



## Characterizing value chains' contribution to resilient and sustainable development in European mountain areas

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### ARTICLE INFO

#### Keywords:

Value chains  
Socio-ecological systems  
Sustainability  
Mountain areas  
Europe

### ABSTRACT

Mountain areas have been the testbed for sustainable development models focused on balancing their vulnerability and the value of their natural, cultural, and social resources. In these areas, the continuous adaptive interaction between bio-geophysical and socio-cultural processes assembles Socio-Ecological Systems (SES) characterized by a great diversity of ecosystems and land uses, which provide substantial support for the livelihoods of mountain communities and essential ecosystem services for uplands and lowlands. In this paper, we take value chains to be the operative units of analysis to examine human-natural systems interactions in mountain areas. Value chains mobilize resources and connect actors beyond territorial boundaries and economic sectors to generate economic, environmental, and social values. Strategies for local development of these areas should direct attention to value generation activities and require a systemic, integrated and assets-based approach which explores the potential synergies emerging from the coordination of the diversity of local specificities and considers the opportunities and threats emerging from external sub-systems. This paper proposes a novel comparative framework to characterize value chains contribution to resilient and sustainable development of SESs in mountain areas. This framework is meant for researchers and policy analysts to identify the role value chains might accomplish for a better balance between natural resource conservation and sustainable socio-economic development in European (remote) rural areas. Two mountain food value chains are used to illustrate the framework and test its efficacy. The cases depict two value chain configurations which result in different social, economic and environmental outcomes for the sustainable development of the SES.

### 1. Introduction

In Europe, mountain areas cover 36% of the surface, cross many national borders and are home to 16% of the population (Drexler et al., 2016). Mountain landscapes have a relevant role both in ecological and socioeconomic terms, but at the same time they are fragile and vulnerable environments facing threats such as climate change, land use changes, depopulation, or natural resources degradation. The recognition of the significant contribution of mountains area to the wellbeing of all the population (European Environment Agency, 2010), as providers of highly valued public goods and services that are highly valued in

today's economy (Price, 2015). This contrasts with the presentation of these areas as disadvantaged and backward places (European Union, 2010) with poor development potential. Therefore, the particularities of mountain territories must be accounted for in European policy, in particular cohesion and rural development policies, to devise place-based interventions able to benefit from the possibilities mountains offer (Dax, 2020). In recent decades, although, with modest budgets (Dax and Copus, 2016), development schemes in this direction have been implemented within the "Liaison Entre Actions de Développement de l'Économie Rurale"<sup>1</sup> (LEADER), or more recently, the "Community-Led Local Development" (CLLD) programs which promoted local

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<sup>1</sup> 'Links between activities for the development of rural economy'.

action-based intervention aiming at valorizing the place-specific assets that differentiate (remote) rural areas, such as the mountainous ones. However, mountain specificities have often been lost in the implementation of cohesion policies (Carbone, 2018). Current policy arrangements have been critiqued for not rewarding ecosystem protection in mountain areas (O'Rourke et al., 2016). The Areas with Natural Constraints policy framework, focusing solely on the endogenous low land productivity (Cooper et al., 2006), fails to incorporate the range of programs and policies related to other economic sectors. Instead, mountain development policies must overcome this overly narrow agricultural-oriented rural policy approach and pursue an integrated place-based approach to mountain region development.

In this regard, the long-term vision for rural areas (LTVRA) set out by the European Commission (European Commission, 2021), and the accompanying Rural Pact and Rural Action Plan, offer an opportunity for fostering a multi-funds approach to rural – and mountain – place-based development. These strategies aim at achieving stronger, connected, resilient and prosperous European rural areas strengthening the synergies between territorial cohesion and agricultural policies. However, the design and implementation of this integrated territorial approach should target asset-based development strategies accounting for the specificities and the inherent values of mountain areas (Dax and Fischer, 2018; Euromontana, 2020), building on a) the need to balance between environmental and resource management priorities and socio-economic growth and development (Carbone, 2018; Dax, 2020); b) the need to turn the specific mix of territorial capitals into economic value; c) a clear understanding of the impact that specific activities,

**Table 1**  
Comparison of local and global case-study value chains according to the framework.

	Strong localization (A)	Delocalisation (B)
Resource Units	<ul style="list-style-type: none"> <li>- Endogenous grass botanical varieties</li> <li>- "Sheep-tracks"</li> <li>- Local knowledge and know-how</li> </ul>	<ul style="list-style-type: none"> <li>- Local knowledge and know-how</li> </ul>
Resource System	<ul style="list-style-type: none"> <li>- Natural meadows</li> <li>- Transumance culture</li> </ul>	<ul style="list-style-type: none"> <li>- Transumance culture</li> </ul>
Governance Systems	<ul style="list-style-type: none"> <li>- Valorisation of local SES resources</li> <li>- Local Action Group</li> <li>- Fair distribution of market and non-market values</li> </ul>	<ul style="list-style-type: none"> <li>- Cost minimization</li> <li>- Protected Denomination of Origin from the "Silano" SES</li> </ul>
Actors	<ul style="list-style-type: none"> <li>- Dairy processor</li> <li>- Farmers</li> </ul>	<ul style="list-style-type: none"> <li>- Dairy processor</li> <li>- Farmers</li> </ul>
Practices	<ul style="list-style-type: none"> <li>- Promotion of new pasture practices</li> <li>- Transumance</li> <li>- Local raw milk supply</li> <li>- Processing using traditional practices</li> <li>- Premium pricing of milk</li> </ul>	<ul style="list-style-type: none"> <li>- Raw material supply from the "Silano" and other SESs</li> <li>- Processing using industrial practices</li> </ul>
Assemblages/ Assembled practices	<ul style="list-style-type: none"> <li>- Cultural and experiential tourism</li> </ul>	<ul style="list-style-type: none"> <li>- Fresh stretched curd cheeses</li> <li>- Experiential tourism</li> </ul>
Outcomes	<ul style="list-style-type: none"> <li>- Restricted access to global markets</li> <li>- Valorisation of local SES resources and the multifunctional role of agriculture</li> <li>- Sustainable management of natural resources</li> <li>- Economic viability (sustainability) of farmers</li> </ul>	<ul style="list-style-type: none"> <li>- Competitive advantage on local and global markets</li> <li>- Alienation from the local SES's natural, cultural, and human capitals</li> </ul>
Leverage opportunities	<ul style="list-style-type: none"> <li>- Assemblage with the tourism value chain</li> <li>- Diversification towards cattle meat and sheeps and goats dairy/meat products</li> </ul>	<ul style="list-style-type: none"> <li>- Strengthen the assemblage with the tourism value chain</li> </ul>

technologies, business models, and value chain configurations have on the sustainability and resilience of mountain areas.

Moreover, to fully harness the development potential of local resources, including natural and human and social capital, mountain areas should not be considered in isolation. The nature and strength of their connections with other areas (e.g., lowland regions, neighbouring rural areas) have relevant implications for resilience and sustainable development of mountain areas (Dax, 2020).

In this context of renewed interest for coherent place-based policies, this paper develops a framework aimed at supporting empirical analyses of value chains' contribution to the development of mountain areas through identifying potential leverage points for resilience and sustainable development. Combining Ostrom's Socio-Ecological System (SES) framework (Ostrom, 2009b) with value chain analysis, our framework proposes an approach to operationalise the LTVRA in European mountain areas. The SES framework and its adaptations (Marshall, 2015; McGinnis, 2011) have been used to study a variety of processes (Delgado-Serrano and Ramos, 2015; Dennis and Brondizio, 2020; Jones et al., 2017; Kimmich, 2013), including value chains (Villamayor-Tomas et al., 2015). Value chains, regarded as the full range of tasks that firms and actors undertake to bring a product from conception to end-use, encompass the value generation activities in these remote areas, particularly where development strategies require trading goods and services (Crescenzi and Harman, 2023).

We use here the SES approach to frame the analysis of value chains as institutions that harness resources, including human and social, in both local and extra-local assets stocks (Dax, 2020; Galeano-Barrera et al., 2022) and that might create interactions between different SESs by means of telecoupling (Eakin et al., 2017; Zimmerer et al., 2018).

Value chains have become a useful meso-level unit of analysis to understand development as they illustrate how territorial assets can generate economic value through a series of practices (Jones et al., 2019) as part of the renewed interest in rural entrepreneurship (Dias et al., 2019) in rural studies. In our framework, the activities/operations of these actors are geographically localised. Value Chains identify products, financial and information flows between actors and areas (European Commission, 2018). To account for the essential role of humans as beneficiaries and co-producers of natural and human-derived capitals (Jones et al., 2016), 'mountain value chains' are defined as value chains that have their principal resource base - namely, ecosystem services and the actors that manage them - in mountain areas.

The proposed framework starts from the observation that the material flows that value chains mobilize originate within a SES. Thus, value chains, linking together activities located in different places, create flows of goods and services between a plurality of SESs (e.g., mountains with lowlands), and generate potential leveraging (or locking-in) conditions for territorial development. "Global" and "local" value chains emerge in "a highly dynamic local-global continuum where actors, while adapting to a changing environment, establish multiple relations and animate several chain configurations" (Brunori et al., 2016). In this perspective, the conceptualization of 'value chains' can be extended including a definition of value that includes also non-market goods and services with public good characteristics (Fearne et al., 2012; Kramer and Porter, 2011) and analyses how this extended notion of value is created and distributed between SESs (Baig et al., 2021; Deans et al., 2018; Purnomo et al., 2020).

This is in line with wider rural scholarship, recognizing the importance of territorial assemblages connecting agriculture and ecosystem services (Barnaud and Couix, 2020). These linkages are conceptualized in terms of capitals - the economic framing of various natural and human-derived stocks (e.g., social, cultural, produced and financial) and the benefits they produced to human well-being -, and capital flows - the costs and benefits generated from the use of capitals (TEEB, 2018). In this framework, value chain analysis allows to 1) take into consideration the flows of materials, capitals, and information between SESs, accounting for the goods and services supplied by mountain areas to other

areas and the demand put on mountains (Dax, 2020), and 2) recognise the positive and negative feedbacks from telecoupled SES on local mountain development. Whilst the need for such an approach is clear in territorial development and value chain scholarships, no existing analytical framework was suitable for comparative analyses of mountain based European value chains. To fill the gap, this framework provides a practical approach to the characterization of value chains with a SES perspective, providing the basis for identifying value chains' contribution to the resilient and sustainable development of SESs, the leverage points to act upon - with the related policy implications - to support local development of European mountain areas. The paper is organised as follows. Section 2 provides a review of the literature on the topic; Section 3 illustrates the framework and its conceptual foundations. In Section 4, the framework is illustrated through the analysis of two case study value chains within the "Alto Molise" SES. The paper concludes with Section 5 and 6 where limitations and suggestions for further research developments are also discussed.

## 2. Updating mountain rural development strategies: the role of value chains

From the end of last century, scholars and rural movements have developed a radical critique to rural development conceived of as modernization. While in a first phase the critique was mainly focused on resistance to globalisation processes (Van der Ploeg, 2012) and to oppose endogenous development to exogenous development through 'distantiation' from technology and markets (Van der Ploeg, 1994), the evolution of these approaches has strived to combine tradition with innovation (Zagata et al., 2020), refusal of the capitalist logic with engagement with markets (Van der Ploeg, 1994), social innovation with technological innovation (Bosworth et al., 2020). Post-productivist approaches (Marsden, 1999; Ward, 1993; Wilson, 2001) have shown how the countryside can generate a multiplicity of goods and services, emphasizing how symbolic and place-sensitive production is necessary for the integration of mountain areas on global markets (Brunori, 2006). This 'neo-endogenous' perspective (Ray, 2006) has inspired several successful initiatives across Europe (Bosworth et al., 2016, 2020; Dax, 2020).

Although neo-endogenous approaches are sensitive to local-global dynamics, the changing context focuses on external factors (e.g., climate change), their role in development strategies, and the capacity of mountain areas to respond to them (Dax, 2020). Climate change, migration, global tourist flows, competing land uses, changes in urban configurations and in labour markets, ageing of population, new (digital) technologies, are strongly affecting the livelihoods of mountain communities. These phenomena carry with them opportunities as well as threats. An analysis of the multiple dimensions of vulnerability of these areas is necessary, and development strategies should aim explicitly to improve their resilience (Imperiale and Vanclay, 2016).

A particular role here is played by value chains. Value chains are among the most powerful ways to connect mountain land use systems and societies to other areas. The configurations that value chains assume, and the related governance patterns, regulate the access to material and immaterial resources. The growing attention to the dynamics of the global value chains and of their governance (Gereffi and Fernandez-Stark, 2011) has opened the way to a better understanding of the opportunities and the risks for local economies engaging in global trade. Conversely, the short food supply chain movements (Renting et al., 2003) have provided plenty of examples of how local resources can be mobilized into configurations that allow to keep more value in rural areas.

We highlight two areas of enquiry to shed light on the relation between value chains and mountain development. The first area is value chain sustainability assessment. Footprinting methodologies are increasingly employed to provide information on the environmental impact to consumers, highlighting the 'true cost' of commodities

(Freidberg, 2014). But footprinting measures the impact per unit of product and does not measure the pressure on the resource stocks in given SESs (Brunori et al., 2016). The TEEB (2018) has developed a powerful framework to evaluate the pressures of value chains on natural resources and the variety of the (social, ecological, and economic) dimensions of the outcomes that they can generate but does not consider the role of governance systems that determine these pressures.

The second area of enquiry relates to the interlinkages between different value chains: local vs global, food vs other products and services, as in the emerging bioeconomy (Horlings and Marsden, 2014). Rural enterprises are hubs of relations, and they create a room for manoeuvre through the selective connection to a plurality of value chains. In this regard, we need to analyse how the structure of value chains evolves, how actors connect or disconnect from them and how their practices and flows between activities are changed accordingly (Callon et al., 2002). The understanding of the link between local and external actors, resources and activities, and of the variety of the outcomes that this interaction can generate, will help also to understand the interdependencies between telecoupled SESs, as flows within value chains reallocate resources among their embedding SESs. The SES framework (Ostrom, 2009a) and its adaptation to capture the dynamic processes by which decisions and outcomes in SESs are realized (McGinnis, 2011; McGinnis and Ostrom, 2014) provide tools to analyse how competing or cooperating governance systems regulate individual and collective practices that use local resources. Therefore, methods to explore the distribution of the costs and benefits of the value created across different SESs are needed.

Conceptually, these two areas of enquiry can ground development strategies based on the 'selective openness' of mountain areas: that is, the transformation of local resources into economic value can be based on connecting to existing telecoupled networks or to building new telecoupled networks that encourage internal coordination and avoid unbalanced power relations (Brunori, 2006). These new lenses on rural development highlight the rationale for combining value chain analyses with the SES approach.

## 3. A framework to address the interplay between value chains and socio-ecological systems

The standard SES framework was designed to provide an analytical tool to investigate and explain the processes related to the supply (from the natural system) and appropriation (from the human system) of natural resources (Ostrom, 2007, 2009a). It has been associated with a large variety of theories and concepts in the realm of nature-human interactions (Binder et al., 2013; Cox et al., 2016), generating a variety of methodologies and applications (see Partelow, 2018 for a detailed outline).

Our proposed framework (Fig. 1) builds on the representation of a SES developed by McGinnis and Ostrom (2014) by centering value chains analyses as instruments to investigate synergies and trade-offs between natural resources, human actors, and the value adding practices taking place within the same and/or between different SESs. The framework is focused on understanding the way diverse materials and non-material flows (e.g., values, social norms and rules, cultural knowledge) among actors associated with a value chain affect the sustainability and resilience of the related SES. It also maintains the hierarchical structure of the SES framework but integrates it with components that explicitly account for the structure, governance, and relational configuration of value chains. This framework has two aims: to provide a conceptual basis for understanding the contribution of value chains to the sustainability and resilience of mountain SESs; and to facilitate the identification of leverage points to stimulate transformations in value chains' configurations that increase the resilience of SESs in mountain areas.

Marshall (2015) suggested similar adaptations to generalize the standard SES framework for application to food systems. The author

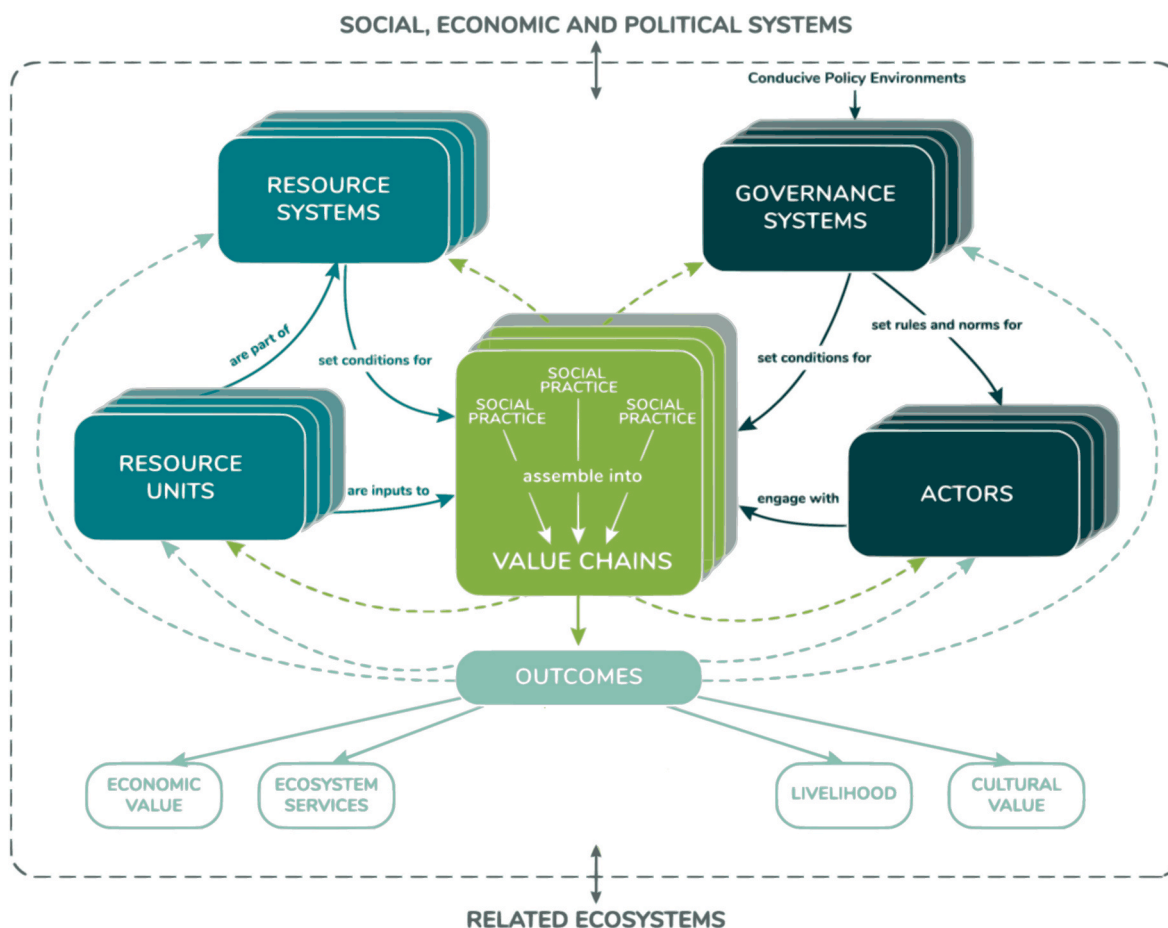


Fig. 1. SES Framework integrating social practices and value chains<sup>4</sup>.

suggested the inclusion of two subsystems – transformation systems and products – in the standard SES framework to account for the transformation activities that play a central role in food systems (Marshall, 2015). Compared with the adjustment proposed by Marshall (2015), the alternative strategy we propose avoids increased complexity and ensures a more stringent coherence with the standard SES framework. Moreover, it has the advantage to handling more efficiently the vertical and horizontal coordination, relational space, governance systems, as well as the business models and the technology pathways affecting actors’ interactions, value chain activities, and the social, economic, and ecological outcomes of the value chain.

### 3.1. Value chains and SES: the role of practices

In the proposed framework, value chains generate pressures on and create value in the local SESs through the practices enrolled in different stages of the value chain: e.g., production, processing, and retailing. According to the theory, social practices are routine interactions between actors and their environment including resource units and other actors (Bourdieu, 1977; Shove et al., 2012). Through social practices, actors operate as individuals and/or groups in a defined social context. Social practices are based on culturally shaped norms, habits, beliefs, and expectations. They are developed within the actors’ relational space (Harvey, 2006; Murdoch, 2006) and are affected by normative, cognitive, and technical systems of rules. Each practice generates a variety of social, economic, and ecological outcomes. In our framework, we highlight practices aimed at creating and distributing value (Maxwell, 2007; Pearce and Turner, 1990). Through social practices, local resources are mobilized, used in, and reproduced by the local economy and society, and are recognized and converted – at least partially – in

monetary value (Zasada et al., 2015). Business activities involve a multiplicity of practices related to production, processing, transport, sales, communication, administration. Value chains are patterns of coordination between actors aiming to the delivery of a given product/services to final users (Christopher and Peck, 2004; Porter, 1985), and connect actors performing different practices.

The amount of value actors can create is affected by the natural, social, and economic resource systems of the area, which constitute the territorial capital (Camagni, 2008). The valorisation of the multifunctional role of agriculture (e.g., landscape preservation, cultural heritage) has been found to be an important driver for restructuring the rural economy, through the diversification of farming activities (Lange et al., 2013). However, the development of rural areas is determined by the interactions of local communities with the external environment. In the proposed approach, these interactions are addressed in the “Socio, economic and political systems” subsystem external to the SES. Local actors’ agency and control on development pathways external to the SES (e.g., protected area designation) is minimal, thus, as suggested by (Li et al., 2019), the proposed framework focuses on the analysing the internal SES’s components functions and structures (e.g., value chains, local actors, governance, resource systems) to identify strategies to improve rural communities’ resilient capacity.

The governance system is a multi-level system, where “territorial” governance systems are directly affected by local actors whose normative, cognitive, and cultural norms will condition the other SES’s subsystems (see Fig. 1), while larger scale governance systems (e.g., national, European, global value chains governance systems) are outside local actors’ control. These external governance subsystems can delimit the “territorial” governance systems.

Value chains are also economic institutions centred on interaction



among natural and human resources to generate market goods and services, as well as ecosystem services and public goods, defined as non-rival and non-excludable economic goods (Cowen, 1985) and the ecosystems functions, processes and structure that generate benefits to human beings (Danley and Widmark, 2016; Dasgupta, 2021), respectively. The nature of these natural-human systems interactions is bidirectional: value chains' actors exchange goods, services, knowledge, etc. used to generate market outputs, but at the same time providing opportunities to maintain – or create new – space for the delivery of ecosystem services and/or public goods only indirectly related to the value chain (e.g., hydrogeological risk prevention).

To make value chain analysis helpful in designing strategies of sustainable development of mountain areas, we need to avoid 'reification' of value chains - considering them as unchangeable structures - and highlight the role of local actors. The evolution of business, in fact, implies a continuous connection/disconnection of practices with and from broader networks (Brunori, 2006). Each time relationship with a new client or a new supplier is established, the network changes its shape. When a new product standard is introduced - a new safety rule, a new quality label - business actors must rearrange their networks. Value chains are thus continuously evolving.

At the same time, however, business actors seek stability in the value chain, as stability reduces transaction costs, increases trust, and creates opportunities for innovation and growth. To capture the tension between stability and evolution in value chains, and to highlight the role of local actors in value chains, we conceptualise value chains as assemblages of practices (DeLanda, 2006; Deleuze and Guattari, 1988). Looking at value chains as assemblages underlines their dynamic evolution, the possibility for actors to engage, through their practices, in different value chains at the same time, and allows an analysis of the processes of consolidation, growth, or crisis of value chains.

In a value chain, practices evolve in relation to other connected practices. Change in the value chain is transmitted through the objects of exchange between actors in a value chain: the raw material, semi-finished products, and services. The stability of a value chain allows actors' coordination based on rules such as tacit quality schemes, informal contracts, and trade conventions.

### 3.2. Value chain and SES: the dynamics

When the search for an operational space in a value chain takes a strategic character, actors strive to develop a set of principles that allow them to make production and marketing choices (Contzen and Forney, 2017). In an enterprise, business models (Burkhardt et al., 2011; Osterwalder and Pigneur, 2010) are different modes of assembling practices. The search for a more comfortable operating space can bring the actor to disconnect to one value chain to reconnect to another one, and this attachment/detachment process implies a different set of outcomes between the different subsystems.

All core subsystems, their components, and the mechanism guiding their interactions generate the outcomes of the SES: the economic value as well as its social and natural components, its vulnerability and resilience to exogenous factors (e.g., climate change, pressures from other systems) (Gunderson and Holling, 2002; Holling, 1973; Walker et al., 2004).

The outcomes of practices are assessed in relation to the multiple governance systems to which they respond: for example, quality for the value chain, profitability and reputation for the breeder, soil conservation for the local governance system. Thus, when practices are embedded into value chains, they are not only regulated by territorial governance systems, but by telecoupled value chain governance systems as well. Actors of the value chain mediate between the multiple governance systems that affect their practices and try to solve potential conflicts between different systems of rules. In this way, they create an operational space to comply with the respective governance systems and at the same time to maximize their own goals.

As the normative goal of our framework is to assess the contribution of value chains to the resilience of SESs, we need to analyse the synergies, the trade-offs and the conflicts between sub-systems and assess the outcomes of the interactions between human and natural systems in a SES. Local policy environments and the capability of stakeholders to identify lock-in and leverage points remains of key importance to ensure the resilience of mountain areas (Bock, 2016). To ensure the sustainable development of mountain areas, conducive policy environments are needed, where stakeholder commitment, financial resource availability, market strategies and facilitating mechanism of policy design and implementation support the development of value chains configurations coherent with the sustainability performance goals required (Araral et al., 2012).

### 3.3. Value chains as connectors between socio-ecological systems

Value chains and SES are affected by "Related Ecosystems", which are all subject to the overall climate conditions and evolution and to the Social, Economic and Political Settings. A rule or norm established at a large governance scale (e.g., European Commission, World Trade Organization) or a technological trajectory (e.g., renewable energy) outside the SES inevitably also influence the governance and the practices shaping the value chains within a SES. The methodological complexity of the sustainability assessment of a value chain is related to the fact that their activities are in different places, and their connections create interdependent systems. Practices carried out in one place may have indirect and delayed impacts on distant SESs and may generate multiple feedback loops.

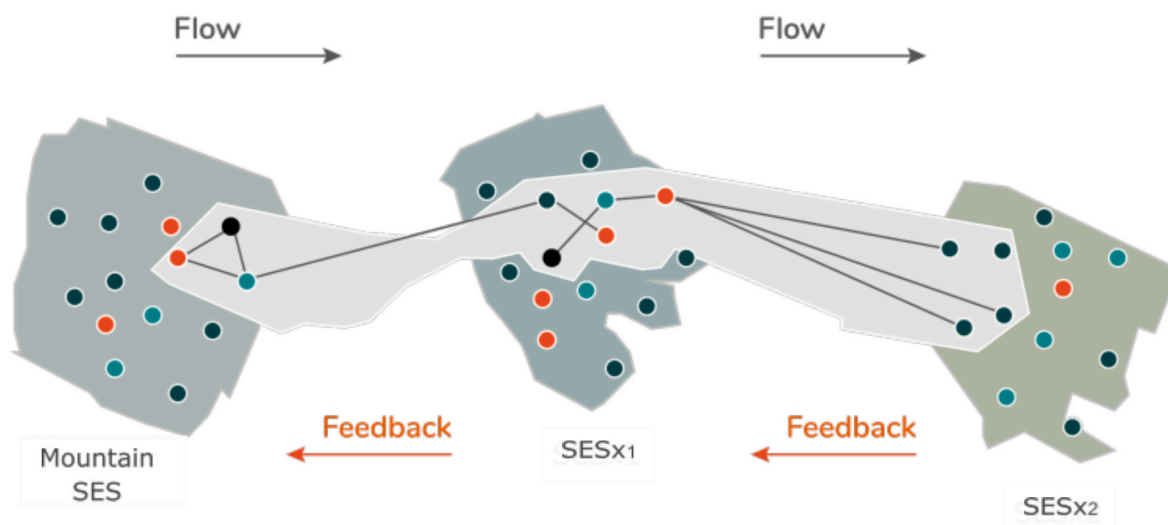
Through these connections, value chains can affect different SESs, regarding both the value created and distributed within each SES, and the vulnerability and resilience of the interconnected SESs. For mountain areas, these effects are very important, given their fragility and their weakness in comparison with other areas.

In this perspective, value chains (and the social practices they are built upon) can be conceived of as patterns that telecouple distant or neighbouring SESs (Hull and Liu, 2018; Liu et al., 2013). Telecoupled SESs interact through unidirectional or bidirectional flows of materials and information that are transferred by actors engaged in social practices which are connected to other social practices through value chains.

Each SES, in a telecoupling can behave as sending, receiving or spillover system, according to the flows being analysed (Fig. 2). The material and information flows between SESs in a telecoupling generates socio-economic and environmental consequences that can promote or prevent the transition towards more sustainable and resilient SES (Eakin et al., 2017; Hull and Liu, 2018; Zimmerer et al., 2018). Therefore, any political, economic, cultural, technological, governance and ecological change affecting the SESs, can generate new dynamics in the flows and impacts in the telecoupled system.

Different SESs, as represented in McGinnis and Ostrom (2014), can telecouple through flows of practices and through their outcomes at local level. In a SES, the resource units, the resource systems, the governance systems, and the actors interact through practices to assemble a value chain which generates a range of outcomes (e.g., commodities, ecosystem services, cultural and social values), but also negative effects, (e.g., resource depletion, elite capture of the benefits). If these interactions and outcomes remain within the SES, we face a "short" value chain (where the shortness relates to geographical proximity). Otherwise, some of these interactions and outcomes can cross the SES boundaries affecting other SESs in the process of telecoupling, as found in global value chains.

Changes in the governance of value chains can alter the interplay of the sending SES and the receiving SES, transforming the material and information flows among these SESs and thus the structure and boundaries of the telecoupled system. The dynamic outlined can generate a feedback mechanism where the effects of sending SES on receiving SES affect in turn the sending SES. For example, if the demand



**Fig. 2.** Telecoupled SESs through value chains. (Green dots: Resource units and systems; Red dots: practices; Light-green dots: Actors and governance; Black dots: outcomes). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

of a product based on local resources in the SES creates pressure on the local resource system by encouraging extraction practices exceeding its carrying capacity, it may lead to reduced availability, and its supply to receiving SES will decrease. This may increase the product price and would encourage the search of the receiving SES for suppliers in other SES. In this way, the boundaries of the telecoupled system will be extended. The inclusion of the new SES can, in turn, decrease the amount of output demanded by the receiving SES in favour of the newly added SES. Effects and feedbacks mechanisms are important properties of telecoupled systems, they can be positive or negative, and can affect the socio-economic and environmental properties of the telecoupled SESs, thus promoting or hindering their sustainability and resilience (Liu et al., 2013).

Recognizing and assessing the telecoupling can help to tailor development strategies for mountain areas. In fact, understanding the link between internal and external actors, resources and activities can facilitate 'selective openness' of SES and the construction of sustainable coupled systems: that is, connecting to or establishing new networks, both internally and with other areas, that can maximize transformation of local resources into socio-economic value, encourage internal coordination and avoid unbalanced power relations (Malapit et al., 2020). Indeed, networks allow the access to material, monetary, information and knowledge, influence, and social resources; and successful network configurations generate synergies between local assets and external resources, mitigating vulnerabilities, harnessing the emerging opportunities and boosting resilience.

Having illustrated how value chains are embedded in a SES and drew attention to dynamic and telecoupled practices by mountain actors, governed by multi-level governance systems, section 4 provides an application to mountain food products.

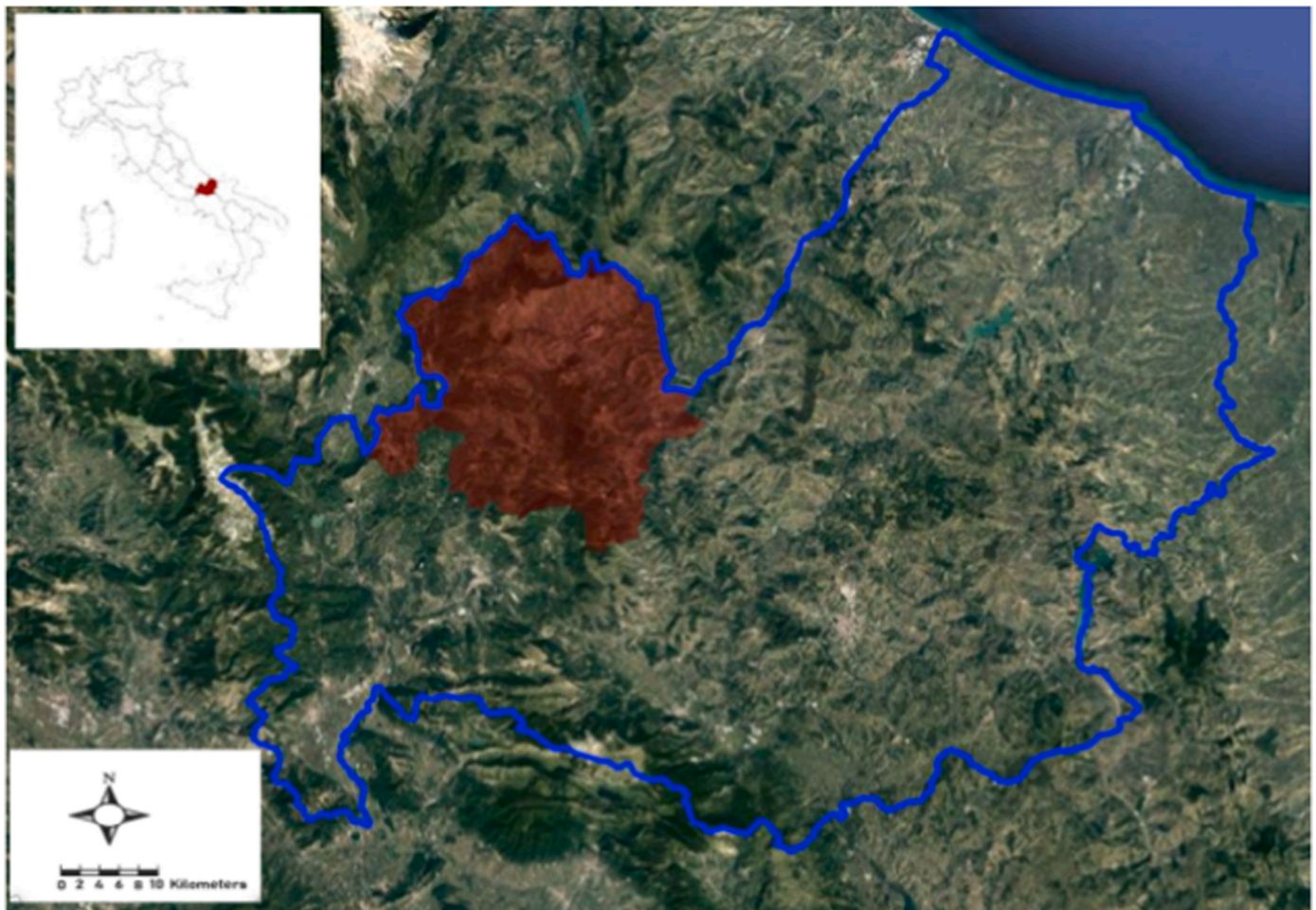
#### 4. Illustrating the framework: the "Alto Molise" socio-ecological system

To illustrate the framework, a dairy value chain has been described in relation with the embedding SES. This meso-level approach is implemented using different dairy farms as a lens through which the meso-level patterns are considered. Fifteen in-depth interviews were carried out with key informants performing distinct functions along the value chain and involved in local natural resources management in the "Alto Molise" SES (3 public authority/policymakers, 2 researchers, 4 farmers, 3 non-agricultural business representatives, 3 producers associations). The key themes in the interviews covered the elements

characterizing the framework. These include the type of actors, the practices they engage with and the resource units and systems these practices rely upon, the rules and norms shaping the governance systems as well as the value chain outcomes. The telecoupled connections with other SESs were also explored during the interviews. The interviews were recorded, transcribed, and coded deductively following the proposed framework.

##### 4.1. The region

This framework has been illustrated with a local traditional cheese value chain in the Molise Region (Italy) considering firms that enact the value chain differently within the same SES. The "Alto Molise" SES, located in an internal area of the Central-Southern Apennines (Fig. 3), is characterised by extensive pastures and wood areas involved in the agro-silvo-pastoral economy, such as the livestock sector (cheese and meat) and forestry-related products (wood, honey and truffles). Low-intensity livestock farming and low-intensity grassland areas prevail in the area. The SES was, until the beginning of the last century, at the centre of flourishing commercial traffic linked to the transhumance livestock practice. The value chain connects the resource system (i.e., permanent grasslands and meadows), livestock farming practices (in some cases linked to the traditional transhumance practice that is almost disappeared), the dairy processing practices (still partially made with craft techniques), drawing on socio-cultural heritage (e.g., the mountain farming and artisan culture) of the area. However, the decline of agro-silvo-pastoral activities and handicraft economy caused migration processes that impoverished and weakened the territorial capital of the area. Climate and economic crises are intensifying this decline. Increasing temperature combined with long period of drought and short intense precipitations are reducing permanent grasslands and meadows productivity. Moreover, higher temperatures impact negatively on livestock health and fertility, reducing milk production. Furthermore, increasing farming costs, lower milk market prices, ageing of the population, and decreasing workforce turnover in agriculture are reducing mountain grazing. To illustrate (Jaccard and Jacoby, 2019) the proposed framework, we analysed the role of two dairies both producing a local traditional cheese (the "Caciocavallo" cheese). This dairy product needs to be made with raw milk from grazing cows in mountain permanent grasslands and meadows and bears the PDO (Protected



**Fig. 3.** The territory of the “Alto Molise” socio-ecological system. (Blue line: Molise regional administrative borders. Red area: “Alto Molise” SES). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Designation of Origin)<sup>2</sup> label, and it is marketed in the local, regional, and national markets. The “*patronage*” governance model prevails in local dairy value chains. This model uses local resources by organising the value chain around a key actor who holds a market power compared to others, typically the cheesemakers. Therefore, we use the single dairy farm processors (a micro-level perspective) as an entry point for the analysis and a lens through which the meso-level patterns are considered since these processors are the central node linking the value chain to the resource system managers and to the consumers of the final products. These dairies have developed different business models within the local cheese value chain: one (A) with a more prominent local-embedded dimension and the other (B) with a delocalised profile (see Table 1). These differences impact the evolutionary processes of the social practices and their effects on the resilience and sustainability of the “Alto Molise” and the telecoupled SESs.

#### 4.2. Business model A: strong localisation

In our case study, there is a strong link between actors and value chain practices through the strongly localised businesses (hereinafter: A) build on the interaction between local breeders and a dairy processor

<sup>2</sup> Protected designation of origin (PDO) identifies food products that originate from a specific European region, are characterized by specific qualities, and have a strong link with the territory they are produced, in terms of both production of raw materials and processing.

(Fig. 4a). Breeders rely on the uniqueness of the SES resource units composed of endogenous grass botanical varieties which characterize the natural meadows resource system present in the SES. Together with the historical tradition of the “transhumance” culture which produced an exclusive stock of local knowledge and know-how, this resource system characterises the territorial capital of the “Alto Molise” SES and is the basis for the milk production stage of the cheese value chain.

The dairy processor in A (Dairy A) is a family business with more than three centuries of history, mostly spent supporting the dairy practices tradition in the so-called “transhumance civilisation”. The processor is embedded in the local SES itself, with which it has (co-) evolved, until its current configuration. Dairy A has installed a fair collaboration with local breeders, as it uses only local pasture-based milk to produce the traditional cheese, while the breeders supply raw milk with high-quality standards.

Moreover, Dairy A is a breeder itself that recognizing the importance of protecting the SES’s components (e.g., agriculture, landscape, history, traditions, social norms), has initiated the process of (re)appropriation of downstream phases of the dairy value chain. This awareness has also been translated into the governance rules of the value chain. By choice, value chain A is entirely dependent on the local SES resources and actors. The advantage of this strategy is to create a reputation of the product based on its quality. The scarcity helps to increase the selling price, which allows local breeders to receive a price-premium, even twice the market price, in exchange for products with very high-quality standards.

The governance system in use by Dairy A pursues a valorisation



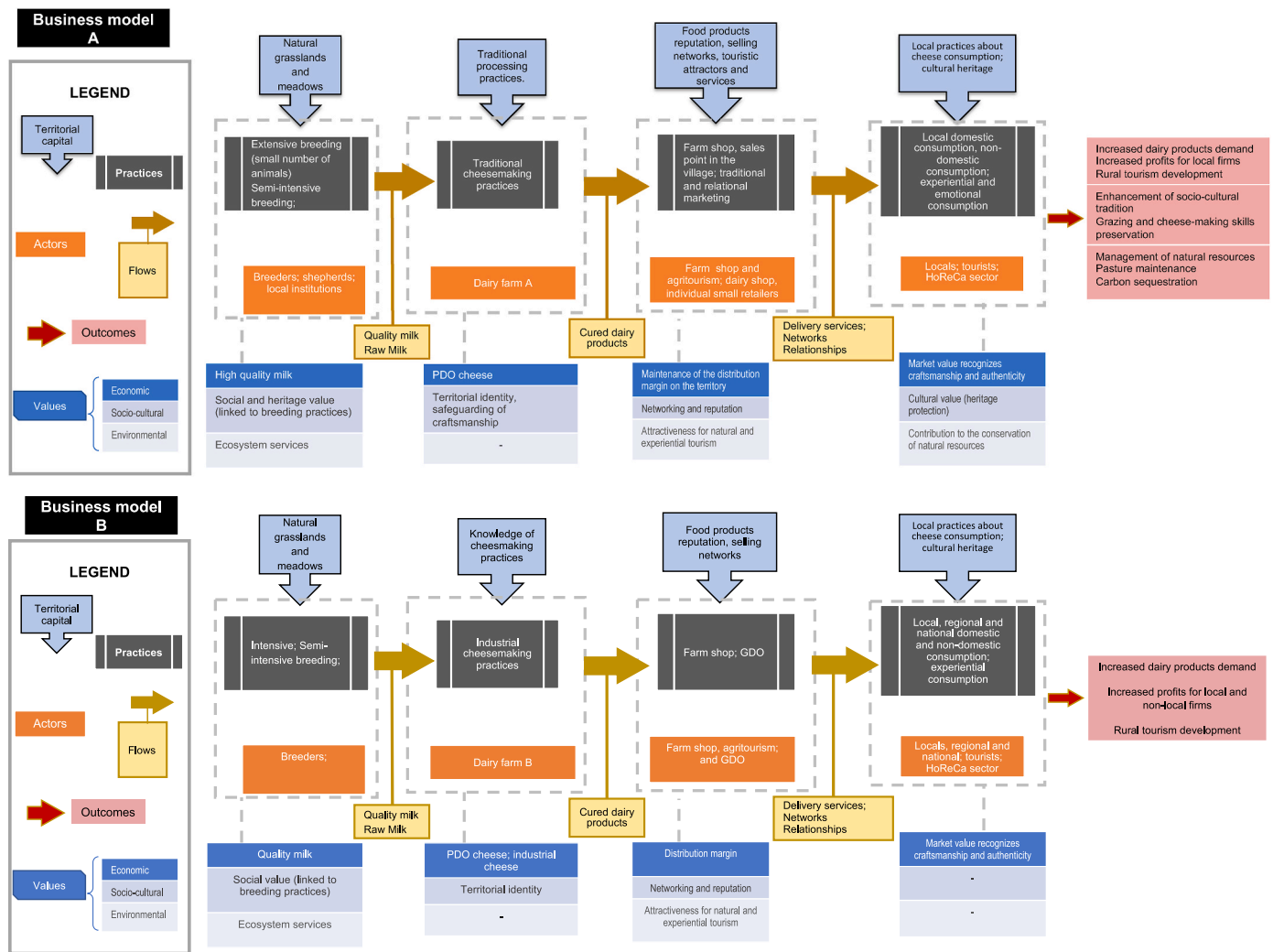


Fig. 4. Diagrammatic representation of the “Caciocavallo” cheese value chain in the “Alto Molise” SES:a) business model A and b) business model B.

strategy based on the exploitation of the SES’s positive non-market values (e.g., botanical wealth of local pastures, transhumance, and cultural heritage) by assembling with other “local” value chains such as tourism, and thus strengthening the connection with the local SES. The connection with the tourism value chain is centred on the valorisation of “tratturi” (sheep-tracks) which allows tourists to new cultural and experiential tourism practices (trekking along the sheep-track), learning about the area while appreciating the elements of territorial capital involved in the value chain. To assist the assemblage with the tourism value chain, Dairy A has contributed to the establishment of a local governance system, promoted by the Local Action Group (LAG)<sup>3</sup> with the aim to encourage a more profitable use of the SES’s resources (agricultural land, biodiversity, landscape, etc.), reducing the risk of land abandonment and natural resources degradation. The traditional

cheese produced in A is marketed mainly at the local and regional level through direct sales, e-commerce and Dairy A sales networks which includes small supermarkets and the HoReCa sector. Case A demonstrates the framework through illustrating how value chain practices build on and mediate interactions between the actors, local governance systems, and resource units and systems. It is telecoupled with other SES that send tourists to walk and consume local products; and that receive the cheese for sale in supermarkets and the HoReCa sector. External systems governing the PDO certification also condition the value chain practices; but are configured with local governance rules and norms. The resulting outcomes are increased economic value for the local producers and processors, and more protection for ecosystem services, landscape and cultural heritage. However, the long-term livelihoods remain vulnerable to external threats (climate, inflation) and the dependence on the local patron.

<sup>3</sup> A Local Action Group (LAG) is a partnership between public and private actors (e.g., local authorities, community groups, non-governmental organizations (NGOs), farmers, and other stakeholders) that works to promote rural development and the sustainable use of natural resources in a specific geographical area, such as a rural region or a group of municipalities.

<sup>4</sup> Interactions among the SES subsystems (green boxes) result in a system of interactions (yellow-green box) that generates outcomes (white boxes) that feedback to subsystems (light mint green-dashed arrows). External social, economic, and political subsystems sit outside the SES boundary (grey dashed line). Source: adjusted from McGinnis and Ostrom (2014).

#### 4.3. Business model B: delocalisation

Like A, the delocalised business model (hereinafter: B) generates from the interaction between the same type of actors (a dairy processor and breeders) but the difference is that some milk producers are located outside the boundaries of the “Alto Molise” SES (Fig. 4b). Although this configuration is less common in the SES’s area, most of the SES dairy products comes from business model B which is centred on a dairy processor (Dairy B). Dairy B has created its industrial business model by



pursuing practices that focus on costs minimization and economies of scale, combined with a processing quality control. This transition towards the industrial model, sustained by technological investments and the increase in the production scale, initially, led Dairy B to the progressive alienation from other actors in the “Alto Molise” SES. The business model of Dairy B aims at exploiting the reputation of the traditional cheese of the area, while aiming at enlarging its production and commercial scale. The most evident effect of this strategy is the diversification towards more uncured cheese products (e.g., mozzarella cheese) to ensure the monetary flows to make this business model efficient. However, this strategy has supported a progressive replacement of the agro-silvo-pastoral activities and the socio-cultural heritage of the SES, with intensive livestock breeding practices (e.g., shifting from grazing to stables, feeding animals with purchased fodder), which brings to the substitution of local dairy cattle breeds in favour of highly-productive dairy cattle breeds and the abandonment of common permanent grassland and meadows.

Dairy B strongly relies on the reputation of the “Alto Molise” territorial capital, but its interactions with local resource systems, traditions (transhumance), and actors (breeders) are only marginal. Indeed, to support its business model and contain the costs of raw material procurement, Dairy B engaged in dynamic telecoupling processes with breeders located in other SESs to sustain its production scale. For example, Dairy B telecoupled with the “Silano” neighbouring SES to exploit the commercial opportunity offered by the local PDO scheme. Thus, Dairy B can profit from place-based certification while sourcing resources from outside the “Alto Molise” SES. Moreover, the telecoupling involves also the downstream flows of uncured cheese products with are marked outside the SES.

However, the constant connection/disconnection with other SESs ensures the promotion of the SES's dairy production beyond the SES's boundaries and allows the actors in value chain B to receive constant feedbacks on the quality of the produce and the satisfaction of the demand, allowing for the implementation of marketing strategies which often have retrofitting effects on the practices within the SES (e.g., reduced exploitation of natural pastures).

Also in B, the connection with the local SES has been recently strengthened through the assemblage of value chain's practices with the tourism value chain, oriented towards the protection and valorisation of the SES's natural resources. Local and external governance systems are enrolled in these interactions. Again, the case is telecoupled with other SES that send tourists to walk and consume local products; and that receive the cheese for sale in supermarkets and the HoReCa sector. External systems governing the PDO certification also condition the value chain practices; but here local governance rules and norms are threatened by the industrial business model practices. The resulting outcomes are increased economic value for the local processor who is reacting in an economically rational manner to external threats (climate, inflation) but less positive outcomes for ecosystem services, cultural heritage, landscapes and the milk producer livelihoods.

The two case studies demonstrate the framework through illustrating how value chain practices build on and mediate interactions between the actors, local governance systems, and resource units and systems of a SES (case A) or through telecoupling with neighbouring SES actors and resource units (case B). The cases depict two value chain configurations which result in different outcomes for the sustainable development of the SES.

Positive transformations can be induced in case A through improving the connection between breeding, dairy production, and tourism activities. These assemblage can directly increase local dairy products demand and the revenues of dairy firms, while indirectly boost local actors cooperation and social network, and promote positive advancements in infrastructure network (e.g., roads, accommodations). Moreover, supporting the assemblage of case A with the cattle meat value chain (e.g., promoting the breeding of two purposes cow breeds) can allow income diversification to the breeders/farmers. Similarly, stimulating the

connection with the sheep and goat value chain can contribute to restore and recover the natural grassland and traditional grazing practices. Whereas, straightening the assemblage with the tourism value chain is identified as the only leverage point for case B.

## 5. Discussion

This study builds on the need to turn value chains development and upgrading strategies towards public goods production and the reduction of negative externalities (Baig et al., 2021; Purnomo et al., 2020) by providing a systematic approach to address these issues. The proposed framework combines the SES approach with value chain analysis (from production, processing, distribution to final consumption) to identify how the configuration of value chains might provide resilience to disruptive trends (e.g., economic marginalisation, depopulation) and recognise leverage points to improve the sustainability of mountain SESs. To achieve this goal, mountain value chains should aim at transforming local resources into social and economic values, thus reducing the risk of unsustainable social, economic, and environmental outcomes. This aim can be achieved through a) diversification of outputs, b) the creation of market oriented institutions, and c) strengthening the local networks (Li et al., 2019). Moreover, recognizing the relevance of telecoupled SESs supports value chain's actors in tracking the 'external' factors affecting the value chain and, thus, identifying the changes in practices that might led to beneficial outcomes for the sustainability of the SES.

The illustration of the proposed framework to the Alto Molise SES reveals that the two cheese processors generate different configurations according to the type of practices value chain's actors are engaged in. Different practices and assemblages result in distinctive business strategies that might contribute or challenge the sustainability of mountain SESs. The two case studies show how value chains can be conceptualized as assemblage of the interactions among SES's actors, resource systems, and governance systems, and how different value chain's configurations – strictly local (case A) or telecoupled with neighbouring SESs (case B) – might result in different outcomes for the sustainable development of the SES.

The proposed framework hinges on the SES approach and extends the value chain analysis from concentrating only on the economic implications of value chains practices to a wider focus on the complex dynamics that generate the ecological, social, and economic outcomes. The framework highlights the contexts in which value chains are embedded and the opportunities to generate value through the valorisation of local resources (territorial capital) (Morris and Kirwan, 2011; Sonnino, 2007), and telecoupling. This means positioning mountain areas' resilience and sustainability within a “problem-determined approach” rather than a “system-determined approach” (Eakin et al., 2017), meaning that the boundaries of the analysed system are determined by the issue of concern rather than by spatial, institutional, or geopolitical boundaries. This further develops the call for strategic policy support frameworks and actor-oriented approaches in the territorialization of public policies made by previous rural resilience (Knickel et al., 2018) and geography (Debarbieux et al., 2015) scholars.

In this revised SES framework, value chains, and the practices they are assembled from, are the operative units of analysis to examine the responses to external stressors (e.g., depopulation, macroeconomic shocks, and climate changes), and to design local place-based policy interventions fostering the transition towards sustainable and resilient mountain and rural areas. In the proposed framework, the SES analysis provides the meso-level approach to capture the diversity of factors and types of interactions between natural resources, actors, and governance systems determining value chain configurations, which is more useful for regional (mountain) development rather than firm based or national based value chains analysis. Moreover, enhancing the understanding of nature-human interlinkages promotes integrated approaches in the design and implementation of socio-economic and environmental

development policies (Dax, 2020).

Additionally, acknowledging value chains as instruments of telecoupling different SESs, this framework delivers information on the connectivity and relational coordination structures governing the material, knowledge and information flows affecting natural resources, ecosystems and rural livelihoods at distinctive spatial and temporal scales.

The contributions of value chains, especially in the agri-food sector, to sustainable development of rural areas have been the target of several research focused, among others, on the role of social capital (Abbey et al., 2016), value-based food chains (Laursen and NOE, 2017; Saul et al., 2022), social and geospatial embeddedness (Brinkley, 2017), and informal institutions (Klein et al., 2022). These studies suggest that enhancing social capital, the degree of shared values and informal enforcement of sustainability issues, within rural value chains is key to motivate value chains' actors to engage in transformative collective actions that adapt to the opportunity and resources locally available fostering their contribution to sustainable development.

Supported by post-normal science, Kirwan et al. (2017) proposed a multi-dimensional set of 24 attributes for an effective sustainability assessment of food value chains, allowing for multiple stakeholders' perceptions to be acknowledged. According to the authors, this inclusive approach promotes the adoption of reflexive forms of governance that allows value chains' actors to anticipate unintended consequences and adapt their regimes of practices before they become unsustainable.

In face of the uncertainty and unpredictable outcomes of climate change and socio-economic disturbances, this contribution adopts an adaptive management framework to guide appropriate policy choices (Holling and Meffe, 1996). Combining the SES framework with value chain analysis allows to identify potential misallocations of the SES resources, with the possibility to design policies capable to improve this allocation, and to identify place-based priorities, shaping new plans and strategies to sustain the economic, social, and environmental functions of mountain and rural value chains, including the diversity of values stakeholders' groups associate with them, and thus fostering the transition towards sustainable development of the SES.

There is tension between a clear and evidence-based analytical approach to support policy design and recognise the specificity of mountain value chains dynamics. This framework provides both the elements and structures of value chains for comparative analyses whilst allowing space to consider the role of non-economic capitals and how they manifest in sustainable choices and behaviours (e.g. Cusworth, 2020).

We propose this framework as a potential solution for increased policy coherence (Schleyer et al., 2015) within the EU that truly considers sustainable development of mountain areas. It provides the systemic approach needed to overcome unintentional consequences of single-focus policies, whilst providing instruments that could fit with the bureaucratic requirements of EU policy processes (e.g., ex-ante and ex-post policy evaluations). It highlights the importance of making mountain areas resilient, given their vulnerability to shocks (European Environment Agency, 2009; European Environmental Agency, 2010), drawing attention to mountains as needing recognition whilst adhere to the wider ambitions set for all EU rural areas as expressed by the LTVRA. However, the framework avoids essentialising mountain areas by placing them firmly within a telecoupled, sometimes global, nested SES system and illustrated the variety of dynamics in place – for example within the Alto Molise area.

Considerable work remains following the implications of the proposed adjustment of the standard SES framework. For instance, accommodating the value chains associated with a SES means that the second-tier indicators need to be extended to include value chains activities (e.g., practices, assemblages, material and non-material flows and outcomes), as well as the attributes affecting them (e.g., governance structure, relational configurations, business models, power distribution). Rural scholarship has helped driving the turn to social and

environmental justice concerns within value chain analyses (Ros-Tonen et al., 2015) but much of the scholarship is directed at the Global South (e.g. Baig et al., 2021; Bullock et al., 2018; Deans et al., 2018). This paper highlights the relevance of using value chains and SES to frame policy concerns within the EU. In this regard, further application of this framework, with the required adaptations, to analyse value chain contribution to SES resilience and sustainability in specific mountain and rural contexts will allow the development of indicators that are contextually appropriate and for which monitoring is feasible. The challenge remains to keep the systemic and complex adaptive dynamics whilst making the framework tractable and operational, through the definition of indicators and data requirements. Moreover, the policy implications of value chains transformations towards improved contributions to the sustainability and resilience of SESs are characterised by a high degree of context specificity, thus requiring the definition of analytical tools to design suitable policy instruments and interterritorial coordination/governance mechanisms of the human-nature interactions. Research efforts should also be directed towards the identification of analytical tools for capturing the formal and informal sets of social, economic, and technical norms prompting actors' engagement in defined practices and assemblage with specific value chains. Understanding the pertinent sets of rules and norms can support priority definition and the shaping of new place-based policies in the logic of sustainable development of SESs in the mountain and rural areas.

As our research focus is in mountain areas, we propose the framework for these territories, but it will equally work, with the required adjustments, for any SES where production activities are organised around value chains.

## 6. Conclusions

The adjusted SES framework developed in this paper integrates value chain analysis to accommodate the value generating activities contextualised within specific systems of social, economic, institutional, and technical norms, into the standard SES framework. . This framework is developed for researchers and policy analysts to identify place-based priorities balancing natural resources conservation and sustainable socio-economic development pathways of mountain and other rural areas. Thus, it can support the implementation of the European Long-Term Vision for Rural Areas (LTVRA). As observed by its instantiation with two value chain studies within the Alto Molise SES, the framework responds to the need for a multilevel-hierarchical approach to analyse the interrelation between value chains and socio-ecological processes and identify the sets of norms and rules (social, economic, and technical) mobilizing natural, economic, and social resources within the context of SESs. It also highlights the importance of simultaneous local and telecoupled system analysis, understanding endogenous and exogenous relationships in value chains, including how mountains provide the foundations of many lowland economic activities and the dependency of mountain development pathways on lowlands forces. Maintaining consistency with the standard SES framework, the proposed framework has the advantage to handle more efficiently sustainability problems related to the value generating practices and the dynamic relationships along value chains. The framework provides a way for policy to support and amplify business strategies and opportunities, to enable endogenous and participatory place-based development.

This study does not pretend to offer a fully developed model, but we are confident that the proposed framework can serve as a solid foundation for advances in the study of how value chains outcomes and SESs sustainability and resilience can evolve in tandem, thus indirectly promoting integrated, multi-funds, and assets-based approaches in the design and implementation of development policies for remote rural areas.

Significant work remains in developing this framework to make it a more practical instrument for structuring multi-disciplinary inquiries into SES sustainability and resilience issues in the context of the

mountain and rural development policies. The operationalisation of the proposed framework requires participatory approaches to adjust it to the specific problem and to capture the interdependencies among multiple resource systems and actors carrying out multiple activities under multiple normative, institutional, technical, economic, and environmental constraints. Moreover, these approaches might be effective to identify desirable futures and project trajectories of change toward sustainable development of SESs in mountains and rural areas and therefore help to realise the positive long-term vision of Europe's mountains and rural areas.

### Author contributions

All authors contributed to the study definition and design. Material preparation and analysis were performed by **Michele Moretti, Gianluca Brunori, Corrado Ievoli, Angelo Belligiano, Ivano Scotti, Francesco Felici e Stefano Grandò**. The first draft of the manuscript was written by **Moretti Michele and Gianluca Brunori, Angelo Belligiano and Ivano Scotti** contributed to the development of the case studies narrative, and all authors commented on previous version of the manuscript. **Kirsty Blackstock and María Mar Delgado-Serrano** critically reviewed the first drafts and suggest the appropriate changes. All authors read and approved the final version of the manuscript.

### Data availability

Data will be made available on request.

### Acknowledgments

The authors are thankful to the three blind reviewers for their constructive comments and feedback on previous drafts of the paper. This research was funded under the MOVING project (Mountain Valorisation through interconnectedness and green growth - [www.moving-h2020.eu/](http://www.moving-h2020.eu/)) as part of the Horizon 2020 Programme (Grant Agreement No.: 862739). The views expressed in this article are solely those of the authors.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2023.103022>.

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