

PRINCIPAL ACADEMIC TUTOR

Anna Osello, Civil Construction Engineering, Politecnico di Torino

ACCADEMIC TUTORS

Paolo Oliaro, Dipartimento di Architettura, Ingegneria delle Costruzioni e Ambiente Costruito, Politecnico di Milano

Edoardo Patti, DAUIN, Politecnico di Torino

Enrico Fabrizio, DENERG, Politecnico di Torino

Francesco Laio, DIATI, Politecnico di Torino

EXTERNAL TUTOR

Chiara Ferroni, HUB NODES S.c.a.r.l

TEAM MEMEBRS



Chiara Bottarelli, Integrated Product Design, Politecnico di Milano



Giampaolo Conti, ICT for Smart Societies, Politecnico di Torino



Eleonora Digirolamo, Architecture for Heritage, Politecnico di Torino



Leonardo Di Nardo, Aerospace Engineering, Politecnico di Torino



Federica Gentili, Management Engineering, Politecnico di Torino



Kosar Mohammadi, Architecture for Heritage, Politecnico di Torino



Executive Summary

In the Italian context, where mountains and remote valleys suffer from limited accessibility and inadequate infrastructure, depopulation naturally emerges as a consequence for villages and towns located in those areas. This, in turn, makes efforts to revive local communities increasingly challenging. To reverse this trend and ensure the long-term viability of local economies, a deep understanding of the issue and well-informed decision-making are essential. GORSE was established in response to this challenge. Its mission is to develop a research-driven project focused on analyzing the various causes of depopulation and formulating effective methodologies to address them, ultimately aiming to repopulate these areas and revitalize local communities.

The Cervo Valley in Piedmont served as our primary investigation area. Due to its diverse environmental conditions, we chose to focus on a more specific location, better aligned with the GORSE brief and that of the external institution NODES: Desate, a scarcely accessible abandoned town. Then, to bridge the gap between initial analysis and practical solutions, we developed and distributed tailored questionnaires. These surveys reached a diverse group of stakeholders, including enterprises, second homeowners, local residents, tourists, and big city residents, all possessing varied levels of interest and influence within the valley. Their responses were crucial in understanding that the core drivers of depopulation are geographic isolation, compounded by the lack of public transport, as well as the absence of modern amenities and essential services. Stakeholders' specific needs and requirements guide us toward our ultimate proposed solution for reversing depopulation: a combination of Digital Twin development and the 'Albergo Diffuso' model.

To counteract the depopulation, we advocate a multi-faceted approach, based on:

- The establishment of an 'Albergo Diffuso' with revitalized communal spaces and requalified guest dwellings
- The development of self-sufficient infrastructures
- The employment of Digital Twin technology for safer simulations, predictive analytics and real-time monitoring for long-term resilience

The combination of fieldwork, stakeholder engagement, and digital innovation ensures that each step is grounded in both the reality of the site and the needs of its actual and potential community. However, the GORSE project does not stop here: it aims to provide a replicable framework for other territories facing similar issues, proving that reversing depopulation is possible through research, design and innovation.

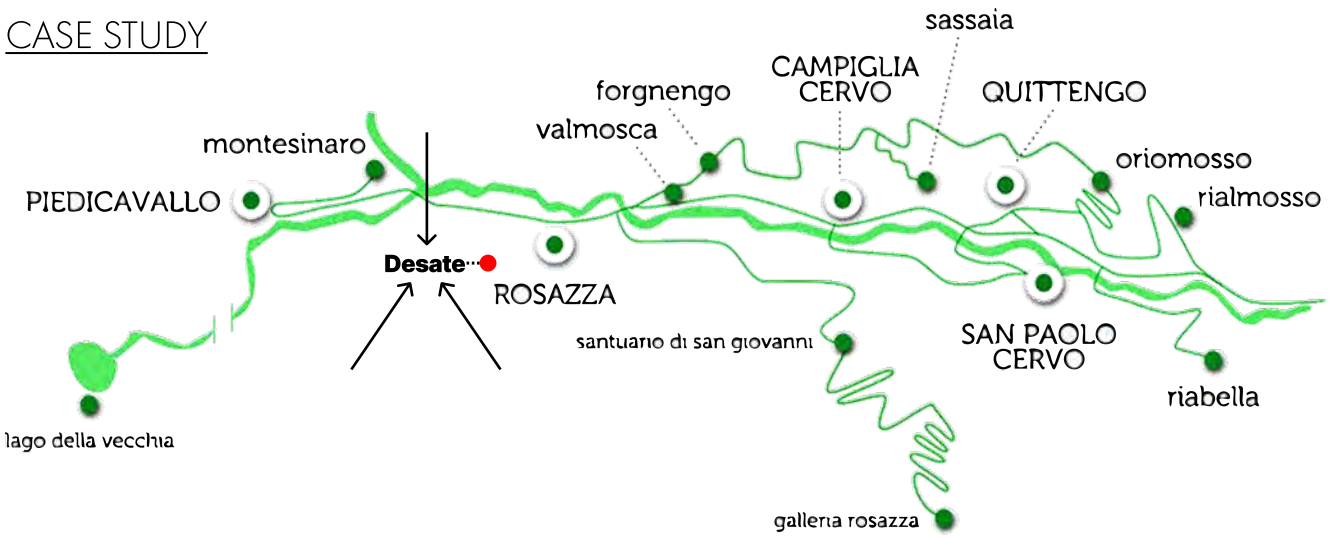
Key Words

Depopulation, Digital Twin, Albergo Diffuso, Adaptability

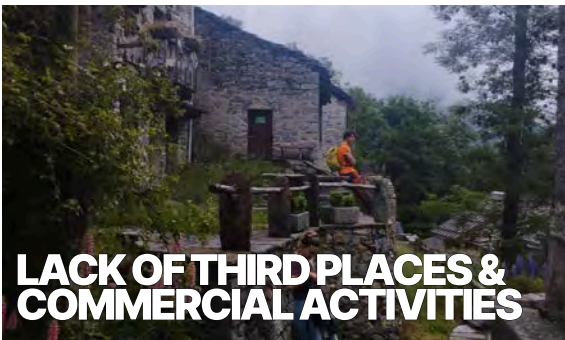


Google Earth view of Desate.

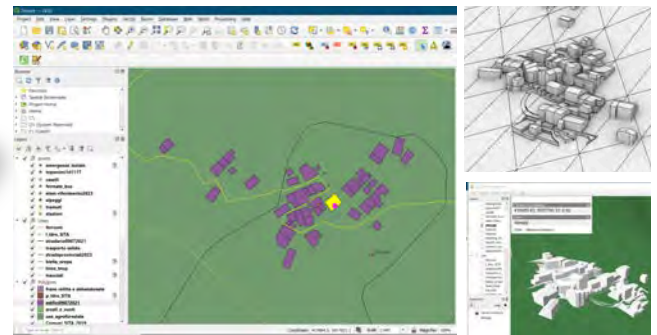
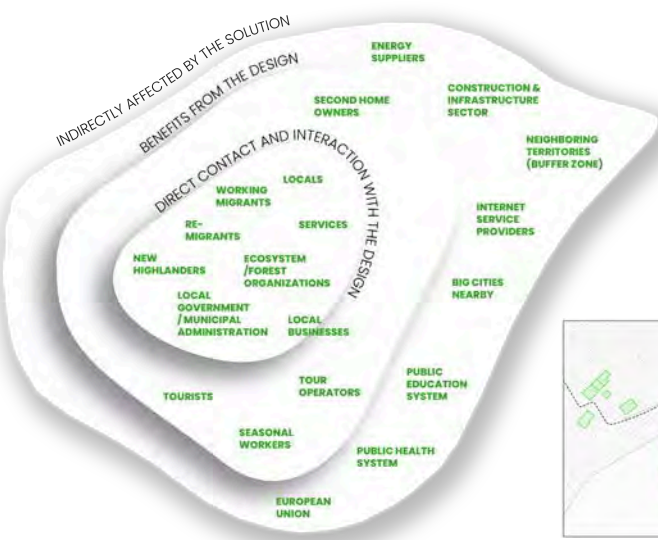
CASE STUDY



ON-SITE ANALYSIS



PROJECT DEVELOPMENT



Project description written by the Principal Academic Tutor

The GORSE project tackles the depopulation of Italian mountain areas, taking the Cervo Valley in Piedmont as its main case study and the nearly-abandoned hamlet of Desate as focus area. The issue is caused by geographical isolation, inadequate transport connections, lack of services, and scarce economic opportunities. The objective is to reverse this trend through informed design and digital innovation, combining analysis of the causes with stakeholder engagement, and the use of a Digital Twin to simulate sustainable solutions. The strategy unfolds into three phases: assessing the current conditions and understanding the dynamics of depopulation, proposing solutions like architectural regeneration, and simulating long-term sustainability and inclusiveness. To achieve this, the team conducted site visits, surveys, and interviews with different stakeholders, while the PESTLE analysis helped framing the political, economic, social, technological, legal, and environmental dimensions of the issue. The findings revealed that the stakeholders underlined the importance of the quality of life, cultural heritage preservation, creation of sustainable jobs, and reliable connectivity. The multidisciplinary approach of the team brought together expertise from design, engineering, architecture, and ICT, ensuring that the solution combined technical feasibility with social and cultural sensitivity.

The solution identified lays on the Italian concept of the “Albergo Diffuso”, which involves retrofitting interventions and the integration of the dwellings into a hospitality network. This model merges cultural preservation with tourism, while fostering community engagement and encouraging new long-term residents. The strategy also foresees the restoration of communal spaces, development of self-sufficient infrastructure, rainwater collection, and local food production, as well as the deployment of a Digital Twin to simulate the impacts of the interventions, both at the design and implementation phases. Through this, decision-making becomes evidence-based and long-term investments can be optimized. This digital platform allows scenario testing, real-time monitoring, and data-driven evaluations of different strategies, making the GORSE methodology both effective and replicable.

Ultimately, the GORSE project functions as a prototype within the EU-funded NODES ecosystem and is fully aligned with Italy’s National Recovery and Resilience Plan (PNRR). It provides a replicable framework that can inspire regeneration strategies for mountain and rural territories across Italy and Europe, demonstrating that through knowledge, planning, and collaboration, depopulation can be transformed into an opportunity for renewal.

Team description by skill

The GORSE project team is composed of six students whose multidisciplinary expertise was essential to addressing the objectives of the project.

Chiara Bottarelli is an Integrated Product Design student from Politecnico di Milano. She was responsible for the production of all visual outputs, including photographs, photo editing, renderings, videos, posters, and presentations using tools such as Lightroom and Figma.

Federica Gentili is a Management Engineering student from Politecnico di Torino. She played a crucial role in the feasibility analysis and in the evaluation of the proposed concept, with particular attention to aspects such as performance, sustainability, and socio-economic impact.

Eleonora DiGirolamo and Kosar Mohammadi are Architecture for Heritage students at Politecnico di Torino:
Kosar was responsible for the digital development of the project’s Digital Twin. This involved the collection and management of survey data to create a GIS of the village, the updating of terrain information, and the construction of a comprehensive 3D model organized into multiple layers using tools such as QGIS for geospatial mapping, Rhinoceros 3D and Autodesk AutoCAD for detailed modeling.
Drawing on the model of the albergo diffuso, Eleonora was responsible for the architectural dimension of the project, from the initial ideation and concept design to the detailed elaboration of masterplans for the entire village. This also included the production of detailed architectural drawings of residential units and shared spaces, developed primarily through AutoCAD. She also served as the Team Controller. In this capacity, she oversaw the coordination and supervision of organizational processes, including the collection and monitoring of project-related expenses.

Giampaolo Conti and Leonardo Di Nardo are respectively ICT for Smart Societies and Aerospace Engineering students at Politecnico di Torino:
Their combined background in complex systems design, communications systems, artificial intelligence frameworks and data analysis equipped proved highly relevant to the development of the research strategy and the integration of the available data in the model. They played an active role in stakeholders communication, conducting field visits in the area, making interviews with local residents and re-analyzing the responses collected through the various communication channels.

Goal

While the project focuses on the Cervo Valley, and specifically on the hamlet of Desate, as a case study, its ultimate goal is to generate insights and solutions that can be applied to other mountain villages facing similar demographic, social, and economic challenges. The GORSE project aims to reverse the trend of depopulation by leveraging a Digital Twin to support informed design and decision-making.

Our framework for mountain regeneration is based on the following principles:

- Integration of physical and digital innovation: architectural regeneration is combined with Digital Twin simulations to guide sustainable planning and investment.
- Preservation of cultural and environmental heritage: interventions respect local identity, landscapes, and traditions, while encouraging the adaptive reuse of existing structures.
- Community-driven approach: development takes place in close collaboration with residents, second-home owners, entrepreneurs, and potential newcomers, ensuring that real needs and aspirations are addressed.
- Focus on long-term resilience: the framework supports remote work, sustainable livelihoods, and year-round economic vitality beyond seasonal tourism.
- Transferability and scalability: the methodology can be adapted to different mountain and rural areas while remaining aligned with broader digital and green transition strategies.

Understanding the problem

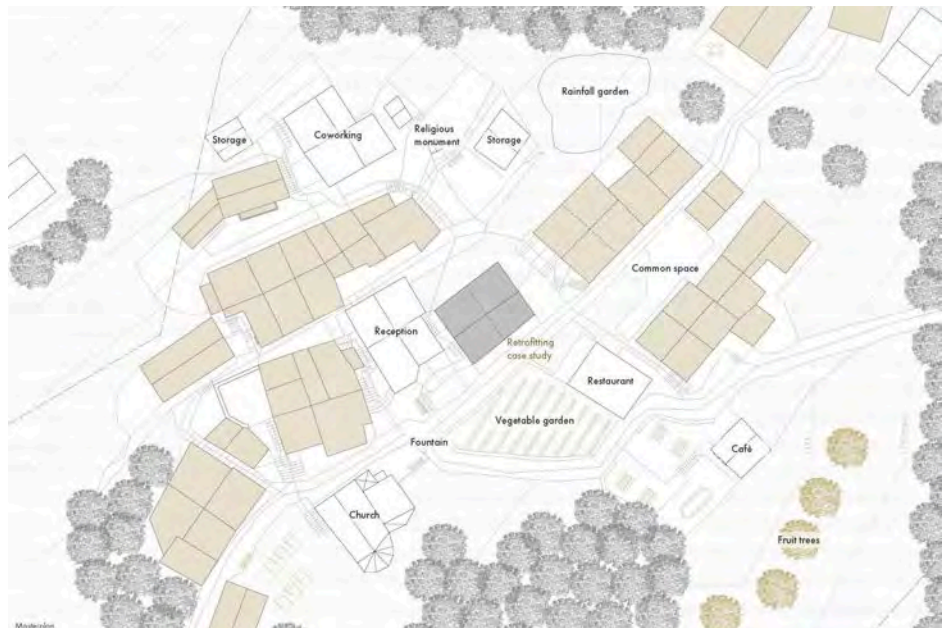
Mountain villages across Italy and Europe are experiencing a persistent trend of depopulation, driven by structural challenges that extend beyond individual communities [1].

Geographic isolation, limited accessibility, and inadequate infrastructure make daily life in these areas increasingly difficult. Essential services such as healthcare, education, and reliable public transport are often absent or insufficient, while digital connectivity, a prerequisite for modern work and communication, remains patchy or non-existent in many rural locations. Over time, these barriers have led to the progressive abandonment of once vibrant hamlets, leaving behind underutilized housing stock, disused community spaces, and fragile local economies.

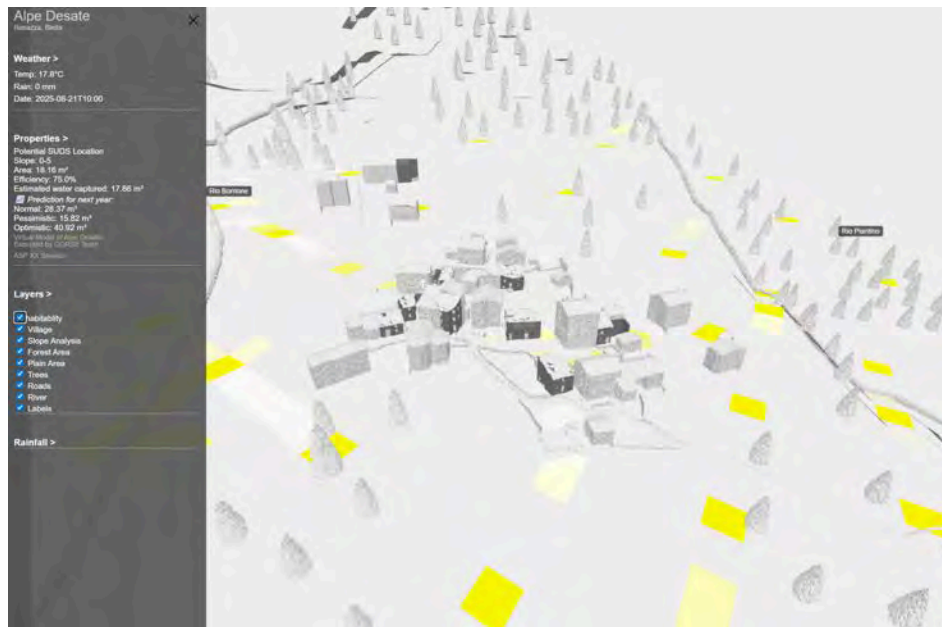
Depopulation is not only a demographic issue but also a social and cultural one. As residents leave, the traditions, practices, and identities that have shaped these regions for centuries risk being lost. Moreover, the lack of a stable resident population undermines the viability of local businesses, weakens social cohesion, and accelerates the decline of public services. Seasonal inflows of tourists or second home owners can temporarily alleviate the situation, but they fail to provide the year-round economic and social stability required to sustain these communities [2].

At the same time, broader global and national dynamics intensify the problem. Climate change is increasing the vulnerability of mountain areas, with rising risks of landslides, floods, and biodiversity loss [3]. Legal and administrative hurdles, such as fragmented property ownership and restrictive regulations on historic buildings, further complicate the reuse of abandoned assets. Economically, while tourism and remote working represent growing opportunities, they can only succeed if paired with adequate infrastructure and long-term planning.

Therefore, reversing mountain depopulation requires more than isolated interventions or short-term projects. It demands a systemic and sustainable approach that integrates cultural preservation, economic revitalization, environmental resilience, and technological innovation. Without such an approach, mountain villages like Desate in the Cervo Valley risk continuing on a trajectory of decline, with valuable cultural heritage and natural resources at stake.



Masterplan.



The Desate web application visualises habitability status, slope analysis and predicted water catchment through color coding.

Exploring the opportunities

Several strategies have already been attempted to address mountain depopulation. Tourism driven revitalization has brought temporary vitality but tends to generate seasonal dependence, with businesses thriving in the summer and struggling in the winter. The promotion of second home ownership has preserved some buildings and kept connections alive, yet these properties are often inhabited only for short periods, offering little contribution to year round stability. The albergo diffuso model, which repurposes abandoned housing into a dispersed hospitality system, has emerged as a more structured solution that respects heritage and enhances tourism, but on its own it risks becoming another seasonal strategy unless paired with stronger social and economic measures [4]. At the same time, new opportunities are emerging. The global spread of remote work allows families and professionals to consider relocating outside metropolitan areas, provided that reliable connectivity and basic services are available. Mountain villages can position themselves as attractive alternatives by combining natural and cultural heritage with digital infrastructure. In parallel, digital innovation, particularly the adoption of Digital Twins, offers a powerful tool to support regeneration. These virtual replicas of the territory can simulate interventions, monitor resources, and test long term scenarios, providing decision makers and communities with evidence based guidance and reducing the risks associated with investments [5]. Taken together, these opportunities point toward the need for an integrated approach. By combining traditional hospitality models with modern remote working possibilities and advanced digital tools, it is possible to design strategies that move beyond fragmented interventions and instead create sustainable, resilient, and replicable solutions for reversing depopulation in mountain areas.

Generating a solution

Our proposed solution centers on the implementation of the Albergo Diffuso model, a hospitality system that reuses existing housing stock within the hamlet of Desate to create a network of guest accommodations managed under a single structure. Unlike conventional hotels, which rely on new construction and centralized facilities, the Albergo Diffuso relies on restoring traditional dwellings and communal spaces, thus preserving the architectural identity of the village. Guest rooms are distributed across the hamlet, while common services such as reception, dining, co-working spaces and gathering areas are organized in refurbished communal buildings. This model provides visitors with the comfort of modern hospitality while immersing them in the authenticity of the local cultural and natural environment. The primary function of the Albergo Diffuso is not only to attract tourists but also to act as a catalyst for wider regeneration. By restoring abandoned houses, it demonstrates the feasibility of reusing existing assets rather than letting them decay. By revitalizing the central square and shared facilities, it re-establishes the social role of public spaces and fosters a renewed sense of belonging among residents and second home owners. By stimulating new flows of visitors, it creates opportunities for local businesses and entrepreneurs, from restaurants to artisanal shops, thereby generating a cycle of economic activity that extends beyond seasonal peaks [4].

The sustainability of the Albergo Diffuso model requires careful attention to infrastructure and resource management. Desate is only accessible on foot, which makes the hamlet both attractive and challenging. For this reason, the solution integrates self-sufficiency measures, such as rainwater harvesting for irrigation, vegetable plots for food cultivation, and renewable energy systems adapted to the mountainous environment. These measures reduce dependence on external supply chains, strengthen resilience to climate-related stresses, and increase the long-term viability of year-round living in the hamlet.

To validate and refine the concept, we employed a Digital Twin of Desate, developed as a decision support tool. The Digital Twin integrates geospatial, architectural, and environmental data into a dynamic virtual model of the hamlet. It accepts as input information such as the number and condition of houses, rainfall patterns, energy requirements, and stakeholder feedback. It then outputs visualizations and predictive scenarios, allowing us to test how the Albergo Diffuso would perform under different conditions. For example, simulations explored how rainfall could sustain small-scale agriculture, how many houses could realistically be restored for hospitality, and how the seasonal influx of visitors might impact infrastructure and resources.

The Digital Twin also allowed us to explore extreme and long-term scenarios. We simulated the case of continued depopulation, in which limited investment leads to further deterioration, as well as the opposite case of successful regeneration, in which the Albergo Diffuso attracts not only visitors but also permanent newcomers such as remote workers or returning families. By testing both positive and negative outcomes, the Digital Twin helped us identify the conditions under which the Albergo Diffuso can be most effective, ensuring that the proposed solution is both feasible and resilient.

The solution was tested using a combination of architectural modeling software, geospatial tools, and visualization libraries. QGIS was employed for mapping and analyzing geographic and environmental data, Rhinoceros 3D and AutoCAD were used to reconstruct and model the hamlet's architecture, and Three.js provided the interactive platform for presenting the Digital Twin. These technical tools were complemented by data collected from field visits, stakeholder questionnaires, and interviews, ensuring that the simulations reflect not only technical parameters but also the social and cultural realities of the valley. Through this iterative process, the Albergo Diffuso model, validated and enhanced by the Digital Twin, emerged as a comprehensive solution. It preserves cultural heritage, revitalizes social and economic life, and leverages technology to anticipate future challenges. Most importantly, it provides a replicable framework: the same methodology can be applied to other depopulated mountain villages, where the combination of adaptive reuse and digital validation can transform abandonment into opportunity.

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