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Mutual Adaptation in Adaptive Reuse Practice: The Case of Borgo Monteruga And The Apulian Olive Cultural Landscape

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Abstract

This contribution presents the case study of the adaptation of Borgo Monteruga, a strategic and synergistic adaptive reuse project that follows a mutual adaptation approach for both an architectural asset and a cultural and productive landscape.

Current environmental and energy challenges the economic and social balance of Mediterranean landscapes. This phenomenon is evident in Salento territory, where the Xylella fastidiosa bacterium has devastated the traditional olive crop, obliterating the iconic olive-growing landscape and leading to the abandonment of vast tracts of land. Within this context, the dismissed 1930s farm village of Borgo Monteruga is part of a cultural landscape in danger. Consequently, the reuse of Borgo Monteruga offers an opportunity to develop a pilot strategy to revitalize both the village and its surrounding landscape.

The project has two objectives. First, reconstructing the Apulian cultural landscape involves replanting the olive trees. This effort addresses contemporary challenges such as climate change and sustainable energy production by integrating an agrivoltaic system as an economic driver to support the adaptive reuse process. Second, the recovery of Borgo Monteruga serves as a model for the rehabilitation of other early 20th-century rural settlements within a regional network.

The research project employs a research-by-design method through the single case study methodological approach. The design project itself is the tool to both understand the phenomenon of abandonment of this historic 1920 farm village.

The “research by design” approach aims to develop a site-specific project that exemplifies best practices. The project aspires to redefine Mediterranean-built heritage as an inseparable part of its cultural landscape. Thus, cross-scale adaptation should be conceived as a mutual process, integrating architecture and landscape, function and production, agricultural tradition, and contemporary challenges.

Keywords

Cross-scale approach; Synergic adaptive reuse; Research-by-design; Cultural landscape restoration; Historical farm-village

1. Introduction

The Italian landscape is one of the most historically admired cultural landscapes in the World (Settis, 2010), and it is mainly the result of the stratification of centuries of agricultural activity (Sereni, 1961).

Throughout history, the Italian landscape has been strictly related to agricultural production. Agriculture is essential for humans because it is the main source of energy supply for assuring livelihood and strength to the organisms (Colombo, 1996; Smil, 2017). Technical and social advancements and the cultural implications of mankind depend above all on the available energy (Smil, 2017); the activity of energy production has always been of crucial importance to develop any kind of production. For this reason, agriculture played a key role in the relationship between humans and their environment, defining landscapes that properly embodied the values and cultures of communities at a given time (Pasqualetti, 2012).

According to the consideration that agriculture is, in fact, energy production (Colombo, 1996; Smil, 2017) and with the definition of energy landscape - a landscape whose appearance is characterised purely by energy production activities (Pasqualetti, 2012; Allemand, 2021) - then we can state that the agricultural landscapes are essentially energy-productive landscapes (Allemand, 2021; Stremke et al., 2022) which have undergone numerous transformations over the centuries, both for the advancements in agricultural activity and the economic market, and for the new issues and the technical progress in the energy field.

Today, energy landscapes are facing important moments of transition (Allemand, 2021). Agriculture faces climate change challenges, monoculture economies, and increasingly frequent ecosystem imbalances (Hultgren et al., 2025), while land dedicated to agriculture continues to shrink in favour of other needs, such as renewable energy production (Havrysh et al., 2022). Particularly in the Mediterranean context, it is increasingly occupied by renewable energy production plants, which are gradually trying to replace the more compact fossil fuel plants.

According to these considerations, multiple issues are impacting the countryside in the Mediterranean context. Current literature often addresses agricultural change and energy production separately; however, integrated design-driven frameworks that strategically address both within Mediterranean rural landscapes remain underexplored.

The research work presented in this paper offers an example of an approach capable of considering both agricultural and energy transitions to develop mutual growth strategies to meet contemporary challenges.

The approach proposed within this research is a research-through-design approach (Nijhuis & de Vries, 2019), focused on a specific case. According to the principles of the research-through-design activity, this method allows overcoming the complexity caused by the presence of multiple factors (like the ecological problems, the energy production issue, the landscape perception, the social acceptance of the intervention, and so on) to face the problems with an overall perspective (Roggema, 2017). The final objective is to demonstrate how contemporary energy landscapes can provide an opportunity to implement mutual development models between different productive activities, including landscape quality and environmental aspects. The approach proposed in this contribution is strategic in optimising the available land in our countryside, and is indispensable for generating new landscape types that are able to meet contemporary challenges without simplifications or rhetorical approaches.

Although Italian agricultural landscapes historically acted as energy-productive cultural systems, current studies typically separate agricultural transformation from energy transitions. As a result, design-driven strategies that integrate renewable energy deployment with agricultural heritage and maintain landscape quality in Mediterranean rural areas are lacking. For this reason, the present study does not include quantitative data on the energy production performance of the agrovoltaic system. This limitation stems from the early stage of system implementation and the need for extended monitoring to generate reliable and representative results. Nevertheless, recognizing the importance of such data for a comprehensive assessment of feasibility and long-term sustainability, these aspects will be addressed in subsequent phases of the research. In the meantime, this study advances a design-based framework that bridges the current gap by envisioning energy landscapes that safeguard the cultural and environmental values of the Mediterranean context. Future developments will further deepen and strengthen the scope and relevance of this work.

1.1. The Salento (Apulia region, Italy)

The agricultural landscape of Salento, in the Apulia Region, located in southern Italy, is a clear example of this situation. Historically rich in different production cultures (i.e., olives, vineyards, crops, and tobacco) and at a crucial point in the lower Mediterranean markets, it gradually moves towards a monoculture of olive trees, which has been developed in these lands since ancient times. During the 18th and 19th centuries, olive oil, once produced to be used for lighting, gradually became a luxury edible product, while energy production changed, leading to the use of fossil fuels and the spread of electricity. In this context, the Salento landscape became an iconic agricultural landscape dedicated to the culture of olive trees, whose edible oil is protected and famous throughout the world (Composeo, 2015)

During the last decades, two very different phenomena have impacted this landscape, severely threatening its integrity, but also opening new possibilities and future paths.

On the one hand, the Xylella fastidiosa infection has completely devastated the olive landscape, which today sees both its aesthetic value and its main agricultural economy disappear. In even years only (2012-2019), this infection has caused a significant loss of agricultural production, generating economic damage of about 7 billion euros (Fargione et al., 2021). To this is added the problem of the depreciation of agricultural land affected by the Xylella bacterium, which in some cases has contributed to the collapse of the value of infected areas even by 70 %.

This phenomenon has erased a part of the cultural and economic value of this very specific landscape, rooted in agricultural production. How could this be addressed as an opportunity instead of a tragedy only? May we consider the need to recover this landscape as a potential for integrating others' productive potentials?

It is a matter of fact that the electricity produced by the two coal-fired power plants in the Apulia region, particularly in Brindisi, is gradually being replaced by renewable energy production, wind, and photovoltaic. During the last decade, the Apulia Region has seen an exponential growth of technologies and plants for renewable energy, recording, only from 2010 to 2016, an increase of +173% of installed power, reaching more than 43.000 renewable energy plants spread in the territory. Solar PV (Solar Photovoltaic system) is the most widespread technology within the Region, for 97.9% of the total renewable energy plants, and this makes Puglia the first region in Italy for solar energy production; most of the photovoltaic fields are located in Salento. This phenomenon has generated highly criticized energy landscapes (as they are not properly designed and planned), but also opens up economic opportunities (by giving new functions to infected and now useless fields) and opportunities to rethink new cultural landscape types, which can become parts of the future heritage.

This landscape is characterised not only by land use in terms of production, but also by the built heritage that has supported such production, providing shelter to inhabitants employed in the agricultural production cycle, and, perhaps, tomorrow might work for energy production too. The built heritage related to agriculture in the Salento region is related to the agrarian reform from the 1930s, which built several farm villages along with the remediation of this land. Most of these settlements are today dismissed and, more generally, not linked to agricultural production anymore. In this paper, the selected case study of Borgo Monteruga is one of them.

1.2. Adaptive reuse of a dismissed productive landscape

Can the reuse practices traditionally applied to built heritage be adapted, with the necessary adjustments, to these landscapes as well? First, we need to recognize that productive landscapes (such as agricultural ones) may also be considered part of cultural heritage. The definition of which forms and artefacts are deemed worthy of preservation—and how to preserve them—is an evolving concept. However, the preservation of “obsolete forms,” even when they no longer serve contemporary needs, is a relatively recent concern, even within European culture (Stubbs, 2009).

This article aims to explore, through the project, how energy, culture, and transformation can synergize in the fragile Mediterranean landscapes that are on the verge of reinventing their traditional productive identity. These landscapes, rich in cultural heritage, are examined through the lens of sustainability and heritage conservation.

This project applies a phenomenological approach, which examines phenomena as they occur and reflects on them retrospectively to draw general insights (Moran, 2000). It seeks to apply adaptive reuse from a cross-scale perspective.

By analyzing a post-agricultural landscape alongside the dismissed built heritage of Borgo Monteruga through the lens of its potential for adaptation. The research project aims to focus on the morphological characteristics that might define the variations in its transformation process. The landscape here is meant as a palimpsest (Machado, 1976) that, through a "research by design" approach, is accommodating to interplaying yet different shifts of use: the former olive fields to an agrivoltaics landscape for energy and olive oil production, and the dismissed rationalist farm-village to a hybrid infrastructure for users.

1.3. Methodological approach

The contribution presents research work developed using a research-through-design approach. The project becomes a tool for testing possible solutions that can help both better understand the nature of the landscape that exists today and imagine possible alternative solutions for the future. In Landscape Architecture research (Deming, Swaffield, 2011), the research-through-design approach is a method that has only developed in recent years, and uses design drawings to synthesise a broader and more complex process of research and design experimentation (Nijhuis, de Vries, 2019).

This approach is particularly beneficial for developing landscape and landscape-transformation research, because this subject is characterised by a high degree of complexity (Roggema, 2017; Nijhuis, de Vries, 2019). The landscape, including different instances, values, and actors, is a subject that is almost impossible to read and interpret according to specific points of view. On the other hand, the project grants the possibility of treating the subject in its entirety, including the individual peculiarities that define it, without them all being equally studied or examined in depth (Roggema, 2017).

In this research, the research-through-design approach was applied to a specific case study. The aim is not to develop several design solutions to compare, but rather to develop a single solution, a synthesis of a series of reasonings, which can then be analysed and criticised constructively. For this reason, at the end of the research work, the project obtained is not necessarily the only possible or the best solution in absolute terms. On the contrary, the project developed corresponds to a possible solution that makes certain potentialities visible and simultaneously opens up specific critical questions. In this way, the purpose of research by design is not to obtain a project but to investigate a design strategy capable of subverting the usual or more traditional techniques.

In developing this project, the approach synthesises a few main demands. On the one hand, the initial problem was to reconstruct the Apulian agricultural landscape, characterised by olive groves. On the other hand, there was a need to make this operation economically sustainable. For this reason, energy production was included. At this point, it was crucial to think about the landscape impact of this type of intervention, and the visual impact of the photovoltaic panels, as well as their impact on the natural system and biodiversity. In this way, the project became a research tool, because it was the instrument capable of coherently synthesising the simultaneous application of multiple actions (Roggema, 2017) – as indicated in the guidelines of the Landscape Architecture discipline (Deming, Swaffield, 2011).

The project presented here was verified, at the conclusion stage of the research, through a discussion with experts from other disciplines, such as agronomic sciences, sociology, and the landscape approach, the developers of the business plan. The solution presented responds to the various issues that are included in the landscape problem, transforming the starting conditions into opportunities to generate an innovative type of landscape, capable of responding to the needs but also the cultural aspirations of our time (Allemand et al, 2021; Stremke et al, 2022).

From a more operational point of view, all research maps were created from digital mapping databases and then edited, supplemented, and manually corrected following a project site visit and on-site measurements. Photographs were taken specifically for the research, using a drone that enabled the acquisition of an overall view of the entire property.

The table below (Table 1) summarizes the main phases of the research-by-design approach in relation to the inputs, the outputs, and the objectives.

Table 1. Research-by-design approach summary (by the authors, 2022)

Phase	Inputs / Data Sources	Outputs / Deliverables	Connection to Research Objectives
1. Analysis (Weeks 1–4)	Landscape context; agricultural heritage; historical maps and photos, energy production data, and EU regulatory framework. On-site fieldwork.	Contextual maps; identification of key landscape-energy issues, photos.	Illuminates historical interactions between agriculture and energy use; frames challenges in Mediterranean rural landscapes
Research-Design (Weeks 5–8)	Analysis outputs; research-through-design principles; comparable best-practices analysis in adaptive reuse and landscape renewal.	Conceptual frameworks; preliminary design sketches	Starts integrating agricultural heritage and energy transitions via design orientation
3. Design Proposal (Weeks 9–12)	Conceptual design drafts; stakeholder/environmental considerations	Finalized design proposal; strategic spatial design model	Demonstrates how renewable energy can coexist with agricultural heritage while preserving Mediterranean landscape quality

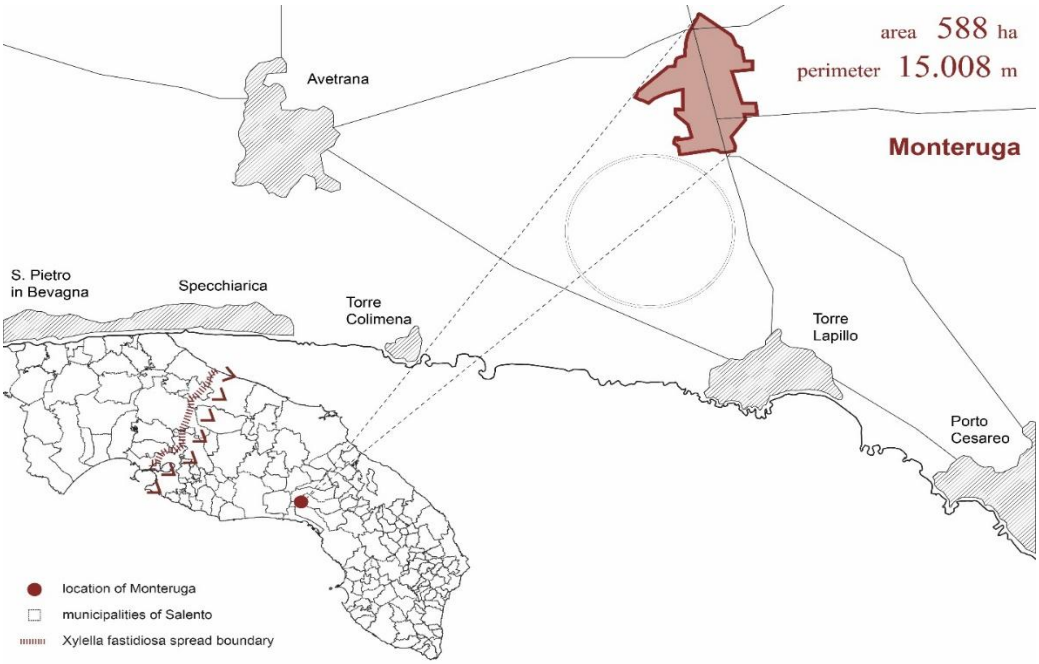

Figure 1 - location of Monteruga within the Salento area affected by the Xylella infection (by the authors, 2022).

2. Borgo Monteruga case study: a cross-scale analysis

As Figure 1 shows, Monteruga is located in a rural area, in the countryside between different municipalities in the

Province of Lecce (Veglie, Nardò, Avetrana e San Pancrazio Salentino). The small settlement is at the centre of a vast land property of 588 hectares, enclosed within a perimeter of more than 15.000 meters. For this reason, this case study offers the opportunity to develop a unitary, multi-scale project that moves from the architectural to the landscape scale.

The orography is without significant relief, and the current lack of trees creates a monotonous and flat visual effect. The only visible elements, which are also significant morphological elements of the landscape, include some lines of secular trees, historic dry-stone walls for the delimitation of the field, and a network of water canals for irrigation.

Historically, this area was mainly dedicated to the culture of olive trees, while some fields are deputed to the cultivation of vineyards and arable land; the *Xylella infection*, however, has caused a drastic change in the agricultural landscape, leading to a current almost desert configuration of neglect and unproductivity (Vigliocco et. Al, 2024).

Within its boundaries, the property contains one main property, the farm village from the 1930s, joined with an original settlement dating back to the 1850s, another secondary farmhouse (named Masseria Ciurli), and several other small ruins of agricultural and breeding buildings.

The land is crossed by three asphalted roads connected to the neighbouring towns and villages, and by several unpaved paths which define and structure the territorial morphologies. Despite these roads, Monteruga is a very isolated agricultural property, located far away from settlements, main events and fairs locations, or other agricultural productive farmhouses.

Considering all these features, Monteruga is a very significant and iconic example of the Salento rural landscape, whose high-quality aesthetic and environmental biodiversity have been strongly threatened in recent decades by a uniform monoculture approach and, later, by the *Xylella infection* and other environmental issues, as climate change, desertification, and increasing air pollution. Monteruga is not only an account of what has happened or is happening in recent periods, but it is also an important experiment of what can become in the future too.

Given the vastness of the area and the favourable climatic conditions, some energy speculation projects envisage the ruthless construction of forty-two wind turbines in the area, whose visual impact on the landscape would be destructive. In this context, the implementation of other energy technologies and new agricultural strategies seems to be the necessary solution to safeguard a natural landscape, its cultural values, and biodiversity (Veglie News, 2021).

As Figure 2 shows, within this vast portion of land, the farm settlement of Borgo Monteruga is nowadays visible from any place in the surroundings, due to the absence of trees, removed in 2020 after the Xylella infection spread.

Figure 2 - Aerial view of the Borgo Monteruga and the surroundings (by the authors, 2022).

The main building in the property is Borgo Monteruga (represented in Figure 3), one of the fourteen rural villages of the agrarian reform 1924 -1933 in Apulia. The farm village is an isolated agricultural settlement. Its isolation is a key factor, offering the potential for a collaborative approach to reimagining the agricultural landscape. Building in two main phases, the settlement is divided into the historical village from the 1850s and the farm village from 1928. (Biasco 1932, Mainardi 1994) The settlement hosted about 800 inhabitants in the 1960s, with residential dwellings for more than 30 families, a school, a church, and other facilities for workers and their families, along with buildings for manufacturing the products from olive trees, vineyards, and tobacco plants. The settlement is completely abandoned. It hosts temporary uses such as a film venue or photo shoot set. The village is structured by multiple

buildings arranged along a spacious courtyard. The total plot covers approximately 85,000 square meters, with the built area occupying over 8,500 square meters of gross floor space.

In full accordance with agrarian reform principles and the application of rationalism along with the fascist regime's narrative, the plan layout of the rural village of Monteruga is reminiscent of that of an ancient Roman colony, a kind of citadel characterized by regular streets and sharp, geometric architectural lines. While the nucleus of the ancient farm takes up the closed courtyard layout of the Apulian farms, the Borgo is described on three sides but opens onto the territory to the south. Even the north side, although closing on the church, overlooks the landscape. The resulting image is metaphysical.

Figure 3 – General plan and morphological consistency of the Borgo Monteruga (by the authors, 2022).

3. A mutual adaptation project

The adaptation of this landscape involves addressing both its tangible and intangible elements. This includes replanting olive trees and fostering the conditions necessary to revive the olive-growing economy. By analyzing the established components of the Apulian landscape, the design elements needed for its mutual adaptation can be identified and implemented. As Figure 4 summarizes, three main actions, in a specific timespan (T0-T4), lead to this development: A1) reactivating olive oil production through the reimplanting of olive trees; A2) enhancing the production diversity by perceptive mitigation, and the new agrivoltaic park; A3) boosting the use of this landscape through new cycle-pedestrian paths and the re-functioning of Borgo Monteruga. The timeline considers four main phases: 1) design phase, 2) planting and construction, 3) operation, and 4) substitution.

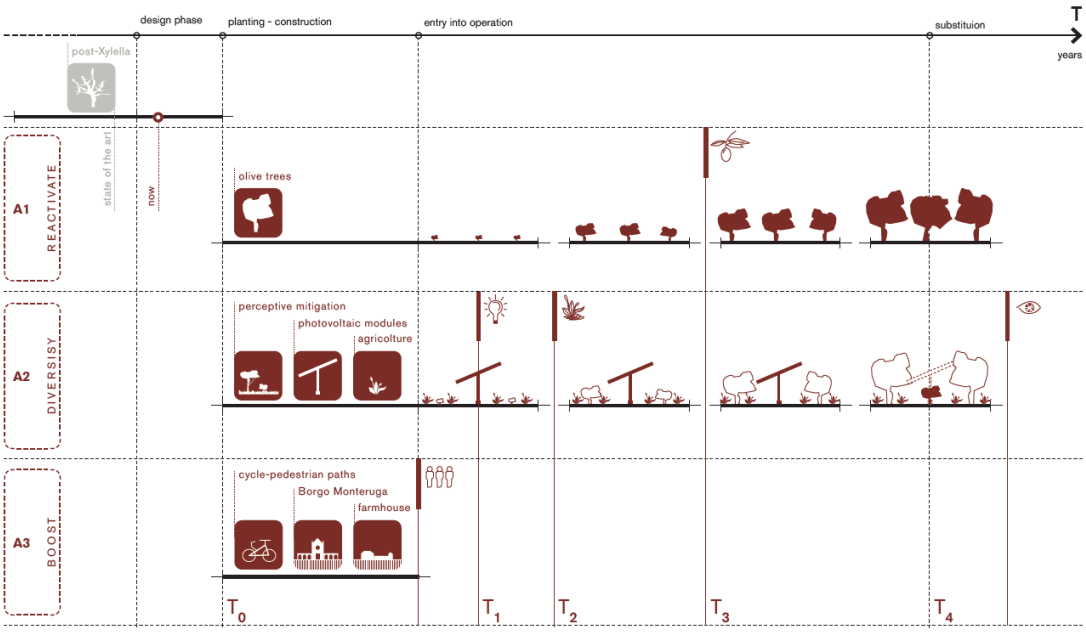

Figure 1 - Multilevel timeline of the project, organized in 3 design actions (by the authors, 2022)

Creating new alliance alliances between population, production, environment, and landscape is one of the main goals of the project; re-inhabiting Monteruga does not mean bringing the agricultural village back to its origins but, starting from the interpretation of its potential, imagining a new balance between the settlement and the landscape where it is located, between the agriculture and the new energy production systems, between the nature and what is artificial.

So, designing the Monteruga landscape means acting on both its material and immaterial components. It means replanting the olive trees and creating the conditions to reactivate the olive-growing economy. This responds to the first action envisaged by the project (A1 = Action 1, as Figure 4 shows), the reactivation of the olive trees' agricultural activity. The project defines a geometric grid of 12x12 meters for planting olive trees, to continue the tradition of the historical olive fields, and aims to re-create the landscapes that the Xylella has destroyed.

This ambitious project meets an essential economic problem; indeed, covering almost 600 hectares with new olive trees (approximately 100,000 hedgerow olive trees and more than 2,000 individual olive trees) and waiting for the first olive production after many years, is economically unsustainable. A strategy is essential for supporting the costs of such a project, and the energy issues during this period of transition can become an opportunity for imagining new types of energy agricultural landscapes. This is the second action envisaged by the project, the production and landscape diversification (A2 = Action 2, as Figure 4 shows).

The second action (A2) of the project aims to strategically introduce photovoltaic energy production, partially substituting the lines of trees, for producing green energy; at the end of the solar panels' life cycle, after about thirty or forty years, they can be replaced with new olive trees, to gradually restore a completely natural landscape. In doing so, the landscape carries on its historical vocation as an agricultural and energy landscape, but at the same time incorporates the new values of the energy transition and contemporary challenges, becoming a new type of innovative and experimental landscape.

Similar approaches have already been tested in European and Mediterranean contexts and have proved helpful in supporting the reintroduction of agricultural species at risk or to be reintroduced in contexts particularly affected by drought.

These experiences certainly include the agrivoltaic technique used for reintroducing cedar trees in Calabria, Campania, Sicily, and Sardinia (the Greenhouse project in Scalea, Calabria, is exemplary). If one moves instead to colder climates (to northern Europe, for example), one finds experiments in agri-voltaic integrations to support the cultivation of raspberries (North Brabant, Holland). The panels protect these delicate plants from too much sun and weather, initiating positive synergies.

However, these simulations are tested experimentally on relatively small portions of land. The project proposed in this case aims to reason on a large scale, re-imagine small production plants, and redesign entire landscape portions. Precisely considering the vastness of the area of intervention, it is not uniformly designed; on the contrary, the design changes and adapts at points when approaching the village of Monteruga, when flanking roads, or when approaching property boundaries. Therefore, areas exclusively dedicated to olive trees alternate with agrivoltaic areas of olive trees and panels, which in turn may have denser or more distant plots. The aim is to create an agricultural and photovoltaic landscape with varying densities.

The diversification envisaged by the second action (A2) of the project involves not only the photovoltaic installation, but it is also an agricultural issue too. A not monotonous landscape and a rich environment do not only mean reintroducing olive trees and introducing solar technologies, but they also mean re-creating the lost conditions of a multiplicity of cultures, diversity, visual variation, and visual and ecological non-homogeneity. To achieve this aim, the final layout is also enriched by the presence of different cultures (Figure 5). This operation is supported by agrarian studies for selecting those cultures that fulfil three basic requirements:

- selected crops must be compatible with soil conditions and with the cultivation of olives, under whose trees they must develop;
- selected crops must be able to integrate with photovoltaic technology, the shading of which affects the amount of light the crops can receive;
- The selected crops must be able to be managed in a mechanised way (to ensure the economic sustainability of the project).

Considering these requirements, the selected adding crops are artichokes, legume plants, and lucerne.

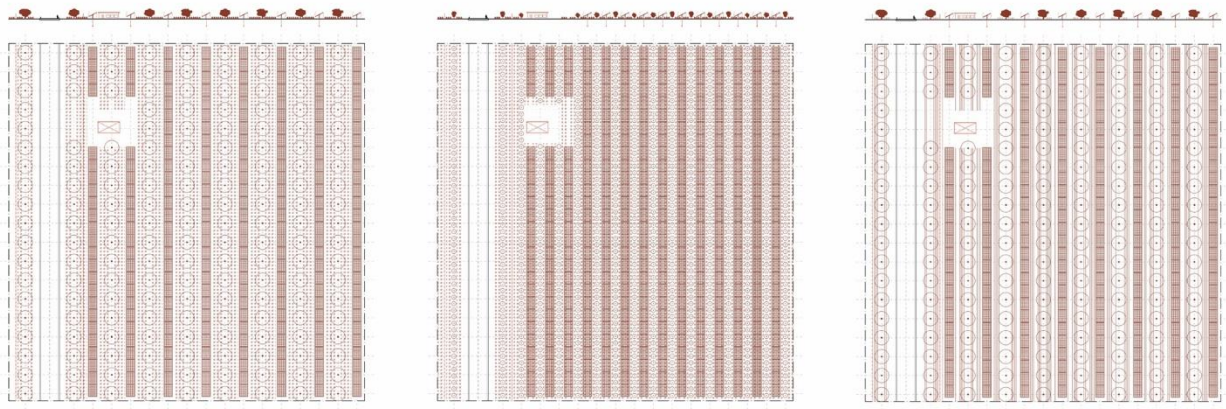

Figure 2 - examples of olive tree fields integrated with photovoltaic arrays and different types of other crops (by the authors, 2022)

The landscape project becomes, after all these measures, a meticulous project that is anything but uniform. It is a very site-specific project, in which the focus is always on how to manage the boundary lines, the connection or separation between different areas, the reconstruction of a landscape that is coherent but never monotonous, agricultural but never monocultural, energetic but also natural.

The landscape project is meant to be triggered and supported by the re-inhabitation of the farm village through the adaptive reuse of existing buildings and to include actions on the cyclo-pedestrian path (A3 = Action 3, as Figure 4 shows). The following figure summarizes the adaptive reuse proposal along with the olive trees re-implanting. Such a proposal does not provide a functional pattern, but instead focuses on compatible uses.

The third action (A3) involves the creation of a new cycling and pedestrian path that connects Borgo Monteruga and the farmhouse to the existing road network. It also includes the adaptive reuse of Borgo Monteruga through minimal volumetric additions that reinforce the existing structure and character of the settlement. Architectural elements such as the built footprint and the dry stone walls serve as guiding axes for the orientation of a 12-by-12-meter grid used for the planting of olive trees (see Figure 6)

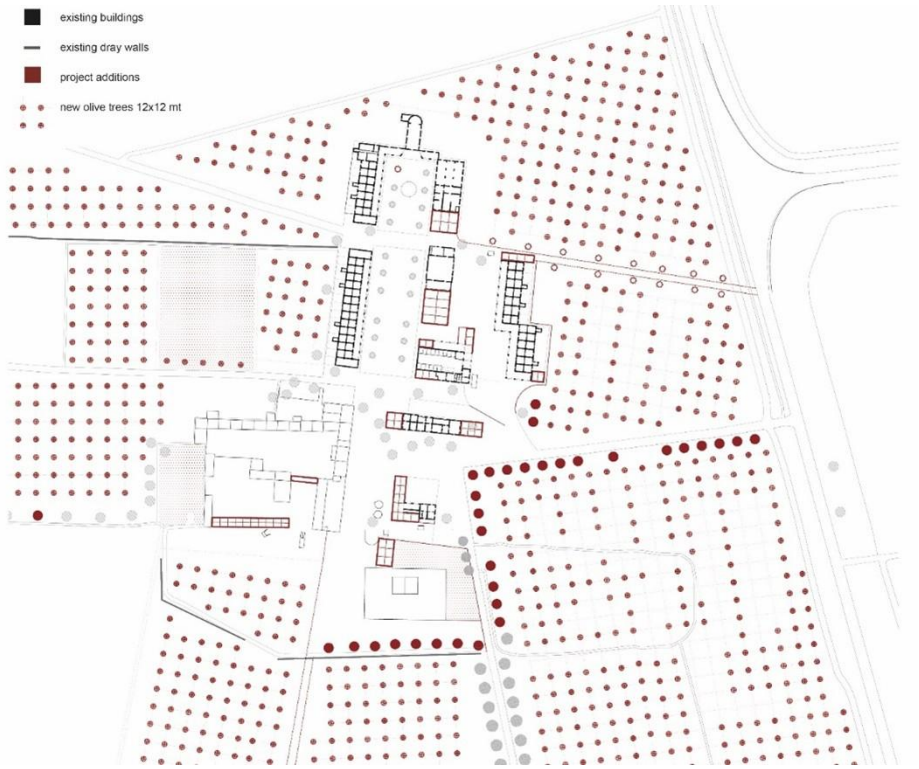

Figure 3 – Final proposed layout for Borgo Monteruga and the surroundings (by the authors, 2022).

4. Conclusion: toward a mutual approach

The mutual adaptation of Monteruga is not about restoring the agricultural village to its original state, but rather about reinterpreting its potential to envision a new equilibrium. These farms, deeply rooted in history, are to be regarded as cultural heritage that should play an active role in the recovery and revitalization strategies of rural Mediterranean landscapes.

Through this study, Borgo Monteruga is presented as both an exemplary and experimental case. While the developed project responds to the initial challenges, its ambition extends further. The intention is to test the possibilities offered by a mutual design approach—one that harmonizes new energy technologies, traditional agricultural practices, and the conservation of protected farm villages.

Regarding limitations, as outlined in the introduction, the absence of quantitative performance data—due to the early stage of system implementation—remains a constraint. Nevertheless, future research will expand on this framework through long-term monitoring, enabling a more comprehensive assessment of its feasibility and sustainability.

However, the main limitation of this case study lies in its unique context: it examines a single property with a settlement recognized as architectural and cultural heritage following extensive landscape loss caused by the Xylella fastidiosa epidemic.

This approach could be applied to other rural Mediterranean areas where agricultural land is abandoned or degraded—such as post-Xylella zones in Apulia—or regions affected by monocultures, soil depletion, and climate stress, by diversifying agricultural and energy production to revitalize and sustainably redesign exhausted landscapes.

Looking ahead, the project sets a foundation for broader implementation strategies. These include establishing adaptable design guidelines for similar rural contexts, developing partnerships with local communities and institutions to ensure long-term stewardship, and creating frameworks for sustainable energy integration and agricultural tourism. The outcomes from Borgo Monteruga may inform policy recommendations and funding strategies at the regional and national levels.

In doing so, this contribution represents a valuable first step in imagining and shaping innovative, resilient, and culturally embedded practices for the future design of Mediterranean landscapes.

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Ethics approval

Not applicable.

Conflict of interest

The author(s) declare that there is no competing interest.

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