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RE-PUBLIC SPACES

D1.2.1 STRATEGY FOR ADAPTING FOUR HISTORIC COURTYARDS TO CLIMATE CHANGE IN THE CITY OF PINEROLO

RE-PUBLIC SPACES

Version 1

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TABLE OF CONTENTS

1. Characteristics of the urban complex

1.1. Historical background of Pinerolo

The area where Pinerolo stands has been inhabited since prehistoric times. Initially a rural settlement, with the donation of land to the Abbey of San Verano in 1064, Pinerolo began to take shape as a town, eventually becoming — by the end of the 13th century — the capital of the Principality of Acaja, a cadet branch of the House of Savoy. During this period, the city was divided into the "upper part" (the Borgo), on the hill, and the "lower part" (the Piano). The Acaja Castle, of which only a portion remains today, dominated the "upper part."

In the 15th century, Pinerolo lost its status as the capital to Turin. In the following years, marked by numerous French invasions, the city's walls were expanded and reinforced. Pinerolo is strategically located, providing access from the Alps to the Po Valley, and therefore it was long contested between the Savoys and France, a situation that increased the military importance of the city. Under French rule in the 1600s, several buildings and military fortifications were erected including the Armory, which is now the City Hall.

When the city returned to the Savoys at the end of the 17th century, the dismantling of the French fortification system (the barracks and city walls) began. Stripped of its walls, Pinerolo started to expand into the surrounding lands from the 1700s onward. This period saw the construction of the Ospizio dei Catecumeni, now known as Palazzo Vittone.

A further expansion took place in the 1800s, after Napoleon's downfall, driven by both economic growth and renewed military significance due to the relocation of the Military Cavalry School to Pinerolo, which was housed in a newly built large barracks, the Fenulli Barracks.

The city's growth continued at the end of the 19th century and the beginning of the 20th century, fueled by industrial development and the new railway link with Turin. After the fascist regime and the war, the expansion continued in the post-war period due to the growth of the metalworking industry. The decline of industry in recent decades, along with the reduction of military activities, has left many "gaps" in the city, which represent both a challenge and a significant opportunity for urban regeneration.

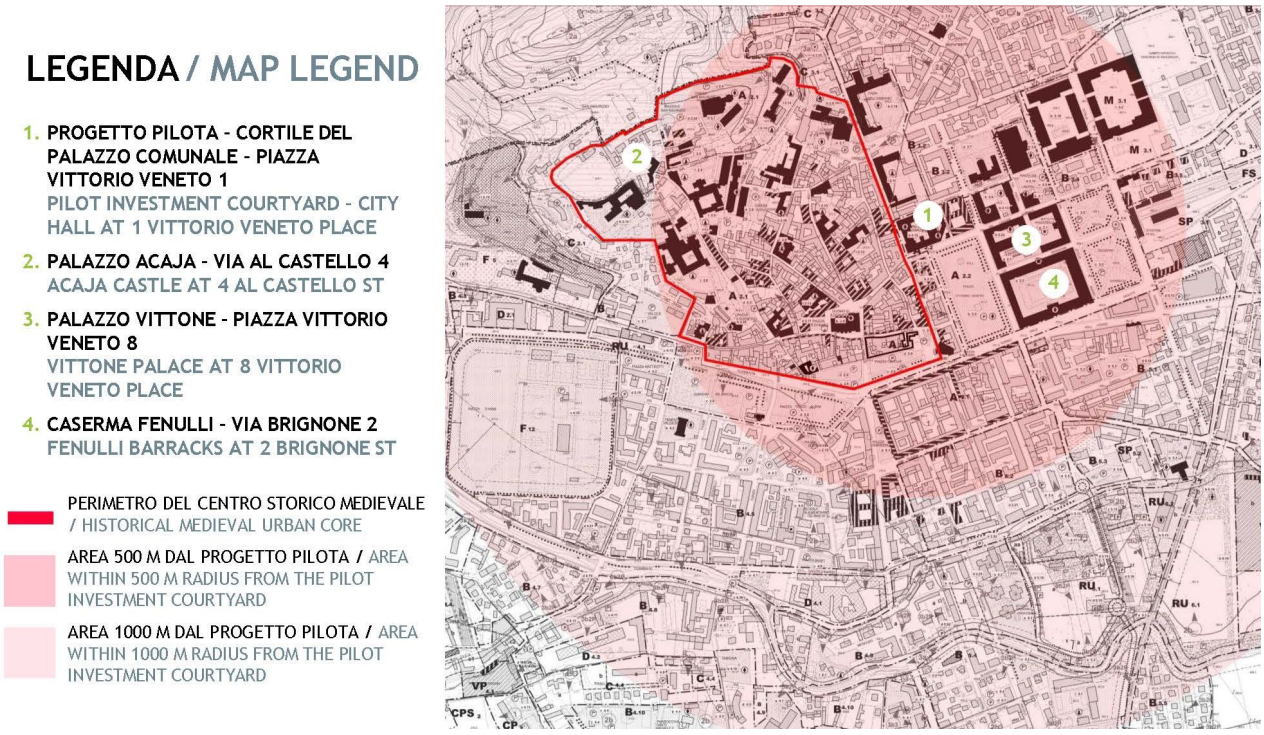


Figure 1. Location of the analyzed courtyards in the context of Pinerolo's historic center, Source: Pinerolo - Charter of Cortyards

1.2. The Historic Urban Core

The historical urban morphology of Pinerolo's *centro storico* (historical centre) is a classic case of organic medieval development, adapted to a sloping topography on the lower reaches of Mount Pepino. The city's growth pattern is characterized by a concentric and radial structure, originating from its defensive core.

The street network presents a dendritic pattern dominated by a dense and intricate grid of narrow, irregular streets (*vie*) and lanes (*vicoli*). This layout, typical of pre-modern urbanism, prioritized defensive efficiency and maximized land use. Key thoroughfares, often lined with arcades (*portici*), serve as primary circulation axes, leading to central nodal points such as the Piazza San Donato and the Piazza della Cavalleria.

The built environment is architecturally stratified, showcasing a variety of historical styles. While the core fabric is predominantly medieval, with structures featuring load-bearing masonry of local stone and brick, there are significant Renaissance and Baroque additions. Key typological elements include:

- Palazzi signorili: multi-story residential buildings with articulated facades, often featuring decorative friezes, cornices, and frescoed interiors.
- Case a corte: courtyard houses, which represent a common residential typology, providing private interior spaces within the dense urban fabric.

- Religious architecture: prominent ecclesiastical structures like the Duomo di San Donato and the Chiesa di San Maurizio act as monumental anchors, distinguished by their Romanesque and Gothic revival elements.

The urban fabric is characterized by a high degree of spatial continuity and morphological cohesion. The use of consistent materials and the preservation of historical building lines contribute to a unified visual and textural landscape, reflecting a continuous process of urban adaptation rather than a planned, singular development. The historical military function of the city is also evident in the urban layout, with the former Scuola di Cavalleria complex representing a significant later addition that reconfigured a portion of the urban edge.

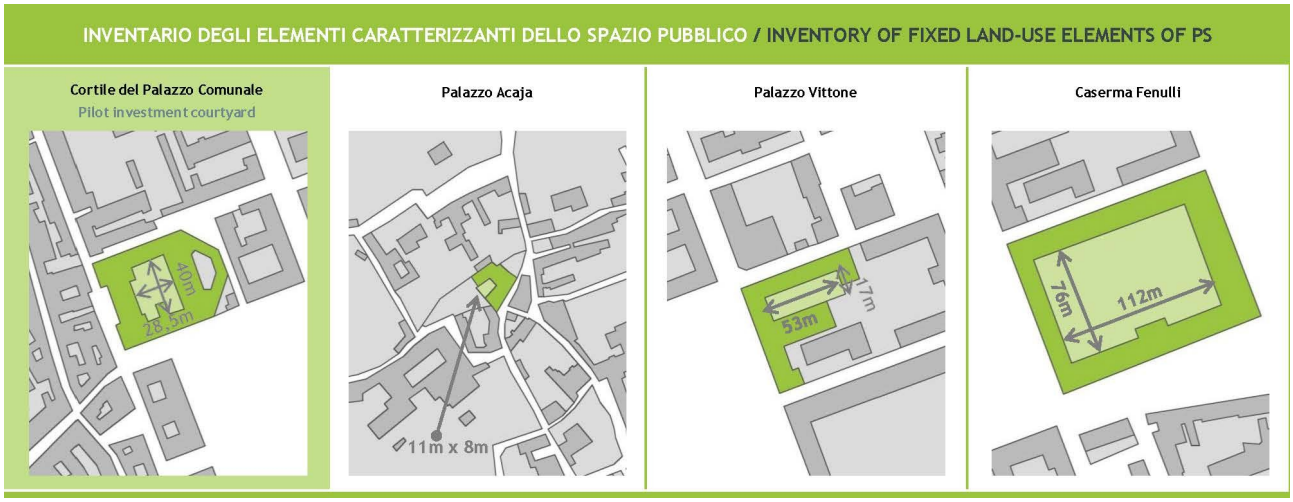


Figure 2. Inventory of the analyzed courtyards by size and shape. Source: Pinerolo - Charter of Cortyards

1.3. Characteristics of the Courtyards

The courtyards that characterize the city of Pinerolo exhibit a great variation of construction types, layouts, and dimensions, reflecting their different construction periods and uses. The courtyards selected for this analysis, chosen from those owned by the Municipality of Pinerolo, reflect this diversity of characteristics. Within the historic city, dating back to medieval times, the internal courtyards are characterized by their small dimensions, winding through a very compact urban fabric due to being compressed within the defensive walls. In later periods, with the growth of the city, its increasing military importance, and the demolition of the city walls, the spaces expand. At the same time, the courtyards evolve from merely being a distribution space to becoming functional areas.

The following courtyards were therefore selected for detailed analysis and assessment within the project:

- Cortile del Palazzo Comunale (Pilot investment courtyard)
- Cortile del Palazzo Acaja

- Cortile del Palazzo Vittone
- Cortile della Caserma Fenulli

Figure 3. Inventory of the analyzed courtyards - Photographic views of the selected courtyards. Source: Pinerolo - Charter of Courtyards

Several characteristic architectural and design elements contribute to the identity of selected courtyards.

The courtyards chosen for this inventory were built in different eras and for different purposes, therefore they present different construction and decorative elements. However, all courtyards have facades with large windows and there is a significant presence of brick. As regards the conservation of the historical identifying characteristics, all four courtyards are part of buildings listed by Soprintendenza per i Beni Architettonici e Paesaggistici. Gates, fences and doors, as currently installed, exhibit a traditional design in line with the historical character of the urban fabric. The City Hall has a wrought iron gate that leads to a portico, while the other courtyards are closed by wooden or wrought iron gates. These elements appear to be original or restored in keeping with the historical context; however, they show signs of wear, such as cracks in the wood and misalignments, which can compromise both their safety and overall functionality, as well as their aesthetics. All the courtyards analysed are closed off from the outside, except for the courtyard of Palazzo Vittone, which originally had a different layout.

Despite their diverse origins and individual peculiarities, the courtyards share a common identity that aligns perfectly with Pinerolo's historic character, thanks to the use of traditional materials and design elements that echo local architecture.

1.4. Accessibility

The courtyards analysed here are partially accessible (except for Palazzo Acaja, which is not accessible for disabled users); the access level is at street level, but there are no dedicated pathways/tactile paths for the visually impaired/appropriate signage. Furthermore, the permeable paving may be uneven and, therefore, pose an obstacle for users with reduced mobility.

In line with the need to preserve the historical features, solutions should be implemented to enhance the accessibility of public spaces. In the case of interventions on protected heritage sites, while it is necessary to obtain permission from the Superintendence, in 2008 the Ministry of Cultural Heritage and Activities issued guidelines for overcoming architectural barriers in places of cultural interest. These guidelines can provide recommendations for balancing the need to protect a historical site with the issue of accessibility.

2. Urban and climate context

2.1. Climate characteristics and adaptation potential

The municipality of Pinerolo, located in the Piedmont region of Italy, possesses a unique geographical and topographical context that fundamentally shapes its climate. Situated at the foot of the Alps, a key topographical feature that significantly influences its local climate, the city lies at a critical interface between mountainous terrain and the expansive Po Valley plain. This transitional position subjects the area to a combination of alpine and continental meteorological influences, resulting in a climate with a high degree of seasonal and diurnal variability.

Summers in Pinerolo are typically warm and can be humid, with average daily high temperatures ranging from approximately 24°C to 27°C during the hottest months of July and August. However, it's not uncommon for temperatures to exceed 30°C during heatwaves. Winters, by contrast, are cold, with average daily highs often below 10°C. Nighttime temperatures frequently drop close to or below freezing, and the city can experience snow, though snowfall is generally not as heavy or prolonged as in the nearby mountains.

Precipitation is distributed throughout the year but tends to be more significant in the spring and autumn. May and November are often the wettest months, with a notable increase in rainfall. This pattern is characteristic of the Po Valley, where moisture from

the Mediterranean and Atlantic fronts can be trapped by the Alps, leading to frequent precipitation. The driest period is typically in the winter, particularly in January. The combination of its Alpine-influenced temperatures and seasonal rainfall pattern defines the specific climatic context of Pinerolo, which is distinct from both the Mediterranean climate to the south and the strictly alpine climate to the west.

Recent climatic trends for the Pinerolo area align with broader patterns observed across the Po Valley and the rest of Northern Italy, which indicate a clear warming trend. Over recent decades, there has been a noticeable increase in average temperatures, particularly for minimum temperatures. This warming is not uniform throughout the year; while all seasons are affected, some data suggests a more significant rise in summer and early autumn. This trend also manifests in an increase in the frequency and intensity of extreme weather events, such as heatwaves and periods of drought, which are becoming more common and prolonged.

Climate change projections[1] for Pinerolo forecast a continuation and acceleration of these trends. Under various emissions scenarios, the region is expected to experience a further increase in mean annual temperatures. This rise is anticipated to be particularly pronounced in the summer, leading to more frequent and intense heatwaves. The number of "tropical nights," where temperatures remain high overnight, is also projected to increase, which has significant implications for human health and agricultural productivity.

Beyond temperature, future climate models project significant changes in precipitation patterns. While the total annual rainfall may not decrease substantially in all scenarios, its distribution is expected to become more irregular. This means Pinerolo will likely experience fewer but more intense rainfall events, increasing the risk of flash floods and hydrogeological instability. Conversely, this shift in precipitation, combined with higher temperatures, will contribute to longer and more frequent periods of drought, especially in the summer. These changes in the hydrological cycle will have critical impacts on water availability for agriculture and urban use, as well as on the snowpack in the nearby Alps, a crucial source of water for the region's rivers and aquifers.

[1] Source: CMCC (Centro Euro-Mediterraneo sui Cambiamenti Climatici, www.cmcc.it) and ARPA Piemonte (Agenzia Regionale per la Protezione Ambientale, www.arpa.piemonte.it)

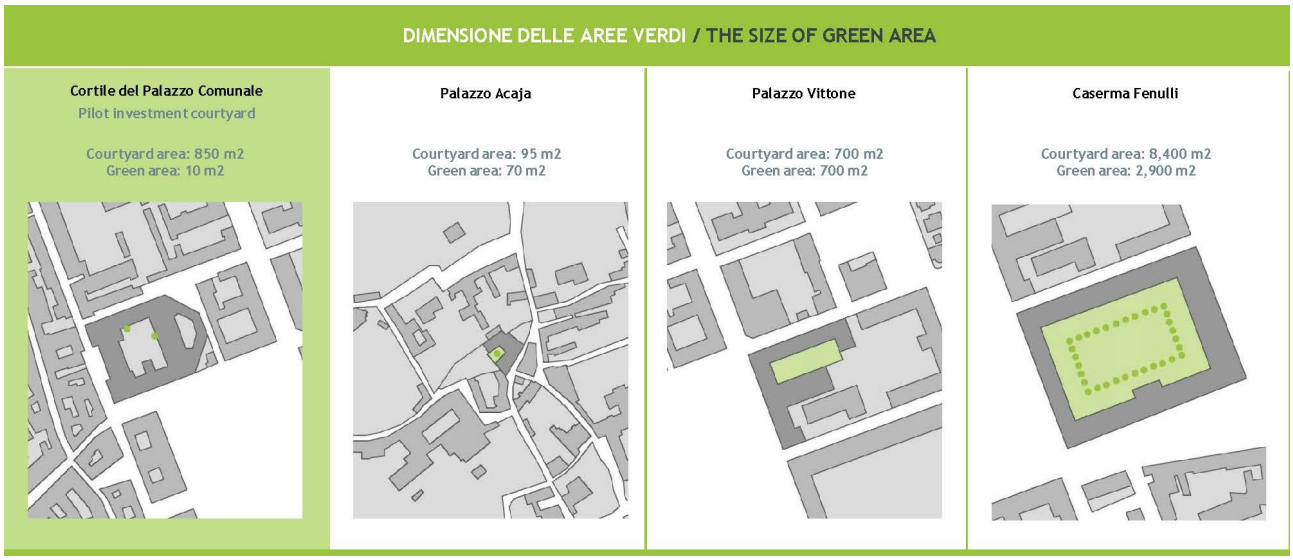


Figure 4. Inventory of the analysed courtyards - The size of green areas. Source: Pinerolo - Charter of Courtyards

The selected courtyards have the following characteristic:

- **Shape**: three of the selected courtyards are characterized by a rather enclosed and intimate spatial configuration. Surrounded on three sides by notably tall buildings, they have a predominantly square or rectangular plan that clearly defines their boundaries. In contrast, the courtyard of the Fenulli Barracks offers a sense of greater openness and spaciousness. Although it is also bordered by buildings, its larger form and dimensions create a more airy and less confined space compared to the other courtyards.
- **Surfaces and materials:** the courtyard of the City Hall has an entirely asphalted and waterproof surface. Furthermore, during the summer period, it becomes an important heat island. As for the other courtyards, the pavement covering material is cobblestone or gravel, therefore the soil is permeable.
- **Sunlight and ventilation:** the courtyards exhibit varying conditions of sunlight and ventilation. Three of the four courtyards (Cortile del Palazzo Comunale, Cortile di Palazzo Acaja e Cortile di Palazzo Vittone) are enclosed on all sides, severely limiting direct sunlight exposure to less than four hours per day. This enclosed configuration, combined with limited airflow, results in low to medium ventilation, which contributes to heat accumulation and poor air circulation, especially during the summer months. In contrast, one courtyard (Cortile della Caserma Fenulli) is completely open, allowing for a much higher degree of both direct sunlight and natural ventilation, creating a significantly different microclimate within the space.
- **Greenery and biodiversity:** the presence and management of greenery across the four courtyards vary significantly, highlighting a range of approaches from intentional landscaping to neglect. The City Hall Courtyard has the most minimal vegetation, limited to climbing plants like oleander and hibiscus on the exterior

walls of the Municipal Police building, with no lawn or ground-level greenery. In contrast, the Palazzo Acaja Courtyard is defined by a single, prominent palm tree, which serves as the primary arboreal element, while its low greenery consists of unmanaged, spontaneous weeds. The Palazzo Vittone Courtyard features a central and expansive lawn, providing a functional and aesthetic green carpet, though its unkempt state with overgrown grass detracts from its appearance. Finally, the Fenulli Barracks Courtyard offers a more balanced mix of mature linden trees and an adjoining lawn, yet its low vegetation is also dominated by weeds, and its walls are covered in invasive ivy. The overall state of low vegetation in all courtyards, with the exception of the City Hall's absence of it, points to a general lack of proper maintenance, which compromises both the aesthetic and functional quality of these spaces.

These characteristics directly relate to the four key climate adaptation strategies.

2.1.1. Urban Heat Island (UHI) and Heat Waves

To combat the urban heat island effect and heat waves affecting Pinerolo's courtyards, strategies should focus on reducing heat absorption. The entirely asphalted surface of the City Hall Courtyard, for example, should be replaced with permeable, low-emissivity materials like light-colored pavement or permeable pavers that allow vegetation to grow. For the courtyards of Palazzo Acaja and Palazzo Vittone, where permeable surfaces already exist, increasing vegetation cover would maximize evaporative cooling. The installation of shading structures such as pergolas with climbing plants or shade sails would reduce direct sun exposure, lowering the perceived temperature and improving thermal comfort for visitors.

2.1.2. Torrential Rains - Water Management

Managing stormwater is another crucial challenge, particularly due to the increase in torrential rainfall. Areas such the City Hall Courtyard, with its entirely impermeable surface, may represent critical points according to the climate change trends related to rainfall. For this space, and for others with less efficient paving, adopting sustainable drainage systems is essential. Installing permeable pavements (like the cobblestone or gravel already present in other courtyards but in need of improvement) allows water to filter into the ground, reducing surface runoff and the risk of flooding. Additionally, rainwater harvesting systems could be implemented for irrigating green areas, creating a virtuous cycle of water resource management and decreasing the strain on the urban drainage network.

2.1.3. Nature-Based Solutions (NBS)

Nature-Based Solutions (NBS) offer an integrated approach to addressing climate issues. The reintroduction and care of vegetation are central to these solutions. In all the courtyards, the planting of dense-canopy trees and shrubs should be encouraged. In

addition to providing shade and contributing to evaporative cooling, these plants absorb air pollutants. For example, areas such the Palazzo Vittone Courtyard, with large lawns, have big potential for implementing raised flower beds or "rain gardens" that can manage water and increase biodiversity. Furthermore, replacing weeds with low-maintenance native species would improve the aesthetic and ecological resilience of the courtyards.

2.1.4. Building Green Infrastructure (GI) and Biodiversity

Creating Green Infrastructure and enhancing biodiversity are fundamental to the ecological well-being of the courtyards. Currently, the presence of invasive species like ivy and spontaneous weeds does not contribute to a healthy ecosystem. Future strategies should include the removal of these species and their replacement with plants that support local fauna, such as pollinating insects and birds. For example, in the Fenulli Barracks Courtyard, vegetation could be enriched with fruit trees and flowering plants. The installation of green roofs and facades on some building fronts could also increase the available vegetated area, providing additional habitat, improving the thermal insulation of the buildings, and making the spaces more resilient to climate change.

2.2. The Urban Heat Island phenomenon

The Urban Heat Island (UHI) phenomenon is a critical consequence of climate change at the local scale. The UHI effect, defined as the temperature difference between urban areas and their cooler rural surroundings, is intensified by rising global temperatures, creating a dangerous feedback loop. The heightened heat from UHIs poses a direct risk to the health and well-being of urban populations, particularly the elderly, and is a major challenge for urban planners and city officials[2].

The severity of this issue in Pinerolo is underscored by its participation in the RE-PUBLIC SPACES project, whose explicit focus on combating heat islands in historic urban centres through shared studies and revitalization efforts validates the problem as a recognized, high-priority challenge. The transnational scope of this initiative confirms that Pinerolo's microclimatic issues are part of a wider European concern, giving local interventions a significant strategic weight and relevance.

2.2.1. Urban Heat Islands: causes and architectural vulnerabilities[3]

The UHI effect is a result of a combination of physical processes unique to urban environments. The primary drivers are:

[2] Source: "Can Turin beat the heat? The socioeconomic factors at play in the urban heat island effect in an Italian city", https://www.preventionweb.net/drr-community-voices/can-turin-beat-heat-socioeconomic-factors-play-urban-heat-island-effect

[3] Source: Understanding the Urban Heat Island Index | CalEPA, https://calepa.ca.gov/climate/urban-heat-island-index-for-california/understanding-the-urban-heat-island-index/

- **Heat-absorbent surfaces:** urban landscapes are dominated by dark, low-albedo surfaces such as asphalt and concrete. These materials absorb a high amount of solar radiation during the day and then slowly release this stored heat into the atmosphere at night, preventing the city from cooling down and posing a heightened health risk.
- **Lack of vegetation and evaporative cooling:** trees and other vegetation provide natural cooling through evapotranspiration, the process of water evaporating from leaves and soil. This process requires energy and thus cools the surrounding air. The absence of sufficient green space in densely built areas eliminates this natural cooling mechanism.
- **Waste heat generation:** human activities within urban areas, including the operation of vehicles, industrial machinery, and air conditioning systems, generate significant amounts of waste heat that contribute to the overall thermal load.
- **Urban canyon effect**: the geometry of tall buildings and narrow streets can create an "urban canyon" effect. This configuration traps solar radiation during the day and can block wind flow, preventing the natural ventilation that would otherwise cool the streets and surfaces.

A successful strategy for climate adaptation and UHI mitigation in historic centres such as Pinerolo must be multi-faceted and integrated.

Table 1 provides a framework linking the specific causes of UHI to actionable, evidence-based interventions.

Table 1. Framework of UHI causes and related mitigation strategies

UHI cause	Mitigation strategy	Rationale & Context
Heat-absorbent surfaces (low albedo)	Increase albedo of urban surfaces using light-colored materials.	Dark pavements and roofs absorb solar radiation, releasing it as heat at night. Using light-colored, reflective materials for pavements and roofs reduces heat absorption.
Lack of urban vegetation	Implement green infrastructure such as urban greening and green roofs.	Vegetation provides shade and cools the air through evapotranspiration. The RE-PUBLIC SPACES project's focus on increasing vegetation in courtyards aligns with this strategy.
Poor urban	Enhance natural	The geometry of narrow streets

ventilation (urban canyons)	airflow through strategic urban design.	(urban canyons) can trap heat and block airflow. Strategic tree planting and design can channel winds to improve air circulation. Local meteorological data indicates that prevailing winds are from the northeast and east, especially in spring.
Inefficient energy use and building materials	Improve building insulation and utilize passive cooling and mechanical ventilation.	Buildings, especially in historic centres, can be inefficiently insulated, leading to higher indoor temperatures and a greater demand for energy-intensive cooling. Local companies in the Pinerolo area specialize in mechanical ventilation and insulation, indicating the local availability of these solutions.
Rainwater runoff	Implement sustainable water management and rainwater capture systems.	Impermeable urban surfaces prevent rainwater from soaking into the ground, leading to rapid runoff and a loss of cooling from evaporation. The RE-PUBLIC SPACES project's objective to improve rainwater management in the Palazzo Comunale courtyard directly addresses this issue.

The unique context of Pinerolo's historic centre requires recommendations that are both effective and sensitive to its cultural heritage.

1) **Prioritize green infrastructure in courtyards:** the courtyards are ideal spaces for targeted green interventions. The strategic incorporation of green infrastructure is a highly effective method for combating the Urban Heat Island effect. By strategically planting trees and other vegetation, these spaces can be transformed into shaded, cooler microclimates. This strategy aligns perfectly with the objectives of the RE-PUBLIC SPACES project and has the added benefit of preserving the aesthetic and historical character of the architecture.
2) **Conduct micro-scale urban planning studies:** for a city with Pinerolo's specific urban form, generic recommendations are insufficient. A detailed micro-scale analysis of the historic centre's street orientations and wind patterns would provide the data necessary to make informed decisions about the placement of vegetation and shade structures. This ensures that interventions are precisely

tailored to maximize natural ventilation and cooling, leveraging the city's topography and prevailing winds.

3) **Promote albedo and sustainable material use:** beyond vegetation, the project should explore the use of architectural and material-based solutions to reduce heat absorption. Utilizing high-albedo, or reflective, surfaces for roofs, roads, and building facades can significantly reduce the amount of solar energy absorbed by the urban environment. This would allow more heat to be reflected back into the atmosphere rather than being stored and re-radiated at night. This approach is a practical and effective way to lower temperatures at the local scale.

4) **Integrate sustainable water management with urban greening:** the project's goal of improving rainwater management should be a central component of any greening strategy. Implementing rainwater capture systems can provide a self-sustaining water source for vegetation, further enhancing the cooling effect through evaporation. This integrated approach creates a resilient system that addresses multiple climatic challenges simultaneously.

5) **Policy and planning framework:** to ensure the long-term success of the RE-PUBLIC SPACES initiative, its findings could be integrated into the city's broader policy and planning framework. Pinerolo can draw from the results of RE-PUBLIC SPACES project to develop a climate resilience plan based on the data and models presented in the project documentation, including updated building codes and urban planning regulations able to incentivize climate-friendly design and prioritize the creation of green and cool public spaces. Finally, the project should be a catalyst for public awareness campaigns and citizen participation, educating the community on the causes and effects of UHIs and empowering residents to become active participants in the city's climate adaptation efforts.

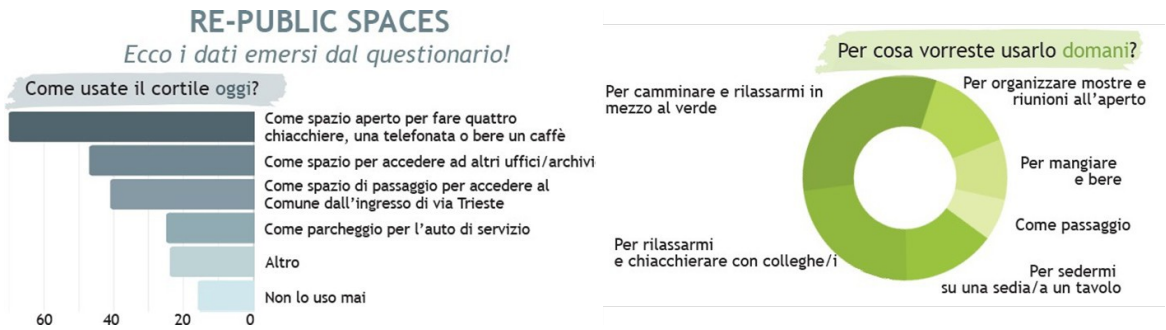
2.3. Public participation and tenant education

A public consultation was conducted between January and March 2025 to gather input on the current and future use of the courtyard. The process was led by LAQUP, a specialized association for participatory planning. The consultation was highly successful, involving more than half of the municipal employees—the primary daily users of the space—through a combination of online questionnaires and in-person meetings, referred to as "world cafes".

The high level of participation from the key stakeholders is a critical indicator of the project's health and its potential for long-term success. The project is not an external imposition but a response to the expressed needs and expectations of those who will use it every day.1 The information gathered during this process was used to define a set of priority needs and expectations that guided the subsequent design decisions. This stakeholder-driven approach ensures that the final design is not just a theoretical

solution but a genuinely functional and appreciated space, increasing the likelihood that the revitalized courtyard will be well-used and maintained for years to come.

Figure 5. Pictures from the world cafè (18 feb. 2025)



The public consultation, conducted through an online survey and a World Café event, revealed a strong consensus among participants regarding the challenges and potential solutions for the selected courtyards. A majority of respondents identified the lack of greenery and the poor maintenance of existing vegetation as major issues. The survey

also highlighted concerns about the poor air circulation and heat accumulation in the City Hall Courtyard, which is characterized by its entirely asphalted surface.

Participants in the World Café sessions further elaborated on these findings, offering specific proposals. A recurring theme was the need to transform this space into a more liveable and resilient environment. Solutions proposed included the introduction of more permeable surfaces to mitigate the urban heat island effect and manage stormwater runoff. The idea of creating rain gardens and integrating green infrastructure like vertical gardens and green roofs was also widely supported. There was a clear desire for the courtyard to become more functional, not just visually appealing. Participants suggested introducing public seating, recreational areas, and improving overall accessibility. The shared outcome of the consultation was a collective vision for the courtyard to be revitalized using nature-based solutions to enhance their ecological value and contribute to the city's climate adaptation strategy.

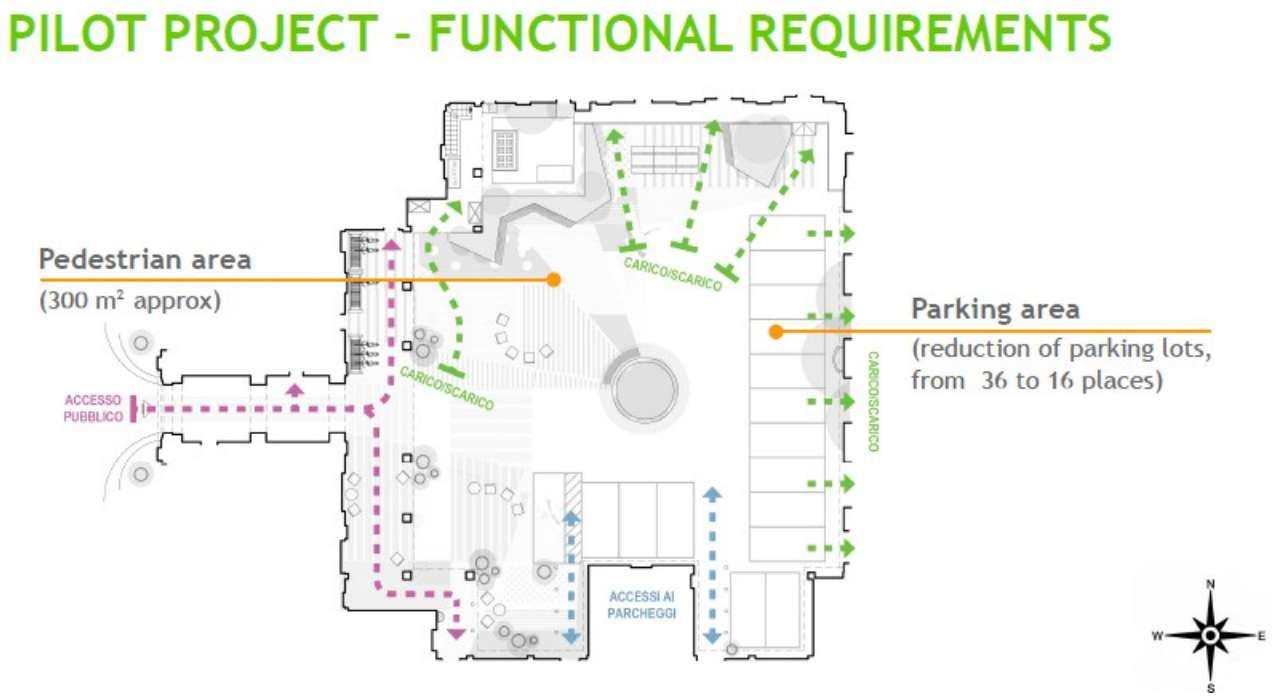


Figure 6. Functional requirements for the revitalization of the City Hall courtyard - Elaborations after the World Café

2.4. Requirement framework

In order to redevelop the courtyard and revitalize it as a welcoming space, conducive to relaxation and socializing, the Administration has reduced the parking area to just 16 spaces. This will free up additional car-free spaces within the courtyard.

The project's goal is to redefine the layout of the courtyard spaces through a comprehensive design that, taking advantage of the space "gained" by the reduction in parking spaces, introduces new relaxation and social areas, primarily for office workers

but also for residents using municipal services, with particular attention to reducing the heat island effect during the summer.

The intervention described here is therefore aimed at:

- reduce the area designated for parking of cars;
- ensure good flexibility in terms of spatial organization, aimed at guaranteeing the possibility of adapting to multiple future uses (meeting times, institutional and cultural activities, but also ordinary and extraordinary maintenance);
- implement “bioactive” surfaces by introducing new potted plantings with carefully selected plant species based on exposure, climate, water requirements, and maintenance needs;
- introduce new furnishings that encourage enjoyment, interaction between people and socializing within the courtyard;
- promote thermal comfort in the courtyard, with particular attention to reducing summer heat through the introduction of shading devices, greenery, and asphalt pavement treatment with lighter, more reflective colours.

2.5. Planned interventions

Based on the above-mentioned needs, the proposed project includes the following interventions:

1. Reduction of parking spaces;
2. Introduction of new vegetation:
    - transformation of the central reinforced concrete basin into a flowerbed;
    - introduction of new greenery in pots (maximum size of flowerpots 90 x 90 h 90 cm);
3. Introduction of new furniture and movable seating, which can be easily moved when needed to take advantage of solar exposure depending on the season;
4. Shading of the sunniest area, located on the north side, to mitigate the effects of summer heat. Shading is provided by the introduction of a new pergola structure;
5. Asphalt floor colouring through the use of light colours which increase their albedo, thereby reducing the perceived temperature.

3. Strategic framework

The Municipality of Pinerolo is implementing various strategies and actions to adapt to and mitigate climate change, in line with European and national commitments. These initiatives fall into several areas, from sustainable mobility to urban regeneration.

3.1. Sectoral plan provisions

3.1.1. Municipal Building Regulations

The Municipal Building Regulations stipulate the following provisions:

1. «The pavement [of courtyards in the historic center] should preferably be made of cemented or non-cemented cobblestones, squared stone slabs, or small cubes or slabs of porphyry. Asphalt or "opus incertum" are expressly excluded. Other types of pavement will be evaluated on a case-by-case basis.»
2. Within courtyards, new fences between properties or towards public spaces can be constructed:

– In historic centers, areas of high value, or listed buildings, new fences are only allowed with living hedges with a maximum height of 1.50 meters.

– In other areas or buildings, fences are allowed only with living hedges up to

– 1.50 meters high, with an interposed metal mesh.

Courtyards are generally reserved for condominium use. Their subdivision is only allowed with hedges not exceeding 0.60 meters in height.

Different provisions are assessed depending on the intervention area and the requirements imposed by the Superintendence, where applicable.

The colors and materials of historic buildings, except in specific cases, must be maintained.

Encouraging bicycle use while discouraging car use: In the courtyards of both new and existing buildings, bicycle parking for residents or workers who have access to the building must be obligatorily provided. The allocation of these spaces should include at least 1 bicycle parking space per residential unit, or 2.5 bicycle spaces for every 100 m^2 of gross floor area (GFA). […] The maximum covered size for each bicycle parking space should not exceed 2 meters in length and 0.80 meters in width. Smaller provisions for bicycle parking are only permissible in cases where construction is demonstrably impossible.

Where possible, it is better to discourage the use of courtyards as car parking spaces, promoting pedestrian or bicycle access instead.

In accordance with the historic characteristics to be preserved, solutions should be provided that enhance the accessibility of public spaces. In cases involving interventions on protected heritage sites, while retaining the need to obtain the competent authority's opinion from the Superintendence, the Ministry of Culture issued guidelines in 2008 for overcoming architectural barriers in sites of cultural interest. These guidelines can provide advice on how to balance the protection of historic assets with accessibility needs.

3.1.2. PAESC

The PAESC provides some recommendations to follow:

- Water conservation and rainwater reuse: For new buildings and those undergoing renovation with an adjacent area designated for private green space and/or a courtyard larger than 100 m^2, the use of rainwater is mandatory. Rainwater should be collected from the building rooftops and channeled into a cistern for the irrigation of the private green space (including gardens), cleaning of courtyards and walkways, car washing, and for supplying toilet flushing systems, unless specific needs related to productive activities require special provisions. If applicable, a dual distribution network may be used.
- Soil permeability of building lots: In the case of new construction, or renovations or repairs, when replacing existing impermeable coverings such as asphalt, concrete, or paved surfaces with cement joints, it is mandatory to use permeable pavements to reduce soil impermeabilization. This is especially important for areas that do not require highly resistant coverings, such as courtyards […]. For optimal functionality, the sublayer must have a permeability coefficient of k>10^-4 m/s. Examples of permeable pavements that can be used include: grass, plastic or concrete grids with grassing, cobblestones with wide grass-filled joints, permeable asphalt and concrete, and/or absorbent materials, etc.

3.1.3. Mobility and infrastructure

One of the municipality's main actions is the adoption of the Urban Sustainable Mobility Plan (PUMS) in 2018. This strategic plan aims to reduce reliance on private vehicles and promote more eco-friendly alternatives. The planned measures include:

- Development of cycling mobility: Creating new bike paths and improving existing ones to encourage cycling.
- Reorganization of local public transport: Enhancing urban and suburban lines to make them more efficient and attractive to citizens.
- Increasing road safety and creating Zone 30 areas to reduce the environmental impact of traffic.

These actions, also funded by European projects like the MUSIC project[4], aim to make the city safer, smarter, and more conscious, with a direct impact on reducing polluting emissions.

3.1.4. Adaptation and resilience plans

Pinerolo has joined the Covenant of Mayors for Climate and Energy, committing to reducing CO2 emissions and increasing the resilience of its territory. The process for the municipality's Sustainable Energy and Climate Action Plan (SECAP) is based on a detailed analysis of historical climate data and future projections. The analysis has shown a rising temperature trend, particularly in summer, and a higher frequency of extreme events like heat waves.

Furthermore, the municipality participates in specific European climate adaptation projects. For example, it's involved in a project with its twin city of Gap (France) focused on mitigating urban heat islands through the "vegetalization" of urban spaces, as demonstrated by the intervention in the City Hall courtyard. The Metropolitan City of Turin, of which Pinerolo is a part, has also developed a "set of climate change adaptation strategies and actions" that Pinerolo can implement, focusing on vulnerabilities like hydrogeological risks and water scarcity management.

3.1.5. Green infrastructure development

Pinerolo's strategies also focus on the implementation of green infrastructure. The goal is to make urban spaces more permeable and capable of absorbing and managing rainwater more effectively. This includes:

- Replacing impermeable surfaces, such as asphalt, with permeable materials to reduce surface runoff.
- Increasing vegetation through urban reforestation projects, green walls, and green roofs, to improve air quality and provide natural cooling.

These actions are aimed not only at combating the urban heat island effect but also at preventing flooding, making the urban fabric more resilient to extreme climate events, demonstrating the will to pursue the "urban vegetalization" and creating shaded areas to combat heat islands.

3.2. Guidelines and principles for strategic actions

To integrate courtyard revitalizations with the city's strategic vision, the following actions are proposed:

- **FUNCTIONING/USE: TRAFFIC ORGANISATION.** The Municipality of Pinerolo promotes sustainable mobility through actions that encourage cycling, with the

[4] MUSIC - Mobilità Urbana Sicura, Intelligente e Consapevole, https://www.interreg-alcotra.eu/it/music-mobilita-urbana-sicura-intelligente-e-consapevole, and MUSIC 2 - https://interreg-alcotra.eu/it/music-2-mobilita-urbana-sicura-intelligente-e-consapevole

goal of reducing the presence of cars within the city. The Municipal Building Regulations stipulate that: "In the courtyards of new and existing buildings, parking for bicycles of those who live or work in the buildings accessible from these courtyards must be allowed. The allocation of these spaces must ensure at least one bicycle parking spot per residential unit or 2.5 bicycle parking spots per 100 square meters of gross floor area (GFA). […] The maximum covered dimensions for each bicycle parking space cannot exceed two meters in length and 0.80 meters in width. Smaller bicycle parking facilities are acceptable only in cases of proven impossibility of implementation. The rack must be securely anchored to the ground and must allow for easy locking of the bicycle frame (not just the wheel) to a fixed element, using a standard anti-theft device. Bicycle parking for the building's users must always be allowed in the spaces pertaining the building, where such spaces exist."

- **FUNCTIONING/USE: ACCESSIBILITY.** In line with the need to preserve the historical features, solutions should be implemented to enhance the accessibility of public spaces. In the case of interventions on protected heritage sites, while it is necessary to obtain permission from the Superintendence, in 2008 the Ministry of Cultural Heritage and Activities issued guidelines for overcoming architectural barriers in places of cultural interest. These guidelines can provide recommendations for balancing the need to protect a historical site with the issue of accessibility.
- **FUNCTIONING/USE: SAFETY.** Lighting is present in the courtyards currently in use, but absent in the ones without a designated function. Non-slip flooring is not present, except in the playground within the courtyard of the Fenulli barracks, which is used for school activities. The courtyard of the Town Hall is protected by video surveillance at the access points (vehicular and pedestrian). Where present, flowerbeds/greenery are bordered by stone curbs. Considering the different functional needs, the above-mentioned characteristics should be implemented during the revitalization of the courtyards.
- **FUNCTIONING/USE: OPENING UP AND CONNECTING SPACES.** Respecting the characteristics of the courtyards, during the revitalization process a connection with the exterior space can be considered - if not physically, at least visually.
- **FUNCTIONING/USE: INTRODUCTION OF SERVICES INTO THE PUBLIC SPACES.** Currently these services (such as stands, markets, kiosks, ice rinks) are not present. Some public courtyards (e.g., the courtyard of the Fenulli Barracks, the courtyard of Palazzo Vittone) have hosted events in the past, with the installation of temporary stalls and kiosks (for fairs, exhibitions, events) or stages for outdoor theater performances. Once revitalized, these courtyards could once again host temporary events and entertainment activities (concerts, outdoor cinema, etc.). The design could take these opportunities into account and include the necessary provisions.
- **FUNCTIONING/USE: USE BY SPECIFIC GROUPS.** The courtyard of the Fenulli Barracks, which is located within a building primarily used by a school (High School), has a multifunctional sports field – for football, basketball, and volleyball – exclusively for student use. During the revitalization of the courtyards, the installation of these facilities may be considered, where compatible with the

intended use of the building and the courtyard. The courtyard of the City Hall is predominantly used by employees, therefore, during the design phase, the needs of this specific group will be taken into account.

- **ECOLOGY: NBS VEGETATION, AMOUNT OF CONCRETE PAVEMENT AND BIOLOGICALLY ACTIVE SURFACES, SUSTAINABLE URBAN FURNITURE.** Maintain the original permeable pavements and, where possible, increase the quantity and quality of the vegetation. Maintain permeable pavements where they already exist and increase them where possible. Consider solutions that promote biodiversity.
- **ECOLOGY: DRAINAGE, WATER COLLECTION.** Currently, there are no solutions related to drainage and water collection. The PAESC (Sustainable Energy and Climate Action Plan)provides some guidelines to follow regarding water conservation and rainwater recovery, collected in tanks and reused for the irrigation of ancillary green areas (including vegetable gardens), the cleaning of courtyards and passageways, car washing, flushing systems, etc.
- **ECOLOGY: PHOTOVOLTAICS, ELECTRIC CAR CHARGING STATIONS.** The installation of photovoltaic systems can be considered if compatible with the property on which it is installed (the opinion of the Heritage Office may be required).
- **ECOLOGY: WASTE MANAGEMENT.** Waste management within the courtyards is currently unregulated and contributes to the degradation of the space. With the revitalization of the courtyards, it is advisable to consider the installation of a system to conceal the waste bins.
- **HISTORIC AND IDENTITY ELEMENTS OF PS: ELEMENTS AND FEATURES THAT FORM THE IDENTITY OF THE PS.** It will be essential to preserve the historical elements that characterize each courtyard, in accordance with the instructions provided by the competent Superintendence. Any new installations must harmonize as best as possible with the surrounding context in which they are placed.
- **IMPROVEMENT OF GREEN AREAS.** The introduction of plant species within courtyards should take into account the following: whether the species is native – to preserve local biodiversity; and the species' resistance to climate fluctuations and its adaptability to integration in an urban space (e.g., avoiding tall trees with large root systems). Existing greenery should be preserved as much as possible. The greenery can provide shading: possible options should be considered.
- **PROTECTION OF HISTORIC ELEMENTS AND VALUES/IDENTITY.** The protection of historical elements and the identity value of a property, when subject to restrictions, is defined by current national, regional, and municipal regulations. Most of the historic courtyards in the city are privately owned or privately owned with public access, and therefore subject to the applicable private building regulations. The courtyards of Pinerolo are not characterized by a single style or distinctive features, as each one reflects the historical period in which it was created, as well as its original function. It will be essential to preserve the historical elements that define each courtyard, in accordance with the guidelines issued by the competent Superintendence. Any new installations must be

harmonized as best as possible with the surrounding context in which they are integrated.

- **IMPROVEMENT OF AESTHETICS.** Improvement actions should start with an analysis of each individual courtyard, in order to preserve and protect its specific characteristics. The revitalization should include an overall project that takes into account all aspects that may involve the courtyard, including those that will not be immediately implemented. The intervention can be carried out in phases, depending on needs and financial availability; what matters is that the project is considered as a whole, using a unified approach, so that all elements added in subsequent phases are compatible. This can help create the unique identity of the courtyard.

3.2.1. Scope of Work and Estimated Costs

The following table presents selected and analyzed courtyards in Pinerolo, with regard to the proposed scope of work and the estimated costs of potential revitalization investments. Each concept is designed to enhance environmental sustainability, strengthen social functions, and improve the overall quality of urban space. Planned measures include rainwater management, de-sealing of impermeable surfaces, introduction of diverse vegetation, installation of irrigation and retention systems, as well as the addition of urban furniture to foster community use. For each courtyard, the estimated revitalization cost has been calculated on the basis of its total area and a standardized cost per square meter.

Table 2. Scope of work and estimated costs for selected courtyards in Pinerolo (Italy)

NO.	ADDRESS OF THE COURTYARD	SCOPE OF WORK	ESTIMATED REVITALISATION COST BASED ON AREA AND COST PER 1M²
1.	***Piazza Vittorio Veneto 1, Pinerolo (TO), Italy***	***Flooring*** *Using heat reflective paint to reduce the urban heat island effect (floor artwork).* ***Green Infrastructure & Plantings*** *Planting of low and medium vegetation in large pots, adapted to the urban conditions and microclimate of the courtyard.* ***Circulation & Surfaces*** *Reduction of the area intended for*	*Yard Area:* ***850 m²*** *Cost per 1 m²:* ***€ 105*** *Total Revitalization Cost:* ***€ 89.260***

		parking (from 35 to 16 parking places); *Creation of a new pedestrian area for social interaction (in connection with the results from the participatory process with municipal employees- january 2025).* ***Infrastructure & Utilities*** *Relocation of municipal waste containers;* *Relocation of electric car charging point;* *Relocation of bicycle parking.* ***Urban Furniture*** *Addition of benches, bins, tables, pergolas.* *Elements designed to foster everyday comfort and support social interaction among colleagues but also among citizens who go to the municipality to use the public services.* ***Reuse of existing elements*** *Transformation of the old fountain into a large central flowerbed.*	
2.	***Palazzo Acaja Via al Castello 4 Pinerolo (TO), Italy***	*Installing sails shades to reduce the urban heat island effect.* *Construction of water retention tanks for irrigation.* *Greenery - Planting of low and high vegetation in pots.* *Small architectural elements creating a friendly space that fosters interpersonal relationships.* *Technical solutions to overcome the medieval staircase and make the courtyard accessible to all.*	*Yard Area:* ***95 m²*** *Total Revitalization Cost:* ***€ 40.000***
3.	***Palazzo Vittone Piazza Vittorio Veneto 8, Pinerolo (TO),***	*Installing sails shades to reduce the urban heat island effect;* *Construction of irrigation systems combined with the construction of water retention tanks ("water catchers");* *Greenery - planting of low and high*	*Yard Area:* ***700 m²*** *Total*

	Italy	*vegetation, green walls in the form of evergreen clematis, jasmine or vine to be placed close to the existing arcades;* *Small architectural elements creating a friendly space that fosters interpersonal relationships (outdoor furniture).*	*Revitalization Cost:* ***€ 74.000***
4.	***Caserma Fenulli*** ***Via Brignone 2,*** ***Pinerolo (TO), Italy***	*Greenery - planting of low and high vegetation;* *New outdoor draining flooring.* *Construction of irrigation systems combined with the construction of water retention tanks ("water catchers") and contruction of new fountain;* *New playground project.*	*Yard Area:* ***8.400 m²*** *Total Revitalization Cost:* ***€ 500.000***

3.2.2. Implementation Timeline

The revitalization of the four selected courtyards will be carried out through a strategic, phased approach, aligning with both the investment scope of the RE-PUBLIC SPACES project and the future budgetary planning of the Municipality of Pinerolo. This phased strategy ensures a systematic and well-monitored progression from initial pilot projects to a broader, city-wide application.

Short-Term Actions (2026)

The initial phase will focus on a high-impact pilot project. During this period, the **Town Hall courtyard** will undergo a complete revitalization. This will serve as a test case, with comprehensive monitoring of the ecological and social outcomes. The insights gathered here will be crucial. Concurrently, the city will prepare the **guidelines for climate change adaptation** for courtyard spaces in historic urban centers and a **charter for green and sustainable courtyards**, a key deliverable of the RE-PUBLIC SPACES project. These documents will provide the foundational principles for all future interventions.

Medium-Term Actions (2027-2031)

Following the pilot, the medium-term phase will expand the project's scope. The primary focus will be on monitoring the long-term results of the Town Hall courtyard's revitalization to understand its enduring benefits and identify any necessary adjustments. At the same time, the municipality will begin initial consultations and

prepare detailed concept designs for the remaining courtyards. A significant effort will be dedicated to **securing additional funding** for the implementation of these subsequent projects, a critical step for their realization. Public education campaigns on sustainable practices will also continue, building community awareness and support for the broader initiative.

Long-Term Actions (2030+)

The final phase represents the culmination of this strategic vision. The successfully tested courtyard model will be expanded to other sites within Pinerolo's historic center. This systematic expansion will be guided by the adaptation guidelines and the green courtyards charter developed in the short term. The ongoing public education campaigns will be maintained, reinforced by the tangible results of the implemented strategies. Finally, continuous **monitoring, data collection, and reporting** will be established as a standard practice. This will not only keep Pinerolo's citizens informed about the sustainability measures but also provide a robust data set for future urban planning and policy decisions.

3.2.3. Expected Impacts

By strategically linking local courtyard renewal with Pinerolo's overarching municipal plans, we anticipate achieving a wide range of positive impacts. These interventions are designed not as isolated projects but as integral components of the city's broader ecological and social vision.

Environmental and social benefits

On an environmental level, these revitalizations are expected to significantly mitigate the Urban Heat Island (UHI) effect, leading to more comfortable microclimates and enhanced well-being for residents and visitors. The introduction of permeable surfaces and greenery will also improve air quality and help manage stormwater.

From a social perspective, these initiatives will foster stronger community bonds by creating more inviting and functional public spaces. This will cultivate a heightened sense of shared ownership and, ultimately, improve the overall quality of life for Pinerolo's citizens.

Educational and economic opportunities

The revitalized courtyards will serve as living laboratories, providing tangible, on-the-ground examples of effective climate adaptation strategies. These spaces can become powerful educational tools, inspiring similar sustainable practices throughout other neighborhoods.

Economically, the project is poised to generate multiple benefits. It will lead to a reduction in long-term infrastructure maintenance costs and create new opportunities for green jobs in areas like urban landscaping and ecological restoration. Moreover, by

showcasing its commitment to resilience, Pinerolo will enhance its reputation as an attractive and forward-thinking city, potentially drawing further investment and tourism.

A phased, scalable approach

The phased implementation strategy, beginning with the Town Hall courtyard, is designed to be both a practical example and a symbolic anchor for urban transformation. By aligning this initial pilot with a thorough evaluation of three additional courtyards and with the city's climate change goals, Pinerolo is establishing a clear precedent. This "test-and-replicate" model ensures that insights gained from the first project can be effectively applied to the remaining three locations as funding becomes available. This scalable approach guarantees that the lessons learned at one site can successfully guide future investments, ensuring a cohesive and impactful city-wide transformation.

4. Conclusions

The pilot project for the courtyard of Pinerolo's Town Hall provides an exemplary demonstration of how urban regeneration can effectively and comprehensively address contemporary climate and social challenges. The project is not limited to a simple aesthetic restyling, but is based on an in-depth analysis of microclimatic dynamics and user needs.

Through a strategy that combines the reduction of impervious surfaces, the increase of albedo through pavement coloring, and the introduction of green infrastructure and shading, the project provides a robust and scientifically based response to the problem of urban heat islands. At the same time, its strength lies in the co-design approach, which transformed the courtyard from a neglected parking area into a place of civic gathering, deeply connected to the community that experiences it daily.

This experience represents a virtuous and fully replicable model. The adopted methodology, which begins with public consultation and culminates in a design that integrates technical and social solutions, can serve as a reference for other historic cities seeking to revitalize their public spaces with a view to resilience. The Pinerolo project is not only a success for the city, but also a tangible contribution to the development of a methodology and guidelines for public authorities, as envisioned by the objectives of the RE-PUBLIC SPACES project. Its documentation, which includes the pre-intervention analysis, the consultation process, and a detailed description of the implemented solutions, provides a practical and validated tool for the future of urban planning across the Interreg Central Europe region.

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List of Figures

List of Tables