Strategies for adapting the dense Italian cities to the climate change. The case study of the San Salvario historical neighborhood

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Scientific debate, research, approaches and good practices

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Contents

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Strategies for adapting the dense Italian cities to the climate change

The case study of the San Salvario historical neighborhood

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Abstract
The urban fabric of European cities is subject to significant pressures from human activity and climate change. The devastating effects of climate change on urban environments threaten the quality of life of citizens and ecosystems. In particular, historic and dense-tissue cities face challenges in adapting their established urban fabric devoid of green areas. The lack of green spaces for social gatherings becomes a critical issue in addressing the climate and environmental crisis. Dense cities such as Barcelona and Copenhagen are promptly responding to the climate emergency through adaptation plans.
This essay identifies the 19th-century neighbourhood of San Salvario in Turin, as a case study to develop a morphological analysis aimed at proposing nature-based strategies to improve the adaptation potential and resilience. The design elements identified in the two best practices cities inspire hypothesizing replicable architectural solutions in dense urban contexts such as the study area under consideration. Finally, the paper addresses the limitations arising from the lack of holistic strategic planning, which in the case of Turin is based on fragmented interventions disconnected from the existing ecological network rather than on a long-term plan. The paper also reflects on the need to include additional assessments of ecosystem services, taking into account their economic valuation.

Keywords
Adaptation; Climate Change; Healthy City; Nature-Based Solutions; Green Infrastructure.

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1. Introduction

The effects of excessive anthropogenic impacts, combined with the intense phenomenon of urbanization (Mazzeo & Polverino, 2023), are pushing cities to face the need to resiliently redefine their spaces and architectures (Guida, 2022 a; Negrello et al., 2022). According to a study conducted by Martinez-Solan et al. (2021), European cities, particularly those in the Mediterranean region, will be the primary hotspots of climate change, experiencing significant disruptions in terms of both increased seasonal averages and extreme weather events (Guida, 2022 b). Cities are undergoing rapid and profound changes and are subject, along with their populations and ecosystems, to various climate stresses. As reported in the Report on Climate Change Risk Analysis (2020), among the countries in the Mediterranean region, Italy is one of the most affected by extreme phenomena, with a 55% increase compared to 2022 (CMCC, 2023). Especially in the last years, prolonged periods of drought were experienced in Northern Italy between 2022 and 2023, while severe floods occurred in Bologna in May 2023.

Among the factors amplifying the impacts of these phenomena in urban contexts, the primary cause is the lack of widespread green infrastructure due to extensive soil impermeabilization. Indeed, soil impermeabilization through construction and artificial materials is one of the main forms of degradation associated with urban development and expansion, influencing microclimatic dynamics within and around urban areas (Fini et al., 2017). The high anthropogenic pressure on the soil, resulting from its impermeabilization, can also cause flood risks by altering the urban hydrological cycle. This leads to a reduction in the capacity to intercept, store, and infiltrate rainwater, especially considering the changing precipitation patterns associated with climate change. Furthermore, there is an increasing frequency of intense short-term rainfall events that jeopardize the safety of citizens and infrastructure (Costa et al., 2021).

Another aspect contributing to the need to redesign the urban environment in European cities is the nature of the surfaces (asphalt, concrete, stone, etc.), with limited green areas or high albedo, exacerbating the urban heat island (UHI) phenomenon (Perini et al., 2021), which is further amplified by the expected increase in the frequency and intensity of heatwaves in the coming years (Rousi et al., 2022). Consequently, this not only has a negative impact on the urban system in terms of the poor resilience of the built fabric but also leads to a decline in the psychophysical well-being of citizens (Negrello et Ingaramo, 2021; Tong et al., 2021) and significant disparities in access to green spaces for disadvantaged groups (Hasee, 2017).

After highlighting the negative environmental and social outcomes of the climate crisis in dense European urban areas, a third economic factor also emerges: the costs resulting from the effects of climate change. These include energy consumption for cooling, health costs associated with increased mortality and morbidity during heat waves, and expenses related to restoration after extreme flood events (Ceci et al, 2023).

This calls for reconsidering the urban design of current public and private spaces, aiming to intensify and densify green infrastructure and implement targeted solutions, such as nature-based solutions, to address the current deficiency, especially in densely populated urban areas (De Noia et ali, 2022). The strategic role of the environmental system in sustainable urban development is widely recognized, particularly within urban areas. In fact, greenery significantly contributes to environmental conservation (Coticelli, 2015) and citizen health (Angrilli, 2021). However, significant obstacles hinder the establishment of a robust green infrastructure system in consolidated urban areas. These obstacles include real estate speculation and climate change, which threaten the survival of existing green areas (e.g., through prolonged periods of drought). Furthermore, a critical point concerns urban planning systems: despite the existence of climate resilience plans, there is difficulty in implementing strategic projects for green densification (e.g., through targeted nature-based solutions), as urban policies tend to favour models of dense cities by utilizing abandoned (or even virgin) land to meet the growing demand of the real estate market (Coticelli, 2015), despite the demographic decline in cities like Turin.

It is important to emphasise that while the development of a dense city represents a sustainable model for reducing land use, it does not necessarily guarantee the resilience of urban environments (Neuman, 2005) to the direct effects of climate change, which they are partly the cause.
The objective of this research is to illustrate the challenges that dense urban fabrics in Italian cities, composed of narrow streets, devoid of vegetation, and characterized by high soil impermeability, face by introducing an analytical method that identifies and analyzes the criticalities and potential of the morphologies of spaces and architectures in the target neighbourhood under study. The aim is to propose replicable nature-based solutions for climate change mitigation and adaptation, solutions that have already been tested in other contexts, to enhance the well-being of citizens (healthy cities) and the environment. The proposed solutions are the result of an analysis of best practices at the European level which have been critically examined and re-proposed in the identified case study. To this end, the choice of the analysis location and design proposal has fallen on the San Salvario neighbourhood, situated in the city of Turin. Specifically, the focus will be on the "quadrilatero" (Bocco, 2007), the neighbourhood's original settlement developed in the second half of the 19th century, which still exhibits many typical characteristics of that era's villages. Elements such as courtyards, distribution of balconies, narrow streets, high population density, and construction are just a few examples of features found in 19th-century neighbourhoods in other Italian cities like Milan, as well as in European cities like Barcelona and Paris. Additionally, as highlighted in the appendices of the "Strategic Plan for Green Infrastructure" published by the Municipality of Turin (2020), the area presents an underdeveloped green space system. The near absence of green infrastructure renders the neighbourhood vulnerable to environmental risks and poses health concerns for its residents, such as the heat island effect and poor air quality, while also limiting the presence of meeting spaces and socialization within the neighbourhood.

2. Best adaptation practices: Barcelona and Copenhagen

In this section, two European cities that have developed adaptation plans, characterized by different climates, have been selected. The geographical selection was made to obtain a diversified sample of climates and, consequently, NBS solutions. The objective is to demonstrate how it is possible to address the climate emergency in various European contexts by implementing Nature-Based Solutions.
The choice fell on two cities that exhibit recurrent urban forms in European urban fabrics, such as grid patterns (mostly composed of modules) or less regular patterns (not derived from the precise juxtaposition of a module). The selected cities are Barcelona, characterized by a typically Mediterranean climate, and Copenhagen, with a Baltic-continental climate.

1.2 Barcelona

Barcelona has ambitious plans, such as the Climate Plan 2018-2030, to make the city increasingly sustainable and socially inclusive. The main objectives are to reduce high summer temperatures and promote sustainable mobility by discouraging the use of private vehicles. Building upon these considerations, Salvador Rueda has developed the concept of "Superblocks," aiming to surpass and reinterpret the traditional "blocks" conceived by Cedrà in the early 20th century in a sustainable manner. The project (fig. 1) involves grouping nine urban blocks into a "superblock," where pedestrian areas are created and private vehicles are only occasionally permitted. This enables the implementation of nature-based solutions and permeable surfaces, creating more community-dedicated spaces (Ajuntament de Barcelona, 2022). Initially, the project faced opposition from motorists and merchants. However, initial doubts were dispelled as residents began to enjoy the benefits of a traffic-free neighbourhood, thereby allowing for project expansion (Comelli, 2019). Among the adaptation-focused projects implemented by the municipality of Barcelona, which incorporate the application of NBS, the following streets are noteworthy: Carrers de Consell de Cent, Rocafort, Comte Borrell i Girona, and Carrer Pi i Margall, Pasajes san Juan) and Superilla Sant Antoni (Ingaramo et al., 2023.

Among the recurrent Nature-Based Solutions for mentioned urban spaces, we can identify: biodiversity corridors, depaving, new permeable/green pavements, increased tree coverage, rain gardens, and pocket gardens.

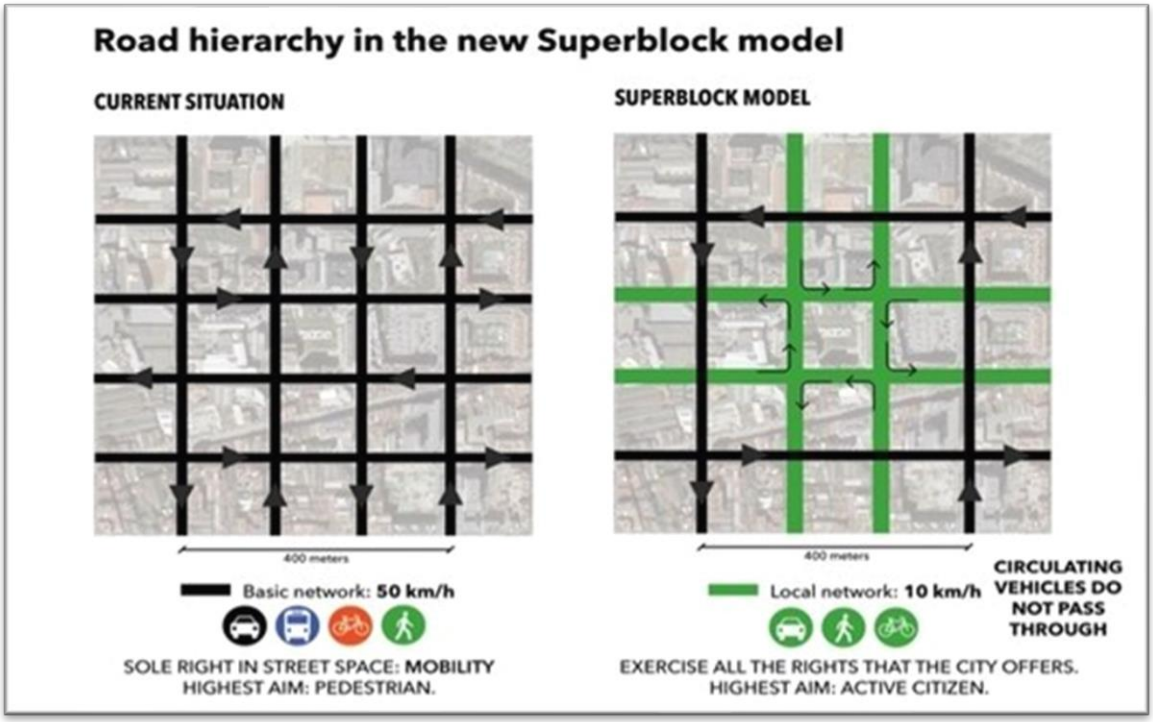


Fig.1 Barcelona "superilla" or superblock model in comparison with the current traffic flow

2.2 Copenhagen

Copenhagen stands out among European cities for its morphological modification of urban space aimed at increasing the resilience of the built environment (Negrello, 2023). The Danish capital is a virtuous example of how climate change can facilitate urban development (Xu et al., 2021). Since 2011, the municipality has adopted a proactive plan to address the climate crisis and mitigate the impact of future calamities. The severe cloudbursts in 2008 and 2011 resulted in extensive damage, highlighting the potential influence of future climate events on the city, prompting the administration to develop the Copenhagen Climate Plan, approved in 2015.

Within this plan, local architects were called upon to develop a comprehensive masterplan. Among them, SLA Architects also took charge of implementing one of the solutions designed to address the challenges related to rainwater drainage (fig.2) in the Inner Nørrebro district, directly involving the community. The solution is based on the creation of a robust urban green infrastructure that specifically addresses the issue of managing torrential rains to prevent flooding, while simultaneously creating a new series of cohesive urban spaces that provide a stronger social community, greener and more natural experiences and new creative opportunities for all residents of Copenhagen. A central aspect was the engagement of citizens in the project's development, making them personally responsible for the care of the neighbourhood (Ingaramo & Negrello, 2023; Negrello, 2023). Hans Tavsens Park is a rainwater collection basin during storms for the Inner Nørrebro district. The excess rainwater is then directed through Korsgade to Lake Peblinge. Along the streets, two solutions are adopted: a portion of the water is absorbed and biologically purified by vegetation, while another portion is channelled along the sides of the roadways, where visible or underground artificial streams are established. Among the identified projects, Sankt Kjelds Square and Bryggervangen,Klimaquartier Østerbro, green roofs along Kalvebod Brygge (Ikea, Cactus Tower), and Enghaveparken are mentioned. Among the recurring Nature-Based Solutions for the mentioned urban spaces, we can identify: biodiversity corridors, rain gardens, bioswales, public green roofs and green walls.

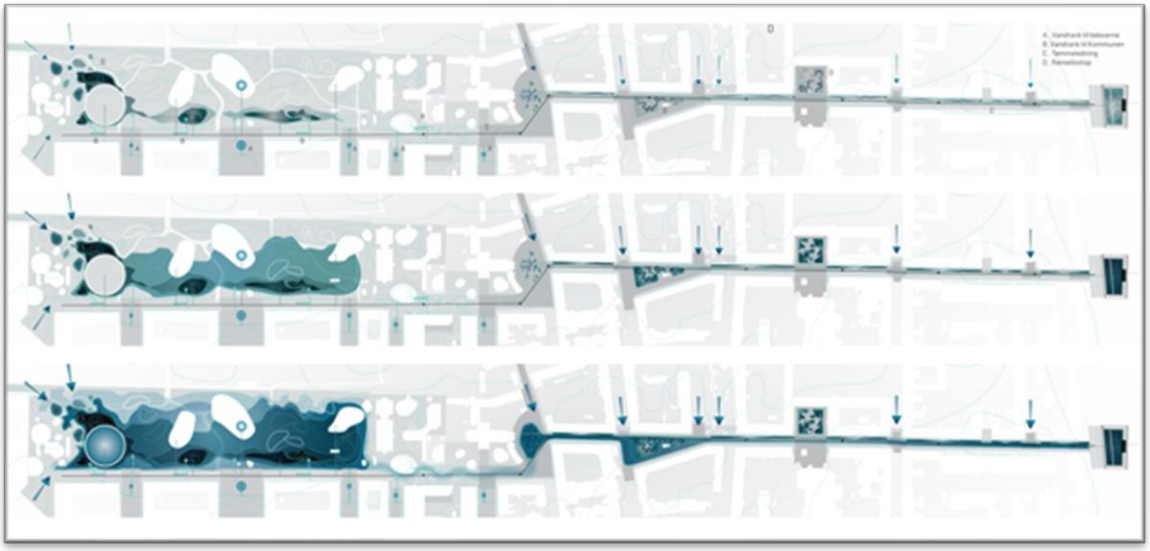


Fig.2 The project *The Soul of Nørrebro in Inner Copenhagen.* Diagram of water management

3. Best practices: NBS abacus

Building upon the analysis of approaches outlined in the best practices of Barcelona and Copenhagen, this study identifies and categorizes project interventions that integrate green elements (Nature-Based Solutions) and are better suited for dense and compact urban contexts. Specifically, by considering sustainable development goals and urban resilience as foundational concepts, the study identifies design strategies (Tab.1) addressing environmental, social, inclusive, and economic aspects, as outlined in the matrix. The solutions presented indicate the scale of intervention, the primary benefits (environmental, social, economic), and the corresponding SDGs.

4. Methodology

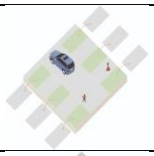
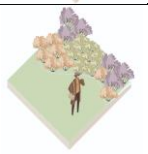
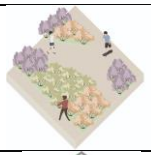
The research is dedicated to identifying strategies, interventions, and solutions aimed at enhancing the ecological potential of urban spaces and adapting morphologies and architectures to the impacts of climate change in cities characterized by a dense built fabric within the Italian context.

The term "dense urban fabric" refers to an urban area characterized by the concentrated presence of buildings, infrastructure, and activities within a relatively limited space. This urban configuration often results in higher building density and reduced availability of public open spaces and green areas. Dense urban fabric poses specific challenges and opportunities in terms of architectural and urban design, mobility, environmental sustainability, and quality of life.

Defining Italy as the geographical area of study, the city of Turin was selected for its characteristics, as outlined in the next paragraph. The chosen area is the historic district of San Salvario, representing the typical historical Italian dense city fabric.

The research is structured with an initial analysis of the dense fabric under examination, upon which subsequent NBS will be experimented. The analysis, replicable in other contexts, aims to identify the main elements constituting the built environment, focusing on the following categories:

1. Green analysis: this aims to highlight the state of the art (and, in this case, the absence) of various types of green spaces present in the area.
2. Built morphology analysis: this involves examining buildings, streets, and public and private spaces to identify their main features and the types that would require subsequent interventions. To facilitate this, a classification system was developed to categorize the identified urban elements.

NBS - Action	Graphical Disposition	Area	Benefits	SDGs
Biodiversity Corridor/ Greening		Square Street	thermal comfort / cooling / permeability / biodiversity / better air quality/ new social place	3 11 13 15
Parking Desealing		Square Street Courtyard	water management / permeability	3 6 11 13
Draining Green Pavements And Parkings, New Tree-Lined Avenues		Street	permeability / better air quality / biodiversity / thermal comfort / new social place	3 10 11 13 15
Pedestrianization / Greening		Square Street	permeability / better air quality / biodiversity / thermal comfort / new social place	3 10 11 13 15
Raingarden (Vegetated space for rainwater management)		Square Courtyard	water management / permeability / biodiversity / new social place	6 11 13 15
Bioretention area/ Bioswale (area or channel designed to slow and capture stormwater runoff, filter pollutants and increase rainwater infiltration)		Square Street Courtyard	water management / permeability / biodiversity	3 6 11 13 15
Biodiversity Hot Spot Between Parkings (Small areas with diversified tree species to promote pollinators.)		Square Street Courtyard	water management/permeability / biodiversity / thermal comfort / new social place	3 6 11 13 15
Pocket Garden (Interstitial gardens positioned in urban gaps such as intersections or between buildings)		Square Street Courtyard	permeability / biodiversity / new social place	3 10 11 13 15
Green Wall		Buildings	thermal comfort / biodiversity / new social place	3 10 11 13 15
Extensive Green Roof		Buildings	permeability / thermal comfort / biodiversity	3 10 11 13 15
Intensive Green Roof		Buildings	permeability / thermal comfort / biodiversity / new social place	3 10 11 13 15

Tab.1 Abacus of selected strategies

The second phase encompasses the implementation of NBS identified in the state-of-the-art best practices related to climate adaptation. This involves incorporating the identified best practices into the urban layout of San Salvario. The proposed interventions are designed to enhance the proportion of permeable surfaces, green spaces, and high-quality public areas. According to the strong sustainable model, such interventions that enhance the biosphere also foster social values and stimulate the local economy (Ingaramo & Negrello, 2023).
The final phase involves the quantitative analysis in terms of percentage change post-intervention. The following aspects have been considered:

- permeable surface area;
- presence of trees;
- spaces for social interaction.

4.1 Case Study: San Salvario, Turin

The study was conducted in the historic district of San Salvario, located in the city of Turin, one of the selected cities for the "100 climate-neutral cities by 2030 - by and for the citizens" project by the Mission Board for Climate Neutral and Smart Cities. From an environmental perspective, the city as a whole presents significant challenges and a limited capacity to adapt to climate change (Ellena, 2022).
Despite being considered the "green capital" of Italy due to its abundance of trees, Torino is reported by Legambiente to have one of the worst air quality levels among European cities. Furthermore, Torino's Climate Resilience Plan indicates that 46% of the municipal territory is at medium/high risk for heat island phenomena, particularly in densely built and impermeable flat areas such as the San Salvario district.
The analysis focused on the historical core of the district (fig.3), known as the "quadrilatero", delimited by physical barriers such as Corso Vittorio Emanuele to the north, Via Nizza to the west, Corso Massimo D'Azeglio to the east, Corso Marconi to the south. The district features a strictly grid-like urban structure, reminiscent of the Roman patterns found throughout the historic city. This characteristic can be considered a potential asset as it allows for the replication of solutions and actions within the "quadrilatero" area.
Despite the vibrant nightlife and the lively setting of restaurants and bars, the absence of high-quality urban spaces hinders the daytime usability of public space within the inner fabric of the neighborhood. Nevertheless, the neighborhood demonstrates particular dynamism along the thoroughfare of Madama Cristina, where the local market is also active during the morning.
The dichotomy between day and night leads to different experiences of the urban space: during the day, the neighbourhood life is primarily concentrated along the commercial axes of Via Madama Cristina, where the local market is located, Corso Guglielmo Marconi, and Corso Vittorio Emanuele, which connects the Centro district with San Salvario. Conversely, during the nighttime hours, the most frequented areas of the district are located near Largo Saluzzo.
After the closure of daytime activities, the neighbourhood transforms into an outdoor social lounge, with social spaces concentrated in the terrace areas of various dining establishments. However, the district lacks high-quality public spaces where people can sit amidst greenery or multifunctional and inclusive areas to install urban furniture and children's play areas.
San Salvario has also been the subject of experimental initiatives by the municipal administration, which has approved the creation of specific pedestrian areas. However, there is no comprehensive and structured vision aimed at pedestrianization and traffic reduction within the district.
This very lack has prompted some groups of citizens to initiate bottom-up participatory processes to identify strategic areas for the development of pedestrian and green spaces for the community, as exemplified by the "Largo al Giardino" project, proposing the transformation of Largo Saluzzo into an open square for all. Lastly, the characteristics of this neighbourhood, including its spatial layout, presence of local activities, market,

shared mobility infrastructure, subway, bicycle lanes, proximity to the central train station, university, etc., make it suitable for embracing the concept of the "15-minute city" (Rhoads & et al., 2023).

Fig.3 Framework of the project area (black buildings)

4.2 Analysis of green spaces

The territory of the San Salvario quadrilateral, despite its proximity to Torino's main park, Valentino Park, lacks green areas (Fig.4). Nonetheless, it features some tree-lined avenues and sporadic tree plantings, which, in certain instances, exhibit subpar quality.

The only public green spaces are entirely represented by the tree-lined avenues of Corso Massimo D'Azeglio, Corso Vittorio Emanuele II, and Corso Guglielmo Marconi, as well as select segments adorned with smaller and sparser trees, such as Via Nizza or Via Claudio Luigi Berthollet.
Conversely, private greenery predominantly resides within courtyards or private gardens, primarily extending westwards towards Valentino Park. In the absence of other nearby natural havens where citizens can unwind or take respite, these spaces serve as the exclusive green enclave of the neighbourhood.
This discernment arises from the annexes of the "Strategic Plan for Green Infrastructure" (Comune di Torino, 2020), which substantiate that denizens of the San Salvario quadrilateral lack access to green expanses within 300 metres of their dwellings (excluding lots proximate to Corso Massimo).

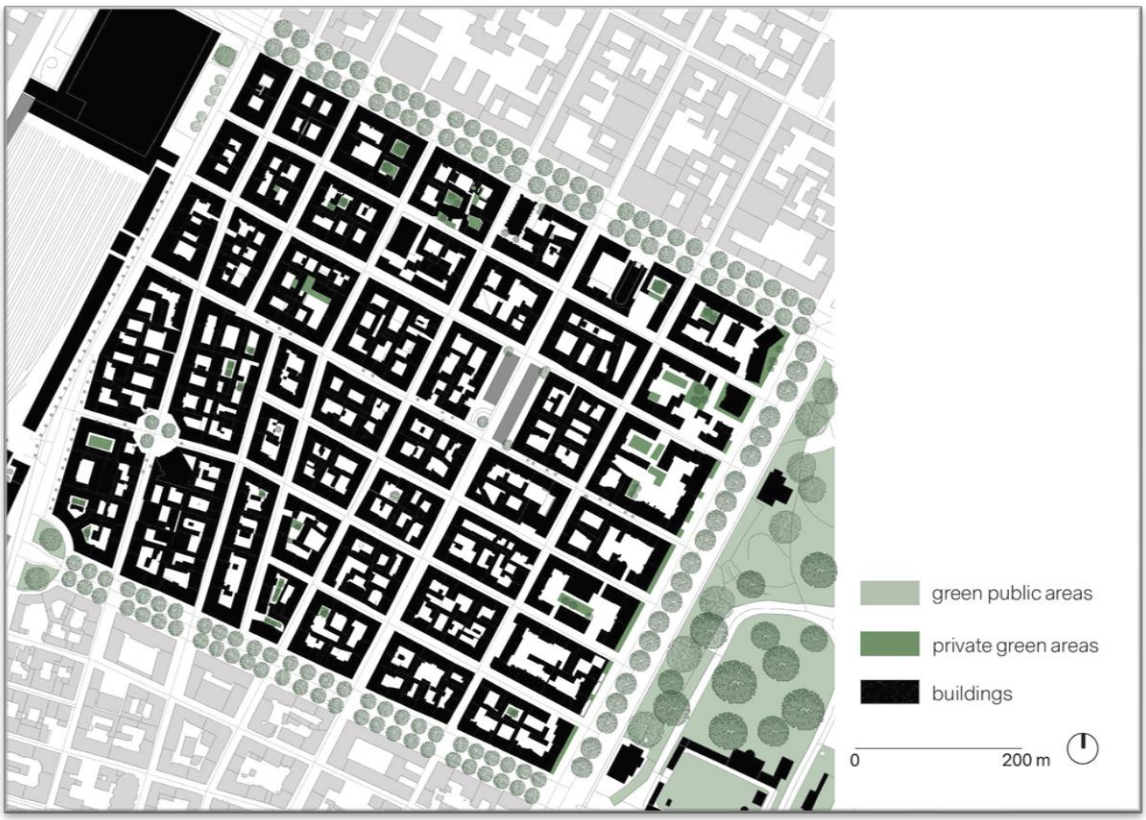


Fig.4 Map of the state of green areas

4.3 Morphological analysis

The analysis of morphology plays a fundamental role in identifying the forms of the built environment and the potential for the introduction of green infrastructure to address critical issues in the neighbourhood, both from an environmental and social perspective. Specifically, key and recurring elements have been identified within this studied urban fabric, including squares (fig.5), streets (figg.6-7), courtyards (figg.8-15) and buildings.
It is important to note that, in addition to courtyard architectural typologies, there is a significant lack of quality spaces due to the predominant allocation of land for roads and on-street parking, despite the presence of a dense public transport network (including the underground) and cycle paths in the neighbourhood.
The presence of private vehicles is also observed within courtyards, often converted into parking areas, as well as in squares, or rather, potential squares, which are often divided by high-traffic roads, thereby creating a lack of social spaces in the neighbourhood.
As depicted in fig. 4, the urban fabric is characterized by a limited presence of green infrastructure, which hampers surface permeability.

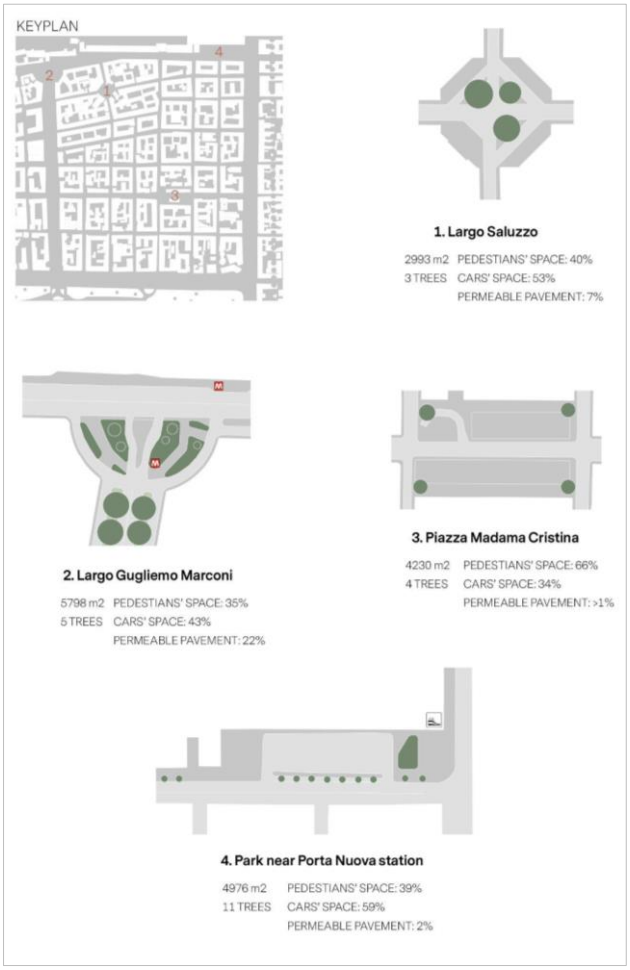


Fig.5 Analysis of square

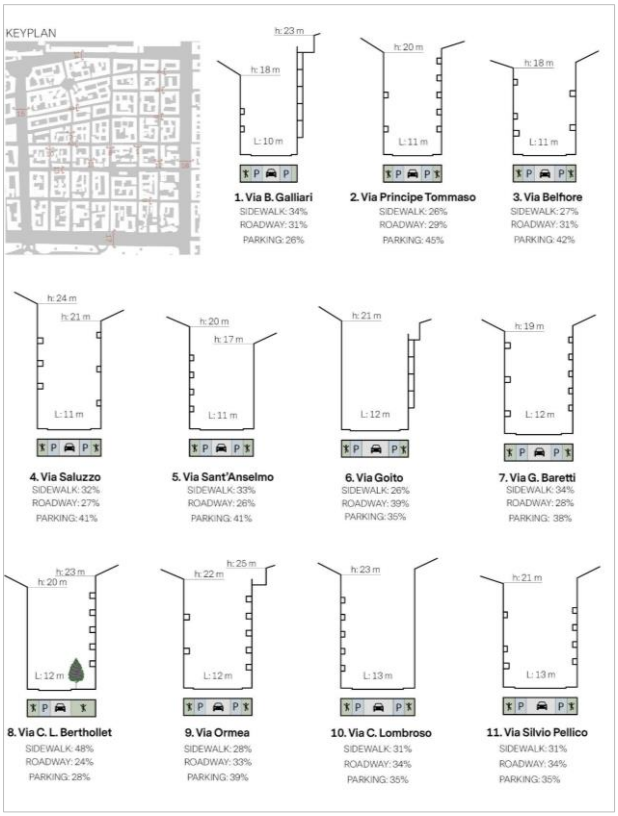


Fig.6 Analysis of streets - (part 1)

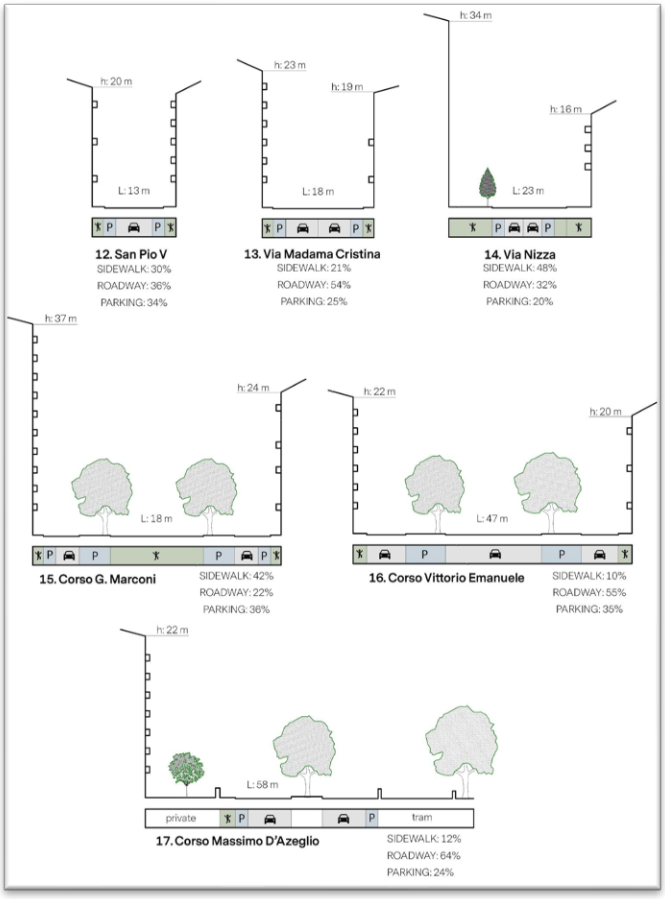


Fig.7 Analysis of streets - (part 2)

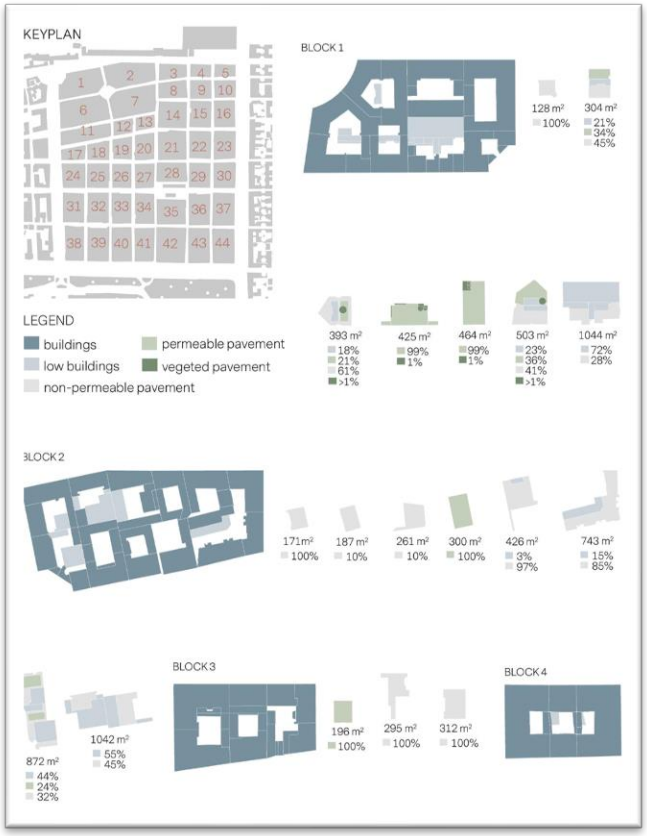


Fig.8 Analysis of the courtyards (part 1)

Fig.9 Analysis of the courts (part 2)

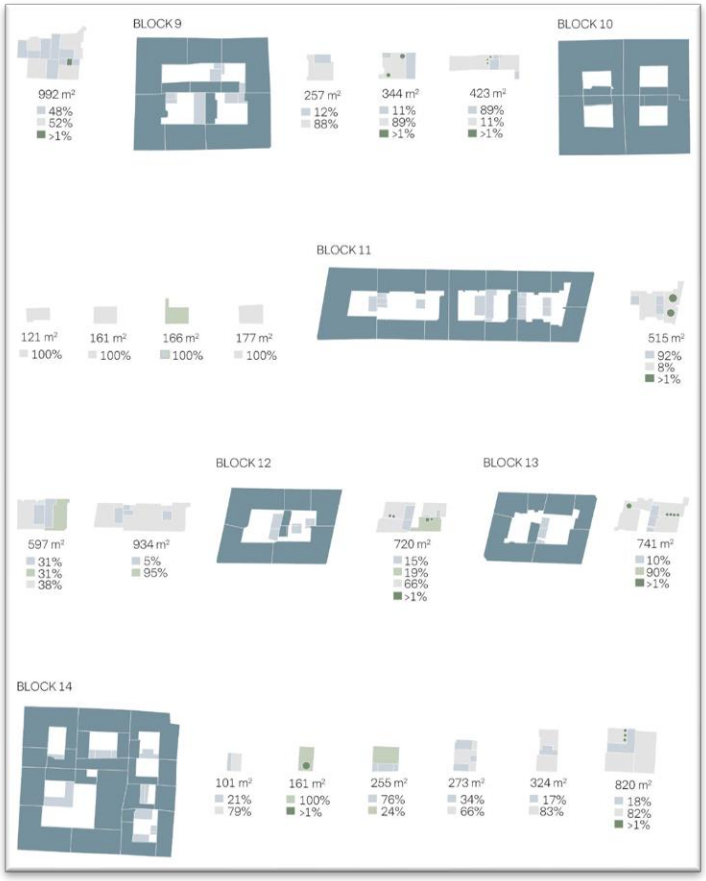


Fig.10 Analysis of the courts (part 3)

Fig.11 Analysis of the courts (part 4)

Fig.12 Analysis of the courts (part 5)

Fig.13 Analysis of the courts (part 6)

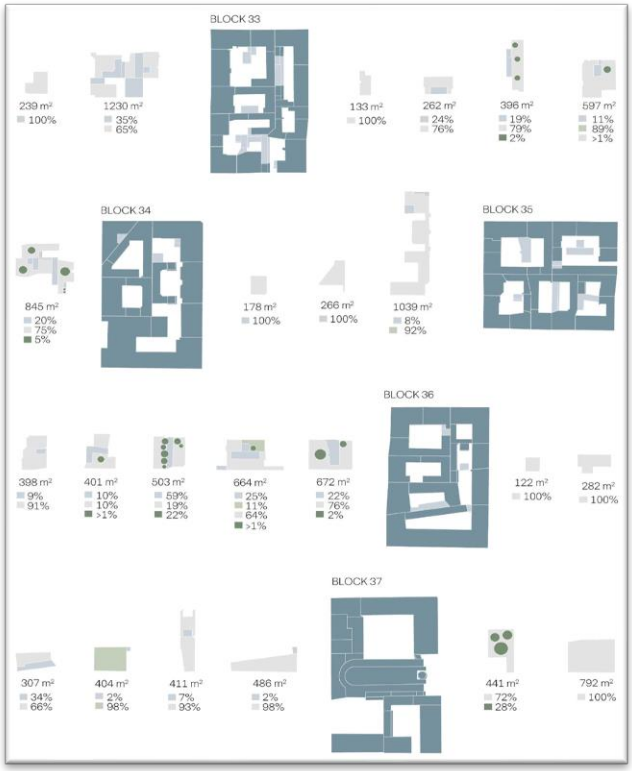


Fig.14 Analysis of the courts (part 7)

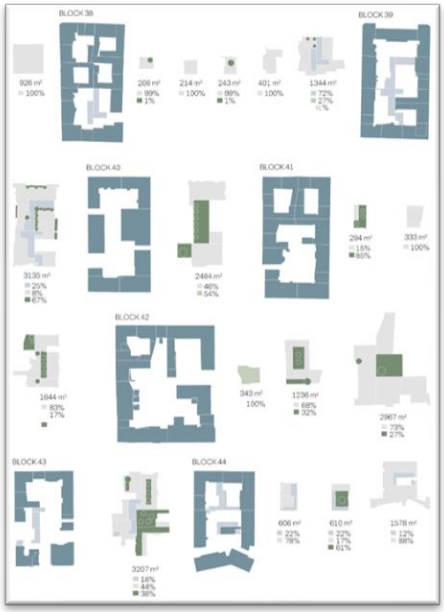


Fig.15 Analysis of the courts (part 8)

Table 2 categorizes the most relevant morphological characteristics constituting the neighborhood fabric. It identifies spatial typologies (extensive, linear, vertical) and assesses the potential of these spaces in green transition projects, considering both environmental and social aspects, while also highlighting their limitations to be considered in the projects.

Element	Development area	Limits	Potential
Square	Extensive area	Existing infrastructure* Historical/landscape features Spaces with pre-existing identities	high
Street	Linear area	Existing infrastructure* Acceptance of extraordinary interventions**	medium
Courtyard	Extensive area	Private/semi-private places Historical/landscape	high
Building	Vertical area	Private/semi-private places Historical/landscape	medium

*(sewerage, district heating, energy, telecommunications, etc.)
**road pedestrianization, reduction of parking space, new bike lanes, etc.

Tab.2 Table of the main elements of the morphology of San Salvario

5. Application and result

The comprehensive analysis conducted on the neighborhood distinctly reveals that the shortage of public spaces for socialization and the absence of green areas are currently compromising the area's quality of life, significantly influencing the overall adaptability of the city.

This predicament exposes both residents and the architectural heritage to noteworthy risks in the face of extreme events. The foremost objective is, therefore, to fortify and optimize the existing spaces, aiming to ensure a substantial improvement in the quality of life and bolster urban resilience.

Considering the recurrent presence of internal road sections measuring between 10 and 12 meters, courtyard buildings characterized by recurring dimensions and modularities, along with distinctive public spaces like the captivating Largo Saluzzo, three representative elements were singled out for each category. These elements are earmarked for redesign through the implementation of Nature-Based Solutions (NBS).

The pilot cases pinpointed for redesign interventions utilizing NBS are Largo Saluzzo, Via Baretti, and the internal courtyard of block 13 (Fig.16).

Fig.16 Map of the selected locations

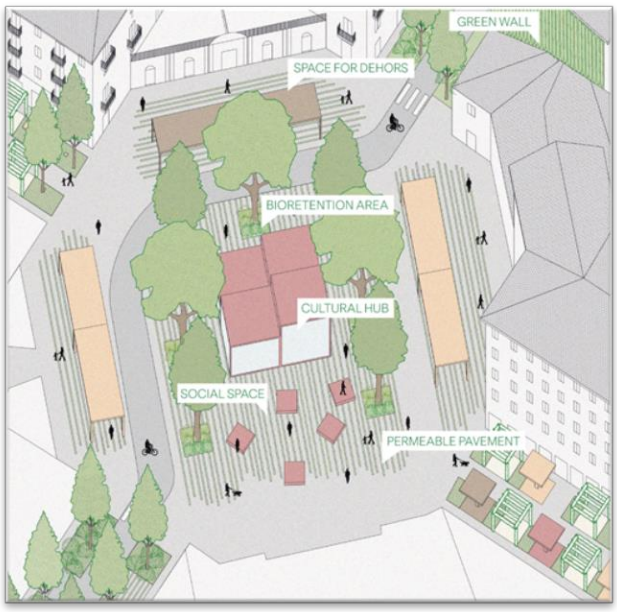


Fig.17 3D view of project in Largo Saluzzo

The NBS, delineated in the matrix (Table 1), were selected by considering the specific context of San Salvario (streets, internal courtyards, squares), aligning with the desired benefits and functionalities, as well as the Sustainable Development Goals (SDGs) to pursue.

Concerning the streets, projects were diversified with a focus on reducing car space to promote pedestrianization, considering the outstanding connectivity to the city and its adjacent center. The area boasts exceptional public transportation access, featuring three metro stops, proximity to the train station, dedicated cycling lanes, and an expansive underground parking facility – albeit currently underutilized – situated in the adjoining Parco del Valentino. For the high-traffic streets where cars have unrestricted access, the applied strategies entailed increasing the width of sidewalks and reducing parking spaces, thus allowing for the integration of vegetation and permeable surfaces. In pedestrian streets, on the other hand, a denser vegetation approach was chosen to enhance citizen utilization, especially during the summer, and efforts were made to separate spaces between cyclists and pedestrians.

Lastly, given the lack of significant gathering spaces in San Salvario, the revaluation of social spaces became crucial. For these areas, inclusive spaces were created for the neighbourhood, introducing biodiverse "pocket gardens," and due to limited space availability, multi-level solutions were adopted. We present below the results of three proposed projects for the area under investigation (fig 16). The first project (fig.17) is dedicated to Largo Saluzzo, currently an octagonal square crossed by two perpendicular vehicular streets and characterized by a limited presence of vegetative elements. The project's objective is primarily to limit private car traffic on one of the two streets, increase the presence of vegetation and permeable surfaces on-site, and transform it into a safe social space. In the heart of the square, a cultural center has been established to serve as a focal point for engaging social activities. The decision is motivated by the fact that currently, transit traffic is primarily generated by residents in the area and by service vehicles for catering establishments. Additionally, individuals passing through in futile search of parking contribute to the traffic, given that the area is predominantly occupied by bar terraces. Furthermore, for over four years, there has been an active citizens' association called "Largo al Giardino," which supports the area's conversion process through a bottom-up approach in collaboration with the municipality.

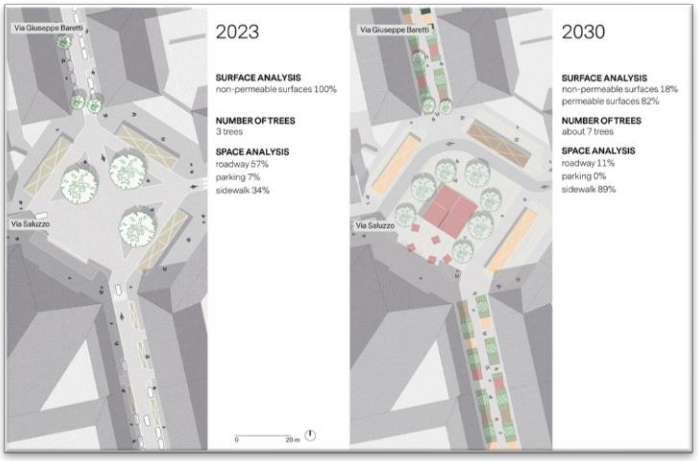


Fig.18 Before and after, project in Largo Saluzzo

Fig.19 3D view of project in Via Baretti

As shown by the data in fig.18, the project has increased permeable surfaces (82% of the surface is draining, compared to the pre-intervention 100%) and bioretention areas, introducing new biodiversity and reducing the risk of flooding. The decision to incorporate new high-albedo trees and pavements, on the other hand, mitigates the urban heat island effect, enhancing the livability of the area during warmer periods. Blank walls are treated with vertical greenery, contributing to the creation of a cooler and more biodiverse environment.
Regarding the street, we provide the example of a pedestrianized street, Via Giuseppe Baretti (fig.19). Currently, the street is traversed by cars, there are few parking spaces on both sides and terraces, while the sidewalk area is minimized. The project aims to transform the street into a pedestrian zone, restoring spaces for vegetation, permeable surfaces and public space. The project is composed of three areas: one dedicated to pedestrians and two dedicated to rows of trees of different species, biodiversity hotspots and vegetated pergolas. Architectural choices based on NBS contribute significantly to reducing the temperature in a high pedestrian traffic area, given the presence of bars and restaurants.

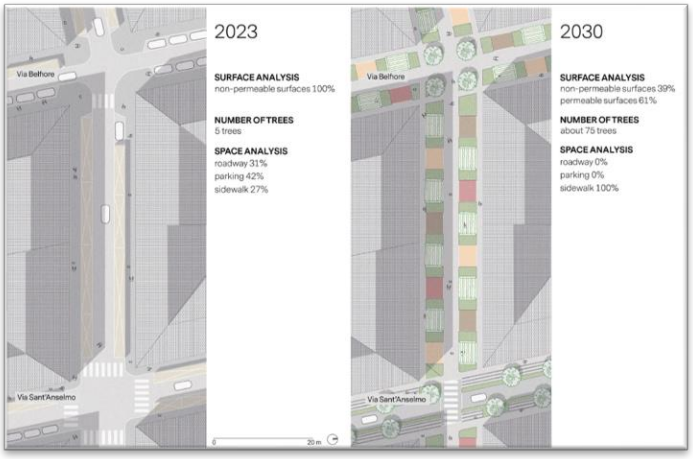


Fig.20 Before and after, project in Via Baretti

Fig.21 3D view of project inner courtyard

Additionally, they create retention areas for first rainwater in the event of sudden precipitation, helping minimize flooding, in contrast to the current situation that poses risks in this regard. Moreover, by reducing vehicular traffic, additional benefits are achieved, including a decrease in air pollutants and an overall

improvement in residents' quality of life. A roadway space has been considered for the passage of emergency vehicles, property owners, and waste collection. Figure 20 quantitatively illustrates how the implementation of NBS allows for the creation of greener environments, capable of increasing opportunities for social interaction and stimulating greater vibrant economic activities((Scalisi and Ness, 2022), particularly within the catering sector. This is because the public space project contributes to enhancing both aesthetic and microclimatic qualities.The third pilot case concerns plot number n, consisting of residential buildings. Despite being a private fabric, the courtyard space can be conceived as a collectively used area among different condominium units, similar to the courtyards found in Cerda's Eixample model in Barcelona.
Simultaneously, possible architectural solutions have been explored for one of the buildings, such as communal green roofs (of a more private nature compared to the courtyard) and facades adorned with vertical greenery. Currently, the courtyard is entirely paved and used for parking cars. The decision was made to initiate projects primarily oriented toward environmental and social development.

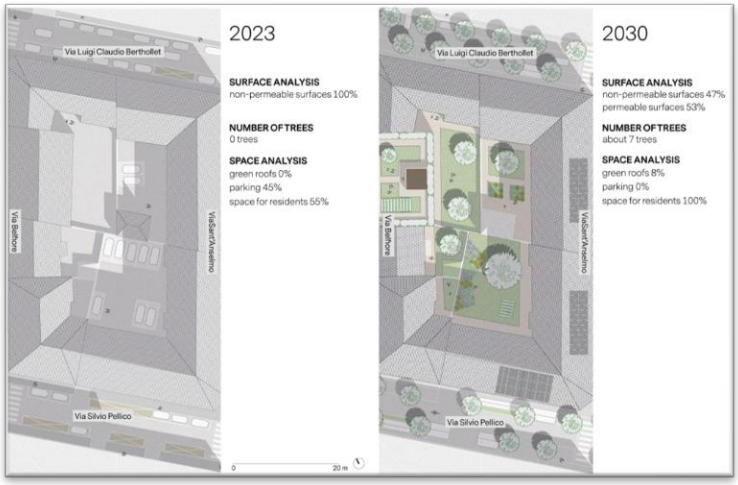


Fig.22 Before and after, project inner courtyard

The initial phase entailed the elimination of numerous existing parking spaces. The subsequent step involved introducing vegetation in the courtyards to create more evocative and healthful landscapes. Special attention was given to incorporating "rain gardens" to efficiently manage rainwater and enhance biodiversity, thereby creating a communal space for residents to foster social interactions (Fig.21). Once again, the prospect of "greening" the city stands to have a positive impact on inhabitants who, within an urban context, have limited opportunities for interpersonal engagement. This proposal poses a greater challenge, as while the public space project is managed by the municipality, the private sector faces more significant barriers, including economic and regulatory constraints (for example, if the building is subject to preservation restrictions). Nevertheless, the aim was to demonstrate how the application of NBS in architecture can contribute to the development of resilient and adaptive urban fabrics (fig. 22).

6. Conclusion

The analysis and experimentation conducted in the San Salvario neighborhood provide an opportunity to explore replicable nature-based approaches, demonstrating their suitability in dense Italian urban contexts and their contribution to increasing adaptability, improving urban quality, and promoting the values of the Agenda 2030 (SDG) and the New European Bauhaus. From quantitative data (expressed as a percentage before and after the intervention), it is evident that nature-based solutions, initially identified in the literature and subsequently implemented specifically in the three pilot cases, contribute to enhancing quality, resilience, and biodiversity. This demonstrates the feasibility of NBS even in high-density contexts through targeted interventions in public spaces and adjustments to internal mobility. From a biodiversity perspective, these

initiatives transform sterile urban surfaces into ecological corridors, supporting pollinator life and promoting overall biodiversity. This aligns with the Biodiversity Strategy 2030 and the European Commission's "New Deal for Pollinators" initiative. Additionally, the increased vegetation and improved urban quality of communal spaces have a positive impact on the psychophysical well-being of the community, transforming the neighborhood into a dynamic space aligned with the concept of the "15-minute city." This not only contributes to creating a more cohesive society but also fosters a more vibrant urban economic dynamic. The experimentation has partially implemented the application of NBS within the context of the architectural project, prioritizing a greater focus on public spaces. This decision was guided by the concept that the city should ensure climate adaptation for the entire population through its communal areas. However, it is worth noting that some proposals initially directed at private residential buildings could offer replicable solutions in public structures or unrestricted settings (where volume and usage conversion are feasible, such as transforming pitched roofs into extensive/intensive green flat roofs) to provide green and communal spaces in highly densified and green-deprived environments. One of the inherent limitations of this study lies in the absence of a strategic adaptation plan, conceived as a comprehensive masterplan where various proposed projects can be synergistically integrated. Unlike other cities such as Copenhagen, which has developed a climate adaptation plan and a Strategic Flood Masterplan, or Barcelona with its "Green Axes" plan, Turin's climate resilience plan lacks an overarching masterplan to systematically guide the implementation of NBS, as seen, for example, in projects like Hans Tavsens Park or the Osterbro masterplan, integrating Sustainable Urban Drainage initiatives at the neighbourhood and urban levels. Therefore, from the perspective of urban planning and design, it becomes crucial not only to adhere to guidelines but also to develop an integrated strategic vision that connects green spaces, common assets, and private areas, coupled with a reduction in private mobility in the heart of the neighborhood, promoting an empathetic and participatory approach to urban design. Although the research has partly developed a quantitative analysis of surfaces transformed into public spaces, focusing on percentage values such as depaved and draining surfaces and the number of plants to be planted, future experiments could delve into the microclimatic impact through the use of software like Envi-met. Further studies could more comprehensively explore the ecosystemic and monetary values resulting from the application of nature-based solutions, employing dedicated software such as I-tree. As evidenced in Copenhagen's projects if Klimaquartier Østerbro, active citizen engagement proves to be pivotal, constituting a critical factor to be taken into account in subsequent initiatives. This participatory involvement is aimed at overseeing and fostering a sense of community as an integral part of the design process for communal spaces and their associated objectives. In the context of San Salvario, an inclusive approach should encompass grassroots participatory endeavors, akin to those undertaken by the "Largo al Giardino" group, advocating for the establishment of a green square and other public spaces.

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Image Sources

Fig.1 Barcelona Municipality, Urban Mobility Plan (https://www.bcnregional.com/).

Fig.2 Copenhagen-based architectural firm SLAhttps://www.sla.dk/en/.

Figg. 3-22 are elaborations by Giorgia Somale under the supervision of the authors.

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