europe challenges related to compliance were noted. This, in turn, was related to the availability of public finance that is associated with dealing with complex bureaucracy to comply with EU norms, certification, and animal welfare standards.

4 Discussion

Extensive literature on livestock systems and territorial development (*Animal Task Force*, 2025; Dupé et al., 2025) shows that MVCs contribute well beyond food production, a pattern reflected in the Argentinian and European highland cases examined here. Our MVC representations are based on sample cases rather than regional models; however, they still illustrate how natural resources, local development, traditional practices, and economic activities interact to generate additional benefits. Across both contexts, the conceptual MVC includes three shared subsystems related to local development, diversification of products, and environment, with people subsumed within these subsystems in the Argentinian system and made transparent as a community subsystem in Europe. These subsystems contain feedback loops that may reinforce either positive or negative trajectories, functioning as virtuous or vicious cycles depending on conditions. One of the benefits of constructing these system models is the ability to explore system dynamics when challenges are introduced and enable the identification of actions that can mitigate the impact of unwanted consequences.

Despite contextual differences, both MVCs face comparable challenges. In Argentina, the abundance of natural resources is challenged by climate change, which can increase droughts and affect the availability and quality of natural resources like pasture and water (Bondaruk et al., 2022), as reported by the initiative's interviewees. Predation and competition from wild grazers further strain the system. The impact of these challenges may compromise the environmental subsystem that underpins traditional production, turning it into a vicious cycle, negatively affecting pasture production and forage availability, with a flow on to negative impacts on the rest of the system. This may be prevented by adopting specific strategies for sustainable pasture use, like rotational grazing, to restore and maintain adequate grassland productivity (Ren et al., 2021). Here, extension services and own-farm investment play an important role in supporting the application of sustainable practices (a leverage point) to preserve the ecosystem and the abundance of the natural resources, thus contributing to mitigating the impact of climate change. In European initiatives, those impacts are formally addressed through public subsidies, a leverage point, whereas the Argentinian initiatives we explored lack equivalent policy instruments. In this region, support to farmers is mainly discretionary and provided by NGOs and international entities, intensifying the risk of creating negative, vicious system dynamics (Marsden and Hovardas, 2020; Singer et al., 2023). Even without public financing, the initiatives we explored in Argentina were able to combine traditional production systems, landscape stewardship, and cultural heritage, drawing tourists to the region. The presence of tourists leads to the diversification of products and services to generate additional income for farmers, as pointed out by Ammirato et al. (2020). The resulting short supply chains and related marketing of these diverse products and experiences to continuously add value (Augère-Granier, 2016; Martinez and Park, 2021) offer a way to mitigate the high-cost structures that challenge farm economic viability. Yet, supportive policy is needed to facilitate collective action and the establishment of short supply chains (De Roest et al., 2018). System analysis shows that policies aimed at specific outcomes may generate unintended effects elsewhere in the MVC. The adoption of public subsidies in Europe is a policy that helps maintain environmental and economic viability

(Gazzarin and Jan, 2024). Targeting environmental outcomes encourages the application of sustainable practices. They, in turn, are recognized through the certification of certain products that can add value to farm economics and to local development. There are, however, negative outcomes associated with the complex bureaucracy in complying with EU norms, reducing the attractiveness of farming, decreasing the likelihood of on-farm succession, and resulting in an increase in rural exodus. This compromises the ability to recruit skilled labor to produce specialized products, restricting income and employment generation, both countering the competitiveness of the meat sector toward other markets. Similarly, the unintended consequence of attracting more tourists is the increasing pressure on the territory, which can compromise both the ecosystem and landscape maintenance. However, it also creates an opportunity to develop a model of tourism based on valuing ecosystem services, as highlighted by Mazzocchi and Sali (2022). This highlights the need for a portfolio of actions that will enhance the whole system and mitigate unintended negative consequences.

This study has demonstrated the importance of locating points of influence for systemic change, identified as leverage points. Due to the differing contexts between Argentina and Europe, each has its own set of levers targeting similar subsystems. For instance, due to the lack of public subsidies, Argentinian initiatives use “own farm investment,” where the owners can control how they invest, whereas the European initiatives are reliant on public subsidies. In both contexts, ensuring diversification of products and attracting agrotourism are actions aligned with the leverage points. Exploring the interplay between the impact of challenges on the system and the points of leverage may enable a greater understanding of system dynamics and offer an opportunity to test the efficacy of the interventions. For instance, in Argentina an identified lever is “application of sustainable resource management.” This lever targets the environmental subsystem where climate change has a strong influence on feed and water for traditional production. Therefore, acting on this point can contribute to mitigating the impacts of climate change. However, application of sustainable resource management may be tied to the economics of the system, and therefore both the “traditional production” and “own farm investment” levers will need to be activated to pay for any increased costs. Abson et al. (2017) have proposed the potential of collective activation of leverage points to amplify behavior change within a system, resulting in system transformation.

Taking a systems approach has revealed insights that are not available when breaking the system into its component parts. However, as described in the methodology, this study has its limitations, which mean that caution is required to extrapolate to the wider geographical context. The primary data source, initiatives’ interviews, had built in interviewer–interpretation layering where the initiative actor’s perception was recorded by the interview team, after the interview process, following discussion within the team, with a potential to reflect the interviewers’ perceptions and interpretations of what was said by the interviewee. On the other hand, the richness of co-construction along the way and the contributions of different disciplines to this methodological construction offer rigor and relevance for several different contexts. There was then another layer of interpretation from the team that used the interview material to develop variables and construct conceptual maps of the MVC. However, the strength of the approach to constructing the

CLDs enabled more than one viewpoint to dominate and expand the richness of the interrogation. The CLDs were not validated by the actors, and the data were not triangulated with other data sources except when insights were explored in the literature. This means that the CLDs presented in the study come from the interpretations of the local meat value chain, and that the observed differences within and between the systems are potentially due to this reason, rather than underlying system properties. Consequently, for future perspectives, having actors directly involved in model construction would give greater confidence in the underlying assumptions. Therefore, the findings of this study are presented as indicative of themes emerging from within these diverse settings, rather than as generalizable conclusions to the wider meat value chain.

The potential of this systems approach means that, in future studies, CLD construction with those who are interviewed and involved in the wider community can offer a tool for farmers, agribusiness, policy, and community agents to collectively visualize their systems and learn about interrelationships and interdependencies. This enables transparency by exposing worldviews and assumptions, reaching consensus on system representation, and building collective agreement on leverage points and actions for positive change.

5 Conclusion

Despite limitations related to data availability, the complexity of capturing system dynamics, and reliance on actors’ views, this study offers an interpretive, systems-based perspective that helps to explore benefits beyond food production in highland MVC and to better understand the potential role of these systems in ISDH.

Using a systems perspective enabled the exploration of relational dynamics that are not easily captured when analyzing system components in isolation. Mapping relationships and leverage points highlighted potential virtuous and vicious cycles and pointed to opportunities for more targeted interventions. The comparison of contexts also suggests that, even when facing similar challenges, place-based strategies may be more appropriate than uniform solutions.

Overall, this work provides conceptual models that can inform future research and highlights the value of applying this in collaboration with actors involved in delivering ISDH on the ground.

Data availability statement

The datasets presented in this article are not readily available because, according to the HIGHLANDS.3 project data collection policy and the information given to interview partners, the only information that will be open accessible is the “ISDH platform.” This platform is still under construction. Data used in reporting is anonymized, and no access is provided to data that could potentially reveal the identity of respondents. Requests to access the datasets should be directed to andrea.ceppatelli@studenti.unipd.it.

Ethics statement

The studies involving humans were approved by Highlands.3 steering committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CP: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft. CB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft. MV: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft. AC: Conceptualization, Investigation, Software, Writing – original draft, Data curation, Formal analysis, Methodology. PS: Formal analysis, Methodology, Investigation, Writing – review & editing, Conceptualization. J-FT: Formal analysis, Methodology, Investigation, Conceptualization, Writing – review & editing. ES: Conceptualization, Investigation, Supervision, Writing – review & editing, Methodology. LW: Data curation, Supervision, Writing – review & editing, Conceptualization, Software, Methodology, Writing – original draft, Investigation, Formal analysis.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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