EXPLORING THE STREET AS A SPACE FOR MITIGATION AND ADAPTATION TO CLIMATE CHANGE

A TACTICAL CASE STUDY IN TURIN'S URBAN AREA

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Tutor:
Prof. Massimo Crotti

Candidate:
Laura Valentina Paérez Ortega

Co-tutor:
Prof. Mario Artusso
Arch. Ilaria Tonti

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ABSTRACT

The climate vulnerability in the urban areas of Turin is currently facing an unfavorable increase. Research has shown the increase in temperatures and the amount of rain intensity in the urban areas of Turin and the expected projections confirm a deterioration in the climatic conditions in future years. This study aims to define the feasibility of the road profile as a suitable field of intervention to implement nature-based solutions (NBS) as tools for mitigating and reducing the climate vulnerability in the urban areas of Turin. The research was based on a systematic review of international and local cases of urban interventions focused on the mitigation and reduction of climate vulnerabilities in urban contexts and always in the public space and the street as an action field. Additionally using a standardized methodology, each case study was compared in qualitative and quantitative terms. Moreover, several interviews were conducted with experts and actors in the urban sphere of Turin to know their points of view regarding the public space and the street as the scenario for urban intervention regarding the theoretical concepts already studied.

A preliminary design was carried out in the street corridor of two urban zones of Turin that undergo the most relevant environmental risks such as high air pollution and high land superficial temperature. The study carried out took into consideration the current condition of the street in terms of the infiltration capacity and physical-environmental conditions.
The design proposal and its respective analysis demonstrated that by the arrangement and new distribution of the street components the nature-based solutions (NBS) and urban green infrastructure (UGI) could be implemented in a replicable typology over the street profile over certain conditions to ensure their feasibility.

The Mitigation strategies applied, and the spatial quality of the new street profile showed an improvement in increasing ecosystem services, plus the enlargement and improvement of public space conditions, promoting, and enforcing the use of public spaces by the community as well as the enforcement of alternative and soft mobility methods.
Furthermore, the proposed streetscapes showed an integration of urban design, environmental considerations, and community enhancement. Together, these proposals underscore the importance of thoughtful urban planning in creating sustainable and livable public spaces.

Introduction

As the adverse effects of climate change continue to manifest, the urgent need to implement effective mitigation strategies has become of great importance. In urban areas, where population density and infrastructure development are concentrated, climate change impacts are amplified, making these areas particularly vulnerable affecting the health and wellbeing of citizens. (IPCC, 2022)
Loss of biodiversity due to urbanization and the associated degradation of ecosystem services are predicted to impact the physical, psychological, and economic well-being of communities particularly in urban areas (Connop et al., 2016). To reverse these trends, it is necessary not only to put back greenspace and nature in urban areas but to put back biodiverse, functioning ecosystems (Connop et al., 2016). In one hand nature-based solutions (NBS) offer promising approaches by utilizing natural systems to mitigate environmental challenges, In the other hand, some challenges exist such as space Limitations, and Long-term maintenance. Therefore, Integrating nature-based solutions (NBS) into consolidated urban infrastructure systems as the mobility grid holds significant potential for mitigating climate change impacts.

This thesis aims to demonstrate that streets represent a feasible field of action in mitigating and reducing the adverse effects of climate change in urban areas, concurrently enhancing community living conditions and well-being. This objective will be achieved through the introduction of NBS within a replicable typology system applied to street corridors in a tactical case study conducted in Turin's urban area as aforementioned improving not just the resilience to climate vulnerabilities but the environmental conditions and exosystemic services of the studied areas.

The Mobility infrastructure, viewed as a system that considers land availability along the corridor, offers a modular framework for street interventions. The modular nature of these interventions makes the implementation of NBS in a segmented manner both feasible in terms of maintenance and adaptable to land availability. It is important to note that the mobility infrastructure constitutes the most extensive impermeable network within the urban system, measured in square meters. This infrastructure plays a pivotal role in diminishing soil infiltration capacity, contributing to environmental and social challenges*

The general objectives considered are the mitigation and reduction of climate vulnerability as well as improving the space quality and the wellbeing of the community. More specifically the aim is the incorporation of Urban Green Infrastructure (UGI) and nature-based solutions (NBS) in a holistic intervention within the mobility infrastructure while enlarging public space areas. UGI and NBS are insights of immediate importance; growing urbanization is one of the anthropic causes of UHI. The UHI phenomenon has a negative impact on the life quality of the local population causing thermal discomfort, summer thermal shock, etc. (Barbieri et al., 2018).

**Such as, decrease of soil infiltration capacity, increase of run off, increase of floods cases in urban areas, increase of air pollution (particulate material PM10), And deterioration of health and wellbeing due to high levels of noise and air pollution, as well as biodiversity loss.*

To address these challenges, a strategic and replicable approach involves the thoughtful incorporation of Urban Green Infrastructure and nature-based solutions into street corridors. This contextualized application serves as a tactic to mitigate climate vulnerability in urban areas and establishes adaptability to confront environmental and social challenges. By strategically implementing these tools within the urban fabric, the initiative aims to create a positive impact on both the immediate living conditions of the community and the broader resilience of urban areas in the face of climate-related issues.

This paper as well as the line of investigation and action is organized in three parts.
The first one, known as the analytical one is where the theoretical framework is developed and the current debates concerning three main concepts that conform the pillars for the investigation are reviewed. This concept was reviewed to understand the role of street corridors as an effective public space item and its role in the process of mitigate and reduce the climate vulnerability to meet the environmental and social needs of the city and its citizens. The public space and more particularly the road network can be considered not merely a functional infrastructure for transportation; the road as a new architectural and spatial concept, the road is also a carefully designed and architecturally significant artifact. Roads possess inherent architectonic and spatial qualities that contribute to the overall urban fabric and aesthetic appeal of a city (Éric Alonzo,2017). On the other hand according to the Restorative urbanism paradigm the public space is a component that can bring mental and physical well-being to a very variated range of users while improving the environmental condition of the space. In the other side the resilience urban paradigm expresses the capacity of the urban environment to adapt from hazards by recognizing the problem, reducing the risk by exposure reduction, and implementing mitigation strategies.

The second part of this paper is the methodological one and describes the process of analysis done with the theoretical framework applied into Turin's urban context. This chapter starts with a review of Turin's plans for urban development.
and the current environmental framework in which Turin is moving on. Additionally, this chapter also encloses Overview of Turin's Public space case, some interviews done to experts and actors of municipal institutions to obtain an overview of positions and opinions on the role of public space and the mobility system regarding aspects such as climate vulnerability and risk management. Moreover, the goal is to understand how the theoretical debates on climate change can be materialized.

Furthermore, the third part reports the methodology used in the mapping and data collection practices, inherent to the spatial study of the city of Turin, the experimental area of this research. Emphasis is done to the method of procedure as tactic strategy for carrying out the analysis of punctual streets profiles three approaches were identified and analyzed according to the type of intervention that should be consider. Then these 3 approaches were contrasted to choose a suitable area of intervention with a supported base. By comparing the different approaches, it became possible to identify their respective strengths and weaknesses. Finally, a preliminary design was carried out in the street corridors in two urban areas of Turin, each one with different physical and environmental characteristics. For all the cases was performed the analysis and calculation of the physical conditions and the soil quality conditions and represented graphically the current condition of the road.

From the design proposal the expected results are the improvement of the previous conditions, this means, improvement of space quality by increasing the effective public space area and is expected also an improvement in the capacity of the landscape to mitigate and reduce the climate vulnerability, this by increasing the infiltration capacity and improving thermal comfort conditions by increasing vegetated areas. On the basis of the findings achieved in this paper some recommendations are proposed to meliorate the accuracy of urban intervention approach evaluation. The analysis suggest future studies should consider conducting further analysis at the intervention approaches stage, employing multiple indicators and additional parameters to achieve a greater evaluation between the multiple approaches, hence a better decision making on the street interventions based on greater quantitative data.

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1,1 A NEW PUBLIC SPACE APPROCH

LEARNING THROUGH THEORY

a) Nature-based solutions for a Resilient public space.

NBS for climate mitigation

Nature based solutions are inspired and supported by nature, are also cost-effective solutions; provides social and economic benefits by building resilience. Resilience is the capacity of a system to recover or adapt to adverse situations or changes. In an urban concept urban resilience is the ability of an urban system to absorb, recover and prepare for future impacts (Martino,2022)

The NBS are locally adapted, resource-efficient and done by systemic interventions. According to the European Commission et al. (2021) the NBS Must benefit Biodiversity and support the delivery of ecosystem services.

According to the World Economic Forum (2023), the most likely and most impactful global risks of the century is (amongst others) extreme weather, biodiversity loss and natural resource crises.

To approach to these risks which have as root-cause the environment degradation and climate vulnerability, **the European Commission et al. (2021) support and encourage member states to enforce the application of the Nature based solutions in their contexts** due to their excellent way of addressing societal and environmental challenges. The NBS can reduce the number of persons adversely impacted by natural disasters, also reduce direct and indirect financial losses due to natural and climate hazards, additionally in economic opportunities terms NBS can increased property value, retail and commercial activity in proximity to nature-based solutions.

> “Climate change is affecting ecosystem ser-vices connected to human health, livelihoods, and well-being”
> (IPCC,2022)

Cities are primarily responsible for the polluting and climate-changing emissions that come from them. The important percentage of population living in urban areas occupy only 3% of the planet’s surface, home to 54% of all human beings, but they consume 70% of global energy, 80% of food and emit 75% of pollutants and greenhouse gases. (SOS4LIFE, 2019).

Climate and environmental risks are the core focus of global risks perceptions over the next decade, according to the analysis done by the World Economic Forum (2023) the burdens on natural ecosystems will continue growing.

Impact of Nanture-based solutions

NBS can have different ranges of interventions in terms of impact and scale in which is conceived, the Intervention can be minimal or inexistent as establishing a conservation area to stop or decrease the degradation of an area; or the range of intervention can be more extensive like the creation of new ecosystems with different scale impacts such as the creation of a pocket garden or a the a stabilizing and regulating ecosystem for coastline as a mangrove. Nature-based solutions concepts can be classified in four-dimension scales as strategic, spatial, soft engineering and performance.

According to the European commission the societal challenges the NBS can address can be organized in 12 groups according to the ecological services provided (European Union, 2021)

The NBS are mostly recognized for Adressing Climate resilience challenges as well as Water managment practices, mitigate and reduce Natural and Climate Hazards. However, NBS also contributes to several challenges as green space management, Biodiversity enhancement, Improving of Air quality and Place regeneration. Additionally, the NBS offers collective opportunities for citizen involvement in stewardship actions such as enhance Knowledge for sustainable urban transformation, Participatory planning, social cohesion, and generates Improvements on health and wellbeing and New economic opportunities (European Union, 2021).

		NbS Dimensions
Strategic	**EbA**	*Ecosystem-based Adaptation*
	Eco-DRR	*Ecosystem-based Disaster Risk Reduction*
Spatial Planning	**GI**	*Green Infrastructure*
	BI	*Blue Infrastructure*
	GBI	*Green-Blue Infrastructure*
	UF	*Urban Forestry*
Soft Engineering	**SuDs**	*Sustainable Dreinage system*
	EE	*Ecological engeineering*
	BMPs	*Best Managment practices*
	LID	*Low impact development*
	WSUD	*Water sensitive urban design*
	ESS	*Delivery of ecosystem services*

Figure 1. *Nature Based Solutions Dimensions. Source: European Commission et al. (2021)*

In addition to environmental benefits, NBS can also provide economic and social benefits. For example, the restoration of degraded land and the protection of natural areas can boost tourism and recreation opportunities. NBS can also enhance social cohesion by providing spaces for community activities and improving the quality of life of urban residents. (European Commission, 2020)

However, there are challenges to implementing NBS effectively. One of the challenges is the lack of understanding and awareness of the potential of NBS among policymakers and the general public. Another challenge is the need for innovative ways of implementing the NBS in a way the costs of maintenance are reduced.

Despite these challenges, the European commission has recognized the potential of NBS and is promoting their implementation through various policies and initiatives, such as the European Green Deal, the Biodiversity Strategy for 2030, and the Farm to Fork Strategy. By promoting NBS, the EU aims to achieve its environmental, economic, and social goals and contribute to global efforts to address climate change and sustainable development.

Overview of an Urban paradigm

The unsustainable management of resources in urban areas is threatening society and the environment but also the environmental degradation due to the unsustainable growing of urban areas increasing the effects of climate change. (U.N, 2023) The most perceptible effect of environmental degradation on urban areas can be show with the Urban Heat Island phenomenon.

If analyzed the European context, Europe is one of the most urbanized continents in the world, an unsustainable sprawl of urban infrastructure most of the times means soil sealing; this is the permanent covering of a surface by impermeable material. According to the European commission Agency (2010) is one of the main soil degradation processes since affects essential ecosystem services as well as Biodiversity. **This is without any doubt one of the main challenges in terms of environment degradation on account of the lack of water absorption, filtering, and buffering capacity of the soil.**

Furthermore, in urban areas the high percentage of dark and impermeable areas due to asphalt and concrete paving is a relevant amount. This material has a low albedo, this means this material absorbs most of the solar radiation understand as heat. All this heat is accumulated leading to the increase of surface and air temperature, generating the phenomenon known as The Urban heat island (UHI), this is the significant difference of temperature between an urban area from its surroundings due to the physical conditions and modifications done to the urban environment (SWD, 2012)

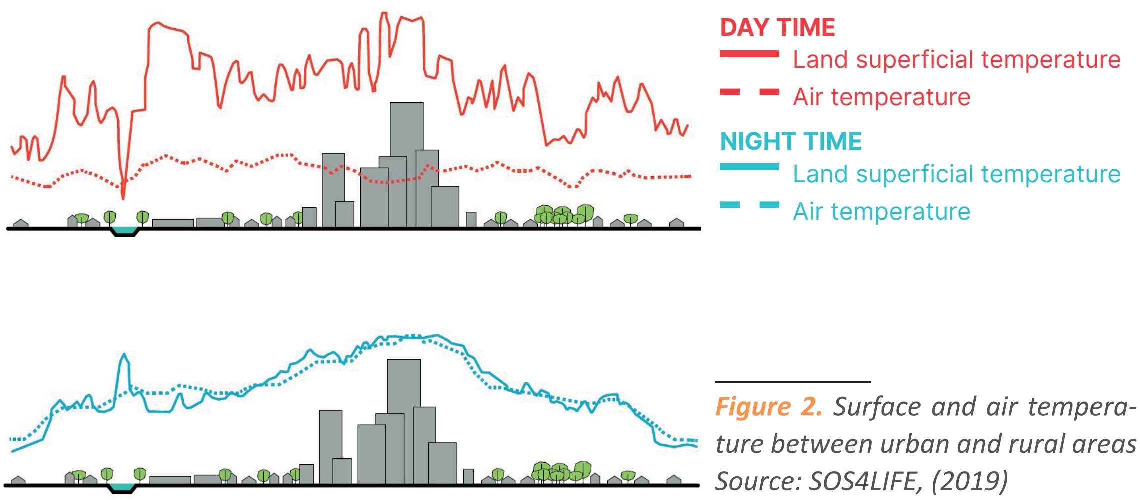

Figure 2. *Surface and air temperature between urban and rural areas Source: SOS4LIFE, (2019)*

The points of discontinuity in this phenomenon are represented by the green areas where the albedo is higher, and the accumulation of heat is low or absent. The features that improve this phenomenon in the green areas are the infiltration capacity of the soil, the presence of vegetation capable of cool down air temperature via evapotranspiration and the water bodies that by evaporation have a similar effect over air temperatures

(SOS4LIFE, 2019)

As expressed by the European Commission et al. (2021) the UHI have been identified as an urgent global warming issue and the Nature based solutions have become a core element of the European Green Deal, also have a decisive role on achieve certain European economy targets stipulate in the EU Bioeconomy strategy plan. *

The European Green Deal scope is to transform the EU into a modern, resource-efficient, and competitive economy, ensuring no net emissions of greenhouse gases by 2050, one of its main instrument and deliverables is the EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil". The European Green Deal's Zero pollution Action plan for 2050 have as aim creating a toxic-free environment by reducing pollution at source, this aim is divided in several targets as: Reducing waste generation and improving air, water and soil quality.

According to the European environment Agency (2022) Air pollution is the main environmental health problem in the EU. More than 200.000 premature deaths were registered in the european union countries, and the mayority of these deaths are registered mainly in urban areas due to the exposure of fine particulate matter.

According to the IPCC Report 2022 the main contributions to Climate resilient development in urban context are three categories such as Nature based solutions, social policy and physical infrastructure. This is because the first two categories show how the limitations of the third one can be mediated, Reason why the interdisciplinary work of these three categories has a considerable positive role in adaptation strategies and building climate resilience in urban contexts.

> "Nature-based solutions offer a wide range of potential benefits, including protecting ecosystem services, supporting biodiversity, and mitigating climate change "
> (IPCC, 2022)

**The bioeconomy strategy supports the Commission's political priorities for accelerate the deployment of a sustainable European bioeconomy.*

Impact in the European Union

Recent investigations and articles have highlighted the importance of public spaces in promoting urban resilience in the European Union (EU). For example, a study by the European Environment Agency (2019) emphasizes the need for green and blue infrastructure in urban areas to mitigate the impacts of climate change and promote social cohesion.

In addition, several EU initiatives focus on enhancing urban resilience through public space design and management. For instance, the Urban Agenda for the EU aims to improve the quality of life in urban areas by promoting sustainable and inclusive urban development, and the Horizon 2020 research program supports innovative solutions for urban resilience.

Moreover, the COVID-19 pandemic has highlighted the importance of public spaces in promoting urban resilience. The pandemic has forced cities to rethink their public spaces to ensure social distancing and promote outdoor activities. Many European cities have implemented temporary measures such as pop-up parks, pedestrianized streets, and expanded cycling infrastructure to provide safe and accessible public spaces (Garmendia, et, al. ,2020).

However, challenges remain in enhancing urban resilience in public spaces. For example, funding for public space design and maintenance can be limited, and there can be a lack of awareness and participation among stakeholders. In addition, ensuring equitable access to public spaces can be a challenge, especially in disadvantaged communities (Vojnovic, 2019).

Overall, promoting urban resilience in public spaces is a critical challenge for the EU, and there is a growing recognition of the importance of public space design and management in achieving this goal. By investing in public spaces, cities can enhance their resilience to various shocks and stresses, promote social cohesion, and improve the quality of life of their residents.

"Nature-based solutions offer a wide range of potential benefits, including protecting ecosystem services, supporting biodiversity, and mitigating climate change" IPCC, 2022

SOS4LIFE- Emilia Romagna Region Case study

Save Our Soil for LIFE is a demonstration project that intends to contribute to the implementation on a municipal scale of the European guidelines on soil protection and urban regeneration with reference to the Guidelines on best practices to **limit, mitigate and compensate for soil sealing** [SWD (2012) 101].

The regeneration of climate and urban areas is without doubt the main concept and goal of the Project Save Our Soil for LIFE by improving resilience to the ongoing climate change. The main guidelines have as framework base **the Nature based solutions as main techniques**, furthermore the solutions must be also considered for the inhabitant's benefit, this means the public space must be design for the attractiveness, the health, and the social inclusion.
The project Save the soil for life promote by the territorial, urban, and landscape planning service of Emilia Romagna place in two volumes guidelines and specific referents with the aim of improving resilience in urban areas throughout the implementation and guidance of nature-based solutions strategies and techniques.

Figure 3. Save Our Soil for LIFE guidelines. Source: (SOS4LIFE, 2019)

The conditions of the cities in Italy have a different scenario more than 70% of the population lives in cities and this percentage is destined to increase further. According to the Project for live initiative by the EU commission the actions on soil protection and urban regeneration must be implemented in a municipal scale to mitigate and compensate the soil sealing actions taken in the past and current years.

Under the view of the European commission standards for carrying out of the guidelines, the transdisciplinary collaboration between the various stake holders assures the achievement of the aim since the urban and climatic regeneration are complex topics and requires mandatory a plurality of actors from different fields to reach more efficient solutions. (SOS4LIFE, 2019)

b) Public space for social wellbeing

The Restorative urbanism paradigm.

After the 2020 pandemic the discussion was all directed to public health polices and for the case of public space wasn't far from it. The lockdown done in several countries around the world to avoid the contagion of the COVID-19 virus makes visible the importance of psychosocial health this means social contact and interactions, in this way, is visible the role of public space as a place where social interactions occur, and these are crucial part of our mental health.

According to the authors Roe and McCay (2021), these are critical factors in shaping the psychological well-being of individuals the lack of these social interactions, this means, loneliness and lack of social belonging are critical risk factors mostly implicated in suicide (Joiner, 2005) Therefore the relationship between the public space and the Mental health is a complex concept and construction relating to a person's optimal experience with the environment (Ryan & Deci, 2001)

Mental health challenges increase with warming temperatures, trauma associated with extreme weather and loss of livelihoods and culture (IPCC, 2022)

The authors Roe and McCay analyze a new way of designing cities, placing mental health and wellness at the forefront this means Restorative urbanism is shown as a new urban paradigm for mental health, due to the high rate of people suffering from mental health issues in cities, since the probability of experiencing a severe mental disorder is increased by living in urban areas. The human relationships experienced in dense urban environments where activities must be done in proximity to others cause a different perception of public space.
The Restorative Approach for analyzing the public space takes into account wellness and life quality as the main pillars of what space planning should be, where the Restorative capacity is the quality of an environment to foster recovery from mental fatigue. (Roe & McCay, 2021)

Figure 4. Characteristics of a Restorative city. Source: Roe & McCay, (2021)

The Restorative approach takes into account seven spheres to consider these are the natural systems such as green and blue infrastructure improving space conditions that impact the user perspective and the user way of interaction having a direct impact on mental health and well-being, in the other hand the Playable and active character of the public space refers to the way urban design improves and assures the opportunity to practice physical activity and play activities, The public space should also have sensory signals capable to be understood by the users that gave them a hint of what is happening in the surroundings in a perceptional level and finally the Inclusion and the Neighborly character of the public space in terms of amenities, enough facilities for all age user and flexibility of the space to host variate activities

Originally the OASIS project planned to transform 10 schoolyards into cool islands through innovative techniques and nature-based solutions in an integrated approach (Urban Lab of Europe, 2021). After successful results in 2022 already 75 schoolyards were intervened and transformed into cool islands with the implementation of eco-innovative products and materials which allow infiltration, asses a better thermal performance, and represent a low carbon footprint (Thiollier & Sitzoglou, 2022).

The two main scopes of each courtyard intervention are to reduce the climate risk by implementing greenery and infiltration capacity of the surface and second strengthen social cohesion since the social bonds are a key factor to resilience.
The first scope is done by incrementing greenery and increasing infiltration both to reduce UHI effects and flood risk due to heavy rainstorms and the overloading of the sewer system capacity of the city in certain areas.

OASIS program Study Case

According Météo-France the temperature in the city of Paris will have an increase of 1°C to 4°C due to the more intense and frequent heatwaves and due to the phenomenon of UHI which amplifies the heatwaves impact. The Urban heat island phenomenon can be analyzed by the amount of green area per capita, in the inner city, there are 5.8 m² of green spaces per capita (Urban Lab of Europe, 2021).

The study done by the administration of Paris of how to increase that percentage of green areas to decrease the UHI effect over the city, result in the implementation of a Climate Change Adaptation Measure of "Cool Islands" in School yards. In Paris the network of schools and high schools managed by the city presents an opportunity because in total, schoolyards cover 73 hectares of asphalted and impervious surfaces (Urban Lab of Europe, 2021)

Figure 5. ***First:*** *OASIS School Courtyard Tandou 19 arr. Laurent Bourgogne / Ville de Paris.* ***Second:*** *OASIS Pre-scholar School Courtyard Maternelle Emeriau 15e. Source: Laurent Bourgogne / Ville de Paris Source: Urban Lab of Europe, (2021)*

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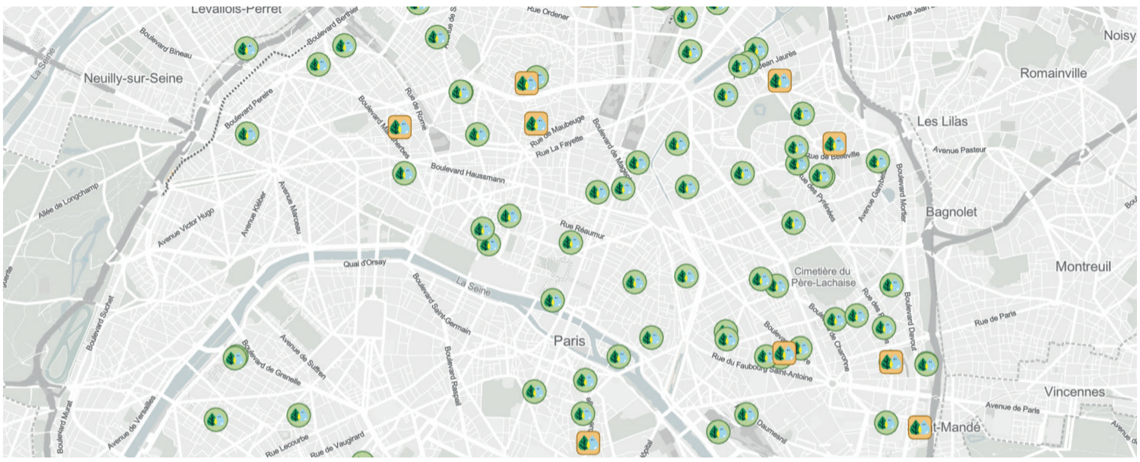


***Figure 6.** OSIS School Courtyard Parmentier 10e. Laurent Bourgogne / Ville de Paris. Second image: Distribution of OASIS Program over school and high school courtyards. Ville de Paris. Source: Urban Lab of Europe, (2021)*

Evidently the biggest strength of the OASIS program as a Climate Change Adaptation Measure is the multiple applicability across the urban context of Paris. Once the 10 first courtyards were intervened and successful the next scope was to keep on implementing the same model in several courtyards to reach an expected outcome in terms of climate risk reduction.

c) Street profile as ground of experimentation

The architecture of the road as action field

Adopting small solutions capable of being replied to several times, can cumulatively improve hydrology across a Metropolitan area (Sidder, 2019) In fact, the Department of Civil and Environmental Engineering, University of Wisconsin-Madison US performed several simulations of low-impact interventions to know which of them (or which combination of interventions) were the most effective to alter runoff, improve deep drainage and Evapotranspiration.
The simulations run by Voter & Loheide (2018) result in three different types of interventions, Impervios-centric, which are intervention over impervious surfaces, Pervious-centric which are interventions to improve he soil conditions and holistic Intervention which are the collaboration between the two first types. According to the investigation, there's a greater result when combining the Impervious and previous interventions than when using them separately.

The feasibility of these interventions depends on various factors, including site-specific conditions, policy support, and financial considerations. While Nature-based solutions offer numerous benefits, some challenges exist such as Space Limitations, Implementing NBS may require significant land availability, which can be a constraint in densely populated urban areas. On the other hand, the Long-Term maintenance of NBS interventions, such as green infrastructure, demands ongoing maintenance and care to ensure their effectiveness and longevity. Additionally, the Initial costs associated with NBS implementation and maintenance may be higher compared to traditional street

Figure 7. Corso Re Umberto service lane (Contoviale), Torino.

interventions.

So a feasible solution to implement NBS could be via replicable typology over the street corridors where the land availability is considered along the corridor and due to the modular nature of a street intervention the Replicable typology of NBS and street ordinary interventions are approaches considered to work out together.

The feasibility of nature-based solutions for street interventions can be optimized through integration and synergistic approaches. For instance, the so-called Green Streets are the integration of NBS elements within street interventions, such as incorporating green or blue infrastructure for stormwater management or creating green corridors, enhancing their effectiveness and environmental benefits. (European Commission, 2020).
Other benefits such as improved walkability, increased property values, and enhanced social cohesion strengthen the case for the implementation of this solution over street corridors.

The feasibility of implementing these approaches depends on various contextual factors. To achieve sustainable and resilient urban environments, a combined approach that integrates NBS and street interventions can provide optimal results, maximizing the benefits of both strategies while addressing environmental targets as well as runoff reduction, water infiltration capacity, increasing passive cooling strategies, and improving the special quality of street corridors.

Figure 7 bis. *Vi Gian Domenico Romagnosi, Torino.*

Road profile as intervention area and the Cross section as a design tool

In urban planning, the integration of nature-based solutions (NBS) and ordinary street interventions are two approaches that could work together to improve and enhance urban environments. NBS focuses on incorporating natural elements and processes to address various urban challenges, while street interventions involve the modification and redesign of urban streetscapes. (Sidder, 2019)

Ordinary Street interventions focus on reimagining urban streetscapes to constantly improve functionality, environmental performance, and urban embellishment. These interventions encompass various elements, such as pedestrianization soft mobility infrastructure, and vehicular and public transport infrastructure.
Application of NBS over street profile offers benefits such as the improvement and enhancement of mobility and users' security; Redesigning streets can prioritize soft and active transportation modes, enhance connectivity, and improve overall mobility for residents while significantly reducing accidents creating safer environments by reducing vehicular speed levels. An additional benefit is the eventual Economic Boost; revitalized streetscapes attract more foot traffic, fostering economic activity and supporting local businesses. (European Commission, 2020).

The Architecture of the Road.

The road is not merely a functional infrastructure for transportation, as the PhD, teacher Éric Alonzo (2017) states the road is also a carefully designed and architecturally significant artifact. Roads possess inherent architectonic and spatial qualities that contribute to the overall urban fabric and aesthetic appeal of a city. From the layout of the road network to the design of individual streets, various architectural considerations come into play. The alignment, width, and curvature of roads are intentional design choices that shape the visual character and flow of movement within an urban environment.

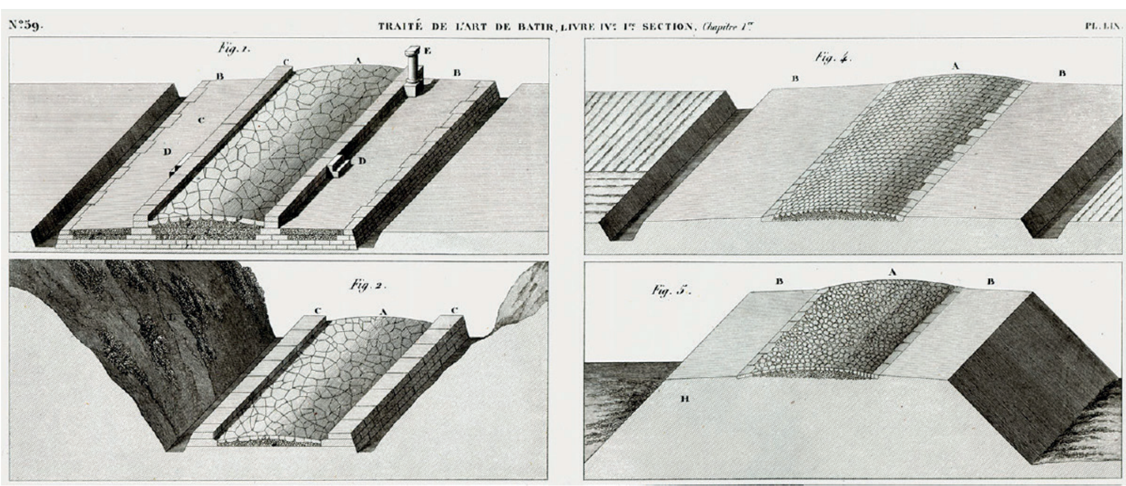


Figure 8. *The art of road and bridge engineers. Source: Lucarelli (2018)*

Furthermore, the architectural elements such as sidewalks, medians, and lighting fixtures incorporated into road design further enhance their spatial quality and contribute to the overall urban experience. The road serves as more than just a pathway for vehicles; it is a fundamental element of the built environment that influences the design and functioning of surrounding buildings and public spaces. Therefore, recognizing the road as a design and architectural artifact is crucial for appreciating its impact on the spatial composition and aesthetic coherence of cities.

The relationship between garden design and the historical development of urbanism is integral and carries profound significance. Gardens, with their carefully curated landscapes, have played a pivotal role in shaping the evolution of urban spaces throughout history. Garden design principles, such as the arrangement of plants, the use of pathways, and the incorporation of water features, have influenced the planning and layout of cities.

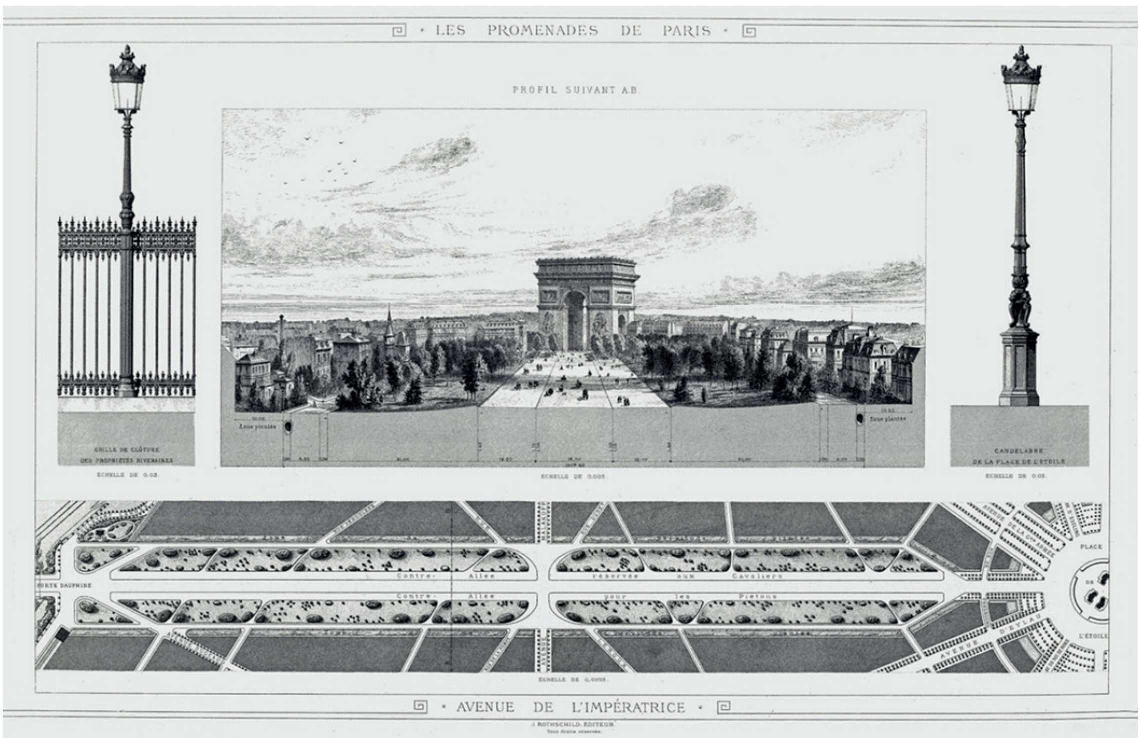


Figure 9. "Avenue de l'impératrice". Source: A. Alphand, Les Promenades de Paris (1867)

The interplay between gardens and urbanism is particularly evident in the concept of the road. The road is not merely a functional connector; it holds a deep connection to the surrounding landscape. As roads traverse through different environments, they become conduits for discovering the diverse features of the landscape.

According to some reviews done over the work of Alonzo is supposed that this connection between the garden and modern urbanism is especially significant in the context of tourism, as roads serve as pathways for travelers to explore and experience the natural and man-made beauty of a place. By following roads, tourists can encounter the urban and architectural landmarks, and other landscape features that contribute to the richness and allure of the touristic experience. Therefore, the road acts as a gateway, seamlessly integrating the landscape into the historical development of urbanism and transforming it into a conduit for exploration and discovery. (Alonzo, 2017)

Figure 10. *"The road as a technical ground" Source: Le Magasin pittoresque (1852: 397)*

Since the 18th century, the perception of the road has transformed into that of a complex and multi-functional technical machine, serving not only as a means for regulating traffic but also as a conduit for various other essential functions.

The road has evolved beyond its basic purpose of facilitating transportation to encompass a range of intricate systems that contribute to the overall functionality and livability of urban environments. (Alonzo, 2017) This expanded vision of the road acknowledges its potential to serve as a platform for the regulation of air ventilation, water flows, and

natural light distribution. By integrating elements such as ventilation ducts, service lines, and drainage systems, roads have become integral components of urban infrastructure, actively influencing the quality of the surrounding environment.
This approach to road design in the 1900s recognizes the interconnectedness of various urban systems and leverages the road's extensive network and accessibility to optimize the efficient distribution of vital resources. Consequently, the road has transitioned from a mere thoroughfare to a multifaceted technical device, playing a crucial role in shaping modern urban landscapes.

The invention of the automobile marked a significant turning point in the relationship between architecture and town planning, leading to an increased separation between the two disciplines based on the abstraction of circulation (Alonzo, 2017). Before the widespread adoption of cars, urban planning, and architecture were more closely intertwined, with the design of buildings and public spaces considering the needs and patterns of pedestrian movement.

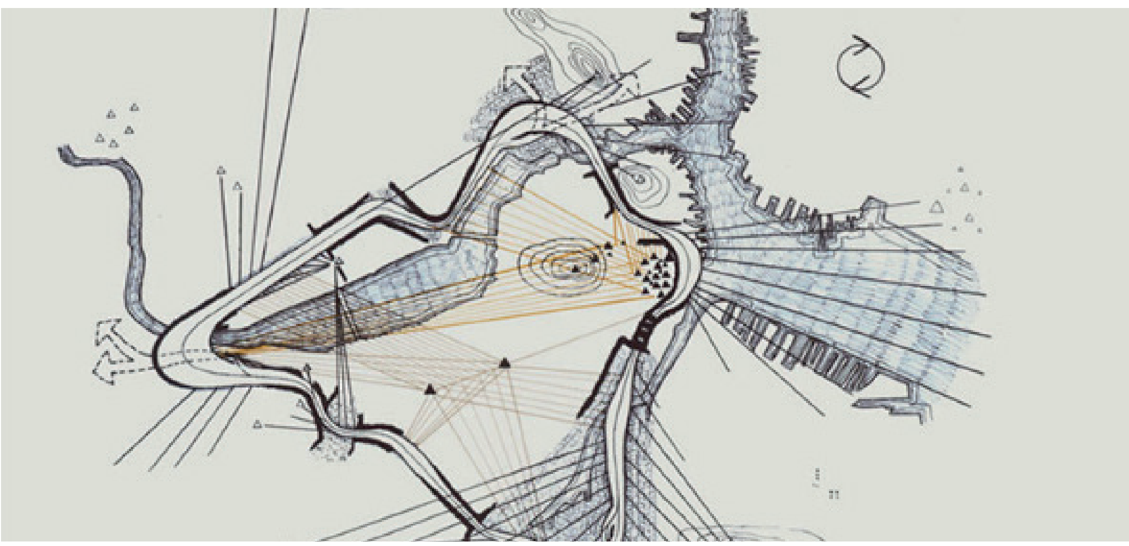


Figure 11. ***First image:*** *The Terrifying Beauty of the Twentieth Century Source: R. Koolhaas (1995).* ***Second image****: The View from the Road, "The goal approach" - Landmarks seen driving. Source: D. Appleyard, K. Lynch and J. R. Meyer (964 : 14-15)*

However, the rise of automobile culture brought about a shift in priorities, emphasizing the efficient movement of vehicles over the human experience of the built environment. As cities adapted to accommodate the growing number of cars, town planning became more focused on creating networks of roads, highways, and parking facilities, often at the expense of other considerations such as pedestrian-friendly streetscapes and public spaces.

This emphasis on circulation as a primary design driver led to a separation between architecture, which primarily concerned itself with individual buildings, and town planning, which dealt with the broader organization of the urban fabric. The increasing abstraction of circulation in urban planning, heavily influenced by automobile-centric thinking, created a divide between architectural design and the overall planning of cities, resulting in the fragmentation of urban spaces and a diminished sense of place.

The cross section as tool

The cross section serves as a powerful tool for studying public space due to its ability to illuminate the fundamental aspects of shape, proportions, and composition within the urban environment. By analyzing the cross section of a space, researchers can gain valuable insights into the physical dimensions and characteristics that define its spatial configuration.

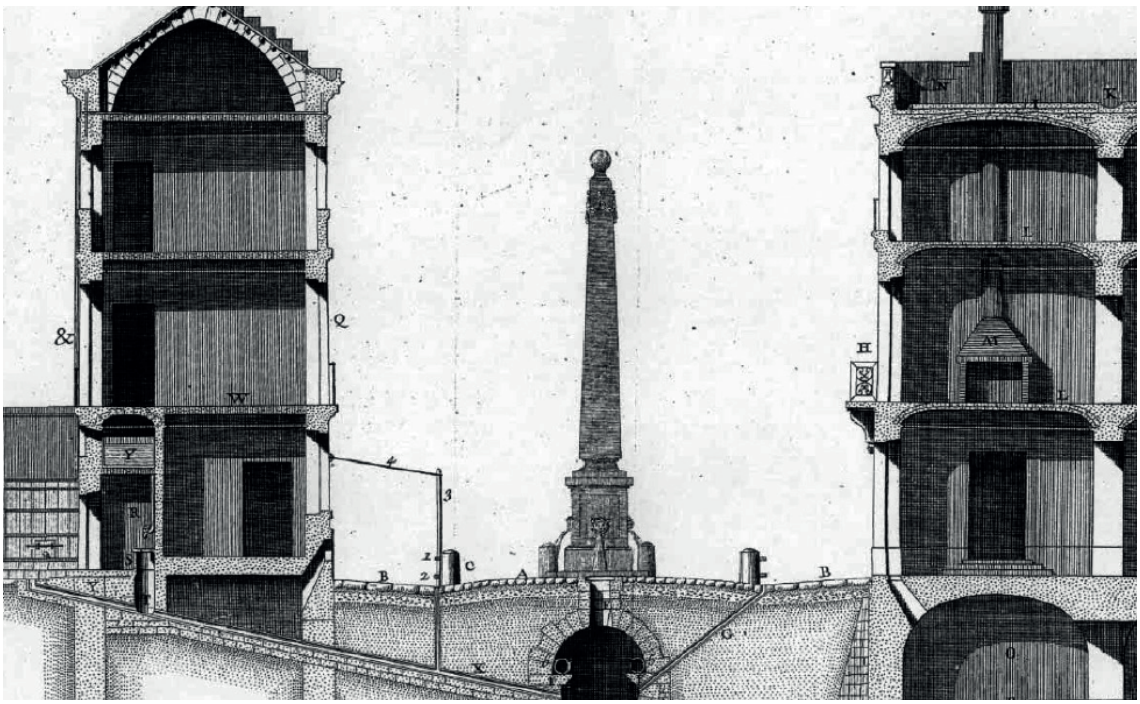


Figure 12. *Urban public space design in modern times. Source: Di Robilant & Mellano (2019)*

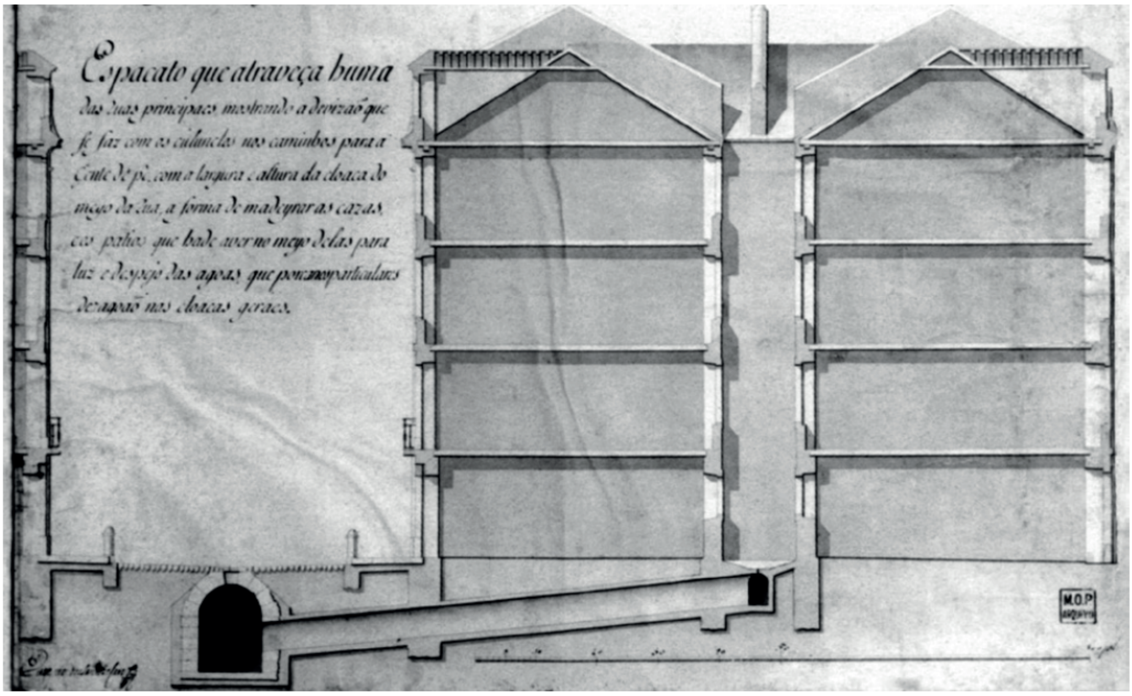


Figure 13. *Pierre Patte and the ideal street for Paris 1769. Right image: Eugenio dos Santos Lisboan refurbishment after the earthquake of 1755*

“Through careful examination of the cross section, researchers can discern the hierarchical arrangement of spaces, identify focal points, and assess the overall functionality and accessibility of the public realm.” (Di Robilant & Mellano, 2019)

For instance, the cross-section provides a visual representation of how different elements interact and coexist within the urban fabric, such as buildings, roads, sidewalks, and green spaces -if they exist. It allows for a comprehensive understanding of the spatial relationships between these components, revealing patterns of organization and connectivity.
Figures 12 and 13 represent the analysis of two rods of modern Europe in France and Portugal respectively, the fact that the street sections don’t present any human figures reveals to the authors the image that the city represented then as a purely technic device a very common idea for modern architects and urbanist from Ildefons Cerdà, to Ludwig Hilberseimer, to Le Corbusier of the Charter of Athens.

Moreover, the cross-section not only captures the tangible aspects of public space but also offers a glimpse into its qualitative aspects. It provides a means to explore how the composition of the urban space influences the human experience within it. For instance, the cross-section can shed light on the interplay between natural and built elements, revealing the integration of vegetation, lighting, urban furniture, and other components that contribute to the overall ambiance and usability of the public space. Additionally, the cross-section helps us understand how different proportions and spatial arrangements impact human behavior and social interactions.

By examining the cross-section, one can analyze the distribution of activities and users, identify potential barriers or bottlenecks, and assess the overall comfort and safety of the public space. In essence, the cross-section serves as a crucial analytical tool for unraveling the intricate relationship between the physical attributes of public space and the lived experiences of individuals within it.

Attractive and democratic streets a case study in Turin

This article delves into the relationship between public space and its physical characteristics, challenging the assumption that any space can automatically fulfill the right to public space. Drawing inspiration from Henri Lefebvre's concept, the hypothesis put forth is that a truly effective public space should be rich in diverse uses and users, creating a dense and vibrant environment.

The specific question asked by the authors was the conditions most favorable for pedestrian use of an urban road and what are the conditions in which this can be counterproductive.

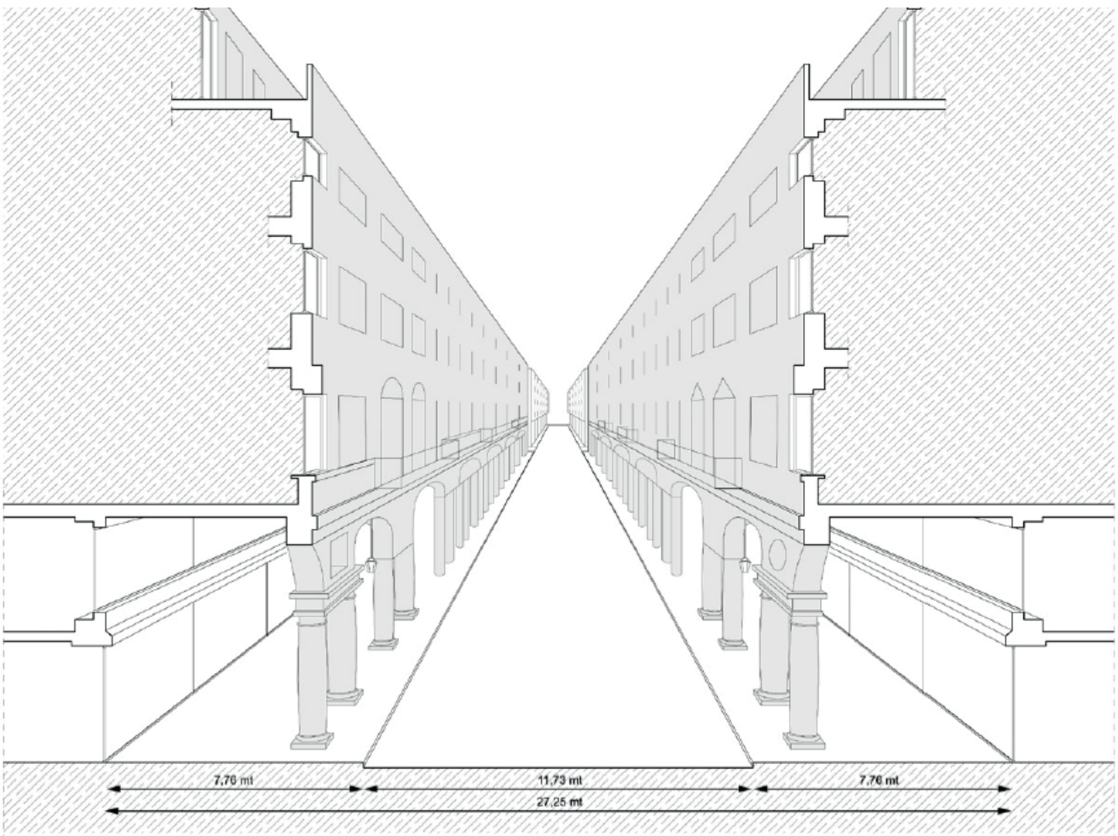


Figure 14. Via Roma profile current situation. Turin. Source: Di Robilant & Mellano, (2019)

Figure 15. Via Roma profile and an alternative use. Turin. Source: Di Robilant & Mellano (2019)

In Turin, as the city has experienced quantitative growth, the historic center stands out as an exception due to the prevalence of an urban grid layout rather than the uniformity of its architecture. As explained by the authors Di Robilant and Mellano (2019) the urban grid, characterized by a network of intersecting streets at right angles, has played a significant role in shaping the unique identity of the historic center.

Unlike other parts of the city that have undergone more substantial architectural transformations, the historic center has maintained its grid-like structure, preserving its historical fabric and spatial organization. This adherence to the urban grid has contributed to the preservation of Turin's architectural heritage, with buildings and structures reflecting diverse architectural styles and periods. The grid's persistence has allowed for a harmonious coexistence of architectural diversity within a coherent urban framework, creating a visually captivating environment that showcases the city's rich historical layers. Thus, it is the prevalence of the urban grid in Turin's historic center that sets it apart and renders it an exceptional enclave amid the city's overall growth and evolution.

This density, in turn, naturally engenders a form of social control within the public space. The level of density is influenced by factors such as the size, shape, and perceived aesthetic value of the space. Therefore, it becomes crucial to contemplate the physical attributes of a public space before making urban political decisions regarding it. For example, not all streets are suitable for pedestrianization, as some may be too wide to maintain a critical plurality and density, resulting in a loss of attractiveness and social control. The historical center of Turin serves as a compelling case study for exploring these dynamics. (Di Robilant & Mellano, 2019)

1.2 STATE OF THE ART

ONGOING DISCUSSIONS

a) International case studies

To find effective strategies to reduce environmental risk and climate vulnerability in urban contexts is fundamental to have a glance at successful cases around the European context analyzing the different characteristics of the urban models applied by their administrations to achieve adaptative and mitigation goals in their contexts.

The following cases have gained international acceptance because their initiatives mitigate climate change impacts directly at the community level and have resonated globally, becoming a symbol of innovative urban planning that prioritizes climate resilience.

Such interventions have been selected not only because they reduced carbon emissions and improved air quality but also for encourage social interactions and promote local economies and healthier lifestyles. The acceptance of these climate-conscious public space designs on an international scale underscores their importance in mitigating the effects of climate change.
The next cases to be analyzed are the Barcelona Super blocks case where the administration took advantage of their particular urban morphology and applied some strategies to improve the public space experience for residents and public transport expecting a reduction of 19% of private motorized transport. Another case to be analyzed is St. Kjeld's Neighborhood also known as the first resilient district case in Copenhagen where via public and private partnership the reduction of floods in the neighborhood was reduced by successful management at street level of rainwater.

The last case analyzed was the case of the Godsbanearealet district, a well-developed masterplan project centered on the reduction of water volume into the sewerage system, to avoid overcharges and possible floodings, therefore the district design duplicates the permeable areas, and more than half of these new permeable areas area design as accessible recreational and sports zones. This last case showed the possibility of redesigning the whole public area considering parks, streets, and unusable (abandoned) areas.

Barcelona Super Blocks Case

The Barcelona Superblock model is an innovative urban and transport planning strategy that aims to reclaim public space for people, reduce motorized transport, promote sustainable mobility and active lifestyles, provide urban greening, and mitigate the effects of climate change (N. Mueller, et al, 2020).

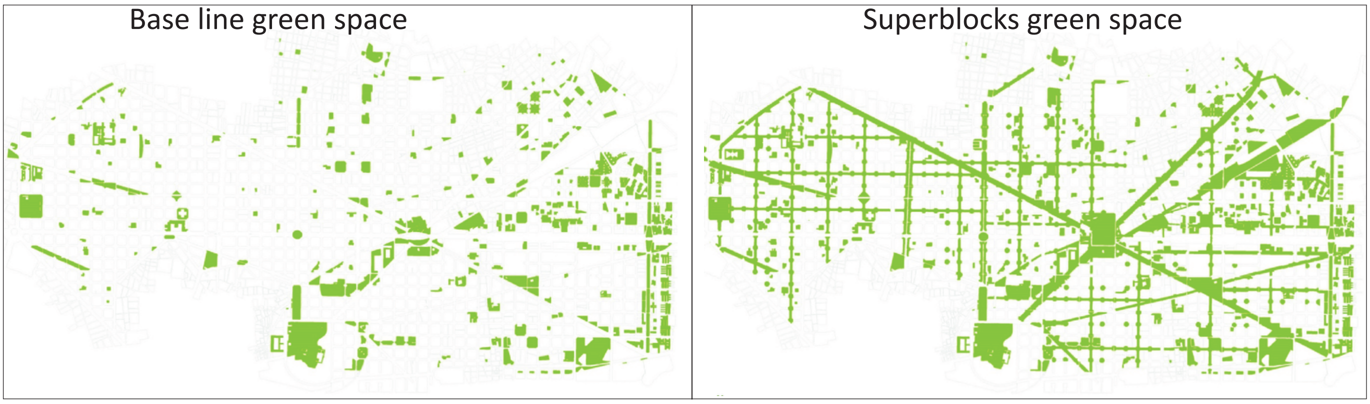


Figure 16. *Green space before and after Superblocks implementation. Source: Ajuntament de Barcelona (2020)*

The Study carried out by a multidisciplinary group headed by Natalie Mueller (2020) estimated the health impacts that the implementation of the entire Superblocks model would have over Barcelona by carrying out a Health Impact Assessment (HIA) by this methodology was estimated the expected changes over 5 indicators after the implementation of the urban model, scaled available risk estimates and finally calculated the health impacts in percentages.

Figure 17. *Superblock intervention analysis over Sant Antoni Neighborhood. Source: Done by the author based on Barcelona city council photo gallery.*

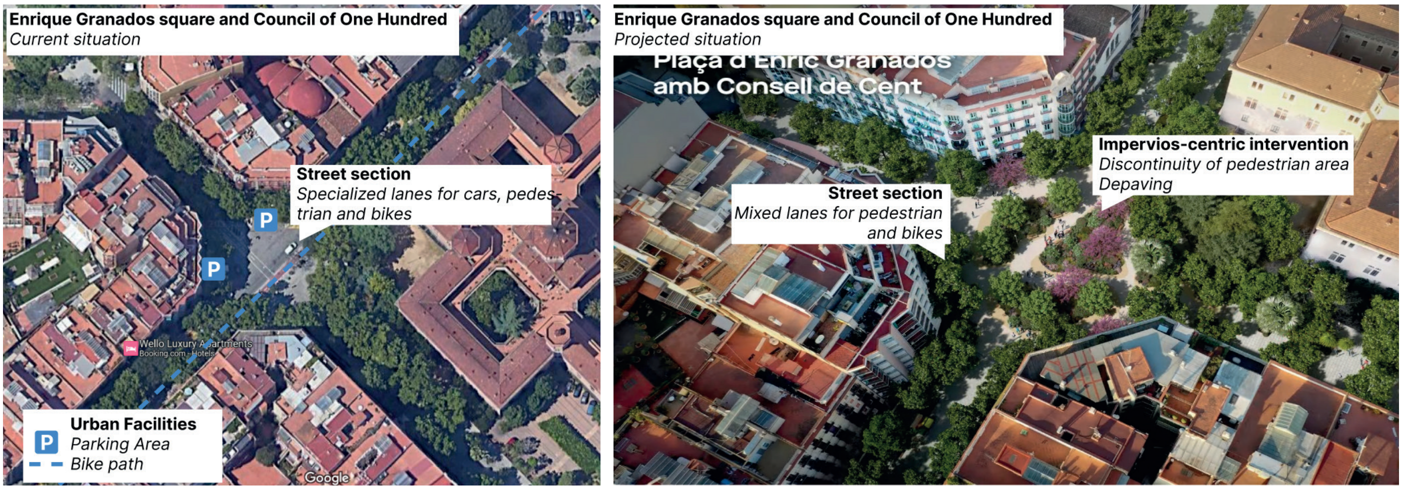


Figure 18. Superblock future development analysis over Enrique Cuadrado square and Council of One Hundred. Source: Done by the author based on Barcelona city council photo gallery.

Despite being an urban model, the superblocks are also considered a Public health strategy because of the potential to reduce premature mortality by increasing physical activity as a consequence of private motorized transport reduction by 19% and Decreasing sound pollution (By decreasing car speed on roads) by 5,4%.
Air pollution is the largest environmental health risk in Europe and significantly impacts the health of the European population, particularly in urban areas (European Environment agency, 2022) So is a great accomplishment the reduction on air pollution by 24 % with the implementation of the Superblocks model. Additionally, the model assures an increase of green space by 13% This means improving the infiltration capacity of soil helping the urban sewer system, and reducing the urban heat island phenomenon.

With the implementation of the 503 Superblocks and according to the Health Impact Assessment done by the municipality, around 667 premature deaths could be prevented annually by the improvement of the urban environment in the city of Barcelona.

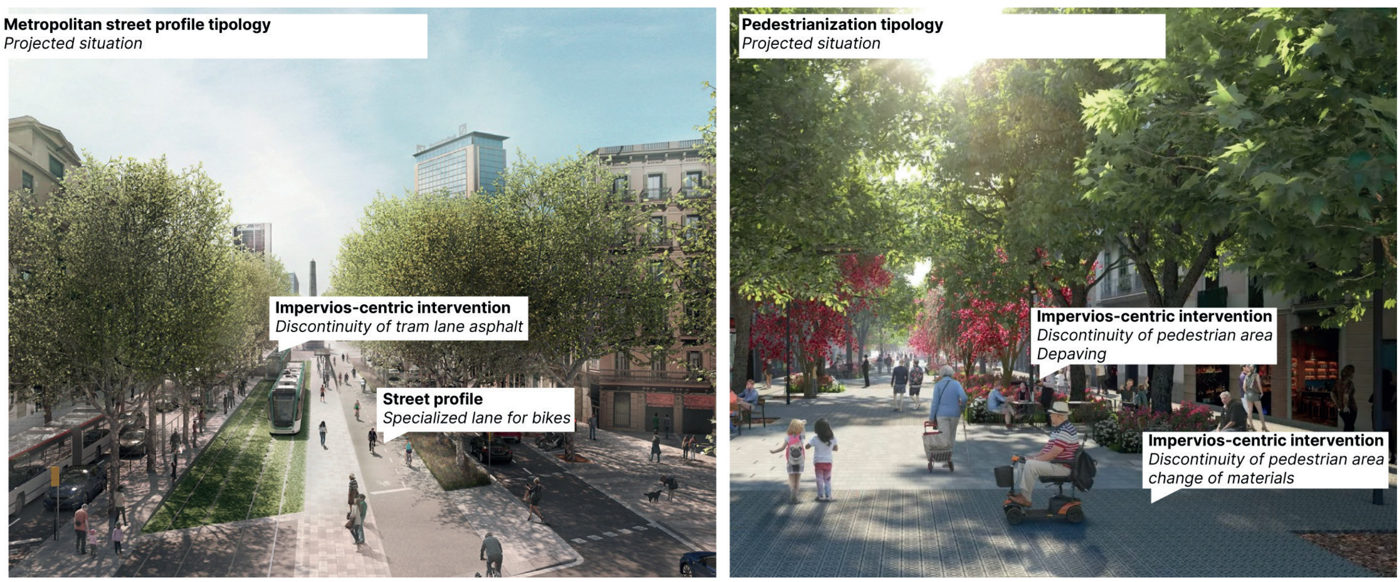


Figure 19. Superblock intervention analysis over Sant Antoni Neighborhood. Source: Done by the author based on Barcelona city council photo gallery, https://www.barcelona.cat/

St. Kjeld's Resilient Neighborhood case

St. Kjeld's Neighborhood is located in Østerbro, after dramatic experiences with intense rainfall and cloudbursts was clearly visible the inability of the sewer system to handle extensive amounts of rainwater as the volume already experienced by the city of Østerbro in last years. The flooding damaged several properties and as expected for climate change consequences the intensity of rainfall is expected to increase.

Therefore, the Technical and Environmental Administration of Copenhagen (2016) established the Klimakvarter. dk as a project where the main aim of their urban model strategy is focused on rainwater management to secure the city against heavy rain with emphasis on leading water away from residential areas to no-damage areas, detent and retain the rainwater from cloudbursts.
The intervention over the neighborhood is done at is strategic street intersection where the hard surface can be narrowed enough to allow the usual residential traffic and offer an area to allow permeable surface and walkable area to be enjoyed by residents.

Figure 20. Intervention of St. Kjeld's Neighborhood in strategic street sections. Source: TREDJE NATUR (2016)

Figure 21. Intervention of Road intersection in St. Kjeld's Square. Source: TREDJE NATUR (2016)

Besides ensuring a safer neighborhood for the residents the objectives are to increase the permeable areas by 20% and manage locally the 30% of rainwater instead of being managed by the sewer system.
The implementation of the urban strategy is planned on two fronts, the first one is an intervention over the street level in road intersections and wide-width streets where the hard surface is sub-rated.

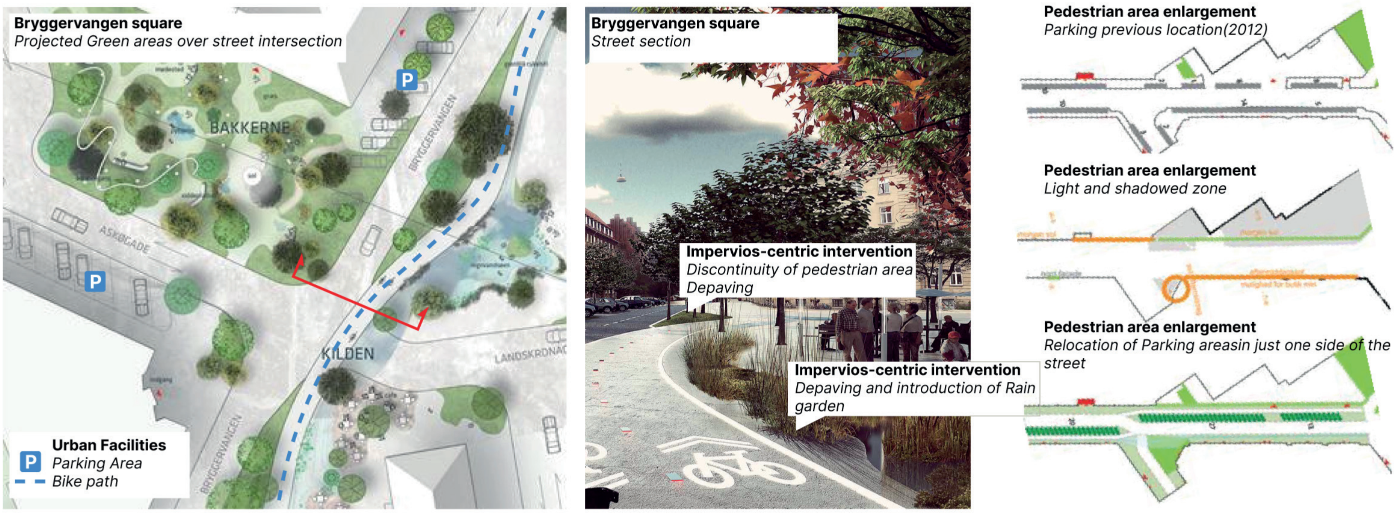


Figure 22. St. Kjeld's analysis over Bryggergen Square. Source: Done by the author based on TREDJE NATUR images

The second way is in the courtyards of Building blocks. This neighborhood has a residential morphology that allows a common courtyard for residents where the hard surface is unnecessary and instead can be used for water storage and as an infiltration area of permeable surfaces, additional the interior surfaces of the residential building are also intervened with passive interventions as green all to reduce energy consumption in summer by cooling down the building's surface.

Strategies: Re-location of parking spaces to allow enlargement of pedestrian paths. Discontinuity of impervious pavement. Implementation of rain gardens as divisor areas from bike paths to pedestrian or communal areas.

Godsbanearealet Sustainable district case

Denmark has been experiencing a rise in extreme rainfall events as cloudburst that overcharge the sewer system. To avoid a collapse of the public sewer system and eventual damages of private and public properties The government of Denmark has stablished The Danish national climate initiative “Klimaspring” (climate leap). This Initiative support and promotes the research and development of solutions for climate change challenges.

The masterplan of Godsbanearealet district is in the City of Aalborg, was designed by The WERK company and have as design core the rainwater management (SuDs). The water is collected and delayed on its way to the sewer system to avoid overcharge of the public sewer system and therefore floodings.

Figure 23. Water way and permeable surfaces. Source: Wichmann + Bendtsen (2016)

Figure 24. Godsbanearealet district Master plan. Source: Wichmann+Bendtsen (2016)

The district was once the Freight train terminal. The district has an industrial past which was the reason some of the rail ways were maintained as part of the project and design principle. (Landezine, 2016)

The Main Features of Green and Blue infrastructures solutions applied over the district are mainly depaving zones to allow infiltration; after the intervention, the permeable areas increased from 7 to almost 15 hectares, of which 12 hectares were intended for urban park this means effective and accessible public space.
Also, some water ways or water channels were implemented to recollect superficial water runoff. Additionally, the lawns and sportive areas are placed strategically at certain levels to create Basins to store and delay water in the case of cloudburst or intense rainfall. (Landezine, 2016)

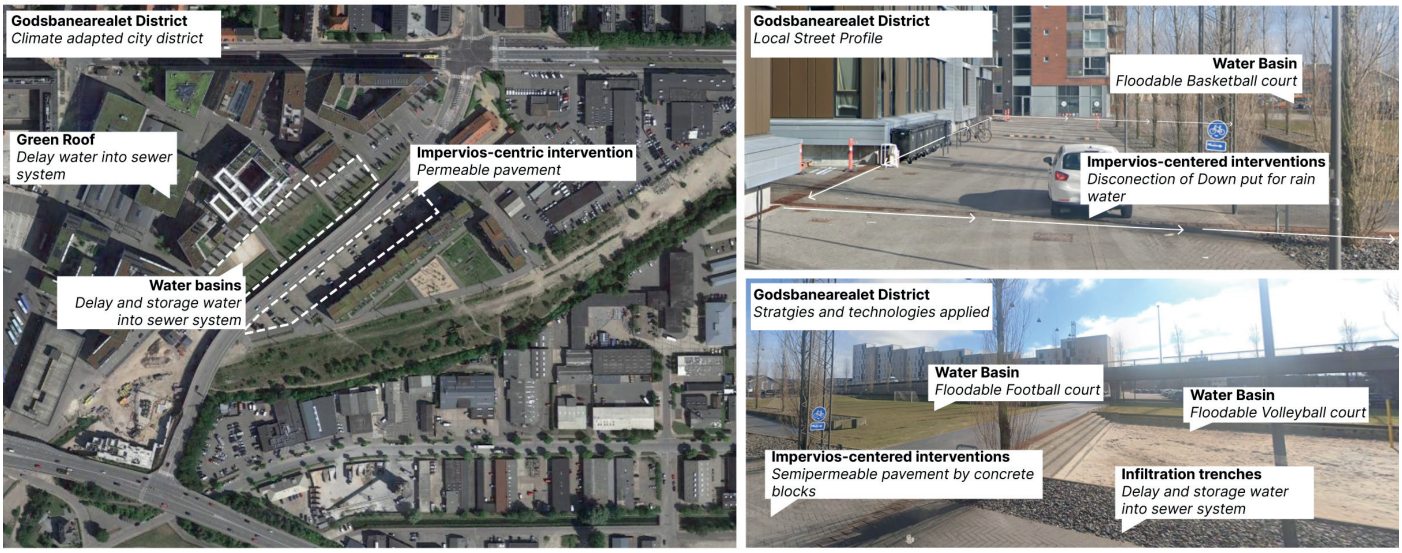


Figure 25. Analysis over Godsbanearealet district. Source: Done by the author based on Wichmann & Bendtsen images

Considering the hydraulic fragility of the city the masterplan also considers the building's roof and endue them with green infrastructure as green roof to delay water into the public sewer system and also leverage process of phytoremediation that occurs same with raingardens features.

The strength of the project is the valuable transformation of an abandoned and unused space into an effective public space which brings social benefits to resident's well-being by creating sportive areas, meeting places and cooler shaded areas. Additionally the intervention will improve the resilience of the city due to the mitigation and adaptation processes through NBS of the district that would affect positively the surroundings and the city infrastructure assessing two main Hazards as floodings and Heat waves, from one side the superficial water management reduce the flooding risk by reducing water volume in the sewer system and in the other hand reduce the UHI impact by reducing the air temperature through the increasing of trees density and green surface.

Strategies: The goal is to manage locally a large volume of water, minimizing rainwater run off through establishing green roofs, and by use of percolation and storage in waterbeds and basins around the site.

Analysis

Contrasting urban case studies holds significant importance in urban analysis. By juxtaposing different cases, the investigation gains valuable insights into the diverse strategies, tools, indicators, and challenges that each case faced. This approach facilitates the identification of effective solutions and best practices. The process fosters a holistic understanding of urban dynamics. The following matrix of comparison compares the three cases based on the previous theoretical background aspects in terms of Risk management, nature-based solutions and dimensions implemented, and Ecosystemic services provided.

	Nature Based solutions *Implemented solutions*	**Techniques - Strategies** *Implemented*	**Materials** *Implemented on Main features*	**Positive Results** **Negative Results**
Barcelona Super blocks *Enalargement of public space*	Green furniture	**Urban Intervention.** Enlargment of public space and reduction of private movilization	**Pedestrian area:** No Material modification. Use of former asphalted lanes and urban furniture	+ Reduction of private mobility + Reduction on local emmisions - No inplementation of passive cooling strategies cooling strategies (No depaving)
St. Kjeld's, Copenhagen *Resilient Neighborhood*	Depaving Rain Garden Water Basin	**Suburban Intervention.** Channels and rain gardens to manage water flow into port	**Water channels:** Continuos pavemet unobstructed **Pedestrian area:** Semi-permeable pavement and permeable green soil	+ Improvement of drainage system + Urban embellishment + Improvement of soil infiltration + Reduction of land surface temperature + Reductin of floodigns
Godsbanearealet, Denmark *Climate adapted city district*	Green Roof Water Basins Infiltration trenches Semi-Permeable paving Disconection of Downput	**Urban Intervention.** Reduction of Runoff Increasing infiltration Terrain intervention to allow Basins and water storage	**Road:** Interlocked blocks **Parking:** Permeable pavement **Park:** Permeable green soil	+ Reduction of Run-off + Temporary water storage + Strategies and sportive green area

Figure 26. *Matrix of comparison.*

Certainly, a check over climate-conscious public space interventions is fundamental to verify the diverse attributes and strategies implemented in other urban models around the European context and validate the feasibility in the local context of Turin with their particular environmental and morphological characteristics.

These cases can be useful to adopt similar strategies in Turin, fostering a more sustainable future for urban areas. Considering that the climate conditions in Turin as in the other case studies requires singular strategies.

Conclusions

01

The first case analyzed of the Barcelona Super blocks is an urban and transport planning strategy that aims the enlarge public space, enforce public transport, and reduce private transport. This model applies green furniture and depaving as NBS, the most recent interventions implement semi-permeable pavement. This urban model has a positive result the reduction of private mobility, the reduction of local emissions, the enforcement of soft and public mobility, and the enforcement of the public spaces as Neighbourly and inclusive spaces for residents.

02

The case of St.Kjelds is an urban model strategy focused on the reduction of flooding risk by improving rainwater management. This model applies rain gardens, water channels, and depaving as NBS, the implemented materials are discontinuous pavement for pedestrian paths, permeable green areas for rain gardens and surroundings, and continuous pavement for water basins. As positive results, the Neighborhood of St. Kjeld's has reduced the water volume on the sewerage system improving its functioning and reducing the risk of flooding, reducing the permeable surface, and enlarging the public space.

03

The third case of this case study analysis is the Godsbanearealet master plan that aims at the reduction of runoff to reduce the water volume in the sewerage system. This masterplan applies several NBS to increase infiltration and allow water storage as green roofs, water basins, Infiltration trenches, and semipermeable paving. The implemented materials are discontinuous paving as interlocked blocks, permeable pavement for the parking areas, and permeable green surfaces in all the park areas. The positive result of this intervention is the reduction of runoff, the temporary water storage of the terrain features, and the enforcement of public space with the improvement of recreational areas.

The first two cases are urban models that apply general strategies to intervene in an urban area, anticipating a future development of the model into surrounding areas while achieving their initial objectives and thresholds.
On the other hand, the third case is a district master plan that applies strategies considering the specific characteristics of the site intervention. This case does not consider a replicable action of their applied strategies in the surrounding districts.
This means that the two first cases are urban models that can be replicable in different and diverse urban contexts with a "portfolio" of general strategies, resulting in an extensive method to reach the initial objectives, even if their scale of intervention differs. The first one has as target a city scale and the second one has as target the neighborhood scale being their interventions and strategies more specific and more technic.

2.1 TURIN AS EXPERIMENTATIVE GROUND

THE ROLE OF PUBLIC SPACE IN TURIN

a) Urban transformation

The role of green infrastructure historically in Turin had barely an aesthetic value since the beginning of the 19th century when the city started expanding after the falling of the perimetral walls. Once the walls didn't impede anymore the urban expansion of Turin into the surroundings. A system of tree-lined avenues was created over the old trace of the now-gone city walls which had the scope of embellishment and recreation for citizens (Comune Turin, 2020).
The public gardens appeared for the first time in the second half of the 19th century as the Parco del Valentino, which had an enlargement at the end of the same century and some other interventions for embellishment. At the beginning of the 20th century, the first hilly parks were established in half century several parks and green areas were established next to the river sides as Parco Colletta in the 80s.

Was just at the end of the 20th century with the creation of the UNEP* and the first meeting of the IPCC** when the environmental debate started to gain a voice in the world as well as in the administration of Turin. The debate on the redevelopment of the riverbanks of Turin's rivers was given in the 70s at the same time the green infrastructure and its benefits started to gain importance and another debate started about the redevelopment of marginal and degradation areas by implementing an organic and green public space which would connect the several urban parks. The first suggestions were established in the City Master plan of 1980 as "Rapporto preliminare di Studi sul Sistema del verde"

Turin has dealt with severe episodes of flooding and heatwaves. Historically In 1994, 2000, and 2016, the city suffered considerable damage due to the flooding of rivers that cross it, and, in 2003, it recorded the first emergency linked to heat waves - a phenomenon that has been increasing in recent years - with a sharp rise in the city's mortality rate. (Turin 2030 – Sustainable and Resilient, 2019) Just in 2022 were registered 3 heatwaves between May and June which were the second highest in temperature registered after 2003.

* *The United Nations Environmental program was created in 1972*

** *The International Panel for climate change had their first meeting on 1988*

Current environmental conditions

Green areas
Regarding the Heat Island risk in Turin the ARPA* Piemonte climate assessment study shows that the high-risk areas which represents the 2% of the city are concentrated on two large groups of industrial buildings located at north and south of the city (the IVECO complex and the Fiat complex) and the 44% of the city is located in medium risk area; Just the 27% of the city is consider a low-risk area.

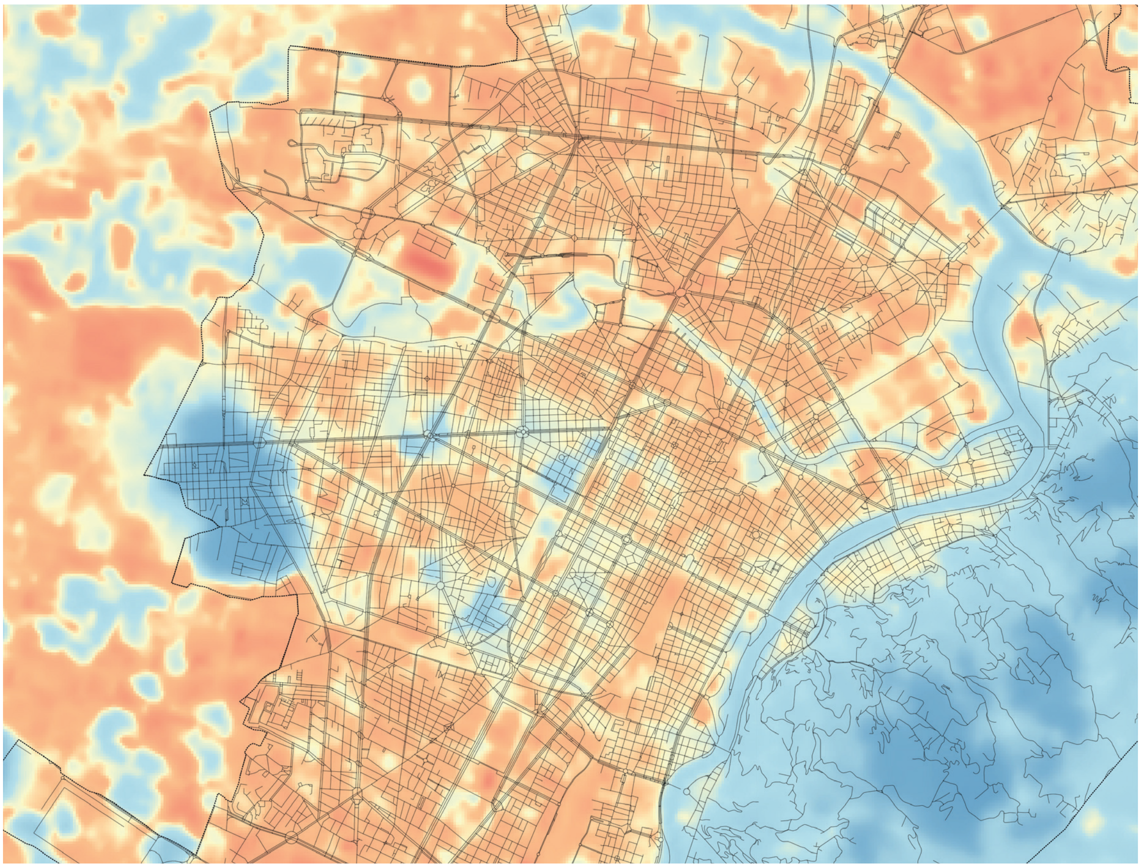


Figure 27. *Distribution of heat island risk classes Cartohraphy base: geoportale.comune.torino.it*

Furthermore, the same assessment study shows the high influence of Industrial buildings areas into the neighboring areas, in a ratio of 50 to 100 meters there's a rising of 1°C to 3°C higher than the city's average temperature. (ARPA Piemonte, 2020)
The green heritage of public management in Turin is calculated around 18.200.000 sqm this means there's 20 sqm per person, even though just the 60% of this public green is open to recreative uses. Despite this, by 2020 Turin was the first city in the ranking of Italian cities with more green square meters (sqm) per capita.

* *Regional Agency for Environmental Protection (Agenzia Regionale per la Protezione Ambientale)*

Even with the enough amount of green sqm percapita according to the WHO Turin continues to suffer great heat waves due to the global climate change. May of 2022 was recorded as the hottest one in the last 60 years.
The number of deaths observed between 9 and 30 May 2022 among residents of Turin who died in the regional capital is equal to 541 (ARPA, 2022)

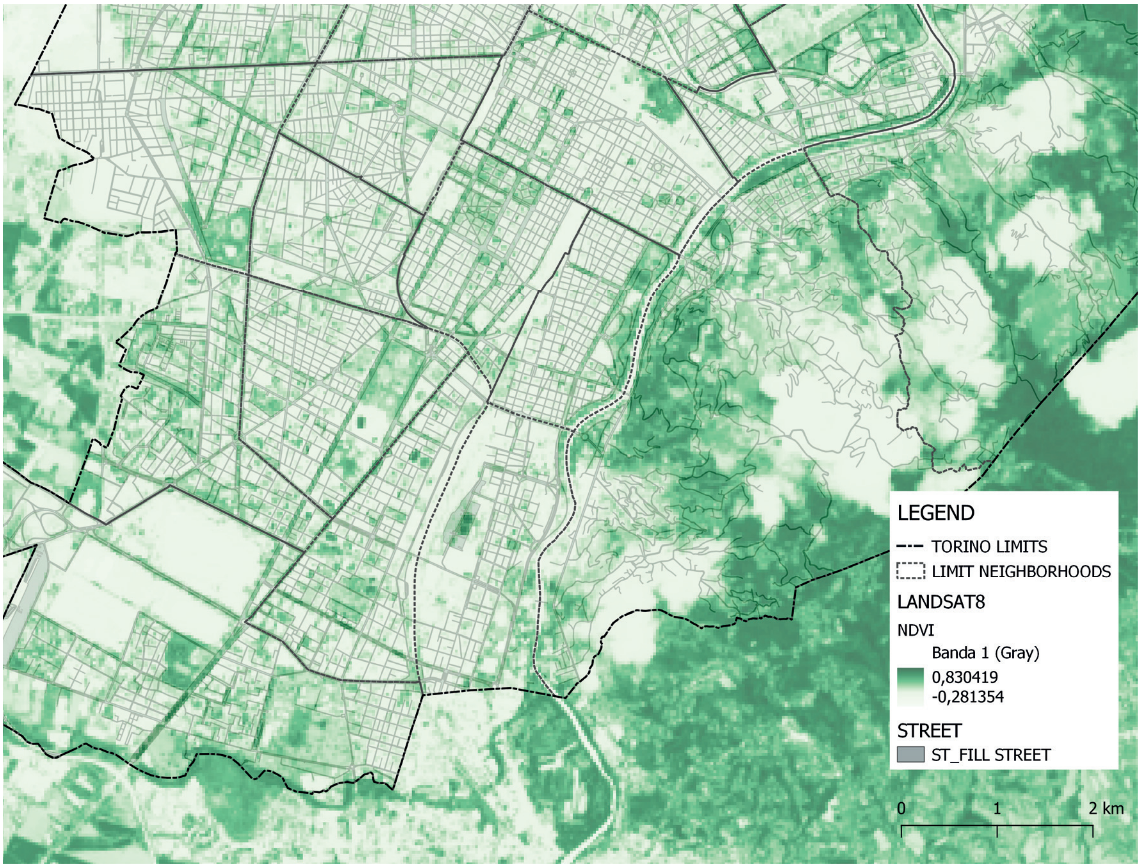


Figure 28. *NDVI Quantification of green vegetation. Cartohraphy base: Landslat satellital images*

It is, therefore, essential to increase green infrastructure to promote the physical and social well-being of the population and to maximize effective ecosystem services to counter the effects of climate change. (Turin 2030 – Sustainable and Resilient, 2019)

Satellite data visualization

With the EO Browser was possible compare through satellite images, set with an specific time range *the current and latest condition of Turin Metropolitan area. Such as the normalized difference moisture Index (NDMI) ** that helps to determine vegetation water content and monitor droughts. In this specific case is useful to understand the behavior of pervious surfaces in an urban area, this area stress the urban microclimate, and in the other side the blue areas are the ones with a normal moisture index making this areas cooler.

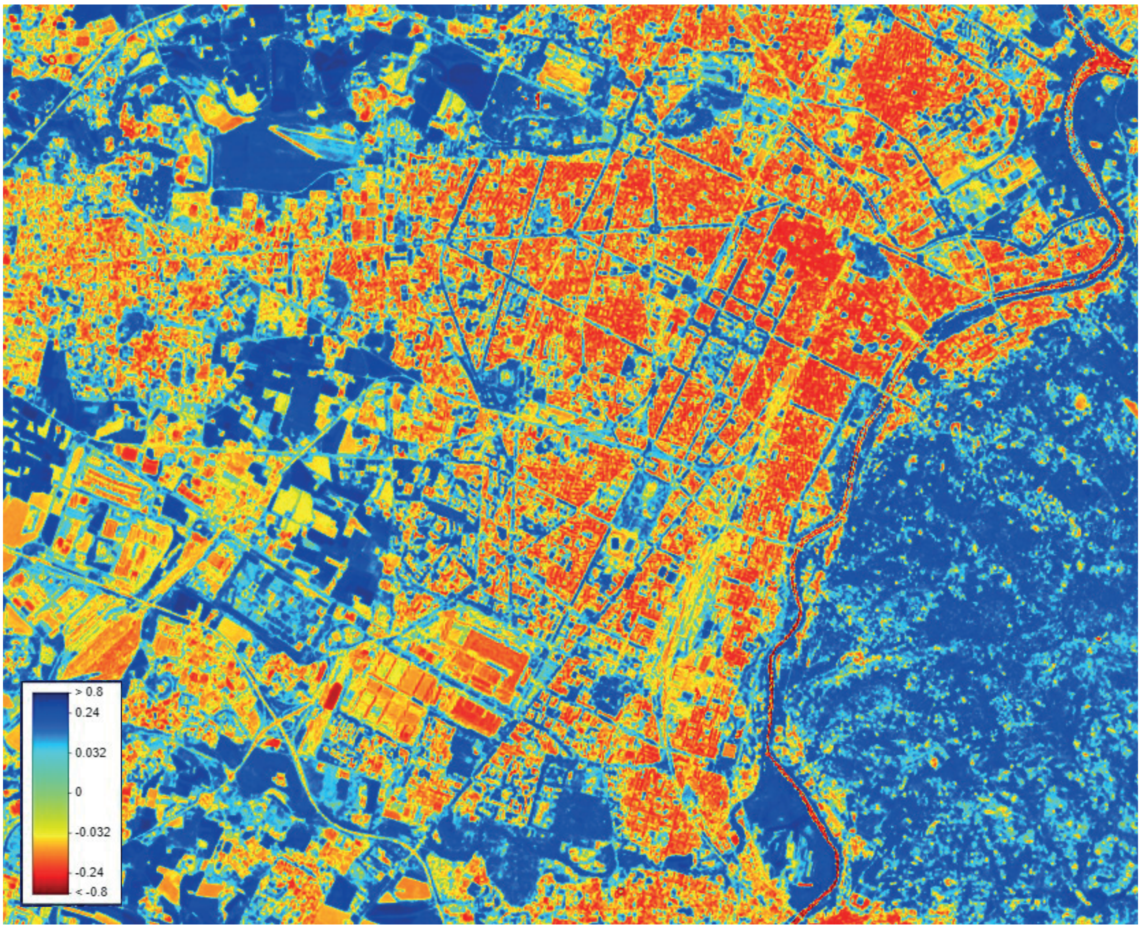


Figure 29. Normalized Difference Moisture Index.

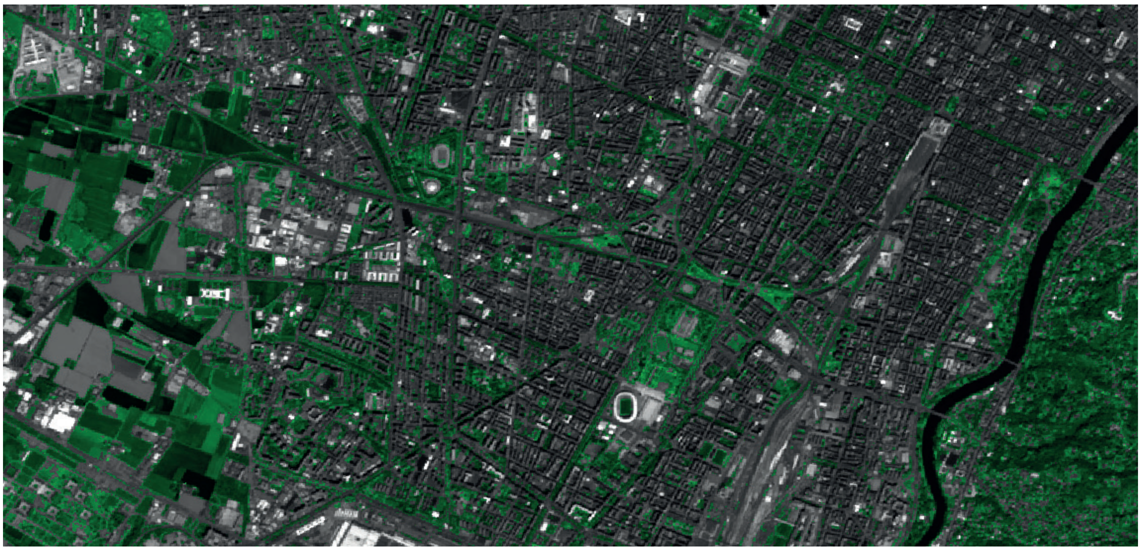
NDMI shows the vegetation water content and monitor droughts

-Negative values correspond to barren soil.
-Values around zero correspond to water stress.
-Positive values represent high canopy without water stress

* *The Time range for all satellite images where set on 19th April with a cloud coverage of 0.4%*

** *The value range of the NDMI is -1 to 1. Negative values of NDMI correspond to barren soil. Values around zero correspond to water stress. High, positive values represent high canopy without water stress.*

The Green city script ***visualization separates built up areas from vegetated ones and allow to compare the build area in the urban context, built up areas are displayed in grey - white and vegetation is displayed in green, so is more understandable that not every green area behaves in the same way in the urban microclimate because the moisture index shows the real water content in this green areas that of course in the suburban area is higher than in some central urban areas.



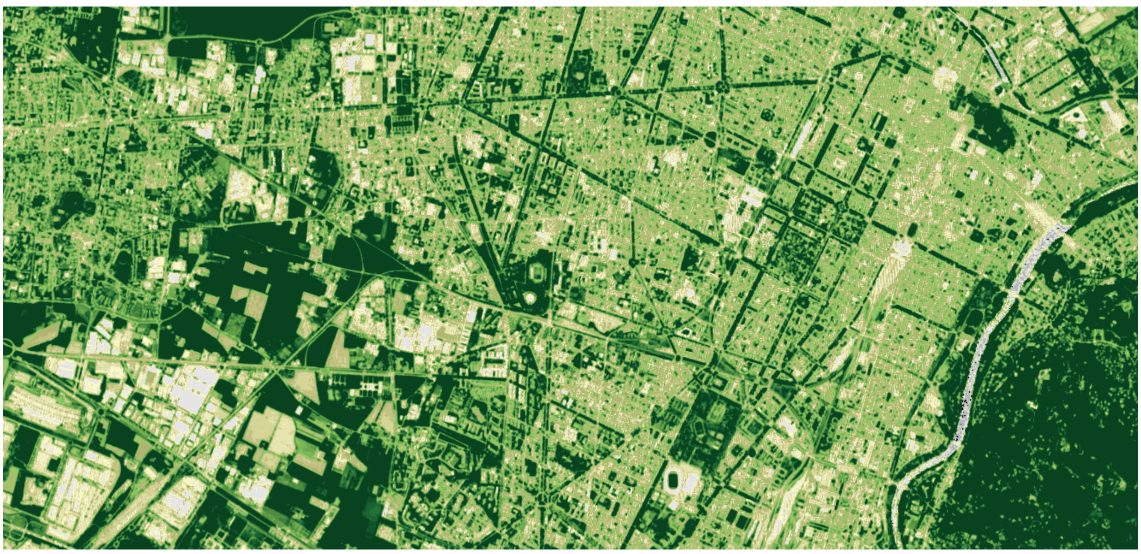


Figure 30. FIrst image Green city script. Second image : The normalized difference vegetation index (NDVI) Source: EO Browser (Retrieved2023)

The normalized difference vegetation index (NDVI) is an effective index that measure the state of vegetation health based on how plants reflect light at certain wavelengths this is useful because healthier is the vegetation present in the green areas better performance would have this area to mitigate the heatwaves.

**** The script considers the Normalized Difference Vegetation Index (NDVI) and true color wavelengths.*

Risk associated.

The temperatures recorded in Turin from 1951 to the present day show a significant upward trend in both maximum and average values, while the minimum temperatures are almost stable or slightly decreasing. (Turin 2030 – Sustainable and Resilient, 2019).
In the last 60 years have been an increase of 2,2°C in average temperatures. An increase of 0,6°C to 0,8°C every 10 years on maximum temperatures this means an addition of 14 days with temperatures above 32°C every 10 years.

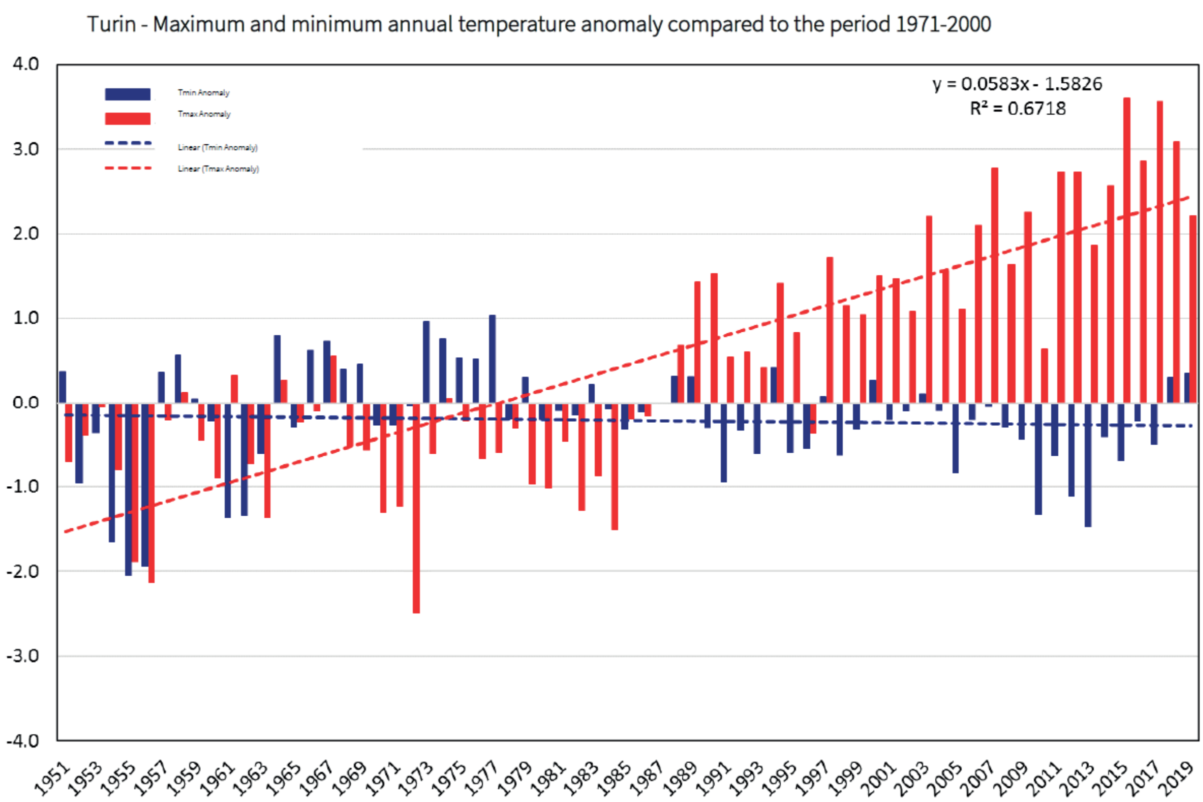


Figure 31. *Maximum (red) and minimum (blue) annual temperature anomaly in Turin from 1951 to 2019. compared to the reference period 1971-2000. Source: Climate vulnerability analysis - ARPA Piemonte*

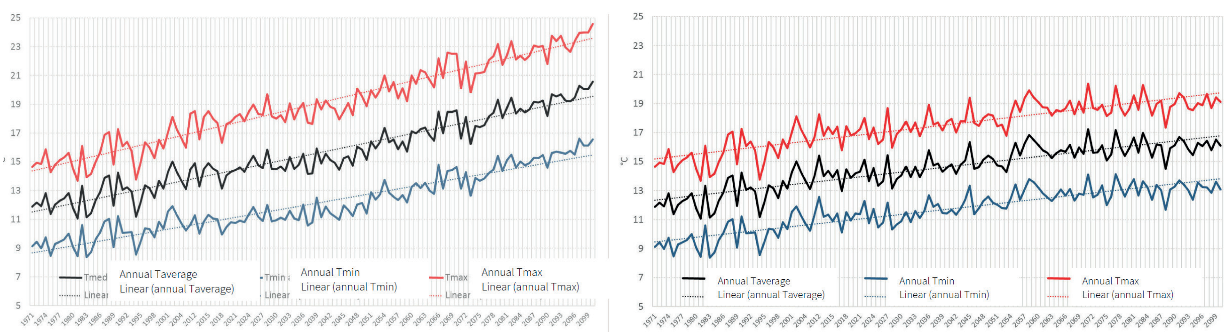


Figure 32. *Trend of average, maximum, and minimum annual temperatures, and respective trend lines for the RCP senario 4.5 (left) and 8.5. (right) Source: Climate vulnerability analysis - ARPA Piemonte. (2019)*

Rain Intensity
Regarding the precipitation in Turin, since 2000, the less rainy years seem to predominate the number of rainy days (> 1 mm) shows a slight downward trend even though that considering the last 30 years there is an increase in average annual rainfall and a slight decrease in the number of rainy days, this means there's an increase in rainfall intensity compared to the thirty years previous to those analyzed (ARPA Piemonte ,2020)

Furthermore, the number of rainy days and the average annual rainfall in the future scenarios shows a downward trend throughout the century.

Hydrological Condition
Turin is in the node of a Complex hydrological system as it is crossed by 4 important waterways: the Po, Dora Riparia, Stura, and Sangone. This makes the city a vulnerable area to flood risk, about 35 km2 of Turin is affected by this risk.

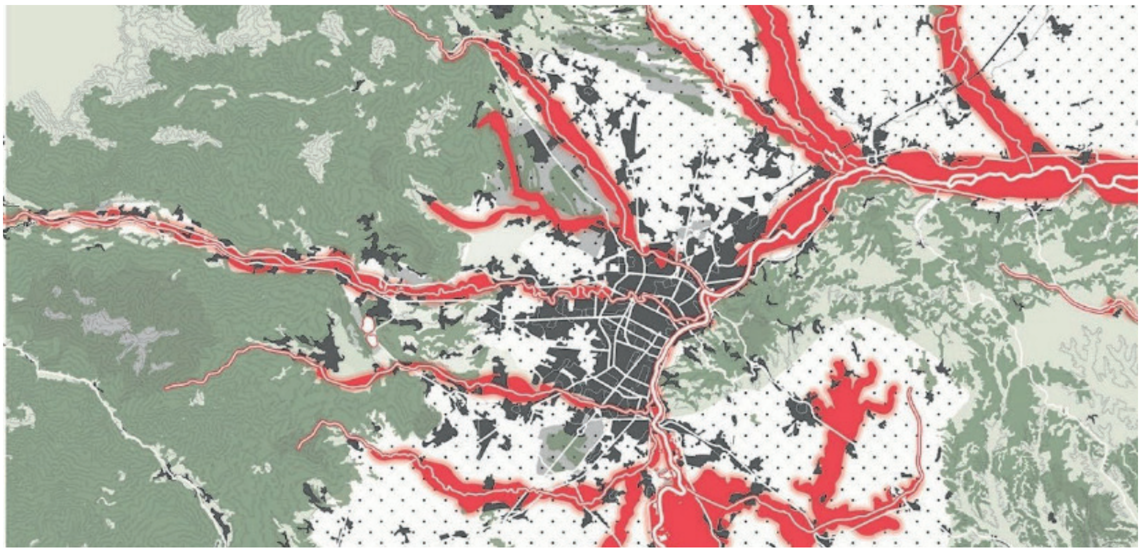


Figure 33. Turin in the surrounding hydrological context. Turin - Towards the metropolitan regional strategy Source: G. Pasqui - Politecnico di Milano and C. Calvaresi – IRS: Institute for Social Research (2019)

According to the RCP 4,5 scenario to 2100 with reduced CO_2 emissions the annual temperature shows an overall increase of 3°C plus an increase frequency on extreme temperatures. In the other hand According the RCP 8,5 scenario to 2100 the annual temperature will have an increase of 6,7°C.

b) Turin’s plan for urban development

Technical and regulatory instruments

Technical and regulatory instruments play an important role in the effective planning and management of territories. These tools serve as the backbone of sustainable development, ensuring that urban areas are organized and implemented in a manner that promotes social inclusion, economic growth, and environmental conservation.

The importance of getting to know the pillars of Technical and regulatory instruments such as the Urban regulatory plan lies in their role of establishing the legal framework necessary to guide the development of the city, ensuring alignment with broader societal goals. These instruments create a synergy, bridging the gap between vision and implementation in urban planning. By promoting order, efficiency, and environmental consciousness.

In the case of Turin, the municipality has set a couple of guidelines in which the urban development and Mitigation strategies attempt to meet certain objectives and thresholds.

The “Turin 2030 – Sustainable and Resilient” action plan. Is a document sustained in environmental pillars such as Climate Resilience, Green infrastructure and NBS, Renewed Public Transport system, and circular economy Department for Environmental Policies - Comune Turin, 2019).

Because of the heavily urbanized urban environment of Turin, the administration has followed a Climate Change Adaptation

Plan* and Not an Adaptation strategy.

Climate resilience	Green Infrastructure	Climate resilience	Circular economy
Mitigation and Adaptation.	*Nature Based Solutions*	*Renewed public transport system, electric and shared*	*Reduction in food waste and others, salvaging materials and recycling.*

Figure 34. *Pillars of Turin’s Climate Change Adaptation Plan. Source: Department for Environmental Policies - Comune Turin (2019)*

* *CCAP: This plan has the goal of defining specific measures and actions to be implemented in order to reduce the vulnerability of its region and its citizens.*

The objectives and strategies introduced in the Climate Change Adaptation Plan that concerns to public space are the following:

• Reduce the occurrence of critical phenomenon (e.g., heat islands, one-off flooding)
• Adapting the urban environment and services to reduce exposure and manage possible emergencies.
• Managing the evolution of urban ecosystems and urban transformation.
• Developing a culture of climate risk in the design of public works (sizing and innovation)
(Department for Environmental Policies - Comune Turin, 2019)

The city is adopting adaptation policies such as **the conversion of Industrial areas into green and permeable areas, strengthen the ecosystem services and maximize their performance**, additionally enhance the green heritage. The green heritage is a topic concerning the adaptation plan in which the main aim is maximize their performance **by increase the total quantity and quality of green areas** in the city with the aid of developing additional green infrastructure in areas with greater climate vulnerability.
(Department for Environmental Policies - Comune Turin, 2019)

A total of 40 actions were identified in the adaptation plan to combat climate change. The following actions are the ones directly related with the public space:

Greenery that shades

Increase number of trees, especially in areas that are more vulnerable in terms of heat island, using resistant tree species able to overcome summer heat stress conditions.

Greenery as a climate refuge

Enhance and optimize greenery functionality, including the hillside area, interventions will be carried out to increase its usability, providing rest areas, checking access routes, and increasing services.

Long term green and land solution

Rainwater drainage areas applicable to urban surfaces (streets, squares, sidewalks, and equipment), as well as rain gardens for to reduce the risk of one-off flooding due to the inadequacy of the infrastructure

Hydraulic invariance principle

Increasing permeability of the land, through de-sealing interventions, or the use of draining materials in areas undergoing transformation or maintenance interventions, and collecting rainwater for subsequent reuse

Protected waterways

preventive structural interventions, such as bank defenses, embankments, raising of banks, aimed at reducing the risk of overflowing.

c) Development of the road profile

Overview to the historical background

Reviewing the urban historical background is crucial for comprehending the intricacies of a Turin's current infrastructure system. The evolution of a city's infrastructure is a testament to its growth, challenges, and the evolution of its road profile over time. By delving into the past, is possible to unravel the innovations, and adaptations that have shaped the city's present urban landscape.

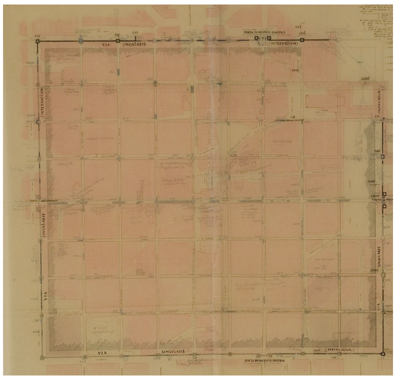
Taking as reference the various sources compiled and organized by the Museo Torino* in their magazine and permanent exhibition "Storia di una citta" the following historical review would present the turn of events in the urban sphere along the history and more likely in the street opting for typological street profiles.
The evolution of the road profile in Turin can be examine in five periods in which the urban morphology had great developments due to external and political conditions that would be presented in the following paragraphs.

Corso Re Umberto, Torino (2023)

** Museo Torino is a project for the protection of urban heritage and active citizenship.*

The ancient and medieval city

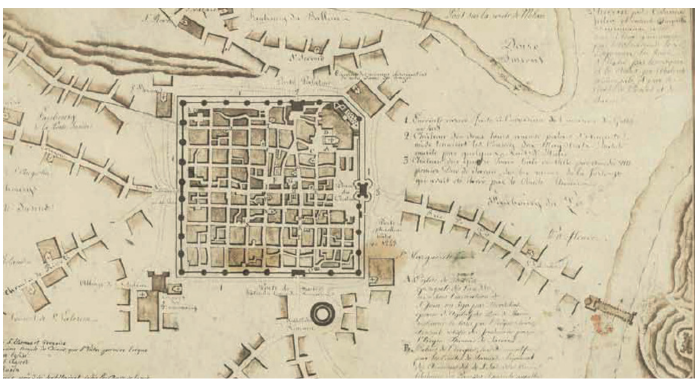
Ancient: can be considered from 25 b.c to 398 a.c After the settlement of the Taurini at the confluence between the Po and the Dora, the "pacification of the Alps" by the Romans led to the foundation of the Augusta Taurinorum colony, a strategic garrison for the control of the passes. From the Porta Palatina to the road network, the structure and morphology of the city are designed by the Urbe.
The Augusta Taurinorum occupied a rectangular space of about 700 x 750m with the north-east corner cut diagonally. The streets were paved with large stones and were around 16 mts – 17 mts runs inside along the entire circuit wall. (Martini, A. & Pirulli, N. 2011)
In the last decades of the 1st century AD. an important urban restructuring is started which sees the construction of an articulated sewage system and, probably, of the aqueduct; the streets are paved with large stones, equipped with sidewalks and public roads between 16 mts – 17 mts wide runs inside along the entire circuit wall. (Martini, A. & Pirulli, N. 2011)



Augusta Taurinorum colony, as a strategic garrison for the control of the passes.
The orthogonality is characteristic of the road network, which still reflects the Roman structure

Figure 35. *Plan of the Roman city, 1900 c.a Source: Andrade, A. (1889)*

Medieval: is characterized by the establishment of the Savoy. Turin stands as a transit node and place of obligatory stop between Italy and Western Europe. The Duke Charles II start the construction of four bastions built at the corners of the city walls.

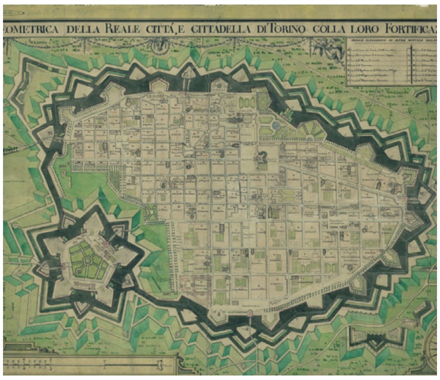


Turin stands as a transit node and place of obligatory stop between Italy and Western Europe. Savoys are stablished in Torino.

Figure 36. *Conjectural reconstruction Turin at the beginning of the 15th century. Source: Martini, A. & Pirulli, N. (2011).*

The modern city

considered from 1580 to 1680, In this period the city of Turin doubles in size and triples the number of its inhabitants.
The image of Turin become substantially redesigned until becoming a continuity ruled icon, set on an orthogonal grid and on the uniform regularity of the street facades.
The urban policy by Emanuele Filiberto stands for fortify and control the existing city; Carlo Emanuele leads the project of the “new city”, which incorporates and envelops the old Roman and medieval city within an almond-shaped wall circuit, almost tripling its size.
The valorization of the urban locations was followed by investment in residences outside the city for the creation of the “corona di delitie”, a ring symbolically traced around the city by the court residences.



→ The valorization of the urban locations was followed by investment in residences outside the city for the creation of the **«corona di delitie»,** a ring symbolically traced around the city by the court residences intended for the celebration of the hunting ritual.

1615. The capital and the territory of the Prince.

1682. Territorial system defined as “Crown of delitie”

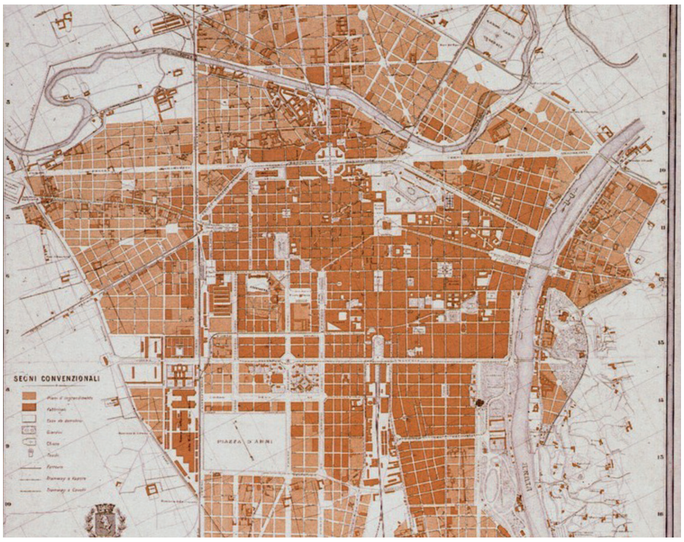
Figure 37. *Pianta geometrica della reale città, e cittadella di Torino colla loro fortificazione. Source: Ignazio Amedeo Galletti, (1790)*

The contemporary city

Can be examine between the 1800s and 1900s due to the high amount of changes presented in each those periods of time. Initialliy the years 1839 and 1881 can be checked previous to the world wars, period in which the city have great changes and adopt new urban and economic solutions. (Martini, A. & Pirulli, N. 2011)
Through the beginning of the 1800 the bastions were dismantled (1802), and squares were connected by new tree-lined promenades.
A new urban cadastre was applied, which divided the city into four districts and assigned names and to the streets and squares; by the end of the first decade (1814) Turin, once again was the capital and maintains the French urban structure.

The second half of the 1800s is characterized by the urban renovation and the large industrial center Turin was becoming. The morphology of Turin changes with the enlargement plan (1852) and demolition of the Citadel plus the the approval of the Novara railway yard. The Cinta Daziaria was established of 11 kilometers long (1853) and the “portico” became the new architectural element that characterized the public and pedestrian space. (Martini, A. & Pirulli, N. 2011)

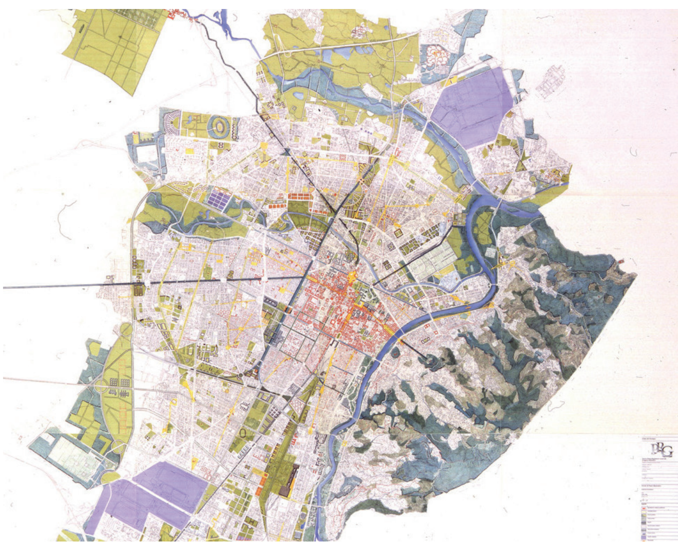
Turin became the capital of the Kingdom of Italy until 1865. By the end of the century Turin start to become a large industrial center and workers' neighborhood arise outside the Cinta Daziaria: Industries and workers' neighborhood are concentrated in San Paolo and beyond zona Dora. The first Fiat factory opens up in Corso Dante in 1899.



1802: The bastions were dismantled, and squares were connected by new tree-lined promenades.
1852: The morphology changes with the enlargement plan and demolition of the Citadel plus the the approval of the Novara railway yard.

Figure 38. *Summary plan with the indication of the previous master plans and the parade ground further transferred to the Crocetta area. Source: Municipal technical office (1886)*

The beginning of the 1900s brought a new masterplan approved by the city in 1908 and between the wars the The Fiat Lingotto and Mirafiori factories were built (1922) and the city grows by large "blocks": industry, planned social housing districts and collective services.
After the second war a new master plan was approved in 1959 and the crisis of the consolidated industrial model manifested leading to a reconversion of productive, urban and architectural paradigms as well as social and cultural plus the great increase of inhabitants exceeding by 1,100,000 inhabitants in 1971. (Martini, A. & Pirulli, N. 2011)
By the last decades of the 1900s the Fiat closes Lingotto, the productive and morphological structure of Turin and the metropolitan area is rethinked (1982) and the general master was approved (1995), focused on public transport, the recovery of the former industrial areas (Lingotto, Spine) and the historical plot.



The general master was approved (1995), focused on public transport, the recovery of the former industrial areas (Lingotto, Spine) and the historical plot.

Figure 39. *General municipal master plan of Turin. Source: Gregotti Associati (1995)*

Analysis and conclusion

Certainly, the urbanism in Turin has marked peculiarities to consider regarding the mobility infrastructure throughout time and could be said based on the current masterplan approved by the city, these peculiarities derive from five events of its urban history:

1. The coincidence of the "modern" city with the traces of the Roman colony in a checkerboard pattern up until the end of the 16th century.
2. The extensions for public projects, coordinated with the fortifications, in the 17th and 18th centuries.
3. The formations of a large-scale territorial system - the most conspicuous in Italy - formed by the royal settlements in the countryside and by the avenues that connect them to the capital as the main axes of the mobility development in the coming years.
4. The removal of the fortified perimeter, which has not been transformed into a circle of avenues, but has been practically canceled, to allow for the direct extension of the internal road mesh in the surrounding periphery.
5. the industrial boom that characterized one time Turin and the change of paradigm in the last decades of the 20th century and the latest interventions from the city to recover the former industrial areas. (Assesorato all'assetto urbano, 1993).

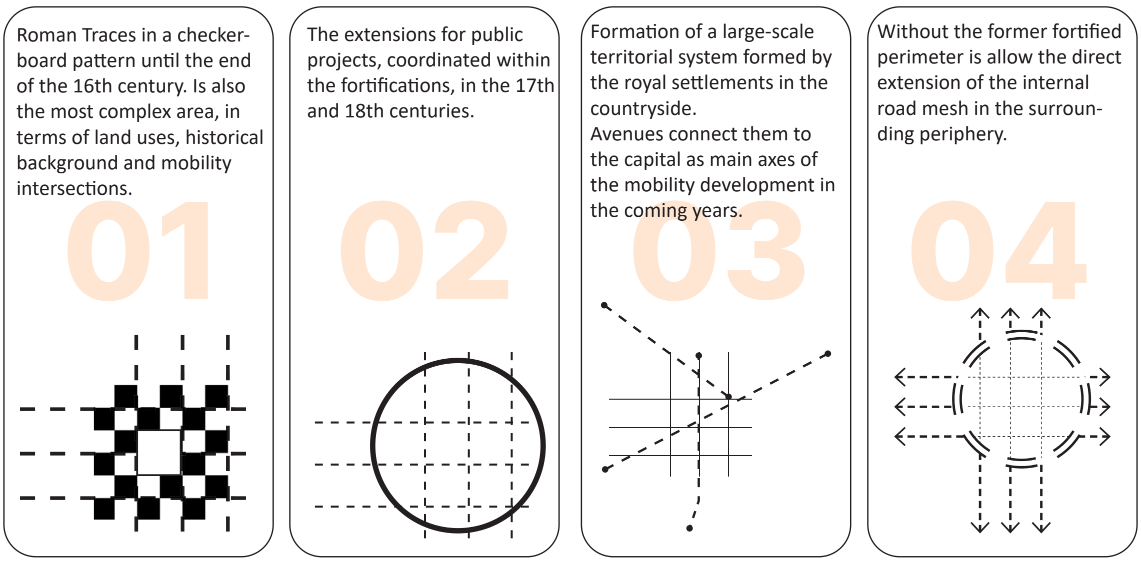


Figure 40. *Schematic diagrams. Source: Done by the author based on the General master plan Assesorato all'assetto urbano. (1993).*

Historical analysis not only reveals the origins of key infrastructure elements in the road profile **like vehicular configuration, environmental qualities, and public transportation systems** but also **sheds light on the social, economic, and cultural forces that influenced their development.**

This insight is invaluable, as it provides a deeper appreciation for the city's identity and provides the knowledge needed to make informed decisions about the urban intervention approaches for a possible proposal over the street corridors and also about its future sustainable development.

d) Urban mobility plan

Street hierarchy and categories

Comprehending the Urban Traffic Plan is important for effective public interventions over streets, and is essential for achieving urban sustainability.
In increasingly congested cities, understanding the parameters of the traffic flow, public transportation systems, and pedestrian pathways is essential. Such understanding allows us to make informed analyses and decisions about street design, ensuring they are efficient in terms of mobility and also environmentally effective in reducing climate vulnerability.

According to The Street Code* every municipality with a given number of residents should adopt the Urban Traffic Plan** . This plan aims to improve the effectiveness and efficiency of the transport system, increase safety, reduction of environmental impacts, improvement of the livability of the urban area. (Istituto Poligrafico e Zecca dello Stato, 1992). Concerns mainly about the technical definition, functional design, and verification of environmental compatibility.

The interventions considered over the street level should consider the PUT as the main regulatory paper and these interventions must be conceived and designed in the logic of the entire mobility system; taking into consideration the different moments of movement (circulation and parking), the different modes of transport (pedestrians, vehicles, collective, alternative) and for the different components of mobility (internal, exchange and crossing for various reasons). (Istituto Poligrafico e Zecca dello Stato, 1992)

The Urban Mobility Plans*** are established in the art. 22 with the scope of satisfying the needs of the population in terms of mobility, ensuring the reduction of air and noise pollution levels. Additionally, the reduction of energy consumption, the increase in safety levels of transport and road circulation, the reduction of private cars, and moderation of traffic.
(Divisione infrastrutture e mobilità - settore mobilità, 2008)

** Il Codice della Strada - Legislative Decree no. 285/92 – art. 36*
*** Piano Urbano del Traffico (PUT)*
**** Piani urbani della mobilità (PUM)*

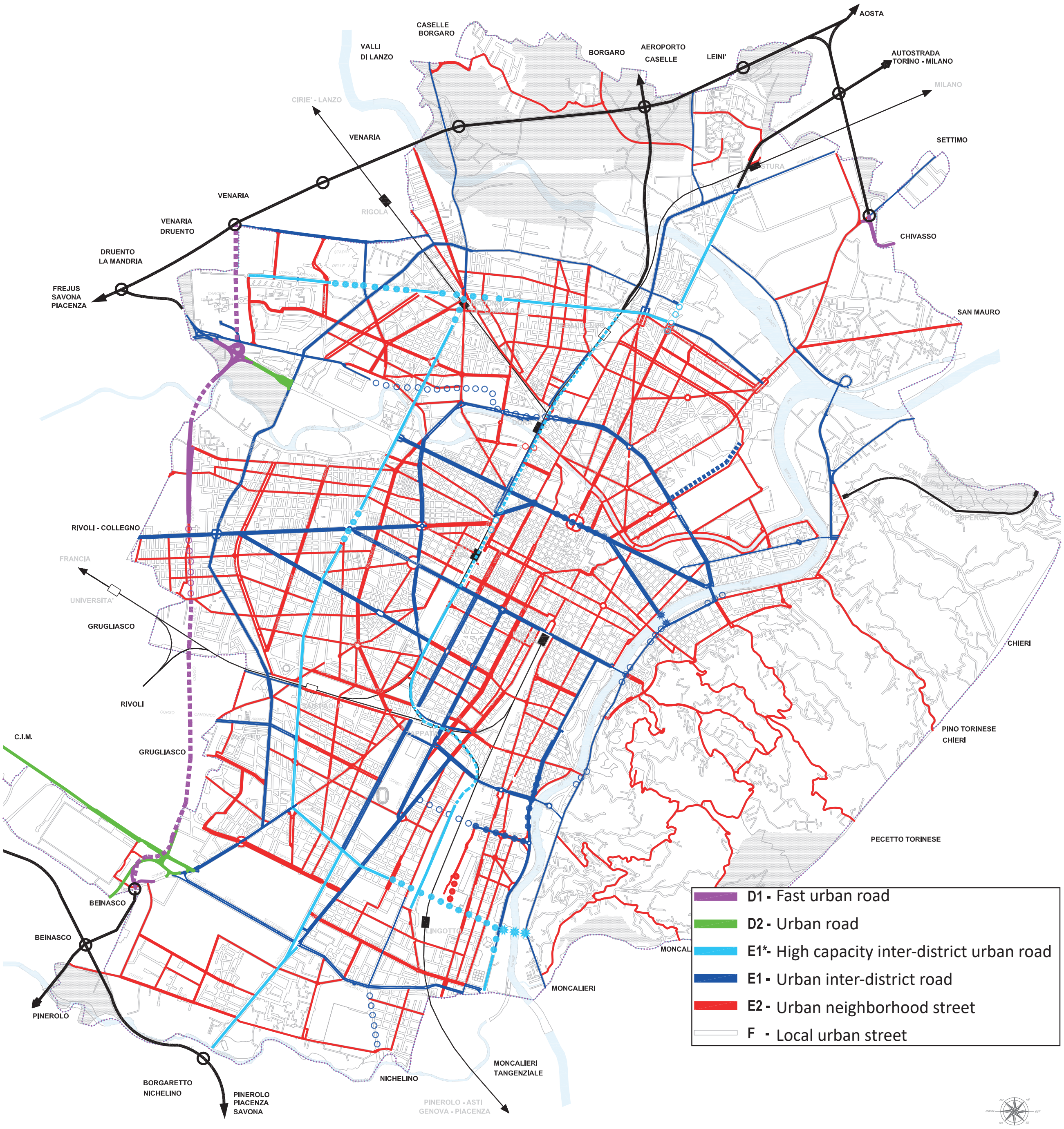


Figure 41. Street Hierarchy. Source: PUMS Infrastrutture e Mobilità. Source: Citta di Turin (2010)

According to the General master plan of Turin The suburban and urban roads are classified, with respect to their own constructional, technical, and functional characteristics (Assesorato all'assetto urbano, 1993), in the following categories:

A – Urban Highway.

B – Main suburban roads.

C – Secondary extra-urban roads.

D – Urban road.

E – Neighborhood urban road.

F – Local urban road.

The street categories relevant in this analysis aimig for the implementation of NBS are the following three: D, E, F. Their description, and functionalities are the following:

D Category Urban Road:
Road with independent carriageways or separated by traffic dividers, each with at least two car lanes and a possible lane reserved for public transport, platform paved to the right and sidewalks, with any intersections at grade traffic lights; for parking, special areas or side strips outside the car lane are provided.
(Assesorato all'assetto urbano, 1993)

Figure 42. Illustrative aerial images for the different street categories presented. a) Str. Del portone b) Corso Trappani. c) Corso Racconigi. d) Via Arvier and Via Sagra S. Michele Source: Taken from Bing maps

E Category District urban road
Single Roadway with at least two lanes, paved verge, and sidewalks; for the stop are provided areas equipped with a special maneuvering lane, outside the roadway.
The function is link between sectors and peripheral neighborhoods. This category includes, in particular, the roads intended for serve the main urban and neighborhood settlements. (Assesorato all'assetto urbano, 1993)

F Category - Local urban road:
Road suitably arranged for the purposes of movement of pedestrians, vehicles, and animals, not part of other types of roads. The function is to directly serve buildings for pedestrians and private vehicular mobility. This category includes particularly pedestrian and parking spots. (Assesorato all'assetto urbano, 1993)

Conclusions

By incorporating public interventions aligned with the Urban Traffic Plan, is possible to improve the environmental performance of public space as a place for mitigation and reduction of climate vulnerability.

These interventions can minimize emissions by reducing vehicular traffic in particular corridors with high air pollution indicators, also the interventions can reduce the noise levels and encourage the use of alternative modes of transport, such as cycling and walking. This holistic approach not only enhances mobility but also fosters a sense of community following the pillars of Restorative urbanism making urban areas more vibrant and livable.

Ultimately, comprehending the parameters of the Urban Traffic Plan is central to establishing an urban intervention approach to conifer the city a functional but also environmentally conscious character, laying the foundation for a truly sustainable urban future.

	Functionality *Description and function*	**Characterization** *Main characteristics*	**Components** *Road requirements*
D Category *Urban road*	Performs the function of distribution, and which can be indicatively made up of urban flow roads	- Distribution movements from the primary network to the secondary network and eventually to the local network. - Medium-distance travel. - Connection between neighborhoods in the urban area.	Road with independent carriageways, lane reserved for public transport, sidewalks, special areas for parking or side strips , both with entrances and exits concentrate.
E Category *District Urban Road*	Performs the function of acces mobility, and which can be indicatively made up of urban neighborhood roads	- Mobility towards the local network. - Short-distance movements. - District connection function in an urban context.	Single Roadway with at least two lanes, paved verge and sidewalks; for the stop are provided areas equipped with a special maneuvering lane, outside the roadway.
F Category *Local Urban Road*	The function is to directly serve buildings for pedestrians and private vehicular mobility.	- Access mobility. - Short distance travel. - Function of connection within the neighbor-hood in the urban context. .	Directly serve buildings for pedestrians and private vehicular mobility.

Figure 43. *Matrix of comparison*

2.2 PUBLIC SPACE MANAGEMENT

URBAN AND PUBLIC SPACE DEVELOPMENT AND MANAGEMENT

2

a) Turin state of the art

Enforcement of adaptation plan

After an overlook to the Adaptation plan Turin have state for 2030 some interventions have been projected over the public space following the guidelines in the Report for a sustainable and Resili-ent Turin. The following references are all interventions projected or applied already in the urban context of Turin.

Valdocco Reference case

Currently this project has two phases the first one was presented and accepted as an experimentation over nature-based solutions for mitigating the UHI phenomenon and improve the rainwater management. The second phase retake the strategies and techniques from the first one applying it in other street profiles. The main intervention is done over the large intersections where the pedestrian path is enlarged.

Enlargement of the space reserved for pedestrians thanks to the creation of "nasi" near the in-tersections. Some rest areas will also be created, where possible flanked by green areas designed to collect rainwater from the streets.

The Strategies: With the enlargement of the pedestrian paths over the intersections the parking areas are expected to be better defined also this enlarged area is expected to be permeable with medium size vegetation.

Figure 44. Analysis over the redevelopment of public spaces "Valdocco Vivibile 2". Source: Done by the author based on images from the Turin municipality.

ProGIreg Reference case

Productive Green Infrastructure for post-industrial urban regeneration is a project funded by the European commission that looks forward to the urban regeneration of post-industrial areas. In Turin the project is located in the Mirafiori district. The project test and implement different types of NBS with the outcome of developing a self-sustain business model within the community. Project financing by the European commission.

ProGIreg develops self-sustaining business models for nature-based solutions, evaluated according to scientific parameters of the multiple benefits they offer for social, ecological and economic regeneration.

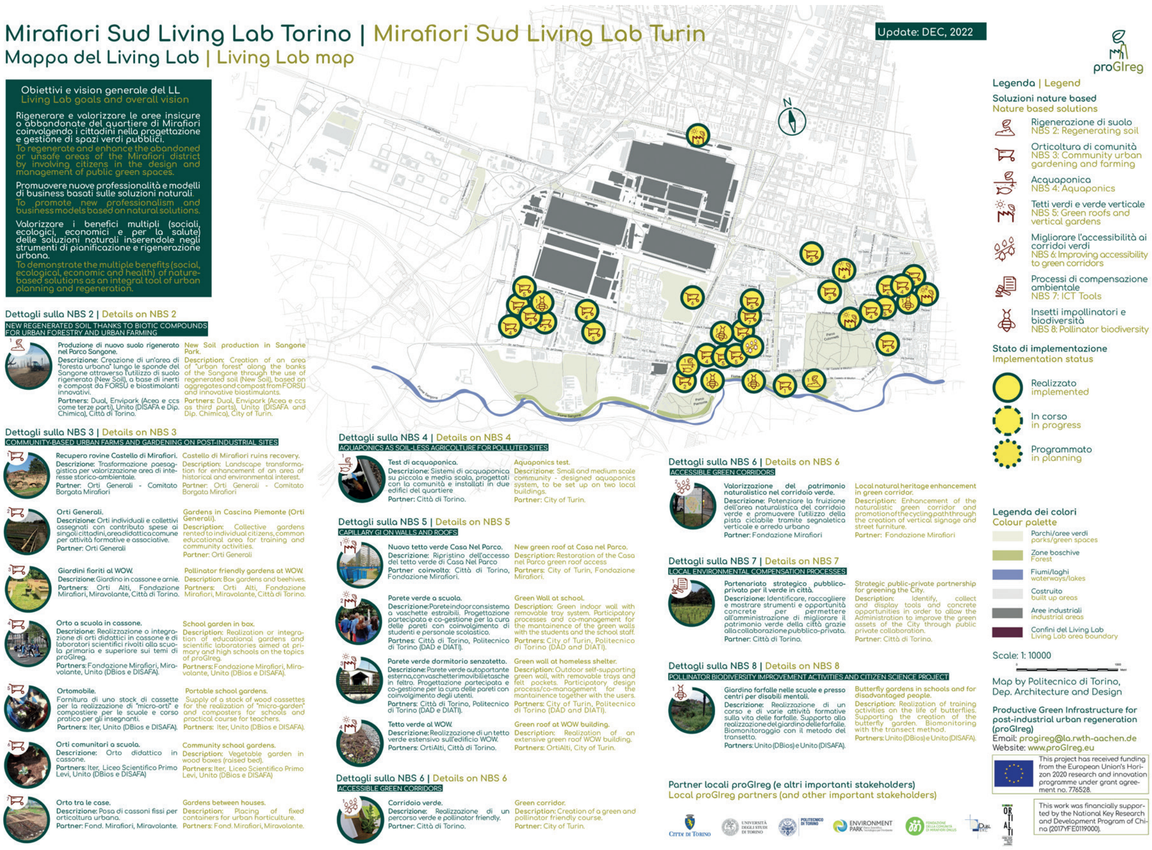


Figure 45. Mirafiori Sud Living Lab Turin. Source: ProGIreg (Retrieved 2023)

The Strategies: Even though the project shows a correct planning and execution* most of the interventions are done over private space, even if those interventions have been in schools are areas not open to all the community but just for the users of those facilities. In general, 7 types of NBS were put in practice as restoration of soil fertility, Urban Farms

* *Project duration from 2018 to 2023. Current Implementation status: Implemented*

and gardens, green walls and roofs, accessible green corridors, and aquaponics. However, the Implementation of NBS over public space is mainly depaving and the restoration of soil fertility is doubt. These interventions are done in green corridors and social gardening interventions. Project financing by the European commission.

Green Corridors: Creation of a green and pollinator friendly pathway. Enhancement of the naturalistic green corridor and promotion of the cycling path through street furniture.

Figure 46. Mirafiori sud living lab case analysis over via Rodolfo Morandi. Source: Done by the author based on google earth images.

Conclusions

As previously presented the action of contrasting holds significant importance and in this stage of the investigation the method would be applied again by juxtaposing other three cases in Turin. This approach facilitates the identification of best practices already applied in the local case.

	Nature Based solutions *Implemented solutions*	**Techniques - Strategies** *Implemented*	**Materials** *Implemented on Main features*	**Positive Results** **Negative Results**
Via valdocco 2 *Street Intrsection intervention*	Depaving Rain Garden	**Urban Intervention.** Enlarge-ment of pedestrian paths over street ntersections	**Depaving:** Grass	+Safetyness of pedestrians +Urban ebellishment - Reduced area of intervention
Mirafiori sud Living lab *Green corridors*	Depaving	**Suburban Intervention.** Improvement of existing paths for pedestrians and bikes	**Depaving:** Gravel over sand.	+ Reduction of impervious area - Not replicable strategy to all the corridor
Corso Enrico de Nicola *Street profile Intervention*	Discontinuity of asphalted roads	**Urban Intervention.** street and parking area intervention.	**Street road:** Asphalt discontinued by stone stripes **Parking:** Bircks pavement	+ Reduction of impervious area + Increase of infiltration +Urban ebellishment

Figure 47. *Matrix of comparison*

b) Overview of Turin's Public space case

Interviews to Turin institutions

To fully understand the role of public space, it is essential to obtain an overview of the various positions and opinions that exist on the subject. There are many different stakeholders with a vested interest in public space, including urban planners, they bring a unique perspective to the discussion, and it is essential to consider these viewpoints when developing strategies related to public space.
In this stage, several interviews were carried out with experts and actors of Turin institutions to obtain an overview of positions and opinions on the role of public space regarding aspects such as climate vulnerability and risk management. Moreover, the goal is to understand how the theoretical debates on climate change can be materialized.

Arch. Chiara Lucchini
Territorial development at Urban Lab

What would you consider **the most effective feature** of Turin's urban infrastructure to achieve climate resiliency?
The soil and its capacity of infiltration and coolness effect.
More impermeabilization means more UHI phenomenon and with less capacity of water infiltration means also more floods with intense raining, sadly is not raining anymore in Turin.

Which are the **main obstacles and/or weaknesses** to enforce climate sustainable approaches (Mitigation and adaptation) in Turin urban interventions?
The sustainable approaches are considered in a technical and strategic level but do not reach the operative level.
Because in an operative level there are other priorities in the urban context, for instance the ordinary maintenance is at top order of priority, nevertheless if the sustainable approaches were bound to the top order priorities task then these sustainable approaches could be implemented in a daily basis maintenance work

Soil sealing is one of the main soil degradation processes since affects essential ecosystem services and increase the UHI phenomenon (ECA 2010). Which are the measures Turin is taking to mitigate the effects of UHI?

“There are small interventions done in certain places for instance at Valentino Park where the objective is to return impermeable that originally weren’t to their capacity of permeable soil. The ideal case would be done this type of works in a more systematic way (with an increased frequency) But is sure these interventions are done in an experimentative way.”

Air pollution is the number one **environmental health problem** in the EU and is mostly strength by private vehicular transportation. Which are the measures Turin is taking to enforce the alternative transportation methods?
The Air pollution have improved if compared with the Industrial ages when all the fabrics were inside the urban core, now there are mor vehicles than then, but the situation have improved. The air quality is also damaged due to several conditions apart from private transportation as it is the heating system in winter and the lack of public transport connections that makes impossible the mobility without a car between Turin and the small towns around, that make part of the Metropolitan area.

Due to the impact of Big-scale Urban projects have the administration considered implementing some requirements over this project to improve urban adaptive and mitigation capacity of the city to climate vulnerability?
“Currently No.
But in terms of water management there’s strategic plan that’s being organized with administration of Turin in an interdisciplinary work called City water cycles”

Which one do you think is **the most relevant area or problematic** in Turin in terms of climate vulnerability?
“The Soil is one of most important areas to work with because of the ecosystemic services it contributes to.
In the other hand the politics and legislation are not a problematic itself, but the awareness of climate vulnerability and the eventual sustainable approaches that all the people around the process of urban transformation should have.”
If there’s a typical technical solution that’s been used and is useful it’s going to be replicated until there’s a new solution with improved characteristics.

Arch. Marta Ugolotti
Maps and data at Urban Lab
What would you consider is the most effective way to achieve climate resiliency in Turin’s urban context?
Adopting small solutions that can be replicated is easier and more effective especially when you work in an urban context like Turin and much easier to intervene in small portions of the city.

Which are the main obstacles and/or weaknesses to enforce climate sustainable approaches (Mitigation and adaptation) in Turin urban interventions?

Adapt or adopt sustainable approaches in large urban areas is a complex activity, the reasons are both economic motivations (cost and maintenance) and urban planning bureaucracy.
It is more probable to mistake in large areas instead of small ones.

Soil sealing is one of the main soil degradation processes since affects essential ecosystem services and increase the UHI phenomenon (ECA 2010). Which is your opinion over the measures to mitigate the effects of UHI in Turin?
There are a lot of implications that doesn't makes the implementation of the NBS over the public space a simple task. Define smaller chunks where NBS implementations would be more feasible is a more suitable way of action.

According to Turin's masterplan which are the main strategies of Which is the **climate risk** in which the administration is more focus currently at Turin?
Can't answer for the city but according with our maps, in the climate risk scene, one of the most relevant climate change risks is the heat island. In this case the interventions via the NBS are important because it helps to decrease the effect of the UHI.
The big industrial blocks that lack of green and permeable areas are the ones with a bigger impact over this effect.

Regarding the floodings, the current meteorological conditions have changed. Is something that people is trying to ignore but eventually Turin will become drier. Now the most evident risk in Turin is the UHI effect.

Arch. Quirino Spinelli
Staff Assistance of the Council member for the urban planning

"Every area consider as public space is up to be Re-Think, at the end all of those actions have impacts"

Which are the urban issues considering as priority in urban planning in Turin according to climate change impacts?
"La sostenbilitá é diventato una urgenza"
Sustainability was something we though as something build throughout time and nowadays sustainability has become something urgent.
Nowadays the public space come across that urgence, nowadays there are new needs, in terms of environmental sustainability, of inclusion, how versatile the space is for allow certain types of activities. This is one of the main priorities for us.

Making a comparison with the planning of years ago, which are the new advances and priorities at urban level?
The "land take " has become an urgence, however the urbanism works slowly, nowadays the urban plan doesn't have any regulation about the matter of land take, we are redoing the regulation urban plan with a special focus on achieving Net- zero results.

And not just Net zero but improving the quantity of permeable soil and ecological services this also means a regenerative focus.

In your opinion today which are the concerns that the municipality of Turin is facing as a result of climate change over public space?
Adequacy of public space to meet the new needs of inclusion and climate sustainability for example is in the first place on the priority list.
The other priorities we have, work under the concept of time and not the concept of urgence.
This means the day after day process of build sustainability, like the Land take matter, is a long-term process.
The Valdocco project is an intervention on nature-based solutions to mitigate the heat island phenomenon (UHI) and improve rainwater management carried out at street intersections. 'Nasi

Given the number of paved kilometers, could the road profile (or cycle path, parking) be considered by the administration as a focal point in which to implement this type of solution such as permeable pavements and discontinuity of impermeable surfaces?
Can be done, Turin is learning a lot from other Italian references. For instance, the one of Emilia-Romagna region.

In your opinion, Is feasible the implementation of permeable or semi-permeable materials on road axes, such as service lane, tram lane, bus lane, cycle path, car parks? In your opinion, what are the limits encountered in proposing similar initiatives?
Yes, Bologna for example has a big bike tradition, this region is composed of small cities with narrow historical cores made, short buildings and brick streets.
In the bike path case is possible to have discontinuity points that allows permeability, nevertheless, must be consider that some semipermeable surfaces can be uncomfortable for the bike users.
(In the other hand Turin was historically the city of the fiat, of the car so the sensibility for the bikes is just recently developed in contrast with the Emilia Romagna region)

In your opinion, it is feasible to think in a hypothetical adjustment of the general master plan, for the inclusion of a few but precise rules aimed, for example, at increasing the permeability of the soils whenever a road axis is restructured?
We're trying to monitor and push the private and public agents to reach a deal, for instance the second line of metro would have a considerable amount of project public space in Barriera di Milano in the northern area in which the abandoned trainline in the "Trincherone" is expected to become a big linear park and the metro line would be undergrounded.

Conclusions

The role of public space in Turin has become increasingly important in contemporary society. The importance of public space lies in its ability to foster social interaction, encourage civic engagement, and promote community cohesion. Nevertheless, the environmental importance of public space is currently a factor that the community and the administration are every day more aware of, due to the effects of climate change.

The soil is one of the most effective features to achieve climate resiliency because of its various ecological services, so why not improve and enhance these services by the implementation of sustainable approaches, these are not integrated into top-list priorities for the administration, so this is the main obstacle to enforcing them.

In terms of opportunities in Turin, there are some interventions for depaving and increasing exosystemic services in public space, but all those cases have an experimental character without being implemented as an ordinary activity in urban planning in Turin, in the other hand the awareness and technical knowledge of all people involves in urban renovation and planning is something should concern us. Adopting small solutions that can be replicated is the most effective way to achieve climate resiliency because is technically easier and more effective in terms of logistics.

Nowadays public space comes across the urgency of sustainability there are new needs, and the public space must be modified and intervened to meet those new needs, one of the most relevant climate change risks is the heat waves increased by the phenomenon of urban heat islands.

Turin is learning to change and adapt from a car-based urbanism to an alternative-mobility urbanism due to the global circumstances to meet the European regulations in terms of sustainable urbanism.

Obtaining an overview of positions and opinions on the role of public space is essential to develop effective strategies that promote the well-being and flourishing of communities. By considering the needs and perspectives of all stakeholders, we can create public spaces that are vibrant, inclusive, and meaningful for everyone.

3.1 METHOD OF PROCEDURE

a) Introduction to the operative part

The operative part consists of two work lines, the first one is developed on an urban scale (city scale) and regards to the approach of intervention for the mobility infrastructure analysis.
Due to the complexity of the mobility infrastructure system, and the road network, it was not possible to choose a single approach; so, three different approaches to interventions were considered. These approaches determine how the analysis and interventions over the street corridors would be applied. Therefore, the starting point comes from the common objective of presenting the NBS as feasible tools in the street corridors as a tactic to mitigate and reduce the climate vulnerability of Turin; then each approach has a specific principle and objective. Each approach has a different range of interventions as well as different strengths.

The approaches were contrasted and compared with qualitative and quantitative data. The quantitative data was collected from open source maps and shape files with GIS software; for instance, in terms of the number of roads to be analyzed, the heterogeneity of road category, the length, and the area to be analyzed and intervention for each approach. On the other hand, the qualitative data come from a SWOT analysis done for each approach.

The second work line of the operative part of this thesis is developed on a local scale as a result of the first line of operation. Once chosen the approach, the next step is to analyze two urban areas of Turin's punctual cases of streets, each one with different physical and environmental characteristics. The analysis of the physical conditions (in terms of space quality, amount of effective public space) and the soil quality conditions (infiltration capacity) is done for each four cases and represents graphically the current condition of the road.

From the design proposal, the expected results are the improvement of the previous conditions, which means, an improvement of space quality, an increase of effective public space, and an improvement in the capacity of the landscape to mitigate and reduce climate vulnerability, this in terms of increasing the infiltration capacity and improving the outdoor thermal comfort conditions, by increasing vegetated areas.

Steps and tools

To carrying out the analysis of punctual streets profiles is clearly that the approach to choose the urban area would rule the final outcomes. Therefore, is proposed three different approaches that would be individually illustrated. The three different approaches would consider the same steps:

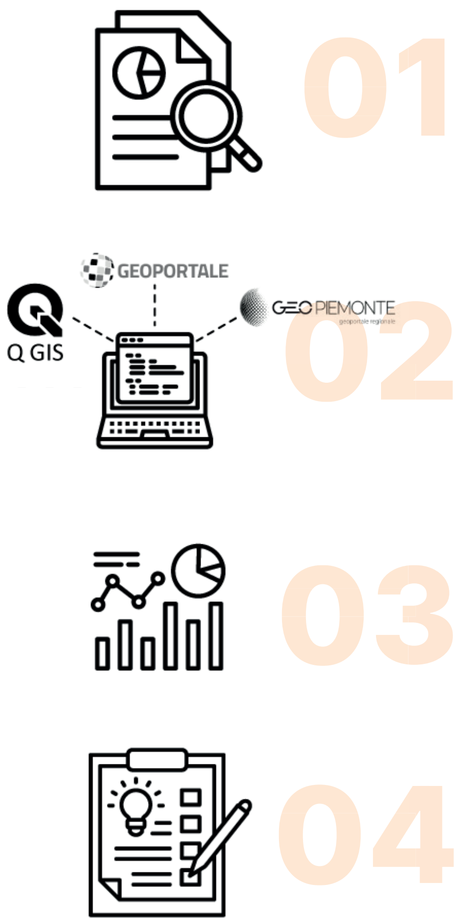


Figure 48. Road profile analysis work-flow. Source: Done by the author

Data collection:
Gather relevant data from various sources, such as government agencies, urban planning departments, research institutions, and community organizations. This data may include land use maps, transportation data, environmental indicators, and historical factors.

Tools:
For analyzing spatial data several tools were used, such as Geographic information systems (GIS) and open mapping tools to analyze and visualize spatial data available in the official sites of the municipality and public environmental agencies. This is useful for understanding distribution patterns and identifying areas of concern.

Key indicators:
These indicators are aligned with the initial objective and provide insights into the various aspects of the urban area. For example, infrastructure quality and physical conditions, infiltration capacity, area suitable to be intervened, and environmental indicators.

Assess infrastructure quality:
Evaluate the quality and capacity of infrastructure within the road profile section. This includes circulation capacity for vehicular, pedestrians, and soft mobility. Additionally, evaluate the environmental quality and capacity within the road profile section. This includes infiltration capacity, the presence of green infrastructure, and the pavement typology.

3.2 EVALUATING THE APPROACHES

OPERATIVE PART

a) Intervention by neighborhoods

First intervention approach

According to the historical research done regarding the urban development in Turin and the different period and circumstances in which the urban grid in Turin have been consolidated, the following approach answers the need to analyze the neighborhoods according to their morphological characteristics, such as the physical infrastructure of mobility, the effective public space and it's the environmental conditions.

Three diverse neighborhoods were chosen according to the historical background analyzed previously. The first neighborhood Borgo San Paolo was chosen according to its formation at the end of the 19th century when the land use shifted from a predominantly agricultural use to the establishment of industrial plants. The second neighborhood to be analyzed is the one of Lucento and Madonna di Campagna, inhabited from the 14th and 16th centuries and which have had different urban solutions and developments from the one of San Paolo. The third area analyzed was the City center or Quadrilateral Romano which embodies most of the city's history and is represented in its morphological conditions.

Specific Principle:
Analysis by site-specific neighborhood

Specific Objective:
Implement NBS in the road profile to mitigate and reduce climate vulnerability in specific urban districts or neighborhood.

A. Borgo San Paolo *B. Lucento - Madonna di campagna* *C. Centro - La consolata*

Figure 49. *Neighborhoods chosen according to be analyzed. Source: www.museotorino.it retrieved October (2023)*

Data collection

The data collected for this approach have been done on two sides, The historical background has been checked from several bibliographic documents and the physical infrastructure of mobility, public space, and environmental conditions have been collected from the open geographical information offered by the city of Turin as shapefiles. For each settlement, the data collected corresponds to brief historical research to understand the connection between the historical period of the settlement and the morphological conditions connected to that background.

Procedure: Additionally for each neighborhood a mean of four streets with diverse categories were considered objects of analysis, to allow the contrast and comparison of the physical conditions between the streets with different categories. For each street analyzed, a survey for the street profile was done, using as a cartographic base reference the open street maps and the shared geographical information provided by the GeoPortale Piemonte. Afterwards considering the current situation and having as main pillars the specific and common objectives each street analyzed would be assigned proposed strategies and actions to be implemented. *

Method: For each neighborhood, the streets were analyzed and compared in a matrix where strategies and actions were considered according to each street typology and physical infrastructure conditions. For each neighborhood, the streets were analyzed and compared in a matrix where strategies and actions were considered according to each street typology and physical infrastructure conditions.

Furthermore, for each street profile, their phisical conditions were calculated and compared within the whole approach intervention areas.
The values for Soil quality, infiltration capacity and length of intervention for each neighborhood and for each approach can be checked in the annex ***Table 1***

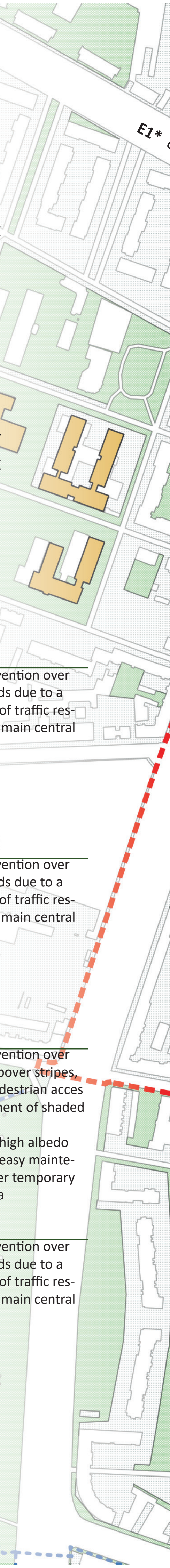
** The Piedmont GeoPortal makes available the shapefiles catalog of geographical information of the Piedmontese territory.*

B
Lucento - Madonna di campagna
C
Centro - La consolata
A
Borgo San Paolo
1:30.000
0
1.000
2.000 m

A. Borgo San Paolo

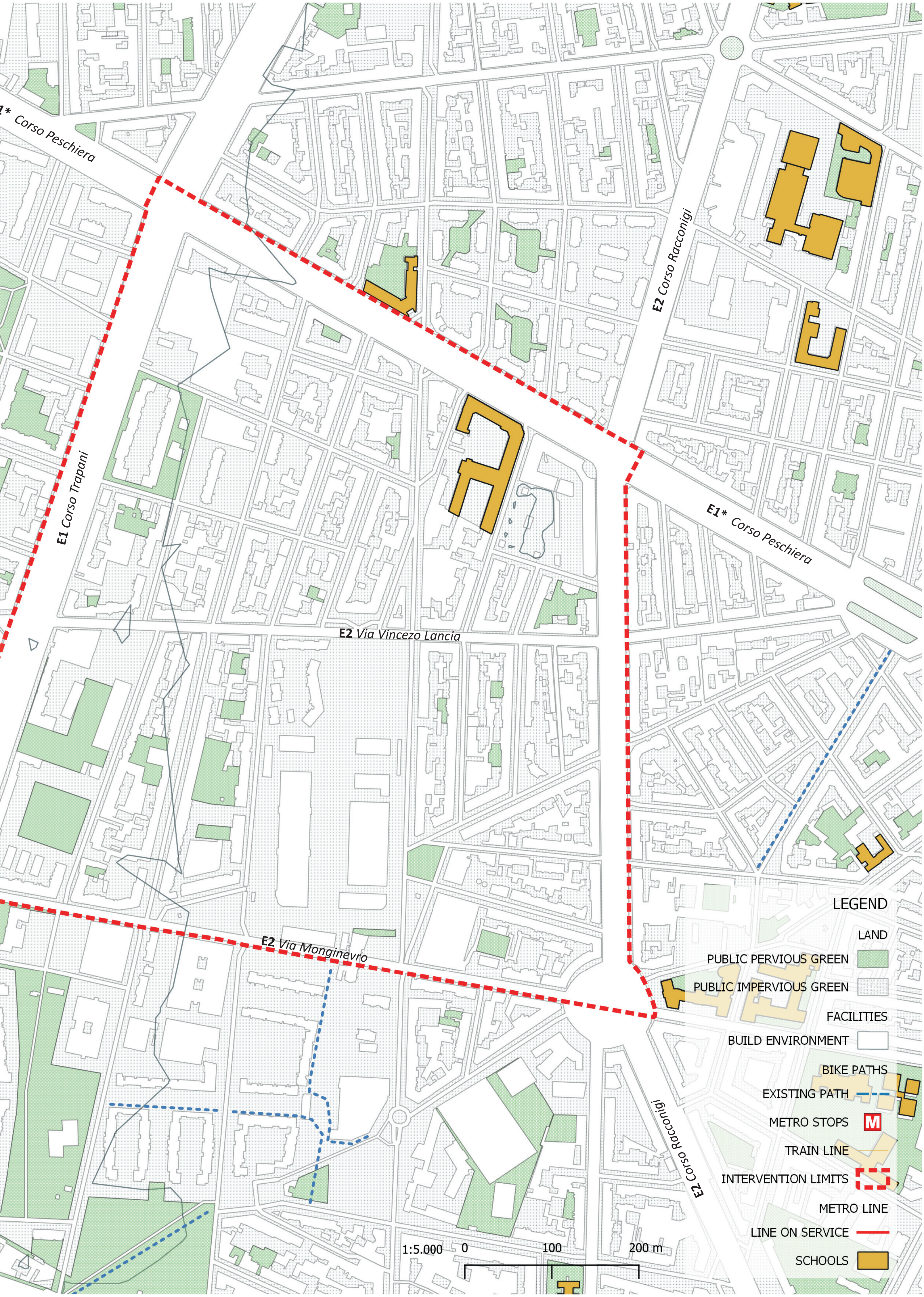
Formed at the end of the 19th century, outside the former Cinta Danziaria, with the establishment of industrial plants. Large groups of workers moved to this neighborhood due to the proximity of factories. In the period between the two world wars, the neighborhood consolidated its industrial vocation as an important working-class district in Turin, but the abandonment of industrial activities carried a series of urban and societal transformations in the neighborhood. Several urban interventions currently take place over the street area in Borgo S. Paolo, most of them are focused on the introduction and connection of bike lanes with the redevelopment of Spina 1.

The analyzed streets are two streets from category E1 Corso Trapani and Peschiera; one street from category E2, Corso Raconnigi, and the Via Vincenzo Lancia from category F. Each one presents a different solution typology as previously stated in the street hierarchy.



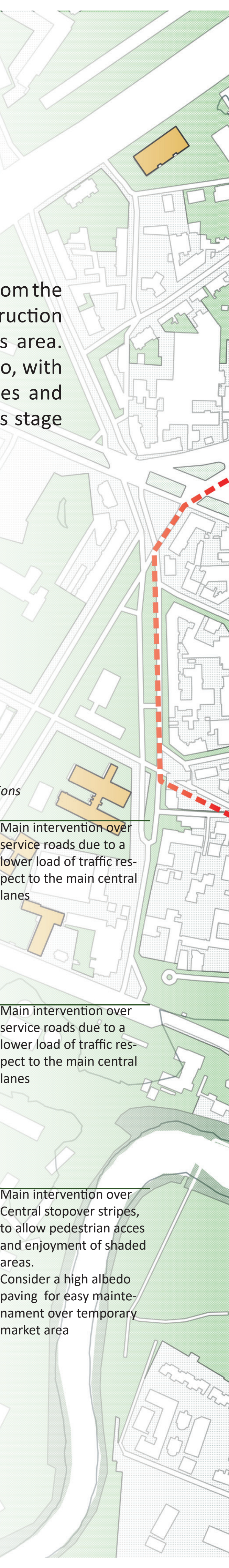
Category PUMS	*Street Name*	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E1*	Corso Trappani	Central driving lanes 3+3 and lateral service roads with 1 to 2 driving lanes each one plus parallel parking lane.	→ Bike lane → Pedestrian path and vehicular lane made of asphalt. → Two lateral stopover spots for perpendicular parking in ground soil. → Two tree lines located over stopover area. → Service roads with two parallel Parking spot.	→ Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes
E1	Corso Peschiera	Central driving lanes 2+2 and lateral service roads with 1 to 2 driving lanes each one.	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt. → Two lateral stopover spots for perpendicular parking in ground soil. → Two tree lines located over stopover area. → Service roads with two parallel Parking spot.	→ Reconfiguration of Road profile and addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes
E2	Corso Raconnigi	Solution 2+2 driving lanes with a central stopover strip (Parking spots - temporary market)	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt. → Central stopover more than 6 meters. → Two line trees in central lane.	→ Reconfiguration of central lane for versatile and temporary uses. → Addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over Central stopover stripes, to allow pedestrian acces and enjoyment of shaded areas. → Consider a high albedo paving for easy maintenament over temporary market area
E2- F	Via Vincenzo Lancia	Driving lanes 2+2 and of them 1+1 is autobus lane.	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt - concrete. → No green spots → Parallel Parking spots in both sides with the autobus lanes.	→ Materials reconfiguration to achieve environmental and comfort conditions. → Increase of soil infiltration capacity → Improving space quality. → Pedestrian enlargement	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes

Comparision Matrix for the first intervention approach, zone A.


E1* Corso Peschiera
E1 Corso Trapani
E2 Corso Racconigi
E1* Corso Peschiera
E2 Via Vincezo Lancia
E2 Via Monginevro
E2 Corso Racconigi
1:5.000
0
100
200 m
LEGEND
LAND
PUBLIC PERVIOUS GREEN
PUBLIC IMPERVIOUS GREEN
FACILITIES
BUILD ENVIRONMENT
BIKE PATHS
EXISTING PATH
METRO STOPS
TRAIN LINE
INTERVENTION LIMITS
METRO LINE
LINE ON SERVICE
SCHOOLS

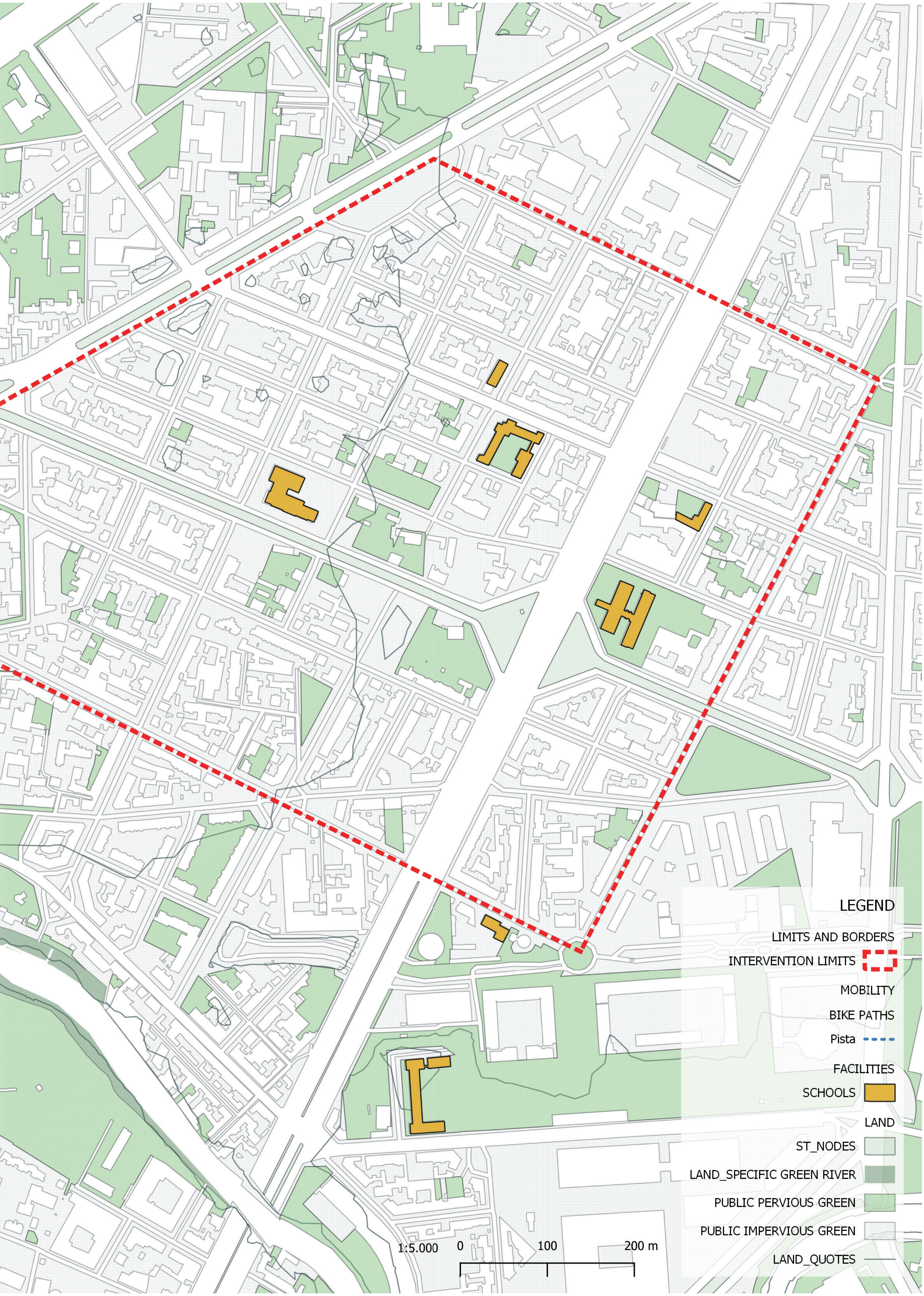
B. Lucento

The historic villages of Lucento and Madonna di Campagna have been inhabited from the 14th and 16th centuries, far from the core of Turin development until the construction of via Pianezza in 1884 which led to a series of urban connections with this area. The streets to be analyzed are those of Corso Potenza, Toscana, and Via Fogligno, with the respective categories of E1*, E2, and F. For each street a set of strategies and actions was proposed according to the common and specific objectives for this stage of analysis.



Category PUMS	*Street Name*	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E1*	Corso Potenza	Central driving lanes 3+3, lateral service roads with 1+1 driving plus lateral tram lane in both sides.	→ Bike lane → Pedestrian path and vehicular lane made of asphalt. → Two lateral stopover spots for perpendicular parking in ground soil. → Two tree lines located over stopover area. → Service roads with two parallel Parking spot.	→ Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes
E2	Corso Toscana	Lateral driving lanes 1+1 and central tram lanes 1+1	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt. → Tram lanes over ground soil. → Low highr vegetation over lateral sides of tram lanes.	→ Reconfiguration of Road profile and addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes
F	Via Fogligno	Single direction driving lane with two lateral parallel parkig	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt. → Single material for all profile road.	→ Reconfiguration of central lane for versatile and temporary uses. → Addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over Central stopover stripes, to allow pedestrian acces and enjoyment of shaded areas. → Consider a high albedo paving for easy maintenament over temporary market area

Comparision Matrix for the first intervention approach, zone B.

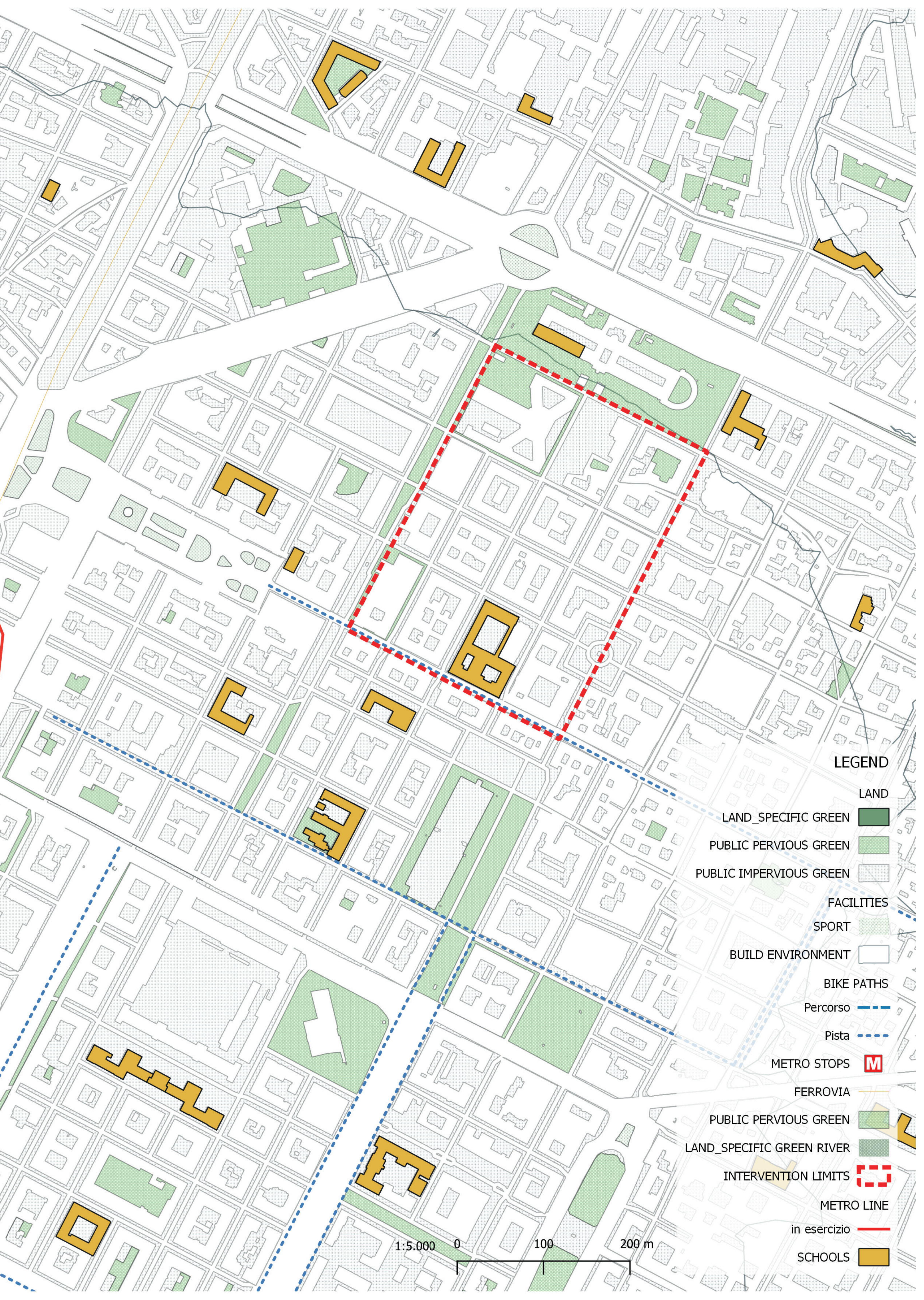

LEGEND
LIMITS AND BORDERS
INTERVENTION LIMITS
MOBILITY
BIKE PATHS
Pista
FACILITIES
SCHOOLS
LAND
ST_NODES
LAND_SPECIFIC GREEN RIVER
PUBLIC PERVIOUS GREEN
PUBLIC IMPERVIOUS GREEN
LAND_QUOTES
1:5.000
0
100
200 m

C. City center – Quadrilatero

The central district is the most antique and the one that embodies most of the historical background of the urban development of the city. The most significant urban development is placed from the second half of the sixteenth century when a long process of ex¬pansion and transformation took place with the Savoys intervention. With the of Filippo Juvarra (1729) an intense urban development activity took place with the replacement of old medieval buildings with modern construction. Nowadays the city center embodies great importance.

Category PUMS	*Street Name*	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
F	Via del Carmine	Single direction driving lane with two lateral parallel parkig lanes.	→ No Bike lane → Pedestrian path and vehicular lane made of asphalt. → Service roads with two parallel Parking spot. → Lateral lane for eventual temporal terraces from local commerce	→ Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes
E2	Via della Consolata	Single direction drive lane and single direction tram lane.	→ No Bike lane → Pedestrian path and vehicular lane made of asphalt. → Service roads with two parallel Parking spot.	→ Reconfiguration of Road profile and addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes
F	Via Carlo Ignazio Giulio	Single direction driving lane with parallel parking lanes at both sides.	→ No Bike lane → Pedestrian path and vehicular lane made of asphalt. → Service roads with two parallel Parking spot. →	→ Reconfiguration of central lane for versatile and temporary uses. → Addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over Central stopover stripes, to allow pedestrian acces and enjoyment of shaded areas. → Consider a high albedo paving for easy maintenament over temporary market area

Comparision Matrix for the first intervention approach streets, zone C.

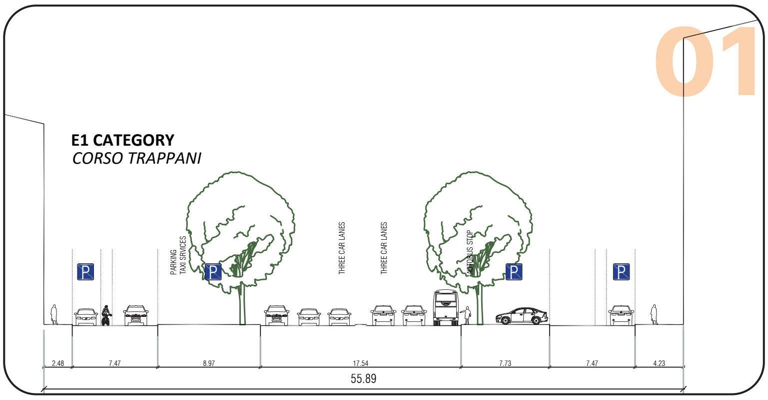

LEGEND
LAND
LAND_SPECIFIC GREEN
PUBLIC PERVIOUS GREEN
PUBLIC IMPERVIOUS GREEN
FACILITIES
SPORT
BUILD ENVIRONMENT
BIKE PATHS
Percorso
Pista
METRO STOPS
M
FERROVIA
PUBLIC PERVIOUS GREEN
LAND_SPECIFIC GREEN RIVER
INTERVENTION LIMITS
METRO LINE
in esercizio
SCHOOLS
1:5.000
0
100
200 m

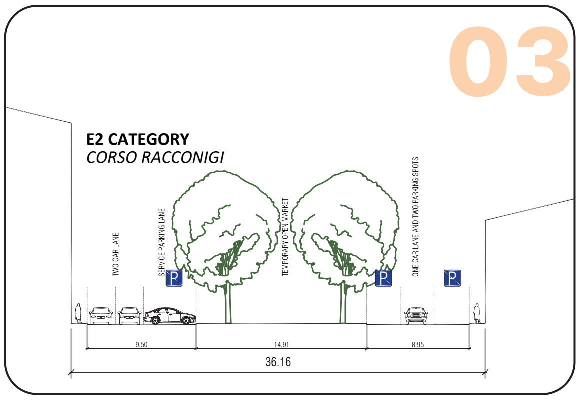
Analysis and Results

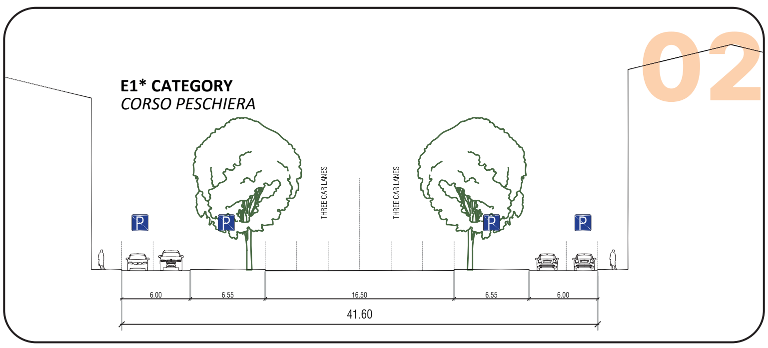
This approach has as a strength a more site-specific character. This means that in implementing this approach the design solutions would be focused on a small scale (Block scale) and the considerations over this design implementation would be taken over. This approach gives the chance to design a specific solution for each settlement given the specific analysis of each road typology of three different sites. This approach allows to designing of public space in complex and diverse conditions with different historical situations through the proposed analysis and line of reasoning.

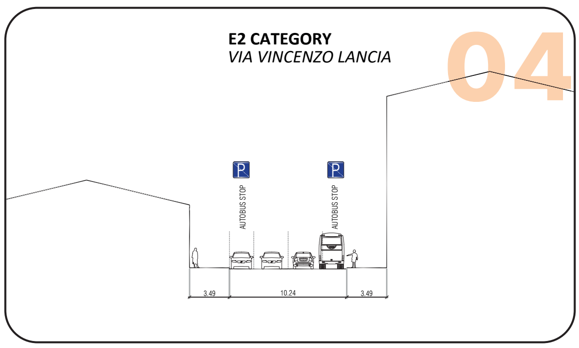
BORGO SAN PAOLO

ZONE A



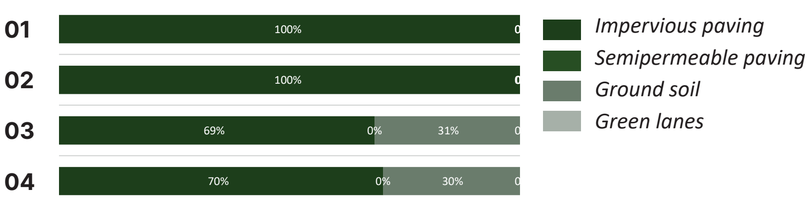






INFLTRATION QUALITY

ZONE A



STRENGHT

Site-specific character. The design intervention would answer specifically to each settlement and more specifically to each neighborhood. The intervention over the street can answer to a close loop between blocks.

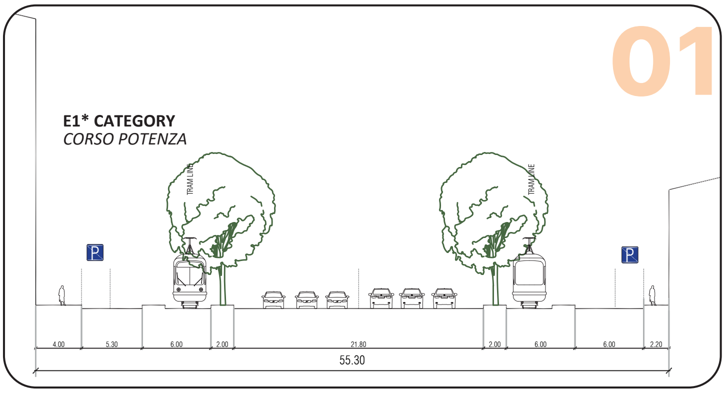
WEAKNESS

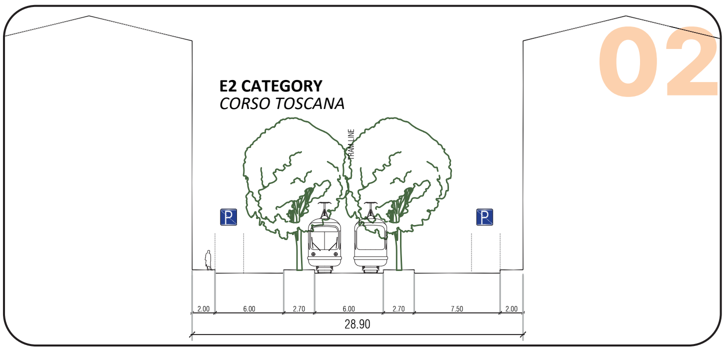
The quantity of punctual actions is greater than other approaches (a different type of intervention for each street typology for the three different settlements)

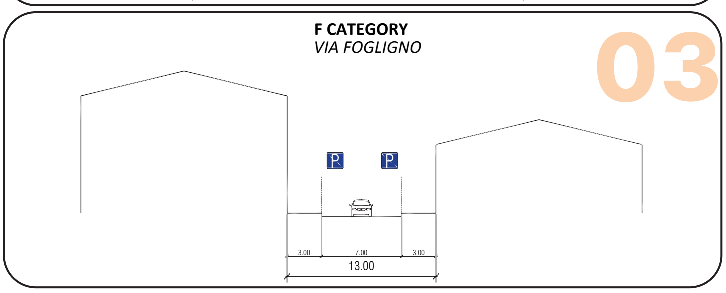
This approach is variable since it can be applied eventually to other settlements with the same line of reasoning, to the same street typologies, and obtain different results, different strategies to be considered and different actions to be applied. On one hand, is positive the amount of diversity the urban environment can show with this approach, yet the amount and variety of interventions needed to satisfy such a specific approach would be higher than the other approaches.

LUCENTO - MADONNA DI CAMPAGNA

ZONE B

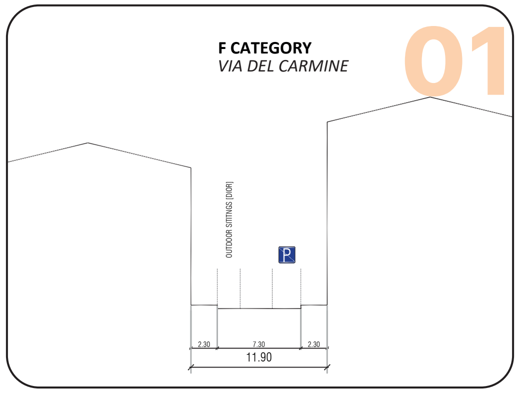


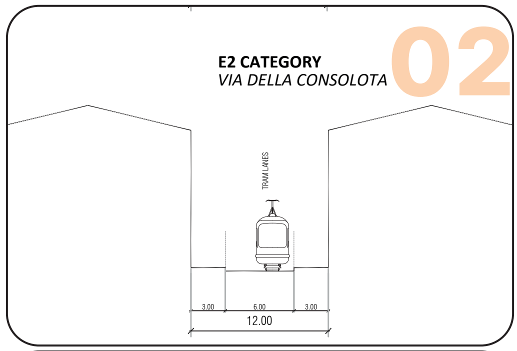


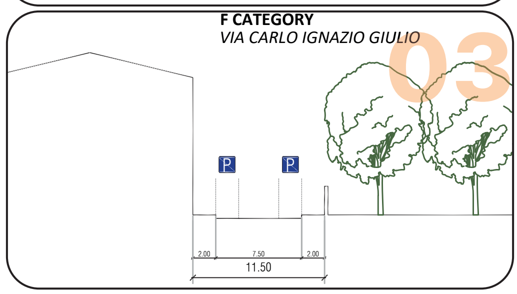


CITY CENTER – QUADRILATERO

ZONE C

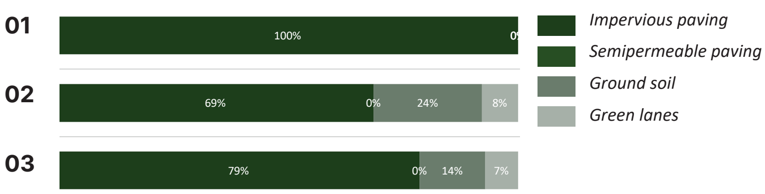






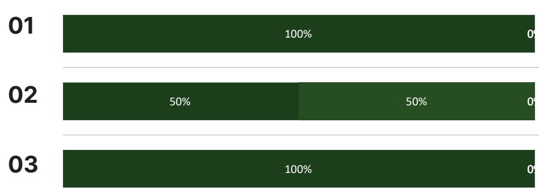
SOIL QUALITY - INFILTRATION CAPACITY

ZONE B



INFLTRATION QUALITY

ZONE C



OPPORTUNITIES

The social component is considered in a further way in difference with the rest of the approaches.

THREATS

Possible elevated cost and long time for the end of the implementation.

b) Intervention by street corridor

Second intervention approach

This approach aims to place the intervention in a circuit in which the initial analysis and implementation of NBS would represent a continuous loop. The former “Cinta Danziaria” left an already consolidated vehicular ring in the urban core of Turin, conformed by two vehicular categories, which means just two types of roads according to the PUMS. Thus, the process of initial analysis, strategies, and application/actions can be reduced to both types of roads. This reduces the process of analysis and on the contrary, increases the action field to around 16 km in a close loop.

Specific Principle: Analysis by large street corridors.

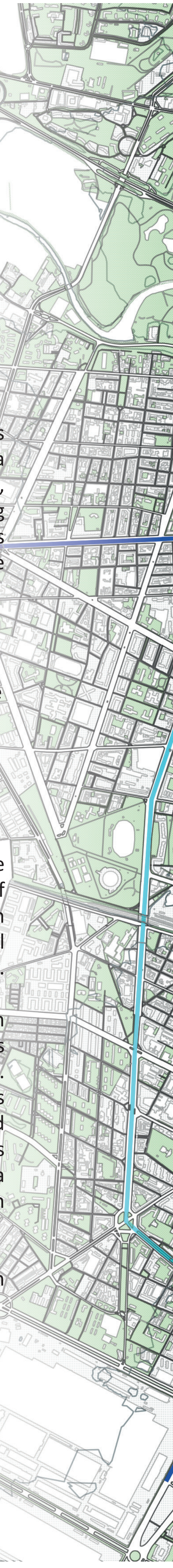
Specific Objective: Implement NBS in the road profile to mitigate and reduce climate vulnerability in large vehicular axes.

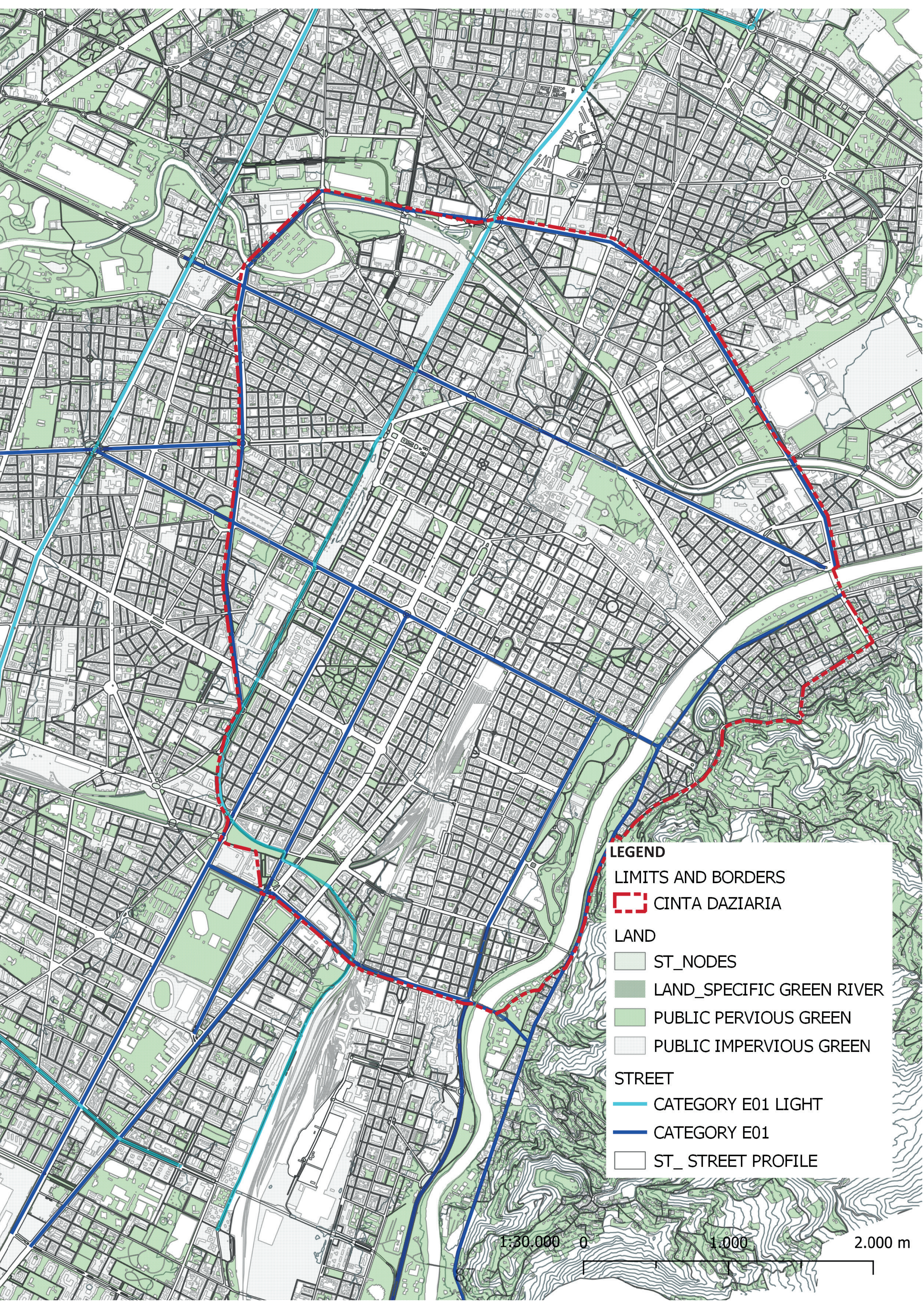
Data Collection

By using open and free data sources the information regarding the mobility infrastructure has been collected from the open geographical information offered by the city of Turin as shapefiles. Once the information is added to the Geographic Information System (QGIS software) the survey of the vehicular roads is complete with additional information from other open cartography sources to achieve a better accuracy.

Once the survey is done the physical and quality conditions (infiltration capacity) are analyzed and the percentage of infiltration capacity is calculated (percentages presented in the analysis and results part). As previously mentioned, a particularity and strength of this intervention approach is the process of data collection, reduced to the analyzed street instead of individuated street analysis as with the last approach (Approach #1) In this case the following streets were considered: Corso Novara, Alessandro Tassani, Francesco Ferruci, Corso Francia and Vittorio Emanuele II; additionally the street categories were also characterized in the table below.

The values for Soil quality, infiltration capacity and length of intervention for each neighborhood and for each approach can be checked in the annex ***Table 2***




LEGEND
LIMITS AND BORDERS
CINTA DAZIARIA
LAND
ST_NODES
LAND_SPECIFIC GREEN RIVER
PUBLIC PERVIOUS GREEN
PUBLIC IMPERVIOUS GREEN
STREET
CATEGORY E01 LIGHT
CATEGORY E01
ST_ STREET PROFILE
1:30.000
0
1.000
2.000 m

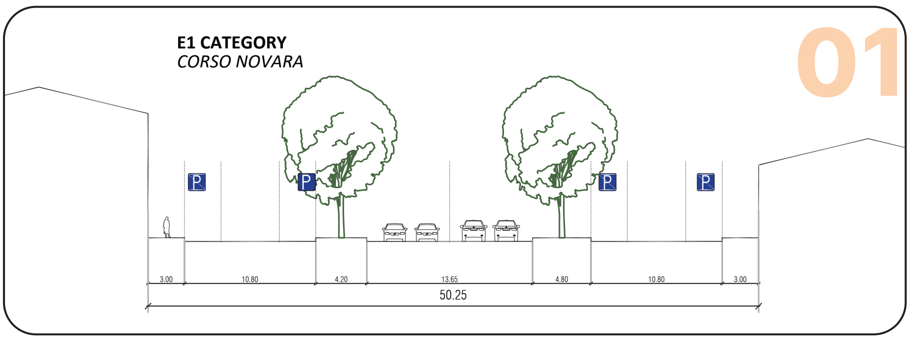
Analysis and Results

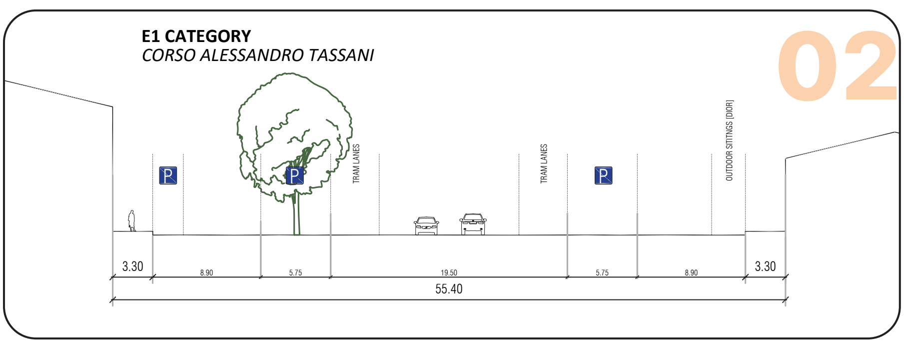
Approach 02
Implementation through Circuit - Cinta Danzaria

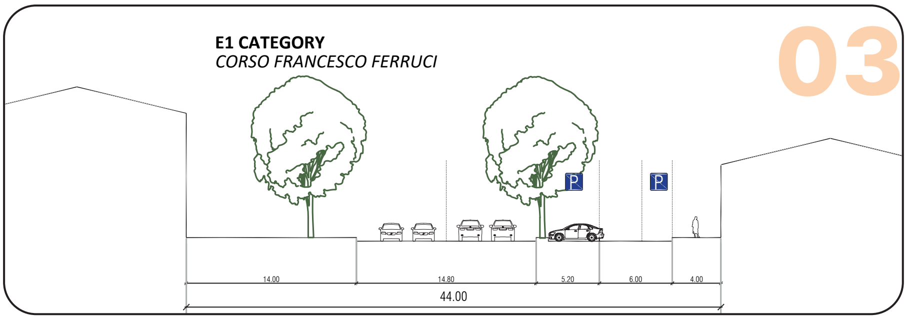
Category PUMS	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E1	Central driving lanes 2+2 and lateral service roads with 1 to 2 driving lanes each one.	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt. → Two green stripes with line trees each one of 4 meters aproximately. No pedestrian access. → Service roads with two parallel Parking spot. → Ocasional concrete tiles in parking spots (Semipermeable pavement)	→ Reconfiguration of Road profile and addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over service roads due to a lower load of traffic respect to the main central lanes

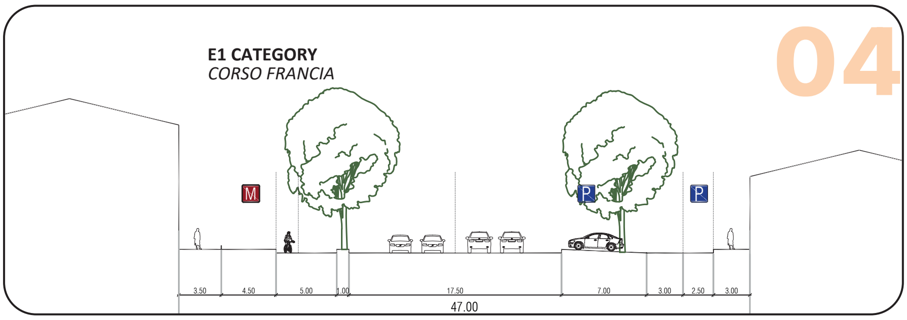
Category PUMS	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E2	Solution 2+2 driving lanes with a central stopover strip (Parking spots)	→ No bike lane. → Pedestrian path and vehicular lane made of asphalt. → Two line trees in central lane. → Ocasional concrete tiles in parking spots (Semipermeable pavement) → Central stopover more than 6 meters.	→ Reconfiguration of central lane for versatile and temporary uses. → Addition of bike lane. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Main intervention over Central stopover stripes, to allow pedestrian acces and enjoyment of shaded areas.

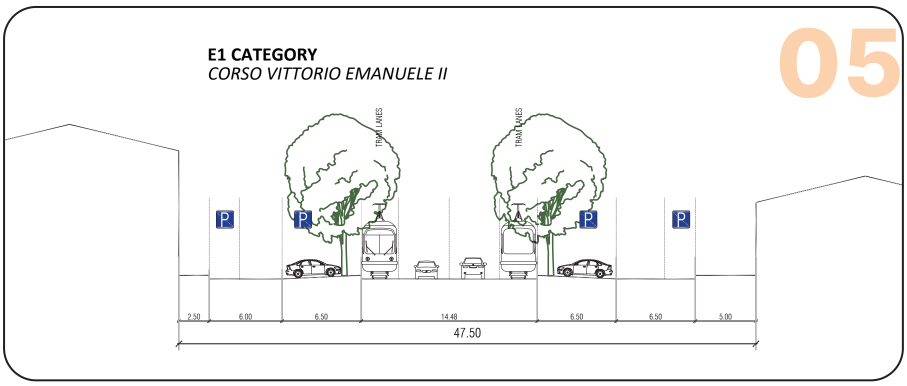
Comparision Matrix for the second intervention approach streets.





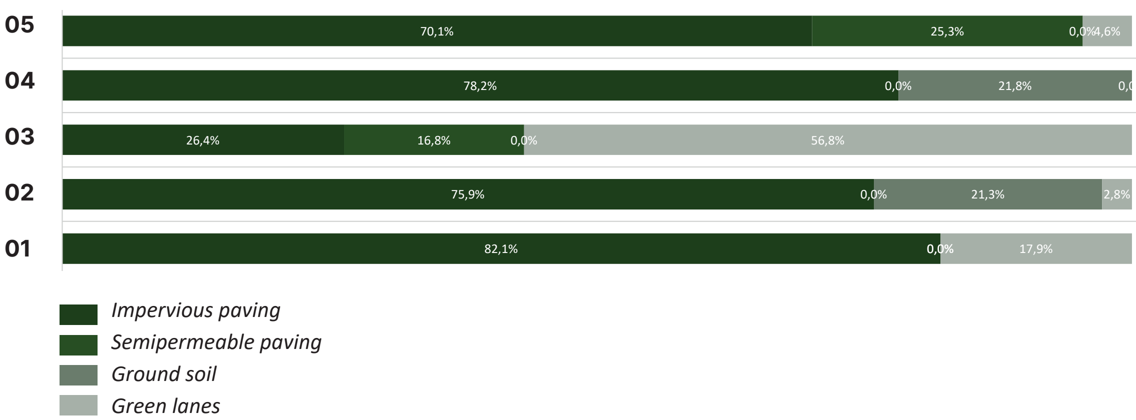






SOIL QUALITY - INFILTRATION CAPACITY

Second approach



SWOT Analysis

This approach deals with the urban capacity of the road, capacity in terms of dimensions, volume of traffic, and available circulation area for users (pedestrian and soft mobility) This approach deals with a bigger scale due to the chosen mobility grid in which the analysis was done.

This approach leverages the greatest strength of the mobility system as a field of intervention, this is the continuity and connectivity through a very complex system as the urban one. No other system in the urban network is as well connected as the mobility one because its function is the one-off assured connectivity for the users. In this case through the perimeter left by the former "Cinta Danziaria" and the current streets that conform that perimeter.

STRENGHT

Once the data of each road that comprehend the circuit is gathered and the survey done the process of street diagnosis is reduced, analysis due to a limited number of actions over a large area of intervention.
This approach presents a bigger area of intervention respect to the alternatives approaches. Leverages the continuity and connectivity of the mobility system.

WEAKNESS

As the scale of the approach is larger, the actions to be implemented do not consider the particularities of each street but the common characteristics of each road category. This doesn't allow a site-specific intervention but a larger scale impact.

OPPORTUNITIES

The applicability of this approach is focused to be applied on large vehicular axes; this means a broader impact of the NBS implemented.

THREATS

The approach considers a greater amount of road sections respect to the alternative's approaches, the amount of data collection and information gathered respect to the other approaches is also more.

c) Intervention by environmental hazard

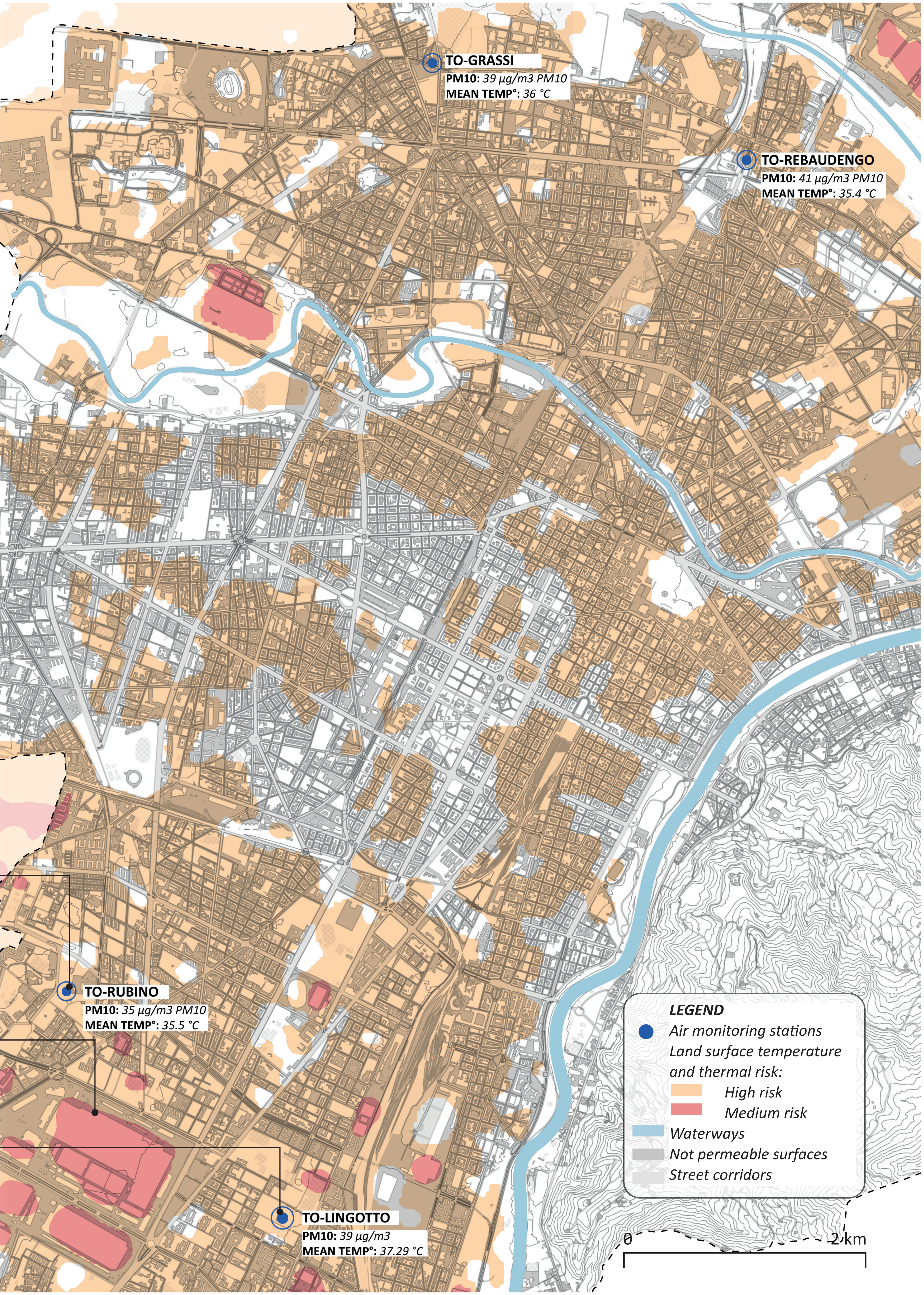
Third intervention approach

The layers considered to be overlapped in this approach were the land surface Temperature, the air pollution according to local and regional sources, and the existing public green areas. The area to be analyzed and eventually intervention was the result of overlapping these three layers. The process of the layers to be overlapped was data collection, analysis and interpretation of the data to be placed in QGIS and represented over the urban area of Turin.

Specific principle: Analysis by environmental hazard

Specific Objective: Implement NBS in the road profile to mitigate and reduce climate vulnerability in zones with highlighted environmental hazard

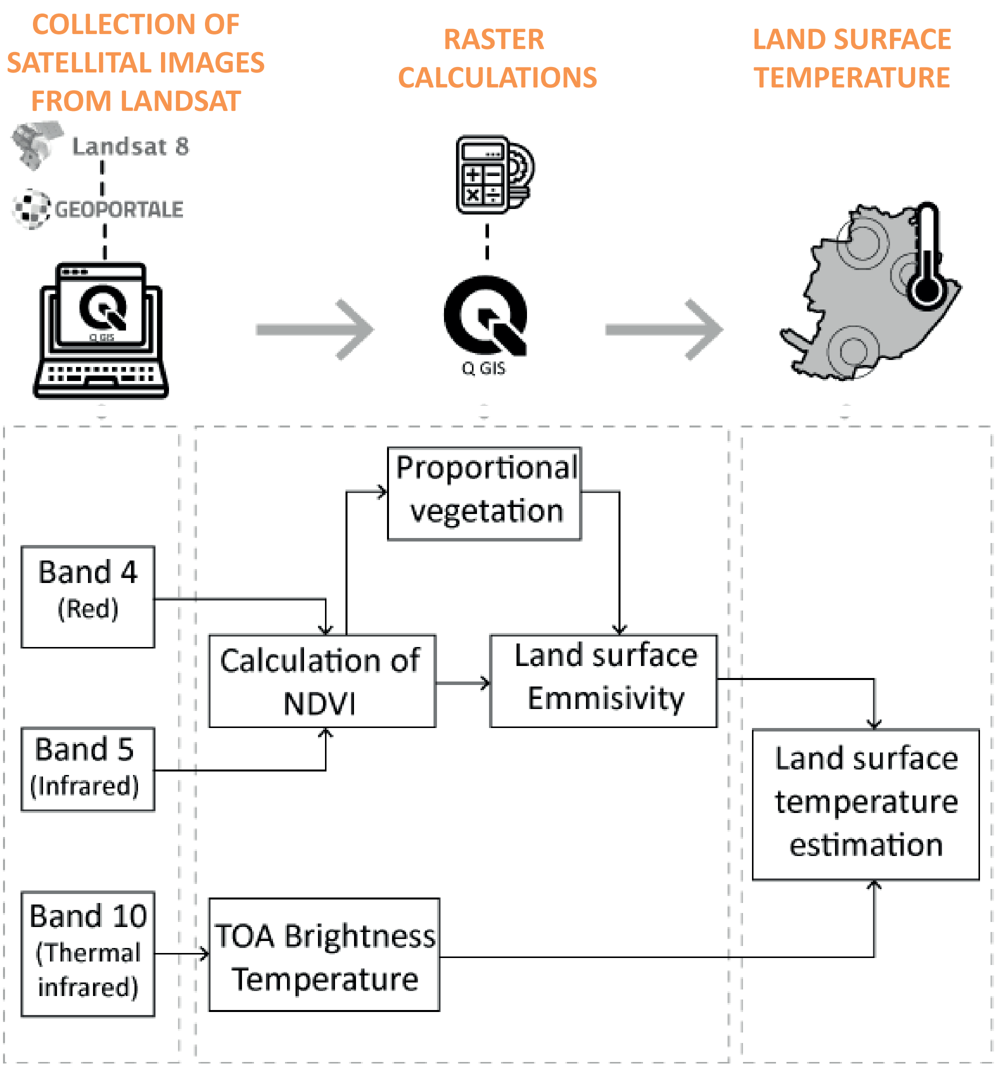
Furthermore, for each street profile, their physical conditions were calculated and compared within the whole approach intervention areas.
The values for Soil quality, infiltration capacity, and length of intervention for each neighborhood and for each approach can be checked in the annex ***Tables 3 - 7***


TO-GRASSI
PM10: 39 µg/m3 PM10
MEAN TEMP°: 36 °C
TO-REBAUDENGO
PM10: 41 µg/m3 PM10
MEAN TEMP°: 35.4 °C
TO-RUBINO
PM10: 35 µg/m3 PM10
MEAN TEMP°: 35.5 °C
TO-LINGOTTO
PM10: 39 µg/m3
MEAN TEMP°: 37.29 °C
LEGEND
Air monitoring stations
Land surface temperature and thermal risk:
High risk
Medium risk
Waterways
Not permeable surfaces
Street corridors
0
2 km

Data Collection

By using open and free data sources such as satellite images from Landsat 8, Atmospheric, urban, and hydrologic information of a given location can be filtered, visualized, and analyzed.

The calculation of the **Land surface temperature** could be done with Landsat data using emissivity estimation as published by Jeevalakshmi. D et al., 2017, therefore the raster images of Landsat 8 from USGS were analyzed on the software QGIS. The downloaded bands were the number 4, 5, and 10 for the period of July in the maximum pick of temperature registered in the summer of 2022. Using the raster calculator procedure over the satellite images the following planimetries were achieved: **TOA Reflectance, NDVI, Proportion of vegetation, TOA brightness temperature** and **Land surface temperature.** Additionally, the process by which the raster calculations can be used with the raster images allows generation of other planimetries such as the **NDMI.**



Work flow for the calculation of the Land surface temperature

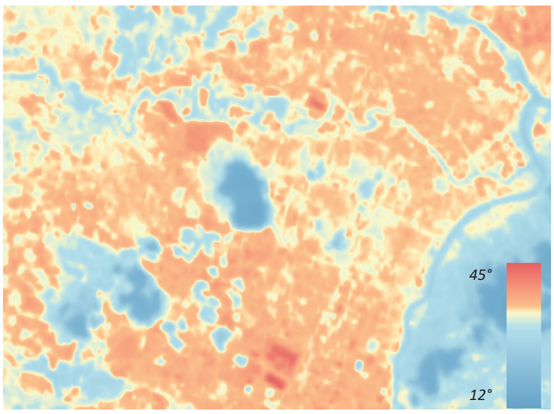
The Existing public green areas from local and regional official websites as shapefiles and compared with the open data sources such as the satellite images from the Landsat 8 and the EO Browser, where maps such as **the Green City script** make easier the contrast between the build areas and the green zones, additionally in the raster calculations the **NDVI** was of great help to contrast and evaluate the state of vegetation health in the public green areas.

The local and regional environmental agencies make public the measurements of **the air pollution** done by the different urban stations in Turin and the metropolitan area. The information was collected, organized, and added into QGIS as added values according to the location of each station. Information such as number of exceedances of the daily limit value and the values of the daily and annual average for PM10.

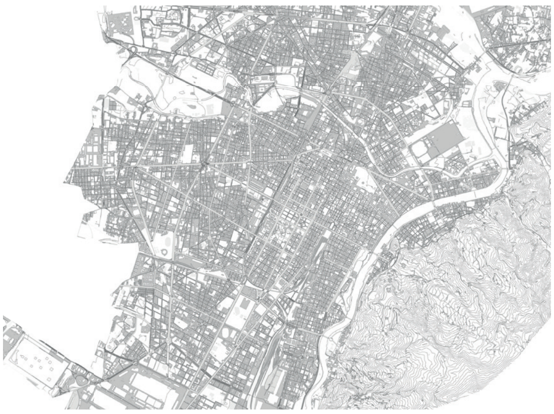
The acoustic situation of the streets was also taken into consideration and the data was recovered from the **acoustic mapping of the City** of Turin that represents the noise levels produced by the different street categories, considering the contribution of private traffic and that of public transport. The mapping reports, the estimated noise levels according to the national daytime and night-time level indicators.

The chosen streets are Corso Giulio Cesare, Via Ninno Oxilia, Via Pio VII, Corso Traiano, Via Porpora, Via Lanzo. This streets belong to categories E1 and E2.

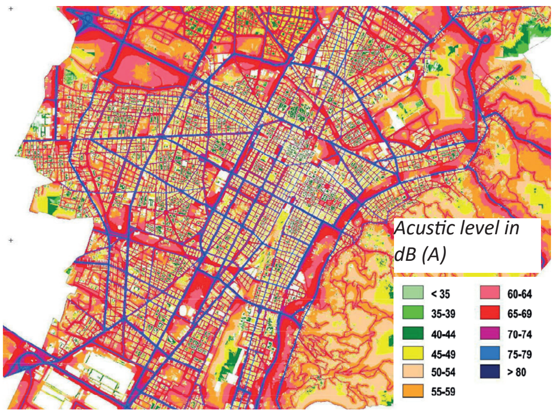
LAND SURFACE TEMPERATURE



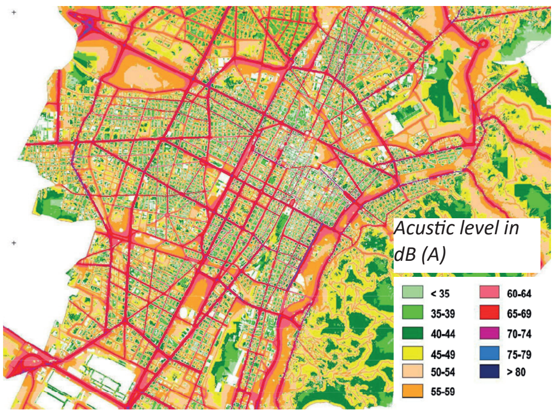
IMPERMEABLE URBAN AREAS



NOISE LEVELS - DAY TIME



NOISE LEVELS - NIGHTTIME



Approach 03
Environmental hazard

A - Lingotto 39 µg/m3 PM10

Category PUMS	*Street Name*	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E1	Via Pio VII	Solution 3+3 driving lanes with lateral parallel parking spots and lateral bike path.	→ Lateral bike lane → Parking lots with semi-permeable pavement and ground soil. → Service roads with two parallel Parking spot. → Lateral tree line	→ Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Creation and enlargement of green areas. → Improve space quality. → Improvement of pavement materials infiltration capacity.
E2	Corso Traiano	Solution 3+3 driving lanes with lateral parallel parking spots and lateral bike path. Tipology of central bus lane	→ Lateral bike lane → Parking lots with semipermeable pavement → Service roads with two parallel Parking spot. → Lateral tree line → Central autobus lanes in both senses	→ Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Creation and enlargement of green areas. → Improve space quality. → Improvement of pavement materials infiltration capacity.

B - Rebaundengo 41 µg/m3 PM10

Category PUMS	*Street Name*	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E1*	Corso Giulio Cesare	Solution 3+3 driving lanes with lateral parallel service roads of 1 to 2 lanes and central tram lanes in both directions. Two green lanes and lined trees.	→ No bike path → lateral parking spots on service roads. → Service roads with two parallel Parking spot. → Two Lateral tree line	→ Improve of urban greenery → Public space enlargement → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Creation and enlargement of green areas. → Creation and improvement of bike paths. → Improvement of pavement materials infiltration capacity.
E1	Via Nino Oxila	Solution 2+2 driving lanes and two autobus lanes.	→ No bike path → Lateral tree line on one side. → Central autobus lanes in both senses	→ Improvement of urban greenery. → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Creation and enlargement of green areas. → Creation and improvement of bike paths. → Improvement of pavement materials infiltration capacity.

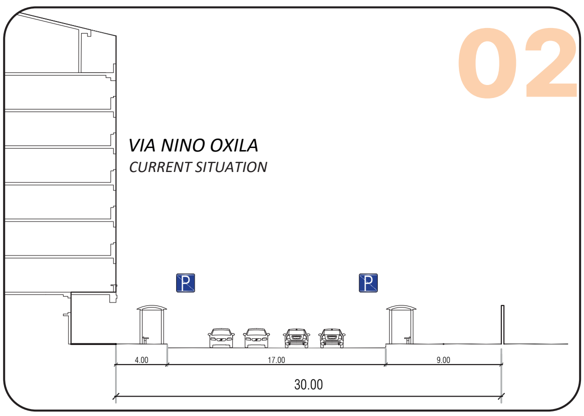
C - Grassi 39 µg/m3 PM10

Category PUMS	*Street Name*	*Solution Typology*	*Current situation*	*Strategies*	*Actions*
E2	Via Lanzo	Solution 2+2 driving lanes with central tram lanes in both directions. No green lanes.	→ Bike path → lateral parking spots → Tram lines	→ Improve of urban greenery → Public space enlargement → Materials reconfiguration to achieve environmental and comfort conditions → Increase of soil infiltration capacity → Improving space quality.	→ Creation and enlargement of green areas. → Improve space quality. → Improvement of pavement materials infiltration capacity.

Comparision Matrix for the third intervention approach streets.

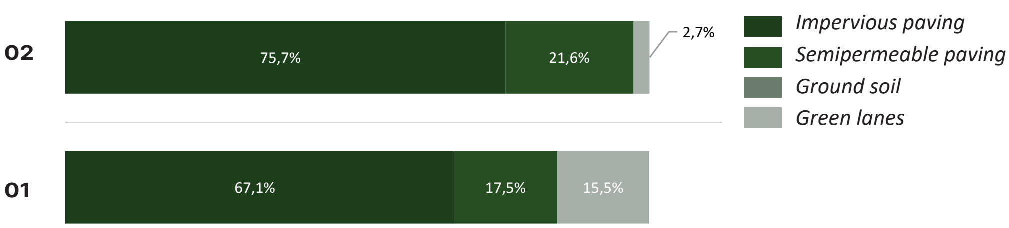
Analysis and Results

After overlapping the different risk layers, the highlighted areas are those where the superficial soil temperature is higher, where the public green areas are lower, where the acoustic mapping presents high noise levels, and where the air pollution of PM10 is higher. Then this approach shows the areas with an eventual environmental risk and points out the areas that need to be improved in terms of thermic comfort, acoustic comfort, and air quality.



SOIL QUALITY - INFILTRATION CAPACITY

ZONE A - REBAUDENGO



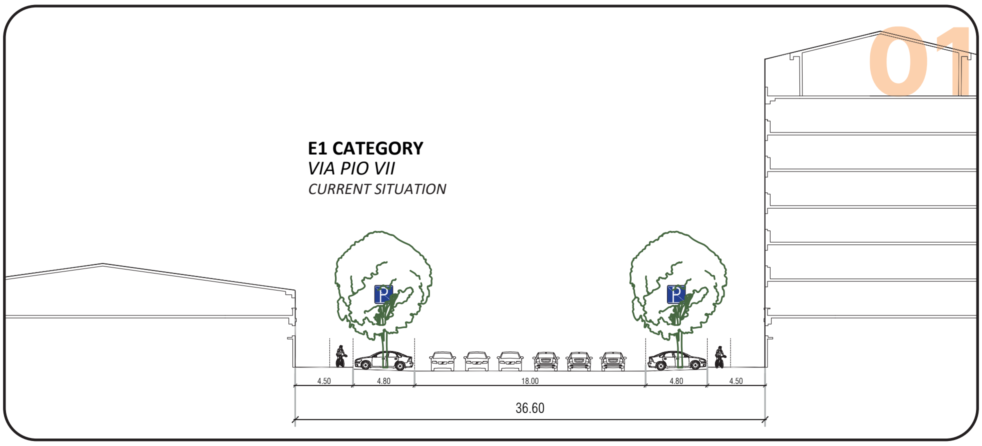
STRENGHT

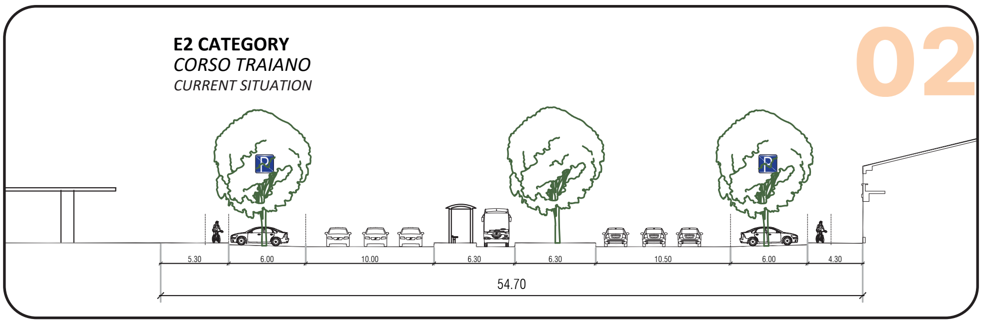
Is an objective approach with and input data and an output diagnosis. There is a problem, a diagnosis, and some actions to threat the problem.

WEAKNESS

The air quality condition is given by the monitored areas which in the urban area of Turin (without considering the ones in the metropolitan area) are just 5 stations, this reduces the accuracy of the approach in terms of risk factor by area.

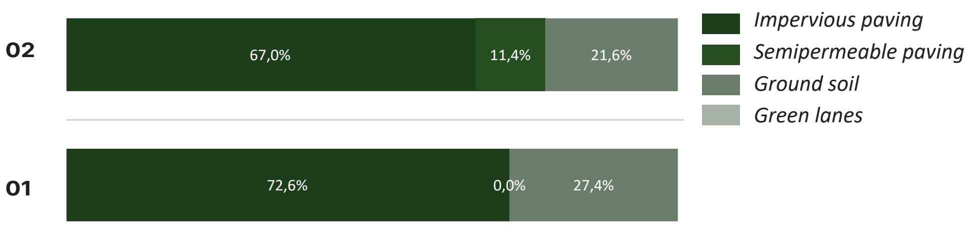
Once the areas are defined the street intersections are selected based on street category to reach at least two different street typologies. Is a more objective approach in the sense that the sum of the four factors is what gives each area a risk factor and an eventual need for intervention to reduce it.





SOIL QUALITY - INFILTRATION CAPACITY

ZONE B - LINGOTTO



OPPORTUNITIES

This approach suits the aim of find vulnerable areas regarding environmental hazards and giving a punctual action to the reduction of this vulnerability

d) Contrast Between approaches

Conclusions and suitability

The approaches shown previously are important to understand different perspectives and principles in which the aim of the study could be carried out, this could help broaden the understanding of the complexity of the urban grid. The importance of carrying out a process of comparison between the three approaches is necessary to choose a suitable area of intervention with a supported base. By comparing the different approaches, it becomes possible to identify their respective strengths and weaknesses. This analysis can provide insights into what each approach does well and where it may fall short. Understanding the limitations and drawbacks of each approach can inform better decision-making.

To carry out a correct process of contrast between the three urban approaches the following criteria were considered and summarized in Figure 54. The criteria to be considered are divided into principles, objectives, and quantitative - qualitative aspects of each approach. The qualitative criteria are summed up in a SWOT analysis (figure 46) done for each approach individually and the strengths and weaknesses are transversally compared between the three of them. Furthermore, the quantitative criteria include info such as the area suitable for intervention, the number of implicated roads and categories, and possible actions applied to the site.

S	W	O	T
Site-specific character. The design intervention would answer specifically to each settlement and more specifically to each neighborhood. The intervention over the street can answer to a close loop between blocks.	The quantity of punctual actions is greater than other approaches (a different type of intervention for each street typology for the three different settlements)	The social component is considered in a further way in difference with the rest of the approaches.	This approach is variable since it can be applied eventually to other settlements with the same line of reasoning, to the same street typologies and obtain different results, different strategies to be considered and different actions to be applied.
Once the data of each road that comprehend the circuit is gathered and the survey done the process of street diagnosis is reduced, analysis due to a limited number of actions over a large area of intervention This approach presents a bigger area of intervention respect to the alternatives approaches.	As the scale of the approach is larger, the actions to be implemented do not consider the particularities of each street but the common characteristics of each road category. This doesn't allow a site-specific intervention but a larger scale impact.	The applicability of this approach is focused to be applied on large vehicular axes; this means a broader impact of the NbS implemented.	The approach considers a greater amount of road sections respect to the alternative's approaches, the amount of data collection and information gathered respect to the other approaches is also more.
Is an objective approach with and input data and an output diagnosis. There is a problem, a diagnosis and some actions to threat the problem.	The air quality condition is given by the monitored areas which in the urban area of Torino (without taking into account the ones in the metropolitan area) are just 5 stations, this reduces the accuracy of the approach in terms of risk factor by area.	This approach suits the aim of find vulnerable areas regarding environmental hazards and giving a punctual action to the reduction of this vulnerability	

Comparision Matrix and SWOT Analysis for the three intervention approaches presented previously.

CONTRASTING APPROACHES

CRITERIA LIST	Intervention by neighborhoods	Intervention by street corridors	Intervention by environmental hazard
Common Objective	To present the NbS as feasible tools to be implemented in the urban public space; specifically in the road profile as an alternative tactic to mitigate and reduce the climate vulnerability of Torino.		
Specific principle	Intervention by neighborhoods	Intervention by street corridor	Intervention by environmental hazards
Specific objective	Implement NbS in the road profile to mitigate and reduce climate vulnerability in specific urban settlement complex by their diversity.	Implement NbS in the road profile to mitigate and reduce climate vulnerability a large vehicular axes.	Implement NbS in the road profile to mitigate and reduce climate vulnerability in zones with highlighted environmental risks.
Roads analysed *[Unit]*	10	5	6
Street category analysed *[Unit]*	4	2	3
Intervention lenght *[Km]*	5.5 Km	16 Km	9 Km
Area to be intervened* *[Percentge of Km by street section]*	32%	47%	49%
Strenghts	→ Site-specific character. → Intervention consider as a close loop between blocks. → The social component could be better ddevelop due to the site-specific focus.	→ Reduce process of street diagnosis. → Limited number of actions over a large area of intervention. → Bigger area of intervention → Larger scale impact.	→ Objective approach with and input data and an output diagnosis. → Mid size intervention among the three approaches
Weaknessess	→ The area to be intervened is the lower among the approaches. → The quantity of punctual actions is greater than other approaches	→ The actions do not consider the particularities of each street but the common characteristics of each road category.	→ Accuracy of the approach depends on the available data done by the environmental competent agencies.

Comparision Matrix contrasting approaches.

* Area appropiate to be intervened: Calculation consider with reduction of one driving lane and non vehicular zones able to be intervented. Percentage calculted in Km respect to the total width of the road profile

Conclusions and suitability

The three approaches present remarkable strengths and important qualitative and quantitative components that make each one of them suitable as approach for urban intervention, nevertheless, the sum up of each criteria together is what defines the better approach to be used in this study.

Summarizing the first approach has as a principle an urban analysis by the site/specific settlements, this can be supported by the number of roads analyzed, the approach with the higher number of roads analyzed, and the one with the bigger variety of street categories, this support the first hypothesis in which this approach could require an extensive analysis than the other approaches because of its variety of elements to study and examine. On the other hand, the strengths of this approach are its site-specific character and the social component inherent to this type of specificity in analysis. Nevertheless, the percentage of area to be intervened is the lower of the three approaches probably because of the local roads category that appear to be the ones with less length able to be intervened.

Furthermore, the second approach presents interesting numbers, it is the approach with the higher intervention length supporting the earliest hypothesis in which the second approach would be aligned into a bigger intervention scale. Additionally, the area to be intervened is also an important percentage that shows the strengths of using large vehicular axes and achieving a bigger area of intervention and larger scale impact.

Moreover, the third approach has as a principle the analysis by environmental hazard, focusing on **zones with highlighted environmental vulnerabilities; this is a big strength of the approach because the approach better aligns with the main objective of the study.** The Area to be intervened presents an important percentage even if the intervention length is not as high as the previous approach, not the lower one among the three. Furthermore, the number of roads and categories analyzed can be considered an opportunity because there is a value between the other two approaches. This means the analysis won't be as specific as the first approach nor as general as the second one. Nevertheless, the weakness of this approach lies in the data shared by the environmental agencies, because the accuracy of the approach depends on the measurements available, which are directly related to the amount of measuring stations placed in the urban area of Turin.

Finally, because of the correspondence **between the principle and specific objective, the third approach is the most suitable for carrying out the next step in the study regarding the intervention of street profiles.** In addition, the quantitative aspect of the third approach supports the decision due to the number of roads and variety of street category that allows an optimal overview of the design in diverse roads.

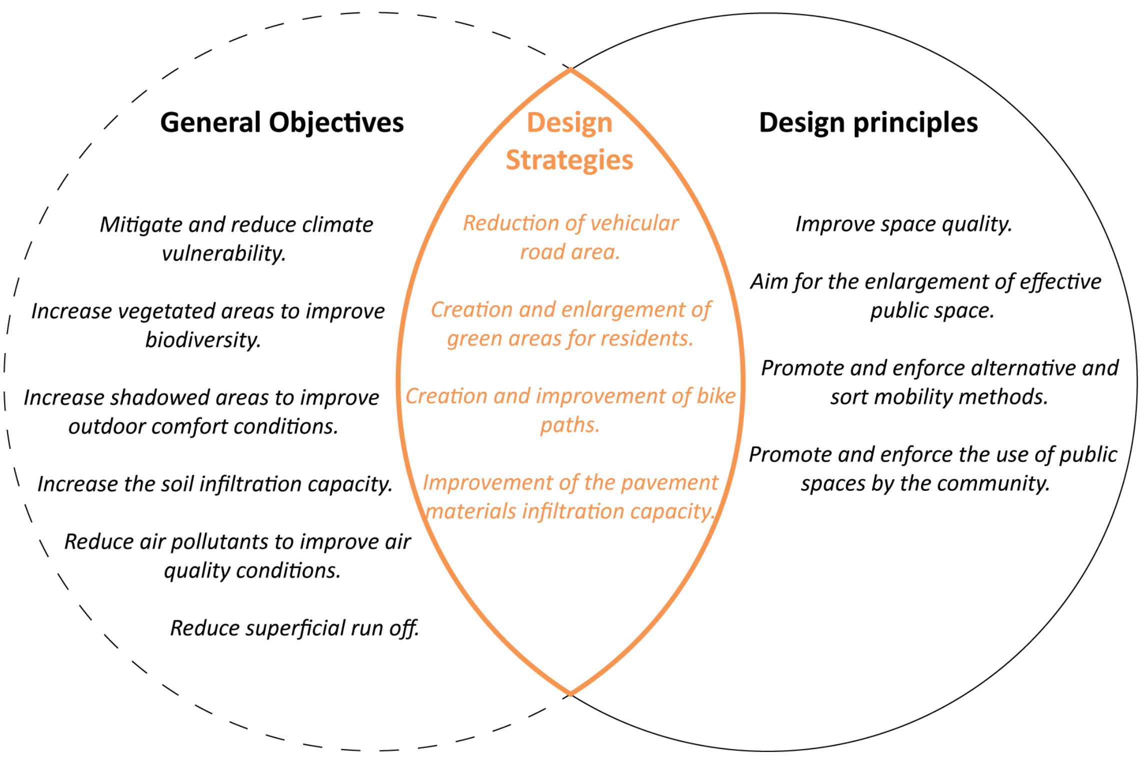
3.3 INTERVENING THE STREETS

STRATEGIES AND TOOLS FOR A PRELIMINAR DESIGN

a) Conditions of operativity

Strategies and actions

The approaches shown previously are important to understand different perspectives and principles in which the aim of the study could be carry out, this help broaden the understanding of **the complexity of urban grid.** Clearly the importance of carry out a process of comparison between the three approaches was necessary to choose a suitable area of intervention with a supported base. By comparing the different approaches, it became possible to identify their respective strengths and weaknesses. This analysis provided insights into what each approach does well and where it may fall short. Understanding the limitations and drawbacks of each approach helped to inform a **better decision-making.**



Design strategies - Concept diagram.

b) Rebaudengo study case

Method of procedure

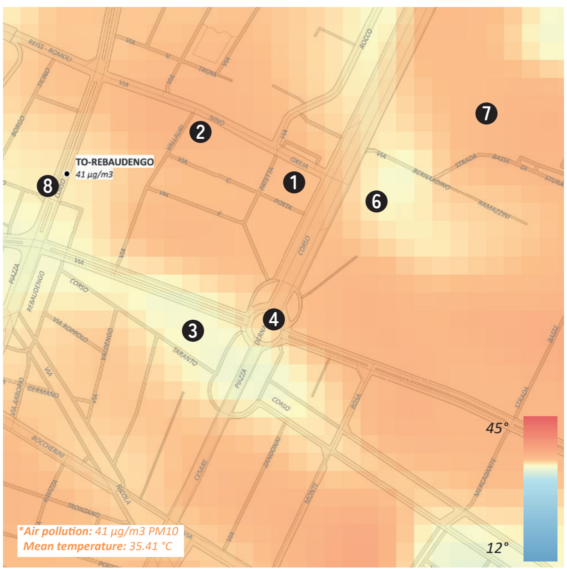
After selecting the Approach the next step taken is the concept, to achieve a precise and optimal design proposal the general objectives and the design principles were considered to create the design strategies, these strategies would be applied over each road section taking into account the particularities of each profile. The Design strategies show the path to follow and the actions to be taken. The actions were divided into three components to have a better comprehension of them: Soil management, Green and blue management, and infrastructure management. Additionally, the design strategies were specified to achieve the general objective of mitigating and reducing the climate vulnerability through the application of NBS in the road profile.

Analysis

From the third approach, two site interventions were considered due to the mapping of the environmental risk. On the north, the area Rebaudengo, and on the south, Lingotto. For both areas an urban analysis (on a scale 1:5000 – A3) was performed in which the infrastructure conditions of mobility, land surface temperatures, permeable and impermeable areas, and noise levels for the day and night time were checked.

LAND SURFACE TEMPERATURE

SCALE: 1:5000 - A3



01 *Scuola secondaria "Bernardo Chiara"*
02 *Parrocchia San Giuseppe*
03 *Giardino Jaquerio*
04 *Piazza Derna*
05 *Multiple gas stations*
06 *Several automobile sales point and automovilistic servi-ces - Mercedez Benz and susuki*
07 *Food and packing storages*
08 *Monitoring stations*

PERMEABLE AND IMPERMEABLE AREAS

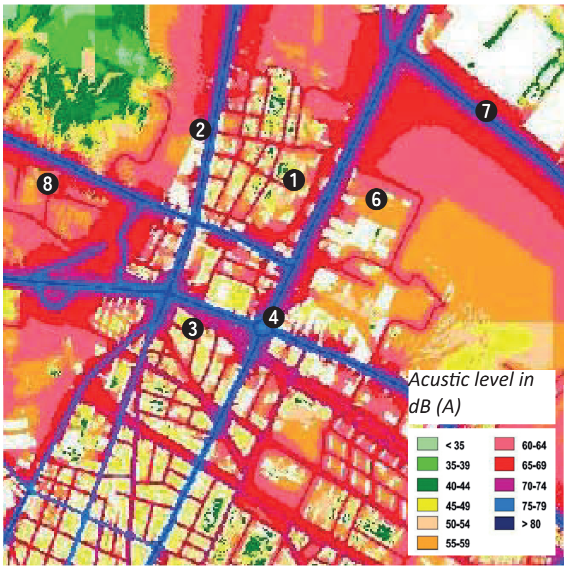
SCALE: 1:5000 - A3

Permeable surfaces

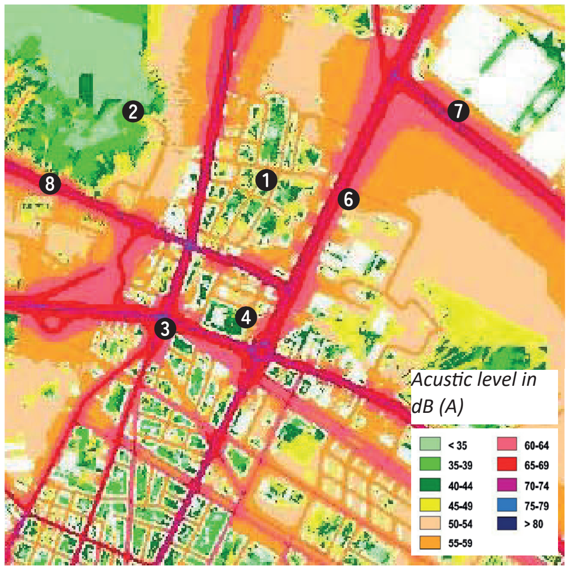
Non permeable surfaces

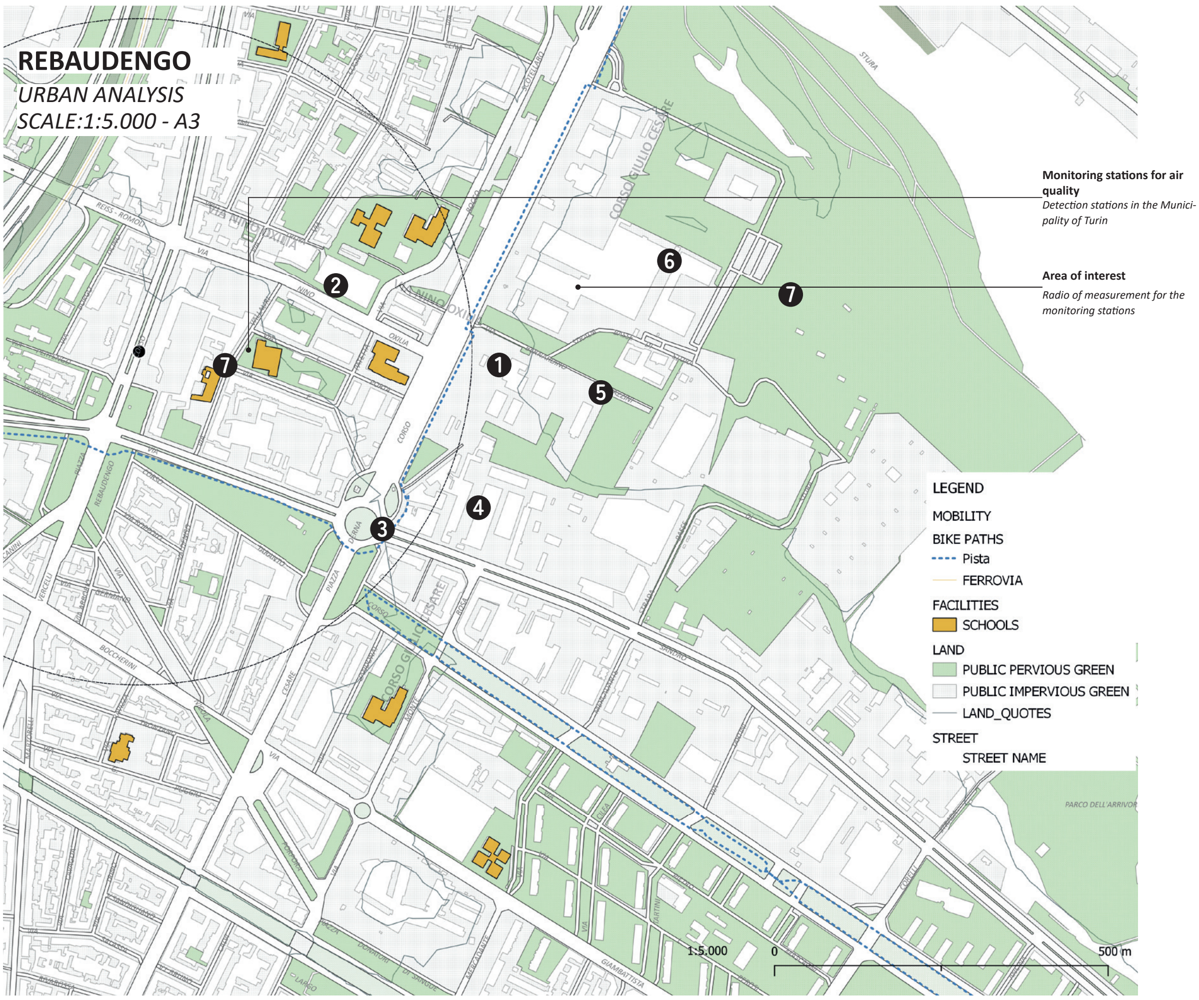
Source: Cartography from GeoPortale

NOISE LEVELS - DAY TIME
SCALE: 1:5000 - A3



NOISE LEVELS - NIGHTTIME
SCALE: 1:5000 - A3





Furthermore the analyses goes into detail in a smaller scale (1:2000 – A3) in which the street profiles and their characteristics are detailed. Additionally, this scale is useful to differentiate the accessible from the not accessible green public space.

LEGEND

Accesible green areas
Soil-Grass
Non accesible green areas
Soil-Grass
Non permeable areas
Pedestrian paths - Private grounds
Bike lanes
Non permeable surfaces

Intervention streets
Non permeable surfaces
Secondary streets - service lanes
Non permeable surfaces
Mix lanes for public acces [Pedestrian and bike]
Semi-permeable surfaces

Existing buildings
-
Vegetated areas
Existing and proposed vegetation
Monitoring stations for air quality
Detection stations in the Municipa-lity of Turin

The street sections already presented previously were structural part of the site analysis because they graphically represented the street physical and quality conditions in percentage terms.

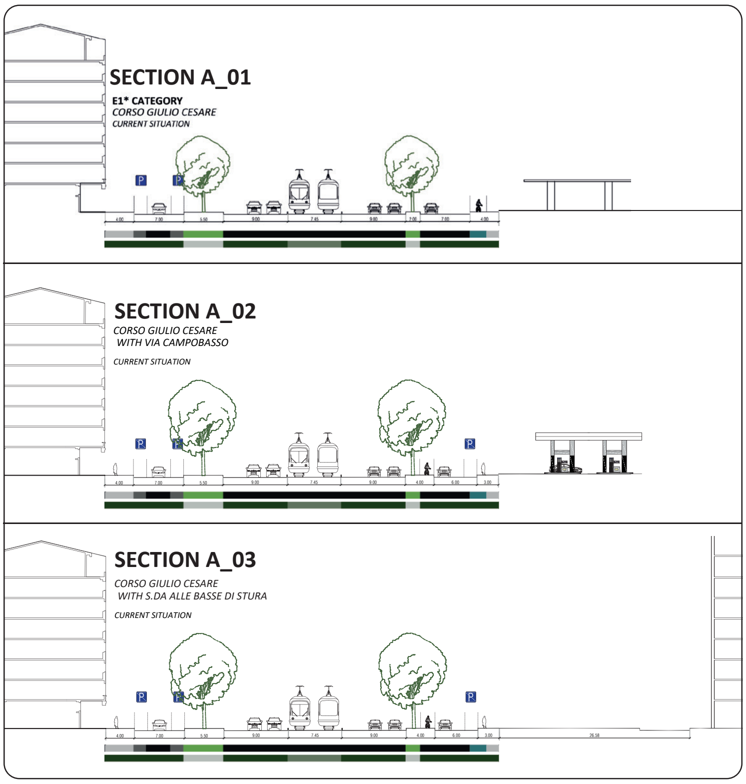
STREET PROFILE - CURRENT SITUATION

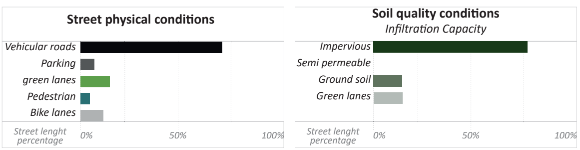
SCALE: 1:500 - A2

STREET PROFILE - CURRENT SITUATION

SCALE: 1:500

CORSO GIULIO CESARE

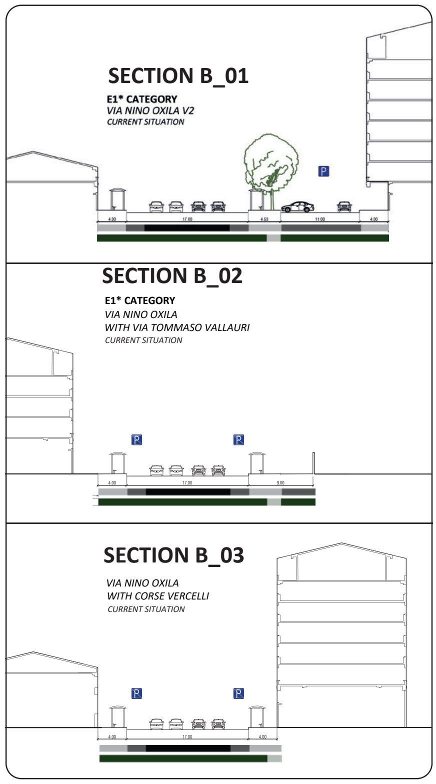


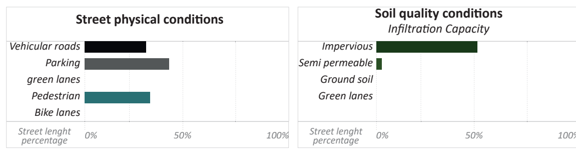


STREET PROFILE - CURRENT SITUATION

SCALE: 1:500

VIA NINO OXILIA



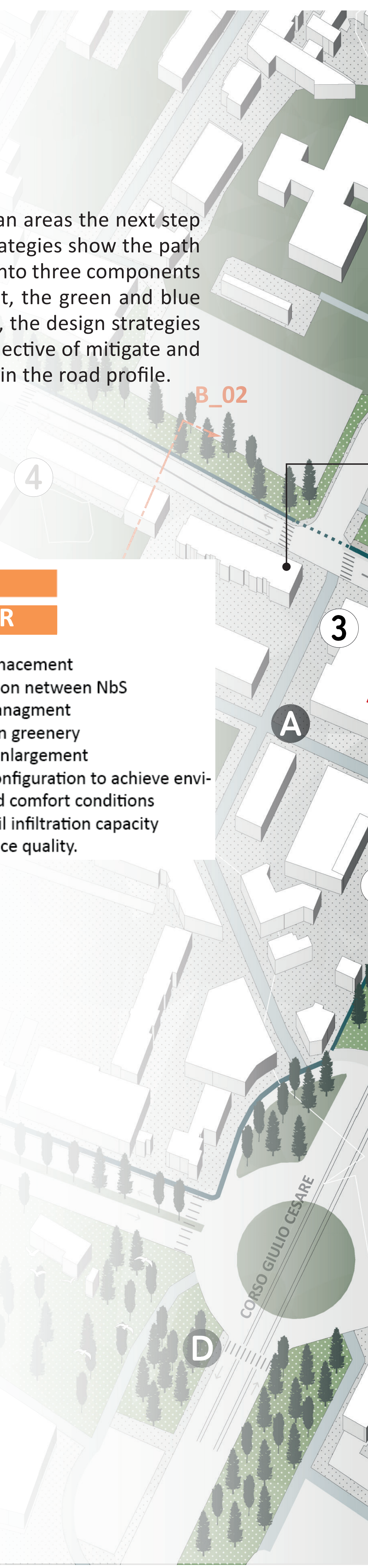


Design proposal

The design strategies are applied and represented in two scales of intervention. The local scale (1:2000) to express the composition within the immediate urban context of each intervention street and its connectivity and relation with the mobility system and the public recreational space.
 The other scale of intervention (1:200) is done over the street profile having as main guidelines the differentiation of the intervened length and the variable length. This last statement means that the proposals take into consideration the irregularity of all the streets, the changes that could be done for instance in the front part of every private property as a setback or a set forward. Every street profile is graphically represented the new physical and soil quality conditions plus the NBS applied, and the ecosystemic services recovered and applied.

Design proposal

Once the analysis is done over three different scales in the urban areas the next step is to follow and apply the strategies and actions. The Design strategies show the path to follow and the actions to be taken. The actions were divided into three components to have a better comprehension of them: the soil management, the green and blue management, and the infrastructure management. Additionally, the design strategies were specified into specific strategies to achieve the general objective of mitigate and reduce the climate vulnerability through the application of NBS in the road profile.



SPECIFIC ACTIONS BY COMPONENTS

Soil Management

S1 Natural Soil-Vegetable
S2 Asphalt paving
S3 Stone and concrete slabs
S4 Dreaning asphalt paving
S5 Mineral paving in “Calcestre”
S6 Brick dreaning pavement for parking
S7 Concrete hole-blocks semipermeable

Green-Blue Management

G1 Infiltration trenches
G2 Floodable basin
G3 Treed mineral squares for temporary use
G4 Tree lined streets
G5 Ground cover vegetation *[Low height]*
G6 Acrubbing masses/Bushes *[Medium height]*
G7 Trees *[Tall height]*
G8 Recover rain water from building’s roof

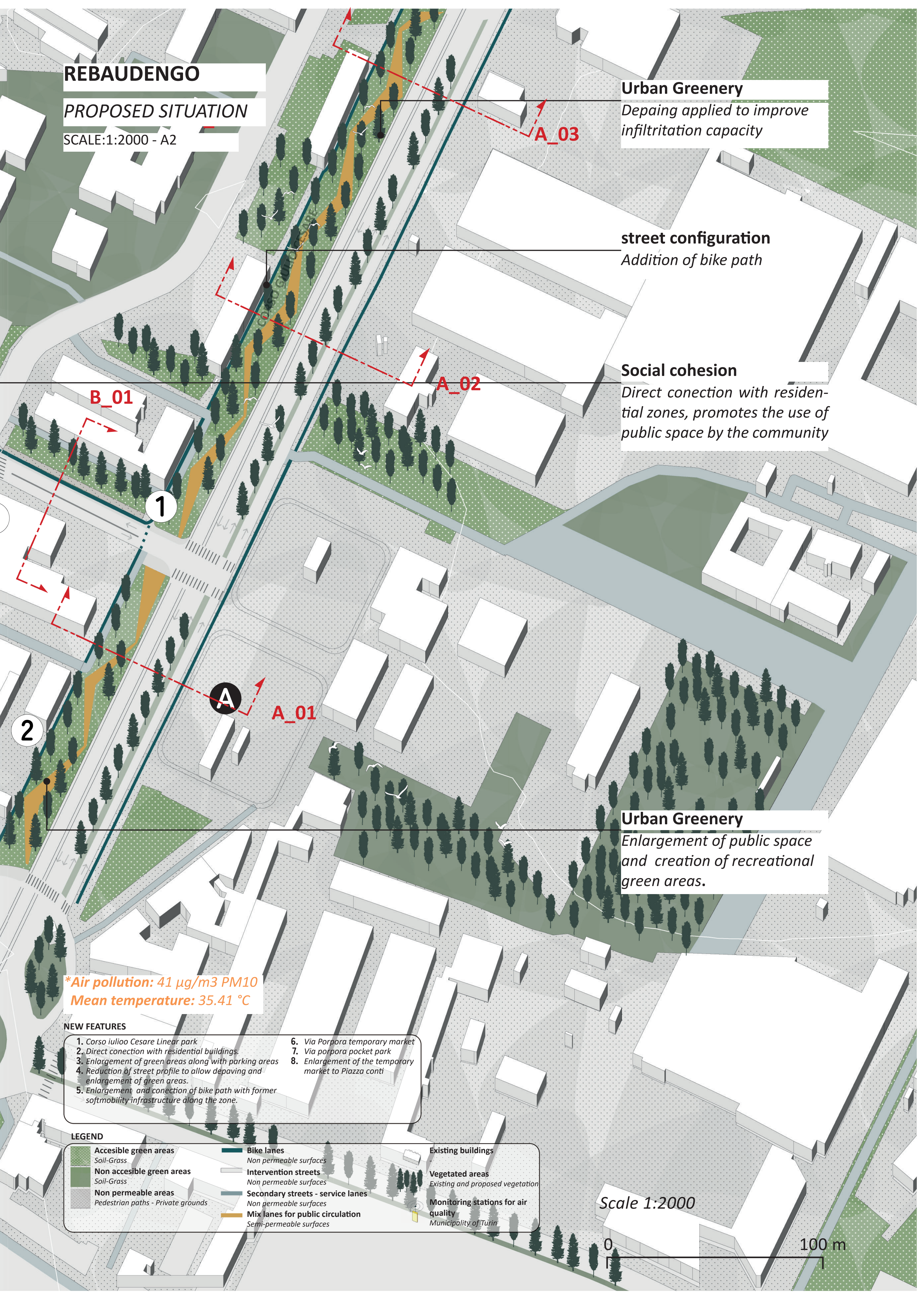
Infrastructure Management

I1 Pedestrian path enlargment
I2 Bike path creation or improvement
I3 Parking lots Creation or improvement
I4 Depaving of impermeable soil
I5 Shaded devices *[Pergola]*
I6 Urban furniture
I7 Passive cooling for air temperature *[Fountain - water spray/mist]*

GENERAL STRATEGIES STR

STR_1 Infiltration enhacement
STR_2 SUDs integration netween NbS
STR_3 Rain water managment
STR_4 Enhance urban greenery
STR_5 Public space enlargement
STR_6 Materials reconfiguration to achieve environmental and comfort conditions
STR_7 Increase of soil infiltration capacity
STR_8 Improving space quality.

Design strategies - Concept diagram.

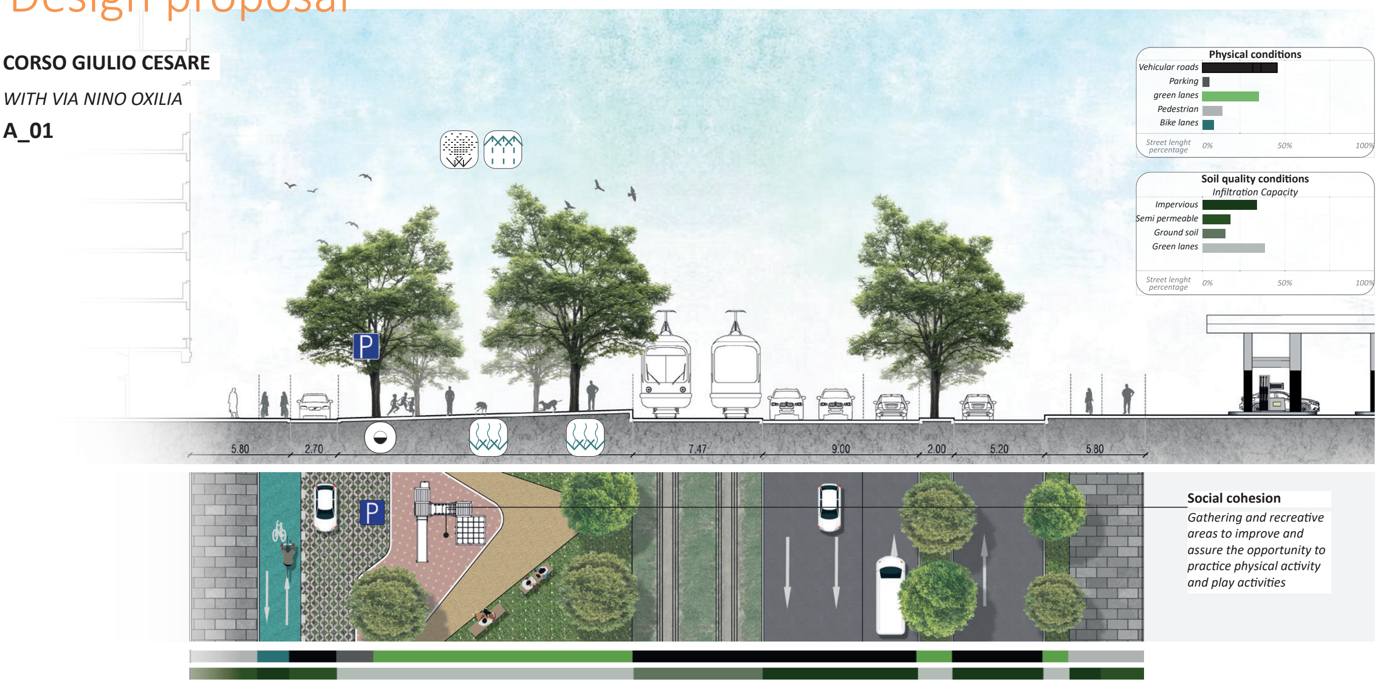

REBAUDENGO
PROPOSED SITUATION
SCALE:1:2000 - A2
Urban Greenery
Depaing applied to improve infiltritation capacity
A_03
street configuration
Addition of bike path
CORSO GIULIO CESARE
Social cohesion
Direct conection with residential zones, promotes the use of public space by the community
A_02
B_01
1
2
A
A_01
Urban Greenery
Enlargement of public space and creation of recreational green areas.
*Air pollution: 41 µg/m3 PM10
Mean temperature: 35.41 °C
NEW FEATURES
1. Corso iulioo Cesare Linear park
2. Direct conection with residential buildings.
3. Enlargement of green areas along with parking areas
4. Reduction of street profile to allow depaving and enlargement of green areas.
5. Enlargement and conection of bike path with former softmobility infrastructure along the zone.
6. Via Porpora temporary market
7. Via porpora pocket park
8. Enlargement of the temporary market to Piazza conti
LEGEND
Accesible green areas
Soil-Grass
Non accesible green areas
Soil-Grass
Non permeable areas
Pedestrian paths - Private grounds
Bike lanes
Non permeable surfaces
Intervention streets
Non permeable surfaces
Secondary streets - service lanes
Non permeable surfaces
Mix lanes for public circulation
Semi-permeable surfaces
Existing buildings
-
Vegetated areas
Existing and proposed vegetation
Monitoring stations for air quality
Municipality of Turin
Scale 1:2000
0
100 m

Design proposal

CORSO GIULIO CESARE

WITH VIA NINO OXILIA

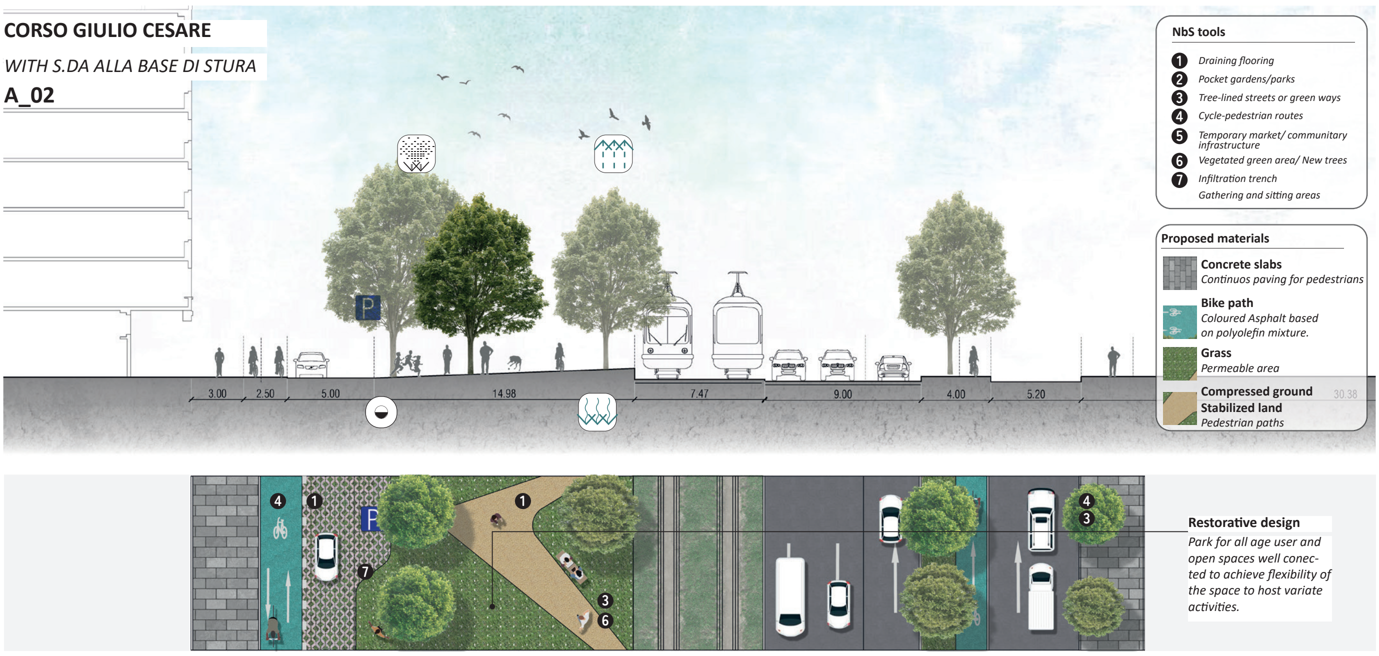
A_01



CORSO GIULIO CESARE

WITH S.DA ALLA BASE DI STURA

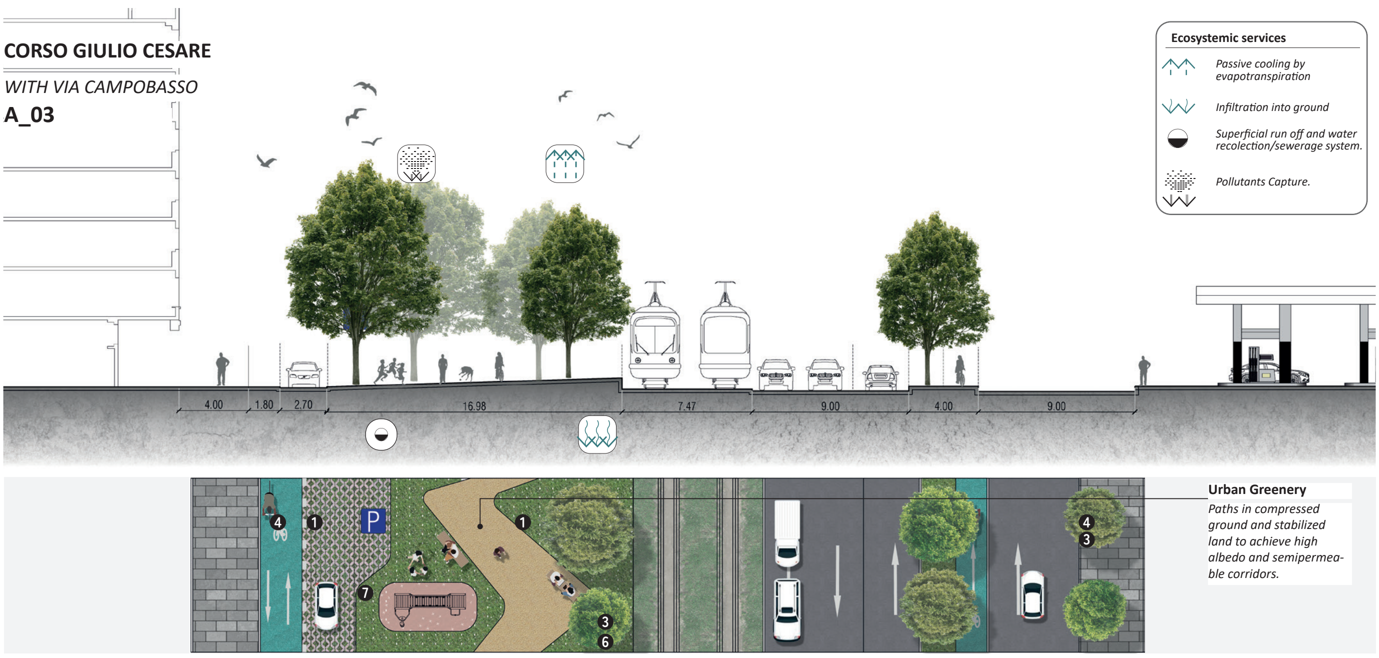
A_02



CORSO GIULIO CESARE

WITH VIA CAMPOBASSO

A_03



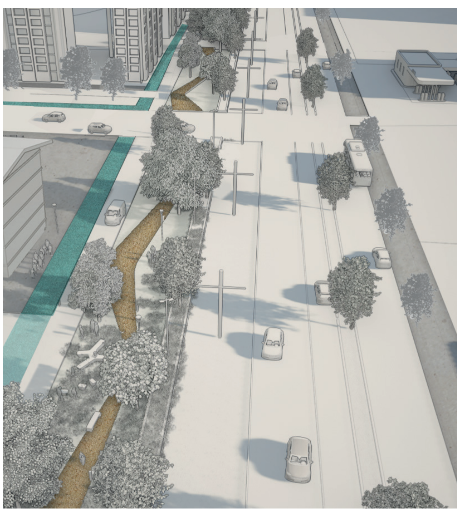
Perspective view of the proposed situation in Corso Giulio Cesare.
(Note: Built context used as graphic reference)

URBAN SCHEMES

GREEN INFRSTRUCTURE

Linear park and green ways along the street corridor

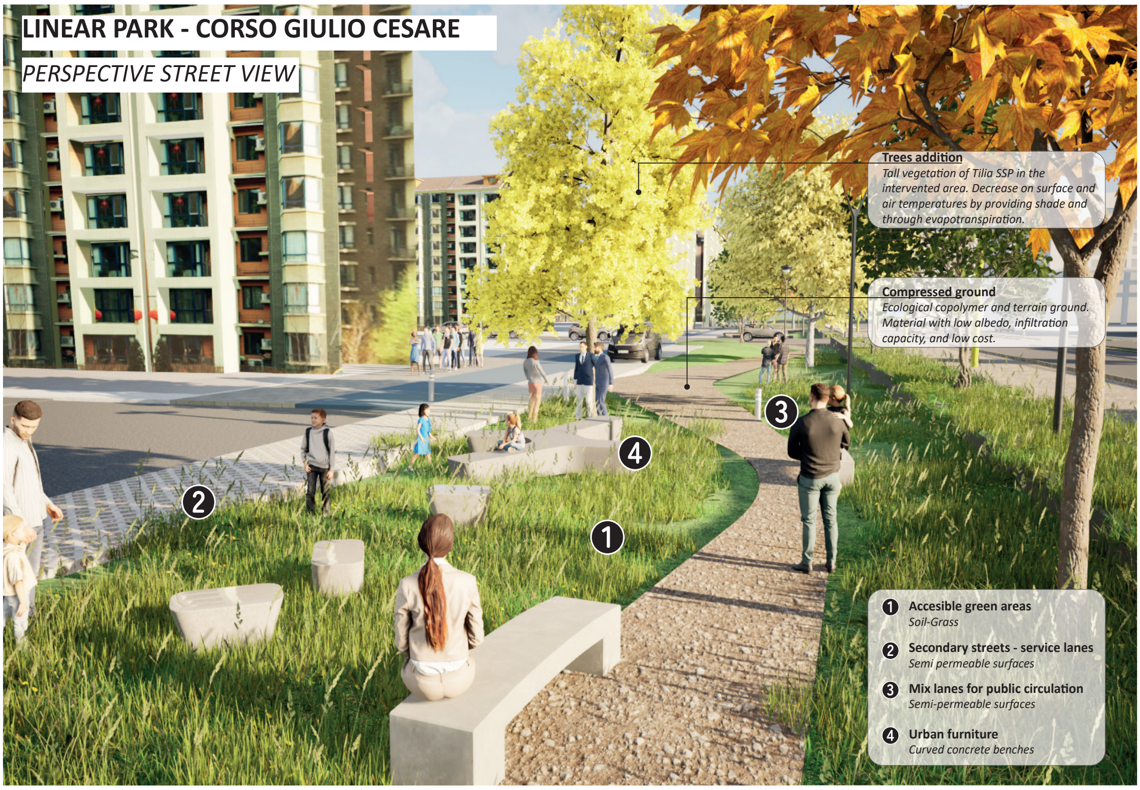
SOFT MOBILITY



Bike paths, mix lanes, and peestrian paths connected beetween them

VEHICULAR MOBILITY

Services lanes, tram lane and vehicular lanes.



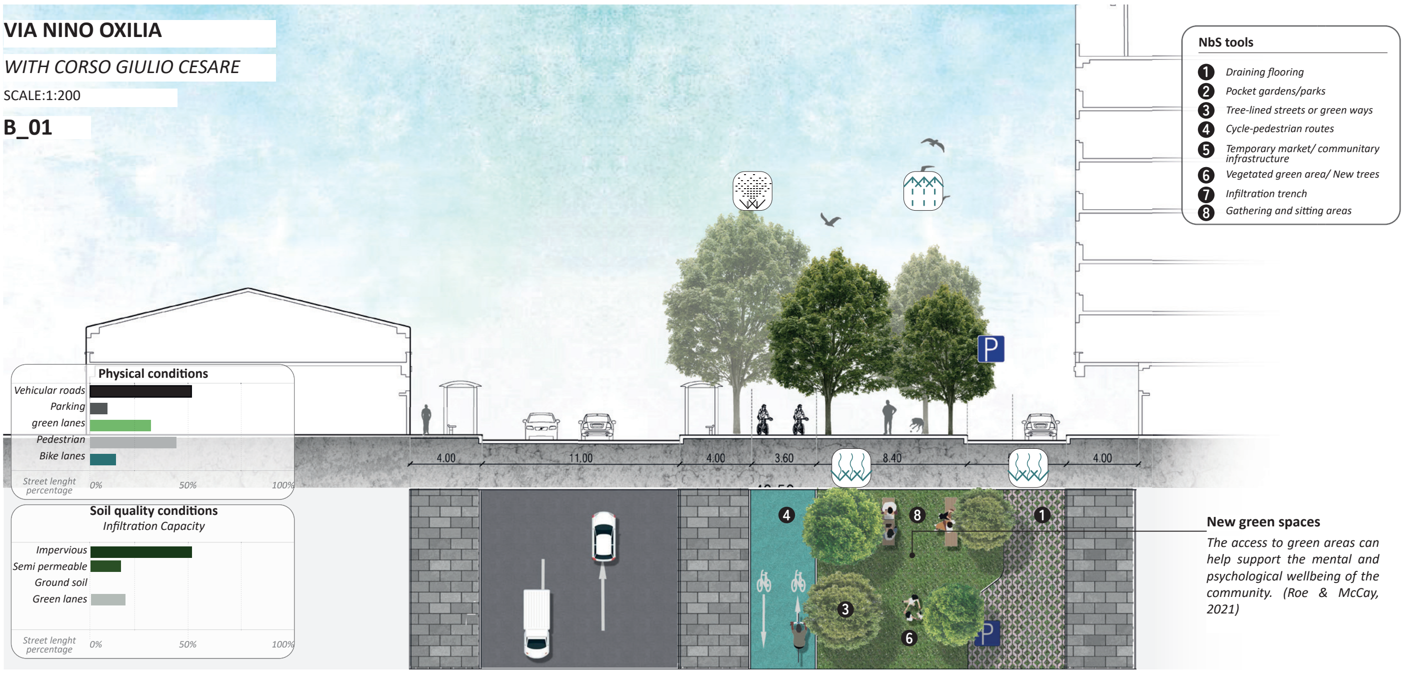
The enlargement of public space not only increases the infiltration capacity of the soil but also improves the wellness of the community, the access to green areas can help support the mental and psychological wellbeing of the community. (Roe & McCay, 2021)
The UGI not only improves environmental conditions and ecosystemic services but also enhances social relationships and connections among the community with new spaces such as gathering areas, playgrounds, and temporary markets.

VIA NINO OXILIA

WITH CORSO GIULIO CESARE

SCALE:1:200

B_01



New green spaces

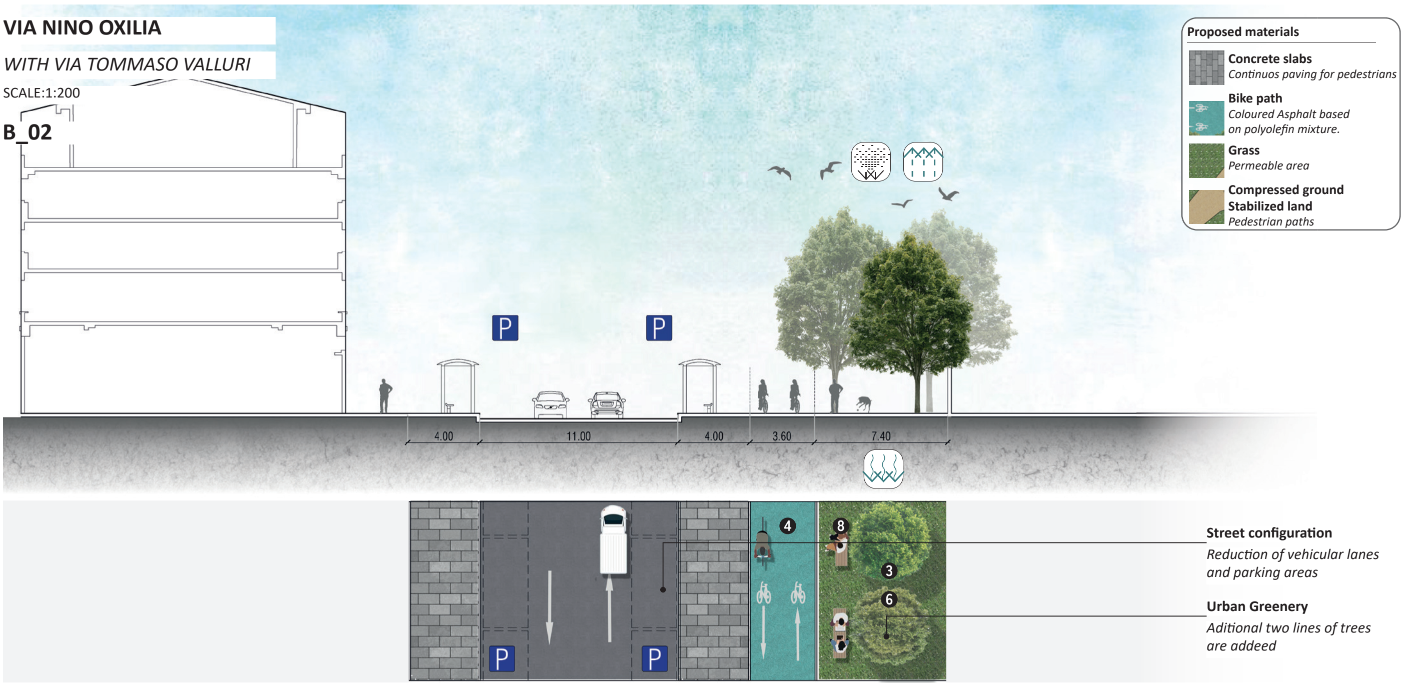
The access to green areas can help support the mental and psychological wellbeing of the community. (Roe & McCay, 2021)

VIA NINO OXILIA

WITH VIA TOMMASO VALLURI

SCALE:1:200

B_02



Street configuration

Reduction of vehicular lanes and parking areas

Urban Greenery

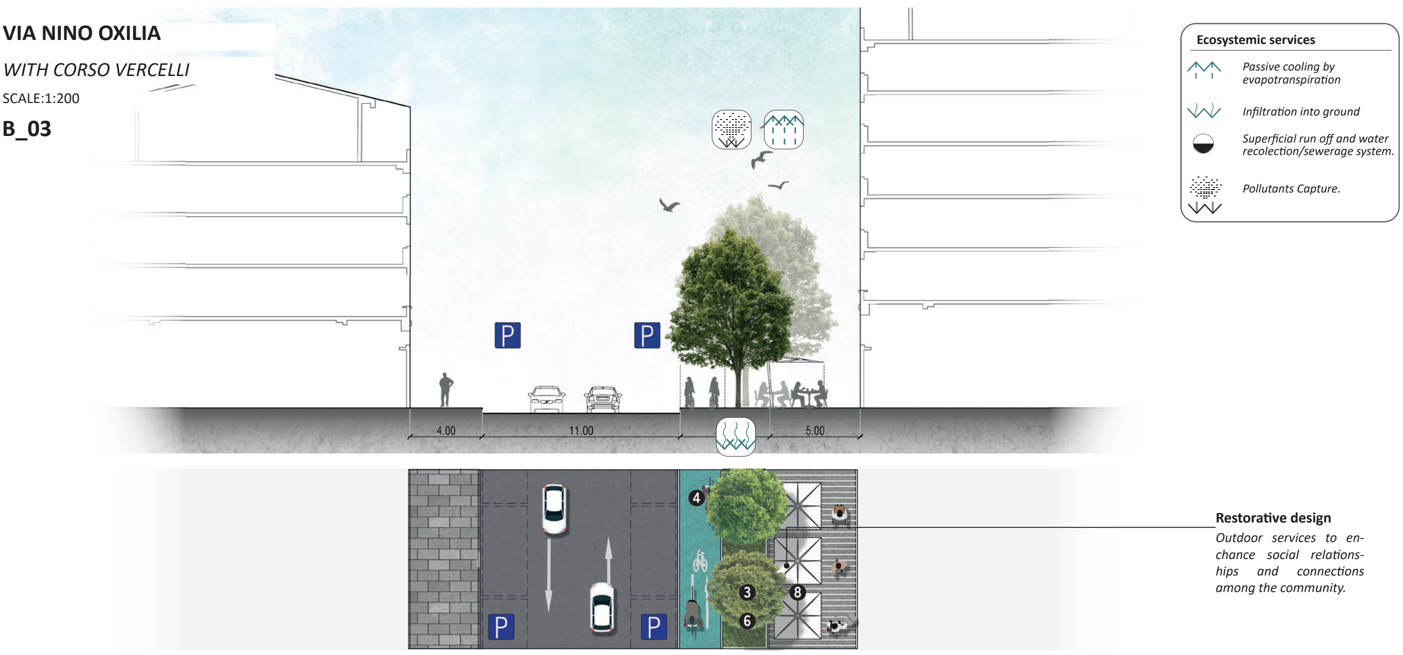
Aditional two lines of trees are addeed

VIA NINO OXILIA

WITH CORSO VERCELLI

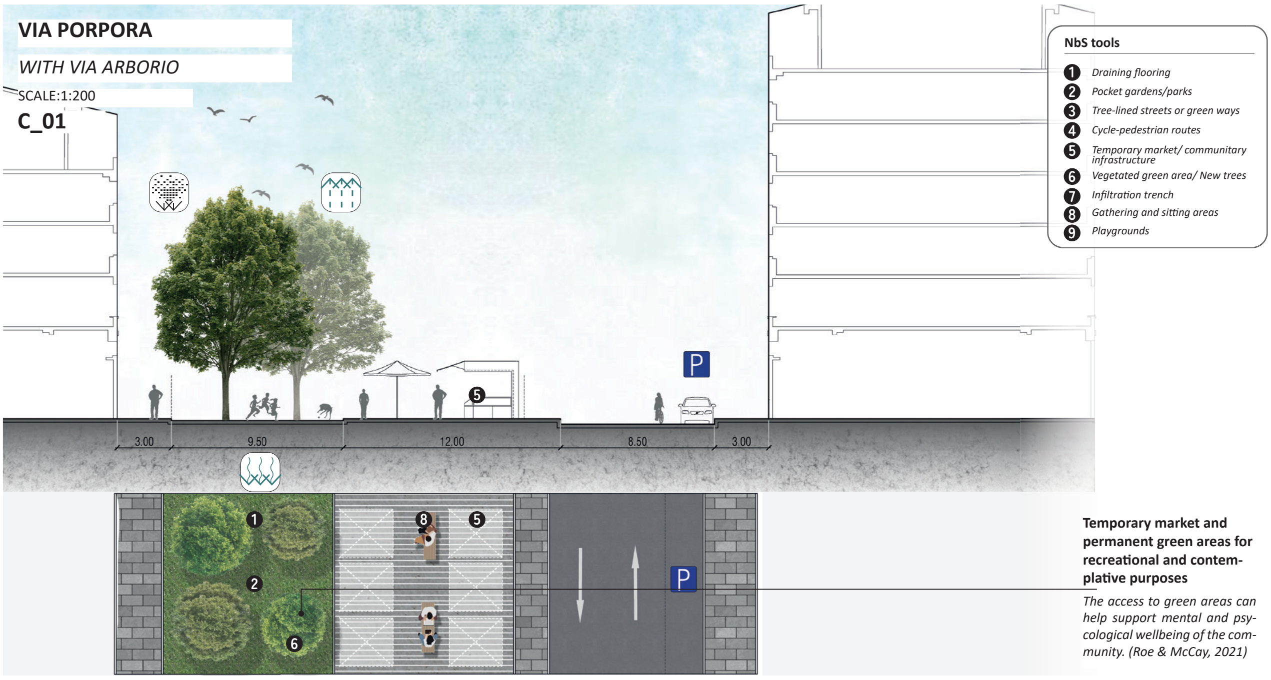
SCALE:1:200

B_03

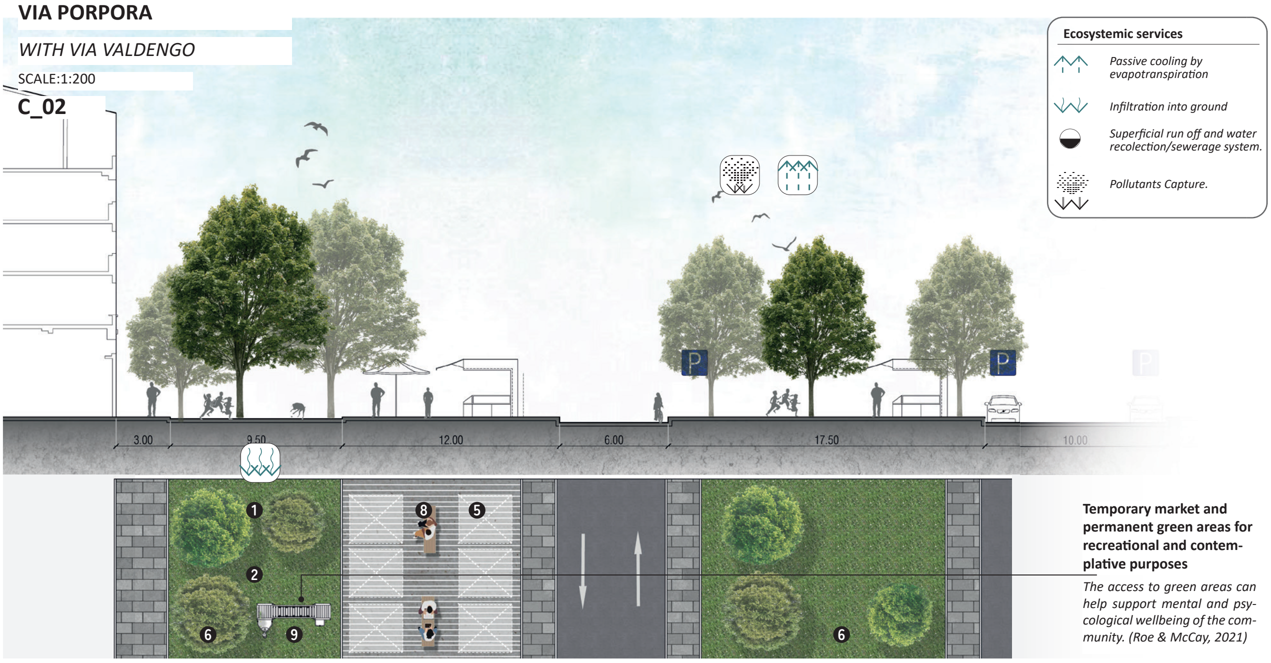


Restorative design

Outdoor services to enchance social relationships and connections among the community.



This street has a main characteristic that is, the street market. It takes place at Via Porpora, in the stretch between via Boccherini and via Arborio; it is an important point of reference for the inhabitants of the area for the sale of fruit and vegetables.; it is also a crossing point between the two commercial axes: Corso Vercelli and Corso Giulio Cesare.
Currently this street lacks of vegetation, green areas, or urban furniture to sit and gather due to the presence of the market. Unfortunately, when there's no market there's also no suitable place for recreation or simply healthy contemplation.
The proposed design aims to create a consistent green pocket park for the street and its inhabitants, along with a designated space for a temporary market.



Results and conclusions

Corso Giulio Cesare.

Due to its condition of high capacity urban street category (E1*), the intervention respects the tram lane and reduces two car lanes of the whole profile. The results on permeable surfaces showed in the elevations and the value charts showed more or less the double of green permeable surfaces increased due to the linear park as a result of the intervention over the service lanes. However, the reduction on vehicular roads maintains the same number of central vehicular lanes because the reduction was applied to the service lanes.

Via Nino Oxilia

On the other hand, Via Nino Oxilia currently has an overlength vehicular profile that can be slightly reduced to improve the soft mobility conditions as the pedestrian and bike mobility, additionally to allow activities such as outdoor cafes and sitting gathering areas. The improvement in terms of alternative mobility is greater than the one in Corso Giulio Cesare just because of the lack of separate bike paths on this street. Nevertheless is also considered that in a street category such as Nino Oxilia (E1) a mixed lane between vehicles and bikes can be considered an option.

Via Porpora.

With the design proposal, the street and its residents would have a constant green pocket park and an established area for the temporary market. The width of the market area is reduced to allow space for a pocket line park. However, to compensate for this loss, the market is proposed to be enlarged in length until via Arborio. In this way, the residents would continue enjoying of the street market plus an improvement on public space infrastructure. Improving the space conditions making it suitable for recreational purposes and increasing Infiltration areas, implementing NBS, and some shadowed areas.

c) Lingotto study case

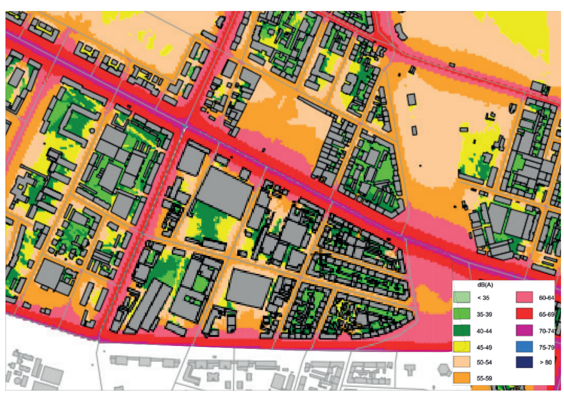
This case follows the same conditions of operability and design parameters established previously. With the same line of process the case study is analyzed and afterward, a design proposal is done.
As previously done, in this case was performed an urban analysis on a scale of 1:5000 in format A2 was performed in which the infrastructure conditions of mobility, land surface temperatures, permeable and impermeable areas, and noise levels for the day and night time were checked.

LAND SURFACE TEMPERATURE

PERMEABLE AND IMPERMEABLE AREAS

ACOUSTIC MAPPING OF ROAD INFRASTRUCTURES
DAY LEVELS

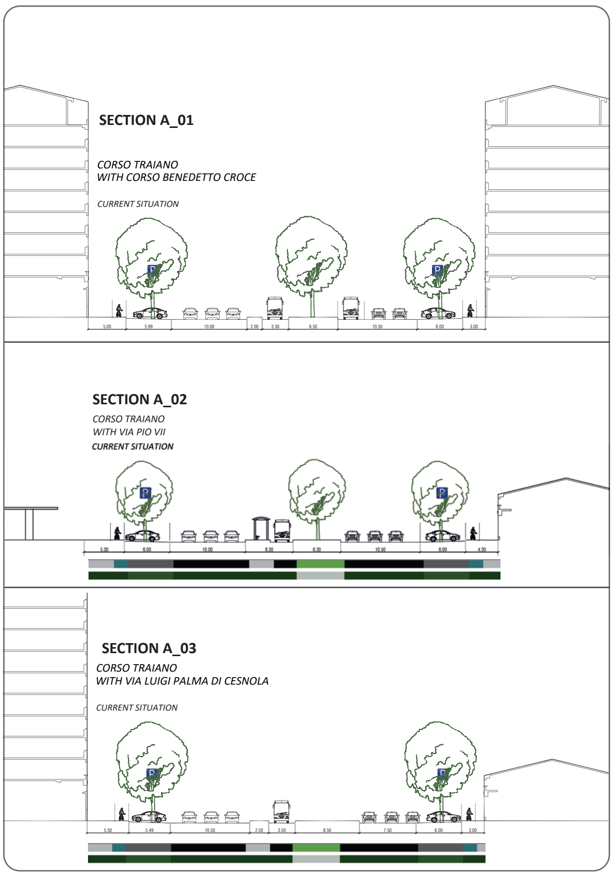
ACOUSTIC MAPPING OF ROAD INFRASTRUCTURES
NIGHT LEVES

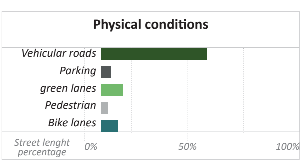


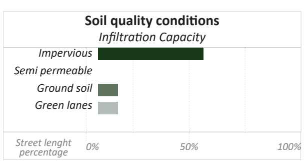
STREET PROFILE - CURRENT SITUATION

SCALE: 1:500

CORSO TRAIANO



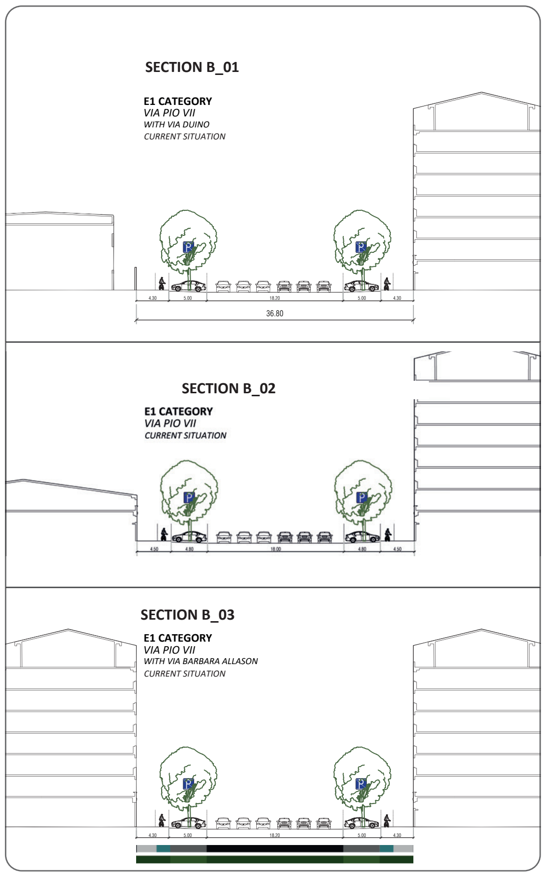


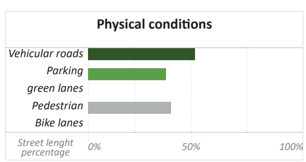


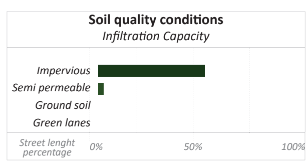
STREET PROFILE - CURRENT SITUATION

SCALE: 1:500

VIA PIO VII







CORSO TRAIANO

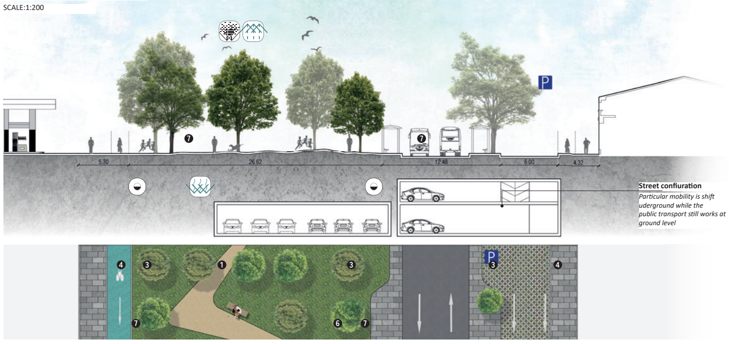
WITH VIA BENEDETTO CROCE

SCALE:1:200

CORSO TRAIANO

WITH VIA PIO VII

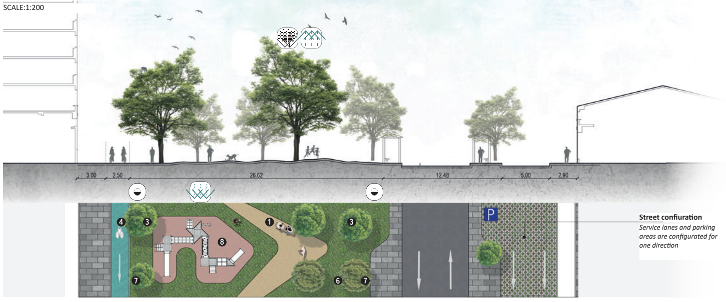
SCALE:1:200



CORSO TRAIANO

WITH VIA CESNOLA

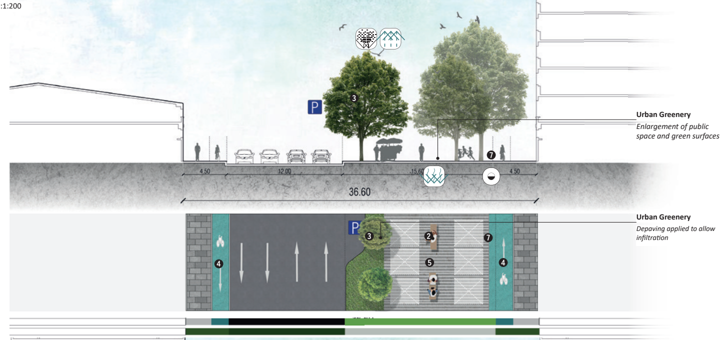
SCALE:1:200



VIA PIO VII

WITH VIA DUINO

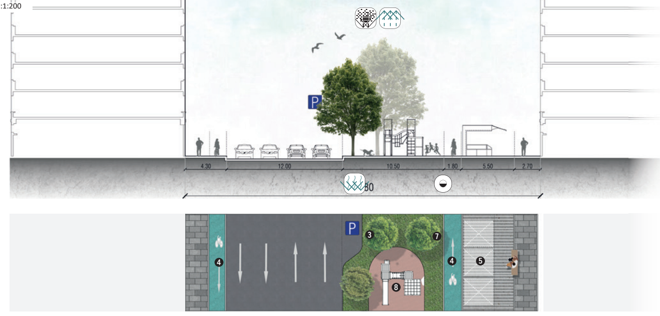
SCALE:1:200



VIA PIO VII

WITH CORSO TRAIANO

SCALE:1:200



VIA PIO VII

WITH BARBARA ALLASON

SCALE:1:200

Results and conclusions

Corso Traiano

With the proposed design the increase on the green areas was about three times more than the current condition. The design case of Corso Traiano is particular due to its street category (E2) the category corresponds to a “Neighborhood” street (Strada urbana di quartiere) nevertheless the profile of this avenue can easily correspond to a high-capacity street. In fact, 17% of the whole section is set for soft mobility, this means is shared between pedestrian and bike users, and less than 5% is for bike users. The existing green areas correspond to around 20% of the street section and are not accessible by users for being placed between a ten-lane avenue. This is what can be considered in urban planning a so-called car-centered design.

The idea to shift the center lanes underground is not, new nor innovative; is a solution that the same municipality of Torino has taken many times before to make mobility more efficient and the ground level safer. This was the case with “The Spina” and the rail shift underground to avoid the traffic jams occurring.
This design proposes the public transport and the lateral service lanes as the remaining lanes at ground level. This way the whole street profile can be used as a line park that reduces the area of asphalt roads increasing the UHI phenomenon that strikes every summer the zone of Lingotto with high surface and air temperatures.

Via Pio VII

Consist of a residential environment at both sides, the idea of reducing one car lane and the parking areas to become this street the gathering area for the community includes not only a pocket park but also playgrounds temporary markets, and the connection itself with the park Vittorio and the rest of the neighborhood.

4.1 EXAMINATION AND FINDINGS

CONCLUSIONS: EXAMINING THE DATA

a) Initial interpretations

Urban Models and Sustainable Approaches

In this chapter, viewpoints and justifications are articulated concerning the investigative, analytical, and operational endeavors undertaken. It delineates the advantage and opportunities, as well as the obstacles and challenges encountered throughout the process. Finally, it delves into the potential prospects that a comparable procedure may encounter in practical applications.

Urban models

The results of this study revealed certain aspects of importance for the Urban planning. In the first place after reviewing different international and the urban local case, decidedly urban development can be considered as a dynamic and multifaceted field that requires adaptable models and strategies to address challenges posed by different cities.
On the basis of the findings, an urban model that employ general strategies to intervene in urban areas, with the foresight to extend their impact to surrounding regions while achieving initial objectives and thresholds, is one of the milestones of this thesis and result from the overview to international urban models.

In the second place the impact and importance of this concept of urban model in this investigation lies in the versatility of an urban approach, which operates with a “portfolio” of general strategies. This approach allows applicability in various urban contexts, creating an extensive method to achieve initial objectives even if the scale of intervention varies.

Turin’s Public Space Case

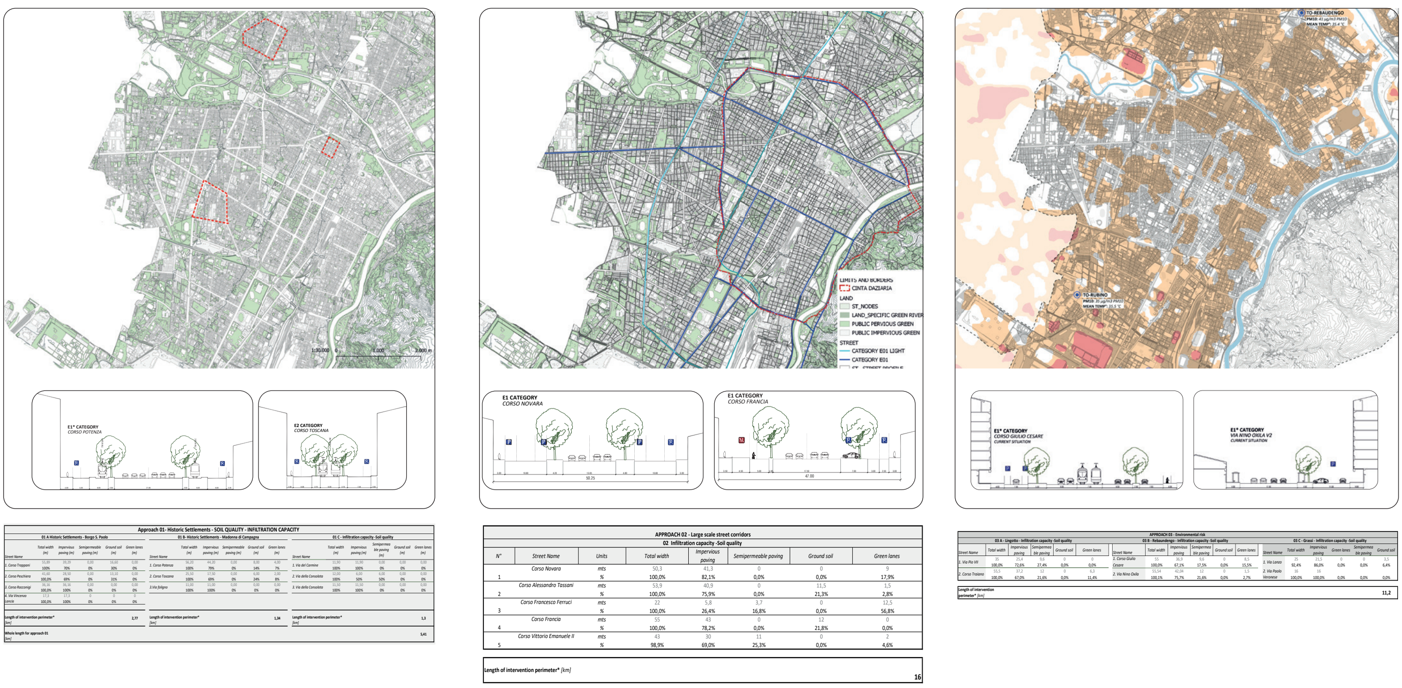
The findings of this research uncover specific elements for the urban intervention method in Turin, where the soil’s ecological services serve as a pivotal element for enhancing climate resiliency. Despite the potential of NBS and UGI, the city faces obstacles in prioritizing these strategies within its administrative agenda. Opportunities for depaving and increasing ecosystemic services in public spaces exist, but these interventions maintain an experimental nature, failing to be integrated into the regular activities of urban planning in Turin.

Moreover, the most effective path towards climate resiliency, as demonstrated by the studied urban cases and the interviews is the adoption of small, replicable solutions. These solutions, being technically simpler and more logistically efficient, can contribute significantly to transforming Turin from car-based urbanism to one aligned with alternative mobility, in response to global circumstances and European regulations regarding sustainable urbanism.

Urban Intervention Approaches

Furthermore, this study highlighted the complexity of mobility infrastructure and road networks, for its intricate nature when analyzing a singular approach proved unfeasible, therefore three urban intervention approaches were analyzed and evaluated with qualitative and quantitative parameters.
The presented approaches offer insights into different perspectives and principles, providing a comprehensive understanding of the intricate urban grid.
Then, by conducting a thorough comparison the strengths and weaknesses of each approach, were identified. The third approach, aligning with both principles and specific objectives, emerges as the most suitable for the subsequent stages of the study. Its quantitative aspects, such as the number of roads and diverse street categories, provide an optimal overview for designing interventions across various streets.

The reasearch higlights the importance of a holistic and adaptive urban model of intervention based on the mobility infrastructure. The streets can achieve actual social and environmental sustainability in the urban context, in punctual replicable solutions. In the local sacle, each intervention can affect the well-being of users and the social conditions of a whole neighborhood by strengthening public spaces while mitigating climate vulnerability.



The three urban intervention approaches. Cartography, street profile analyses, and quantitative data tables. (Tables can be checked in the annex)

b) Results achieved

Strengthening public space by improving street conditions

The proposed design interventions aimed to enhance the existing public space conditions, with a focus on improving space quality, expanding effective public spaces and bolstering the landscape's capacity to mitigate climate vulnerability. This involved increasing infiltration capacity and enhancing outdoor thermal comfort conditions through the implementation of NBS and UGI.

The proposed design and its corresponding analysis revealed that through the reorganization and redistribution of street elements, it is possible to implement NBS (Nature-Based Solutions) and UGI (Urban Green Infrastructure) in a standardized manner across the street profile under specific conditions, ensuring their practicality.

For the first case of Rebaudengo the green lanes were increased about 12 percentage points just for the Via Nino Oxilia case. The conditions and street category of this street make possible such an important increase in opposition with Corso Giulio Cesare which instead had also an increase on permeable surfaces (such as green lanes) of just 8 percentage points*

Before and after situation for Zona Rebaudengo. Proposed design over Corso Giulio Cesare, Via Nino Oxilia, and Via Porpora. scale 1:2000

** See anex Table 4 and 5*

This demonstrated that the improvement of permeable surfaces, and public space enlargement depends directly on the infrastructure conditions of the street and street typology. In categories such as Corso Giulio Cesare with a high traffic volume and the particularity of the tram lines, the intervention should be limited or in other words restricted due to infrastructure preexistences. The service lanes (also called "controviali") in these cases present a considerable opportunity for achieving the implementation of the design strategies and tools.

On the other hand, the increase in terms of soft mobility infrastructure depends also on the current conditions of the street corridor. For instance, the Via Nino Oxilia has an increase in bike lanes because this was implemented on this particular street corridor that previously lacked specialized bike lanes. Instead, the Corso Giulio Cesare because of its character as a metropolitan connection, the infrastructure is more complete. This road has as current state the bike paths considered, even if the current situation could be improved as it was proposed in the preliminary design.

The implementation of mitigation strategies and the enhanced spatial characteristics of the updated street layout resulted in improved ecosystem services. Furthermore, it contributed to the expansion and enhancement of public spaces, encouraging community utilization, and fostering the adoption of alternative and sustainable modes of transportation.

Rebaudengo study case

In conclusion, the urban interventions proposed for the study case of Rebaudengo aim to transform these spaces into more sustainable, inclusive, and vibrant areas. Corso Giulio Cesare's redesign successfully prioritizes public spaces, fostering environmental benefits with increased permeable surfaces and a linear park. It also balances the demands of a high-capacity urban street while prioritizing green spaces, resulting in increased permeable surfaces and improving the mental well-being of the community

Before and after conditions of Corso Giulio Cesare. Three sections were analyzed for the street corridor.
Values for infiltration capacity and infrastructure quality are compared between both situations (Values can be checked in the annex ***Tables 3-7****)*

Via Nino Oxilia, with its focus on soft mobility and mixed-use lanes, reflects a commitment to enhancing alternative modes of transportation and addresses the need of strenght outdoor recreational and leisure activities fostering a more pedestrian-friendly environment.

Via Porpora's unique challenge of a bustling market is met with a creative solution, offering a constant green pocket park and an expanded market area, ensuring continuous community enjoyment and improved public space infrastructure; offering a balance between commercial activities and recreational opportunities. Overall, these proposals signify a thoughtful integration of urban design, environmental considerations, and community enhancement. Together, these proposals underscore the importance of thoughtful urban planning in creating sustainable, livable, and vibrant city spaces.

Proposed condition of Via Porpora with via Valdengo. Green pocket park and an market area

Lingotto study case

In summary, the proposed redesign of Corso Traiano and Via Pio VII exemplifies a different approach to urban revitalization, prioritizing green spaces, sustainable mobility, and community well-being. Corso Traiano introduces a different solution by relocating vehicular lanes underground. This not only triples the green areas, enhancing accessibility and aesthetics but also addresses the historical challenge of avoiding a car-centric design.

This design promotes ground-level public transport, soft mobility, and recreational-leisures activities, transforming the entire street into a linear park, combating urban heat island effects in the Lingotto zone. Via Pio VII's residential focus undergoes a thoughtful shift, converting it into a vibrant community hub by reducing just one car lane, welcoming pocket parks, playgrounds, and temporary markets, and fostering connections with the surrounding neighborhood and Park Vittorio. Together, these proposals signify a commitment to creating sustainable, inclusive, and resilient urban spaces.

c) Exploring opportunities and confronting challenges

The results of this study reveal the important amount of urban cases focusing on urban public space renovation from the implementation of NBS and UGI, therefore the existing research articles encouraged and assisted this investigation into a new field of analysis and application for NBS as it is the intervention in the street corridors.

The review of the urban intervention approaches added key insights about the urban configuration and nature of the mobility infrastructure and the conditions of street infrastructure and soil quality. However, the accuracy of this review could be improved. The lack of precise data regarding air pollution is one of the limitations that the third approach has as a drawback.

For future studies, the following recommendations are proposed to enhance the process of investigation, and evaluation of urban models of intervention.

It is recommended to place greater emphasis on policy development. A further observation is the complex and interdisciplinary character of urban planning. Urban planning encompasses not just the design but also regulation, and management of the physical, social, and economic aspects of urban areas. Given its role in policy formulation and regulation development, a comprehensive understanding of law and public administration is imperative.

Moreover, to enchance the precision of evaluating urban intervention approaches. The analysis underscores the importance of applying multiple indicators and additional parameters to facilitate a more accurate evaluation across various approaches. By incorporating a broader range of quantitative data, decision-making processes can be more effective and accurate. This approach seeks to improve the method and overall accuracy of assessing urban interventions, thereby contributing to improving urban planning strategies and creating more resilient cities.

Regarding the preliminary design proposal is recommended to consider the benefits and drawbacks of the specialized lanes. This typology is sometimes a strength in urban cases where the vehicular speed represents a risk for the user of soft mobility, however for local streets, the mix lanes between soft mobility and vehicles can be a feasible option to reduce car speed and noise levels for the residents.

Final observations

Finally, this study has delved into the realm of urban public space as an action field for implementing mitigation and adaptation strategies, focusing on the implementation of Nature-Based Solutions (NBS) and Urban Green Infrastructure (UGI) within street corridors. The existing body of research provided a foundation for this exploration, revealing a rich tapestry of urban cases. The review of urban intervention approaches offered valuable insights into the complexities of mobility infrastructure, street conditions, and soil quality.

However, the study acknowledges the limitations. For future investigations, emphasis on policy development is recommended, recognizing the interdisciplinary nature of urban planning that requires a comprehensive understanding of law and public administration. To enhance the precision of evaluating urban intervention approaches, the study suggests incorporating multiple indicators and additional parameters for a more accurate assessment. This approach aims to improve decision-making processes, contributing to more effective urban planning strategies and resilient cities. Additionally, the consideration of a thoughtful evaluation of the public space design, its benefits, and drawbacks in different contexts to optimize soft mobility and address values such as wellness and safeness in local streets.

To conclude, the proposed design interventions focused on enhancing existing public spaces through the implementation of Nature-Based Solutions (NBS) and Urban Green Infrastructure (UGI). The analysis revealed that a standardized application of these interventions is feasible, with significant improvements in permeable surfaces, particularly evident in small street categories.

However, it also highlighted the influence of street infrastructure and typology on the practicality of such enhancements. The constraints posed by high-traffic areas, like Corso Giulio Cesare, suggest a need for careful consideration and potential restrictions on interventions. Notably, service lanes emerged as valuable opportunities for implementing design strategies.
The increase in soft mobility infrastructure varied based on the existing conditions of the street corridor. The overall implementation of these strategies contributed not only to improved environmental conditions but also to enhanced ecosystem services, increased public space area, and the promotion of alternative and sustainable modes of transportation.

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Annex

Table 1. *Intervention approach by neighboorhoods. Soil quality, infiltraton capacity*

Approach 01- Historic Settlements - SOIL QUALITY - INFILTRATION CAPACITY

01 A Historic Settlements - Borgo S. Paolo					
Street Name	*Total width (m)*	*Impervious paving (m)*	*Semipermea' ' paving (m,*		
1. Corso Trappani	55,89 100%	39,29 70%	0,00 0%	16,60 30%	0,00 0%
2. Corso Peschiera	41,60 100,0%	28,50 69%	0,00 0%	13,10 31%	0,00 0%
3. Corso Racconigi	36,16 100,0%	36,16 100%	0,00 0%	0,00 0%	0,00 0%
4. Via Vincenzo Lancia	17,3 100,0%	17,3 100%	0 0%	0 0%	0 0%
Length of intervention perimeter* *[km]*					**2,77**

01 B- Historic Settlements - Madonna di Campagna					
Street Name	*Total width (m)*	*Impervious paving (m)*	*Semipermeable paving (m)*	*Ground soil (m)*	*Green lanes (m)*
1. Corso Potenza	56,20 100%	44,20 79%	0,00 0%	8,00 14%	4,00 7%
2. Corso Toscana	25,50 100%	17,50 69%	0,00 0%	6,00 24%	2,00 8%
3.Via foligno	11,00 100%	11,00 100%	0,00 0%	0,00 0%	0,00 0%
Length of intervention perimeter* *[km]*					**1,34**

01 C - Infiltration capacity -Soil quality					
Street Name	*Total width (m)*	*Impervious paving (m)*	*Semipermeable paving (m)*	*Ground soil (m)*	*Green lanes (m)*
1. Via del Carmine	11,90 100%	11,90 100%	0,00 0%	0,00 0%	0,00 0%
2. Via della Consolota	12,00 100%	6,00 50%	6,00 50%	0,00 0%	0,00 0%
3. Via della Consolota	11,50 100%	11,50 100%	0,00 0%	0,00 0%	0,00 0%
Length of intervention perimeter* *[km]*					**1,3**
Whole length for approach 01 *[km]*					**5,41**

Detail: 01-A *Soil quality, infiltraton capacity*

01 A	**Borgo S. Paolo**				
Street Name	*Total width (m)*	*Impervious paving (m)*	*Semipermeable paving (m)*	*Ground soil (m)*	*Green lanes (m)*
1. Corso Trappani	55,89 100%	39,29 70%	0,00 0%	16,60 30%	0,00 0%
2. Corso Peschiera	41,60 100,0%	28,50 69%	0,00 0%	13,10 31%	0,00 0%
3. Corso Racconigi	36,16 100,0%	36,16 100%	0,00 0%	0,00 0%	0,00 0%
4. Via Vincenzo Lancia	17,3 100,0%	17,3 100%	0 0%	0 0%	0 0%

Detail: 01-B *Soil quality, infiltraton capacity*

01 B-	**Madonna di Campagna**				
Street Name	*Total width (m)*	*Impervious paving (m)*	*Semipermeable paving (m)*	*Ground soil (m)*	*Green lanes (m)*
1. Corso Potenza	56,20 100%	44,20 79%	0,00 0%	8,00 14%	4,00 7%
2. Corso Toscana	25,50 100%	17,50 69%	0,00 0%	6,00 24%	2,00 8%
3.Via foligno	11,00 100%	11,00 100%	0,00 0%	0,00 0%	0,00 0%

Detail: 01-C *Soil quality, infiltraton capacity*

01 C -	City center – Quadrilatero				
Street Name	*Total width (m)*	*Impervious paving (m)*	*Semipermeable paving (m)*	*Ground soil (m)*	*Green lanes (m)*
1. Via del Carmine	11,90 100%	11,90 100%	0,00 0%	0,00 0%	0,00 0%
2. Via della Consolota	12,00 100%	6,00 50%	6,00 50%	0,00 0%	0,00 0%
3. Via della Consolota	11,50 100%	11,50 100%	0,00 0%	0,00 0%	0,00 0%

* Area appropiate to be intervened: Calculation consider with reduction of one driving lane and non vehicular zones able to be intervented. Percentage calculted in Km respect to the total width of the road profile

Table 2. *Intervention approach by street corridors. Soil quality, infiltraton capacity*

APPROACH 02 - Large scale street corridors							
02 Infiltration capacity -Soil quality							
N°	*Street Name*	*Units*	*Total width*	*Impervious paving*	*Semipermeable paving*	*Ground soil*	*Green lanes*
	Corso Novara	*mts*	50,3	41,3	0	0	9
1		*%*	100,0%	82,1%	0,0%	0,0%	17,9%
	Corso Alessandro Tassani	*mts*	53,9	40,9	0	11,5	1,5
2		*%*	100,0%	75,9%	0,0%	21,3%	2,8%
	Corso Francesco Ferruci	*mts*	22	5,8	3,7	0	12,5
3		*%*	100,0%	26,4%	16,8%	0,0%	56,8%
	Corso Francia	*mts*	55	43	0	12	0
4		*%*	100,0%	78,2%	0,0%	21,8%	0,0%
	Corso Vittorio Emanuele II	*mts*	43	30	11	0	2
5		*%*	98,9%	69,0%	25,3%	0,0%	4,6%

Length of intervention perimeter* *[km]*	**16**

Table 3. *Intervention approach by environmental risk. Soil quality, infiltraton capacity*

APPROACH 03 - Environmental risk

03 - Lingotto - Infiltration capacity -Soil quality					
Street Name	*Total width*	*Impervious paving*	*Semipermeable paving*	*Ground soil*	*Green lanes*
1. Via Pio VII	35	25,4	9,6	0	0
	100,0%	72,6%	27,4%	0,0%	0,0%
2. Corso Traiano	55,5	37,2	12	0	6,3
	100,0%	67,0%	21,6%	0,0%	11,4%

03 B - Rebaundengo - Infiltration capacity -Soil quality					
Street Name	*Total width*	*Impervious paving*	*Semipermeable paving*	*Ground soil*	*Green lanes*
1. Corso Giulio	55	36,9	9,6	0	8,5
Cesare	100,0%	67,1%	17,5%	0,0%	15,5%
2. Via Nino Oxila	55,54	42,04	12	0	1,5
	100,1%	75,7%	21,6%	0,0%	2,7%

03 C - Grassi - Infiltration capacity -Soil quality					
Street Name	*Total width*	*Impervious paving*	*Green lanes*	*Semipermeable paving*	*Ground soil*
1. Via Lanzo	25	21,5	0	0	3,5
	92,4%	86,0%	0,0%	0,0%	6,4%
2. Via Paolo	16	16			
Veronese	100,0%	100,0%	0,0%	0,0%	0,0%

Length of intervention perimeter* *[km]*	**11,2**

Detail: *Lingotto study case. Soil quality, infiltraton capacity*

03 - Lingotto - Infiltration capacity -Soil quality					
Street Name	*Total width*	*Impervious paving*	*Semipermeable paving*	*Ground soil*	*Green lanes*
1. Via Pio VII	35	25,4	9,6	0	0
	100,0%	72,6%	27,4%	0,0%	0,0%
2. Corso Traiano	55,5	37,2	12	0	6,3
	100,0%	67,0%	21,6%	0,0%	11,4%

Detail: *Rebaudengo study case. Soil quality, infiltraton capacity*

03	Infiltration capacity -Soil quality				
Street Name	*Total width*	*Impervious paving*	*Semipermeable paving*	*Ground soil*	*Green lanes*
1. Corso Giulio	55	36,9	9,6	0	8,5
Cesare	100,0%	67,1%	17,5%	0,0%	15,5%
2. Via Nino Oxila	55,54	42,04	12	0	1,5
	100,1%	75,7%	21,6%	0,0%	2,7%

Detail: *Grassi study case. Soil quality, infiltraton capacity*

03 C - Grassi - Infiltration capacity -Soil quality					
Street Name	*Total width*	*Impervious paving*	*Green lanes*	*Semipermeable paving*	*Ground soil*
1. Via Lanzo	25	21,5	0	0	3,5
	92,4%	86,0%	0,0%	0,0%	6,4%
2. Via Paolo	16	16			
Veronese	100,0%	100,0%	0,0%	0,0%	0,0%

* Area appropiate to be intervened: Calculation consider with reduction of one driving lane and non vehicular zones able to be intervented. Percentage calculted in Km respect to the total width of the road profile

Table 4. *Intervention approach by environmental risk. Infrastructure quality values for current situation- Rebaudengo study case.*

CURRENT CONDITION - ANALYZED STREETS											
Rebaudengo - Infrastructure quality											
Street Name	*Code section*		*Total width*	*Invariable length*	*Vehicular road*	*Tram lane*	*Parking spots*	*Green lanes*	*Pedestrian path*	*Bike path*	*Area to be intervened**
Via Nino Oxila	***B-01***	*Lenght (m)*	40,5	25,0	17,0		11,0		12,5		26,3
		Percentage	100,0%	61,7%	42,0%		27,2%	0,0%	30,9%	0,0%	65,0%
	B-02	*Lenght (m)*	30,0	25,0	17,0		5,0	5,0	8,0	0,0	15,8
		Percentage	100,0%	83,3%	56,7%		16,7%	16,7%	26,7%	0,0%	52,8%
	B-03	*Lenght (m)*	25,0	25,0	17,0				8,0		10,8
		Percentage	100,0%	100,0%	68,0%				32,0%		43,3%
Corso Giulio Cesare	***A-01***	*Lenght (m)*	55,0	53,0	32,0	7,5	5,0	7,5	8,0	1,8	20,1
		Percentage	100,0%	96,5%	58,2%	13,6%	9,1%	13,6%	14,6%	3,3%	36,6%
	A-02	*Lenght (m)*	55,0	53,0	31,0	7,5	7,5	9,5	7,0	1,8	21,5
		Percentage	100,0%	96,5%	56,4%	13,6%	13,6%	17,3%	12,7%	3,3%	39,1%
	A-03	*Lenght (m)*	55,0	53,0	31,0	7,5	7,5	9,5	7,0	1,8	21,5
		Percentage	100,0%	96,5%	56,4%	13,6%	13,6%	17,3%	12,7%	3,3%	39,1%

** The area to be intervented is consider with the sum of the pedestrian lanes, parking* spots and a fraction of the vehicular lenght consider as one car lane

Table 5. *Intervention approach by environmental risk. Infrastructure quality values for proposed situation- Rebaudengo study case.*

PROPOSED SITUATION - ANALYZED STREETS											
Rebaudengo - Infrastructure quality											
Street Name	*Code section*		*Total width*	*Invariable length*	*Vehicular road*	*Tram lane*	*Parking spots*	*Green lanes*	*Pedestrian path*	*Bike path*	
Via Nino Oxila	***B-01***	*Lenght (m)*	40,5	25,0	16,5		2,5	8,4	12,0	3,6	
		Percentage	100,0%	61,7%	40,7%		6,2%	20,7%	29,6%	8,9%	
	B-02	*Lenght (m)*	30,0	25,0	11,0		5,0	7,4	8,0	3,6	
		Percentage	100,0%	83,3%	36,7%		16,7%	24,7%	26,7%	12,0%	
	B-03	*Lenght (m)*	25,0	25,0	11,0		5,0	1,4	9,0	3,6	
		Percentage	100,0%	100,0%	44,0%		20,0%	5,6%	36,0%	14,4%	
Corso Giulio Cesare	***A-01***	*Lenght (m)*	55,0	53,0	17,2	7,5	2,5	18,0	9,8	2,5	
		Percentage	100,0%	96,5%	31,3%	13,6%	4,5%	32,7%	17,8%	4,5%	
	A-02	*Lenght (m)*	55,0	53,0	19,2	7,5	2,5	17,2	6,8	4,3	
		Percentage	100,0%	96,5%	34,9%	13,6%	4,5%	31,3%	12,4%	7,8%	
	A-03	*Lenght (m)*	55,0	53,0	16,9	7,5	2,5	19,2	7,8	3,6	
		Percentage	100,0%	96,5%	30,8%	13,6%	4,5%	34,9%	14,2%	6,6%	

Table 6. *Intervention approach by environmental risk. Infrastructure quality values for current situation- Lingotto study case.*

CURRENT CONDITION - ANALYZED STREETS											
Lingotto - Infrastructure quality											
Street Name			*Total width*	*Invariable length*	*Vehicular road*	*Tram lane*	*Parking spots*	*Green lanes**	*Pedestrian path*	*Bike path*	*Area to be intervened*
Corso Traiano	***A-01***	*Lenght (m)*	52,5	52,5	24,2		13,0	6,6	9,0	2,5	28,5
		Percentage	100,6%	100,0%	46,1%		24,7%	12,6%	17,1%	4,8%	54,3%
	A-02	*Lenght (m)*	54,70	52,5	23,5		12,0	9,6	9,6	3,6	29,1
		Percentage	100,0%	96,0%	43,0%		21,9%	17,6%	17,6%	6,6%	53,2%
	A-03	*Lenght (m)*	52,50	52,5	21,7		12,5	11,1	8,5	2,5	27,1
		Percentage	102,5%	100,0%	41,3%		23,8%	21,1%	16,2%	4,8%	51,6%
Via Pio VII	***B-01***	*Lenght (m)*	36,80	36,6	18,2		10,0	1,0	8,6	2,5	25,7
		Percentage	102,7%	99,5%	49,5%		27,2%	2,7%	23,4%	6,8%	69,7%
	B-02	*Lenght (m)*	36,60	36,6	18,0		9,6	1,0	9,0	2,5	25,6
		Percentage	102,7%	100,0%	49,2%		26,2%	2,7%	24,6%	6,8%	69,9%
	B-03	*Lenght (m)*	36,60	36,6	18,2		10,0	1,0	8,6	2,5	25,7
		Percentage	103,3%	100,0%	49,7%		27,3%	2,7%	23,5%	6,8%	70,1%

**Green lanes on Via Pio VII are considered as a continuous green area*

Table 7. *Intervention approach by environmental risk. Infrastructure quality values for proposed situation - Lingotto study case.*

PROPOSED SITUATION - ANALYZED STREETS

Lingotto - Infrastructure quality											
Street Name			*Total width*	*Invariable length*	*Vehicular road*	*Tram lane*	*Parking spots*	*Green lanes*	*Pedestrian path*	*Bike path*	
Corso Traiano	***A-01***	*Lenght (m)*	52,5	52,5	12,0		5,0	25,6	12,4	2,5	
		Percentage	100,1%	100,0%	22,9%		9,5%	48,8%	23,7%	4,8%	
	A-02	*Lenght (m)*	54,7	52,5	13,0		5,0	26,6	15,1	3,6	
		Percentage	100,0%	96,0%	23,8%		9,1%	48,7%	27,6%	6,6%	
	A-03	*Lenght (m)*	52,5	52,5	12,0		5,0	26,6	11,4	2,5	
		Percentage	100,0%	100,0%	22,8%		9,5%	50,7%	21,8%	4,8%	
Via Pio VII	***B-01***	*Lenght (m)*	36,6	36,6	12,0		2,5	10,5	7,0	3,6	
		Percentage	87,4%	99,5%	32,8%		6,8%	28,7%	19,1%	9,8%	
	B-02	*Lenght (m)*	36,6	36,6	12,0		2,5	15,6	9,0	2,5	
		Percentage	106,8%	100,0%	32,8%		6,8%	42,6%	24,6%	6,8%	
	B-03	*Lenght (m)*	36,6	36,6	12,0		2,5	16,0	8,8	3,6	
		Percentage	107,4%	100,0%	32,8%		6,8%	43,7%	24,0%	9,8%