Interdisciplinary Spatial Documentation for the Revitalisation of Minor Historical Centres: A Systematic Literature Review

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Abstract. The Rural Alpine (RA) territories, especially in Italy, are facing a complex crisis of demographic decline, service reduction, and environmental vulnerability. While Minor Historical Centres (MHCs) possess significant cultural and architectural value, their revitalisation is often hindered by fragmented data and a lack of integrated planning tools. This paper presents a Systematic Literature Review (SLR) analysing 84 identified multidisciplinary sources across seven thematic pillars. The review serves as a foundational step to identify the requirements and variables for a future spatial multi-dimensional methodology. The methodology would be able to synthetise a list of indicators necessary for evidence-based decision-making. The review identifies a structural misalignment between "hazard-blind" architectural documentation, "heritage-blind" environmental risk assessments, and a pervasive detachment from the socio-economic realities that define a settlement's actual habitability. Findings reveal that only 7% of current literature achieves a high level of interdisciplinary integration, leaving a significant gap in operational tools for decision support.

Keywords: Minor Historical Centres (MHCs) · Rural Revitalisation · Systematic Literature Review · GIS Documentation · Environmental Risk · Socio-Economic Viability · Spatial Multi-Criteria Analysis (SMCA)

1 Introduction

Rural Alpine (RA) territories across Italy and the broader European context are experiencing long-term processes of demographic decline, service reduction, and infrastructural fragility. These dynamics have disproportionately affected small villages, hamlets, and historical centres, many of which have undergone partial or total abandonment over

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the last decades [1–3]. In mountainous areas like the Alps, depopulation is further intensified by environmental restraints, including landslides, avalanches, and climate-related changes that increase exposure and maintenance costs [4, 5]. Minor Historical Centres (MHCs), small-scale settlements characterised by cultural, architectural, and landscape value, are particularly vulnerable within this context [6, 7]. Despite their recognised heritage significance and their renewed potential contribution to territorial regeneration, especially in the post–COVID-19 period, they often remain marginal within mainstream conservation and planning frameworks. Their limited demographic scale, fragmented ownership structures, and weak administrative capacity set back effective integration into standard policy instruments. While a range of regeneration initiatives have been implemented over recent decades, outcomes have frequently been uneven or modest, rarely producing long-term structural change [8–12]. As a result, many interventions remain episodic, project-based, or weakly embedded in long-term governance strategies. At the same time, national and European policy frameworks, including the Italian National Strategy for Inner Areas (SNAI), the Piano Nazionale di Ripresa e Resilienza (PNRR), and the EU Long-Term Vision for Rural Areas, clearly promote the revitalisation of marginal territories and historical settlements [11, 13–15]. However, there is often a clear disconnection between policy ambitions and their implementation in practice. Documentation initiatives, hazard assessments, demographic analyses, and funding programmes tend to be developed in parallel rather than in coordination, relying on heterogeneous datasets and incompatible spatial or semantic frameworks. This fragmentation makes it difficult for local administrations and planners to assess the potential for re-inhabitation in a systematic, risk-aware, and evidence-based way. Emerging geospatial datasets, such as Copernicus land monitoring [16], national and regional geoportals (such as Istituto Nazionale di Statistica (ISTAT), Agenzia Regionale per la Protezione Ambientale (ARPA), etc.), hazard inventories, and statistical archives, offer opportunities to understand RA territories with high spatial and thematic resolution. Yet these resources are rarely integrated into unified workflows that bridge environmental risk and physical building stock conditions with socio-economic indicators, such as accessibility to services, local market viability, and demographic resilience. This lack of a multiscale approach prevents the development of operational tools capable of supporting strategic decision-making for the re-inhabitation of MHCs in hazardous and fragile contexts. This means that while these areas hold cultural and architectural value, their survival depends on more than just physical preservation; it requires a strategy supported by strong, data-driven frameworks (both qualitative and quantitative). While the survival of MHCs is often linked to strategic repopulation, this research acknowledges that ‘repopulation’ must be defined through a broad, multidisciplinary lens. Scientific evidence suggests that viability in RA territories is increasingly driven by alternative strategies, such as seasonal reactivation, where temporary inhabitants provide essential economic surges, and adaptive reuse of heritage assets for decentralised services or hospitality. Consequently, the Spatial Multi-Criteria Analysis (SMCA) includes indicators for digital connectivity and service accessibility to evaluate the potential for service reorganisation and hybrid living models. This ensures the framework identifies opportunities for resilient development that transcend traditional permanent residency, aligning with the flexible territorial strategies proposed by SNAI.

1.1 Terminology and Territorial Semantics

The classification of RA territories involves a complex intersection of geographical and administrative semantics. Because the stakeholders involved in rural policy often employ divergent terminology, it is essential to clarify these concepts before the literature investigation. While the operational focus of this study is centred on the Italian landscape, a broader European Alpine perspective is fundamental to the research scope. The Italian Alps are part of a contiguous geographical, environmental, and cultural macro-region characterised by shared challenges, such as climate-related geotechnical instability and demographic fragility, which transcend national borders. Consequently, the European scale provides the necessary scientific and morphological context for understanding MHCs; moreover, the cross-border approach could give a comprehensive understanding of MHC phenomena. Within the broader European RA context, this study focuses on MHCs, a term that encompasses a diverse typology of small-scale settlements including hamlets and villages [17]. To ensure a high level of contextual accuracy for the Italian landscape, it is essential to incorporate localised terminology such as "borghi" and "centri storici minori", which carry specific cultural and morphological connotations often missed in broader international datasets [18]. While these terms are central to current policy instruments and funding initiatives, they are frequently associated with tourism-led initiatives that may overlook the structural socio-economic fragilities of the territory. In this study, 'borghi' is utilised as a key search descriptor to ensure alignment with existing academic databases and Italian national policy frameworks. However, the analysis prioritises 'functional habitability' and long-term re-inhabitation viability over episodic, project-based interventions. Furthermore, Alpine territories frequently overlap with the regulatory definition of Inner Areas (Aree Interne). As highlighted by SNAI, these regions are defined not only by their physical elevation but by their "peripherality", measured as the distance from essential service hubs. This classification implies that the mountainous nature of a settlement is often one of the primary drivers of its socio-economic isolation, requiring a nomenclature that integrates both topographic and policy-driven indicators [19].

1.2 Research Gaps and Objectives

The current scientific literature and institutional inventories provide extensive data on the physical aspects of settlements and environmental hazards. However, these domains are rarely intersected with each other or with the socio-economic realities that define a settlement's actual habitability. Traditional documentation practices remain largely hazard-blind, while environmental risk studies are often heritage-blind, treating abandoned villages as static geographic points rather than dynamic social systems. Most documentation frameworks fail to quantify the functional viability, such as accessibility to job markets, service proximity, and community resilience. This fragmentation leads to a fundamental paradox in current rural policy. Despite the proliferation of funded proposals and international initiatives, from "Case a un euro" [20] to SNAI [13], there is still no statistical evidence of a reversal in depopulation. Instead, demographic trends suggest the phenomenon is intensifying, with the UN World Urbanisation Prospects [21] projecting that 68% of the global population will reside in urban areas by 2050. This persistent

abandonment not only threatens cultural identity but accelerates ecological degradation, increasing downstream risks such as floods and landslides [22]. The failure of these initiatives often stems from a lack of continuity and a failure to integrate local development needs with technical safety, frequently relying on short-term cultural projects that lack the supporting infrastructure for long-term settlement. This is further compounded by the fragmentation or total absence of open data (spatial, statistical, and historical) in many MHCs. Consequently, the primary research gap is the lack of an integrated methodology that synthesises technical spatial layers with socio-economic indicators. This research is driven by the need to align documentation with current European and national policy frameworks, such as the PNRR, which advocate for territorial cohesion but lack operational tools to link risk governance to economic viability [14, 15]. Against this backdrop, the primary objective of this research is to identify the methodological requirements and variables for a future SMCA through a systematic review of the current state-of-the-art. The Systematic Literature Review (SLR), adapted from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [23] approach, serves as a foundational step to bridge the gap between 'hazard-blind' and 'heritage-blind' studies by synthesising an interdisciplinary set of indicators. Consequently, this study seeks to answer: Which spatial, environmental, and socio-economic variables are necessary to assess the re-inhabitation potential of MHCs within a unified framework? To effectively document and understand MHCs, it is essential to adopt an interdisciplinary approach that captures their inherent complexity. Consequently, the fragmented state-of-the-art is synthesised by the authors across seven thematic pillars: (1) **GIS-based documentation,** (2) **hazard and climate exposure,** (3) **RA settlement morphology,** (4) **re-inhabitation strategies,** (5) **policy frameworks,** (6) **social dynamics,** and (7) **economic viability**. This taxonomy is methodologically aligned with the multidisciplinary principles of the Historic Urban Landscape (HUL) and the multidimensional indicator logic of the SNAI. These pillars constitute a "Revitalisation Lifecycle", a concept synthesised from the integrated management principles of the HUL approach [8] and the multi-scalar policy logic of the SNAI [19], that bridges the gap between static physical documentation and the dynamic factors necessary for re-inhabitation. The framework organises the SLR into three progressive phases: Baseline Pillars (1–3) establish the physical and environmental "shell"; Strategic Pillars (4–5) address the governance and planning context; and Viability Pillars (6–7) evaluate human and economic sustainability. This structure serves to identify the specific requirements and variables for the proposed SMCA.

The paper outlines the SLR methodology in Sect. 2, considering part of the PRISMA approach. Section 3 identifies structural gaps in current practices, providing the evidence base for Sect. 4, which proposes an interdisciplinary framework and future directions for managing and revitalising risk-prone territories through the identified SMCA variables.

2 Methodology: Systematic Literature Review

This study establishes a conceptual and methodological foundation for hazard-aware, multi-scale documentation through a SLR considering part of the PRISMA approach, selected to synthesise a fragmented body of research spanning geomatics, environmental engineering, heritage studies, socio-economic analysis, and spatial planning. Across

the globe, rural territories are increasingly affected by rapid urbanisation, demographic aging, and climate change, pressures that undermine their social, economic, and cultural resilience. In Italy, this challenge is particularly significant due to its alpine morphology and dense network of historic hamlets, which represent both a condition of vulnerability and a strategic opportunity to test resilient development models. The SLR identifies the methodological requirements for current GIS and spatial documentation methods, evaluates the availability of hazard and climate-risk datasets, and identifies a first group of possible variables necessary for data-driven strategies supporting re-inhabitation. By systematically integrating these domains, the review aims to identify critical gaps between existing documentation practices and the operational needs of rural regeneration policies, ultimately providing a replicable, interdisciplinary foundation for the proposed SMCA framework.

2.1 Strategy and Sources

The search process was designed to bridge the gap between academic theory, institutional data, and operational policy. Recognising that documentation of MHCs requires a layered understanding of the territory, the identification of relevant sources followed the four-tiered strategy detailed in Table 1. The process moved from high-level peer-reviewed research in Scopus to establish the state-of-the-art in Multi Criteria approach and heritage studies, followed by web searches and snowballing [24] to capture multi-scale methodologies and MHC semantics. Finally, gray literature and statistical data were integrated to align strategic policy objectives with quantitative indicators for demography and risk. This approach ensures the review is not merely a summary of papers, but a synthesis of the actual tools and regulations governing rural revitalisation in the RA context.

Table 1. Multidisciplinary Source Categorisation.

Source category		Specific repositories	Main research contribution
Academic databases		Scopus	State-of-the-art in GIS, MCA, & heritage studies
Web search		Google Scholar, General Web search, ResearchGate	Supplementary case studies, contemporary hospitality models
Snowballing		Backward/forward citation tracing	Multi-scale methodologies & MHC semantics & ontologies
Gray literature	Policy framework	EU Rural Vision, Alpine Convention, SNAI, PNRR	Strategic objectives for rural regeneration & policy drivers
	Statistical & environmental	ISTAT, ISPRA, Copernicus	Quantitative indicators for demography, & risk

To identify the requirements and variables for the proposed SMCA, the research identified seven thematic pillars representing the "Revitalisation Lifecycle" previously mentioned in Sect. 1.2. This categorisation ensures covering the lifecycle of a revitalisation project: from its physical/morphological baseline (Pillars 1, 2, 3) to the strategic and policy drivers (Pillars 4, 5) and the human and economic aspects (Pillars 6, 7). This decision is based on the multi-domain nature of re-inhabitation and because the process involves a wide array of stakeholders, from residents and private investors to regional policymakers and environmental engineers. Consequently, 4 primary domains of intersection from these pillars were selected: **(i) Technical-Spatial Documentation**, which focuses on multi-scale GIS workflows and the digital documentation of the architectural shell of MHCs; **(ii) Environmental-Risk Assessment**, addressing the geotechnical constraints and climate-related hazards that define the physical limits and safety of the Alpine territory; **(iii) Strategic-Planning & Revitalisation**, investigating data-driven policy frameworks and territorial strategies aimed at reversing rural depopulation; and **(iv) Socio-Economic & Decision Support**, which evaluates the human element through social and economic indicators while utilising a Multi-Criteria Approach to determine the long-term viability and repopulation potential of abandoned hamlets. The initial search phase revealed a high volume of unrelated results, particularly from global contexts outside of Europe that did not share the specific morphological or legislative constraints of the Italian RA regions. To address this and set geographical and thematic boundaries, the search strings in Table 2 were specifically calibrated to balance geographic depth with policy precision. For instance, the initial search for environmental hazards yielded over 7,000 records. Therefore, a macro-scale (European/Alpine) perspective was applied to strings (i) and (ii) to capture environmental hazards and climate-risk datasets, as RA territories share contiguous geomorphological vulnerabilities that transcend national borders. Keywords such as "alpine," and "mountain area," were integrated to isolate settlements with these specific geotechnical vulnerabilities. Conversely, a micro-scale (Italian) focus was prioritised in strings (iii) and (iv) by integrating localised qualifiers like "borghi" and "aree interne" to ensure compatibility with the specific regulatory and funding frameworks of the SNAI and PNRR. As a result of integrating specific settlement and geographical qualifiers, the corpus was narrowed to research specifically addressing the intersection of geotechnical risk and built heritage in RA areas.

The SLR was conducted within a defined temporal and linguistic scope to ensure contemporary relevance and historical depth. It covered the period from 2000 to the present, aligned with the evolution of modern GIS and the emergence of major European rural development policies. It included literature in English and Italian, reflecting the dual need for global methodological standards and specific national case studies. The primary focus is restricted to Europe, with a specific emphasis on the Italian RA regions.

2.2 Screening and PRISMA Workflow

Following the initial identification of records from databases (n = 44), policy literature (n = 22), snowballing (n = 20), and web searches (n = 28), a four-stage screening process was applied by adapting the PRISMA workflow specifically for the identification and selection of multidisciplinary sources. While this study does not follow the full PRISMA 2020 clinical protocol, such as formal protocol registration or independent

Table 2. Scopus search strings for the four domains.

Domains	Scopus strings	N
(i) GIS-based multi-scale documentation	TITLE-ABS (“rural village” OR “small village” OR “historic centre” OR “minor historical centre”) AND (GIS OR “multi-scale” OR “spatial documentation”) AND (“Alpine”)	23
(ii)Hazard & climate exposure	TITLE-ABS (“alpine” OR “mountain area” OR “inner area” OR “borghi”) AND (“hazard” OR “risk” OR “avalanche” OR “landslide” OR “debris flow” OR “flood”) AND (“GIS” OR “spatial modelling” OR “remote sensing”) AND (“historic settlement” OR “MHC” OR “small village”)	8
(iii) Re-inhabitation & rural revitalisation	TITLE-ABS (“re-inhabitation” OR “repopulation” OR “adaptive reuse”) AND (GIS OR “spatial planning” OR “data-driven”) AND (“borghi” OR “MHC” OR “abandoned village” OR “historic settlement”)	6
(iv) Socio-Economic & Decision Support	TITLE-ABS-KEY (“indicator”) AND (“decision support system”) AND (“village” OR “hamlet” OR “borghi”) AND (“spatial” OR “GIS”)	7

double-screening, the approach was utilised to ensure a transparent, replicable, and rigorous funnel for narrowing the initial corpus of 114 sources to the final 84 key references. As detailed in Fig. 1, first, duplicate records across the four strings of Scopus and four source categories were identified and removed. Second, titles were screened to exclude unrelated disciplines, and studies that focused on non-European geographical contexts. Third, abstracts were evaluated against strict eligibility criteria; records were excluded if they focused on large metropolitan areas rather than MHCs, or if they presented purely historical/archival narratives lacking explicit spatial or GIS data. Furthermore, records were removed if they lacked explicit spatial data. This thematic filter further excluded studies focused solely on macro-regional scales, tourism marketing, or industrial agriculture, as these do not address the structural challenges of re-inhabitation. Finally, full-text articles were accessed, with the exclusion of non-open-access reports declared as a limitation to prioritize data accessibility for territorial stakeholders. This process resulted in a final corpus of 84 references, achieving a strategic equilibrium between high-impact peer-reviewed research and institutional policy data (SNAI, PNRR, and Alpine Convention reports). The selection of databases and keywords was specifically calibrated to MHC vocabulary and existing hazard datasets (Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), ARPA), ensuring the resulting methodology is interoperable with national and European data standards.

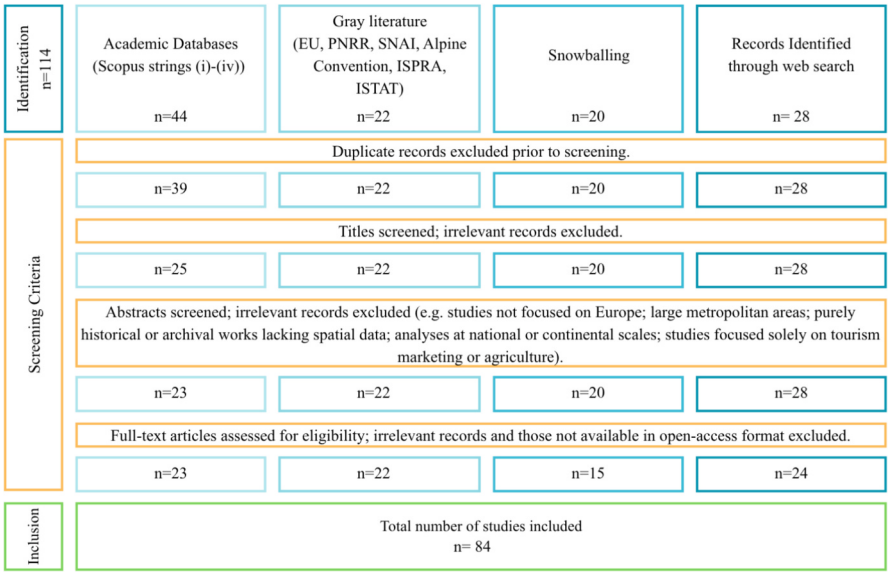

Fig. 1. Adapted PRISMA-style flow diagram with the results of the SLR.

2.3 Methodological Scope and Limitations

The SLR was designed to balance academic rigor with operational utility. To ensure that the derived indicators remain accessible to local administrations and territorial stakeholders, the search was primarily focused on open-access sources, thereby prioritizing 'data democracy' in rural revitalisation planning. While Scopus served as the primary academic database, the inclusion of gray literature, including reports from ISTAT, ISPRA, and the Alpine Convention, was essential to capture the local-scale policy data and localised socio-economic indicators that are often absent from global academic databases. Furthermore, the screening and scoring process was conducted by the authors through a collaborative internal review to ensure thematic consistency across the seven pillars, providing a multidisciplinary quality check on the final corpus.

3 First Results and Discussions

The SLR process initially identified 114 records across the four primary search domains. After applying the inclusion and exclusion criteria, specifically filtering for geographical relevance, spatial data availability, and thematic focus, the corpus was refined to 84 key references. A comprehensive summary of these identified sources is provided in the Annex. A significant observation during the screening phase was the high volume of research originating from outside Europe, particularly from China and Southeast Asia. Studies such as those by Chen et al. (2017) on village-level poverty and Zhang et al. (2025) on data driven heritage demonstrate that multidimensional spatial modelling for rural settlements is a prominent global interest. Despite their relevance, these studies were excluded to maintain the strictly European and Alpine legislative focus of this

research. The exclusion of these high-quality international models confirms a critical research gap: the primary challenge in the RA context is not a lack of models, but a lack of integrated spatial documentation that bridges global technical methods with local Alpine vulnerability and Italian national strategies.

3.1 Thematic Distribution and Pillar Weighting

The final 84 references were analysed using a thematic content analysis to evaluate their relevance to the seven pillars. Each source was rated on a qualitative scale from 0 to 4 to quantify the depth of integration within the SLR. To ensure consistency, the following scoring rubric was applied: 0 (Absent), where keywords related to the pillar do not appear in the text; 1 (Incidental), where the pillar is mentioned as context but its objectives are not integrated into the methodology; 2 (Conceptual), where the pillar is discussed as a relevant factor but lacks specific variables or data application; 3 (Partial), where the pillar is a significant component of the research methodology and findings; and 4 (Core Focus), where the pillar is the primary objective and driver of the study's analytical framework. The distribution of these ratings across the corpus is visualised in Fig. 2.

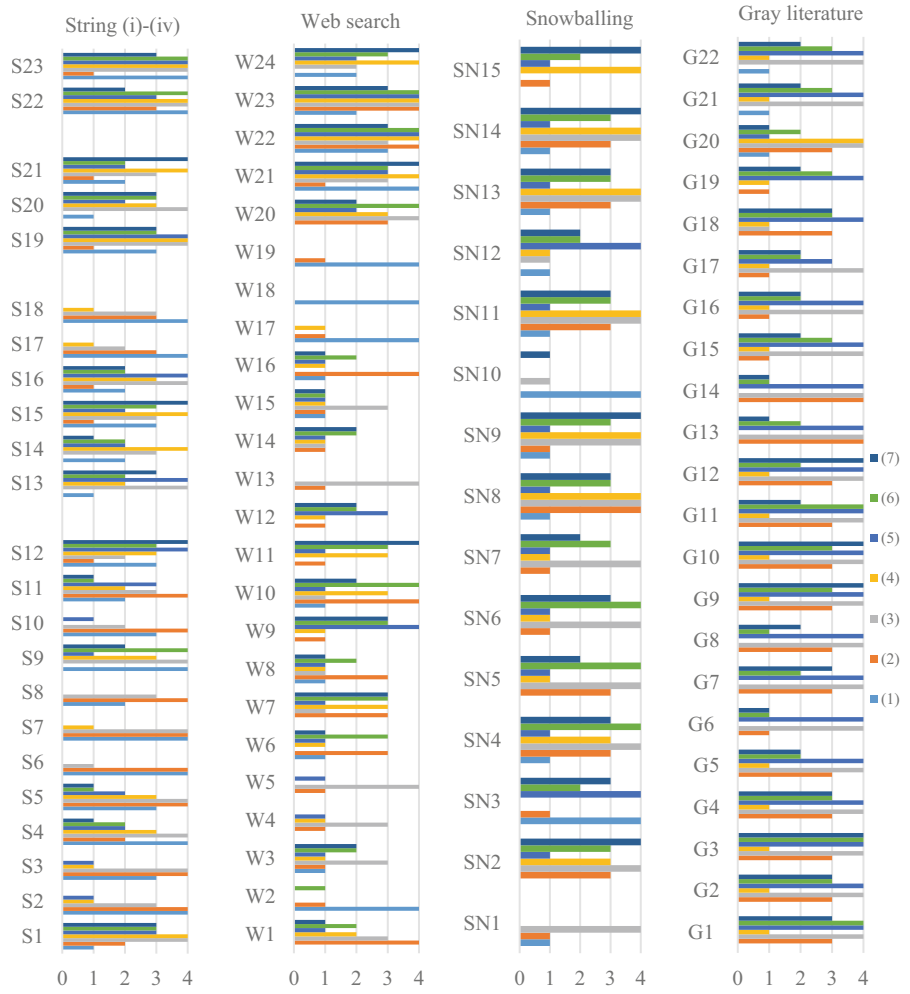

Fig. 2. Thematic rating based on search sources. Pillars: (1) GIS-Documentation; (2) Hazard-Exposure; (3) RA-Morphology; (4) Re-inhabitation Strategies; (5) Policy; (6) Social; (7) Economic. Scoring: 0 = Absent to 4 = Core Focus.

Table 3 synthesises the results of the thematic content analysis by identifying the specific references that achieved high-relevance scores (3 or 4) across the seven pillars. This matrix serves as a cross-reference tool, mapping the final corpus of 84 sources to the specific domains where they offer the most significant methodological or theoretical contributions. The "Count" row quantifies the frequency of high-relevance occurrences for each pillar, highlighting the relative density of research in areas like RA settlement morphology compared to the more limited focus on GIS-based documentation or policy frameworks. By isolating these core contributions, the table provides the evidentiary basis for the extraction of the interdisciplinary indicators and variables subsequently utilised in the SMCA framework.

Table 3. Thematic coding matrix (1)–(7) = thematic pillars as mentioned in Sect. 1.2.

Thematic pillars	GIS-Documentation(1)	Hazard-Exposure(2)	RA-Morphology(3)	Re-inhabitation Strategies(4)	Policy(5)	Social(6)	Economic(7)
References with 3 = Partial OR 4 = core Focus values in relation to (7) pillars	S2, S3, S4, S5, S6, S7, S9, S10, S12, S15, S17, S18, S19, S22, S23, W2, W17, W18, W19, W21, W22, SN3, SN10	S2, S3, S5, S6, S7, S8, S10, S11, S17, S18, S22, W1, W6, W7, W8, W10, W16, W20, W22, W23, SN2, SN4, SN5, SN8, SN11, SN13, SN14, G1, G2, G3, G4, G5, G7, G8, G9, G10, G11, G12, G13, G14, G18, G20	S1, S2, S3, S4, S5, S7, S8, S9, S11, S13, S14, S15, S16, S18, S19, S20, S21, S22, S23, W1, W3, W4, W5, W13, W14, W15, W20, W21, W22, W23, SN1, SN2, SN4, SN5, SN6, SN7, SN8, SN9, SN11, SN13, SN14, G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G20, G21, G22	S1, S4, S5, S9, S12, S14, S15, S16, S19, S20, S21, S22, S23, W7, W10, W11, W20, W21, W22, W23, W24, SN2, SN4, SN8, SN9, SN11, SN13, SN14, SN15, G20	S1, S11, S12, S13, S16, S19, S22, S23, W9, W12, W21, W22, W23, SN3, SN12, G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G21, G22	S1, S9, S12, S15, S19, S20, S22, S23, W6, W7, W9, W10, W11, W20, W21, W22, W23, W24, SN2, SN4, SN5, SN6, SN7, SN8, SN9, SN11, SN13, SN14, G1, G2, G3, G4, G9, G10, G11, G15, G18, G19, G21, G22	S1, S12, S13, S15, S19, S20, S21, S23, W7, W9, W11, W21, W22, W23, W24, SN2, SN3, SN4, SN6, SN8, SN9, SN11, SN13, SN14, SN15, G1, G2, G3, G4, G7, G9, G10, G12, G18
Count	23	42	61	30	36	40	34

The analysis of the 84 references reveals a structural misalignment between documentation, risk assessment, and policy. While the seven pillars are frequently discussed in isolation, their operational integration remains critically weak. Current literature on MHCs often focuses on architectural documentation that remains hazard-blind and socio-economically detached. This fragmentation highlights a significant decision-support gap. Although frameworks like the PNRR and SNAI emphasise the strategic value of MHCs for territorial cohesion, the literature primarily offers qualitative governance analyses rather than operational datasets. Consequently, a methodology to bridge policy objectives with technical spatial documentation, required for future project selection and long-term monitoring, remains underdeveloped. Figure 3 quantifies thematic integration by tracking how many of the seven pillars each reference addresses with high significance (scoring 3 or 4). While papers scoring in only one or two pillars represent specialized contributions, the data reveal a critical lack of interdisciplinary depth: only 7% of the corpus bridges 6 or 7 pillars. This finding confirms that current research fails to provide holistic variable sets needed to define a comprehensive SMCA.

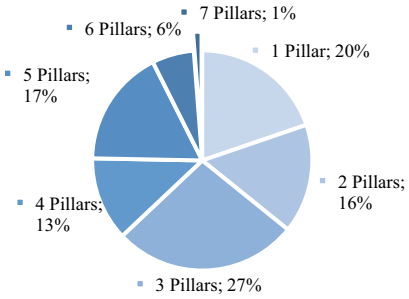

Fig. 3. Distribution of high-relevance scores across (7) thematic pillars.

4 Conclusion and Future Perspectives

The SLR of 84 multidisciplinary sources confirms a structural misalignment between documentation practices, risk assessment, and regional policy. While the RA context is characterised by high architectural value, it remains trapped in a cycle of demographic decline and environmental fragility [4]. Current research frequently treats these settlements as static shells, focusing on physical preservation while remaining hazard-blind to risks and socio-economically detached from the realities of modern habitability. To bridge these gaps, this research highlights the potential of an SMCA integrated into spatial analysis. Unlike a traditional Multi Criteria Analysis (MCA), which may treat variables as homogeneous across a territory, the proposed SMCA acknowledges that data varies significantly across space, requiring a site-specific, multidimensional lens. Furthermore, this approach intentionally moves beyond CBA (Cost-Benefit Analysis), as purely monetary transposition would drastically reduce the complexity of these inherently spatial and interdisciplinary challenges. The indicators detailed in Table 4 represent a synthesis of the requirements identified across the seven thematic pillars. The proposed framework holds the potential to serve as an operational tool to support strategic decision-making and guide targeted investments from national and European policy frameworks, such as the PNRR and SNAI. Moreover, a future Web-GIS platform could be a user-friendly tool in which the stakeholders involved in MHC actions can visualise and query the data. The WebGIS can provide a multi-level and multi-scale living tool that allows non-technical stakeholders and local administrations to monitor long-term regeneration progress and transition from territorial mapping to building-level documentation.

A critical next step for this framework is the transition from “top-down” institutional data to “bottom-up” community insights. Future perspectives include actor-based data collection, which involves organizing structured questionnaires and interviews with local stakeholders, such as residents, private investors, and planners, to refine the social resilience indicators used in the SMCA. Additionally, the research highlights the possibility for Digital Twin interoperability, evolving the Web-GIS into a dynamic environment capable of simulating climate-change impacts on building-level vulnerability in real-time. This transition could ensure that documentation remains a living tool for long-term rural regeneration. Ultimately, the survival of MHCs depends on a shift from episodic, project-based interventions to a data-driven, risk-aware governance model that ensures these territories are not only preserved but actively re-inhabited.

Table 4. Interdisciplinary Indicators for SMCA. Pillars: (1) GIS-Documentation; (2) Hazard-Exposure; (3) RA-Morphology; (4) Re-inhabitation Strategies; (5) Policy; (6) Social; (7) Economic.

Domain	Indicator Category	Specific Spatial/Quantitative Indicators	Pillar Ref
Baseline (Pillars 1–3)			
Technical-Spatial	Physical "Shell" Condition	Building decay levels, structural typology (URM), and architectural value/authenticity	(1), (3)
	Settlement Morphology	Volumetric consistency, urban grain, and presence of "borghi" specific connotations	(3)
Environmental-Risk	Geotechnical Hazards	Landslide susceptibility, avalanche zones, and debris flow history	(2)
	Climate Exposure	Flood risk (hydraulic), soil erosion, and climate-related maintenance costs	(2)
Strategic (Pillars 4–5)			
Strategic-Planning	Policy Alignment	Proximity to SNAI focus areas, PNRR funding eligibility, and EU Rural Vision goals	(4), (5)
	Adaptive Reuse	Potential for "Albergo Diffuso" models or public property availability	(4)
Viability (Pillars 6–7)			
Socio-Economic	Accessibility	Distance from essential service hubs (peripherality) and transport infrastructure	(6), (7)
	Functional Viability	Digital connectivity (broadband), proximity to job markets, and local market viability	(6), (7)
	Demographic Resilience	Population age index, migration trends, and community capacity for re-inhabitation	(6)

A Appendix: Detailed SLR Corpus

This annex provides the complete database for the 114 references selected through the SLR process detailed in Table 5. Each source is coded by its primary domain across the seven thematic pillars: (1) GIS-based documentation, (2) hazard and climate exposure, (3) RA settlement morphology, (4) re-inhabitation strategies, (5) policy frameworks, (6) social dynamics, and (7) economic viability.

Table 5. SLR by Search Strategy and Inclusion Criteria (S = String search, W = Web search, SN = Snowballing, G = Gray literature, E (prefix) = Excluded studies; In. = Include, EX. = Exclude. (1)–(7) = pillars.

Source	Code	Title	Status	Relevant pillars or ...
Academic database - String (i)	S1	Grecchi, M.; Colucci, A.; Malighetti, L.E.; Speciale, F..Reinventing Mountain and Rural Villages Strategies for Regeneration in the Perspective of a Circular Economy,2025	In.	(3), (4),
	SE1	Terrone, M.; Mandarino, A.; Piana, P.; Faccini, F..Identification, computation, and mapping of anthropogenic landforms in urban areas: Case studies in the historical centre of Genoa, Italy (UNESCO World Heritage),2024	Ex.	Genoa Large scale
	S2	Barrile, V.; Bibbò, L.; Bilotta, G.; Meduri, G.M.; Genovese, E..Geomatics Innovation and Simulation for Landslide Risk Management: The Use of Cellular Automata and Random Forest Automation,2024	In.	(1), (2),
	S3	Ardizzone, F.; Esposito, G.; Cavalli, M.; Crema, S.; Fiorucci, F..Sediment connectivity as a key to understand geomorphic effects of the Storm Alex in two mountain catchments of the Mediterranean Alps (Italy),2024	In.	(2), (3),
	SE2	Hussain, A.; Schmidt, S.; Nüsser, M..Dynamics of Mountain Urbanisation: Evidence from the Trans-Himalayan Town of Kargil, Ladakh, India,2023	Ex.	India outside Eu
	SE3	Zhuang, Q.; Hussein, M.K.; Mohd Ariffin, N.F.; Mohd. Yunos, M.Y.; Chen, S..Rural landscape characterization from the perspective of the tourist using online reviews: A case study of Yayou Gou Village in Shandong, China,2022	Ex.	China outside Eu
	SE4	Jiménez-Espada, M.; Cuartero, A.; Le Breton, M..Sustainability Assessment through Urban Accessibility Indicators and GIS in a Middle-Sized World Heritage City: The Case of Cáceres, Spain,2022	Ex.	Middle-Sized City.
	S4	Colucci, E.; Lingua, A.M.; Kokla, M.; Spanò, A..Minor historical centres ontology enrichment and population: An Hamlet case study,2022	In.	(1), (3),
	S5	Colucci, E..Mountain Hamlet Heritage Between Risk and Enhancement,2022	In.	(2), (3),
	S6	Nappo, N.; Peduto, D.; Polcari, M.; Stramondo, S.; Michetti, A.M..Subsidence in Como historic centre (northern Italy): Assessment of building vulnerability combining hydrogeological and stratigraphic features, Cosmo-SkyMed InSAR and damage data,2021	In.	(1), (2),
	SE5	Petrosino, P.; Claudia Angrisani, A.; Barra, D.; Jicha, B.R.; Calcaterra, D..Multiproxy approach to urban geology of the historical center of Naples, Italy,2021	Ex.	Naples large scale
	SE6	Faccini, F.; Giardino, M.; Paliaga, G.; Perotti, L.; Brandolini, P..Urban geomorphology of Genoa old city (Italy),2021	Ex.	Genoa large scale
	SE7	Martinát, S.; Cowell, R.; Navrátil, J..Rich or poor? Who actually lives in proximity to AD plants in Wales?,2020	Ex.	Unrelated
	S7	Busetti, A.; Calligaris, C.; Forte, E.; Mocnik, A.; Zini, L..Non-invasive methodological approach to detect and characterize high-risk sinkholes in urban cover evaporite karst: Integrated reflection seismics, PS-INSAR, leveling, 3D-GPR and ancillary data.,2020	In.	(2), (1), (3),
	S8	Pérez-Rey, I.; Riquelme, A.. A multi-approach rockfall hazard assessment on a weathered granite natural rock slope,2019	In.	(2),
	SE8	Vallis, S.; Gálvez, F.; Swidan, M.; Orchiston, C.; Ingham, J..Classical Temples and Industrial Stores: Survey Analysis of Historic Unreinforced Masonry (URM) Precincts to Inform Urban Seismic Risk Mitigation,2018	Ex.	Unrelated
	S9	Onitsuka, K.; Ninomiya, K.; Hoshino, S..Potential of 3D visualization for collaborative rural landscape planning with remote participants,2018	In.	(1), (3), (6),
	SE	Deng, Y.C.; Tsai, F.; Hwang, J.H..Landslide characteristics in the area of Xiaolin Village during Morakot typhoon,2016	Ex.	Taiwan outside Eu
	S10	Trigila, A.; Iadanza, C.; Esposito, C.; Scarascia-Mugnozza, G..Comparison of Logistic Regression and Random Forests techniques for shallow landslide susceptibility assessment in Giampilieri (NE Sicily, Italy),2015	In.	(2),
	SE10	Morelli, S.; Battistini, A.; Catani, F..Rapid assessment of flood susceptibility in urbanized rivers using digital terrain data: Application to the arno river case study (Firenze, northern Italy),2014	Ex.	Firenze large scale
	SE11	Caserta, A.; Martino, S.; Bozzano, F.; Govoni, A.; Marra, F..Dynamic properties of low velocity alluvial deposits influencing seismically-induced shear strains: The Grottaperfetta valley test-site (Rome, Italy),2012	Ex.	Unrelated
	S11	Pirlone, F.; Sotgia, Z.; Spadaro, I..Sustainability in the Safety Measures of the Historical-Cultural Heritage against Hydraulic Risks,2012	In.	(2),
	S12	Fusco Girard, L.; De Toro, P..Integrated spatial assessment: A multicriteria approach to sustainable development of cultural and environmental heritage in San Marco dei Cavoti, Italy,2007	In.	(5), (7),
Aca	S13	Pilogallo, A.; Saganeiti, L.; Fiorini, L..Deep Dive into the Recovery Fund: A (Real) Chance for Inner Areas? The Abruzzo Region Study Case, Italy,2025	In.	(3), (5),

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d	S14	Oteri, A.M..Perspectives in the Debate on the Future of Abandoned Heritage in Inner Areas. The Contribution of Architectural Preservation in the Post-Pandemic Era,2025	In.	(4),
	S15	Trovato, M.R.; Sanzaro, D..A Knowledge and Evaluation Model to Support the Conservation of Abandoned Historical Centres in Inner Areas,2024	In.	(4),
	S16	Limongi, G.; Napolitano, A.; Galderisi, A..What Future for Small Historical Centres in Inner Areas? The Case Study of Guardia Sanframondi in the Campania Region,2024	In.	(3), (5),
	S17	Sanzaro, D.; Trovato, M.R.; Circo, C..An Interpretive Ruination Model of the Built Heritage in Inner Areas: The Case Study of the Neighbourhood Granfonte in Leonforte,2023	In.	(1),
	SE12	Colucci, E.; Lingua, A.M.; Kokla, M.; Spanò, A..Minor historical centres ontology enrichment and population: An Hamlet case study,2022	Ex.	Duplicated
	SE13	Bell, B.A.; Fletcher, W.J.; Hughes, P.D.; Fink, D.; Rhoujjati, A..Palynological evidence from a sub-alpine marsh of enhanced Little Ice Age snowpack in the Marrakech High Atlas, North Africa,2022	Ex.	Unrelated
	S18	Magnini, L.; Bettineschi, C..Object-based predictive modeling (Obpm) for archaeology: Finding control places in mountainous environments,2021	In.	(1),
Academic database - String(iii)	SE14	Çakan, M.R.; Kishal, E.; Yaman, A..The Morphology of Continuity: An Analytical Documentation of Vernacular Architecture in Phoenix Rural Settlements,2026	Ex.	Turkey outside Eu.
	S19	Rossitti, M.; Torrieri, F..Territorial Inequalities in Adaptive Reuse Opportunities: Evidence from Lombardy Region ,2026	In.	(3), (4), (5),
	S20	Tsamos, G.; Vlami, A.; Sarantakou, E.; Christidou, A..Heritage Hospitality and Sustainable Tourism in Mountain Cultural Landscapes: The Case of Zagori Within the UNESCO Framework,2025	In.	(3),
	S21	Barelles-Vicente, E.; Torner-Feltrer, M.E.; Llinares Millán, J.; Aparicio-Fernández, C..From Ruin to Resource: The Role of Heritage and Structural Rehabilitation in the Economic and Territorial Regeneration of Rural Areas,2025	In.	(4), (7),
	SE15	Zhang, Z.; Hu, X.; Liu, W.; Bao, R..Data-driven heritage revitalisation: Exploring the paradigm of Lifen adaptive renovation evaluation based on space syntax,2025	Ex.	Relevant China.
	SE16	Zhao, T.; Zhang, W.; Zhou, J.; Chen, Y.; Jiang, J..Niche divergence of evolutionarily significant units with implications for repopulation programs of the world's largest amphibians,2020	Ex.	Unrelated
Academic database - String(iv)	S22	Caselli, B.; Panebianco, A.; La Placa, S.; Laera, R..GIS-Based Accessibility and Safety Assessment in Small Historic Centres in Inner Areas. Pilot Application in Stigliano and Interoperability with a Digital Twin,2026	In.	(1), (3), (4), (6),
	SE17	Ren, L.; Li, J.; Zhuang, J..Integrating Electroencephalography (EEG) and Machine Learning to Reveal Nonlinear Effects of Streetscape Features on Perception in Traditional Villages,2025	Ex	Relevant China
	S23	Moghadam, S.T.; Pignatelli, M.; Collin, A.; Lombardi, P..Renaissance of villages for the revitalisation of marginal areas,2022	In.	(1), (3), (4), (5), (6),
	SE18	Juhairiyah, J.; Andiarsa, D.; Indriyati, L.; Ridha, M. R.; Prasodjo, R. S.; Dhewantara, P. W..Spatial analysis of malaria in Kotabaru, South Kalimantan, Indonesia: An evaluation to guide elimination strategies,2021	Ex.	Unrelated.
	SE19	Chen, Y.; Wang, Y.; Zhao, W.; Hu, Z.; Duan, F..Contributing factors and classification of poor villages in China,2017	Ex	Relevant China.
	SE20	Ding, B.; Li, X.M.; Sun, X.H.; Wang, R.Q.; Zhang, S.P..Impacts of economic development models on ecosystem service values: A case study of three mountain villages in Middle Shandong, China,2016	Ex.	China outside Eu
	SE21	Mo, H.-Y.; Wang, Y.-J. Yu, Z.-Y..The design and research of poverty alleviation monitoring and evaluation system: A case study in the Jiangxi province,2009	Ex.	Unrelated
Web search	W1	ISPRA / ISTAT (within MASE framework).Demographic scenarios, residential mobility and impacts of climate change in the Alps. Intermediate Report focusing on the Italian and partly Austrian Alps,2025	In.	(2) (3) (5), (6),
	W2	Colucci, E..Geospatial Ontology to Support the Documentation of Minor Historical Centres. PhD Thesis,2022	In.	(1), (3), (4),
	W3	Agnoletti, M.; Errico, A.; Santoro, A.; Dani, A.;Preti, F..Terraced Landscapes and Hydrogeological Risk.,2019	In.	(2), (3),

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	W4	Nunes, A.N.; Coelho, C.O.A.; De Almeida, A.C.; Figueiredo, A..Soil Erosion and Hydrological Response to Land Abandonment.,2010	In.	(2), (3),
	W5	Picarelli, L.; Lacasse, S.; Ho, K..The Impact of Climate Change on Landslide Hazard and Risk,2020	In.	(2), (3),
	W6	Benedini, D..Borghi Abbandonati: Censimento di un'Italia che Scompare.,2018	In.	(3), (4), (6),
	W7	Amodio, T..Territories at risk of abandonment in Italy and hypothesis of repopulation,2022	In.	(4), (5), (6), (7),
	W8	publicarchitecture@polimi. 2009..Geografie dell'Abbandono. La dismissione dei borghi in Italia,2009	In.	(3), (4), (6),
	W9	Cotella, G..Territorialising EU Cohesion Policy in Inner Peripheries.,2024	In.	(3), (5), (7),
	W10	De Rossi, A.; Crotti, M.; Dini, R..Viaggio in Otto Borghi.,2015	In.	(3), (4), (6),
	W11	Delon, M., & Graziano, T. .L'iniziativa "case a un euro" contro la marginalità territoriale in Italia: mercificazione o rivitalizzazione?,2023	In.	(4), (6), (7),
	W12	De Luca, G..I borghi come monumento, questo l'intento del bando nazionale sulla rigenerazione,2023	In.	(4), (5),
	W13	Kim, H.; Lee, D.; Park, C.; Kil, S.; Son, Y.; Park, J..Evaluating Landslide Hazard Using RCP 4.5 and 8.5.,2015	In.	(2),
	W14	MacDonald, D.; Crabtree, J. R.; Wiesinger, G.; Dax, T.; Stamou, N.; Fleury, P.; Gutierrez Lazpita, J.; Gibon, A..Agricultural Abandonment in Mountain Areas of Europe.,2000	In.	(3), (5), (7),
	W15	Cassar, M. & Pender, R. .Climate Change and the Historic Environment.,2003	In.	(2), (4), (5),
	W16	Rolli, G. L. .Salvare i centri storici minori. Proposte per un atlante urbanistico dei centri d'Abruzzo,2005	In.	(2), (5), (6),
	W17	Colucci, E.; Kokla, M.; Noardo, F..Ontology-Based Data Mapping to Support Planning in Historical Urban Centres.,2021	In.	(1),
	W18	Colucci, E.; Xing, X.; Kokla, M.; Mostafavi, M.A.; Noardo, F.; Spanò, A..Ontology-Based Semantic Conceptualisation of Historical Built Heritage from Point Clouds.,2021	In.	(1), (2),
	W19	Colucci, E.; Kokla, M.; Mostafavi, M.A.; Noardo, F.; Spanò, A..Semantically Describing Urban Historical Buildings Across Different Levels of Granularity.,2020	In.	(2), (3), (4), (6),
	W20	Mercalli, L..Salire in Montagna: Prendere Quota per Sfuggire al Riscaldamento Globale.,2020	In.	(1), (3), (4),
	W21	Jeong, J. S.; García-Moruno, L.; Hernández-Blanco, J.; Sánchez-Ríos, A.; Ramírez-Gómez, Á..Identifying priority areas for rural housing development using the participatory multi-criteria and contingent valuation methods in Alange reservoir area, Central Extremadura (Spain),2017	In.	(1), (4), (7),
	W22	Fantechi, F.; Urso, G.; Modica, M..Can extreme events be an opportunity? Depopulation and resilience of rural communities in Central Italy after the 1997 earthquake,2020	In.	(2), (4), (5), (6),
	W23	De Montis, A.; Ledda, A.; Ganciu, A.; Serra, V.; De Montis, S..Recovery of rural centres and "albergo diffuso": A case study in Sardinia, Italy,2015	In.	(2), (3), (4), (5), (6),
	W24	Jovanović, R.; Almeida; García, F.; Cortés-Macías, R; Parzych, K..Assessment of wine tourism potential in the countries of the former Yugoslavia,2025	In.	(4), (7),
	WE1	Colucci, E.; Lingua, A.M.; Kokla, M.; Spanò, A..Minor Historical Centres Ontology Enrichment and Population.,2022	Ex.	Duplicate
	WE2	Cross, J. A..Megacities and Small Towns: Different Perspectives on Hazard Vulnerability.,2011	Ex.	Not open access

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	WE3	Predieri, A. .Report for the VI Convegno A.N.C.S.A.,1971	Ex.	Not open access
	WE4	Rosenzweig, C.; Solecki, W.; Hammer, S.; Mehrotra, S. .Urbanisation of climate change: Responding to a new global challenge.,2013	Ex.	Not open access
Snowballing	SN1	Horton, P.; Jaboyedoff, M.; Zimmermann, M.; Mazotti, B.; Longchamp, C..Flow-R Model for Debris-Flow Susceptibility.,2013	In.	(3),
	SN2	Bacci, E.; Cotella, G.; Staricco, L.; Brovarone, E.V..Quale accessibilità per le aree interne? Temi, sfide e prospettive per le politiche,2020	In.	(3), (7),
	SN3	Prezioso, M..Quale territorial impact assessment della coesione territoriale nelle regioni italiane,2018	In.	(1), (5),
	SN4	D'Alessandro, S.; Salvatore, R.; Bortoletto, N..Ripartire dai borghi per cambiare le città.,2020	In.	(3), (6),
	SN5	De Rubertis, S..Dinamiche insediative in Italia: spopolamento dei comuni rurali,2019	In.	(3), (6),
	SN6	Covino, R..Aree interne: una marginalità che parla al futuro.,2017	In.	(3), (6),
	SN7	Battisti, G..Le aree interne: un'interpretazione geopolitica.,2017	In.	(3), (6),
	SN8	Onni, G. & Pittaluga, P..Territori dell'abbandono. Strategie di rigenerazione per contesti spaziali e sociali in crisi demografica,2021	In.	(2), (3), (4),
	SN9	Canonaco, B. & Molezzi, F..The Recovery of The Beauty of Minor Historical Centers The Albergo Diffuso As A Means Of Reviving What Has Been Built,2016	In.	(3), (4), (7),
	SN10	Randazzo, G.; Italiano, F.; Micallef, A..WebGIS Implementation for Dynamic Mapping and Visualization of Coastal Geospatial Data: A Case Study of BESS Project,2022	In.	(1),
	SN11	Sau, A..La rivitalizzazione dei borghi e dei centri storici minori come strumento per il rilancio delle aree interne,2018	In.	(3), (4),
	SN12	Ginzarly, M.; Houbart, C.; Teller, J..The Historic Urban Landscape approach to urban management: a systematic review,2021	In.	(5),
	SN13	Pirlone, F..I borghi antichi abbandonati. Patrimonio da riscoprire e mettere in sicurezza,2016	In.	(3), (4),
	SN14	Morena, M.; Truppi, T.; Del Gatto, M. L..Sustainable tourism and development: the model of the Albergo Diffuso,2017	In.	(3), (4), (7),
	SN15	Vallone, C. & Veglio, V.."Albergo Diffuso" and Customer Satisfaction: A Quality Services Analysis,2013	In.	(4), (7),
	SNE1	Carrosio, G..I margini al centro. L'Italia delle aree interne tra fragilità e innovazione,2019	Ex.	Not open access
	SNE2	Paolella, A..Il riuso dei borghi abbandonati. Esperienze di comunità,2019	Ex.	Not open access
	SNE3	Corrado, F.; Dematteis, G.; Di Gioia, A..Nuovi montanari. Abitare le Alpi nel XXI secolo.,2014	Ex.	Not open access
	SNE4	Bertinotti, L. .Da borghi abbandonati a borghi ritrovati.,2020	Ex.	Not open access

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	SNE5	Silvestrelli, P..Hospitality innovation through historic sites requalification in Italy: evidences from Marche Region,2012	Ex.	Not open access
Gray literature	G1	ISTAT. La demografia delle aree interne.,2024	In.	(3), (5), (6),
	G2	ISTAT.The Geography of Inner Areas in 2020.,2022	In.	(3), (5),
	G3	European Commission.Annex to the Communication: Long-Term Vision for Rural Areas.,2021	In.	(3), (5), (6), (7),
	G4	McEldowney, J..Long-Term Vision for Rural Areas: European Commission Communication.,2021	In.	(3), (5),
	G5	Government of Italy.Adaptation Communication of Italy (UNFCCC Submission).,2023	In.	(3), (5),
	G6	Alpine Convention.Transport and Mobility in the Alps (State Of the Alpes Report 1).,2007	In.	(3), (5),
	G7	Alpine Convention.Water Management in the Alps (State Of the Alpes Report 2).,2009	In.	(3), (5),
	G8	Alpine Convention.Sustainable Rural Development & Innovation (State Of the Alpes Report 3).,2011	In.	(3), (5),
	G9	Alpine Convention.Sustainable Tourism in the Alps (State Of the Alpes Report 4).,2013	In.	(3), (5), (7),
	G10	Alpine Convention.Demographic Changes in the Alps (State Of the Alpes Report 5).,2015	In.	(3), (5), (7),
	G11	Alpine Convention.Greening the Economy in the Alpine Region (State Of the Alpes Report 6).,2017	In.	(3), (5), (6),
	G12	Alpine Convention.Risk Governance in Natural Hazards (State Of the Alpes Report 7).,2019	In.	(3), (5), (7),
	G13	Alpine Convention.Air Quality in the Alps (State Of the Alpes Report 8).,2020	In.	(3), (5),
	G14	Alpine Convention.Alpine Towns (State Of the Alpes Report 9).,2022	In.	(2), (3), (5),
	G15	Alpine Convention.Background Study for State Of the Alpes Report 10.,2023	In.	(2), (3), (5),
	G16	Alpine Convention.Workplan 2023–2025 — Action Group 6.,2023	In.	(3), (5),
	G17	Alpine Convention.Workplan 2023–2025 — Action Group 6.,2023	In.	(3), (5),
	G18	Veith (ed.).Why Invest in Sustainable Mountain Development? (FAO).,2011	In.	(3),
	G19	ISTAT.Forme e livelli dell'urbanizzazione in Italia.,2017	In.	(5),
	G20	Delmonaco, G.; Guarneri, E. M.; Moretti, P.; Nisio, S.; Pompili, R.; Pistocchi, L.; Puzzilli, L. M.; Traversa, F..Le Ghost Cities d'Italia, l'inventario ISPRA (national project summary) ,2023	In.	(5),
	G21	UNESCO.Recommendation on the Historic Urban Landscape (HUL),2011	In.	(3), (4),
	G22	UNESCO.HUL Guidance Notes.,2016	In.	(3), (5),

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