Journal of Humanities and Tourism Research 2025, 15 (4), 744-773

Journal of Humanities and Tourism Research

Research Article

The Impact of Permaculture-Based Conservation on the Climate Adaptation of Historic Rural Landscapes: Barbaros Rural Settlement*

Permakültür Temelli Korumanın Tarihi Kırsal Peyzajların İklim Uyumuna Etkisi: Barbaros Kırsal Yerleşimi

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Citation: Öztekin, S. ve Köşklük Kaya, N. (2025). The impact of permaculture-based conservation on the climate adaptation of historic rural landscapes: Barbaros rural settlement. *Journal of Humanities and Tourism Research*, 15 (4), 744-773.

Submitted: 16.09.2025
Accepted: 05.11.2025

Abstract

Global climate change poses serious risks to historical structures and to both urban and rural environments. Historical rural landscapes—shaped by the long-term interaction of people and nature, and encompassing cultural, agricultural, and ecological components—are increasingly vulnerable. Addressing these vulnerabilities requires identifying potential threats and formulating strategies to reduce climate-related impacts. This article adopts a theoretical perspective grounded in permaculture, which prioritizes diversity, ecological processes, and community-based organization, aligning with sustainable strategies to safeguard cultural and natural heritage. The study involved literature review, data analysis, and fieldwork to select a suitable case. Barbaros Rural Settlement in the Urla District of İzmir serves as the example, demonstrating how such an approach can be applied. Findings emphasize the ecological rehabilitation of historic structures to strengthen climate resilience, the integration of regenerative methods into agriculture, and conservation proposals to sustain natural ecosystems.

Keywords: *Climate Change, Historical Rural Landscape, Conservation, Adaptability, Permaculture*

Özet

Küresel iklim değişikliği, tarihi yapılar ile kentsel ve kırsal çevreler için ciddi riskler oluşturmaktadır. İnsan-doğa etkileşiminin uzun süreçte şekillendirdiği ve kültürel, tarımsal, ekolojik bileşenleri kapsayan tarihi kırsal peyzajlar giderek daha kırılgan hale gelmektedir. Bu kırılganlıkların giderilmesi, potansiyel tehditlerin belirlenmesini ve iklim temelli etkileri azaltacak stratejilerin geliştirilmesini gerektirir. Bu makale, çeşitliliği, ekolojik süreçleri ve topluluk temelli örgütlenmeyi önceleyen permakültür temelli kuramsal bir bakış açısını benimsemektedir. Bu yaklaşım, kültürel ve doğal mirasın korunmasına yönelik sürdürülebilir stratejilerle uyumludur. Çalışma, literatür taraması, veri analizi ve alan çalışmalarıyla uygun bir örnek seçilerek yürütülmüştür. İzmir ili Urla ilçesindeki Barbaros Kırsal Yerleşimi, bu yaklaşımın uygulanabilirliğini gösteren örnek olarak seçilmiştir. Bulgular, tarihi yapıların iklim direncini artırmak için ekolojik rehabilitasyonun önemini, tarımsal uygulamalara yenileyici yöntemlerin entegrasyonunu ve doğal ekosistemleri sürdürmeye yönelik koruma önerilerini vurgulamaktadır.

Anahtar Kelimeler: *İklim Değişikliği, Tarihi Kırsal Peyzajlar, Koruma, Adaptasyon, Permakültür*

This study is derived from the doctoral dissertation currently being conducted by Seda Öztekin under the supervision of Prof. Dr. Nezihat Köşklük Kaya within the Restoration Program of the Department of Architecture at Dokuz Eylül University, Graduate School of Natural and Applied Sciences.

1. INTRODUCTION

Historic rural landscapes, which evolve through the interaction between humans and nature, represent composite systems that integrate cultural and natural assets. They serve as critical witnesses to the interplay between natural and anthropogenic environments, bridging past and present (Plieninger, Höchtl and Spek, 2006: 317-321). Shaped by ecological conditions and social traditions, these landscapes are rooted in production and cyclical systems. In the face of major challenges confronting rural communities—such as land abandonment, agricultural intensification, demographic shifts, the loss of traditional and local knowledge, pressures from urban expansion, and climate change (WRL, 2025)—traditional rural landscapes have attracted worldwide interest due to their multifunctionality and their role as vital reservoirs of ecological and cultural diversity (Stockdale and Barker, 2009: 479-492 OECD, 2001; Meeus, Wijermans and Vroom, 1990: 289-352):

Historic rural landscapes, where cultural, natural, and agricultural spheres intersect, are increasingly challenged by the impacts of climate change. Phenomena such as rising temperatures, extreme weather conditions, prolonged drought, air pollution, desertification, strong winds ands sea-level rises contribute to the deterioration of construction materials and pose risks to structural integrity. Shifts in rainfall regimes and variations in groundwater levels further destabilize ecosystems by disrupting biodiversity and weakening local vegetation, which in turn undermines agricultural cycles and lowers yields. These dynamics threaten the sustainability of livelihoods tied to agriculture, animal husbandry, and forestry within historic rural landscapes, exposing them to significant social, economic, and cultural vulnerabilities.

In this context, thoroughly assessing how climate change affects the various elements of historic rural landscapes, identifying possible threats, and formulating sustainability-focused approaches are all crucial. Crafting effective adaptation strategies to address climate change requires both recognizing existing vulnerabilities and developing specific, goal-oriented solutions.

This research is framed around the central question: *In what ways can permaculture design principles contribute to the adaptation and long-term conservation of historic rural landscapes under climate change conditions?* The underlying hypothesis suggests that permaculture provides a comprehensive and sustainable framework capable of guiding adaptation strategies for these landscapes confronted with climate-related challenges.

The central focus of the research is to investigate how permaculture design can be integrated into the climate change adaptation process for historic rural landscapes, identify their conceptual intersections, and develop a conservation approach based on these linkages. The methodology is grounded in qualitative research methods and comprises five main stages:

- Conducting a comprehensive literature review on historic rural landscapes, climate change impacts, and permaculture design principles,
- Establishing the conceptual framework shaping the conservation approach,
- Developing the conservation model,
- Undertaking field-based documentation and survey studies,
- Proposing strategies for the conservation of historic rural landscapes.

The literature review drew upon international reference documents such as UNESCO, ICOMOS, and IPCC reports, as well as the permaculture literature, particularly regarding sustainable land-use systems. The review revealed that the complex nature of historic rural landscapes—encompassing production systems, social relationships, knowledge transmission, and human–nature connections—requires an integrated approach. Within this framework, the study is premised on the recognition that permaculture is one of the few approaches capable of providing responses not only at the physical level but also at the systemic level, integrating local knowledge with contemporary environmental concerns.

Building on the literature review and the analysis of current challenges, a conservation approach aimed at bolstering the resistance of historic rural landscapes against the effects of climate change was developed. This model is structured around core permaculture design principles—design in harmony with natural systems, energy efficiency, diversity, and cyclicality—and incorporates key themes such as vulnerability assessment, resilience enhancement, water and soil management, the safeguarding of traditional knowledge systems, and community participation.

To test the practical applicability of the conservation model, a historically documented rural landscape with high climate sensitivity was selected as the pilot site. The selection was based on UNESCO's cultural landscape assessment criteria, which include aesthetic value, the presence of significant buildings and building ensembles, continuity of land use and lifestyle, the essential contribution of local communities in the landscape and its management, and the presence of significant water-related features (e.g., irrigation systems, lakes, rivers, and coastal landscapes), as well as forests, wooded areas, and notable rock formations (Fowler, 2003). Taking these parameters into account, the village of Barbaros, situated within İzmir's Urla District, was chosen as the research site.

Barbaros Rural Settlement was thus designated as the pilot site for evaluating the practical outcomes of the permaculture-oriented conservation approach and for implementing the five-stage conservation model. Within the scope of the fieldwork, the existing landscape components were documented and analyzed, and their vulnerability to climate change was assessed. Improvement scenarios were then developed in accordance with permaculture design principles. These efforts included the preparation of a landscape values map, a conservation principles map, and permaculture site analyses at scales of 1:40,000, 1:5,000, and more detailed local levels. Data collection methods comprised field observations and documentation, along with the analysis of climate, soil, and water data. The collected data was evaluated through qualitative content analysis. Vulnerability assessments were also conducted on five selected residential buildings within the settlement, and permaculture-based design proposals were formulated. Finally, the strengths of the proposed conservation approach, potential implementation challenges, and recommendations were discussed considering the findings.

2. LITERATURE REVIEW

The first part of this section presents definitions of key concepts alongside the recommendations and resolutions of relevant institutions and organizations, while the second part addresses academic studies related to the subject.

A landscape can be defined as the collective presence of natural and cultural components within a particular territory. Within the field of conservation, evaluating cultural assets together with their environmental context has led to the development of the cultural landscape concept. By the nineteenth and twentieth centuries, landscape studies had become a recognized academic field, and approaches to conserving cultural landscapes began to merge with strategies for nature conservation (UNESCO, 2009).

UNESCO's incorporation of the concept of cultural landscapes into the World Heritage Convention in 1992 marked a significant advancement in the preservation and management of these unique areas. According to UNESCO, cultural landscapes are defined as territories shaped by the interaction between natural elements and human activity. They reflect the historical development of human societies and settlements, influenced by the constraints and possibilities of the natural environment, as well as by a range of internal and external social, economic, and cultural dynamics (UNESCO, 2015).

According to the *Operational Guidelines*, cultural landscapes are divided into three groups: clearly defined, organically evolved, and associative cultural landscapes (UNESCO, 2015). In this framework, rural landscapes are not considered a distinct type but rather a subset of cultural landscapes. Following UNESCO's classification, they are identified as a subcategory of organically evolved cultural landscapes, with particular importance attached to them since they represent the majority within this group (UNESCO, 2015).

The ICOMOS Charter for the Conservation of Architectural Heritage defines cultural landscapes as geographic regions that have evolved over time through the continuous interaction of human societies, their settlements, and the surrounding natural environment—shaped by economic, social, and cultural forces. Such landscapes represent a synthesis of natural and cultural elements co-created by humans and nature, encompassing both wildlife and domesticated species. They may also be associated with significant historical events or activities, often reflecting diverse cultural, historical, and aesthetic values (ICOMOS, 2013).

Historic rural landscapes, which embody the reciprocal relationship between humans and nature, can be analyzed through three interconnected components: cultural, agricultural, and natural environments. The cultural environment—developed in response to human needs and incorporating a variety of building types—includes historic structures built with traditional construction systems, the settlement fabric into which they are integrated, and additional structures incorporated over time. These environments range from the smallest rural units, such as farms, to village-scale settlements, and their number and character are primarily determined by landforms, topography, climatic conditions, agricultural practices, and other economic resources.

Settlement patterns, determined by land use and bearing the imprints of traditional rural life, are shaped in accordance with the geographical features of their region. The rural architectural examples forming these fabrics are directly linked to local needs and functional requirements, embodying an architectural approach that reflects established traditions. Traditional settlements and structures, among the most significant components of historic rural landscapes, are built using locally available natural materials and construction techniques. As such, they represent not only the culture of the region and its society, but also their individuality and distinctiveness.

The *Intergovernmental Panel on Climate Change (IPCC)* defines climate change as "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for decades or longer" (IPPC, 2007). Climate change goes beyond the commonly known phenomenon of "global warming," which refers mainly to rising global temperatures. It also entails significant regional variations in climatic systems, including changes in wind circulation, rainfall distribution, and humidity levels. Moreover, it is associated with a growing frequency and intensity of extreme weather events—such as droughts, floods, heatwaves, and storms—which, in turn, have far-reaching consequences for economic stability, social structures, and ecological systems (Engelbrecht & Willem, 2012). These transformations alter the characteristics of hazards in terms of both vulnerability and exposure. For instance, while precipitation events may occur less frequently, their intensity may increase. Certain areas, particularly mountainous and coastal regions, are highly sensitive to such changes. Moreover, factors including environmental degradation, poverty, and urbanization amplify risks to economic stability, infrastructure, and human life (Rigyasu, 2012).

International climate change policies are built around two key concepts: **mitigation**, which focuses on minimizing or eliminating greenhouse gas emissions and their underlying causes, and **adaptation**, which seeks to strengthen the ability of both natural ecosystems and human societies to cope with current or anticipated climate impacts (IPPC, 2014). While mitigation efforts depend on globally coordinated policy actions, adaptation emphasizes enhancing resilience across local, regional, and global levels.

From this standpoint, a review of guidance and initiatives by national and international organizations indicates that historic rural landscapes are progressively being considered within sustainable conservation frameworks, accompanied by measures designed to enhance adaptation to climate change. Efforts to assess the impacts of climate change on cultural heritage at the international level began in 2004 with the meeting of the International Scientific Committee of the International Council on Monuments and Sites (ICOMOS), continued at the 15th General Assembly in 2005, and were further developed at the 29th General Assembly of the UNESCO World Heritage Centre (WHC) in the same year (Gencer, 2017: 24-30).

UNESCO's 2007 publication, *Climate Change and World Heritage*, was developed to assist State Parties by outlining approaches for anticipating and managing the effects of climate change on natural World Heritage sites. The report provides an in-depth examination of climate-related indicators, including variations in atmospheric humidity, temperature shifts, rising sea levels, dynamics of wind dynamics, desertification, and the interplay between climate change and pollution. It also underscores the diverse physical, social, and cultural consequences these threats pose to cultural heritage (UNESCO, 2007).

Following the ICOMOS Triennial General Assembly, in 2017, efforts to mobilize against the climate crisis accelerated with the support of the Committee's "Climate Action Working Group." Resolution 19GA 2017/30, adopted at the 2017 ICOMOS General Assembly, underscored that climate change constitutes a significant and rapidly escalating threat, drawing attention to the underlying drivers such as fossil fuel consumption, deforestation, and the warming of oceans and the atmosphere. In light of the outcomes of the 2007 "International Workshop on the Impact of Climate Change on Cultural Heritage" and the 2015 Paris Agreement, the resolution emphasized the urgency of rapid and decisive action, and stressed the necessity of updating the conceptual and managerial frameworks through which heritage is understood and administered (ICOMOS, 2017).The report further emphasized the importance of adopting innovative, multidisciplinary strategies across fields like disaster risk reduction, vulnerability analysis, conservation, education, and capacity building. It also highlighted that heritage sites, along with the intangible cultural knowledge of local communities, serve as vital reservoirs of insight in addressing climate change challenges.

The International Scientific Committee on Cultural Landscapes (ISCCL) and the International Federation of Landscape Architects (IFLA), in their 2017 "Principles for Rural Landscape Heritage," addressed landscape components and values comprehensively, drawing attention to emerging threats (ICOMOS and IFLA, 2017).Recommendations by ICOMOS and IFLA state that "agriculture, forestry, animal husbandry, fisheries, and aquaculture, along with the diversity of natural and other essential resources, are indispensable for humanity's future adaptability and the resilience of global human life," thereby emphasizing the necessity of conserving landscape components in an integrated manner (Öztekin and Köşklük, 2023). The 2019 ICOMOS Climate Action Working Group report "The Future of Our Pasts: Engaging Cultural Heritage in Climate Action" stressed the importance of managing rural landscape areas through ecological approaches considering the potential contribution of cultural heritage to climate-resilient development and the risks posed by climate change (ICOMOS, 2019). In 2020, the

ICOMOS General Assembly declared a “Climate and Ecological Emergency,” issuing a collective call for urgent action to safeguard both cultural and natural heritage (Rigyasu, 2012). A three-year scientific plan (2021–2024) was subsequently formulated, developing policies and recommendations concerning climate and cultural heritage. Within this framework, climate-sensitive heritage management and both adaptation and mitigation measures were supported (ICOMOS, 2021). The 2021 ICOMOS “Cultural Heritage and Sustainable Development Goals: Policy Statement and Recommendations” included guidance on integrating climate resilience into heritage management. These recommendations called for leveraging cultural heritage to build resilience against climate change—particularly through landscape-based and community-wide solutions—ensuring the active participation of Indigenous peoples and cultures in biodiversity-related initiatives, identifying and promoting the use of local resources and durable heritage-based techniques, and systematically integrating climate sensitivity assessments, adaptation, and mitigation measures into heritage policies, plans, and projects at all levels. The 2022 ICOMOS agenda on “Cultural Heritage and the Climate Crisis” and the 2023 theme of “Traditional Knowledge, Climate Action, and Transformative Innovation” further reinforced the necessity of contributing more extensively and in more diverse ways to address the risks faced by all heritage sites in the face of the climate crisis.

The Food and Agriculture Organization of the United Nations (FAO) is a key institution in safeguarding agricultural systems, sites, and landscapes of international significance. The FAO emphasizes that such areas are shaped by the cultural influences exerted upon natural resources, grounded in local knowledge and experience, and reflect humanity’s evolutionary trajectory and deep relationship with nature, underscoring the importance of their preservation (Güler, 2018).

The 2014 project “VerSus—Lessons from Vernacular Heritage to Sustainable Architecture,” conducted in France, Spain, Italy, and Portugal, aimed to reveal embedded heritage elements within vernacular heritage and link them with ecological approaches. The project addressed the sustainability dimension of vernacular heritage across three domains: environmental, socio-cultural, and socio-economic. The environmental dimension concerned intervention capacity, pollution and waste reduction, health, and disaster impacts; the socio-cultural dimension encompassed belonging, identity, community development, and cultural landscape conservation; and the socio-economic dimension included support for local economies, promotion of local activities, building longevity, and resource preservation (Versus, 2014).

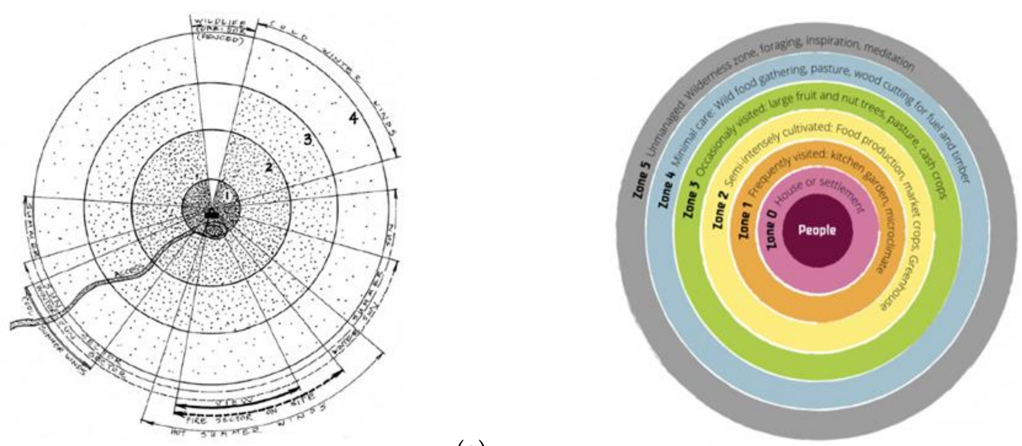
Founded in 2019, the Climate Heritage Network brings together stakeholders from the arts, culture, and heritage sectors to place culture and heritage at the heart of climate action in alignment with the goals of the Paris AgreementUnder the framework of the “Madrid-to-Glasgow Arts, Culture, and Heritage Climate Action Plan,” activities focus on areas such as “the role and communication of cultural heritage in climate action,” “valorization of traditional knowledge,” “adaptive reuse of buildings,” “participation in climate planning,” and “climate-resilient sustainable development” (Gencer, 2022: 36-40, Versus, 2014).

Within the framework of the European Green Deal, the strategy published in 2019 aims to develop coherent policies across sectors such as climate, energy, industry, environment, agriculture, transportation, and finance, to enhance resilience against the climate crisis. The European Green Deal for Cultural Heritage highlights the importance of climate-friendly everyday practices inspired by principles learned from cultural heritage. For instance, the culture of "reuse," which is a fundamental conservation principle in cultural heritage, is identified as contributing to the EU climate targets for 2030 and 2050 (Gencer, 2022: 36-40). The preservation of agricultural heritage in historic rural landscapes, combined with ecological practices added to traditional methods, is expected to protect and sustain the food system. In this context, ecological principles proposed for climate adaptation and lessons derived from traditional built environments are of critical importance. Notable overlaps exist between green or sustainable architectural principles—which emphasize efficient use of resources, energy, and water, alongside minimizing waste—and the time-tested traditional building methods that have evolved over thousands of years in the construction and built environment sectors (Eres and Güler, 2016: 51-64).

Permaculture first took shape in Australia in the 1970s through the pioneering work of David Holmgren and Bill Mollison. Conceived as a holistic land management philosophy, it brings together traditional agricultural knowledge, modern scientific understanding, technological innovation, and practical skills to design human settlements that can respond effectively to ecological challenges. Holmgren conceptualizes permaculture as "consciously designed landscapes that replicate natural patterns and relationships while generating abundant food, fiber, and energy to meet local needs" (Holmgren, 2002). Building on this, Mollison (1998) frames permaculture as the deliberate creation and stewardship of human ecosystems that emulate the diversity, resilience, and stability found in natural systems such as forests. The approach not only seeks to satisfy human needs with minimal environmental impact but also stresses the importance of integrated planning—where land and water management, architectural elements (such as buildings, earthworks, and fences), and human activity are considered as interconnected parts of a whole. In this sense, permaculture can be understood as both an ecological and social design system, aiming to ensure productivity, sustainability, and multifunctionality by fostering cooperative and complementary relationships among diverse species (Mollison, 1998, Ferguson and Lovell, 2014: 251-274).

Permaculture asserts that land-use systems are inherently connected to social systems and presents itself as a framework for designing sustainable socio-ecological land-use practices. In line with this, three fundamental ethical principles guide the creation and management of permaculture systems: caring for the earth, caring for people; and limiting consumption and reproduction while sharing surplus resources (Krebs and Bach, 2018).

The permaculture design process entails making decisions informed by detailed observations of both the land's physical characteristics and its social context, including the users and their interactions. Insights drawn from natural systems guide the relationships among structures, landforms, and other living components. Decision-making is flexible, depending on the interconnections among these elements. Assessing site characteristics prior to locating structures is crucial. Creating slope maps and determining orientations to optimize or mitigate wind and solar exposure are essential for effective sitting. Using this data, slice and zone analyses are performed. Slice analysis in permaculture design involves evaluating environmental factors such as sunlight exposure, prevailing winds, precipitation, fire risk, and the likelihood of flooding. Through this assessment, potential hazards can be identified, including areas vulnerable to fire, exposure to damaging or cold winds, the presence of hot or saline winds, visually unfavorable outlooks, seasonal variations in solar angles, light reflections from water bodies, and zones at risk of flooding. These findings guide the placement of appropriate plant species and structural elements within each slice, while also facilitating the strategic use and redirection of natural energy flows to maximize efficiency. Complementing this approach, zone analysis organizes the spatial arrangement of site components based on the frequency and intensity of human use, thereby aligning design decisions with patterns of daily activity and resource management (Figure 1).



(a) (b)

Figure 1. (a) Sector Analysis; (b) Zone Analysis

In permaculture design, human beings and their communities occupy a central position. The focus extends beyond individuals to encompass collective knowledge, cultural continuity, and shared practices, which together form the foundation of holistic decision-making. Recognizing that all forms of life are interdependent and part of a larger system reinforces social cohesion and supports resilient community structures. Within this framework, the organization of small, responsible communities is regarded as a viable response to contemporary social and ecological challenges. This outlook has shaped the concept of social permaculture, which adapts the ethics and principles of permaculture to human relationships and social systems. Its primary aim is to promote justice, mutual understanding, and well-being—not only at the personal and communal level but also within the broader universal context.

The second part of the literature review includes national and international academic studies, articles, and theses.

In her doctoral dissertation titled "Determination and Principles for the Protection of the Cultural Landscape Values of Gökçeada," Güler explores the notion of cultural landscapes, emphasizing the dynamic interplay between natural environments and human cultural practices. Through the case study of Gökçeada, she develops principles for identifying and preserving local landscape values. The theoretical framework, grounded in UNESCO and ICOMOS documents, is supported by landscape characterization methods and analyzes of architecture, land use, and traditional lifestyles. Findings indicate that spatial organization and cultural continuity are decisive factors for landscape identity. The thesis highlights that social and economic transformations threaten these values and emphasizes the necessity of integrated and participatory conservation approaches (Güler, 2018). In another article, "New Perspectives Brought by the Concept of Historic Rural Landscape," the same author stresses that rural areas should be considered not only in terms of natural or architectural elements but also within the context of human-nature interaction. She argues that historic rural landscapes remain insufficiently defined within cultural heritage frameworks and thus remain invisible within existing legal protection systems. The study provides a conceptual assessment based on the European Landscape Convention, UNESCO's cultural landscape definition, and ICOMOS documents, asserting that rural landscapes are shaped by cultural continuity, production modes, and traditional knowledge systems. According to Güler, this method provides fresh perspectives for the sustainable conservation and management of rural regions. The article underlines the importance of resolving conceptual ambiguities and recognizing rural landscapes as a distinct heritage category (Güler, 2016).

C. İrem Gençer's article, "International Approaches to Climate Crisis and Cultural Heritage Protection," emphasizes cultural heritage as both vulnerable and a resource for solutions against the climate crisis. Within the scope of ICOMOS climate action reports, the author examines the inclusion of cultural heritage in climate policy frameworks, addressing adaptation, mitigation, and resilience strategies. The article advocates holistic and multi-stakeholder conservation approaches that incorporate traditional knowledge systems and cultural landscapes in response to the climate crisis (Gencer, 2022: 36-40). The study by Eres and Güler examines lessons from rural heritage in terms of resilience and adaptation capacity against climate change. It highlights traditional rural settlements' sustainable land use, local knowledge, and social solidarity as models for combating climate change. The authors argue that preserving rural heritage is not only a historical imperative but also an essential adaptive resource for today's climate crisis. They assert the need to restructure conservation policies with integrated approaches that encompass social, ecological, and economic dimensions (Eres and Güler, 2016: 51-64). Gülşah Kaçmaz highlights the critical role of nature-based solutions in addressing the challenges posed by climate change. The article advocates ecosystem conservation and restoration as effective methods for reducing carbon emissions and adapting to climate impacts. Among nature-based solutions, sustainable agricultural practices, permaculture, green infrastructure, and biodiversity conservation strategies are highlighted. The author notes these solutions provide both environmental and social benefits against the climate crisis (Kaçmaz, 2021:82-92). A study by Aktürk and Fluck (2023) investigates traditional buildings in Turkey's Rize region and their methods of adapting to climatic conditions. The research reveals that local architectural techniques and materials enhance climate resilience and suggests that this heritage offers sustainable solutions to contemporary climate challenges. The study demonstrates that vernacular heritage contains important lessons for future climate adaptation strategies (Aktürk and Fluck, 2023).

O'Brien, O'Keefe, Jayawickrama, and Jigyasu (2015) proposed a detailed framework designed to enhance the resilience of cultural heritage in the face of climate-related threats. This model focuses on evaluating climate change impacts on heritage sites, managing associated risks, and formulating adaptation strategies. By combining scientific research with practical applications, the study promotes the sustainable preservation of cultural heritage assets through interdisciplinary collaboration (O'Brien, O'Keefe, Jayawickrama and Jigyasu, 2015). Bell and Morse (2013) describe permaculture as a powerful tool for sustainable heritage management, offering promising and holistic advantages, particularly in terms of participation and ecological integrity. However, they note the need for more fieldwork and applied examples to fully realize permaculture's potential in heritage conservation. They also suggest that incorporating permaculture principles into heritage management policies could create new opportunities, especially for rural and cultural landscape preservation (Bell and Morse, 2013: 1-9). Baldy, Bellon, and colleagues (2018) emphasize the central role of agroecological farming practices in the sustainable management of cultural landscapes in the Mediterranean region. Agriculture is defined as a holistic approach that integrates ecological principles into agriculture along with local knowledge systems and community participation. Consequently, agroecological approaches should be integrated into cultural heritage management policies (Baldy, Bellon and Diakon, 2018). Ferguson and Lovell (2018) evaluate permaculture's place and validity within agroecological farming systems. They argue that permaculture is not merely an alternative farming practice but a scientifically grounded system design approach. Based on David Holmgren's 12 design principles, which underpin permaculture thought, the authors systematically analyze how each principle is supported in current scientific literature. Their qualitative study highlights the need for long-term and comparative research testing all permaculture principles in future studies (Ferguson, R. S., & Lovell, S. T., 2018. Krebs and Bach (2023) examine the scientifically supported core principles of permaculture in agroecological farm system design. The research emphasizes permaculture's contributions to sustainable production, biodiversity, and resource efficiency, presenting scientific evidence on methods that reduce environmental impacts while enhancing productivity. The article evaluates the applicability of permaculture principles in agroecological design and their role in strengthening agricultural system resilience (Krebs and Bach, 2018).

The doctoral thesis by Eller Everett investigates the transformation experienced by environmentally conscious professionals after permaculture education. The study reveals that permaculture is not only a sustainability tool but also a transformative learning process that reconstructs individuals' sense of hope and possibility. Participants reported feeling more hopeful in the face of environmental crises and adopting lifestyles more harmonious with nature through their engagement with permaculture. Everett's work argues that permaculture education enhances individual awareness and contributes to more creative, community-based, and sustainable professional practices. The thesis centers on the role of permaculture in deepening environmental consciousness and its psychological impacts on individuals (Everett, 2025).

This literature review thoroughly outlines the evolution of the cultural landscape concept alongside national and international strategies for its conservation within the context of climate change. It emphasizes cultural heritage as both a vulnerable asset and a resilient resource amid the challenges posed by the climate crisis. Sustainability-focused approaches, including permaculture and agroecological design, are identified as crucial methods for boosting the resilience of cultural landscapes. Additionally, policy and strategy frameworks from international organizations provide a relevant and global perspective for the study. Taken together, the existing body of research offers a solid theoretical and practical foundation for climate adaptation and sustainable preservation of historic rural landscapes, thereby reinforcing the study's methodological and conceptual framework. However, despite this substantial progress, the literature still reveals a lack of comprehensive and practice-oriented approaches addressing the sustainable conservation of historic rural landscapes under the pressures of climate change. This study has therefore been developed to contribute to filling this gap by proposing an integrative, permaculture-based framework for enhancing the climate adaptability of such landscapes.

3. CONCEPTUAL FRAMEWORK

In this section of the article, following a comprehensive literature review, the main theoretical framework of the study is established, and a conservation approach is developed.

Firstly, the ethical principles and design components of permaculture are examined in detail alongside the concept and components of historic rural landscapes. The conceptual intersections and complementary aspects between these elements are systematically analyzed and visually presented through a comparative table (Table 1).

The permaculture principle of care for nature directly relates to the protection of ecological components of historic landscapes, such as soil, water resources, and local flora and fauna. In historic sites, this principle can be applied through the restoration of original historic buildings, traditional water management systems, and the support of local ecosystem diversity. The principle of care for people parallels the continuation of local knowledge and cultural practices accumulated by historic rural communities. This may translate into interventions such as the preservation of traditional agricultural methods, the continued use of traditional construction techniques, and the active participation of local populations in conservation processes. The principle of fair share emphasizes the management of resources not only for present needs but also in consideration of the requirements of future generations. In historic landscapes, this principle can be implemented to prevent the overuse of natural resources, promote sustainable production methods, and ensure the social-ecological balance in landscape use.

One of the key factors defining the value of rural landscapes is the enduring relationship between humans and the land, which is manifested in historically continuous rural lifestyles. Natural areas, shaped by geographical conditions, have historically influenced the organization of settlements, as well as agricultural and livestock zones, to align with human needs. The built environment that developed under these natural conditions forms the cultural environments of historic rural landscapes. The traditional architectural examples that compose these environments were constructed based on the geography and climate data of their locations, thus embodying an ecological character appropriate to their time. Within permaculture design, the use of core and local resources is fundamental. Accordingly, in designing habitats in harmony with nature, buildings are conceived using sustainable and recyclable materials. The optimal utilization of topography, and strategies to benefit from or protect against wind and sunlight, are achieved through a theoretical approach that overlaps with this ecological foundation.

Ecological structures, regarded as energy components in permaculture, are characterized by being constructed with natural building materials suited to local climatic conditions. Agricultural, farming, and livestock activities constitute agricultural environmental data in both approaches. A key criterion in determining agricultural lands is the direct connection between the most fertile soil areas and water resources. Forest areas that form the natural environment represent a shared approach focused on maintaining biodiversity and conserving local fauna and flora species. Although the cultural environment, agricultural environment and natural environment within both design frameworks are separated by invisible boundaries, their interaction and integration remain indisputable.

Table 1. Comparative Framework of Historical Rural Landscape Values and Permaculture Design Principles

Historical Rural Landscape Values	Permaculture Design Principles
Cultural Environment	*Energy Components*
Topography and Land	Ecological Buildings
Traditional Settlement Area	Renewable Energy Technologies
Roads and Transportation	
Agricultural Environment	*Site Components*
Farming Activities and Agriculture	Land and Topography
Animal Husbandry	Climate
Natural Environment	Farming Activities and Soil
Forest Areas	Animal Husbandry
Fauna and Flora Species	Fauna and Flora Species
Water Resources	Water Resources
Intangible Cultural Heritage	Social Permaculture and Community

In historic rural landscapes, human interactions with culture are closely associated with intangible cultural heritage. Within the context of permaculture design, this relationship is expanded to encompass the notion of community, highlighting human and cultural activities as central components. Guided by principles of sustainable human settlement design, permaculture aims to create spaces that coexist harmoniously with nature while giving prominence to community culture and traditional modes of living. Social structures and interactions are modeled on the interconnectedness evident in natural systems. Accordingly, harnessing the potentials of intangible cultural heritage through social permaculture, and integrating local knowledge and practices into processes of adaptation and transformation, is considered an effective and feasible strategy.

Based on this context, a conservation approach has been developed consisting of five stages. The first stage, "Goal Setting," aims to correctly establish the relationship between the areas to be intervened and the values to be conserved while determining adaptation strategies for historic rural landscape components vulnerable to climate change. The second stage, the "Analysis Process," involves identifying historic rural landscape areas exposed or likely to be exposed to climate change, along with their related values. This inventory step includes identifying all landscape elements of rural settlements in their environments. The historic rural landscape values, defined under the headings of cultural environment, natural environment and agricultural environment, allow the analytical separation of tangible and intangible values. Under the cultural environment, traditional settlement areas are identified along with the transportation networks and roads within and surrounding these areas. Physical analyses conducted to determine the current state of original structures within the settlement — including construction techniques, materials, preservation status, use, building system, and number of floors — provide documentation. In the agricultural environment, current assessments of farming, agricultural, and livestock activities, particularly related to traditional settlements, are performed. The natural environment includes the identification of forest areas, lakes and their views, and special flora and fauna species that shape the historic rural landscape scenery. Protected forest areas and sustainable conservation zones are also determined under the natural environment heading.

The data obtained from this second stage of identification and documentation inform the third stage, the "Management Process." In this step, risks causing changes in the historic rural landscape character due to climate change are analyzed. The risk analysis focuses on climate indicators, climate change risks, and their effects on cultural, agricultural, and natural values. This analysis plays a crucial role in identifying the vulnerabilities of historic rural landscape values to climate change and in determining adaptation strategies. Points of vulnerability under risk are identified as open to adaptation, and the potential for recovery through appropriate strategies is assessed. The vision and mission of the conservation effort are defined in this section.

Following the management process, the fourth stage, the "Implementation Process," establishes the interaction between the permaculture design and application methods—serving as the theoretical foundation of the approach—and the documented area. Conservation principles are defined, delineating zones for protection and controlled design. Based on these principles, design decisions are made through zone and sector analyses, followed by the development of recommendations at both landscape and building-scale levels. Action plans for permaculture applications are prepared, along with the identification of financial resources and responsible institutions to support implementation.

The final stage, "Monitoring and Evaluation," involves the regular tracking and inspection of implementation plans. Moreover, existing action plans are reviewed every five years and updated as necessary to adapt to changing social conditions and environmental.

4. METHODS

The "Analysis Process" phase, which constitutes part of the five-stage conservation methodology, has been implemented and exemplified at the scale of the field study, based on empirical data collected on site.

To provide a foundation for the field study, cadastral maps obtained from the Urla Municipality were utilized. Based on these maps, land analyses were conducted at two different scales.

The Land Cover Analysis was carried out at a 1:40,000 scale, using data provided by the İzmir Regional Forestry Directorate of the Republic of Turkey. At the same scale, the Landscape Values Map was prepared using information obtained from both the İzmir Cultural Heritage Conservation Regional Board and the Ministry of Environment, Urbanization, and Climate Change. This map enabled the identification of cultural, natural, and agricultural areas requiring protection.

For analysis at a 1:5,000 scale, the cadastral map again served as the base. Traditional settlement areas delineated on the map were further subdivided at the block and parcel level to allow for more detailed spatial analyses. Consequently, spatial assessments were conducted locally with greater precision.

4.1. Examining the Barbaros Rural Settlement: A Case Study

The Barbaros Rural Settlement, situated in the Urla district of İzmir, occupies a hillside within a mountainous terrain that surrounds a low-lying plain, roughly 20 km from the district center (Figure 2). Positioned at the western extremity of the Aegean Region, the Urla Peninsula exhibits a Mediterranean climate characterized by hot, dry summers and mild, rainy winters (Mater, 1982). The village's location was determined organically, taking into account the slope of the land and access to water resources. It is flanked by protected forest areas to the north and east, while agricultural lands are primarily distributed to the west and south (Figure 3).

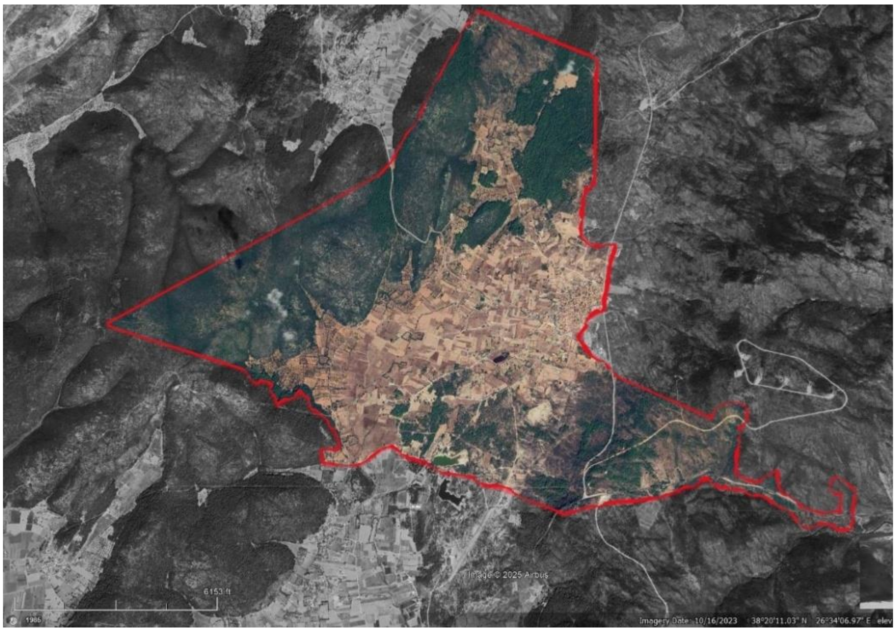


Figure 2. Location of Barbaros Rural Settlement (Google Earth, 2025)

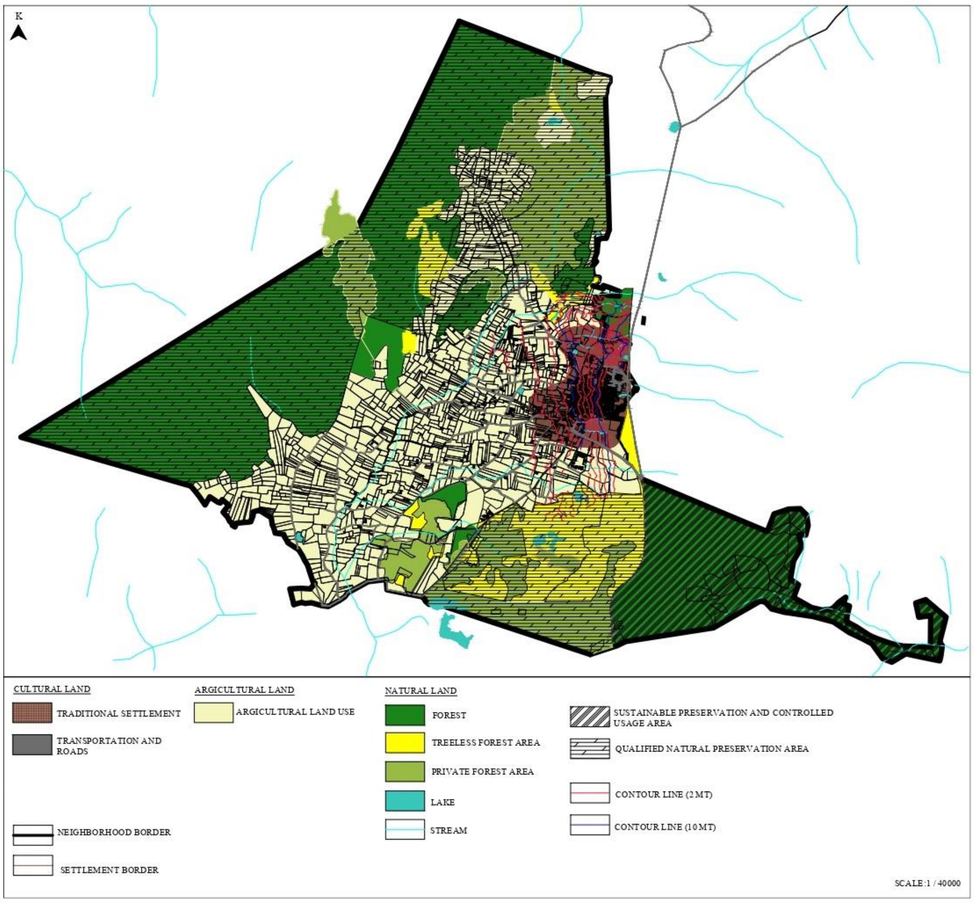


Figure 3. Landuse of Barbaros Rural Settlement (1:40,000).

4.1.1. Rural Lanscapes Values of The Barbaros Rural Settlement

The rural landscape of Barbaros Rural Settlement has been evaluated under three categories: cultural, agricultural, and natural environments, and a 1:40,000 scale map has been produced. These categories were developed in accordance with the conceptual framework of the study. Within the scope of the cultural environment, traditional settlement areas, transportation networks, and roads were analyzed. The agricultural environment encompasses farming activities and livestock breeding. The natural environment includes forested areas, lakes and landscapes, protected zones, significant flora and fauna, as well as archaeological sites (Figure 4).

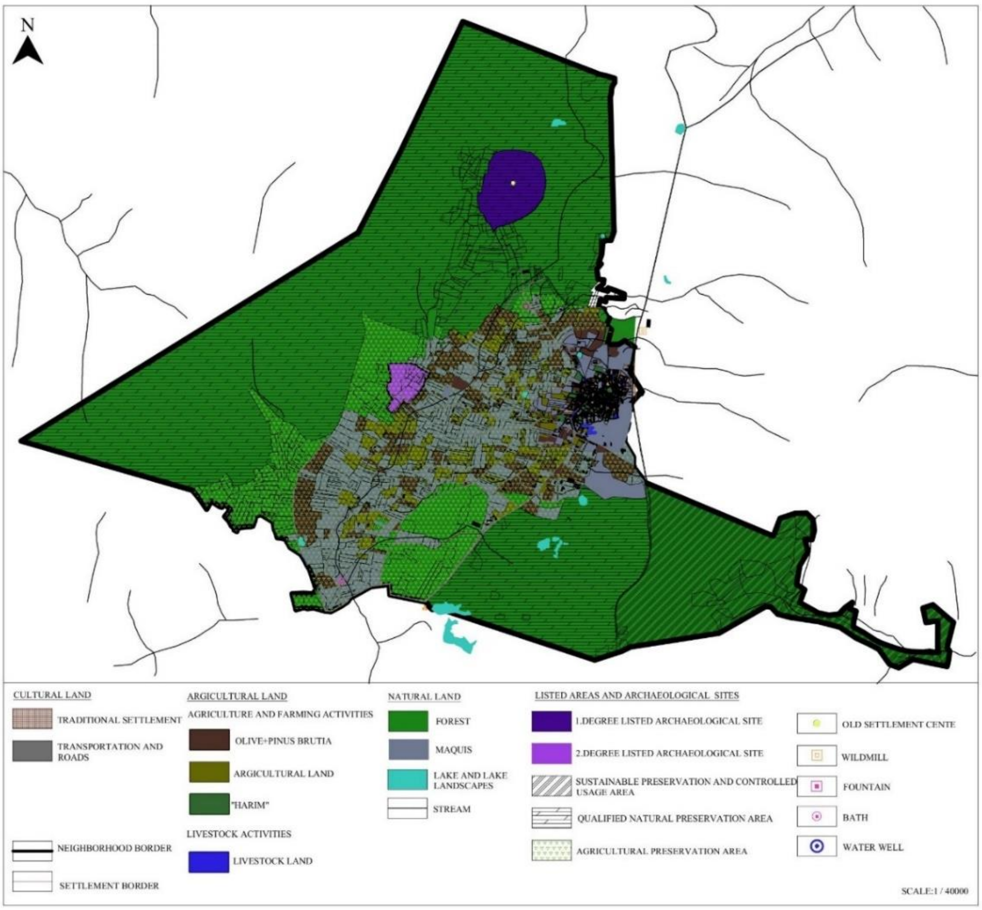


Figure 4. Rural Landscapes Values of The Barbaros Rural Settlement (1:40,000).

4.1.2. Cultural Environment

The traditional settlement of Barbaros demonstrates an organically developed rural layout, reflecting historical patterns of human habitation and land use. Access to the area is provided via two primary entrances from the northeast and southwest. Approaching from the northeastern entrance, Barbaros Street leads directly to the village square, which functions as a central social and commercial hub, containing cafes, coffeehouses, a grocery store, the village council building, and a recently constructed mosque. Streets extending organically from the square are lined with residential buildings and are interspersed with agricultural plots, locally referred to as *harım* (vegetable gardens), areas for livestock rearing, and accommodations for tourism purposes. The southwestern entrance opens onto the Old Barbaros Mosque and its adjacent residential neighborhood, which similarly features a village square, highlighting the settlement's dual-center organization and its integration of cultural, social, and agricultural functions (Figure 5).


(a) (b)

Figure 5. (**a**) Barbaros Street; (**b**) Village Square

The traditional texture of Barbaros Rural Settlement has evolved in response to the local climate, topography, available building materials, and vernacular construction methods. Andesite, slate, and limestone are the most frequently used stones, while timber was sourced from nearby pine forests and soil was occasionally incorporated into structures. Key preserved buildings include the Old Barbaros Mosque (1911) and primarily residential dwellings. These houses, which constitute the settlement's core, were designed to support everyday domestic life. About 80% of households feature courtyards surrounded by ancillary structures such as bakeries, storage facilities, and animal shelters, with some enclosed by stone walls and arches. Entrances typically lead into the courtyard rather than directly onto the street, with access provided via wide iron or wooden doors.

Most original houses are two-storey structures with external staircases. The ground floor generally serves as storage or animal shelter, while the upper floor functions as the living space (Figure 6). Courtyards commonly include separate animal barns and storage rooms, as well as outdoor ovens and toilets. Additionally, spaces for grape pressing, storage of agricultural products, and harım (vegetable gardens) are present to meet family needs. Alongside these two-storey examples, single-storey houses consisting of a single unit also exist (Figure 7).


(a)

(b)

Figure 6. (**a**) Two-Storey Residential Buildings; (**b**) Two-Storey Residential Buildings


(a)

(b)

Figure 7. (**a**) Single-Storey Residential Buildings; (**b**) Single-Storey Residential Buildings

4.1.3. Archaeological Values and Registered Areas

The documented settlement history of the Barbaros Plain dates back at least to the Neolithic period, and these areas are recognized as registered archaeological sites under the protection of the İzmir No. 1 Regional Board for the Protection of Cultural Heritage. Within the study area, four such archaeological zones have been identified. The first two encompass the remains of an ancient bath and water canal uncovered during early 1960s excavations aimed at channeling water from the Başköy well to the village, as well as the Tepeüstü Mound (Yaka, 2019). The third site, Değirmen Tepesi and its surroundings in Birgi, was officially designated as a 1st Degree Archaeological Site on December 14, 2007. The fourth site, located in the Kocabağarası area, is registered as a 3rd Degree Archaeological Site.

Within the traditional settlement, the Old Barbaros Mosque was registered on November 23, 2011. This structure is situated in a courtyard that contains an ancient olive tree, wells, and a cemetery. The Kocataşlar and Mintalar wells were classified as 2nd Group Immovable Cultural

Properties Requiring Protection by the İzmir No. 1 Regional Board for the Protection of Cultural Heritage, as per decision number 12579 dated July 20, 2021.

Additionally, the natural areas include designated and defined "Qualified Natural Protection Areas" and "Sustainable Protection and Controlled Use Areas" (Sarıbekiroğlu, 2017).

4.1.4. Agricultural Environment

Agricultural activities in Barbaros Rural Settlement have been declining since 1965, leading to a diminished economic role for the local community. Mater (1982) describes the soil of the Barbaros Polje as lightly sloped, calcareous, and clay-rich red Mediterranean soil, which historically supported the cultivation of cereals, tobacco, vineyards, anise, olives, potatoes, and a variety of vegetables. Tobacco occupied the largest share of the cultivated land, followed by cereals as the second most prevalent crop. Vineyards were identified as the third most cultivated product (Mater, 1982). According to this study, agricultural land within the boundaries of the Barbaros neighborhood constituted approximately 67% of the total land area in the early 1980s. Of these lands, 53.2% were actively cultivated according to Mater's (1982) maps. Mater, who also conducted soil analysis of the region, classified 79% of the agricultural land as fertile alluvial and colluvial soil, 14% as non-calcareous brown soil, and 7% as terra rossa soil. Based on this data, it is possible to state that a significant portion of the lands within the Barbaros neighborhood boundaries possessed soil of adequate quality for agricultural use.

Currently, the agricultural fields within the traditional settlement have considerably decreased. Mixed vegetable cultivation dominates the remaining farmland, whereas olive groves and vineyards persist only to a limited extent.

4.1.5. Natural Environment

Barbaros stands out for its rich natural heritage in addition to its cultural values. Forested areas, which play a crucial role in the rural landscape due to their biodiversity and ecological features, are primarily concentrated around the Barbaros Plain. The predominant tree species in these forests are pine and oak.

Approximately 20 small ponds, ranging in depth from 1 to 4 meters and covering 100–300 square meters, have existed for centuries around the village and in the surrounding mountains, mainly serving livestock needs. The largest, Kocagöl, spans 10 acres. In the 1990s, around ten additional ponds were constructed for agricultural purposes (Mater, 1982). Beyond these, numerous human-dug ponds in the mountains collect rainwater to supply animals, some of which are believed to date back thousands of years.

These natural features significantly contribute to the settlement's rural landscape values through their landforms, scenic qualities, vegetation, and visual character. Barbaros is situated in a region notable for high plant diversity, forming a unique ecosystem that integrates climate, landforms, vegetation, fauna, water, and soil. In the forest ecosystem, tree and plant species create a natural habitat supporting animal diversity and ecological interactions. In contrast, Barbaros' non-forest vegetation predominantly consists of Mediterranean maquis, including laurel, wild olive, and various shrubs. Species such as oleander, chaste tree, and myrtle are commonly found along stream edges.

4.2. Evaluating the Effects of Climate Change on the Landscape Values of Barbaros Rural Settlement

This analysis was conducted based on climate change indicators developed at national and international scales, regional climate projections, and local meteorological data. The potential climate change impacts and parameters to be considered in the sensitivity analysis were first identified with reference to the indicators defined in UNESCO's 2007 report entitled Climate Change and World Heritage [15]. In addition, reports prepared by local public institutions for the Aegean Region and İzmir Province, along with relevant academic publications, were examined.

The climate monitoring studies carried out within the scope of the Turkish State Meteorological Service's report Climate Projections and Climate Change in Turkey with New Scenarios provided an opportunity to assess the region's long-term temperature and precipitation trends (MGM, 2015). Furthermore, according to the Temperature and Precipitation Assessment, July 2024 report, İzmir, located in the Aegean Region, recorded 7.7 mm of precipitation in July 2024, the lowest among the region's provinces; while its long-term average temperature is 26,5 °C, it rose to 29,1 °C during this period (MGM, 2024).

In determining the indicators, local projections based on international climate change scenarios were also evaluated. According to the study by Fatma Ekin Hüner, for the period 2070–2100 compared to the reference period 1963–1993, the İzmir region is projected to experience a temperature increase of approximately 13.62% under the RCP2.6 scenario and approximately 15.22% under the RCP4.5 scenario. Similarly, the study Aegean Region Drought Projections conducted by Gülten Çamalan and colleagues (TSMS, Ankara) revealed that drought severity and duration in the coastal Aegean are expected to increase as a result of rising temperatures, which will negatively affect soil moisture and water resources (MGM, 2024). Tanrıkulu, Güner, and Bahar (2024) found that, based on 1972–2020 precipitation data from nine Aegean meteorological stations, short-term droughts are frequent and temporary, while long-term droughts are rarer but enduring (Tanrıkulu, Güner and Bahar, 2024).

Based on these evaluations, four main indicators were identified for the Barbaros Rural Settlement: temperature change, desertification, wind impact, and climatic and biological factors. The projected hazards and risks are presented in Tables 2 and 3. Situated within the "management process" phase of the conservation methodology, this analysis reveals the settlement's sensitivity to climate change with respect to its cultural, agricultural, and natural environment, thereby providing the scientific basis for the subsequent development of permaculture-based design decisions.

Rising temperatures and desertification pose a range of hazards, including droughts, heatwaves, declining water levels, increased evaporation, water scarcity, and shifts in seasonal patterns. Seasonal disruptions particularly affect agricultural cycles, undermining both staple crop production and the broader agricultural economy, while limited water availability negatively impacts livestock and farming practices. An expected increase in forest fires threatens local flora and fauna, particularly trees within high-value natural conservation areas, protected zones, and managed forests. Such landscape changes inevitably lead to the loss of natural assets that form part of rural landscapes.

Rising temperatures also have pronounced effects on traditional houses and other structures within the cultural environment. Extreme heat can accelerate material deterioration, such as salt crystallization and stone disintegration, while temperature fluctuations between interior and exterior spaces may cause structural damage. Additionally, diminishing water resources may drive outmigration of long-term residents due to adverse impacts on agriculture and tourism. Increased energy demands for cooling, along with the installation of modern systems in historic buildings, further threaten the integrity of the traditional fabric. Structural elements of registered archaeological sites, particularly baths and fountains, are also vulnerable to material degradation. The drying of wells due to reduced water availability compromises their functionality, reducing their value as components of the historical rural landscape.

The third factor, wind, contributes not only to topsoil loss and surface erosion, which adversely affect agricultural activities, but also facilitates the spread of forest fires. Strong winds, often occurring alongside rainfall, are likely to damage the already deteriorating stone houses within traditional settlements, resulting in material degradation, structural instability, and potential collapse.

Climatic and biological changes are also expected to increase the prevalence of invasive species, which will impact local flora and fauna and alter the visual character of the landscape. The spread of these plants and insects poses a serious threat to traditional buildings, particularly to structural and interior elements composed of organic materials

Table 2. Climate Change Vulnerability Analysis on Cultural Environment

Climate Indicator	Climate Change Hazard	Physical, social and cultural impacts on cultural environment	Examples of cultural heritage at risk
Temperature change	Declining water resources Enhanced evaporation rates Abrupt diurnal and seasonal weather variations Shifts in regional climate patterns Alterations and deterioration in atmospheric quality	Facade degradation caused by thermal stress Biochemical material deterioration Facade damage and heightened material loss from extreme heat Increased stone disintegration, crumbling, and material depletion due to salt formation Potential structural damage arising from internal-external temperature differentials Potential structural damage arising from internal-external temperature differentials Depopulation of rural settlements due to heat-induced relocation Erosion of cultural memory Drying and dysfunction of all water wells	Parcel No: 1389 
Desertification	Drought Extreme heat events Decline in groundwater levels	Soil and surface erosion Salt-induced material weathering Adverse effects on human health Settlement abandonment and structural collapse Erosion of cultural heritage and memory	Parcel No: 1497 
Wind	Rain driven by wind Salt carried by wind Sand mobilized by wind Variable winds, gusts, and directional shifts	Moisture infiltration into porous heritage materials Static and dynamic stresses on historic or archaeological structures Structural damage and collapse Surface degradation resulting from erosion	Parcel No: 1360 
Climate and Biological Effects	Expansion of invasive species Proliferation of existing and invasive insect species Enhanced mold development Alterations in lichen communities on built structures Reduction of native plant materials	Collapse of structural timber and timber finishes Decreased availability of native species for building repair and maintenance Alterations in the natural heritage values of cultural sites Modifications in landscape appearance Community transformations Impacts on the livelihoods of traditional settlements Shifts in family structures due to dispersed and distant sources of livelihood	Parcel No: 1495 

Table 3. Climate Change Vulnerability Analysis on Agricultural and Natural Environment

Climate Indicator	Climate Change Hazard	Physical, social and cultural impacts on agricultural environment	Physical, social and cultural impacts on natural environment
Temperature Change	Declining water resources Enhanced evaporation rates Abrupt diurnal and seasonal weather variations Shifts in regional climate patterns Alterations and deterioration in atmospheric quality	Reduction in intra-village agricultural and livestock activities, accompanied by loss of biodiversity Disruption of the coherence between agricultural zones, plant layouts, and planting schemes Decline in agricultural productivity and land degradation	Initiation of forest fires Ecosystem alterations and loss of native plant species Adverse impacts on fauna Reduction in water availability and associated stress factors Increased groundwater extraction and use of artesian systems
Desertification	Drought Extreme heat events Decline in groundwater levels	Interruption of agricultural activity cycles Decline in crop productivity and degradation of farmland	Desiccation of ponds and streams serving as water sources Increased depth of groundwater withdrawal Initiation of forest fires
Wind	Rain driven by wind Salt carried by wind Sand mobilized by wind Variable winds, gusts, and directional shifts	Depletion of agricultural topsoil Surface-level soil erosion Wind-driven dispersion of frequently applied chemical fertilizers and pesticides	Escalation and propagation of forest fires
Climate and Biological Effects	Expansion of invasive species Proliferation of existing and invasive insect species Enhanced mold development Alterations in lichen communities on built structures Reduction of native plant materials	Emergence of new plant diseases and crop losses Degradation of soil organic structure due to frequent use of chemical fertilizers and pesticides	Changes to the landscape view Loss or reduction of species in the unique flora

5. FINDINGS

The Barbaros Rural Settlement is largely composed of high-quality agricultural and forested areas situated beyond the main traditional settlement core. These forested zones form a vital ecosystem, supporting diverse plant and animal species that contribute to the region's overall biodiversity. The settlement also possesses abundant water resources, including both natural and artificial lakes, further enhancing its landscape value. Historical agricultural and livestock activities across the region demonstrate its longstanding agricultural potential. Data derived from these practices indicate a variety of products, highlighting the area's capacity for sustainable production. Collectively, the landscape reflects a distinct rural character shaped by the integrated interplay of cultural, agricultural, and natural components.

The climate change sensitivity analysis for Barbaros Rural Settlement was conducted to evaluate current and potential future risks to its physical, cultural, and ecological elements. The analysis focused on four primary indicators: temperature variation, desertification risk, wind effects, and climatic and biological threats. Results from these indicators were assessed holistically at the settlement level within the framework of three principal landscape components: the cultural environment, the agricultural environment, and the natural environment.

In terms of cultural landscape values, Barbaros's traditional housing fabric, water structures, street layout, and production areas serve as both carriers of historical heritage and tangible representations of rural life. However, these elements face the risk of losing physical resilience under climate change conditions characterized by rising temperatures and decreasing humidity. Traditional construction materials, including wood and adobe, are especially vulnerable to climatic stressors, resulting in structural degradation and increasing the risk of functional obsolescence.

The agricultural landscape presents a unique spatial pattern shaped by traditional production practices. However, the findings indicate that declining soil moisture, increasing wind erosion, and irregular rainfall patterns threaten the sustainability of existing production systems. To enable agricultural activities to adapt to changing climate conditions, both crop patterns and production techniques will need to be restructured.

Within the scope of natural landscape values, vegetation cover, topographic structure, and local ecosystem components are vulnerable to climate change–driven biological impacts. Shifts in temperature regimes alter the life cycles and distribution of local species, disrupting the natural balance and weakening ecosystem services. Furthermore, the growing potential spread of invasive species threatens the long-term sustainability of local biodiversity.

This multi-layered analysis concludes that the Barbaros Rural Settlement possesses a high degree of sensitivity to climate change. Its geographical characteristics are expected to render the area particularly vulnerable to the negative impacts of wind, especially in relation to temperature changes and desertification. Moreover, changes in weather patterns and seasonal cycles are anticipated to have significant effects on biological formations. The landscape's physical, productive, and ecological attributes are becoming increasingly susceptible to environmental stressors, underscoring the necessity for a climate-adaptive conservation approach to preserve the area's natural and cultural heritage.

In conclusion, the findings highlight the urgent need to develop conservation-based proposals that combine the protection of traditional landscape values with climate change adaptation through an integrated perspective. The methodology developed for Barbaros could, therefore, serve as a model for protection–adaptation strategies in other rural settlements with similar characteristics.

6. RECOMMENDATIONS

To guide sustainable conservation decisions for the historical rural landscape values of Barbaros Rural Settlement in response to climate change impacts, conservation principles were formulated based on the identified threats (Figure 8). This section exemplifies the "Implementation Process" stage. The primary aim is the preservation of cultural and natural assets, with particular emphasis on registered buildings and archaeological sites as highlighted in the landscape values map.

The defined principles were established by determining the sensitive conservation zones and their boundaries within the cultural, agricultural, and natural environments, thereby creating a roadmap for the extent to which the cultural and natural heritage values located within these areas should be preserved, restored, or addressed through permaculture design. Within the cultural environment, priority was given to preventing uncontrolled and poor-quality construction practices and to preserving the integrity of the area. For historical buildings within the settlement, primarily residential structures, comprehensive assessments of structural and material deterioration resulting from climate change were recommended. Restoration efforts were advised to utilize ecological building materials in cases where traditional materials were unavailable.

Furthermore, measures were proposed to integrate permaculture design principles into the management of traditional stone houses and their surrounding parcels.

A buffer zone was designated between the cultural and agricultural environments, within which building conditions were to be regulated and restricted, while also allowing for examples of contemporary architecture. In such contemporary designs, ecological building design criteria, construction techniques, and the use of natural building materials were to be prioritized.

Within the agricultural environment, the main guiding principle was to avoid any construction activities that might compromise the rural landscape or the overall spatial integrity of the area. Another key decision was the preservation of archaeological remains and traces within this environment without any intervention. Agricultural and livestock activities within this zone were to be approached through regenerative agriculture and holistic grazing systems. Soil analysis, as well as the implementation of measures for soil rehabilitation and restoration in accordance with the permaculture approach, were identified as secondary-phase actions.

Within the natural environment, the principle was to protect qualified natural conservation areas along with sustainable conservation and controlled construction zones. The plan emphasized the necessity of restrictions to ensure that construction within these zones be monitored and that permaculture practices be managed, allowing only for buildings belonging to the relevant institutions and organizations.

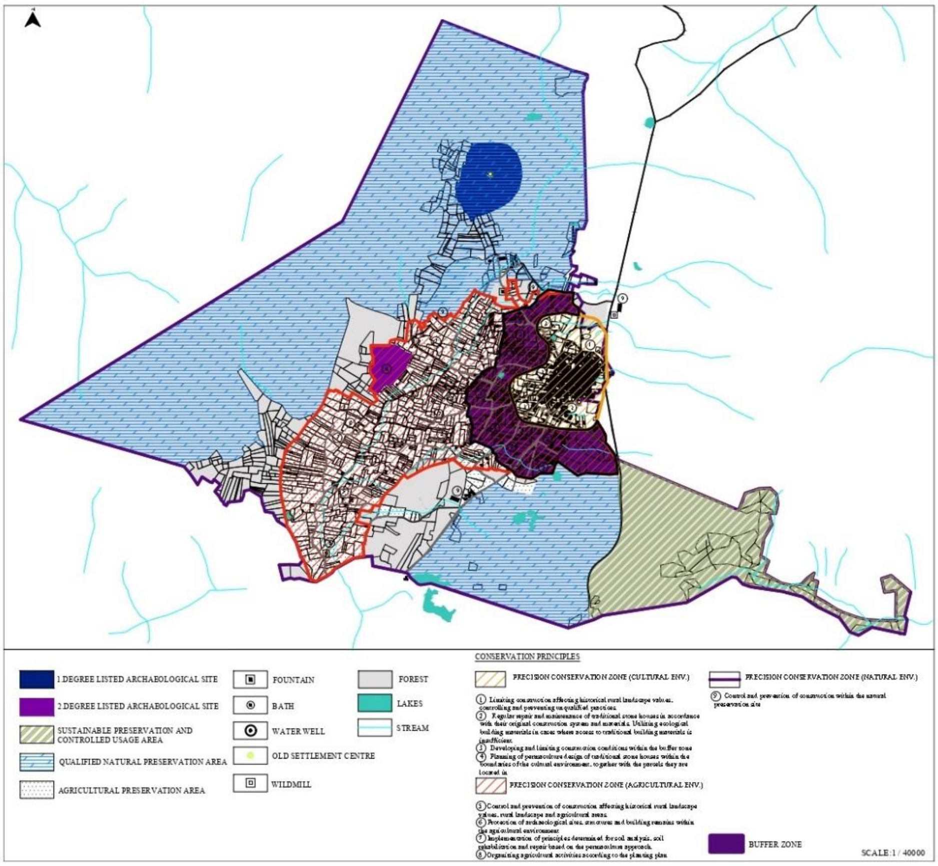


Figure 8. Conservation Principles Map (1:40,000)

Following the establishment of site-specific conservation principles, priority areas for the implementation of the permaculture master plan were delineated (Figure 9). Both sector analysis and zone analysis were conducted in alignment with the protection principles defined for sensitive heritage areas, thereby informing the sequential phases of the design. The sector analysis mapped critical environmental factors, including the seasonal solar trajectories (winter and summer sun angles), the prevailing northerly wind corridors, wildfire risk sectors, and significant view-shed axes. The spatial framework derived from the zone analysis was superimposed onto this sector map to integrate climatic, ecological, and cultural parameters into a unified planning scheme.

In accordance with permaculture zoning principles:

- **Zone 0** was designated as the **cultural heritage core**, corresponding to the historic rural settlement boundary.
- **Zone 1**—functioning as a **buffer interface**—was defined as the transitional belt between the heritage core and its adjoining agroecosystem.
- **Zones 2 and 3** comprised productive agricultural lands, allocated according to their functional proximity and accessibility relative to the core settlement.
- **Zone 4** encompassed sustainable, high-value **forest ecosystems** contiguous with the agricultural zones, serving as ecological support areas.
- **Zone 5** consisted of **ecologically critical wilderness areas** beyond human management capacity, preserved for their intrinsic biodiversity value and ecosystem services.

This zoning framework not only reflects the spatial logic of permaculture design but also integrates **heritage conservation imperatives** with **landscape-scale climate adaptation strategies**.

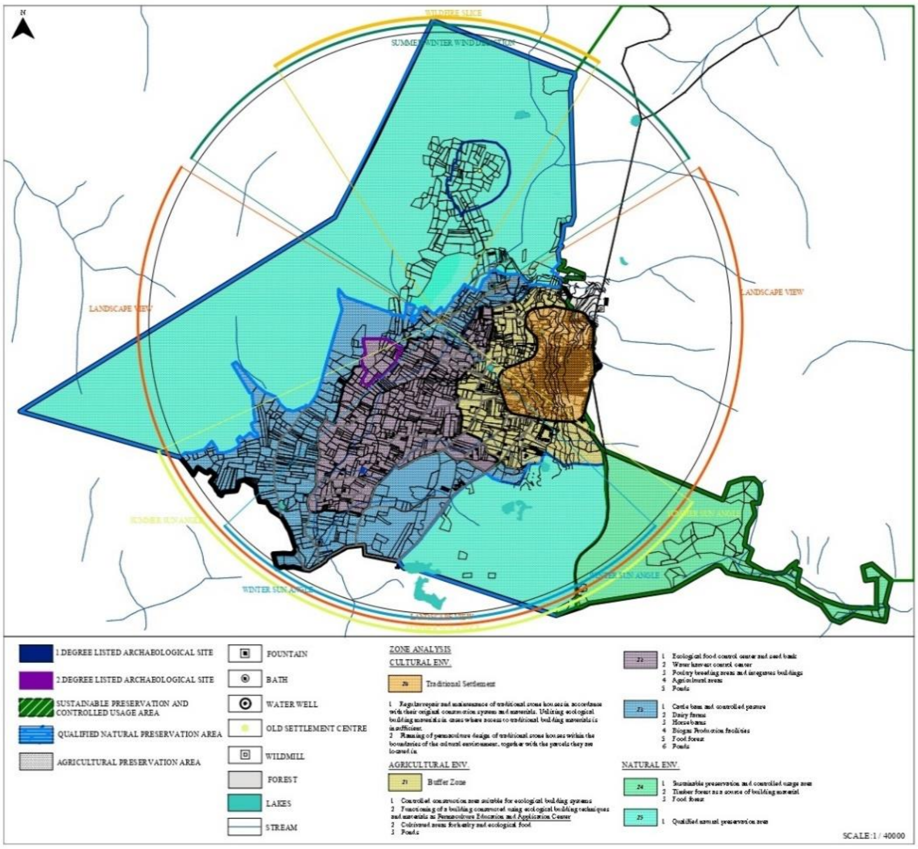


Figure 9. Sector and Zone Analysis (1:40,000)

According to Figure 9, Zone 0 defines the traditional settlement area directly associated with the cultural environment. Zone 1 corresponds to the buffer zone indicated on the conservation principles map and serves as a transitional area between the cultural and agricultural environments. New building designs within this zone are required to comply with technical and methodological standards that ensure resilience to natural disasters and high ecological value. Buildings are recommended to be limited to one story, utilizing stone as the primary local material for load-bearing walls, while interior walls should employ infill systems composed of wooden frame structures filled with straw- or earth-based materials.

For insulation, the use of hemp- and fiber-reinforced lime plaster for facade cladding is suggested, along with thermal insulation panels for flooring. The integration of renewable energy sources into buildings is also encouraged; however, the infrastructure supporting these energy systems must be carefully planned, with installation locations chosen to avoid adverse impacts on the settlement's landscape values.

Zone 2 largely overlaps with agricultural lands, where restorative agricultural practices are expected to guide the cultivation and planning of local crops. Reactivating traditional water wells within these fields is considered essential. To facilitate this, the construction of a water harvesting control center and an ecological food production monitoring center—designed in accordance with new building standards—is proposed. Restorative agriculture aims to enhance the soil's water retention capacity, thereby raising groundwater levels. This would enable the development of both open and closed water collection areas to conserve and expand existing lakes.

Zone 3 includes livestock activities and associated structures, as well as food forests and biogas production facilities. The establishment of a dairy and dairy product processing facility within this zone is considered important for bolstering the local economy.

Zone 4 is identified as a sustainably managed qualified natural area, targeting the expansion of timber forests to provide resources for construction materials.

Zone 5 overlaps with protected forest areas requiring conservation. Construction is strictly prohibited in this zone, and it is deemed appropriate for observation-based visitation only.

Following a comprehensive zoning and area analysis encompassing all landscape values of the Barbaros Rural Settlement, specific designs were developed for Zone 0. Within this framework, permaculture designs were created for five historic stone buildings subjected to sensitivity analysis, considering their respective parcels as representative samples (Table 4). Design decisions incorporated land-use optimization, ecological water cycle system design, integration of plant and animal systems at a small-scale land level, and renewable energy interventions aligned with the ecological restoration of the buildings.

To address the existing structural issues of each building while preserving their original construction methods and materials, the following priorities were established:

- Reconstruction and repair of courtyard walls in the original preserved structures, along with reinforcement where necessary.
- Preservation of existing wet areas in combination with the addition of wet zones to structures proposed for new restoration.
- Structural damage remediation through suitable reinforcement techniques, coupled with material replacement where required.
- Substitution of lost or damaged components using appropriate stone, timber, or brick elements.
- Renewal and application of mortar and plaster according to material samples obtained on-site, ensuring compatibility with original compositions.
- Removal of non-compliant plasters and mortars, including cement, from structures to maintain authenticity.
- Retention and use of original joinery elements while safeguarding existing door and window openings.
- Restoration of collapsed roofs following traditional gable roof designs, together with structural stabilization.

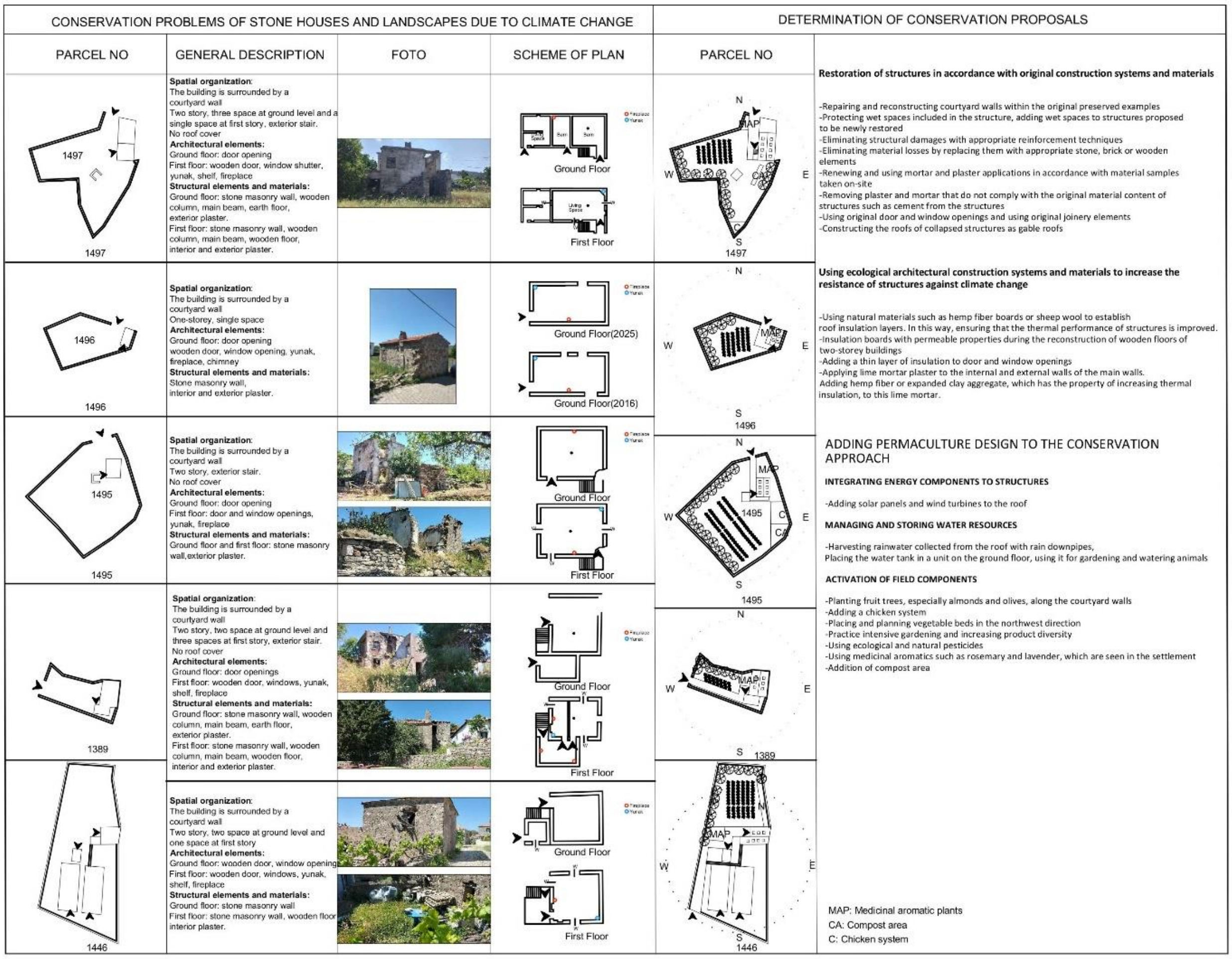
During the renovation of these buildings, it is recommended to apply environmentally friendly construction materials and techniques to boost climate resilience. These measures focus mainly on improving thermal efficiency:

- Using natural resources such as hemp boards or sheep's wool to insulate roofs, thereby enhancing the building's heat regulation.
- Installing breathable insulation panels when rebuilding wooden floors in two-storey houses.
- Adding a thin insulation layer around window and door frames.
- Applying lime-based plaster to interior and exterior walls, mixed with hemp fibers or expanded clay to strengthen thermal insulation performance.

After the renovation of the buildings, both energy and site-specific elements were integrated as essential components of the permaculture design. Solar panels and wind turbines were installed on the rooftops, and rainwater collected from these surfaces was directed via downpipes into storage tanks on the ground floor to support efficient water management. To activate the agricultural and field components, the following interventions were proposed:

- Planting fruit-bearing trees, especially almonds and olives, along the edges of courtyards.
- Introducing a small-scale poultry system.
- Establishing and arranging vegetable plots oriented toward the northwest.
- Promoting intensive gardening practices and increasing the diversity of crops.
- Utilizing ecological and natural methods for pest management.
- Growing medicinal and aromatic plants, such as rosemary and lavender, traditionally present in the area.
- Creating a composting zone for organic waste.
- Implementing rainwater collection and storage systems to optimize resource use.

Table 4. Conservation-Based Permaculture Design Recommendations



In addition to these general recommendations, sample applications were developed for five designated buildings. The residence located on Parcel 1497 is a two-story original stone structure, limited to an area of 450 square meters where permaculture site components can be integrated. Accordingly, alongside the completion of the building's ecological restoration, the permaculture design has been supplemented with other components based on the zoning analysis. Areas most closely related to the stone building, designated as Zone 0, have been identified as Zone 1, comprising medicinal and aromatic plants and a compost area. In the shared area between Zones 1 and 2, a vegetable garden has been designed considering the prevailing wind direction. Within Zone 3, a poultry system has been installed, and afforestation along the eastern boundary of the land is proposed.

The traditional single-story stone building located on Parcel 1496 sits on approximately 200 square meters of land. Based on this scale, some site components have been integrated. The building is positioned in Zone 0 and directly connected to the medicinal and aromatic plant area defined as Zone 1. The vegetable garden design is placed in Zone 2. Afforestation along the eastern and northeastern boundaries of the land is recommended.

Parcel 1495, with an area of approximately 600 square meters, is the largest plot. Accordingly, the permaculture design expands the areas allocated for medicinal and aromatic plants, integrates a poultry system, incorporates a compost area, organizes the vegetable garden, and enlarges the afforestation zone.

The site associated with Parcel 1389 covers roughly 200 square meters and parallels the recommendations made for Parcel 1496.

Finally, Parcel 1446, approximately 750 square meters in size, contains two reinforced concrete structures within the same parcel, distinct from a separately bounded two-story stone house occupying 350 square meters. The site components planned for this area are similar to those developed for Parcel 1495.

CONCLUSION

This study developed a holistic, permaculture-based conservation model aimed at supporting the protection and adaptation processes of historic rural landscapes increasingly vulnerable to climate change, using the Barbaros Rural Settlement as a case study. The proposed conservation approach was conducted within a qualitative research framework. Data collected through direct observations and documentation during fieldwork were analyzed to assess the current conditions of landscape components and their sensitivities to climate change. The design approach was shaped by site-specific sensitivity analyses and evaluations of landscape values. Conservation principles were addressed multilayeredly across the settlement's cultural, agricultural, and natural environment components, thereby targeting both spatial and functional sustainability.

The sensitivity indicators used in the analysis—temperature change, desertification risk, wind effects, and biodiversity—were derived from internationally recognized indicators proposed by IPCC, UNESCO, and ICOMOS, and adapted to local conditions using Turkey-specific climate projections. The validity of the findings was evaluated through comparative analyses with existing literature and prior studies conducted on the case area. Both national and international examples were considered, and the proposed permaculture applications were modeled in alignment with observed environmental conditions in the study area.

Control of variables was ensured by defining subcategories for each landscape component analyzed—namely, cultural, agricultural, and natural environments. For instance, in the cultural environment, factors such as the authenticity of structures, preservation status, and topographic relationships were considered; in the agricultural environment, variables including land slope, soil type, current agricultural use, and biodiversity were collectively evaluated.

The objective of this study was not experimental validation but rather to demonstrate the applicability of the proposed model and illustrate the contribution of permaculture principles to climate adaptation at the case-study level. Accordingly, the validation process was based on field observations aligning with comparable scenarios documented in the literature and the spatial-design coherence of the recommendations.

Within the cultural environment, the restoration of traditional stone houses and their integrated landscape fabric aims to establish cyclical and self-sustaining systems. Regarding the agricultural environment, practices such as regenerative agriculture techniques, holistic pasture management, and the use of local seed varieties were proposed to enhance soil restoration and productivity. These approaches aim to develop resilience against climatic threats while sustaining local production practices.

To strengthen water management and soil health based on permaculture principles, measures such as contour line systems, expanded water catchment areas, compost production, and natural fertilization methods were recommended. Protection of forest areas within the natural environment component, along with the planning of new timber forests, is vital for ensuring continuity of building materials.

For successful implementation, updating the legal and institutional frameworks is essential, integrating rural landscape definitions and strategies into existing conservation legislation. Particularly, increasing the effectiveness of agricultural environment applications necessitates active involvement of local governments and public institutions. It is recommended to establish multi-stakeholder coordination teams composed of experts from local administrations, municipalities, relevant ministries' provincial and district directorates, and universities.

Another critical aspect involves forming permanent teams to monitor, plan, and implement agricultural and livestock activities within the permaculture framework. These teams should have long-term employment to ensure continuity and sustainability. Additionally, educating and raising awareness within local communities to foster participation is crucial. The local population should be integrated into the planning and implementation of conservation and agricultural strategies, ensuring solutions are based on local knowledge and needs. Collaborations with NGOs, associations, and foundations are also considered beneficial in organizing educational programs, cultural activities, and community events that promote the project's cultural and ecological dimensions. Such initiatives not only encourage community engagement but also contribute the necessary awareness and support for the success of conservation and restoration efforts.

A comparable example is The Landworkers' Alliance (TLA) in the UK, a coalition supporting small-scale farms and permaculture projects. TLA leads numerous initiatives prioritizing biodiversity, soil health, and local community involvement. These projects apply permaculture principles to foster environmental protection and social sustainability in rural landscapes. TLA's model exemplifies the creation of resilient and vibrant ecosystems in rural areas (The Landworkers, 2020). Permaculture farms affiliated with national or international institutions similarly reinforce this understanding and contribute to the proliferation of similar practices. For instance, Gut Rheinau in Germany employs agroforestry, forest gardening, and natural cycle-based production techniques, prioritizing soil health, water management, and local ecosystem protection while collaborating with local communities to achieve both environmental and cultural sustainability. Gut Rheinau is a prominent example of permaculture applied to rural landscape conservation and sustainable agriculture in Germany (Schmidt and Kotsch, 2015: 45-58). Another example, La Cañada Verde in Andalusia, integrates permaculture design with traditional Mediterranean farming, emphasizing natural irrigation techniques, soil conservation methods, and native plant use. These practices enhance productivity while preserving the region's historical cultural landscape fabric. La Cañada Verde stands as a tangible example of permaculture's role in rural development and cultural landscape management under Mediterranean climates (Baldy, Bellon and Diakon, 2018).

It is inevitable that adapting the proposed model to different rural contexts will encounter certain limitations. Factors such as financial resource constraints, land tenure issues, demographic decline, market access difficulties, and social resistance can directly impact the feasibility of such projects. Therefore, flexible and participatory planning processes are necessary to tailor the model to local conditions. Research-based projects developed collaboratively with field stakeholders under the leadership of academic institutions are of great importance in this regard.

In conclusion, this study presents a comprehensive model demonstrating how a permaculture-based, resilience-focused, and participatory conservation approach can be developed both theoretically and practically for historic rural landscapes threatened by climate change. Integrating permaculture with spatial planning, local development, and climate policies creates new opportunities for multifunctional landscape designs, resilience indicators, and the preservation of local knowledge systems. Accordingly, this work offers not only a valuable contribution to the literature but also a guiding example for field practice. Future integration of the model with quantitative data and scientific simulations will further strengthen the development of more robust and sustainable strategies for rural landscape conservation.

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