Preserving the past or protecting the future? Harmonizing Cultural Heritage and Climate Adaptation in Siena

Maria Pizzorni*, Irina Karaselnikova, Clotilde Havard, Amit Bhattacharya, Esra Kut Görgün
Corresponding Author Affiliation (*): UNESCO Chair on Urban Resilience, Department of Technology and Innovation, University of Southern Denmark, Campusvej 55, 5230 Odense, Denmark. *Email:* mpiz@iti.sdu.dk

Abstract
Historic cities embody rich cultural heritage and a long-standing relationship with nature, yet they are increasingly vulnerable to climate change. This study examines the intersection of heritage preservation and climate adaptation in Siena, a UNESCO World Heritage Site. Developed through the ISOCARP YPP Workshop "Valleys of Siena," the project addresses urban overheating within the city's dense historic core. Drawing on fieldwork, GIS analysis, and case studies, the research identifies key challenges, including a lack of green space and fragmented green valley systems. Inspired by initiatives such as Paris's "Oasis Schoolyards" and Barcelona's "Streets for Kids," the study proposes context-sensitive strategies—micro-greening, water-sensitive design, thermal regulation, and inclusive public spaces—rooted in community engagement. This approach offers a replicable model for the climate-resilient transformation of historic urban environments.

Keywords: Cultural Heritage, World Heritage Sites (WHS), Siena, UNESCO, Climate Change, Climate Adaptation

Introduction

Cities evolve through a dynamic interplay between human adaptation and their natural landscapes (Izzati & Ikaputra, 2022). While some urban areas undergo rapid transformations, others, like Siena—a UNESCO World Heritage city—have maintained a remarkable continuity, preserving a unique repository of built heritage deeply intertwined with their historical ecology. During the medieval era, Siena thrived by strategically leveraging its natural valleys for resources and microclimate regulation. However, the pressures of modern urban development on the city's fringes are now causing climatic transformations that risk disconnecting new areas from these vital historical and natural roots. Therefore, understanding and leveraging Siena's historical context is crucial to ensure that future developments remain harmoniously integrated with its enduring character and ecological balance.

Climate change, characterized by long-term shifts in temperatures and weather patterns primarily driven by human activities such as the burning of fossil fuels (United Nations, 2024), poses a significant global threat. Despite commitments to net-zero emissions by 2050, global greenhouse gas emissions continue to rise. Cities, though they cover only a small portion of the Earth's surface, are major contributors—accounting for over 70% of global greenhouse gas emissions and consuming over 65% of the world's energy (European Union, 2024). Limiting global warming to 1.5°C is essential for a sustainable future (IPCC, 2022). This warming trend presents significant risks to cultural heritage sites, demanding the implementation of targeted and adaptive conservation strategies to mitigate adverse effects while respecting their intrinsic value. Moreover, climate-related hazards such as flooding, rising sea levels, and increased erosion pose serious threats to cultural heritage sites that were not built to withstand these risks (Prabowo & Salaj, 2023). Siena, as a heritage city, reflects the deep ties between urban form and nature, raising key questions about climate resilience today.

The growing adversities of climate change threaten the identity of historically significant sites globally. Historic urban landscapes (HUL) need integrated adaptive measures to preserve their cultural and natural heritage from climate-induced risks (Fatoric, 2017). The UNESCO Recommendation on the HUL (2011) promotes a landscape-based approach that recognizes the layering of cultural, natural, and built values, encouraging adaptation that respects heritage integrity. Planning, regulatory systems, financial design, and community engagement are the four pillars of an inclusive heritage-based sustainable development and management strategy (UNESCO, 2011). The HUL recommendation (2011) exemplifies landscape-based and community-led preservation and safeguarding strategies that integrate traditional ecological wisdom with contemporary planning. It recognizes tangible aspects—such as historic built fabric and environmental factors—and intangible aspects—such as socio-cultural and economic elements—as well as the engagement of key stakeholders and their governance (Donato and Lohrasbi, 2017). These approaches emphasise blue-green infrastructure, passive cooling, and water-sensitive design while maintaining the morphological and symbolic fabric of historic cores of HULs.

Various studies from European contexts underscore the potential for combining resilience with conservation practices (Pereira Roders & Oers, 2011), acknowledging these as embedded adaptive responses to environmental stress (Mehrotra, 2016).

Historic urban landscapes, like Siena, represent a delicate balance between human culture and the natural environment, and understanding these man-nature ecosystem dynamics is crucial for effective urban management. Siena's unique urban fabric and its historical climate resilience were shaped by a sustainable mechanism that integrated its natural valleys into the city's functioning, likely through careful water management and ventilation strategies inherent in its medieval design. Consequently, the city's growth and transformation over time are inextricably linked to its historical context, forming a rich heritage urban landscape (Adishakti, 2017). While mapping serves as a valuable inventory technique for tracking urban change, this study aims to delve deeper into the qualitative aspects of this evolution in Siena, particularly concerning its climate vulnerabilities within its dense historical fabric.

A significant turning point in Siena's urban development was the approval of its general master plan in 1956 (locally) and 1959 (nationally) (Maggi, 2011). This plan made a deliberate decision to direct new urban growth outside the medieval walls, preserving the "green valleys" within and restricting further construction inside the historic centre (Maggi, 2011) (Figure 1). This commitment to preservation contributed significantly to Siena's historic centre being designated a UNESCO World Heritage Site in 1995, recognized for its exceptional preservation of medieval architecture and urban planning (UNESCO, 2024).

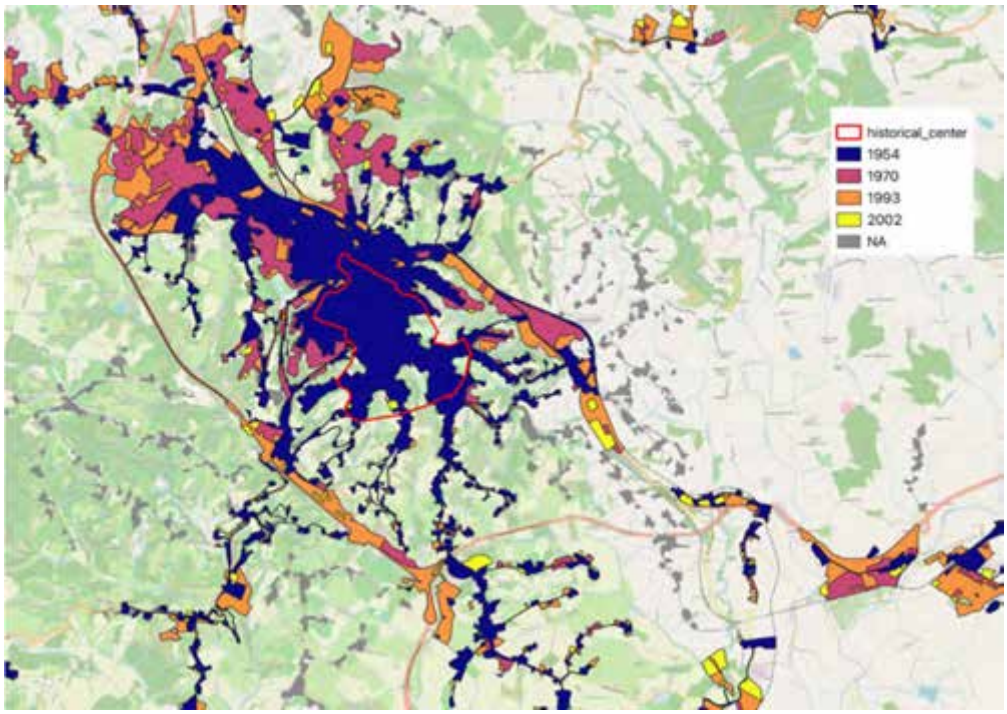

Figure 1. Spatial development of Siena. Author's elaboration.

This study, titled "Preserving the Past or Protecting the Future? Harmonizing Cultural Heritage and Climate Adaptation in Siena," emerged from the ISOCARP YPP (Young Planning Professional) Workshop "Valleys of Siena: Global Ideas for Local Connectivity." Recognizing climate change as a critical threat to the Siena region's ecological balance and its esteemed cultural heritage site, this research is inspired by Italo Calvino's *Invisible Cities*. We interpret the 'invisible' climate-related challenges—such as the intensifying urban heat island effect within Siena's dense historical structure—as being deeply embedded in its heritage-built setting, and we aim to uncover and address them. Ultimately, this project seeks to provide valuable insights for Siena by showcasing how other culturally significant sites have successfully adapted to climate change while maintaining comfortable living conditions for both residents and visitors. It aims to contribute to a more resilient and sustainable future for the city.

Materials and methods

This research employed a mixed-methods approach, combining quantitative spatial analysis with qualitative field research and comparative case study analysis to develop a practical toolkit for climate adaptation in Siena (Figure 2). The methodology was structured to: (1) diagnose the key climate-related challenges facing Siena, (2) study potential adaptation strategies from case studies all around the world, (3) define families of adaptation strategies which can preserve the cultural heritage and adapt to climate change, and (4) contextualize these strategies within Siena's specific historical, social, and environmental context.

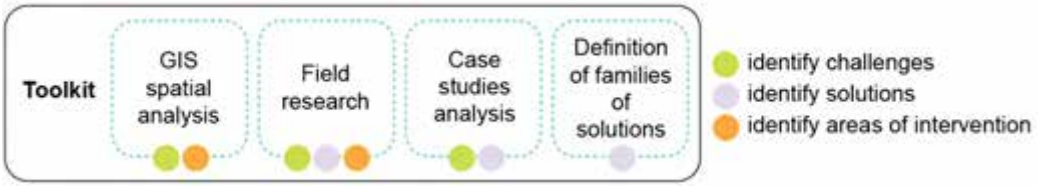

Figure 2. Scheme of the mixed-methods approach used to conduct the study.

GIS spatial analysis was conducted to map urban heat islands (UHIs), evaluate urban density, measure the distribution and quality of green spaces using NDVI, and perform an initial risk assessment to prioritize areas for intervention. **Field research** was undertaken to validate the GIS findings (Figure 3). This involved capturing visual documentation of areas with significant heat stress, extensive paved surfaces, and a lack of green spaces, as well as observations on the disconnection between the city centre and the valleys. Informal conversations with local residents and stakeholders offered valuable perspectives on their experiences and perceptions of Siena's current challenges.

Figure 3. Visual documentation from field research in Siena. This figure presents a selection of images captured during field research. Picture 1 - exploration of the surrounding valleys by bus; Picture 2 - on-foot observation within the valley areas; Picture 3 - the view of the Siena city centre as seen from the valleys; Picture 4 examples of small green interventions, such as potted plants, noted for their potential to contribute to microclimate cooling; Picture 5 - on-site perception of the urban environment; Picture 6 shows the *Tartarugone* parking area, identified as a potential site for future intervention.

A **comparative case study approach** was applied, selecting other UNESCO World Heritage Sites that have successfully implemented climate adaptation strategies, with a focus on urban heat island mitigation and small-scale, temporary interventions.

Based on the challenges identified through GIS, fieldwork, and the UNESCO case studies, we defined several **"families of solutions"**, including: Water Management, Ecosystem Enhancement, Community Engagement, Heat Control, and Places that Foster Belonging. These were then adapted to Siena's context.

By cross-referencing the spatial and qualitative findings with the solution families, we prioritized context-sensitive interventions that align with Siena's heritage values and spatial constraints.

Results

The presentation of the findings begins by outlining Siena's specific challenges. This is followed by an analysis of international case studies from contexts facing similar issues, particularly the intersection of cultural heritage and climate change impacts. Finally, we present defined solution families along with specific proposals for Siena, aimed at harmonizing heritage preservation with climate change adaptation.

Siena's Challenges

Despite Siena's renowned surrounding green valleys, its city centre presents a dense urban structure. Calculating the building coverage ratio within the city walls reveals that approximately 70% of the area is not occupied by buildings, leaving around 30% as built-up. While this relatively low building footprint might initially suggest a "green" centre, the city's valleys, encompassing public and private gardens and orchards, along with larger green spaces like "La Fortezza," are largely disconnected from the daily life within the historic core due to existing barriers. Furthermore, there is a noticeable scarcity of small green spaces integrated within the urban fabric itself. When recalculating the building coverage ratio for the central urban fabric, excluding these larger, often isolated green areas, the figure increases significantly to 47% (Figure 4A). This neighbourhood-level coverage ratio is considerably high, comparable to Densely built areas such as some neighbourhoods in Manhattan (according to the Density Atlas, 2020). The space not covered by building footprints is predominantly composed of impermeable pavements in streets and piazzas. These factors collectively contribute to the emergence of the urban heat island effect, a phenomenon that is projected to become increasingly pronounced as climate change progresses.

Analysis of the historic centre for the urban heat island effect indicated that approximately 30% of its area (excluding the green valleys, specifically 1.946–2.365 and 2.365–2.989 in the legend) is significantly affected by elevated temperatures (Figure 4B).

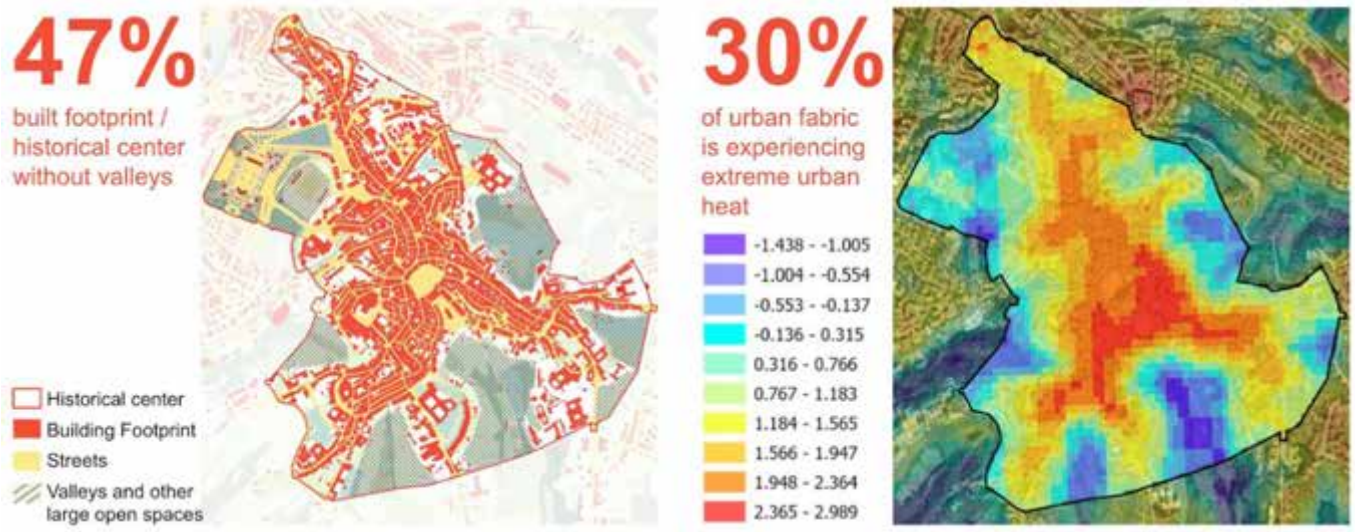

Figure 4. Built-up density and urban heat island (UHI) effect map. Author's elaboration.

Recognizing the stringent UNESCO regulations governing historical sites, we understand that the potential for large-scale interventions within such urban centres is limited. Direct alterations to the historical urban fabric and the creation of extensive greening infrastructure are often challenging. Therefore, our focus will be on small-scale interventions and temporary structures that strategically utilize existing urban spaces. GIS analysis and field research enabled the identification of several hot-spots within Siena's city centre—specific areas experiencing persistent issues requiring prompt attention (Table 1).

Table 1. Hotspots within Siena's city centre and their key challenges.

Picture	Type	Key challenges
	Larger squares	Heat absorption, lack of shade.
	Small squares	Occupied by cars, no greening or shading, lack of seating to stay instead of walking by.
	Main Streets	No or limited shade, lack of vegetation, high contribution to heat effect.
	Schools and public buildings	Fully artificialised, no or limited greening, closed to the public.
	Parking lots	Low urban quality, high contribution to heat effect, impermeable - limit water infiltration, disconnect valleys-city canter.
	Existing valleys	Prevalence of private space (gardens, restaurants, vineyards etc), lack of walkable trails, absence of urban furniture, physical disconnection.

Short interviews with local citizens and experts broadened our perspective beyond the factual data obtained through GIS analysis and documentation of climate challenges, incorporating a crucial social dimension. The Contrada communities' active role in urban life highlights the potential for citizens to act as key drivers in the adoption of sustainable greening initiatives. Considering the challenges that newcomers (e.g., students, migrants) may encounter upon arriving in Siena, we emphasize the necessity for spaces that foster social cohesion and gathering, providing opportunities for meaningful interaction among diverse individuals.

Case Studies Analysis

To address Siena's challenges, we researched potential actions implemented globally to combat similar issues. We compiled a list of relevant case studies: projects that integrate water management, reduce the heat island effect, enhance biodiversity, increase community engagement, and improve the liveability of public spaces. Based on these case studies, our aim was to identify solutions adaptable to Siena's context, enabling the city to confront its challenges while preserving its heritage. These solutions are conceived not only to help the city address its climatic challenges but also to encourage community engagement and create spaces where individuals from diverse backgrounds can meet and participate in common actions.

To address Siena's challenges, our research explored global initiatives tackling similar urban issues. We identified several relevant case studies offering adaptable solutions for water management, heat island reduction, biodiversity enhancement, community engagement, and improved public space livability (Figure 5).

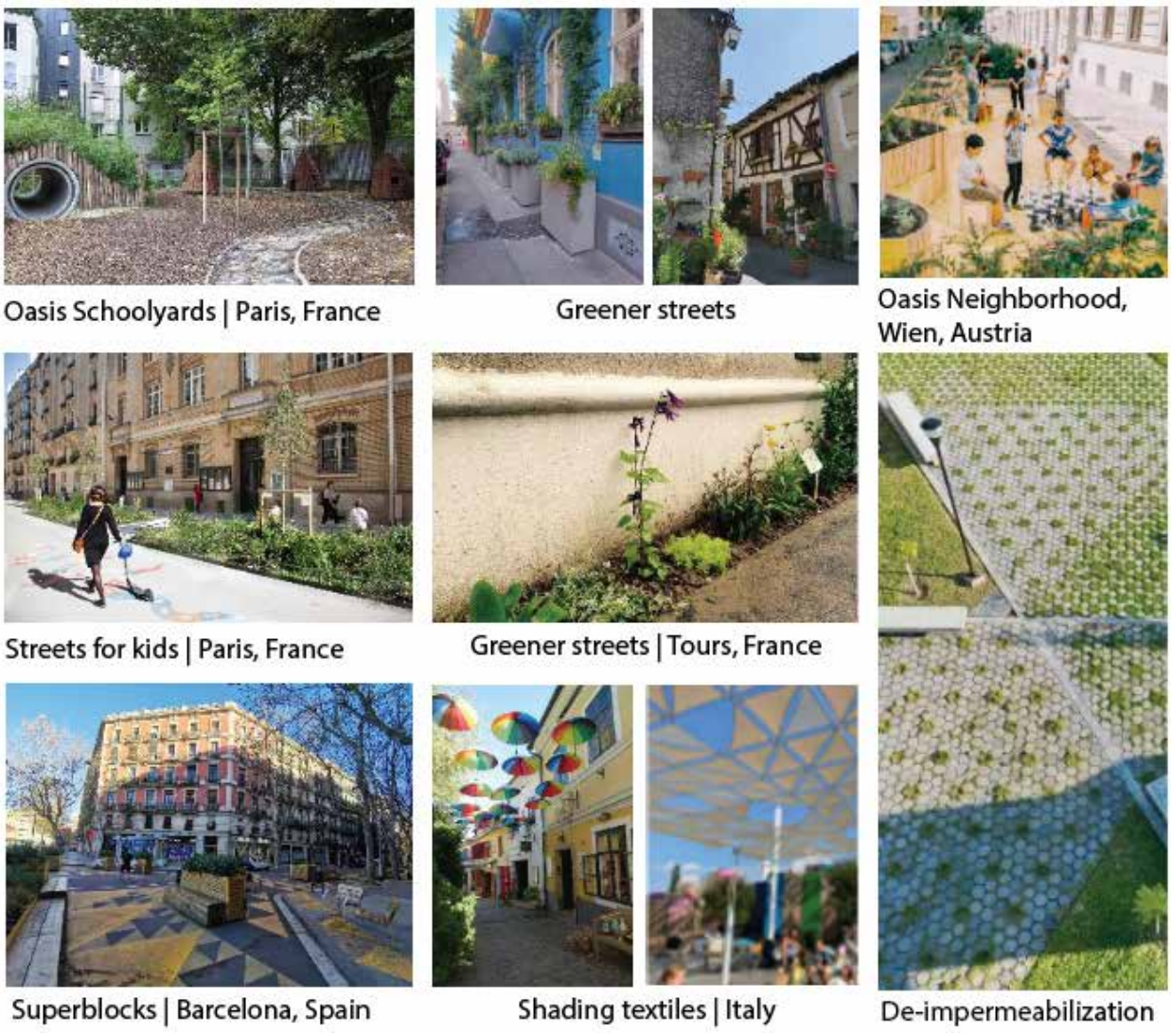

Figure 5. Case studies of cities adapting to climate change with temporary, soft, or green solutions.

One compelling example is the Paris Oasis - Openness, Adaptation, Sensitisation, Innovation, and Social Ties - Schoolyard Programme in France (Climate-ADAPT, 2022). Following the devastating heatwaves of 2003 and 2017, and in response to limited green public spaces, poor water absorption, heat island effects, biodiversity loss, and air pollution, Paris transformed schoolyards by de-impermeabilising surfaces and introducing extensive greenery. By opening these revitalised spaces to the public outside school hours, the city has encouraged community engagement, created vital social hubs, reduced urban heat, enhanced water management and biodiversity, lowered pollution levels, and improved the overall urban experience.

Similarly, the "Streets for Kids" initiative in Paris addressed the scarcity of green spaces, poor permeability, and limited biodiversity (Baierl, 2025). By reducing traffic and introducing greenery through de-impermeabilised streets and tree planting, the city created safer and more welcoming spaces for children and families. This not only reduced the heat island effect but also fostered community well-being and improved the urban ambiance.

Barcelona's "Superblocks" offer another exemplary model. Faced with limited public green space, excessive traffic, and biodiversity decline, the city reimagined car-dominated zones as pedestrian-centred green spaces (C40, 2018). Through the addition of street furniture and vegetation, Barcelona promoted social interaction, improved microclimates, enhanced biodiversity, and increased pedestrian safety.

Vienna's Vienna – Grätzloase initiative exemplifies a citizen-driven response to similar urban challenges (Lee Kuan Yew World City Prize, 2020). Temporary transformations of parking spaces into green community areas empowered residents to reclaim public space. These interventions contributed to heat island mitigation, water management, biodiversity support, and the creation of safer, more inclusive urban environments.

Simple yet impactful solutions, such as the use of plant pots or encouraging residents to green their streets, have been employed in various cities. For example, in Tours, France, the municipality enabled residents to cut through pavements and plant directly into the ground . This initiative tackled impermeability, water runoff, and heat effects while enhancing biodiversity and fostering community care for public space.

In Italy, some municipalities have addressed excessive heat in public spaces by installing temporary **shading textiles** across squares and streets (Fabbri et al. 2023). These installations reduce surface temperatures and promote the use of public spaces for social and cultural activities.

Other effective solutions include de-impermeabilising parking areas using permeable paving systems, such as concrete grids that allow grass to grow. These systems improve water absorption, reduce heat, and increase green cover in highly artificialised environments.

Collectively, these international case studies demonstrate that even modest, low-impact interventions can have wide-reaching benefits. When adapted to Siena's context, such strategies can contribute to a more climate-resilient, liveable, and socially cohesive city, all while respecting and preserving its cultural heritage.

Definition of Solutions

Drawing upon the insights gained from the analysed case studies, several families of solutions have been defined for potential implementation in Siena (Figure 6). These interconnected families are specifically designed to address the city's unique challenges while drawing inspiration from successful climate adaptation strategies observed in other UNESCO World Heritage sites. The proposed solutions are organized around five key areas of intervention. Firstly, **Water Management** strategies aim to enhance water retention and improve drainage systems, thereby playing a crucial role in reducing the risk of flooding and mitigating the adverse effects of the urban heat island. Secondly, **Ecosystem Enhancement** focuses on the restoration and improvement of natural ecosystems within and around Siena, with the goal of increasing biodiversity and improving overall air quality. Thirdly, **Community Engagement** initiatives are designed to empower local communities to actively participate in climate action through collaborative projects and shared stewardship. The fourth area, **Heat Control**, encompasses the implementation of various strategies to reduce heat absorption within urban areas and increase cooling mechanisms, thereby improving thermal comfort. Finally, the creation of **Places that Foster Belonging** is a key focus, aiming to develop accessible and welcoming public spaces that encourage social interaction among diverse groups and ultimately enhance the overall well-being of Siena's residents.

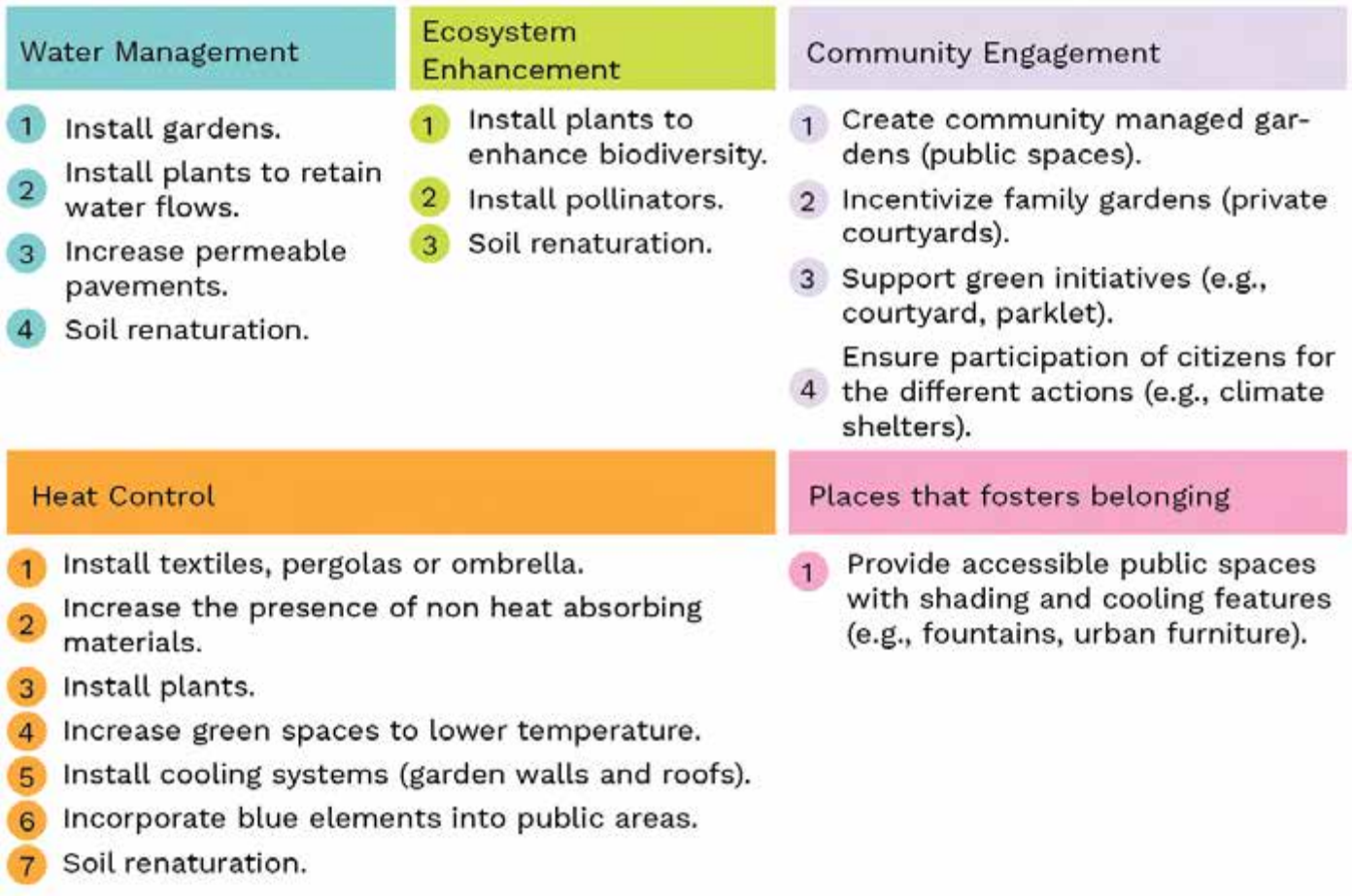

Figure 6. Families of solutions.

Furthermore, we have visually represented these solutions in a matrix (Figure 7) to assist decision-makers in understanding the relationship between specific areas in the city, their identified challenges, and the proposed solutions.

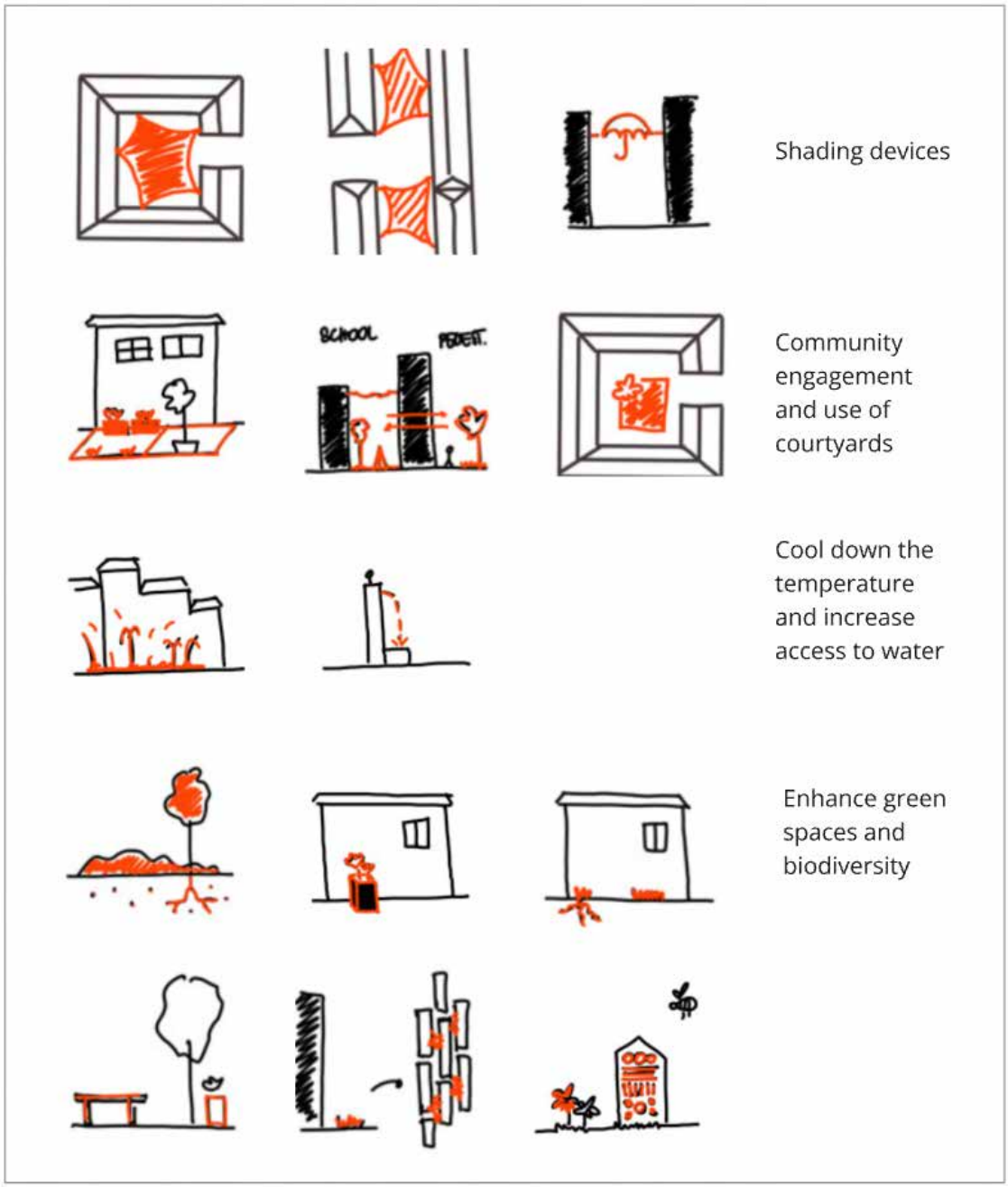

Figure 7. Solutions matrix illustration.

Mapping Actions

All defined solutions were spatially applied to the problem areas identified in the centre of Siena during the analytical phase of this work. The accompanying map (Figure 8) illustrates the locations of all identified hot-spot

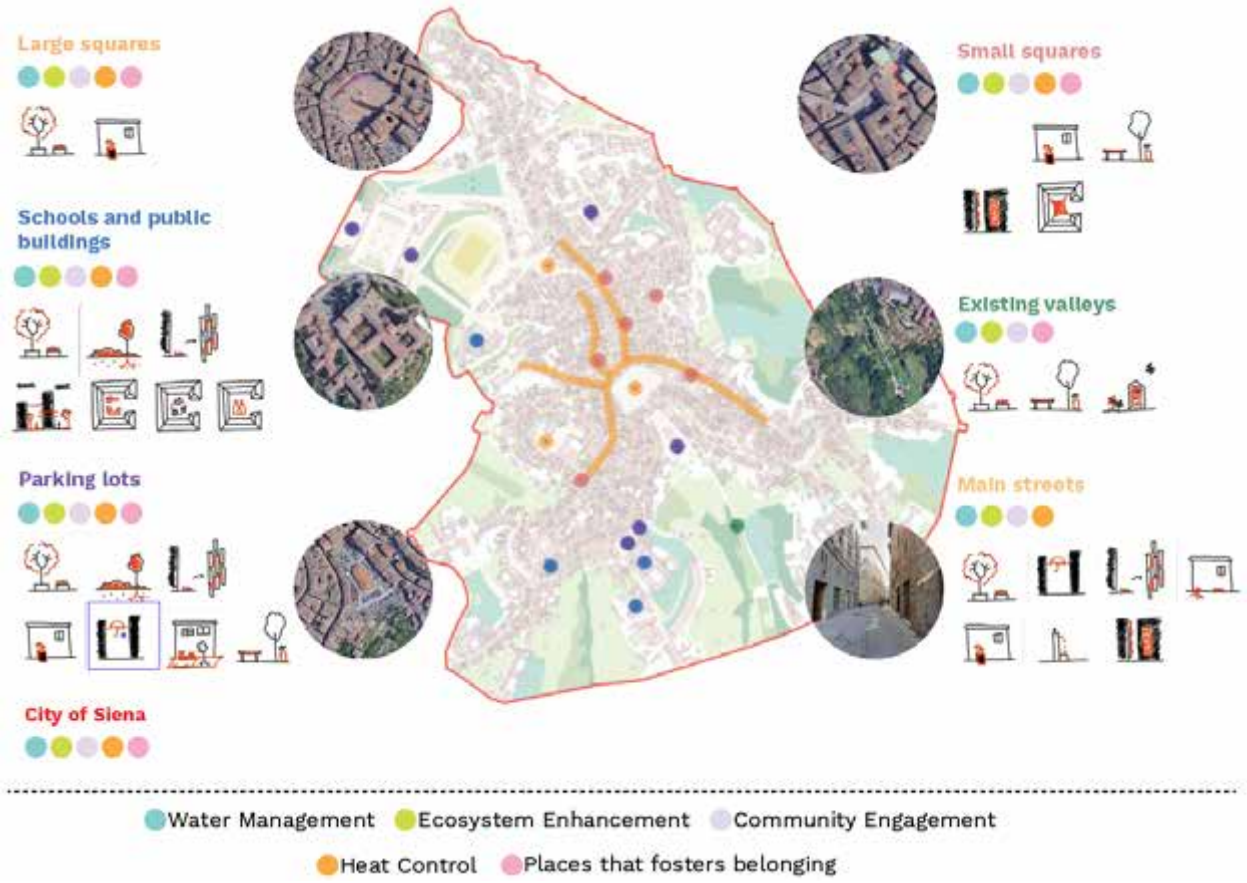

Figure 8. Interventions for climate adaptation map in Siena

Analysis of key urban spaces in Siena reveals specific challenges related to heat absorption, lack of green infrastructure, and limited public amenities. Large squares, while iconic, suffer from excessive heat due to impermeable surfaces and lack of shade, suggesting the need for citizen-involved climate shelters and planted areas to enhance biodiversity and regulate temperature. Schoolyards and public buildings often lack green spaces and could be transformed through soil renaturation, permeable pavements, vegetation, shading structures, and community-managed gardens to improve biodiversity, water retention, and provide accessible, cooled public spaces. Parking lots, prominently located, exhibit low urban quality, contribute to heat effects, and impede water infiltration and social interaction, necessitating similar interventions like soil renaturation, permeable surfaces, planting, and shading, alongside the creation of community gardens and accessible public spaces. Small squares, currently dominated by vehicles and lacking greenery and shade, could be revitalized with planting for biodiversity and heat control, citizen-led climate shelters, shading structures, cooling systems, and accessible, shaded public furniture. Existing valleys, despite their natural presence, lack accessibility and public amenities, indicating a need for pollinator-friendly planting, soil renaturation, enhanced biodiversity, community gardens, and welcoming, shaded public spaces. Main streets, characterized by full artificialization and limited shade and greenery, contribute to the heat island effect, suggesting solutions like increased planting for biodiversity and water retention, permeable pavements, shading structures, expanded green spaces, incorporation of blue elements, use of non-heat-absorbing materials, community gardens, and accessible, cooled public areas, all while maintaining urban mobility. Considering the broader city centre, including incentivizing green development in private courtyards, a combination of these localized solutions can contribute to a more climate-resilient and liveable Siena.

Conclusion

This paper investigated the potential for climate adaptation in Siena, a city distinguished by its exceptionally well-preserved historic fabric and UNESCO World Heritage status, where climate responses must be carefully balanced with cultural conservation. While UNESCO's mandate focuses on protecting cultural heritage, it does not explicitly require member states to address climate change challenges (Nguyen & Baker, 2023). Siena's compact medieval core, characterised by narrow streets, steep topography, and layered historical infrastructures, presents both constraints and unique opportunities for adaptive strategies. Working within the regulatory limits of a UNESCO site complicates asset management for climate adaptation but can also drive innovative, site-specific solutions (Pendlebury et al., 2014).

This project offered an opportunity to critically examine the tension between viewing Siena as a static open-air museum and embracing a dynamic perspective that adapts the city to contemporary and future needs while safeguarding its heritage values. Drawing on a combination of GIS analysis, fieldwork, and international case studies, the study mapped vulnerabilities such as urban heat exposure, limited green infrastructure, and geomorphological challenges within this highly protected environment.

Based on global precedents, four categories of climate adaptation strategies were identified, emphasising how environmental effectiveness can be harmonised with heritage sensitivity. These were translated into locally tailored proposals for Siena, including nature-based interventions embedded within historic street patterns, shaded public microclimates, and the revitalisation of ancient water systems. Consistent with ICOMOS guidance (2019), these site-specific and adaptive solutions respect cultural values while addressing climate risks.

Importantly, the proposed interventions prioritise non-invasive, small-scale actions strategically diffused throughout the city to generate meaningful cumulative impact. This approach aligns with principles of tactical urbanism, favouring reversible and flexible measures that can evolve through stakeholder feedback and municipal collaboration (Lydon & Garcia, 2015). Such flexibility is essential to ensure the long-term relevance and effectiveness of adaptation efforts, while maintaining respect for existing uses and cultural sensitivities.

Although Siena was used as a pilot case to develop this methodology, the framework is intended as a replicable, adaptable toolkit for other historic cities confronting the dual challenges of cultural preservation and climate change. Each application must be carefully contextualised to local histories, urban forms, regulatory frameworks, and cultural landscapes to avoid generic, one-size-fits-all solutions.

This study contributes to the emerging dialogue bridging heritage conservation and climate resilience, offering a place-based planning methodology where formal adaptation frameworks are often lacking. Future research should focus on co-designing interventions with local communities, exploring participatory governance models, and piloting projects to evaluate feasibility, cultural acceptance, and sustainability — ensuring adaptation is both environmentally sound and culturally embedded.

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