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# Tradition and innovation in Mediterranean inner rural areas. The role of sustainable technology on preserving traditional architecture and creating Smart Villages comparing Palermo and Valencia

## Tradición e innovación en las zonas rurales del Mediterráneo. El papel de la tecnología sostenible en la preservación de la arquitectura tradicional y la creación de pueblos inteligentes: comparación entre Palermo y Valencia

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**Abstract:** The objective of this research is to explore pathways for the creation of Smart Villages in the Mediterranean context, with a focus on the Madonie Park—an extensive area comprising 21 municipalities within a UNESCO Global Geopark—and the Province of Castellón in Valencia. These rural territories are currently affected by depopulation, demographic decline, and limited employment opportunities. Through a comparative methodology applied to the villages of Polizzi Generosa and Morella, the study investigates technological implementations in buildings and public spaces able to demonstrate how sustainability and technological innovation can coexist with the preservation of architectural heritage, local history, and cultural identity. The results show that the 'intelligence' of these places lies in their capacity to achieve high standards of quality of life without altering the intrinsic values of protected and well-preserved environments. By integrating tradition and innovation, these villages can offer a contemporary and sustainable model of living, providing an alternative to the dynamics of large metropolitan centres. The scientific contribution of this study lies in proposing a replicable smart rehabilitation workflow tailored to Mediterranean inner rural contexts, grounded in comparative typological analysis and compatible technological integration.

**Keywords:** smart villages; smart rehabilitation; Mediterranean rural architecture; inner areas; sustainable building technologies.

**Resumen:** El objetivo de esta investigación es explorar vías para la creación de pueblos inteligentes en el contexto mediterráneo, con especial atención al Parque de las Madonie —una extensa área que comprende 21 municipios dentro de un Geoparque Mundial de la UNESCO— y la provincia de Castellón en Valencia. Estos territorios rurales se ven afectados actualmente por la despoblación, el declive demográfico y la escasez de oportunidades laborales. Mediante una metodología comparativa aplicada a los pueblos de Polizzi Generosa y Morella, el estudio investiga implementaciones tecnológicas en edificios y espacios públicos que demuestran cómo la sostenibilidad y la innovación tecnológica pueden coexistir con la preservación del patrimonio arquitectónico, la historia local y la identidad cultural. Los resultados muestran que la "inteligencia" de estos lugares reside en su capacidad para alcanzar altos estándares de calidad de vida sin alterar los valores intrínsecos de entornos protegidos y bien conservados. Al integrar tradición e innovación, estos pueblos pueden ofrecer un modelo de vida contemporáneo y sostenible, proporcionando una alternativa a la dinámica de los grandes centros metropolitanos. La contribución científica de este estudio reside en proponer un flujo de trabajo de rehabilitación inteligente y replicable, adaptado a los contextos rurales interiores del Mediterráneo, basado en un análisis tipológico comparativo y una integración tecnológica compatible.

**Palabras clave:** pueblos inteligentes; rehabilitación inteligente; arquitectura rural mediterránea; zonas interiores; tecnologías de construcción sostenible.

## INTRODUCTION: MEDITERRANEAN BASIN, A PLACE TO LIVE IN INNER RURAL AREAS

Known for their red tile roofs or flat terraces, white plasters and stucco exteriors, and ornate archways, Mediterranean-style homes are among the most recognized architectural types worldwide. Although initially inspired by Italy, Portugal, Spain, and other countries bordering the Mediterranean Sea, over time this style has absorbed influences from France, Greece, Morocco, and other regions. Because of these diverse cultural influences,[1] it can also be referred to as Spanish Colonial, Moroccan, Mission Revival, or Neo-Mediterranean, among other names. Despite differences in style and influence, all Mediterranean homes are conceived as relaxing retreats that connect inhabitants with nature. Small houses with large windows and doors opening onto patios, terraces, or balconies are designed to integrate harmoniously with their surroundings, promoting a sense of comfort and well-being. However, there is not a single Mediterranean identity. Rather, there exist multiple Mediterranean identities, shaped not by homogeneity but by unity emerging from diversity, contacts, and interconnections. The perception of the Mediterranean encompasses nature, culture, history, lifestyle, landscape, and, of course, architecture.[2] Addressing the question of identity requires attention to all these aspects.[3] In the context of globalization, there is a growing tendency toward the homogenization of socio-economic realities and local cultures.[4] To resist this, it is necessary to rediscover local identity and valorise territorial skills and specificities.

Local economies, such as those in inner rural areas, need to be strengthened through policies that consolidate self-sufficiency and resilience, forming a foundation for renewed development.[5] Local identities are not obstacles to global economic participation; rather, they represent development models open to exchange. Identifying a territory's vocation establishes a foundation for productive specialisation, rooted in the community's strong local identity. For instance, a company's territorial origin, or the historical and cultural connection of its products with the place of origin, constitutes a key asset for competing successfully in international markets. It is possible to pursue sustainable local development while remaining open to global competition, leveraging the potential of natural communities.

This is particularly relevant for rural areas, often distant from service centres, facing demographic challenges, but endowed with significant environmental and cultural resources, which have become even more attractive in the post-COVID-19 era. Now is the time to "connect" cities and inner areas. The peripherality of rural zones derives from lower accessibility to essential services, which underpin the very notion of citizenship. To prevent peripherality from becoming marginality, it is necessary to reorganize and enhance service provision, improve mobility and transportation infrastructure, and update the built heritage and make it contemporary and functional. Inner rural areas play a crucial role in preserving socio-economic development for local communities, as demonstrated by European-level interventions, such as those under the Common Agricultural Policy. The first quarter of 2020 revealed that low-density rural living can offer significant advantages during epidemics or conflicts, with urban populations being more vulnerable. This has prompted many people to consider relocating to the countryside.

Rural environments offer numerous benefits, but also limitations. Not everyone can adapt to rural life, so relocation must be carefully planned and supported by services comparable to those of cities. Many individuals today, especially those born in metropolitan areas, prefer quieter environments for cleaner air, lower cost of living, stronger social ties, and larger spaces. Cities, by contrast, are denser, more expensive, and often offer smaller living spaces. However, rural life also presents challenges, such as fewer employment opportunities,[6] limited healthcare, infrastructure gaps, and reduced access to cultural amenities like museums or performances. A possible solution lies in improving rural conditions to bridge the gap with urban

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areas. For example, rehabilitating buildings and transforming simple country houses into energy-efficient, high-performance buildings could make rural areas highly competitive compared to urban housing.

The Mediterranean region, moreover, is characterized by similarities across countries. Italy and Spain share numerous traits, including traditional architecture, with their villages and inner areas offering opportunities for comparative analysis. Innovative technological solutions can enhance the "smart" potential of these territories,[7] making them attractive and functional for communities.[8] This research wants to compare the traditional architecture into two rural villages in different countries: the villages of Polizzi Generosa in Sicily, Italy, and the rural village of Morella in Valencia, Spain, emblematic of rural areas rich in traditional architecture, art, and history but currently underutilized. The aim is to demonstrate how advanced technological interventions in building and urban design can revitalize these regions, fostering sustainable, globalized, and economically proactive communities, beginning with the redevelopment of outdated and energy-poor housing stock. This comparative approach not only highlights typological and material differences but also evaluates how context-specific technological interventions can optimize energy performance, user comfort, and environmental sustainability without compromising cultural identity. By linking architectural typology to energy retrofitting strategies, the study provides operational insights for policymakers, architects, and local authorities.

While numerous studies address Mediterranean rural architecture and others focus on Smart Village policies, limited research has systematically connected typological architectural analysis with energy upgrading workflows in a comparative Mediterranean framework. This study aims to fill this gap by integrating conservation theory and smart rehabilitation strategies through a cross-national comparison. Despite the growing body of literature on Mediterranean rural heritage and Smart Village policies, research rarely integrates typological architectural analysis, energy upgrading strategies, and governance tools within a single comparative Mediterranean framework. This fragmentation limits the operational transferability of smart rehabilitation models to inner rural contexts. This study addresses this gap by proposing a comparative and workflow-based methodological model, tested through the cross-analysis of Polizzi Generosa and Morella, aiming to structure technological integration as a conservation-driven process rather than a purely technical upgrade.

## METHODOLOGY: A COMPARISON BETWEEN TWO INNER RURAL AREAS AND COMMON TECHNICAL AND INNOVATIVE SOLUTIONS FOR THEIR SURVIVAL: POLIZZI GENEROSA AND MORELLA

The inner areas of Sicily are deeply influenced by Mediterranean culture, evident in numerous buildings that preserve traditional architectural characteristics. The Madonie mountain area, the focus of this study, exemplifies this heritage. Comprising 21 villages scattered across central Sicily, these communities have largely maintained their historical morphology and architectural charm. Located within a UNESCO Geopark, the area boasts unique flora and fauna, preserved through the combined efforts of the Park Authority and the Superintendence, ensuring that both the landscape and built heritage remain intact. The climate is strongly seasonal, with hot summers and cold, snowy winters, further shaping local building practices. The economy of the Madonie region relies heavily on agriculture and secondary sectors, contributing significantly to the island's production of distinctive "slow food" products. The population is predominantly elderly, and employment opportunities matching local skills are scarce. Depopulation is a pressing issue, prompting the need for innovative strategies to revitalize the area, attract new residents, and ensure adequate services that enable a high quality of life comparable to urban centres.

1a)

1b)

1c)

1d)

**Figure 1.** 1a) Village of Polizzi Generosa, Palermo, Sicily from above. 1b) Municipality of Morella, Castellón, Valencia, from above. 1c) Village of Polizzi Generosa, Palermo. 1d) Morella, Castellón. The image provides a visual comparison between the two rural contexts, highlighting both the landscape and urban patterns. It also explores finer scales, entering streets to reveal the character and materiality of the built heritage.

One of the villages selected as a case study,[9] in this area, is Polizzi Generosa (Figure 1a, 1c), whose history is deeply intertwined with Sicilian events. Conquered by Arabs in 882 and Normans in 1082, Polizzi G. evolved through periods of autonomy and feudal control, ultimately receiving the title "Generosa" from Frederick II of Swabia in 1234. Over centuries, it experienced alternating domination by the Aragonese, Charles V, and others, which shaped its cultural and architectural heritage. Polizzi served as a key trade crossroads between Palermo and Messina, earning the nickname "Florence of the Madonie" due to its wealth of monuments, including castle ruins, fortification walls, and the 1817 Roman aqueduct. Urban regeneration strategies are currently being implemented, leveraging Italian National Recovery and Resilience Plan (PNRR) funds to enhance tourism and valorise the village's art, tradition, and architecture. Summers are short, hot, and dry, while winters are long, cold, and wet.

In the Valencian region (Figure 1b, 1d), similar challenges and opportunities are present. Many rural areas, particularly in the province of Castellón,

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remain sparsely inhabited, with Morella serving as a notable example. This medieval town, 170 km from Valencia and home to 2430 residents, joined the network of Spain's most beautiful towns in 2013. Its strategic location historically connected the Ebro Valley with the Mediterranean, witnessing occupation by multiple civilizations, from prehistoric times to the Middle Ages. Morella's heritage includes a castle, 2.5 km of fortified walls, the Santa Lucía Aqueduct, prehistoric caves, the Camino del Cid, and the Gothic-Renaissance Iglesia de Santa María. Tourism and services are the main economic drivers, followed by agriculture and animal husbandry. The climate is marked by mild summers and harsh winters with regular snow, while terraces and pine, oak, and holm-oak groves reflect centuries of human adaptation to mountainous terrain.

Both villages, Polizzi Generosa and Morella, share common characteristics in their traditional rural architecture. Residential buildings typically feature uninsulated and unventilated wooden roofs, façades with stone or brick cornices, walls in exposed stone or plaster, wooden floors or *bóvedas tabicadas* (timbrel vaults), wooden partition walls, single-glazing windows with shutters, and doors with traditional motifs. The architectural rigor in construction techniques and colours is notable, yet the abandonment of rural areas has left many buildings neglected. Recent incentives in both Italy and Spain aim to restore these historic buildings. In Italy, European funds, including the "Superbonus" are being used for residential rehabilitation and energy upgrading.[10] While, in Spain, the PREE 5000 program (an energy retrofit funding scheme targeting buildings in small and rural municipalities) provides subsidies for energy refurbishment of buildings in municipalities with fewer than 5000 inhabitants, alongside other support for improving the thermal envelope, lighting, and heating systems. Renewable energy solutions such as solar thermal, biomass, geothermal, hydrothermal, and aerothermal systems, often combined with storage batteries, are encouraged. These interventions must balance energy efficiency and modern comfort with heritage preservation, ensuring that historic buildings retain their original character while adapting to contemporary needs. Rural dwellings, such as single-cell tower houses with workshops and residential floors, can benefit from innovative technologies that enhance indoor comfort, outdoor usability, and real estate value, while preserving identity and historical significance.

This study therefore incorporates an analysis of previous research and of the identity-defining features of traditional architecture, aimed at understanding not only the architectural forms and construction techniques, but also the most appropriate strategies for their rehabilitation.

The analysis included: (i) on-site survey and photographic documentation; (ii) typological classification of buildings; (iii) review of regional rehabilitation incentives; and (iv) assessment of climatic performance and energy vulnerability. The workflow model was subsequently derived from the cross-comparison of shared deficiencies and context-specific constraints. The methodology ensures interventions are reversible and heritage-compatible, following a 'knowledge-based construction site' approach that combines traditional understanding with modern performance criteria.

Such an approach enables the identification of technological applications capable of transforming the existing built heritage into a contemporary, liveable asset that meets current residential standards while respecting its historical value. The analysis of material and construction characteristics, building typologies, and architectural features represents, in both case studies, an effective methodological approach for understanding the nature of the built heritage and for identifying both similarities and differences between the two contexts. The objective of this analysis is not purely conservative; rather, it is grounded in the preservation and deep knowledge of the built environment —commonly referred to as a "knowledge-based construction site"—[11] which provides the foundation for informed and compatible interventions.[12] Through visual and

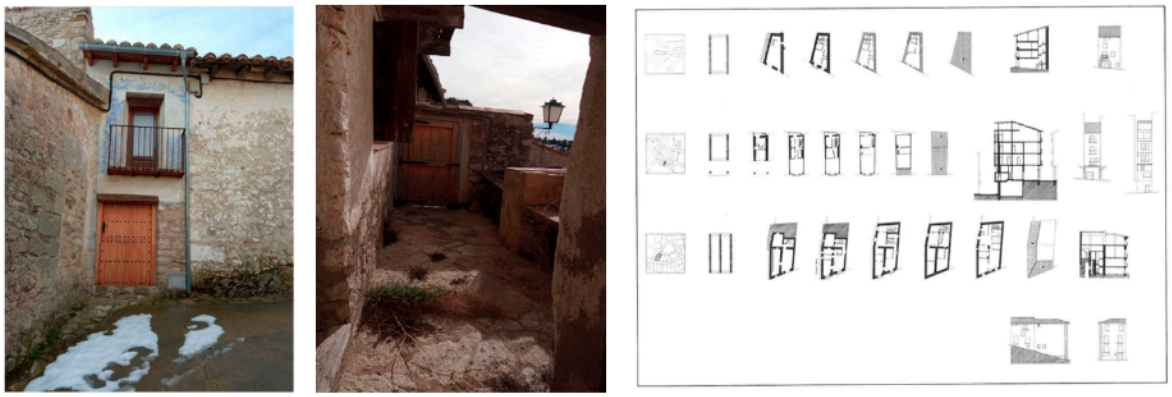

**Figure 2.** A rural house in Morella, Castellón, Spain, and Typological analysis of Morella's rural architecture (2023).


**Figure 3.** A rural house in Polizzi Generosa, Madonie, Sicily, Italy, and Typological analysis of Madonie's rural architecture.

typological analysis, the study seeks to guide transformations that do not distort or compromise the original architectural identity, but instead adapt it through measured, compatible modifications. These interventions are conceived to enhance habitability, energy performance, and functional quality, while ensuring that traditional buildings evolve in accordance with contemporary living requirements and sustainability goals.

By studying exemplary traditional architecture in Sicily (Figure 2) and Spain (Figure 3), this research identifies technological solutions that enable the revival of ancient villages. The goal is to rehabilitate buildings toward near-zero energy performance, integrating sustainable technologies without altering the architectural heritage. Professionals play a key role in defining strategies that make rural areas competitive, attractive, and viable alternatives to urban centres.

## Comparative Analytical Framework

The comparative analytical framework is structured around four main dimensions: (i) morphological and typological configuration of the built fabric; (ii)

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**Table 1 .** Comparative Synthesis between Polizzi Generosa and Morella

| Parameter | Polizzi Generosa (Sicily) | Morella (Valencia) | Common Elements | Main Divergences |
|---|---|---|---|---|
| **Geographical context** | Madonie Mountains, UNESCO Geopark | Castellón Mountains, fortified medieval town | Mountainous inland territories | Different regional governance systems |
| **Demographic trend** | Strong depopulation, aging population | Moderate depopulation, tourism-supported stability | Rural demographic decline | Tourism impact more relevant in Morella |
| **Urban morphology** | Compact medieval fabric, terraced adaptation | Fortified hilltop town, enclosed walls | Dense historical cores | More defensive urban structure in Morella |
| **Construction materials** | Local stone, lime plaster, timber roofs | Local stone, lime mortar, *bóvedas tabicadas* | Traditional masonry techniques | Vaulted floors more common in Morella |
| **Roof typology** | Pitched roofs with Sicilian tiles | Pitched roofs, some flat terraces | Clay tile roofing systems | Climatic detailing differs |
| **Climatic conditions** | Hot summers, cold snowy winters | Mild summers, harsh winters with snow | Strong seasonal variation | Higher summer overheating risk in Sicily |
| **Energy vulnerability** | Uninsulated envelopes, single glazing | Similar envelope deficiencies | Low energy performance (G–F class) | Tourism-oriented renovations more frequent in Spain |
| **Governance tools** | Italian PNRR, Superbonus | PREE 5000, regional heritage incentives | EU-driven funding mechanisms | Different administrative procedures |
| **Landscape protection** | Strong control by Superintendence | Protection through heritage listing | High heritage constraints | Regulatory flexibility differs |
| **Technological compatibility** | Need for high summer shading and passive cooling | Higher winter heating demand | Renewable integration possible | Climatic priority shifts |

constructive techniques and material characteristics; (iii) climatic adaptation strategies; and (iv) governance and funding tools supporting rehabilitation processes. Rather than describing the two villages independently, the comparison aims to identify convergences and divergences that influence the implementation of smart rehabilitation strategies. The objective is to understand how similar Mediterranean rural contexts respond differently to technological integration according to climatic conditions, demographic trends, and institutional frameworks.

The comparative synthesis presented in Table 1 highlights both structural affinities and context-specific divergences that directly influence the feasibility and prioritization of smart rehabilitation strategies. While the two villages share a common Mediterranean constructive culture—characterized by masonry envelopes, clay tile roofing systems, and compact urban morphology—their climatic exposure and governance frameworks introduce differentiated operational constraints. From an energy perspective, both contexts reveal similar envelope deficiencies and low-performance building components, confirming the suitability of a shared intervention workflow focused on thermal upgrading and renewable integration. However, climatic divergence emerges as a decisive variable: in Polizzi Generosa, summer overheating and strong landscape protection measures require passive cooling strategies and minimal visual impact solutions, whereas in Morella, winter heating demand and tourism-driven adaptive reuse favour improvements in thermal inertia and seasonal energy management. Institutional tools further shape implementation dynamics. Although both

territories benefit from European funding mechanisms, differences in administrative procedures and incentive structures affect the scale, timing, and accessibility of rehabilitation processes. These findings confirm that smart rehabilitation cannot be conceived as a standardized technical package, but must be calibrated according to climatic, morphological, and governance-specific conditions. Rather than emphasizing differences alone, the comparison demonstrates the existence of a transferable methodological core adaptable to diverse Mediterranean rural territories. This adaptability constitutes the foundation for the proposed workflow model. The comparison also allows the identification of a transferable workflow core: envelope insulation, passive climate control, renewable energy integration, and landscape-sensitive interventions. While local priorities differ, these elements form a replicable framework for smart rehabilitation in Mediterranean inner areas. Such adaptability demonstrates that technological solutions can be harmonized with both heritage conservation and contemporary living requirements, providing a model that is context-sensitive yet operationally generalizable.

## RESULTS & DISCUSSION: SMART REHABILITATION FOR INNOVATION IN TRADITION

Among the innovative technological solutions (Figure 4) identified worldwide, a primary focus is the structural consolidation of historic buildings using traditional techniques, and, where this is not feasible, the careful application of modern technologies for preservation. The rehabilitation process can be understood as a structured workflow that ensures efficiency and conservation coexist. First, an assessment of the existing heritage is essential (Figure 4), evaluating structural, energy, and functional conditions, including materials, roof and wall construction, floor types, and overall state of preservation. Based on this assessment, structural consolidation is undertaken, prioritizing traditional construction techniques to reinforce existing structures, while modern technologies are applied only when necessary to guarantee preservation and maintain architectural integrity. Energy efficiency represents a fundamental component of the workflow. Buildings can benefit from high-performance insulation in walls, roofs —including ventilated systems— and floors, using natural or nanotechnology-based materials with low thickness and thermal conductivity. Wood fiber insulation integrated with X-LAM panels, heat pump systems providing heating, cooling, domestic hot water, and mechanical ventilation with thermodynamic rehabilitation and electronic filtration, are viable solutions. In addition, geothermal fields with horizontal probes approximately two meters deep can pre-treat incoming air or support free-cooling operations, enhancing indoor comfort.

Advanced home automation technologies play a central role in optimizing energy management and indoor environmental conditions. Radiant heating systems can be integrated into floors or partitions, combined with light screeds and condensing boilers, and complemented by renewable energy sources such as solar or photovoltaic panels or solar thermal systems designed to harmonize with the surrounding landscape. High-performance double-glazing windows, water recovery systems such as rain gardens, and roof gardens help regulate indoor and outdoor temperatures, purify air, manage rainwater, save energy, and enhance biodiversity. LED lighting, automatic shut-off switches, and solar tubes further minimize electricity consumption, while all technological devices are discreetly incorporated to maintain the architectural and historical value of the buildings.

These solutions can raise buildings to near nZEB standards, improving ratings from G–F to A+, reducing costs and enhancing living conditions. These strategies are applicable to both case studies, particularly Polizzi Generosa, where the surrounding natural landscape and the supervision of the Superintendence ensure that heritage protection remains a priority. The challenge is balancing efficiency with compatibility,

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**Figure 4.** Integrated technological framework for the smart rehabilitation of historic Mediterranean buildings. The diagram illustrates a holistic approach to rural heritage conservation, categorised into six strategic areas: (1) Advanced Insulation, utilising wood fibre and ventilated systems; (2) Low-Carbon HVAC, featuring heat pumps and passive strategies; (3) Renewable Integration, including solar, geothermal, and biomass; (4) Smart Automation, for energy management and indoor air quality; (5) Sustainable Water & Landscape, incorporating rain gardens and recycling systems; and (6) Performance Optimisation, aimed at achieving near-nZEB standards while preserving architectural and landscape identity.

using technology to conserve and enhance rather than disrupt. This workflow shows that smart rehabilitation is a strategic approach to revitalising inner rural areas, not just a technical upgrade. By integrating traditional knowledge, innovative technologies, and environmental considerations, historic buildings can become energy-efficient, comfortable, and resilient, supporting sustainable repopulation and the long-term preservation of cultural heritage. Moreover, this integrated approach fosters multi-stakeholder collaboration, combining the expertise of local authorities, conservation bodies, and technological providers, ensuring that interventions are socially, environmentally, and economically sustainable. Such collaboration is essential to guarantee that rehabilitation strategies are not only technically feasible but also aligned with community needs and governance frameworks.

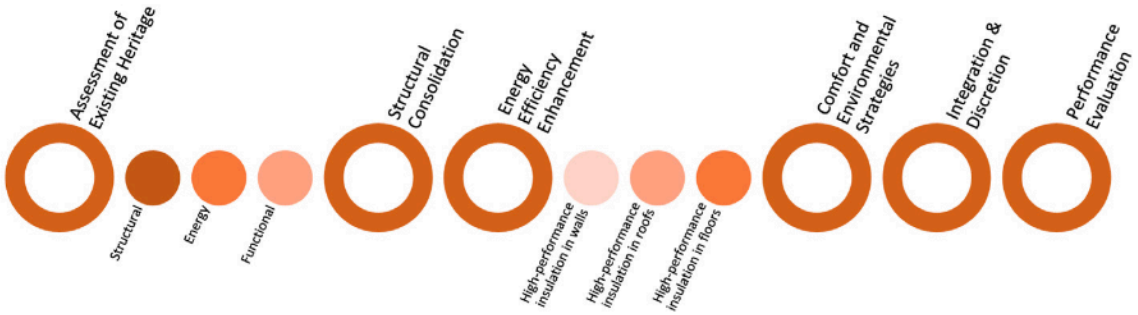


**Figure 5.** Workflow for smart rehabilitation of rural heritage: from assessing the state of conservation and structural consolidation, to energy upgrading through insulation, high-efficiency systems, renewable energy, and home automation, culminating in the enhancement of the architectural and landscape identity of the sites.

This workflow represents the core methodological contribution of the research, as it structures rehabilitation not merely as an energy upgrade, but as a multi-layered process integrating conservation, technology, governance, and landscape compatibility. In this workflow, interventions are prioritized according to context-specific constraints, such as climate extremes, building typology, and governance regulations, ensuring that energy efficiency upgrades do not conflict with conservation standards. By explicitly linking technical choices to typological and climatic characteristics, this approach enables practical decision-making for architects and planners in similar Mediterranean contexts.

### Shared Challenges and Context-Specific Constraints

The comparative analysis highlights that both Polizzi Generosa and Morella face similar structural and energy deficiencies, primarily related to uninsulated masonry envelopes, outdated roof systems, and low-performance windows. These shared vulnerabilities confirm the suitability of a common smart rehabilitation workflow based on envelope upgrading, renewable integration, and indoor comfort optimization. However, important contextual differences influence technological prioritization. In Polizzi Generosa, summer overheating risk and landscape constraints imposed by the UNESCO Geopark status require particular attention to passive cooling strategies, shading systems, and minimal visual impact of photovoltaic installations. In Morella, by contrast, winter heating demand and the strong tourism-driven economy create greater emphasis on thermal inertia improvement, heating efficiency, and seasonal adaptability of buildings used for hospitality purposes. Governance structures also affect implementation. While both contexts benefit from European funding frameworks, administrative procedures and incentive mechanisms differ, shaping the pace and scale of interventions. These divergences demonstrate that smart rehabilitation cannot be applied as a standardized technical package, but must be calibrated according to territorial, climatic, and institutional variables.

## CONCLUSION: TECHNOLOGY AND REHABILITATION AS A SOLUTION FOR THE ENHANCEMENT OF TERRITORIES AND THE CREATION OF SMART VILLAGES

The comparative results demonstrate three principal convergences: first, the structural compatibility between traditional Mediterranean construction

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techniques and contemporary energy upgrading strategies; second, the shared demographic fragility that makes residential rehabilitation a strategic priority; and third, the feasibility of integrating renewable technologies without compromising architectural identity. At the same time, the analysis reveals key divergences. Climatic variations influence technological prioritization (cooling-oriented solutions in Sicily versus heating-oriented strategies in Valencia), while governance frameworks shape the operational pathways for implementation. These differences confirm that smart rehabilitation must be context-sensitive, even within culturally similar Mediterranean territories. The study demonstrates that replicable smart rehabilitation strategies can be developed by combining traditional knowledge with modern technologies, tailored to local climatic, demographic, and governance conditions. Future implementation should include quantitative monitoring and life-cycle assessment to validate energy performance, economic feasibility, and long-term sustainability.

Carefully applied technological innovation in inner rural areas, especially in housing, is a key tool for revitalising nearly depopulated communities. While interventions at the urban scale are widely explored, the liveability of small housing aggregates must receive equal attention. Rehabilitating historic buildings is not merely an architectural act; it represents a strategic choice to provide viable alternatives to chaotic urban centres, transforming inner areas into places that combine cultural tourism with functional, everyday living.[13] Through meticulous analysis and technological adaptation, historic buildings can meet contemporary comfort standards while remaining competitive and attractive for new residents.[14]

The research is limited by the absence of quantitative post-intervention performance monitoring, as the workflow is currently based on typological and technical compatibility analysis rather than empirical energy simulations or real-case retrofitting data. Future research should integrate building performance modelling and life-cycle assessment to validate the environmental and economic impact of the proposed framework.

This research therefore proposes not a catalogue of technologies, but a transferable methodological model grounded in comparative typological analysis and calibrated technological integration. The workflow developed through the comparison between Palermo and Valencia represents a replicable framework for other Mediterranean inner rural territories facing similar demographic and environmental challenges.

Energy efficiency in historic buildings is central to this approach. Integrating insulation in walls, roofs —including ventilated roofs— and floors, using advanced natural or nanotechnology materials with low thickness and thermal conductivity, allows for a dramatic reduction in energy consumption and emissions. The adoption of wood fibre insulation with X-LAM panels, heat pump systems covering heating, cooling, domestic hot water production, mechanical ventilation with thermodynamic rehabilitation, and electronic filtration exemplifies this integration. Additionally, geothermal fields with horizontal probes for air pre-treatment or free-cooling, radiant heating systems embedded in floors or partitions, condensing boilers, and renewable energy sources such as photovoltaic or solar thermal panels can be harmonized with the surrounding landscape. High-performance double-glazing windows, water recovery systems including rain gardens, rooftop gardens, LED lighting, automated switches, and solar tubes further optimize efficiency while respecting the architectural and environmental context. Critically, all technological elements must be discreetly incorporated to preserve the aesthetic and historical value of the buildings. The cumulative effect of these solutions can elevate a building's performance to near nZEB standards, improving energy ratings from G–F up to A+, delivering not only low running costs but also high-quality, sustainable living environments.

Rural areas harbour unique cultural and artisanal traditions that are frequently neglected amid urban expansion. Their preservation demands collaborative engagement among technicians, companies, local administrations, and broader stakeholders. By exchanging knowledge, strategies, and practical solutions, these actors co-create rehabilitation processes that safeguard both tangible and intangible heritage. This model, often conceptualized as an "Art Village," enables communities to harness technological and scientific innovation while reinforcing the collective memory, identity, and cultural value of the area.

A Mediterranean perspective on Smart Village development emphasizes sustainability, local resource valorisation, and cultural continuity. It seeks a balance between human settlements and the natural environment, honouring historical and artistic heritage while promoting strong inter-community relations.[15] Smart Villages integrate technology not as an intrusive force, but as a tool to enhance energy efficiency, comfort, and resource sustainability while simultaneously preserving local traditions,[16] arts, and crafts.[17] In this vision, villages function as holistic systems, where environmental, social, and cultural values converge to create resilient, liveable, and identity-rich communities. Preserving small rural settlements and minor centres is critical not only to maintain the material fabric of architecture but also to protect intangible cultural assets, encompassing art, customs, and collective memory. The disappearance of these villages would signify the loss of entire historical and cultural lineages.[18] Strategic, technology-driven rehabilitation represents a pathway to secure their continuity. The findings also suggest that European and regional funding mechanisms should increasingly align heritage conservation criteria with energy-transition objectives, promoting integrated assessment tools rather than fragmented incentive schemes. By merging tradition and innovation, applying state-of-the-art technologies sensitively, and fostering collaborative practices among professionals, institutions, and communities, Smart Villages can catalyse a sustainable renaissance of inner Mediterranean territories.[19] They can redefine rural living, offering a compelling, viable alternative to urban centres while safeguarding the identity, heritage, and long-term resilience of these extraordinary places. Ultimately, the Smart Village paradigm is not just a technological transformation, but a cultural and spatial reconfiguration grounded in local identity, resilience, and territorial specificity. The comparative analysis between Sicily and Valencia demonstrates that innovation becomes sustainable only when embedded within local architectural knowledge, climatic logic, and governance structures. The proposed workflow therefore represents not a technical prescription, but a decision-support framework capable of guiding context-sensitive rehabilitation processes across similar Mediterranean rural territories. In this perspective, smartness does not replace tradition; it operationalizes it. This reinforces the conceptualization of Smart Villages not merely as a technological upgrade but as a framework for culturally informed, sustainable, and socially resilient rural development.

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[3] David Abulafia, *The great sea: a human history of the Mediterranean* (Oxford: Oxford University Press, 2011).

[4] Federica Bicchi, "Il Mediterraneo, tra unità, frammentazione e oblio," in *Eirene e Atena. Studi di politica internazionale in onore di Umberto Gori*, ed. Fulvio Attinà et al. (Firenze: Firenze University Press, 2022), 153-65, https://doi.org/10.36253/978-88-5518-595-0.13.

[5] The term *inner areas* is used according to the Italian and European policy framework to describe territories characterised by low accessibility to essential services, demographic decline, and structural marginality, yet endowed with significant environmental and cultural resources (Gianpaolo Basile and Aurora Cavallo, "Rural identity, authenticity, and sustainability in Italian inner areas," *Sustainability* 12, no. 3 (2020): 1272, https://doi.org/10.3390/su12031272).

[6] Marco Maialetti et al., "Investigating 'land-use trajectories' in Mediterranean rural areas with official statistics and a multiway factor analysis," *Sustainability* 16, no. 17 (2024): 7644, https://doi.org/10.3390/su16177644.

[7] In this research, the concept of Smart Villages is not intended as a direct rural transposition of the Smart City paradigm. Instead, it is understood as a place-based model that prioritises governance, community engagement, heritage preservation, and compatible technological innovation in low-density and historically stratified contexts (Luisa Lombardo, *Smart villages: tools and strategies for sustainable development in inner rural areas*, *SpringerBriefs in applied sciences and technology* (Cham: Springer, 2026), https://doi.org/10.1007/978-3-032-16031-7).

[8] Stefano Boeri, "Via dalle città, nei vecchi borghi c'è il nostro futuro," *La Repubblica*, April 22, 2020, https://www.inu.it/wp-content/uploads/Repubblica_Boeri_22_aprile_2020.pdf.

[9] Polizzi Generosa and Morella were selected due to their comparable historical stratification, mountainous morphology, climatic conditions, and typological characteristics of traditional rural architecture, despite belonging to different national and administrative contexts (Enrique San-Martín González and Federico Soler-Vaya, "Depopulation determinants of small rural municipalities in the Valencia region (Spain)," *Journal of Rural Studies* 110 (August 2024): 103369, https://doi.org/10.1016/j.jrurstud.2024.103369.

[10] Vincenzo Pica, *Hismacity Pro: Protocollo Historical Small Smart City. Interventi integrati per la riqualificazione dei piccoli centri storici delle aree interne* (Napoli: Edizioni Scientifiche Italiane, 2019).

[11] The expression "knowledge-based construction site" refers to an approach rooted in architectural conservation theory, whereby historical research, material analysis, typological study, and diagnostic assessment precede design decisions, ensuring informed and compatible interventions (Elif Nur Arslan and Gülşen Dişli, "Architectural heritage and traditional knowledge systems: insights from the ancient settlement of Kilistra, Türkiye," *Sustainable Communities* 2, no. 1 (2025), https://doi.org/10.1080/29931282.2025.2477145.

[12] All technological solutions discussed are conceived according to the principles of reversibility, minimum intervention, and visual discretion, in line with international guidelines for architectural heritage conservation.

[13] Cynthia Echave et al., "Boosting rural areas revitalization in the Mediterranean through a cross-cutting approach based on ecological and social resilience," *Resourceedings* 2, no. 1 (2019): 43, https://doi.org/10.21625/resourceedings.v2i1.451.

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**1a.** Image by Luisa Lombardo, 2023. **1b.** Media Travel Es. **1c.** Image by Roberta Prestigiacomo. **1d.** Valencia Bonita. **2.** Image by the author, 2023. **3.** Fatta, Giuseppe, Tiziana Campisi, Marco Li Castri, Salvatore Lo Piccolo, and Calogero Vinci. "La tradizione costruttiva nell'area delle Madonie." In *Architettura di base*, edited by C. Aymerich, A. C. Dell'Acqua, Giuseppe Fatta, P. Pastore, G. Tagliaventi, and L. Zordan, 431-72. Firenze: Alinea, 2007. **4.** Image by the author, 2025. **5.** By the author, 2025.

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