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MASTER THESIS

"Improving Urban Resilience and Sustainability: Revitalizing the Green Infrastructure of Manifattura Tabacchi, Torino"

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Declarations

I Kandimalla Suma Lasya (s301690) a 2021 enrolled student, hereby officially attest that the thesis dissertation that I submitted for the degree of Master of Science in Architecture for Sustainability from Politecnico di Torino is an authentic and bona fide work that I have completed.

This dissertation content hasn't been submitted to any other university or institute for consideration of a degree or diploma.

Date: 10th February, 2025

Signed By,

K. Suma Lasya (s301690)

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ABSTRACT:

Rapid urbanization creates vulnerability and exposure, and when coupled with climate change it escalates urban risks and its consequences. However, to maintain equitable growth and a high standard of living for their citizens, cities, and communities must be resilient and sustainable. Resilience helps cities to prepare, withstand, and bounce back and recover from shocks. Sustainability helps preserve essential resources like air, water, and energy for future generations by reducing environmental damage and using resources wisely. Both resilience and sustainability can improve the city's ability to create a safe and liveable setting.

This thesis aims to explore the relationship between urban resilience and sustainability with a focus on revitalizing the green infrastructure of Manifattura Tabacchi, a historic neighborhood in Torino, Italy that is compatible with the real-time scenario. This study evaluates the strengths and weaknesses of urban communities with the help of the parameters of resilience and sustainability using BIM as a key tool, and these findings are integrated into a design framework.

The special considerations of the site include the preservation of the site's cultural heritage, contemporary urban design concepts, and the flexibility of proposed interventions in response to the upcoming environmental and social issues. By merging the theoretical understanding with an effective design solution, this study intends to provide a reproducible framework for promoting sustainability and resilience in urban communities.

Scope of research:

The scope includes evaluating the neighborhood's environmental, social, and structural aspects and making design recommendations that can be implemented in other similar urban settings.

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01

INTRODUCTION

1.1. Background

Cities worldwide are facing both opportunities and challenges as an effect of urbanization at an unprecedented rate. While urban centres drive economic growth and cultural development, they are also more susceptible to climate change, environmental degradation, and social inequalities. Resilience and sustainability are essential elements of urban planning since rising temperatures, floods, and resource depletion threaten the long-term viability of urban environments.

Cities have to incorporate sustainability, which ensures the use of natural resources for future generations, and resilience, which is the capacity to withstand, adapt, and recover from environmental and social shocks, in order to guarantee equitable growth and a high standard of living. Green infrastructure plays a very important role in achieving these objectives by boosting ecosystem services, improving climate tolerance, and promoting community well-being.

This thesis explores how green infrastructure revitalization can promote urban resilience and sustainability, using Manifattura Tabacchi, Torino neighborhood as a case study. This historic neighborhood faces several urban challenges such as flood risk, poor connectivity, and underutilized public spaces. By tackling these issues, this study hopes to show how nature-based solutions and sustainable urban mobility can transform vulnerable sites into resilient and liveable communities.

Research Problem and Significance:

The Former Manifattura Tabacchi, industrial site is undergoing urban transformation. Like many other historic sites, it is facing problems such as:

- Flood risk: Due to poor stormwater management and severe weather conditions caused by climate change, the site is extremely vulnerable to floods.

- Limited connectivity and accessibility: The area lacks in shared mobility stations, cycling infrastructure, and well-integrated pedestrian pathways.
- Underutilized green spaces: Due to their limited utility, existing open spaces play a smaller role in community engagement and ecological restoration.
- Lack of disaster preparedness: There are no emergency shelters or planned evacuation routes for community-led disaster response planning at the location.

Enhancing site green infrastructure can address these challenges by incorporating nature-based solutions to improve environmental resilience while promoting social and economic well-being. This research is valuable as it offers a replicable design that can be incorporated in other cities that are aiming for resilient focused, sustainable regeneration.

1.2. BIM: Making cities resilient and sustainable

Urban planning is being revolutionized by Building Information Modelling (BIM), which offers data-driven insights that improve cities' resilience and sustainability. Cities must adapt to innovative ideas to create an infrastructure that can withstand disasters, reduce environmental impact, and effectively manage given growing environmental concerns and rapid urbanization. By incorporating real-time data, predictive analysis, and advanced modeling into urban development, BIM plays a crucial role in accomplishing these goals.

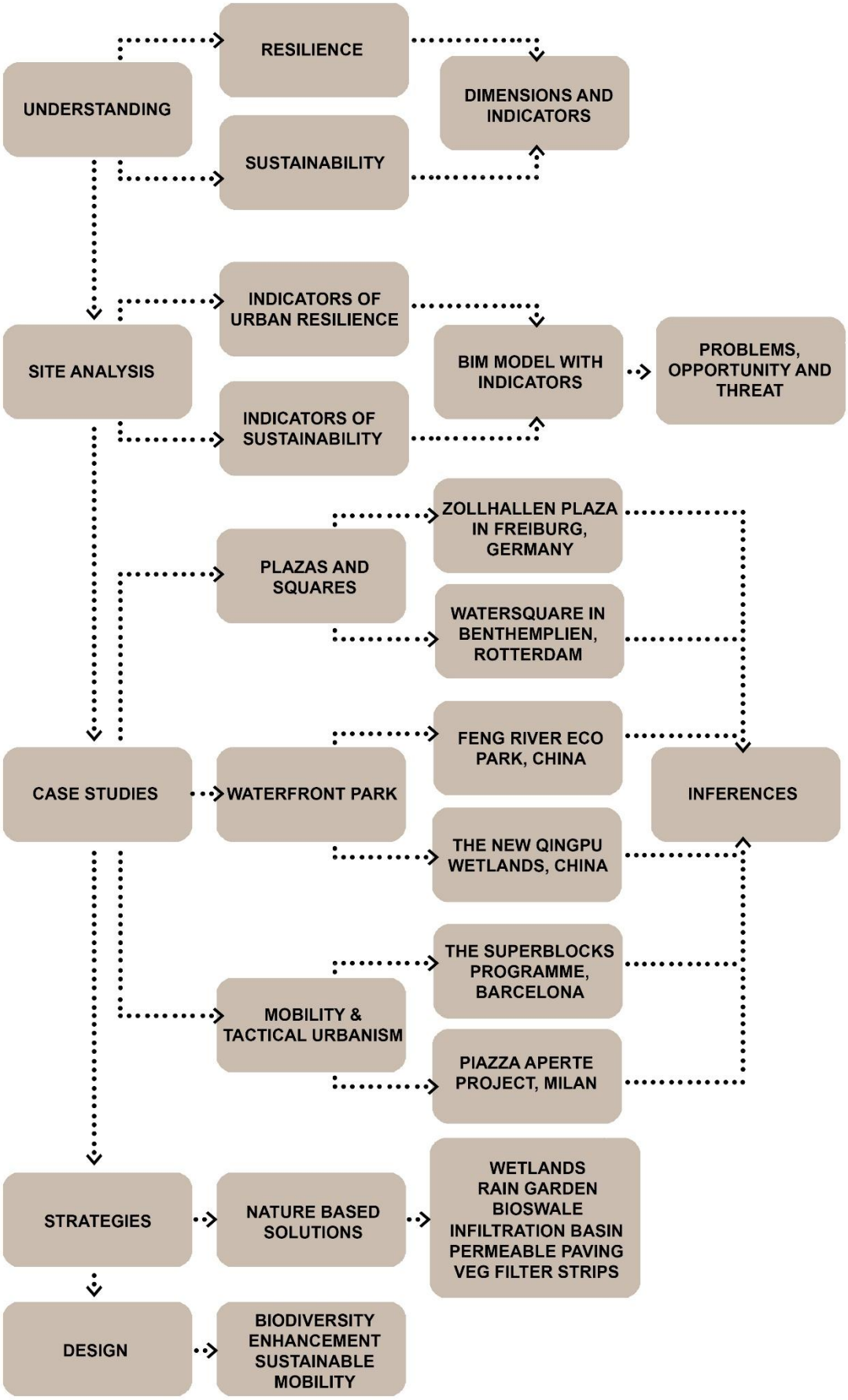
BIM improves urban resilience by facilitating environmental risk analysis. Natural disasters like floods, earthquakes, and severe weather conditions which are commonly faced by cities can affect citizens and disrupt the infrastructure. By integrating BIM with GIS and climate models, planners can detect risks, simulate disasters, and design flood-resilient buildings, effective drainage systems, and improved emergency responses. As a result, cities are well-equipped to withstand and bounce back from environmental challenges.

Beyond resilience, BIM improves sustainable urban development and green infrastructure. It enables optimization of water and waste management, integration of renewable energy, and design of energy-efficient buildings. To lower heat islands and enhance air quality, BIM promotes rooftop gardens, urban forests, and green areas.

Real-time data and predictive modeling can improve the adaptability of urban infrastructure. By integrating BIM IoT sensors and AI, cities can monitor and optimize buildings, transportation, and utilities. Predictive maintenance is made possible by this, preventing expensive repairs and malfunctions. To make cities more resource-efficient and adaptable to changing requirements, BIM also supports automated traffic systems, smart energy grids, and effective public transportation.

As Urban areas expand, Integrating BIM will be key to building smart, liveable, and sustainable cities for future generations.

1.3. METHODOLOGY



CHAPTER

02

RESILIENT CITY

2. RESILIENT CITY:

The capacity of the city to absorb, adapt, transform, and prepare for shocks and stresses along the economic, social, institutional, and environmental dimensions, aiming to maintain the functions of the city and improve response to future shocks. (Lorena Figueiredo, Indicators for Resilient Cities, 2018)

-OECD work definition

2.1. EVOLUTION OF RESILIENT CITIES:

The framework of resilience is based on several other frameworks they are digital cities, smart cities, sustainable cities, and better living in cities.

The aim of digital cities is to incorporate digitalization, it utilizes advanced technologies to make better urban planning, management, and infrastructure, focusing on the protection of the environment and comfortable liveable conditions. The smart cities emphasize on technological advances, while sustainable cities work on the environmental consequences of the city.

The smart city and sustainable city might be considered as a good foundation for the strategic goal of a resilient city. As we move from a digital city to a resilient city the goals expand focus and primary aspects broaden. The digital cities focus on using information and communication technology, the smart city focuses on incorporating modern technology into urbanization, and the sustainable city wants to use the technology to reduce the impact on the environment. The resilient city makes a broad plan including the well-being of people, and their involvement in the management by combining all the features from a digital city, smart city, and sustainable city.

The cities must find a balance between infrastructure, finances, and communal and personal activities while maintaining successful governance to achieve good living conditions in urban areas.

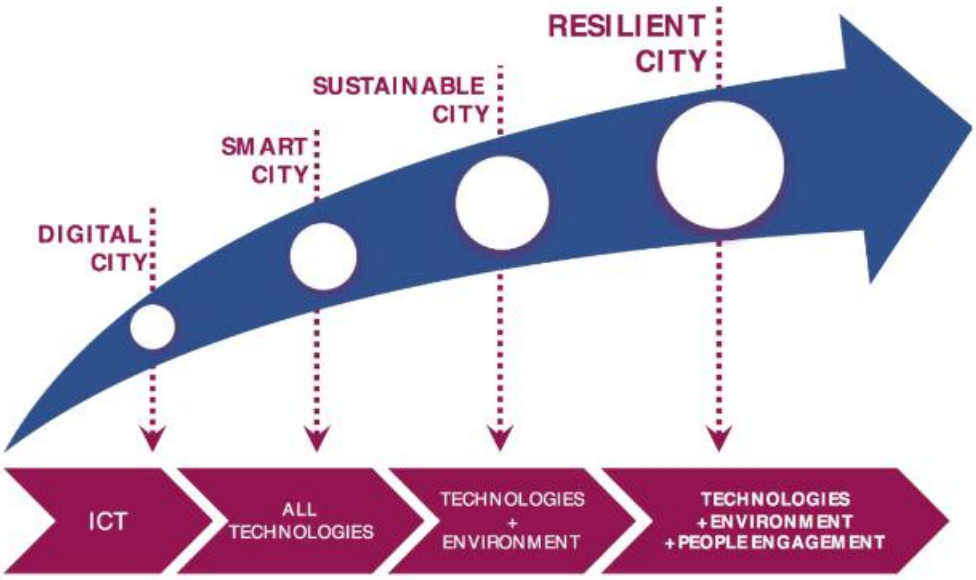


Figure 1: Evolution of resilient cities.

Source: (Monica Bruzzone, 2021)

2.2. URBAN RESILIENCE:

Resilience is the power to get back to normal original state after the stress that has been caused because of natural hazards or disasters. The local community must gain the capacity to bounce back from the risk and adapt to internal and external changes. With the rapid urbanization and climate change urban communities should be ready and know how to tackle the environmental risks. Several countries like Singapore, Germany, and Denmark have made and implemented plans, programs, and initiatives to include sustainability in urban planning.

There are many definitions for resilience but only a few of them are precise. In environmental and social science streams urban resilience has been defined in academic literature with 25 distant definitions. (Sara Meerow, 2015) (Brugmann, 2012)

Table 1: List of the 25 definitions of urban resilience.

S. No	Sources	Summary of Concepts
1	(M. Alberti, 2003)	"…the degree to which cities tolerate alteration before recognizing around a new set of structures and processes" (M. Alberti, 2003)
2	(Godschalk, 2003)	"… a sustainable network of a physical system and human communities" (Godschalk, 2003)
3	(S.T.A. Pickett, 2004)	"… the ability of the system to adjust in the face of changing conditions" (S.T.A. Pickett, 2004)
4	(H. Ernstson, 2010)	"To sustain a certain dynamic regime, urban governance also needs to build transformative capacity to face uncertainty and change" (H. Ernstson, 2010)
5	(Campanella, 2006)	"… the capacity of the city to rebound from destruction" (Campanella, 2006)
6	(J.A. Wardekker, 2010)	"… a system that can tolerate disturbances (events and trends) through characteristics of measures that limit their impacts, by reducing or counteracting the damage and disruption, and allow the system to respond, recover and adapt quickly to such disturbances" (J.A. Wardekker, 2010)
7	(Ahern, 2011)	"…the capacity of a system to reorganize and recover from change and disturbance without changing to other states…systems that are "safe to fail" (Ahern, 2011)
8	(Leichenko, 2011)	"…the ability…to withstand a wide array of shocks and stresses" (Leichenko, 2011)
9	(S. Tyler, 2012)	"…encourages practitioners to consider innovation and change to aid recovery from stresses and shocks that may not be predictable" (S. Tyler, 2012)
10	(Liao, 2012)	"… the capacity of the city to tolerate flooding and to reorganize should physical damage and socio-economic disruption occur, so as the prevent deaths and injuries

		and maintain current socio-economic identity" (Liao, 2012)
11	(A. Brown, 2012)	"… the capacity…to dynamically and effectively respond to shifting climate circumstances while continuing to function at an acceptable level. This definition includes the ability to resist or withstand impacts, as well as the ability to recover and re-organize to establish the necessary functionality to prevent catastrophic failure at a minimum and the ability to thrive at the best" (A. Brown, 2012)
12	(J.E. Lamond, 2009)	"…encompasses the idea that towns and cities should be able to recover quickly from major and minor disasters" (J.E. Lamond, 2009)
13	(S. Lhomme, 2013)	"…the ability of a city to absorb disturbance and recover its function after a disturbance" (S. Lhomme, 2013)
14	(C. Wamsler, 2013)	"A disaster resilient city can be understood as a city that has managed … to: (a)reduce or avoid current and future hazards;(b) reduce current and future susceptibility to hazards; (c) establish functioning mechanisms and structures for disaster response; and (d)establish functioning mechanisms and structures for disaster recovery" (C. Wamsler, 2013)
15	(Chelleri, 2012)	"…should be framed within the resilience (system persistence), transition (system incremental change), and transformation (system reconfiguration) views" (Chelleri, 2012)
16	(Hamilton, 2009)	"ability to recover and continue to provide their main functions of living, commerce, industry, government and social gathering in the face of calamities and other hazards" (Hamilton, 2009)
17	(Brugmann, 2012)	" the ability of an urban asset location and/or system to provide predictable performance – benefits and utility and associated rents and

		other cash flows – under a wide range of circumstances" (Brugmann, 2012)
18	(Coaffee, 2013)	"… the capacity to withstand and rebound from disruptive challenges …" (Coaffee, 2013)
19	(K.C. Desouza, 2013)	"ability to absorb, adapt and respond to changes in urban systems" (K.C. Desouza, 2013)
20	(P. Lu, 2013)	"… the ability of a city to absorb disturbance while maintaining its functions and structures" (P. Lu, 2013)
21	(P. Romero-Lankao, 2013)	"…capacity of urban populations and systems to endure a wide array of hazards and stresses" (P. Romero-Lankao, 2013)
22	(D. Asprone, 2013)	"…capacity to adapt or respond to unusual often radically destructive events" (D. Asprone, 2013)
23	(Henstra, 2012)	" A climate resilient city … can withstand climate change stresses, to respond effectively to climate-related hazards, and to recover quickly from residual negative impacts" (Henstra, 2012)
24	(M. Thornbush, 2013)	"… a general quality of the cities social, economic and natural systems to be sufficiently future-proof" (M. Thornbush, 2013)
25	(I. Wagner, 2013)	"… the general capacity and ability of a community to withstand stress, survive, adapt and bounce back from crisis or disaster and rapidly move on" (I. Wagner, 2013)

2.3. THREE MAIN APPROACHES TO RESILIENCE:

1. **Disaster risk reduction:** When exposed to hazard the ability of a system, community, or society to withstand, absorb, adapt, and recover in a fast and effective way, also maintaining and preserving essential structures and services. (Nations, 2017)
   Scale of analysis: Global and National

2. **Socio-ecological:** "The system's ability to change while withstanding its functions and structure, the capacity of self-organization, increased ability of learning and adaptation" (Holling, 2003)
   Scale of analysis: Cities and communities

3. **Sustainable livelihoods:** "When a shock or stress is faced or occurs the ability of households and communities to maintain basic conditions" (Mark A. Constas, 2014)
   Scale of analysis: Households and communities

2.4. CAPACITIES OF URBAN RESILIENCE:

1. Adaptive Capacity:

The ability of a system, community, or society to adapt and make changes according to the disturbances and also to maintain its functionality. To deal with the challenges in the future its important to learn from past experiences, innovate, and implement strategies. In the context of cities, it's important to update infrastructure to deal with rising temperatures and revise policies based on disasters in the past.

2. Absorptive Capacity:

An ability to endure and absorb the consequences of stresses and shocks without causing damage to the key functions and services. Stability and robustness are prioritized with existing resources, facilities and processes typically used to counter immediate impacts of risks.

3. Transformative Capacity:

Ability to make significant changes to systems, structures, and policies to tackle the vulnerabilities and to prevent long-term risks. To create a more sustainable and resilient ecosystem the polices of urban planning, governance, and societal norms must be revised.

PATHWAY OF RESILIENCE:

An evolution is distinctly visible from equilibrist resilience to evolutionary resilience. Returning to the earlier state after a shock may not be resilient anymore because it has triggered the shock in the first place. Resilient cities should reach a new level of improved normality after the shock. The focus has changed from stability to adaptability and transformation.

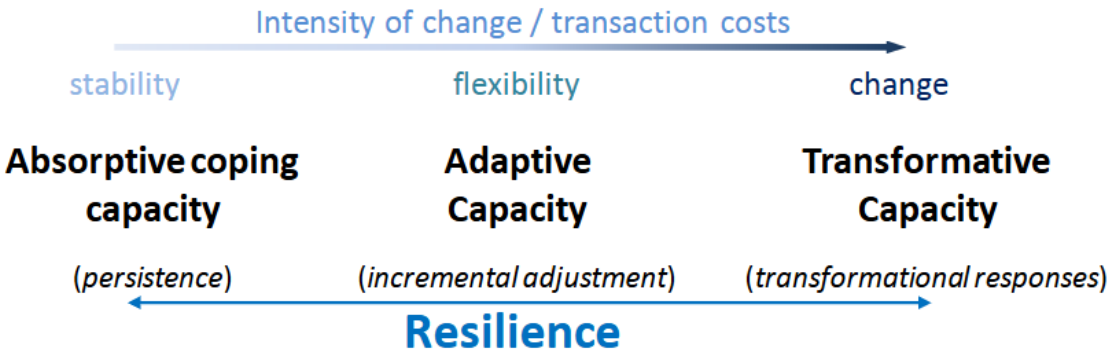


Figure 2: Pathway to resilience.

Source: (Christophe Béné, 2012)

https://doi.org/10.1111/j.2040-0209.2012.00405.x

2.5. QUALITIES OF RESILIENT CITIES:

This strategy incorporates an ongoing cycle of mitigation, response, inquiry, and tracking instead of just immediate post-disaster solutions. The seven key qualities to protect against natural hazards are:

1. Reflective
2. Robust
3. Redundant
4. Flexible
5. Resourceful
6. Inclusive
7. Integrated

1. **Reflective:** Instead of relying on long-lasting solutions based on the review of current shocks and stresses, people and organizations have a process to constantly change the requirements based on the new data. By developing an adaptive preparedness attitude that admits predictability people and organizations can learn from their mistakes.

2. **Robust:** The robust city structures are built to maintain and withstand harsh weather conditions and to still function if one element in the city fails. A reliable device can predict the failures in the system and provide safety to guarantee dependability and protection.

3. **Redundant:** When one function fails it has more options that can fulfil or maintain the essential functional requirements. For example, it has more entry points to the city's services. Depending excessively on a fail-safe system may show a basic lack of resilience.

4. **Flexible:** With rapidly changing situations a city with an adaptable structure can create and execute new strategies. These systems support the decentralization of standard infrastructure by using new technology.

5. **Resourceful:** Individuals and organizations should make investments in their capacity to foresee future urban developments, set goals, and manage resources. The resource capital of a city can enable it to respond quickly to serious events and modify institutions and practices as needed.

6. **Inclusive:** An inclusive approach involves engaging and consulting communities, especially the disadvantaged ones. It's difficult to develop a city's resilience in the absence of the outside world. Resilience requires a shared vision and shared responsibility from many groups within the community.

7. **Integrated:** Investments, making decisions and the city may all work together to accomplish a shared goal. Resilient system integration provides proof of methods that operate at various service levels. A consistent feedback system for collecting information and integrating it in response is necessary.

2.6. DIMENSIONS OF RESILIENCE:

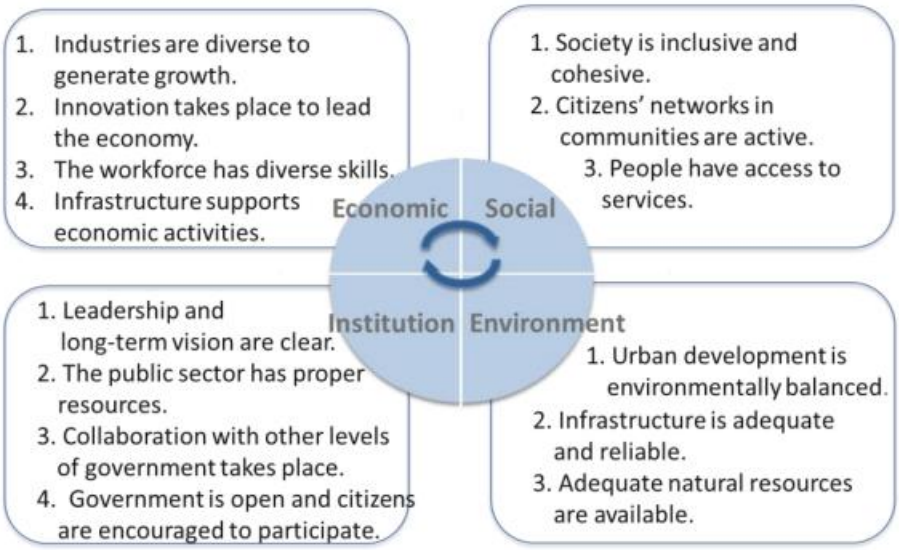


Figure 3: Drivers of resilient cities.

Source: (OECD, 2016)

The four drivers of resilience are

1. **Social Resilience:** The ability of people in the community or society to manage and recover from obstacles like natural hazards or interpersonal disputes is known as social resilience. It shows how important human relations and networks are.

Key Aspects:

- Strong Connections: Strong bonds between neighbours, families, and friends help people to help each other in difficult times.
- Cultural belonging: A community can gain confidence and power by feeling a sense of belonging by celebrating, and sharing values and traditions.
- Flexibility: When a difficulty occurs, communities learn to adapt and resolve the issue.
- Inclusiveness: When everyone in the community has an equal voice in decision-making irrespective of cultural backgrounds or disadvantaged groups.

Example: When a storm occurs, people gather plan together clear the waste, and rebuild their community. This teamwork shows social resilience.

2. **Environmental Resilience:** The ability of an ecosystem to bounce back to normal and the damage caused by natural disasters or human activity is called environmental resilience. It makes sure that ecosystems provide clean air, water, and food.

Key Aspects:

- Biodiversity: A mix of a variety of species makes an ecosystem resilient to changes.
- Natural revival: The ability of Mother Nature to heal itself after a disaster.
- Climate change mitigation: Ecosystem moulding itself to the changing weather patterns to survive.
- Sustainable techniques: Human endeavours that protect and preserve the ecosystem.

Example: When a coral reef is damaged by the storm because it has a diverse range of species and minimal pollution from surrounding activity helps it to revive.

3. **Economic Resilience:** The ability of an economy to deal with shocks like inflation, trade interruptions, and recessions to instantly bounce back to continue to deliver goods, jobs, and services.

Key Aspects:

- Diverse economy: A diversified economy can recover more quickly than the ones that are dependent on one sector.
- Financial stability: Strong savings and banking infrastructure allows economies to handle downturns.
- Innovation: Supporting originality and fresh ideas helps economies adapt to changes.
- Support Systems: To lessen the economic shock the policies from the government, and unemployment insurance are made.

Example: When a scenario like a pandemic occurs, the countries that a very much dependent on tourism are affected so they are diversified into technology and agriculture.

4. **Institutional Resilience:** The ability of governments, organizations, and systems to maintain stability and operate efficiently during times of crisis to ensure public welfare and safety.

Key Aspects:

- Effective Administration: It is important to have a leadership that is responsible, open and flexible.
- Preparedness: Organizations with emergency response plans and disaster plans can act quickly.
- Public faith: People who have faith in the institution tend to follow the instructions in the time of emergency.
- Partnership: Government, non-governmental organizations and communities work together to improve the solutions.

Example: When there is a flood government quickly evacuates people and communicates clearly with the residents.

2.7. INDICATORS OF URBAN RESILIENCE:

Major Dimensions	Major Indicators	Researchers & Time
Adaptive Capacity	Food	(Moench, 2014)
	Water	(Chelleri. L, 2015)
	Land	(P.B, 2021)
	Education, knowledge, skill	(Meerow. S, 2016)
	Health	(Leitner. H, 2018)
	Accommodation	(Davoudi. S, 2013)
	Training	(Malone, 2009)
	Inclusive access to credit and market	(Panampitiya, 2021)
	Social networks	(Adinyira. E, 2007)
	Access to ICT and technology	(Davoudi, Brooks, & Mehmood, 2013)
Absorptive Capacity	Access to transport	(Ernstson, et al., 2010)
	Planning and framework development	(Ribeiro & Pena Jardim Gonçalves, 2019)
	United command development	(Molavi, 2018)
	Determine ahead of each task	(Ribeiro & Pena Jardim Gonçalves, 2019)
	Early warning system	(Brown, Dayal, & Rumbaitis Del Rio, 2012)
	Community support	(Molavi, 2018)
	Urban green space	(Meerow & Newell, 2019)
	Protective infrastructure	(Reischl, Rauter, & Posch, 2018)
	Govern credit and resource distribution	(Nagenborg, 2019)
	Human resource usage	(Moench, 2014)
	Strengthen coverage of disaster management	(Chelleri. L, 2015)
	Utilization of equipment	(Cobbinah, 2021)
	Access to legal and policy system	(Sarker, Wu, Alam, & Shouse, 2020)
	Co-ordination of works of multi-stakeholder	(Ribeiro & Pena Jardim Gonçalves, 2019)
	Communication technology	(Ribeiro & Pena Jardim Gonçalves, 2019)
	Collaboration of multi-stakeholder	(Frantzeskaki, et al., 2019)

Transformative Capacity	Emergency services of the government	(Kim & Lim, 2016)
	Community oriented urban planning	(Godschalk, 2003)
	Monitoring expenses	(Chelleri. L B. A., 2021)
	Human resources and equipment quality	(Heinzlef & Serre, 2020)
	Quality assurance	(Fang, Wang, & Fang, 2016)
	Safety promotion	(Ciumasu, 2018)
	Shared facilities of natural resources	(Sharifi, et al., 2017)
	Inclusive governance for sharing benefits	(Carter, et al., 2015)
	Equal access to community resources	(Bahadur & Tanner, 2014)
	Citizen engagement in policy process	(Ribeiro & Pena Jardim Gonçalves, 2019)
	Community cooperatives/club	(Ribeiro & Pena Jardim Gonçalves, 2019)

Table 2: Major indicators of urban resilience. Source: (XunZeng, 2022)

2.8. PHASES OF DISASTER MITIGATION:

The stages of disaster management provide an organized approach to building resilience. Consider disaster as a periodical event that takes place in four stages:

Phase 1: Mitigation

Phase 2: Preparedness

Phase 3: Response

Phase 4: Recovery

Phase 1: Mitigation

To avoid emergencies in the future, take action to reduce the effect.

Before a disaster happens, there is a phase of mitigation. An organization takes steps to minimize risks and effects of the event while protecting people and the property. Reducing vulnerability

to disaster impacts such as property damage and injuries is the organization's primary objective.

Figure 4: Image of disaster management cycle.

Source: https://home.akitabox.com/blog/4-phases-of-disaster-management/

Phase 2: Preparedness

Taking preventive steps to be ready for any emergency

The preparedness phase also comes before the disaster happens. An organization tries to figure out how a disaster could impact overall productivity and its financial performance. Along with executing preparedness measures, the organization also offers necessary education.

Phase 3: Response

To safeguard individuals and assets amid the crisis, emergency, or catastrophe.

The response phase comes immediately after the disaster hits or occurs. The organizations top priority must be dangers to people, assets, and businesses. The degree to with you are prepared before the disaster hits will influence how safe and healthy the occupants are.

Phase 4: Recovery

To rebuild after a disaster to resume regular activities.

The recovery phase comes after the disaster. This stage involves an organizations recovery from any effects of a tragedy. The organization has attained a certain level of social, environmental, economic, and physical stability by this point of time. The recovery phase takes up to six months to one year and sometimes even longer depending on the severity of the event.

CHAPTER

03

URBAN SUSTAINABILITY

3. URBAN SUSTAINABILITY:

The main objective of urban sustainability to create economically successful, socially viable and ecologically sustainable cities which meet the requirements of future generations as well as current ones.

In order to protect the environment, it places an intense focus on reducing pollution, preserving natural resources, encouraging green spaces and renewable energy. At the same time urban sustainability also ensures that citizens have access to basic amenities like housing, public transit, healthcare and education. In terms of economy, it encourages innovation, job development and resource efficiency, keeping cities resilient and alive.

Table 3: List of the 5 definitions of urban sustainability.

S.No	Source	Summary of Concept
1	(Eastaway & Støa, 2004)	"The perception of sustainability as applied to a city in the metropolitan areas capacity and its region to continue to work at standards of quality of people's life desired by the population without reducing current and future generation's option or having adverse impacts both inside and outside the urban boundary" (XunZeng, 2022)
2	(Schwegler, 2015)	"The word sustainable city has many definitions and it includes or is connected with several other, often contradictory, conceptual designations. They attempt to balance economic progress, life quality, and environmental sustainability." (XunZeng, 2022)
3	(Verma, 2018)	"Urban sustainability is a cross cutting topic that effects the climate, culture, and economy." (XunZeng, 2022)
4	(Wu, 2014)	"Urban sustainability is a vital adaptive mechanism that promotes and preserves a worthy cycle between ecological resources and peoples well being by co-ordinating ecological, economic, and social activities

		for a change within and outside the urban landscape." (XunZeng, 2022)
5	(Russo. A., 2020)	"Ecosystem services are vital for urban sustainability, and they have a direct influence city quality of life." (XunZeng, 2022)

3.1. DIMENSIONS OF URBAN SUSTAINABILITY:

The three dimensions of urban resilience are

1. Environmental Sustainability

Environmental sustainability is one of the main pillars of sustainability. To protect and maintain the natural environment, it places an extreme focus on satisfying present demands without compromising on future demands. Urban vulnerabilities can be reduced and citizens resilience can be improved by incorporating environmental sustainability into urban management techniques.

The demand for environmental conservation has increasingly important due to rising emissions and rapid depletion of natural resources demanding the special attention from government, organizations, businesses, and individuals. Cities can improve their ability to respond to problems and provide more value to their communities by adopting sustainable practices.

2. Economic Sustainability:

The value of both, the resources current value and possible future economic value are explained in detail by the idea of resource planning. Value is described by some factors like properties and responsibilities, saving, patents and intangible properties.

The concept describes how we use, protect, and preserve assets in the urban management to create a value that lasts through recycling, regeneration, and effective usage. In simple terms we protect the resources for future generations to meet their

requirements so we need to limit the usage of natural resources today.

3. Social Sustainability:

Mostly the researches are focused on environmental and economic sustainability and the social sustainability is often forgotten or ignored. For the best long-term outcome all the three elements of sustainability are to be paid attention to. Societies that are economically stable are democratic, diverse, equal and have a good quality of life. Indicators of both social and physical domains are also incorporated in social sustainability.

3.2. INDICATORS OF URBAN SUSTAINABILITY:

Major Dimensions	Major Indicators	Researchers & Time
Environmental sustainability	Fresh water availability	(Maurya, Singh, Ohri, & Singh, 2020)
	Fresh air availability	(Magee, et al., 2013)
	Renewable energy	(Bibri, 2018)
	Green space	(Kong, Liu, & Wu, 2020)
	Waste management	(Zhang, Pan, Yu, & Liu, 2019)
	Community Forestry	(Allen, Tamindael, Bickerton, & Cho, 2020)
	Recycling of waste	(Haapio, 2012)
	Green product	(Reisi, et al., 2020)
	Green transport	(Wu J. , 2014)
	Ecological footprint	(Bibri S. E., 2020)
	Mixed land use	(Zhang & Li, 2018)
Economic Sustainability	Strategy of green development	(Russo. A., 2020)
	Zoning	(Allen, Tamindael, Bickerton, & Cho, 2020)
	Tax policy	(Verma, 2018)
	Green business	(Bibri S. E., 2020)
	Urban growth	(Liang, Xie, Sha, & Zhou, 2020)
	Labour and welfare	(Pan, Tian, Liu, Gu, & Hua, 2016)
	Green banking	(Kong, Liu, & Wu, 2020)

	Production and resourcing	(Haapio, 2012)
	Job Opportunity	(Anejionu, et al., 2019)
Social sustainability	Social equity	(Bibri S. E., 2020) (Ilieva & McPhearson, 2018)
	Community garden	(Schwegler C. , 2015)
	Accommodation	(Kong, Liu, & Wu, 2020)
	Social inclusion	(Zhang & He, 2020)
	Safety net program	(Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017)
	Citizen participation	(Allen, Tamindael, Bickerton, & Cho, 2020)
	Homeless caring program	(Andronie, Lăzăroiu, Iatagan, Hurloiu, & Dijmărescu, 2021)
	Food and nutrition system	(Huang & Wang, 2020)
	Social insurance	(Pan, Tian, Liu, Gu, & Hua, 2016)

Table 4: Major indicators of urban sustainability. Source: (XunZeng, 2022)

3.3. RELATIONSHIP BETWEEN URBAN RESILIENCE AND SUSTAINABILITY:

Conceptually the relation between resilience and sustainability is occasionally misinterpreted. Resilience and Sustainability are applied interchangeably in some situations. Prominent scholars on resilience argue that achieving sustainability in a "world of transitions" requires system resilience. Therefore, resilience and sustainability are not mutually exclusive as a vivid concept.

When seen as a paradigm of environmental management and transformation, there are crucial differences despite their diverse theoretical foundations. Resilience focuses on system modeling, often looking at socio-ecological systems, but may overlook social inequalities. Sustainability on the other hand stresses the importance of balancing economic, environmental, and social justice, which resilience studies tend to focus less on.

CHAPTER

04

STRATEGIES (NBS) AND CASE STUDIES

4. NATURE-BASED SOLUTIONS:

Nature-based solutions are all about tackling societal and environmental issues such as disaster risk reduction, safety of water, and climate change using natural processes. These include creating green infrastructure like urban parks and green roofs, and restoring forests, wetlands, and coral reefs. By absorbing carbon, enhancing biodiversity, and providing protection from natural disasters like floods and coastal erosions, nature-based solutions help mitigate climate change.

BENEFITS

- Availability of green space
- Climate mitigation and adaptability
- Shoreline resilience
- Water management
- Urban revitalization
- Air pollution control
- Holistic wellbeing
- Green economy and opportunities
- Inclusive decision making
- Social equity and harmony

CHARACTERISTICS

Features of Nature-based solutions include

- Action-oriented: NBS focuses on implementing ideas into actions on the ground.
- Multi-functional: NBS provides a wide range of co-benefits including biodiversity, climate change mitigation, and public health.
- Cost effective: The direct and indirect benefits of NBS are likely greater than the cost of setting and maintaining them.
- Multiscale: Possible to use at various scales.
- Context specific: They are supposed to be customized according to the circumstances that exist.

- Co-co-co: Use of participatory methods for co-designing, co-creating, and co-managing NBS to provide solutions that address the needs of various stakeholders.

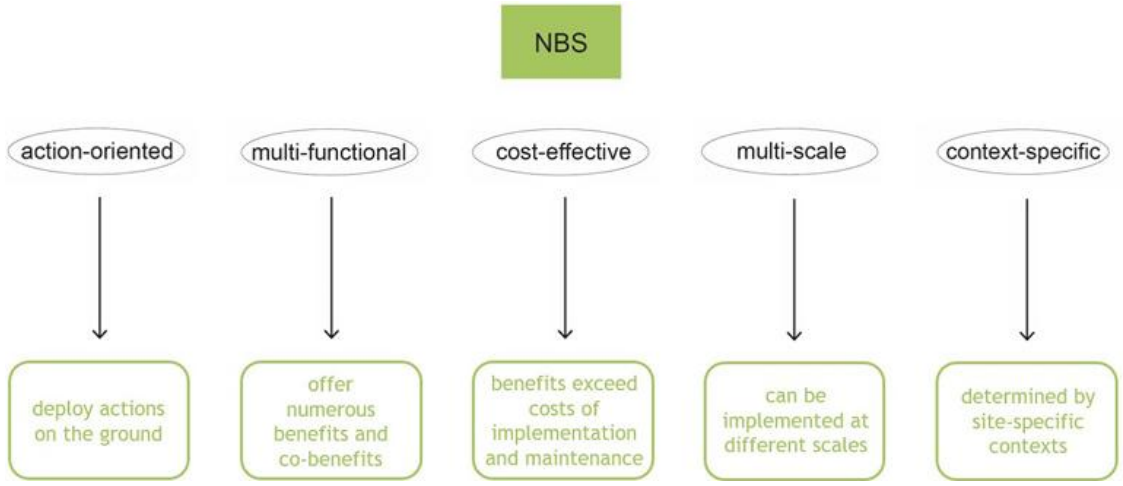


Figure 5: Characteristics of NBS.

Source: (Bernd Eisenberg, 2019)

TYPES OF NATURE-BASED SOLUTIONS

Type 1: Approaches that involve improving the utilization of already existing protected or natural habitats.

Type 2: Approaches focused on developing sustainable guidelines and practices for maintaining and restoring ecosystems.

Type 3: Approaches that involve creating new ecosystems or managing existing ones thorough highly intensive interventions.

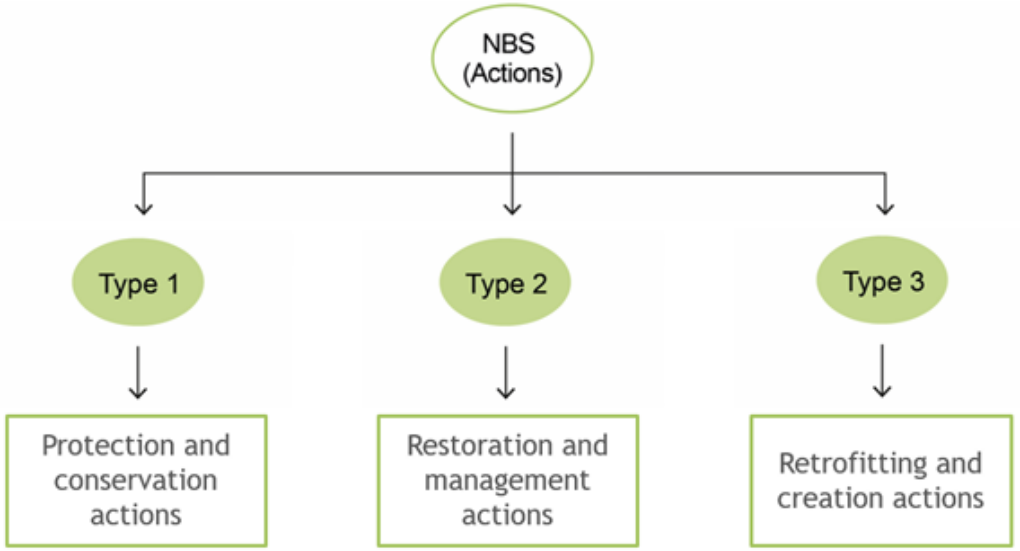


Figure 6: *Types of NBS actions*.

STRATEGIES FOR WATER-SENSITIVE URBAN DESIGN:

4.1.1. CONSTRUCTED WETLANDS:

The natural wetland services are modified for artificial wetlands emphasizing water filtration and storage. The primary purpose of constructed wetlands, which are artificial wetlands is to collect, clean, and store water and greywater runoff in the cities. Constructed wetlands replicate the hydrological dynamics of natural wetlands like marshes, swamps, or lagoons, focusing on water purification and storage, and offer a sustainable approach to urban water management.

Constructed wetlands are substratum-filled shallow basins. Although the composition of the substrate may vary, constructed wetlands are often filled with gravel or sand. Aquatic plants or other vegetation are planted on the substrate layer. Stormwater runoff enters the constructed wetland through an inlet or a pipe. The water is naturally cleaned and filtered as it passes through the wetland in a horizontal flow.

Benefits:

- Water resource management
- Thermal regulation of water
- Improved water quality
- Flood risk management
- Conservation of biodiversity
- Outdoor recreation
- Landscape enhancement

Conditions for Implementation:

- Upland location or gently sloped location
- Enough land available
- Accessible land
- Near source of wastewater
- Compact soil
- No endangered or threatened species
- Near source of wastewater

Figure 7: Constructed wetlands of the Second Wanzhou Yangtze River bridge waterfront ecological park, China. Source: https://www.gooood.cn/landscape-design-of-chongqing-second-wanzhou-yangtze-river-bridge-waterfront-ecological-park-china-by-chongqing-haofeng-planning-and-design-group-co-ltd.htm

4.1.2. BIOSWALES

The bioswale is a landscaped, shallow, gently sloped channel often placed in urban areas between or beside roads to reduce the flood risk during or after heavy rains. Bioswales and rain gardens have similar goals. Surface water runoff, primarily from the roads is absorbed, stored, and transported by bioswales they also filter out the pollutants and sediments as they pass through the soil and vegetation layer.

Native plants with deep roots are often chosen for the bioswales and some swales are equipped with dams and similar structures to support infiltration of water runoff. If they are well-planned and planted with native plants, they can be a viable addition to local stormwater management. They can be implemented in any area, region, or country.

Benefits:

- Stormwater management
- Flood risk management
- Improved water quality
- Improved air quality
- Ecological habitat enhancement
- Improved visual and community value

Potential limitations:

- Limited vegetation - restricted ground-level habitats

Conditions of Implementation:

Stormwater from building roofs and paved areas must be collected to lead them into bioswales. A certain amount of space must be dedicated to implement.

Figure 8: Bioretention swale in Seattle, Washington.

Source: https://www.seattle.gov/documents/Departments/SPU/EnvironmentConservation/9ChupaLathropDamaskeHighPointRedevelopmentOverview.pdf

4.1.3. RAIN GARDENS

A particular kind of garden largely used for small-scale water control, particularly in urban areas is called a rain garden. They collect water runoff from roof surfaces, roads, and highways and are established in artificial environments. Runoff water is captured in the rain gardens and held for a while until it seeps into the ground or flows into the sewage system. Plants absorb and release a certain amount of water. Several components like grass filter strips, water ponds, plants, or sand beds are incorporated into the construction of rain gardens, which come in a variety of designs and configurations.

Other than storing and infiltrating stormwater rain gardens improve aesthetics and increase the amenity value. With proper design and planning rain gardens can survive in any region. However, the selected components such as plants should be native and well adapted to the regional climate.

Benefits:

- Improved water quality
- Flood risk management
- Enhancement of biodiversity and wildlife
- Groundwater recharge
- Aesthetically pleasing
- Easy to maintain after establishment
- Water conveyance
- Enhance property value

Conditions of implementation:

- Location: Place in 3meters from buildings in a naturally wet area
- Soil and Size: Use well-drained soil to handle 10-20% runoff
- Plants: Use of native plants that are water tolerant.

Figure 9: Small-scale rain garden. Source: Andras Kis provided in https://www.nwrm.eu/sites/default/files/nwrm_ressources/u9_-_rain_gardens.pdf)

4.1.4. INFILTRATION BASIN

Infiltration basins are flat, grass-planted areas that are typically dry but after a heavy rain, the water fills up the basin and seeps into the earth.

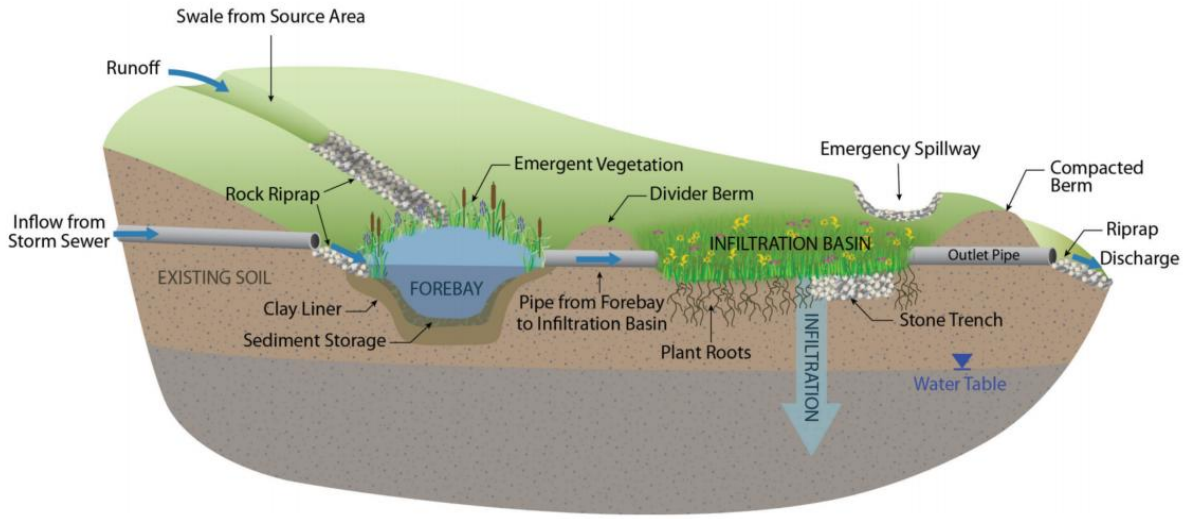


Figure 10: Illustration of Infiltration basin. Source:https://megamanual.geosyntec.com/npsmanual/infiltrationrechargebasins.aspx

Benefits:

- Purifies the rainwater

Conditions of Implementation:

- Availability of space
- Can be implemented in private gardens, parks, and driveways
- Specific levels of rainfall intensity

Types of Infiltration basins are:

1. Dry infiltration basin
2. Wet infiltration basin

- **DRY INFILTRATION BASIN:**

Stormwater is held in a surface storage basin called a dry infiltration pond. After heavy rainfall, the water gets filled in the dry basin and seeps into the earth after a while or goes into the sewer system. If there is no rain then the basin remains dry and can be used as a green area.

Figure 11: Detention pond. Source: https://www.sudswales.com/types/passive-treatment/detention-basins/)

Benefits:

- Manages heavy rainfall
- Enables versatile detention pond usage.

Limitations:

- Restricted design flexibility
- Overloaded green spaces limit leisure space

Conditions for Implementation:

- Can be considered in a space like a park
- Enough space to get floods

- **WET INFILTRATION BASIN:**

Unlike dry infiltration basins, wet basins retain water for long periods creating a small pond-like environment. These ponds can improve the water quality (with downstream infiltration).

Figure 12: Wet retention pond (Source:https://www.vawaters.com/services/stormwater-pond-management)

Benefits:

- Stormwater capture and storage.
- Recycled water for landscaping

Limitations:

- Highly utilized green space leads to limited room for recreation.

Conditions for implementation:

- Included in parks
- Enough space to get floods

4.1.5. PERMEABLE PAVEMENT:

Permeable pavement is made to allow water to seep through its surface and into the ground by improving groundwater recharge and reducing stormwater runoff. In urban settings, it is commonly used for sustainable drainage systems.

However permeable pavement has multiple layers that filter and store stormwater.

- The surface layer consists of porous materials that allow water to pass through. (interlocking pavers, permeable concrete, or asphalt)
- The base layer consists of crushed stone or gravel that serves as a temporary water storage and structural support.
- The sub-base layer consists of sand or gravel which helps in filtration and gradual infiltration into the soil.

Figure 13: Permeable pavement. Source: https://www.gardeningknowhow.com/garden-how-to/design/lideas/permeable-pavement.htm

Benefits:

- Improves water quality
- Stormwater management
- Runoff mitigation
- Regulated water absorption
- Short-term water retention
- Enhances groundwater rechange

Best applications:

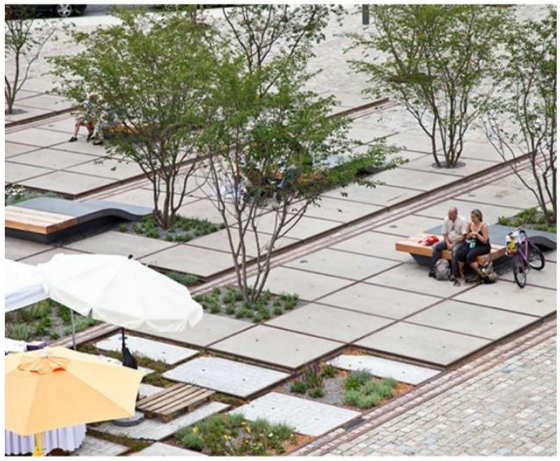
- Driveways and parking lots
- Sidewalks and bike paths
- Urban plazas and courtyards
- Fire lanes and emergency access roads

Limitations:

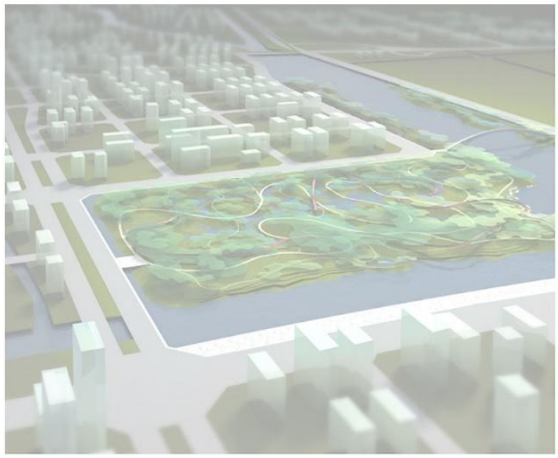
- Limited load on paved areas

CASE STUDIES

SQUARES AND PLAZAS



WATERFRONT PARKS



MOBILITY AND TACTICAL URBANISM

4.2. CASE STUDIES OF SQUARES AND PLAZAS

4.2.1. ZOLLHALLEN PLAZA IN FREIBURG, GERMANY

Type: Squares and plazas / Flood resilience

Site: 5600 sqm

Built-in: 2011

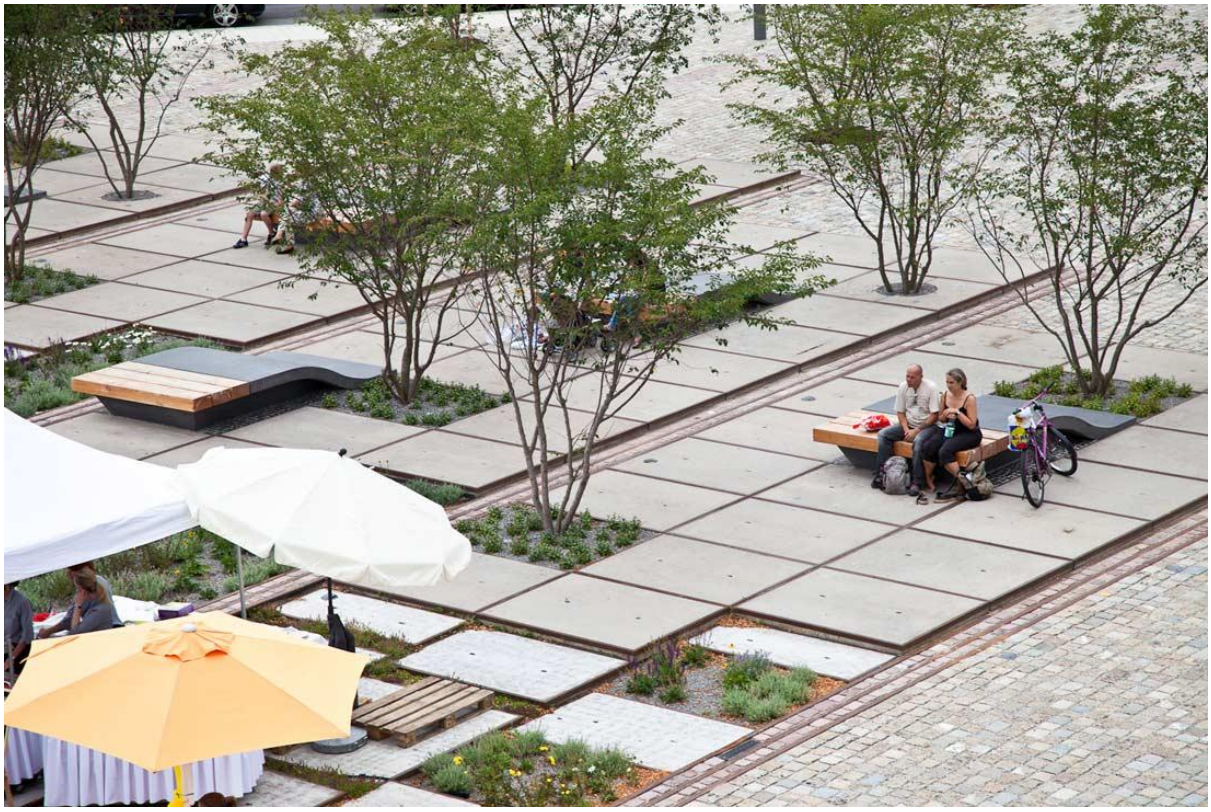


Figure 14: Image of the flood zone of the plaza.
Source:https://landezine.com/flood-zone-on-public-plaza-design-by-henning-larsen/

History: The site was a freight train terminal which has turned into a wasteland.

Vision: To have a city infrastructure that is affordable, low maintenance, multi-functional, and cultural assets.

Aim: To turn the space into a multi-purpose social hub for a local community.

Design Features:

Plazas hold the potential to work as a climate adaptation tool. The designer has disconnected the site from the local sewage

system. Storm has overwhelmed the capacity of the local sewage system. With time, it is observed that incorporating permeable paving and strategically placing planting pockets can mitigate the heat island effect. The water stored under the permeable pavement evaporates and reduces the surface temperature.

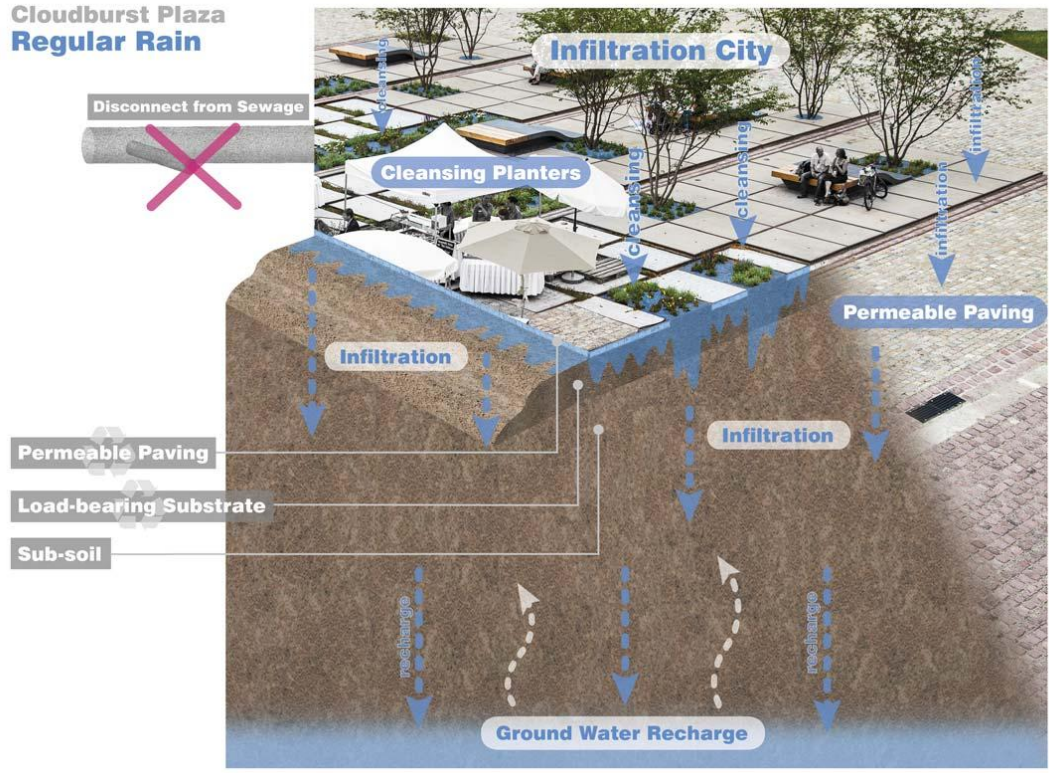


Figure 15: Illustration of sustainable urban drainage system in a cloudburst plaza. Source:https://landezine.com/flood-zone-on-public-plaza-design-by-henning-larsen/

The plaza with bench planting area is designed in such a way that it gets flooded when it rains heavily so that it would improve the soil infiltration capacity. So, it would be a safe zone in extreme situations.

The low-maintenance planters act as infiltration points and the rainwater is diverted to recharge the groundwater table. This innovation helps in reducing hydraulic overload on the sewage system. In this way no rainwater is sent into the sewage and is wasted instead it refills the groundwater.

Enormous-sized furniture is placed in the plaza so that people can spread out and sit comfortably and have their privacy at the same time. The design of the benches resembles the railroad track brakes. Old rail tracks are recycled as paving inlays. The paved area is used for markets and local events. All the best quality hardscape materials are recycled from the old railyard.

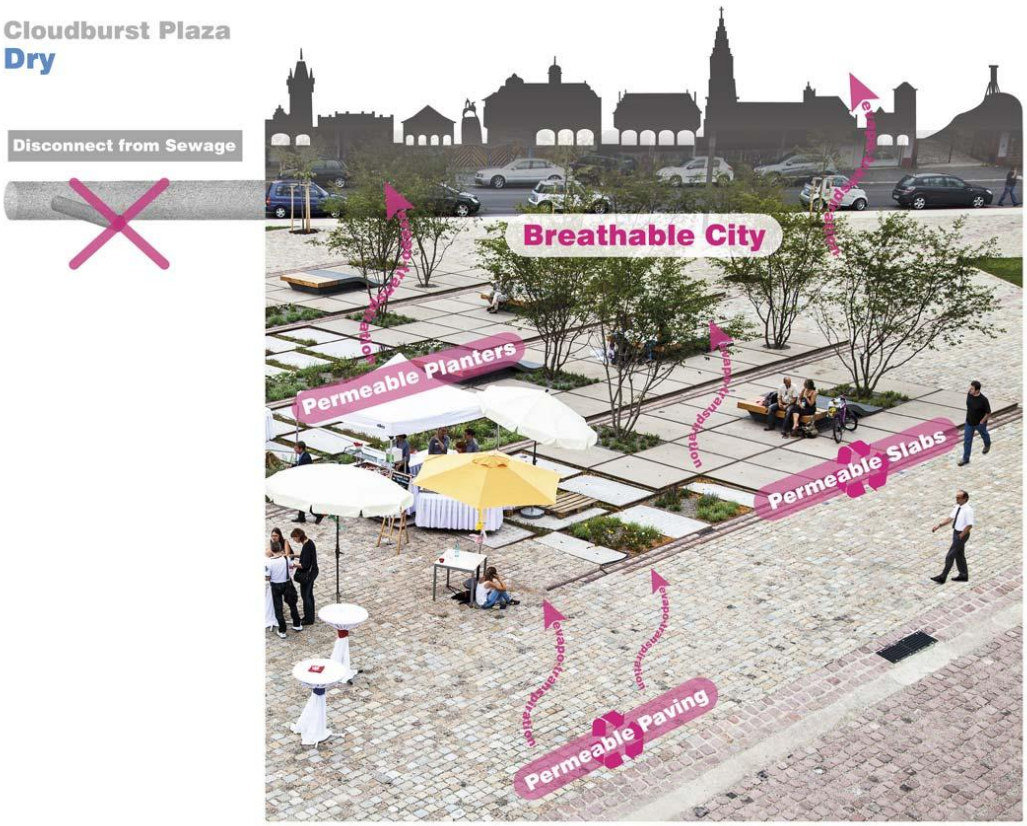


Figure 16: The diagram showcases a dry-phase cloudburst plaza designed for a Breathable city. Source: https://landezine.com/flood-zone-on-public-plaza-design-by-henning-larsen/

4.2.2. WATERSQUARE IN BENTHEMPLIEN, ROTTERDAM:

Type: Public Space/ Water management system

Site area: 1.24 acre

Built-in: 2018

Due to climate change the city of Rotterdam has faced increased rainfalls. So, they have come up with a broader strategy for sustainable water management.

Vision: To create a space that labels water management and a functional public space for city recreation. This project also tried to show innovative solutions for storm water management in urban fabric.

Aim: The squares aim was to reduce the risk of flooding in the urban environment and to by allowing water to store temporarily in the depressions and pools in the landscape. To make a multi-functional space which can be used by the public.

Figure 17: Image showcasing multifunctional urban plaza designed for water management and public use. Source: https://www.urbanisten.nl/work/benthemplein

Design Features:

- Multifunctional design: The square is divided into three zones:
  - Dry Zone: The main space with is used for interaction, activities and events remain dry
  - Wet Zone: When it rains heavily this area is filled with water temporarily which is shallow.
  - Aquatic zone: This zone is like a small size pond which can hold large amount of water
- Water management system: Chanels are designed in such a way that the rainwater is carried or passed to the small storage areas. It is stored temporarily and then released into the drainage or absorbed into the ground.
- Vegetation: To maintain the ecological balance vegetation was placed in the site. This vegetation helps in filtering the rain water and improving the aesthetics of the square.
- Public interactions: The design makes people understand how water is managed and how space is attractive and useful at the same time.

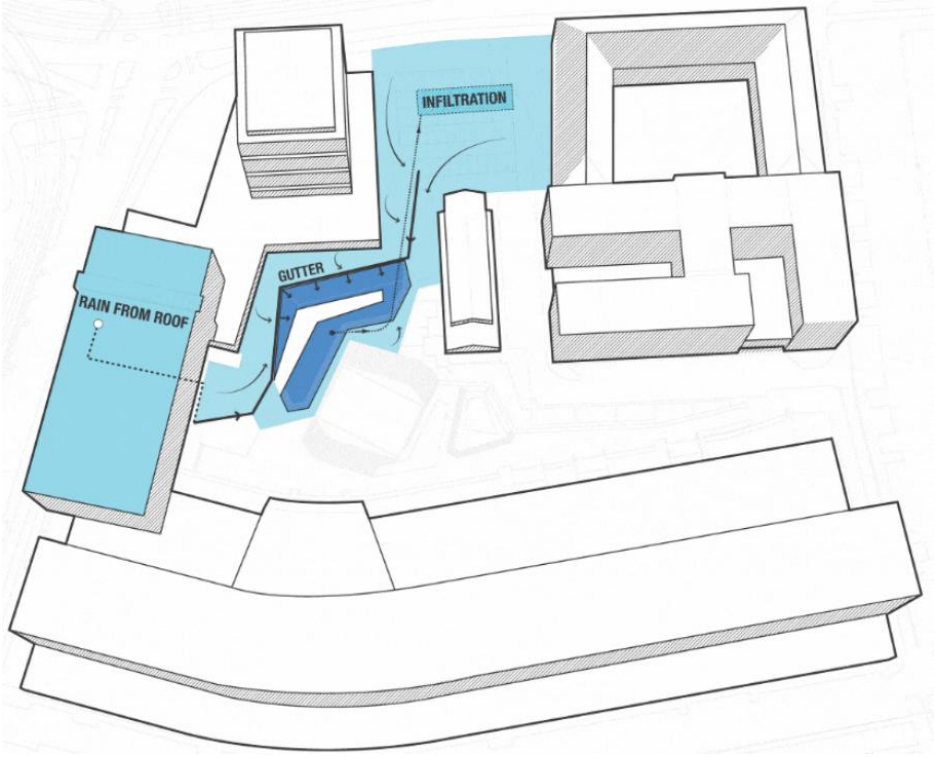


Figure 18: Image showing the flow of rainwater to the plaza.

Source: https://www.urbanisten.nl/work/benthemplein

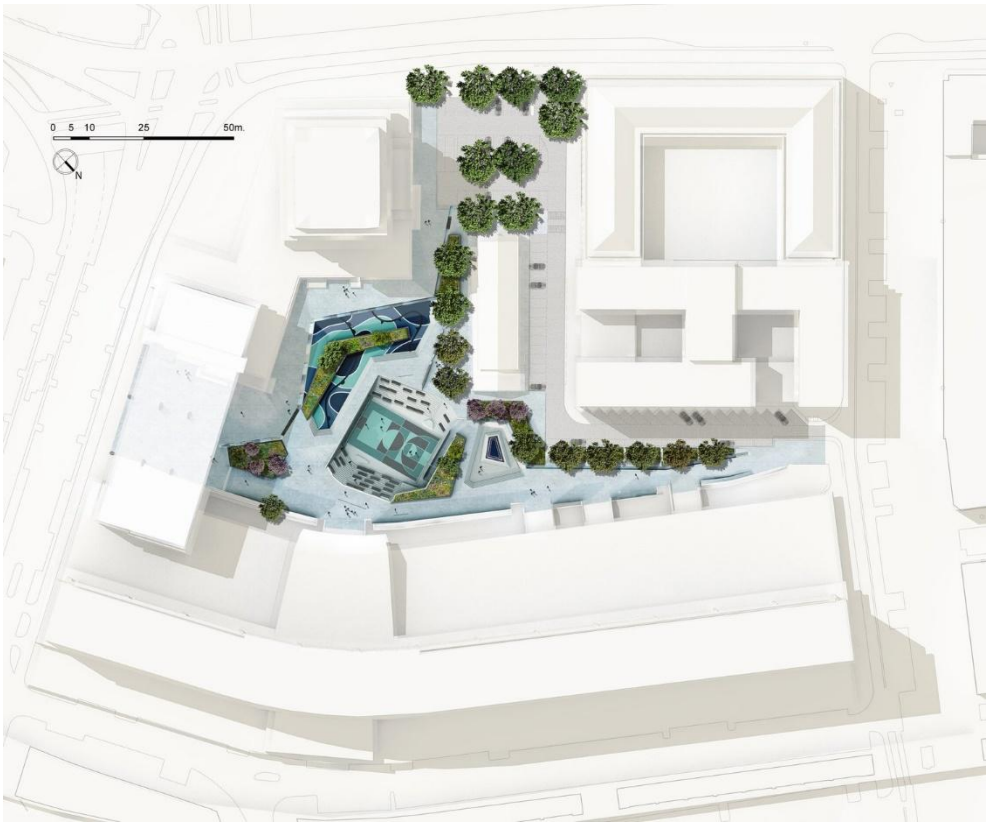
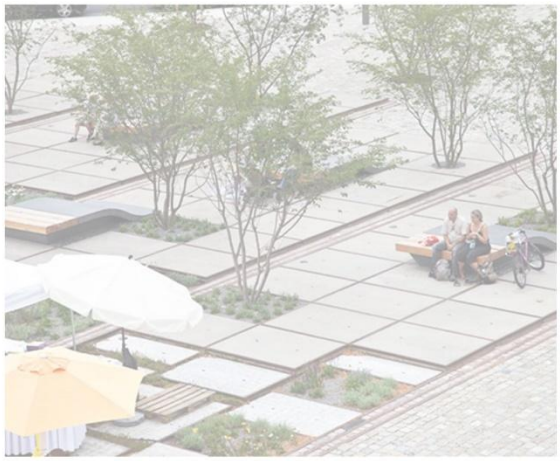


Figure 19: Site plan of the Water square Benthemplein.

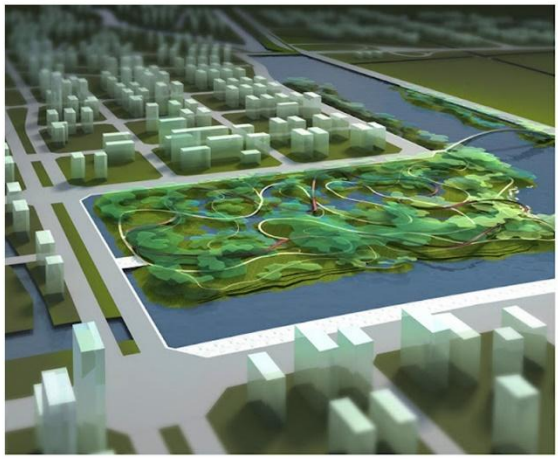
Source: https://www.urbanisten.nl/work/benthemplein

CASE STUDIES

SQUARES AND PLAZAS



WATERFRONT PARKS



MOBILITY AND TACTICAL URBANISM

4.3. CASE STUDIES OF WATERFRONT PARKS:

4.3.1. THE NEW QINGPU WETLANDS, CHINA

Type: Park

Site area: 169 acres

Built-in: 2009

History: Qingpu is a traditional water town consisting of farmlands, rivers, and a conglomeration of lakes. Accelerated industrial development and urbanization have altered it with industries, residential areas, and commercial areas. This has led to air and river pollution and loss of habitat.

Vision: To create a sustainable urban landscape that regenerates the natural ecosystem and creates recreational spaces for the people.

Aim:

- Protect and sustain the natural wetland ecosystem.
- Creating habitat for native plants and animals.
- Providing a natural escape from urban life and educating people about environmental awareness.
- Incorporating sustainable water treatment practices to manage rain and river water.

Design Features: The four key features are

- Three-dimensional pathways: Elevated walkways built 4 meters above the ground level in order to not disturb the natural environment but also allow people to experience the wetlands.
- Vertical landscaping: Lower central areas are surrounded by protective hills to reduce the risk of flooding and to promote diverse vegetation.
- Water management system: The wetlands purify the water in a natural way. The excess water is sent into the Dian Pu River and in the dry seasons this water can be used for irrigation purposes.

- Ecological habitats: the park is designed to promote a healthy and balanced ecosystem by supporting native wildlife.

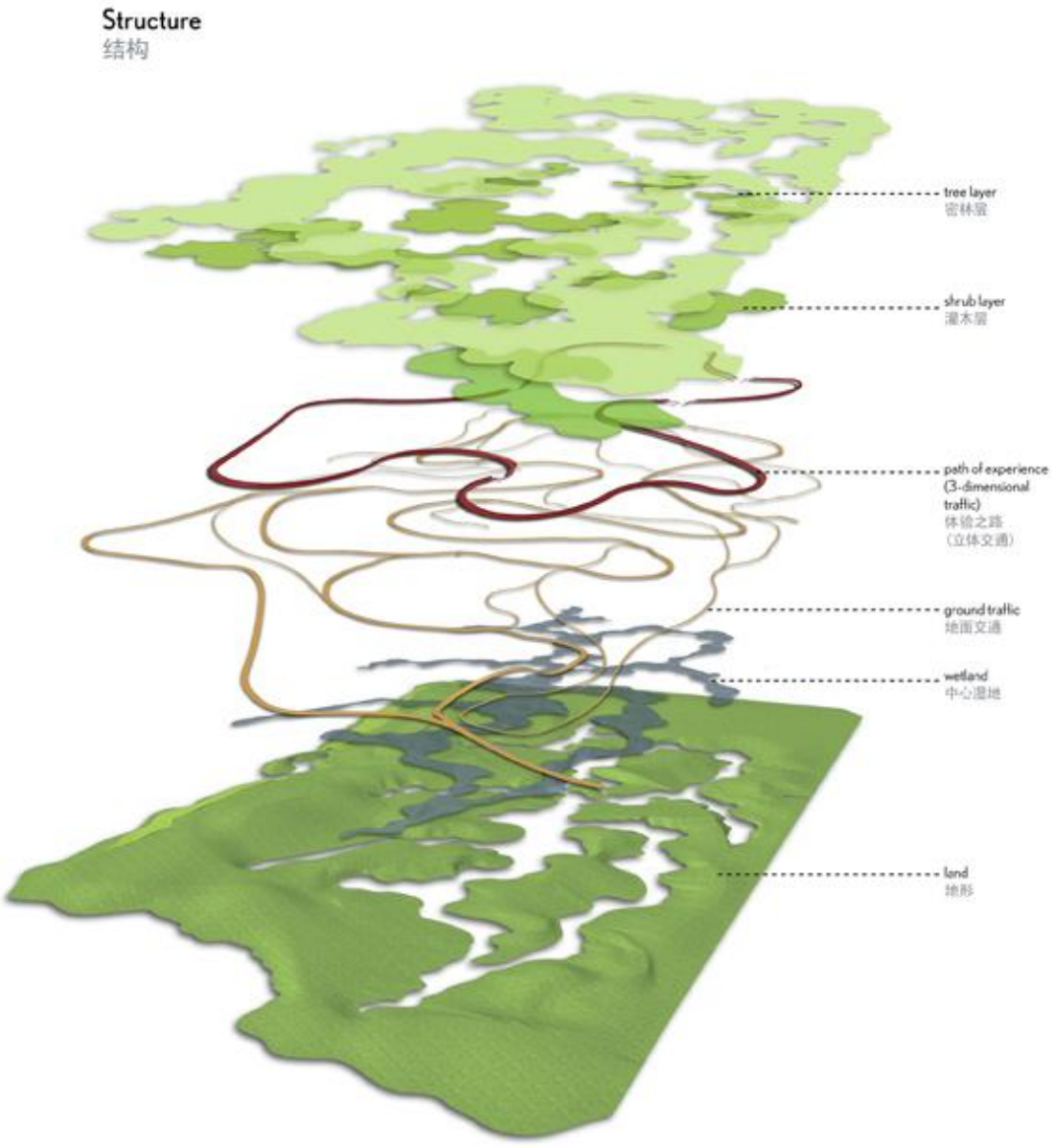


Figure 20: Structure of wetland.

Source: https://www.archdaily.com/98052/the-qingpu-wetlands-logon-architecture

Cultural Preservation:

By creating paths to wander around and viewing areas to watch ships the park has preserved the historical lifeline of the Dian Pu River. The floating amphitheatre evokes memories of cultural performances and the old ships are reused into bars and cafes.

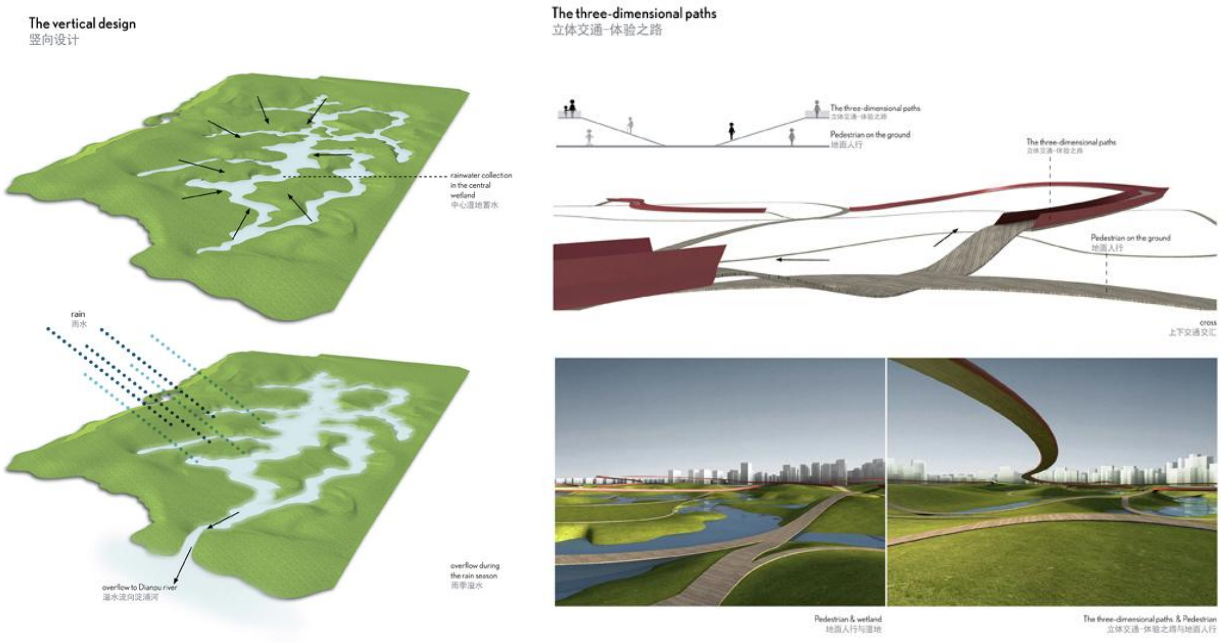


Figure 21: Image on left showing how the wetland works in normal days and during rains. Image on right shows the three dimensional paths designed in the park.

Source: https://www.archdaily.com/98052/the-qingpu-wetlands-logon-architecture

4.3.2. FENG RIVER ECO PARK, CHINA

Type: Park

Site area: 130 hectares

Built-in: 2010

History: Urban expansion has resulted in the environmental deterioration of Feng River in Xian, China. Industrial activities, urban expansion, and unprocessed wastewater release have caused environmental deterioration which resulted in loss of biodiversity and loss of public spaces.

Vision:

To make a model for environmental restoration that combines urban development with environmental sustainability, which leads to a healthy relationship between nature and the city.

Aim: To promote sustainable urban growth while improving biodiversity, water quality, and recreational spaces.

Figure 22: View of Feng River Eco Park. Source: https://mooool.com/en/feng-river-wetland-environmental-design-by-gvl.html

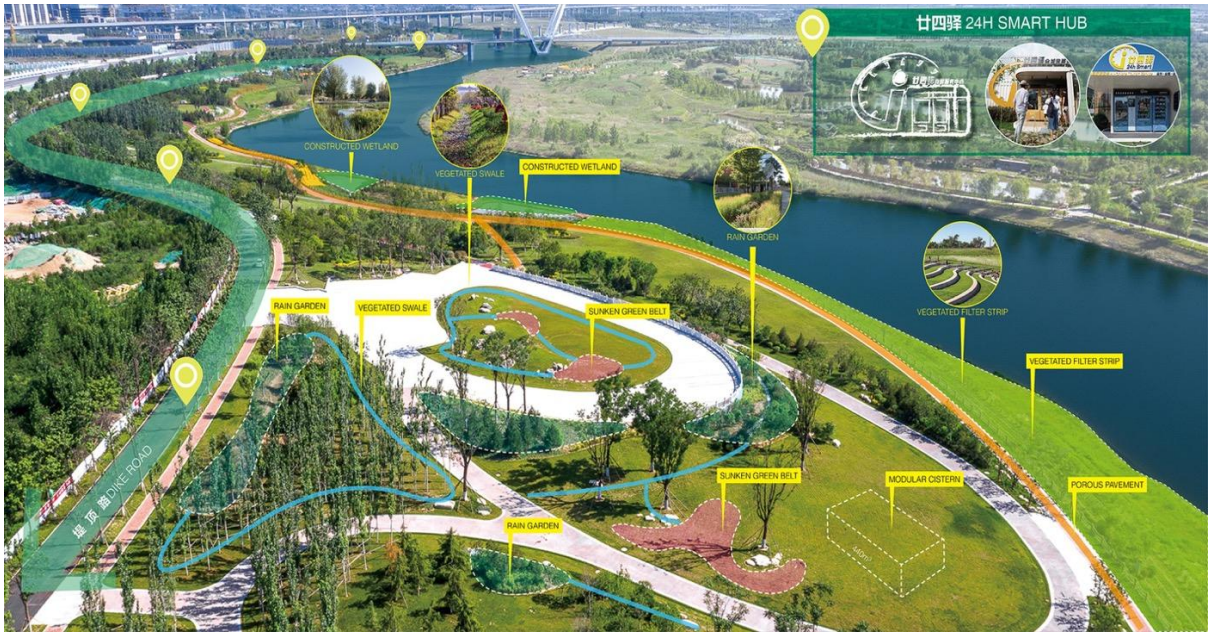


Figure 23: Image showing all the strategies used in the park. Source: https://landezine-award.com/feng-river-eco-park/

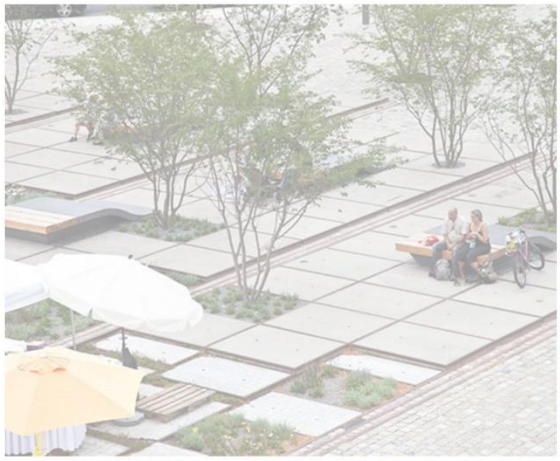
Design Features:

- Ecology and water management: As a part of cities sponge city and water management plans terraces of bio-filtration wetlands are built on the bank of the river to cleanse or purify water before it enters the river.
- Rain gardens, bioswales, contrasted wetlands, infiltration ponds, underground storage tanks, and permeable paving are used to reduce the rainwater runoff from the site into the river. The storage water is reused for irrigation and maintenance purposes of the park.
- Infrastructure: A linear dike road and smart hubs are integrated at the key entries and relate to a three-tier system for walking, jogging, and bicycling. These are connected to self-service food, Wi-Fi, Charging, and restrooms connecting the park to border Xian destinations.

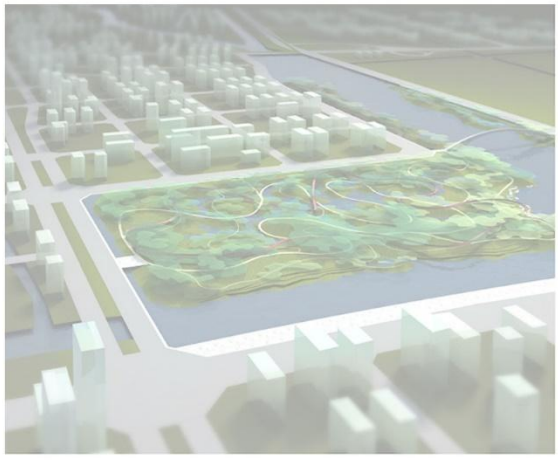
By combining modern amenities with ecological restoration, the park stands as a model for future sustainable development.

CASE STUDIES

SQUARES AND PLAZAS



WATERFRONT PARKS



MOBILITY AND TACTICAL URBANISM

4.4. CASE STUDIES OF MOBILITY AND TACTICAL URBANISM:

4.4.1. THE SUPERBLOCKS PROGRAMME, BARCELONA:

This program is designed to promote equitable, healthy, safe, and sustainable use of urban space. A hierarchy of roads has been set up based on functionality, connectivity, and size. They are main roads used for public transport and fast-moving bicycles, secondary roads used for lesser roles and on residential streets motorized traffic, important to pedestrians, slow-moving bicycles, and minimizing the curb side parking.

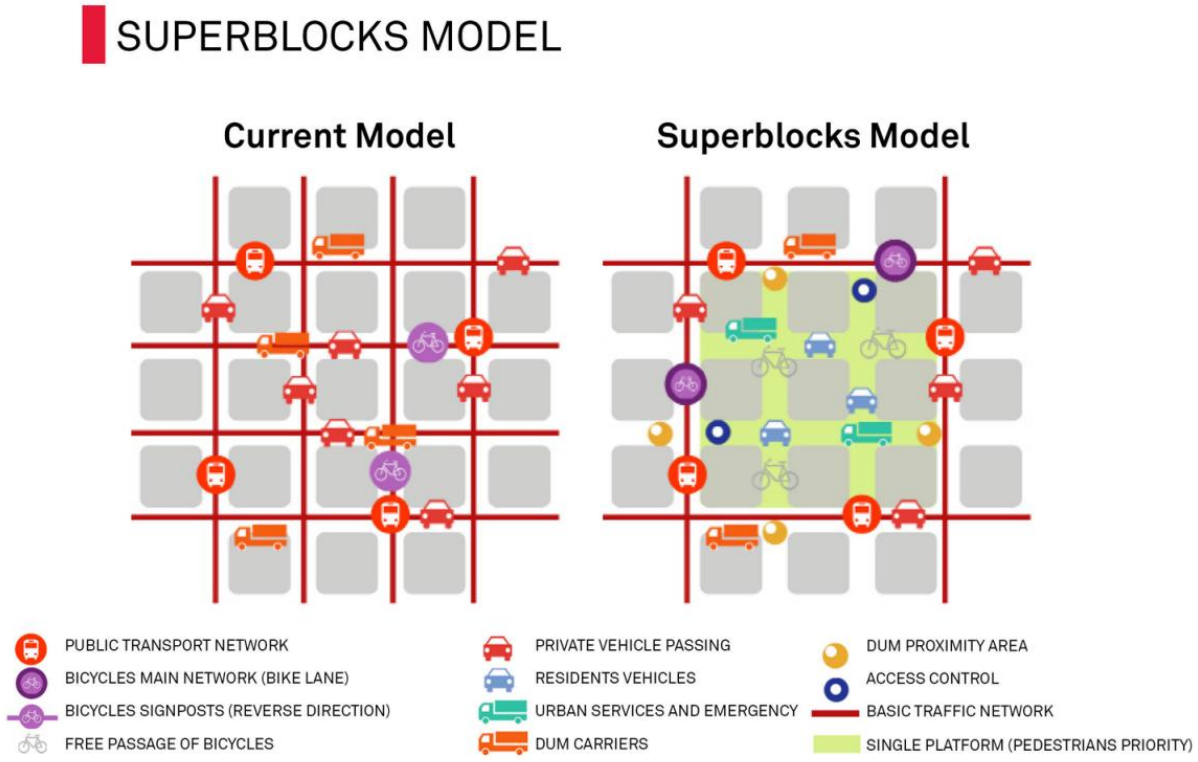


Figure 24: The street system before and after implementing superblock. Source: https://www.mdpi.com/2073-4433/11/4/410

Objectives of the Urban Mobility Plan of Barcelona (Superblocks):

- Safe Mobility: Reduce the accidents
- Sustainable Mobility: Promote sustainable transport modes, decrease air pollution, decrease noise pollution from traffic, reduce energy consumption, and promote renewable energy sources.

- Equitable Mobility: Ensuring a transportation system for all and promoting alternate uses of roads.
- Efficient Mobility: Improving efficiency and integrating new technologies.

Key benefits:

- Community interaction: The free space created in the residential streets is being used for public uses like walking, playing, resting, and increased green spaces. This space has encouraged socializing, improved mental health, reduced loneliness, and created safer walking spaces.
- Safety: Cars are allowed into the residential streets but at 10km/hr speed which ensures safety of pedestrians.
- Noise reduction: The noise has significantly reduced from 57% to 26.5%. This will help in improving peoples health, safety and comfort.
- Economic activity: Local businesses have seen a hike of 30% more activity due to increased foot traffic.
- Equitable: Started to build in low-income neighborhoods to avoid gentrification superblocks were implemented throughout the city.

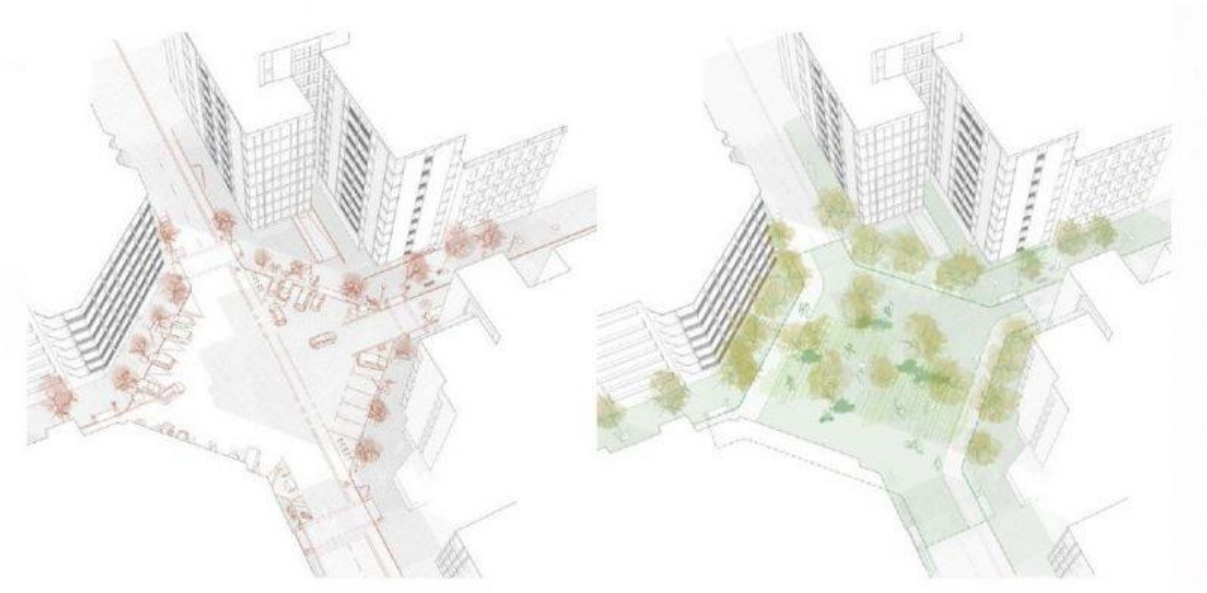


Figure 25: Cross roads (left) to plaza (right) redesigned by Ajuntament de Barcelona. Source: https://ajuntament.barcelona.cat/premsa/wp-content/uploads/2020/11/201111-DOSSIER-Superilla-Barcelona-EN.pdf

Results:

- 40% of traffic reduction in superblocks
- Improved quality of life with more community spaces and safer streets.
- Improved air quality by increasing more green spaces.

Figure 26: Inclusive public spaces created in the superblocks. Source: Ajuntament de Barcelona. Source: https://popupcity.net/insights/superblocks-redesigning-barcelonas-grid-for-pedestrians/

Sources:

https://prod-mobilitat.s3.amazonaws.com/PMU_Sintesi_Angles.pdf

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https://prod-mobilitat.s3.amazonaws.com/PMU_Sintesi_Angles.pdf

4.4.2. PIAZZA APERTE PROJECT, MILAN:

The municipality of Milan has started a project called the Piazza Aperte Project. They used the COVID-19 lockdown to reclaim the outdoor sports and recreational areas. The streets were empty so they could work effectively. They have recognized 38 public squares within the localities of Milan.

Aim: To transform public spaces into vibrant community hubs, to expand pedestrian zones and foster sustainable mobility with an aim to enhance quality of life.

Main focuses:

- Ensure walkways are sufficiently spaced to maintain good clearance from the structural obstacles.
- Converting parking spaces into outdoor spaces for restaurants and bars.
- For schools to have gyms and playgrounds to encourage active spaces.
- To promote the use of outdoor spaces for cultural and sports events.

Figure 27: The tactical urbanism intervention in Spoleto Street, Milan.

Source: https://cities-today.com/the-tactical-urbanism-transforming-milans-streets/

In a neighbourhood scale, Measures can be applied to temporarily changing infrastructure to improve community bonds and they are cycling, walking, and social interaction. A city within 15 minutes of walking distance to access all the nearby services within a distance. (adaptation strategy, Milan 2020)

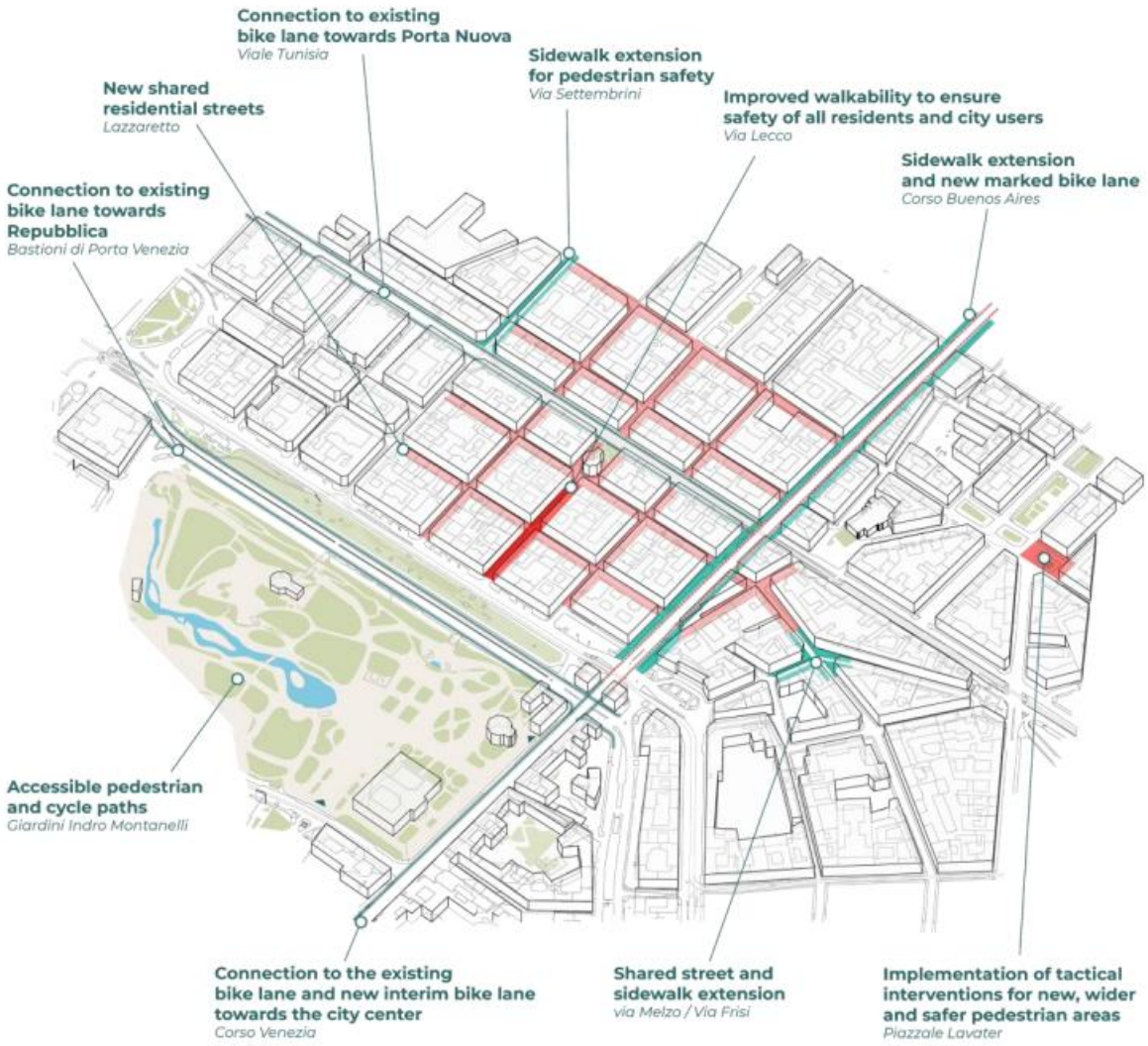


Figure 28: Image explains trail sample of intervention – a model for future implementation. Source: Adaptation strategy, Milan 2020

The Street as a Public Space:

To adjust to the "new normal" streets in areas with limited green spaces should be reimagined as safe, accessible places where children could play and exercise.

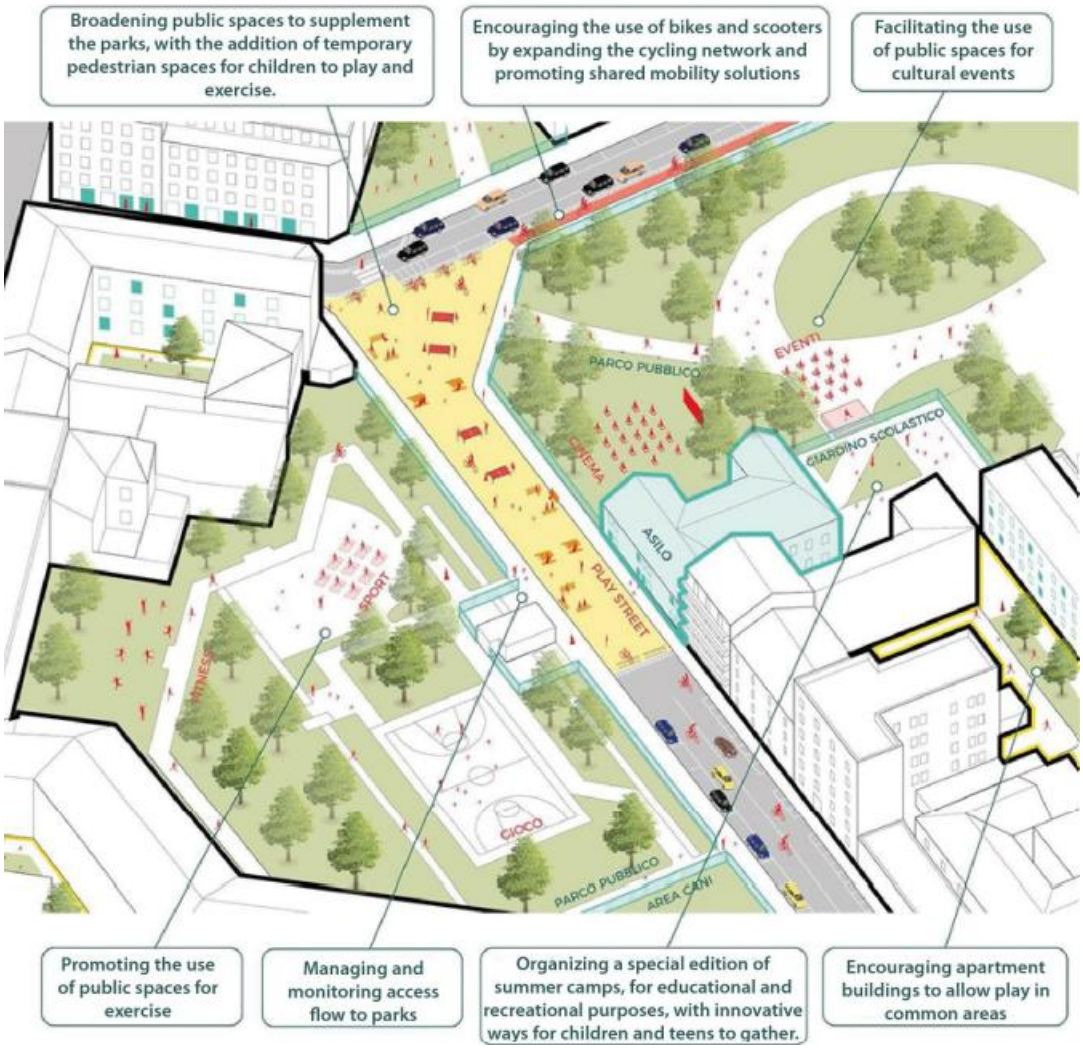


Figure 29: Open streets in the Isola district, Via Toce.

Source: Adaptation strategy, Milan 2020

Piazza Angilberto II:

Location: Piazza Angilberto II

Borough: 4

Year of Completion (tactical): 2018

Year of Completion (Final): 2022

Total area: 1100sq m

New pedestrian area: 900sq m

Furniture:

- 16 benches
- 2 ping pong balls
- 45 planters
- 5 bike racks
- 1 BikeMI point

Community partners: Retake Milano

Final design: MM spa

Figure 30: Before (left) and after (right) design of Piazza Angilberto II.

Source: https://portalril.org/contenido/Piazze%20aperte%20-%20A%20public%20space%20program%20for%20Milan.pdf

A congested and overbuilt intersection transformed into a vibrant pedestrian zone. The sidewalks have been widened and new amenities are added to the space like seating areas, ping pong tables, planters, bike sharing facility, and bike parking.

This new design has helped small businesses opposite the square be more accessible to the community. A cycle track has been executed along Via Comacchio to Piazza Ferrara. The cycle provides safety from fast-moving vehicles.

The effect of the design is visible, cycling activity has increased by 47% and pedestrian movement in the square has increased by 30%

Figure 31: View of Piazza Angilberto II.

Source: https://portalril.org/contenido/Piazze%20aperte%20-%20A%20public%20space%20program%20for%20Milan.pdf

Sources:

- https://portalril.org/contenido/Piazze%20aperte%20-%20A%20public%20space%20program%20for%20Milan.pdf
- Adaptation strategy, Milan 2020
- https://www.comune.milano.it/documents/20126/7117896/Open+streets.pdf/d9be0547-1eb0-5abf-410b-a8ca97945136?t=1589195741171

4.5. INFERENCES FROM CASE STUDIES:

Category	Case study	Common benefits	Best Practices
Plazas and Squares	Zollhallen Plaza, Freiburg	Increased footfall, social interaction, local business growth	• Adaptive reuse of spaces: Converting underutilized spaces into vibrant plazas. • Mixed-use integration: Blending commercial, cultural, and recreational elements.
	Water square, Benthemplein, Rotterdam	Flood Mitigation, recreational use, aesthetic enhancement	• Multifunctional design: Integrating areas for sports, recreation, and gathering spaces with water storage. • Seasonal adaptability: Ensuring operation in both wet and dry seasons. • Participation of the community: Using urban design to increase the knowledge of climate resilience.
Waterfront parks	New Qingpu Wetlands, China	Climate resilience, habitat restoration, improved water quality	• Eco-sensitive design: Prioritizing native vegetation and natural hydrology. • Layered stormwater management: Before the stormwater reaches the large waterbody, it is naturally filtered by a series of constructed

			wetlands. Also using retention and detention basins, rain gardens, bioswales, permeable pathways, and green spaces. • <u>Connectivity for resilience:</u> To prevent human access from interfering with the natural water flow, bridges, and pathways are incorporated with the wetland system. • <u>Adaptive land-use:</u> Maintaining ecological balance while encouraging urban expansion.
	Feng River Eco Park, China	Green corridor creation, tourism boost, recreational spaces.	• <u>Nature-based water treatment:</u> Enhancing water quality through the use of rain gardens, vegetated filter strips, and constructed wetlands. • <u>Integrated flood management:</u> Designing flood plains and retention basins to control overflow. • <u>Recreational and ecological balance:</u> Integrating biodiversity zones, pedestrian pathways, and greenways for overall riverside management.

Mobility & Tactical Urbanism	Superblock Programme, Barcelona	Reduced traffic congestion, better pedestrian experience, local economy boost.	• Green mobility integration: Improving pedestrian-friendly infrastructure, bike lanes, and public transportation. • Tactical Urbanism: Examining short-term closures before long-term fixes. • Gradual implementation approach: Introducing superblocks one by one gradually to get public support.
	Piazza Aperte Project, Milan	Safer streets, increased public space, enhanced vibrancy.	• Rapid, low-cost urban transformation: Using paint, street furniture, and modular elements. • Data-driven decision-making: Monitoring pedestrian activity and public response before scaling it up. • Tactical Urbanism: Examining short-term closures before long-term fixes.

Table 5: Inferences of Case studies.

CHAPTER

05

PARCO REGIO DISTRICT AND SITE

THE CITY: TORINO

"The city with the most beautiful natural position in the whole world is Turin"

- Le Corbusier

TORINO MUNICIPALITY

Popoulation
910,000

Recent Arrivals
130,000

Tourists per year (metropolitan area)
6,000,000

sqkm of surface area
130

Public housing units
18,000

EDUCATION

university students
100,000

Secondary school
160

Primary school
140

University residences
15

Main universities
2

Higer educational institutions
7

TRANSPORT

kms of public tranport service
1,300

km of bicycle path
175

km of ring road
57

tram lines
13

bus lines
83

bike sharing stations
116

km of urban railway
12

km of arcades
18

underground line
1

TORINO METROPOLITAN AREA

million residents

2.3

ranking in Italy

3rd

exports (billions)

18

ranking in Italy

2nd

GDP (billions)

63

ranking in Italy

3rd

companies

240,000

ranking in Italy

4th

Figure 32: Neighborhoods of the City of Turin. Source: https://es.123rf.com/photo_50025932_mapa-administrativo-tur%C3%ADn.html

Figure 33: Site Area. Source: Author

5. ABOUT PARCO REGIO:

Origins and Establishment of the Parco Regio:

One of the oldest ruling houses in Europe, the House of Savoy, has a strong connection to the birthplace of Parco Regio. In 1563, Duke Emanuele Filiberto had a vision to create a crown of delights a network of grand estates and leisure residences for the royal family, so he started strategically acquiring huge areas of land around Turin. One of these, the Royal Park of Viboccone was created in 1568 and represents ducal sovereignty while also acting as a luxurious retreat.

The Viboccone Palace, a magnificent structure designed by the most renowned architect Ascanio Vittozzi, was located in the center of the park. Inspired by the beauty and harmony ideals of the Renaissance, the palace and its surrounding gardens have provided a tranquil heaven from the political and military issues of the day. In addition to serving as a royal residence, the estate played a crucial role in strengthening the Savoyard court's prestige by hosting hunting events and diplomatic meetings.

Transformation into a Hunting Estate and Decline:

After Duke Emanuele Filiberto's rule, Duke Carlo Emanuele I converted the estate into a dedicated hunting reserve, which was a popular activity among the European aristocracy at that time. The park evolved as a private area where aristocrats could conduct lavish hunting, showcasing their dominance over the natural world and enhancing their status in the social.

After the death of Duke Carlo Emanuele I, the estate was neglected and lost its former grandeur. Gradually portions of the estate were leased for farming, changing its purpose from a royal retreat to a more functional or utilitarian area. The French Sieges of 1640 and 1706 caused extensive damage, with the buildings suffering significant damage. The aristocratic period of the formerly prosperous estate came to an end as it began to deteriorate.

Figure 34: The Viboccone palace and park depicted in the Theatrum Sabaudie of 1682. Source: https://www.atlanteditorino.it/quartieri/RegioParco.html

Conversion into a Tobacco Factory:

As Turin was industrialized by the middle of the 18th century, the Royal tobacco factory originally located in Via della Zecca, required more space to meet the increasing demand of production. So the former estate found a new life as part of the growing tobacco industry. In 1758, the old Viboccone estate was converted into a contemporary tobacco manufacturing center.

To ensure the site matched the contemporary industrial standards, architects Benedetto Ferroggio and Giovani Battista were brought in to remodel and expand the site. The key invention was building the canal from the Dora River close to the "Benne" bridge, which supplied a steady supply of water needed for the processing of tobacco. The factory became a symbol of modernism and efficiency reflecting Turin's wider economic revolution.

Industrial Growth and Urban Development (19th century):

By the late 1800's the tobacco factory had grown and employed around 2,000 workers, and it continued to expand throughout the 19th century. Due to substantial urban development brought by this industrial boom, a worker's village was established to house the workers and their families.

For the benefit of a growing population, from the 1860s onwards various social and educational institutions were founded. Among them Umberto I nursery school was founded in 1880 to offer childcare to the families of manufacturing workers was one of them. To ensure that the children in the district had access to basic education, the Abba Elementary School was built shortly in 1882. Moreover, in 1889 the Chruch of San Gaetano da Thiene was completed and it evolved as a space of religious and social activity. The former isolated industrial location was turned into a thriving urban neighborhood after these developments.

Development of Transportation and Infrastructure:

The need for better transportation and infrastructure has increased as the area's population has increased. The main street, Via Maddlene evolved into a key axis of growth, linking the worker's village with the other areas of Turin. The district was further integrated into the city's economic network when the Amedo VIII bridge was built over the Stura River, making it easier to convey people and goods.

In 1884, significant advancements were made in public transportation by connecting Porto Palazzo to Settimo and Bertolla by a "little train". For locals and manufacturing workers, this railway was a vital service that enabled quicker journeys and improved trade connections. Up until 1954, the train operated successfully after that alternative modes of transport replaced it. Piazza Giuseppe Cesare Abba, located in the center of the area became a major gathering place for social and business activities.

Figure 35: Piazza Abba and tobacco factory at the beginning of the 20th century.

Source: https://www.museotorino.it/view/s/3ed9a9aeaf914c05a5fb383ccdafa779

Education and Social Contributions:

The Piazza Abba school served as a social stability pillar in addition to being an educational institution, especially in times of crisis. The structure was repurposed to shelter displaced families during World War II and in 1951 it served as a shelter for those affected by the Polesine flood, which was one of the worst floods in Italian history.

Umberto I nursery school played an important role in supporting the community. It was created as a working-class welfare program to make sure that kids were taken care of when their parents had long working hours at the factory. In 1890, the Italian monarchy formally approved the school's statute through a royal decree, acknowledging its significance.

5.2. ABOUT MANIFATTURA TABACCHI:

In 1778, the new Manifattura Tabacchi was fully operational, beginning its long history as one of the italy's most prominent tobacco factory.

Among the two locations of tobacco factories Via della Zecca and Parco Regio, Parco Regio was the largest production facility in the city and almost all the work was transferred too in 1855. Since high amount of work renovation and expansion of the building began and were completed in 1858. In 1895, Via della Zecca site was abandoned.

The tobacco factory encountered difficulties around the 20th century due to growing governmnet laws and changing consumers preferences. But the factory still contiuned to play a significant role in Turin's industrial sector inspite of this. Like many other industrial sites in Turin, Manifattura Tabacchi was damaged due to air strikes durin World war II. Then tobacco factory was expanded to accommodate the machinary that was subsequntly damaged. Despite these challenges, production went on and the facility came to represent Turin's post war recovery.

Between 1970's and 1980's global tobacco industry began to change due to health concerns related to smoking lead to decline in consumption. First closing some departments and then closing the factory in 1996.

Ex FIMIT Factory:

A Cotton spinning mill was constructed in 1833. It was later subsequently used for spinning of hemp and flax, and then for rice polishing and the building was extended in 1847. In 1874 a nonferrous metal treatment factory and a wool fabric factory in 1881. At the end of the 1950s, the FIMIT company took over, a company that dealt with the production of insulating materials until 1998 and then abandoned. The municipality of Turin has bought the property and has a plan to develop it along with the adjacent area of Manifattura Tabacchi was also closed in 1996, with the help of the University of Turin. The final design proposal has been finalized currently.

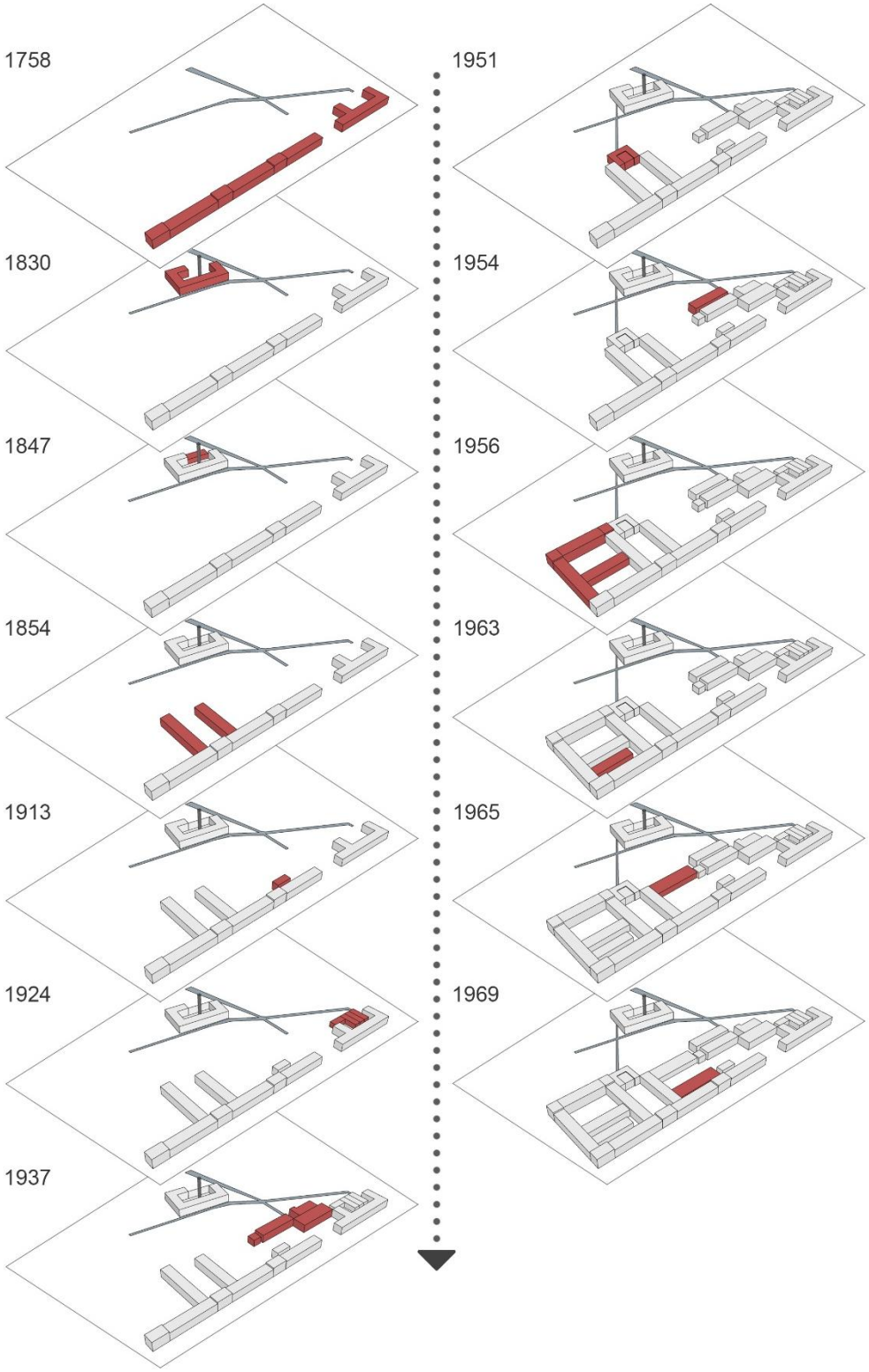


Figure 36: Construction phases of Manifactura Tabacchi, Torino

Source: *Debrevi, Geneva (2013). Manifattura Rehab Centre: the reuse of the Manifattura Tabacchi in Turin as a rehabilitation center. Thesis discussed at the Polytechnic of Turin. Supervisors: Croset P., Ambrosini G., Berta M., Rolando A.*

Future of manifattura tabacchi: proposal

Cultural District:

The Ex Manifattura Tabacchi, Torino has produced cigars and pipe shavings for over two centuries. The goal of redevelopment plan is to make it a cultural district.

It has been agreed by various institutions that the recovered facilities will be used as a university center with student housing, advanced training classrooms, and an archives center. In addition to a warehouse that serves the Institutes of Turin, Asti, Biella, Cuneo, and Verbania, the Archives center will have study and consulting spaces and the General Directorate of Archives of the Ministry of Culture.

The goal of this project is to rejuvenate the historic complex by strengthening the interconnections between its activities and encouraging the revitalization of the neighborhood. Prioritizing public inclusivity, the vision makes sure the archive center evolves into a vibrant area that is open to the public and enhanced by university students.

University Campus:

The current abandoned site can be transformed into a vibrant neighborhood by planning the expansion of Turin's two main universities Politecnico di Torino and University of Turin by planning the new lecture halls and study spaces into the site.

Student Residence:

As the number of incoming students grows the demand for student housing is increasing, so Turin is experiencing a student housing crisis.

Approximately 200 students would be hosted in the proposed university housing, which would also have a canteen with the same capacity. Improving student accessibility will require expanding

public transit, particularly through an extension of Metro Line M2, given the site's suburban position.

Archive center:

Turin has had difficulty organizing, preserving, and showcasing its cultural and historical heritage. Even though the city's rich history keeps growing, appropriate conservation has been hampered by a lack of funding and archival space. Parts of its heritage have gradually deteriorated because of this scarcity.

An example of archive storage that is both practical and incorporated into the surrounding community is the Archive Citadel in Milan. This historic structure also represents a change in viewpoint by connecting current circumstances with upcoming advancements in asset integration, management, and cultural value development.

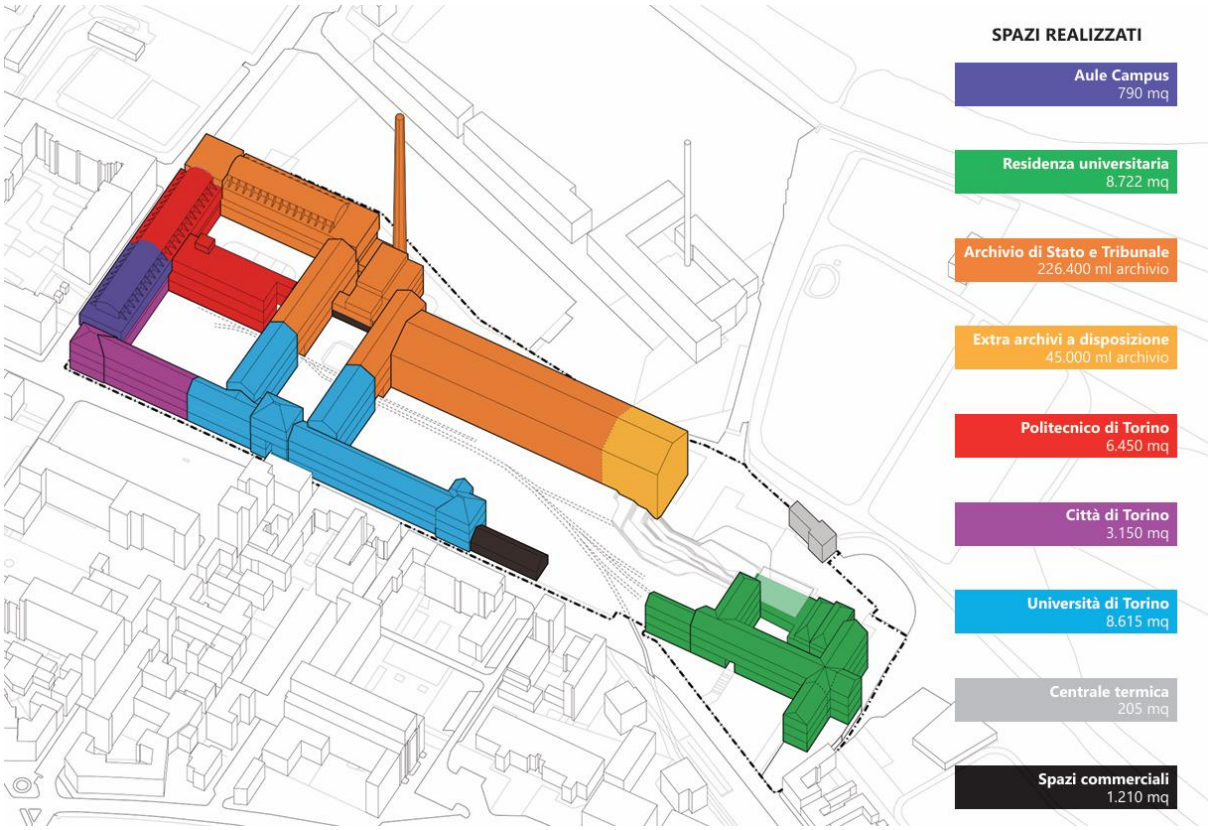


Figure 37: Cultural district proposal for the Ex Manifattura Tabacchi. Source: https://www.agenziademanio.it/export/sites/demanio/download/documentigare_2023_4/231120_Capitolato-tecnico-prestazionale.pdf

LAND USE MAP:

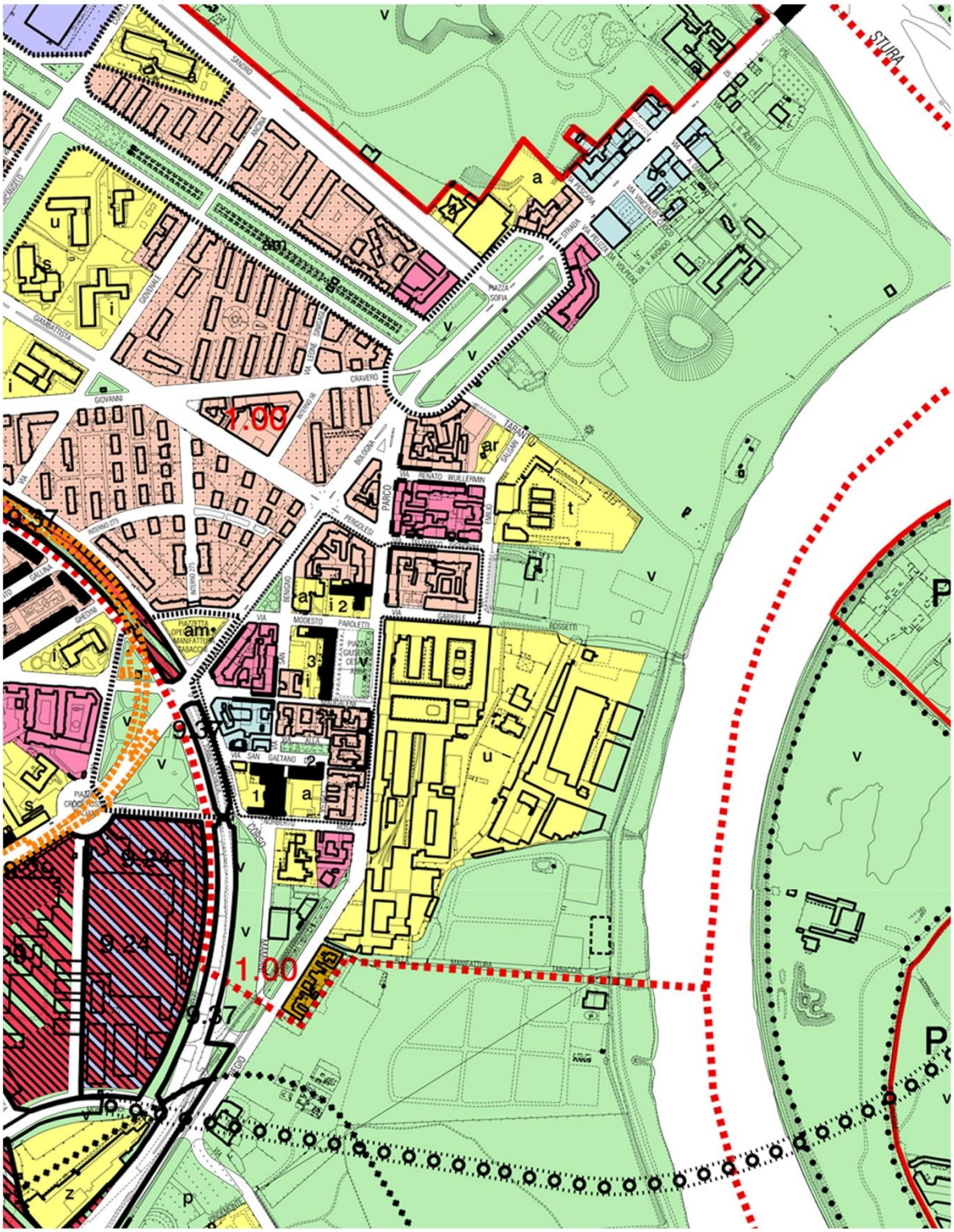


Figure 38: Landuse map

Source: Geoportale 2024

LEGEND OF LANDUSE MAP:

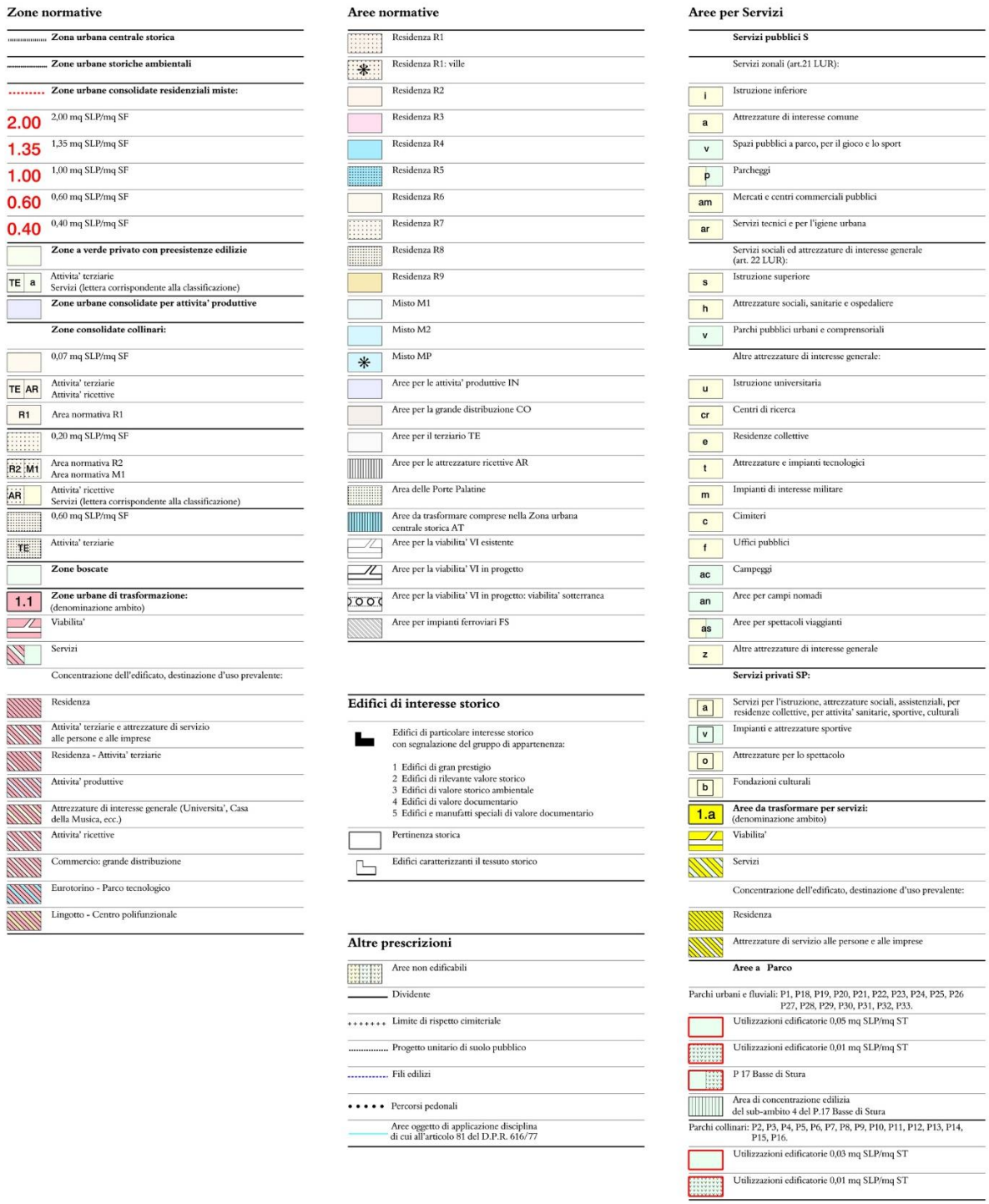


Figure 39: Legend of Landuse Map

Source: Geoportale 2024

CLIMATE ANALYSIS:

Air Temperature:

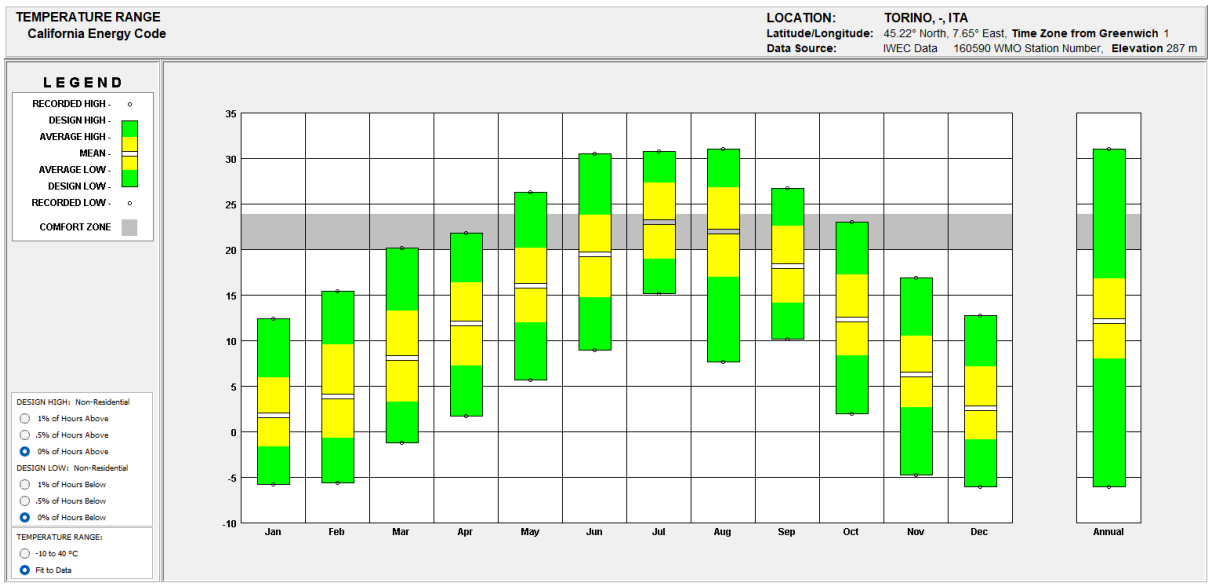


Figure 40: Temperature range analysis of city Turin

Source: Author (Climate consultant)

In Turin winters are moderately cold and dry, summers are quite hot in the plains.

Seasons and extreme recorded temperatures:

- Winters are from December to February and summers are from June to August.
- The lowest temperature in winters is -4°C in December & highest temperature is 16°C in February. The lowest temperature in summer is 8°C in August and the highest in August, which is 31°C.

Comfort zone:

- Since the human comfort level ranges between 20°C to 24°C, July should be considered the best month with a comfortable climate.

Solar brightness and radiation:

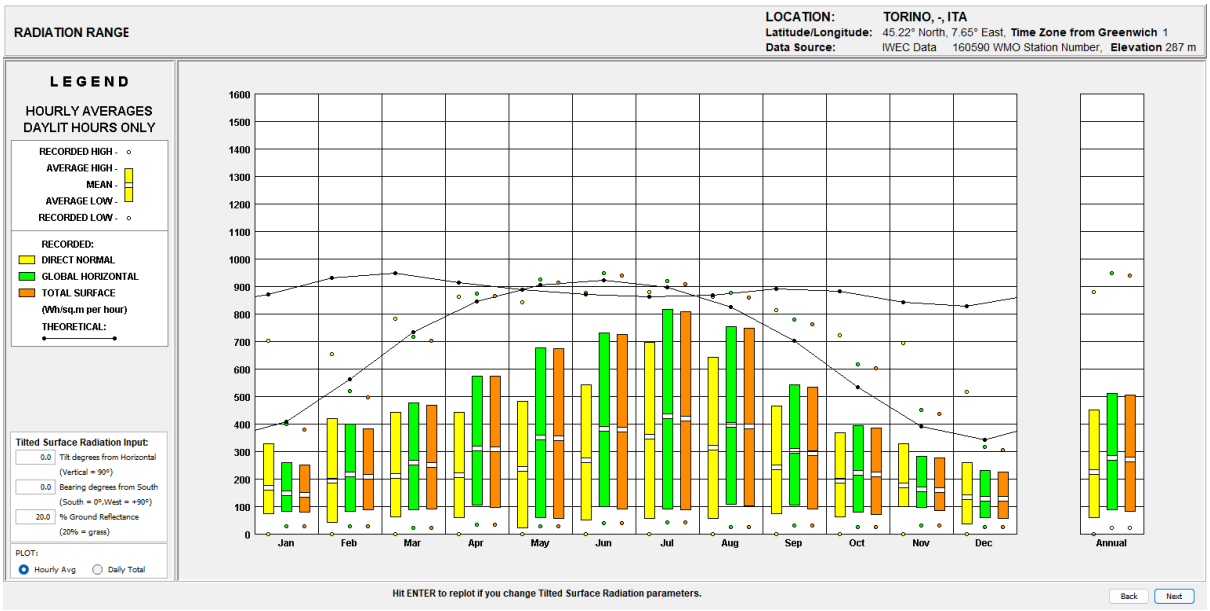


Figure 41: Radiation range analysis. Source: Author (Climate Consultant)

Direct normal solar radiation in the city reaches its minimum in November, about 100Wh/sqm, while the maximum radiation reaches almost 700Wh/sqm in July.

Annual Wind Rose Diagram:

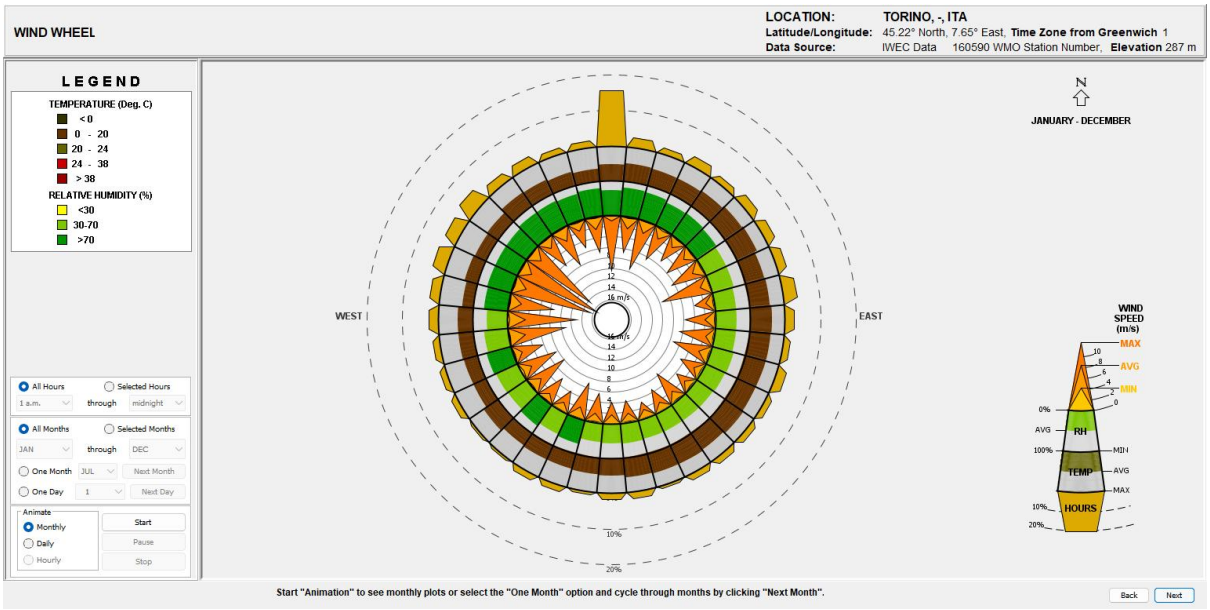


Figure 42: Wind rose diagram. Source: Author (Climate Consultant)

Brown Shade displays the temperature range between 0 -20°C. Light green shade displays relative humidity between 30-70% and dark green shade greater than 70%. Pencil nib-type triangles in light orange shade depicts low wind speed while in dark orange shade depict high speed.

Ground Temperature range:

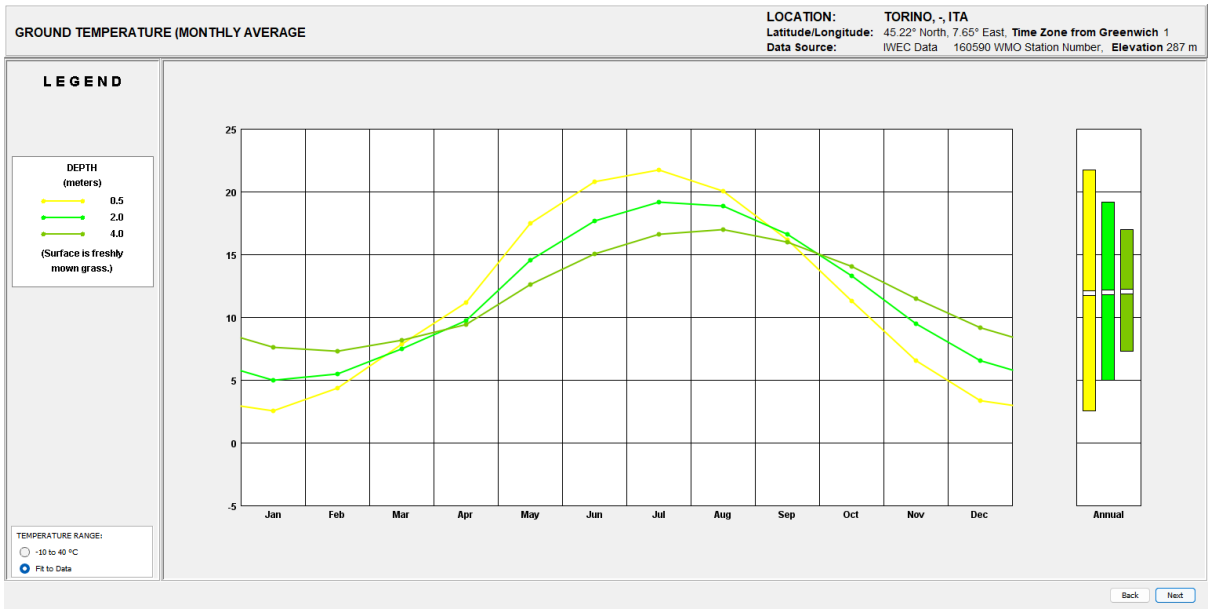


Figure 43: Ground temperature range. Source: Author (Climate consultant)

- 0.5 meters: Peaks in June/July at 25°C and falls in Jan / Dec at 0°C & below.
- 2.0 meters: Shows moderate fluctuation and is more stable compared to 0.5 meters.
- 4.0 meters: Remains most stable throughout the year, with seasonal variations. Remains between 5°C to 15°C all year.

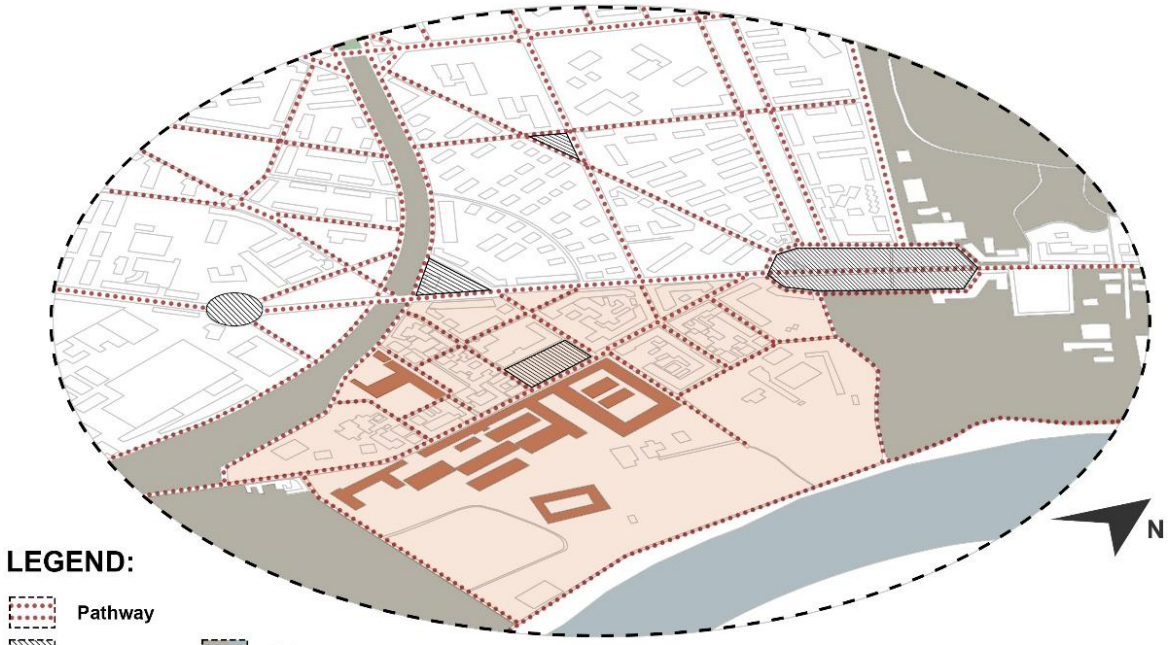
Surface influence:

Large temperature changes arise at shallow depths because of the strong influence of atmospheric factors.

Thermal stability:

Reduced fluctuation at deeper levels shows the soil's ability to act as a thermal buffer.

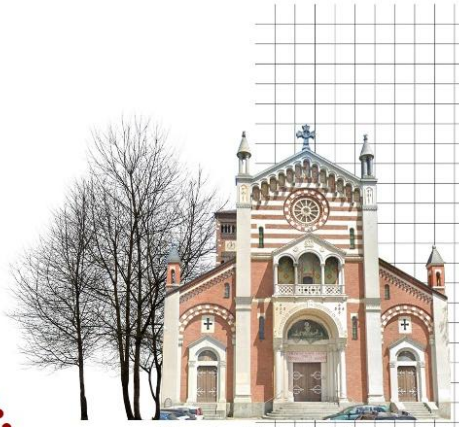
ELEMENTS OF THE CITY: By Kevin Lynch



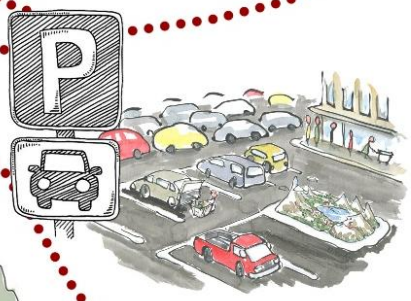
LEGEND:

- Pathway
- Node
- Landmark
- Edge
- District

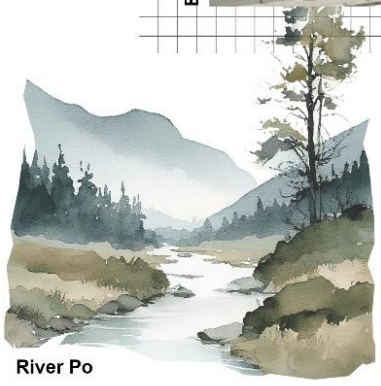
Mental Mapping by KEVIN LYNCH



Church of Saint Cajetan of Thiene



Piazza Giuseppe Cesare Abba



River Po

Parco della Confluenza

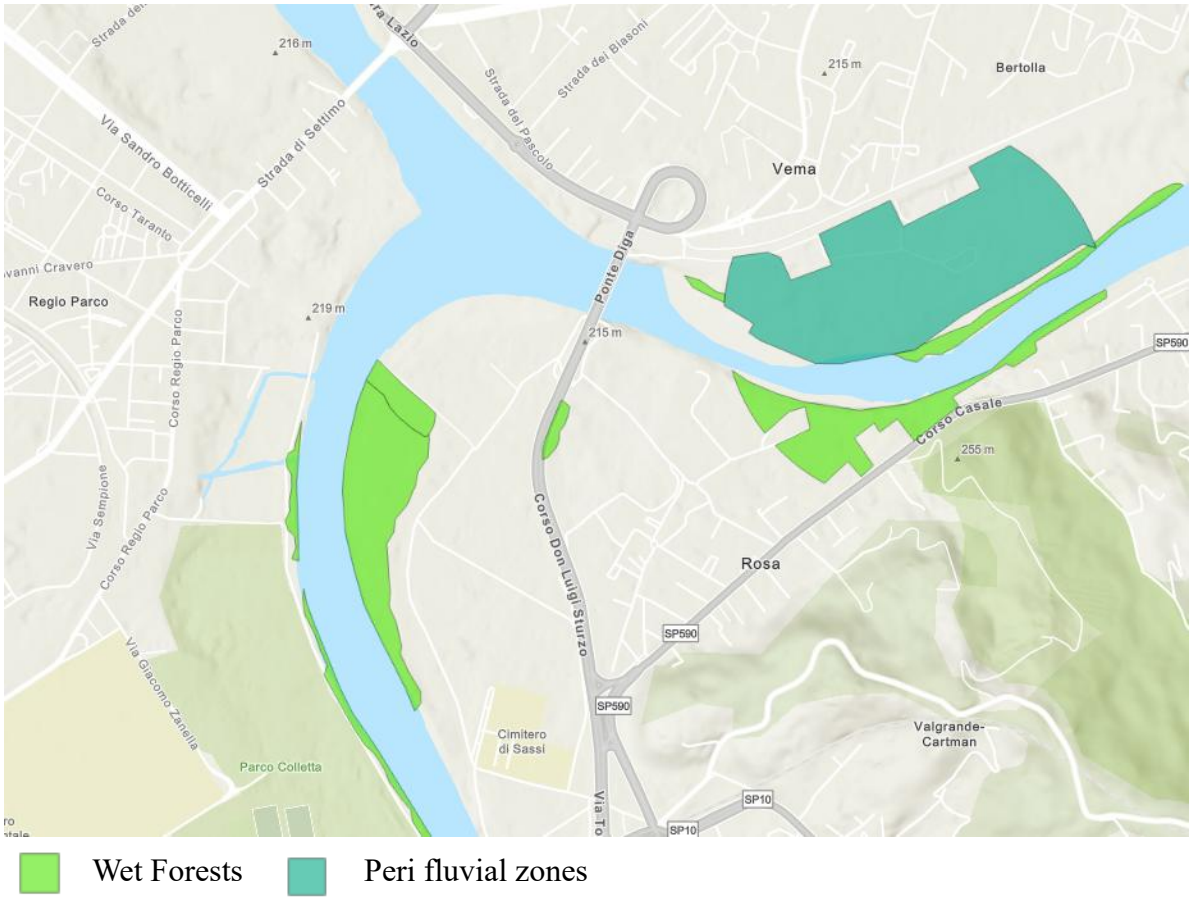


Figure 44: Wetland Census 2024.

Source: ARPA Piemonte

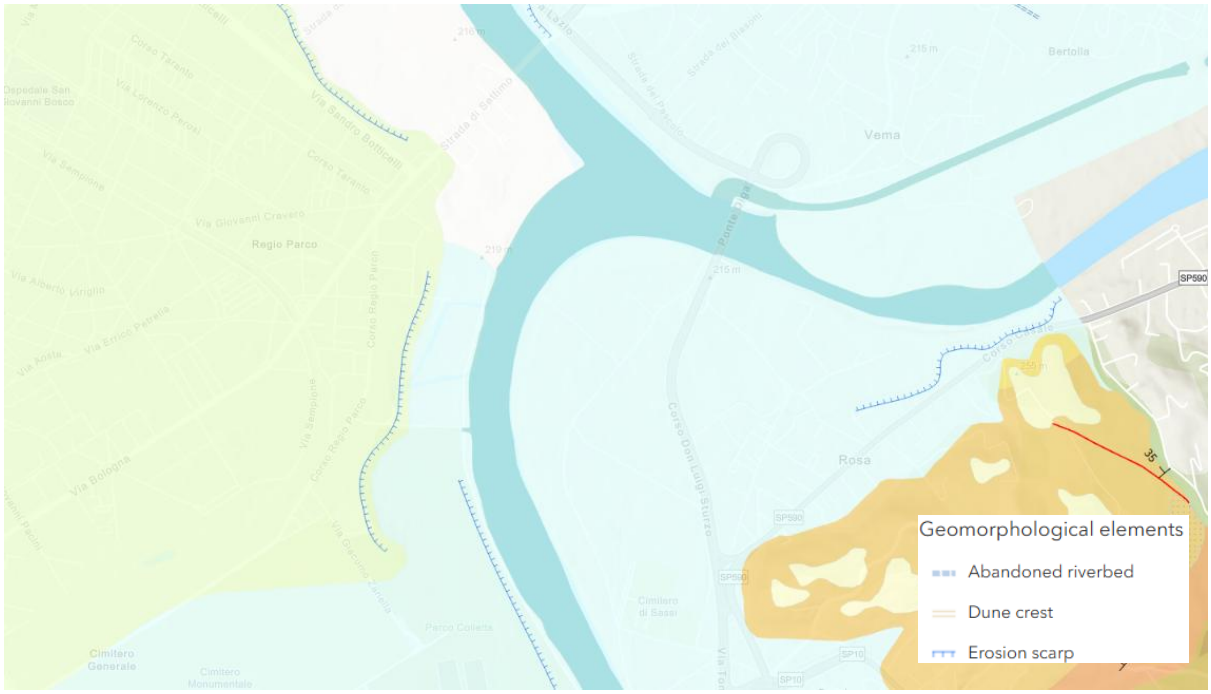


Figure 45: Geology 2024

Source: ARPA Piemonte

5.3. HYDROLOGICAL NETWORK OF TURIN:

The Po, Dora Riparia, Sangone, Stura di Lanzo, and Chisola rivers are part of the "City of Turin" hydrographic network. The region is heavily urbanized so to create space for residential, commercial, and industrial spaces the river was straightened, narrowed, and as well as partially channelized over time.

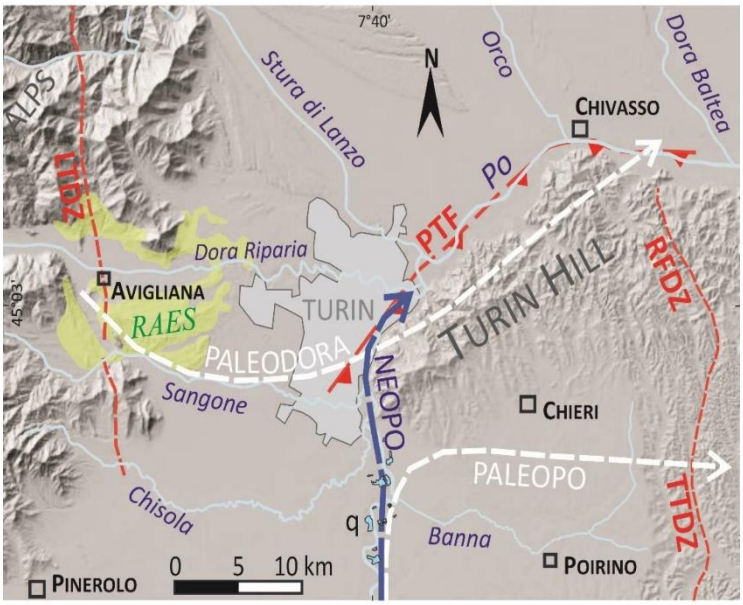


Figure 46: Hydrographic pattern of Po plain. Source: (Maria Gabriella Forno, 2022)

FLOODING IN THE CITY OF TURIN:

"The surface area of 35 Sq km approximately in Municipality of Turin is affected by the risk of flooding. Out of which 60% is at a low-risk flooding zone, 29% is at a medium risk and 11% is at high risk. More precisely, the specific urban areas of the city have been flooded over the past 200 years timespan. This situation was observed for the first time during the October 2000 flood catastrophe and this was the 2nd largest flood to hit in the basin of River Po." (Castellarin, 2009)

HYDROLOGICAL PROFILE OF THE SITE:

Manifactura Tabacchi falls under the class I(P) which means built-up and not built areas are not exposed to the risk of flooding. The strip of land that is between Manifactura and Ex Fimit (Class I and Class III) falls into Class II(P), which is a transition zone with a slightly higher risk of flooding. The Ex Fimit falls under class III(P) which has higher risk of flooding.

The site has 2 man made canals existing and there is absolute non buildable buffer zone of 10meters from the foot of the river.

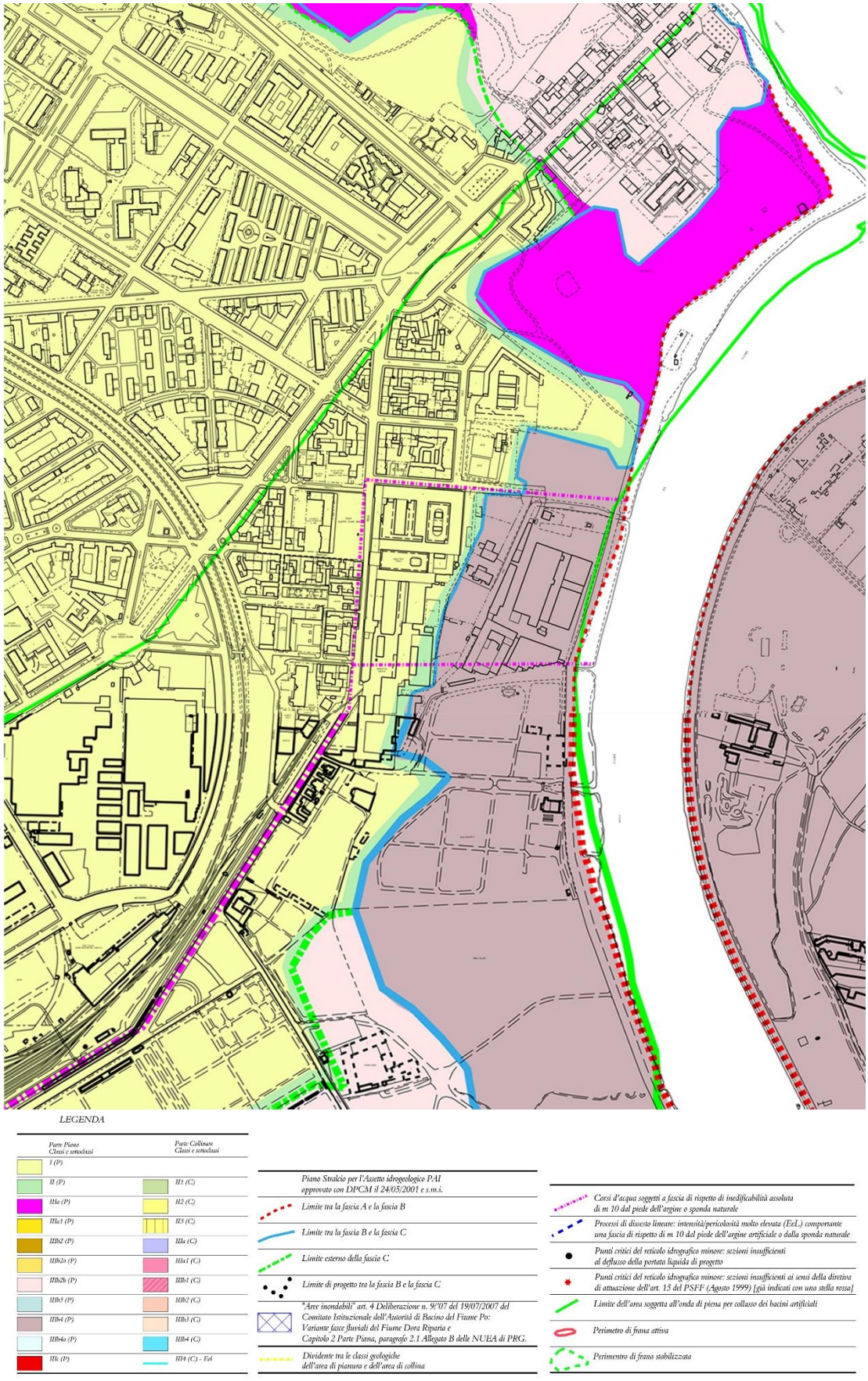


Figure 47: Geomorphological hazard map 2024. Source: Geoportale

Figure 48: Floodable Area

Source: Author

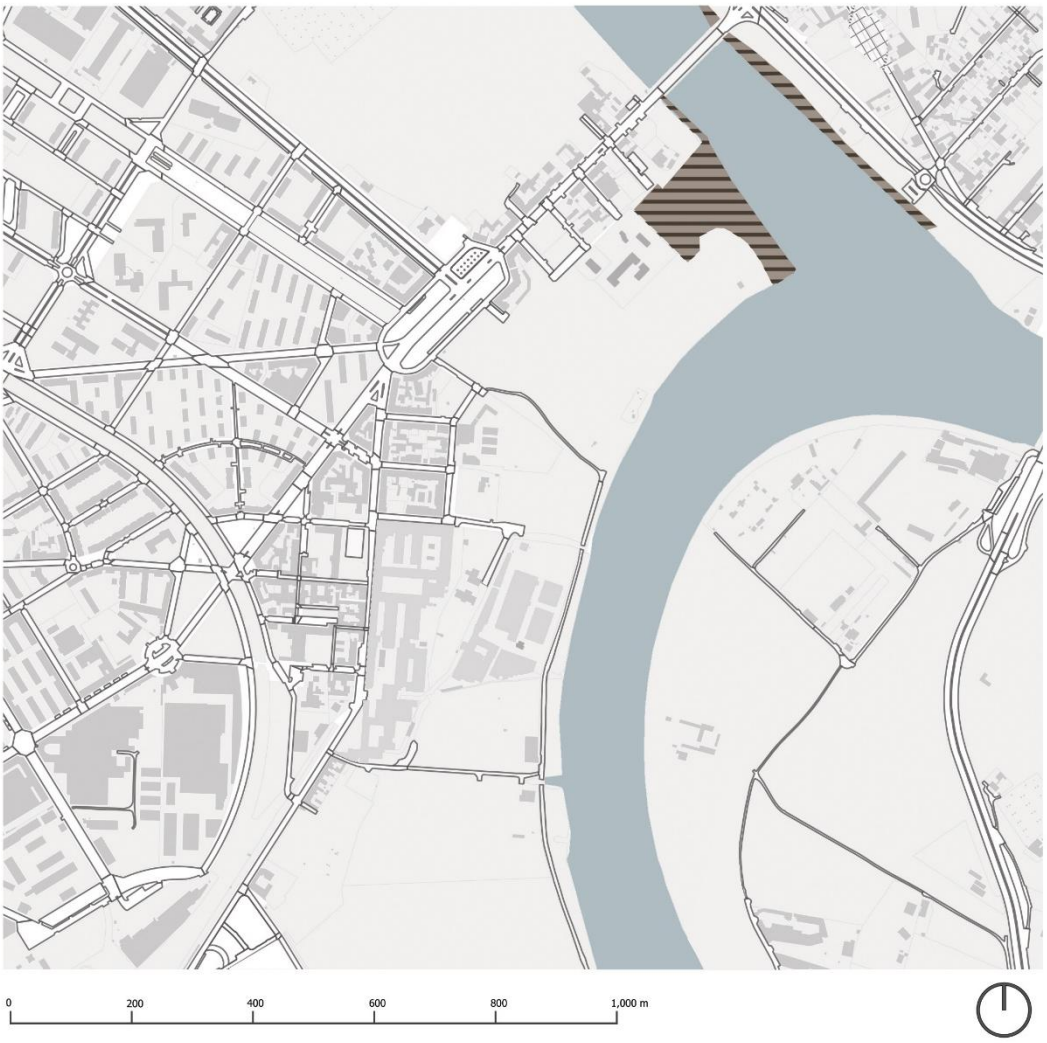


Figure 49: Flooding Event September 1993 – November 1994

Source: Author

Figure 50: Flooding Event 1994

Source: Author

Figure 51: Flooding Event 2000

Source: Author

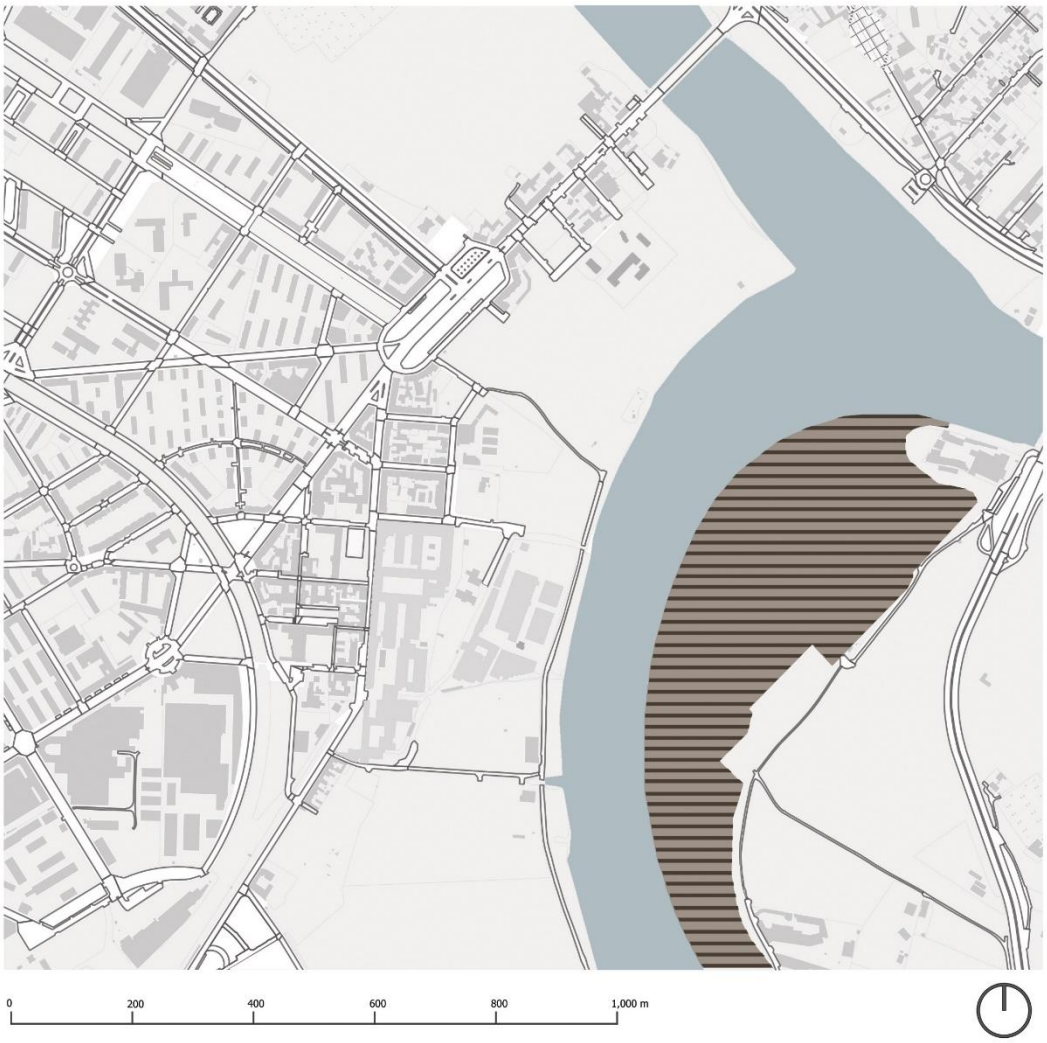


Figure 52: Flooding Event 2016

Source: Author

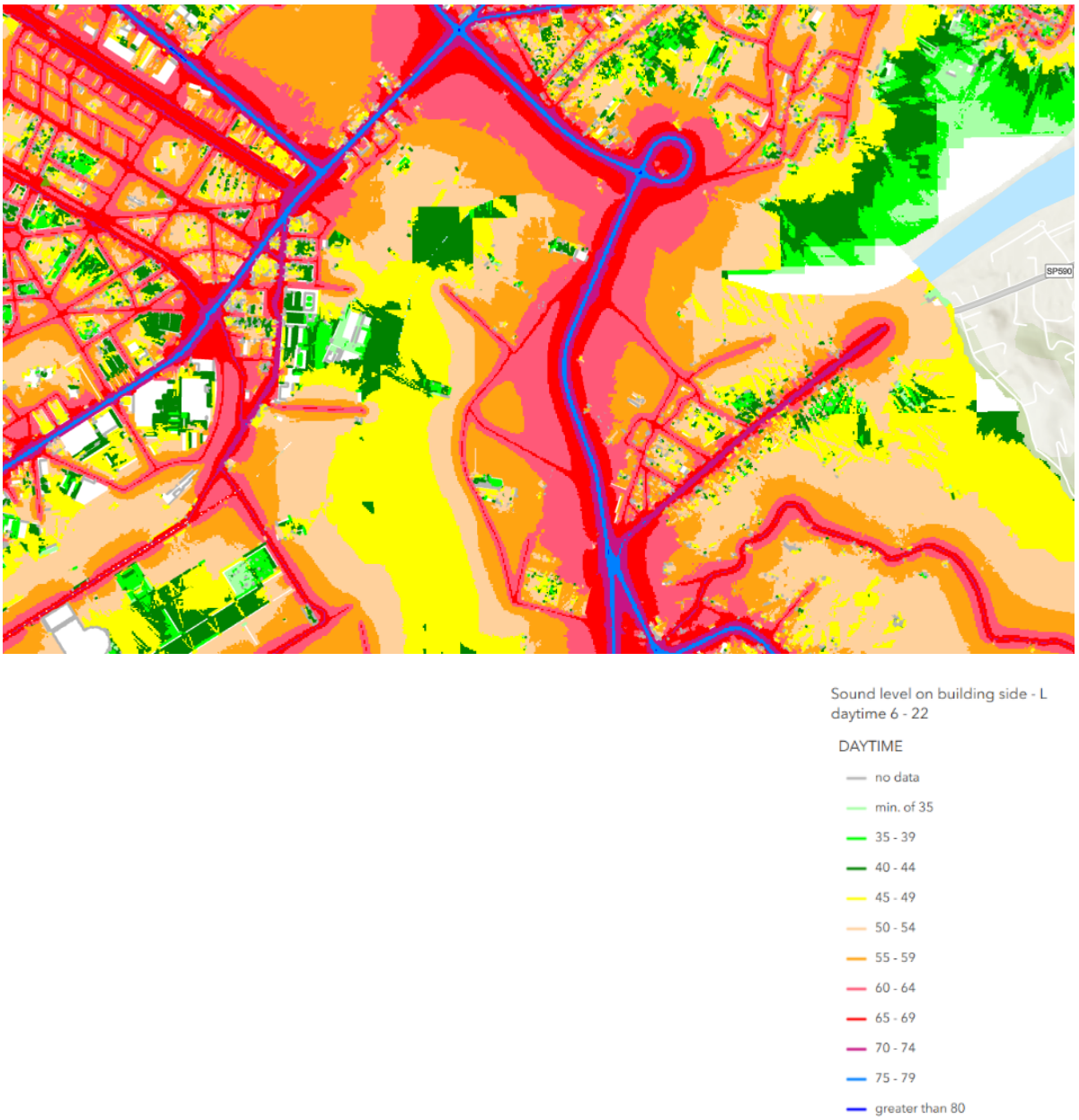


Figure 53: Acoustic Mapping 2024

Source: ARPA Piemonte

Figure 54: Figure Ground Map 2024

Source: Author (GIS)

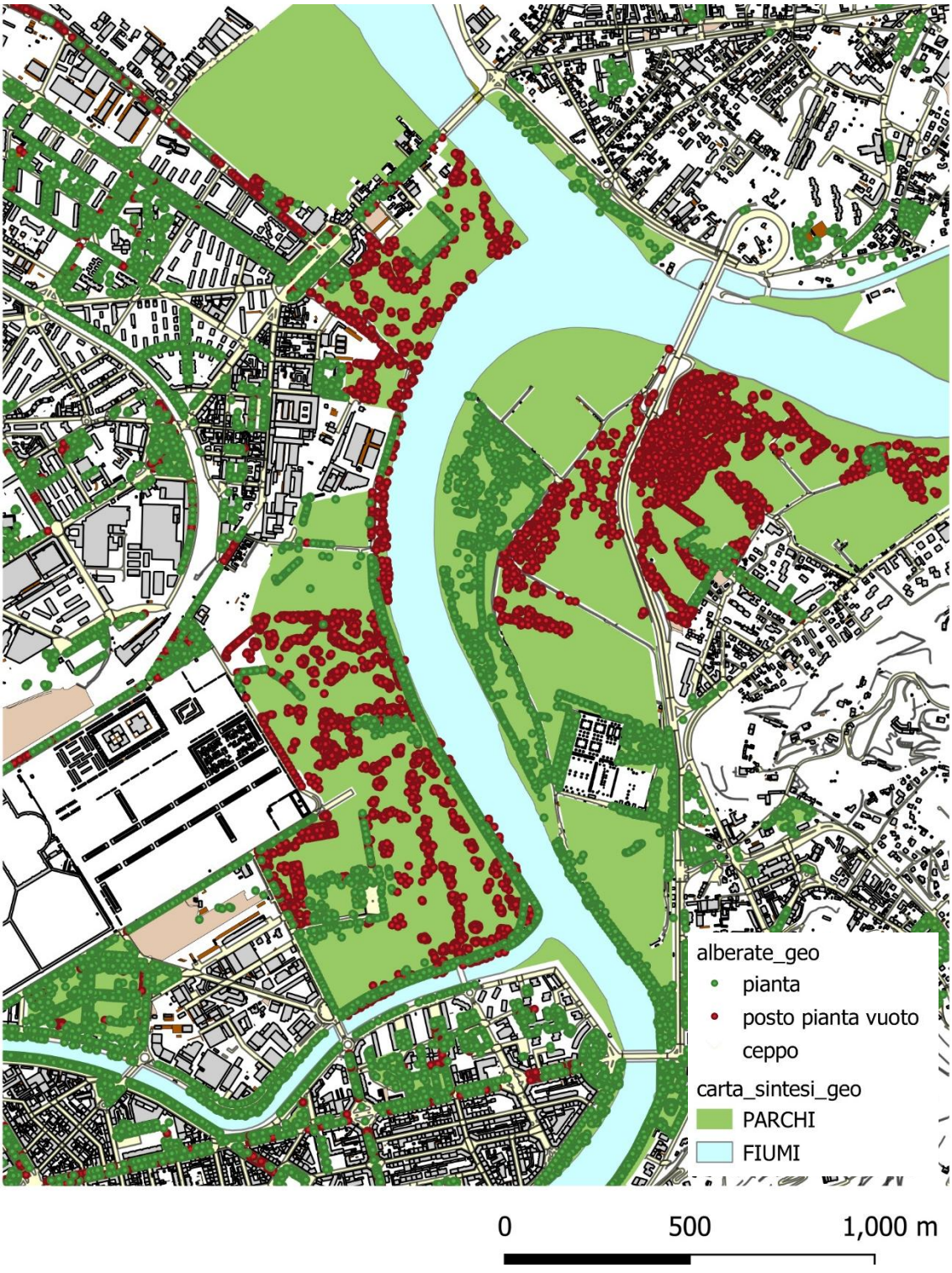


Figure 55: Tree Cover 2024

Source: Author (GIS)

Figure 56: Green Cover 2024

Source: *Author (GIS)*

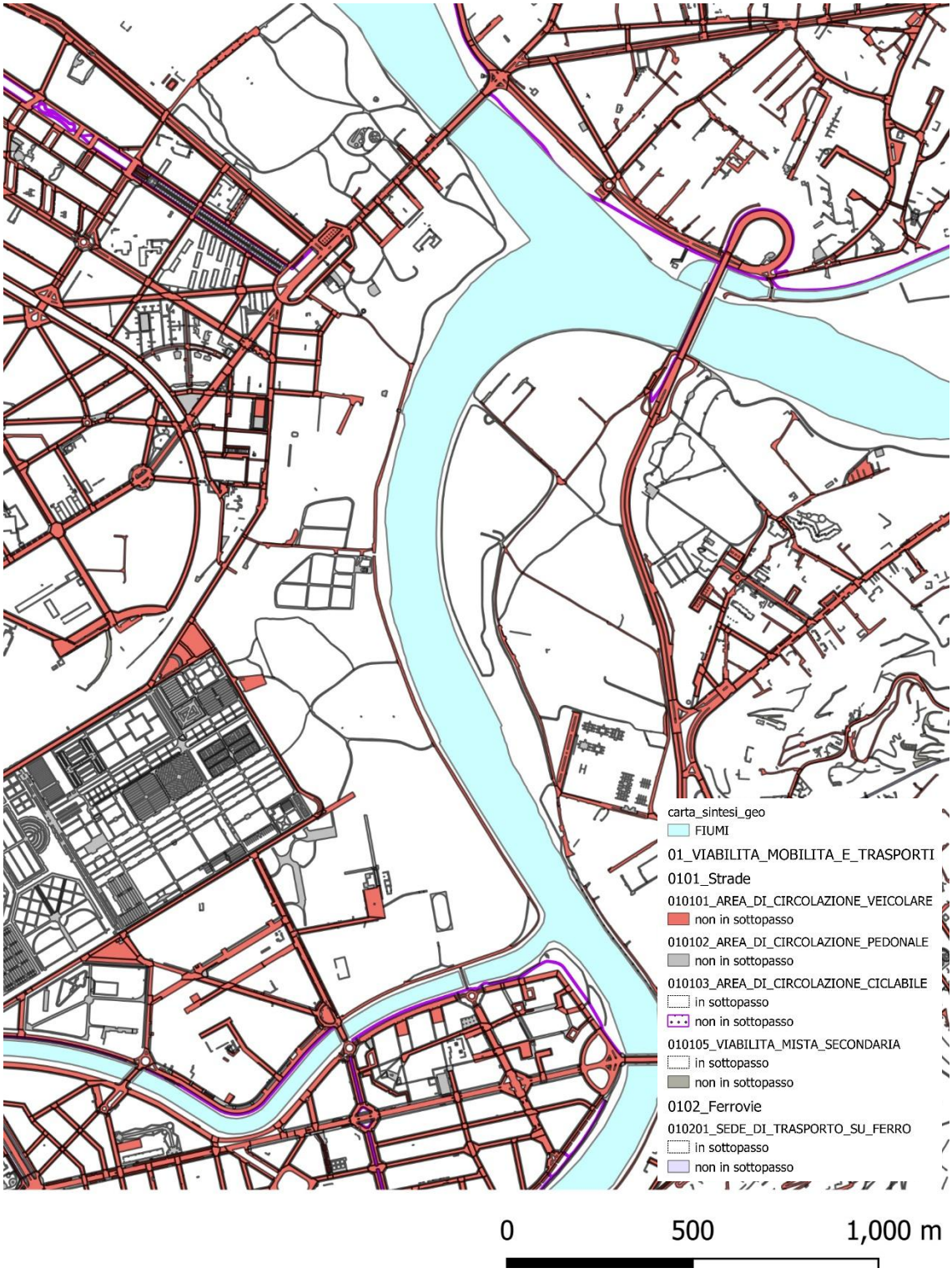


Figure 57: Road Network 2024

Source: Author(GIS)

Figure 58: Road Conditions 2024

Source: Author(GIS)

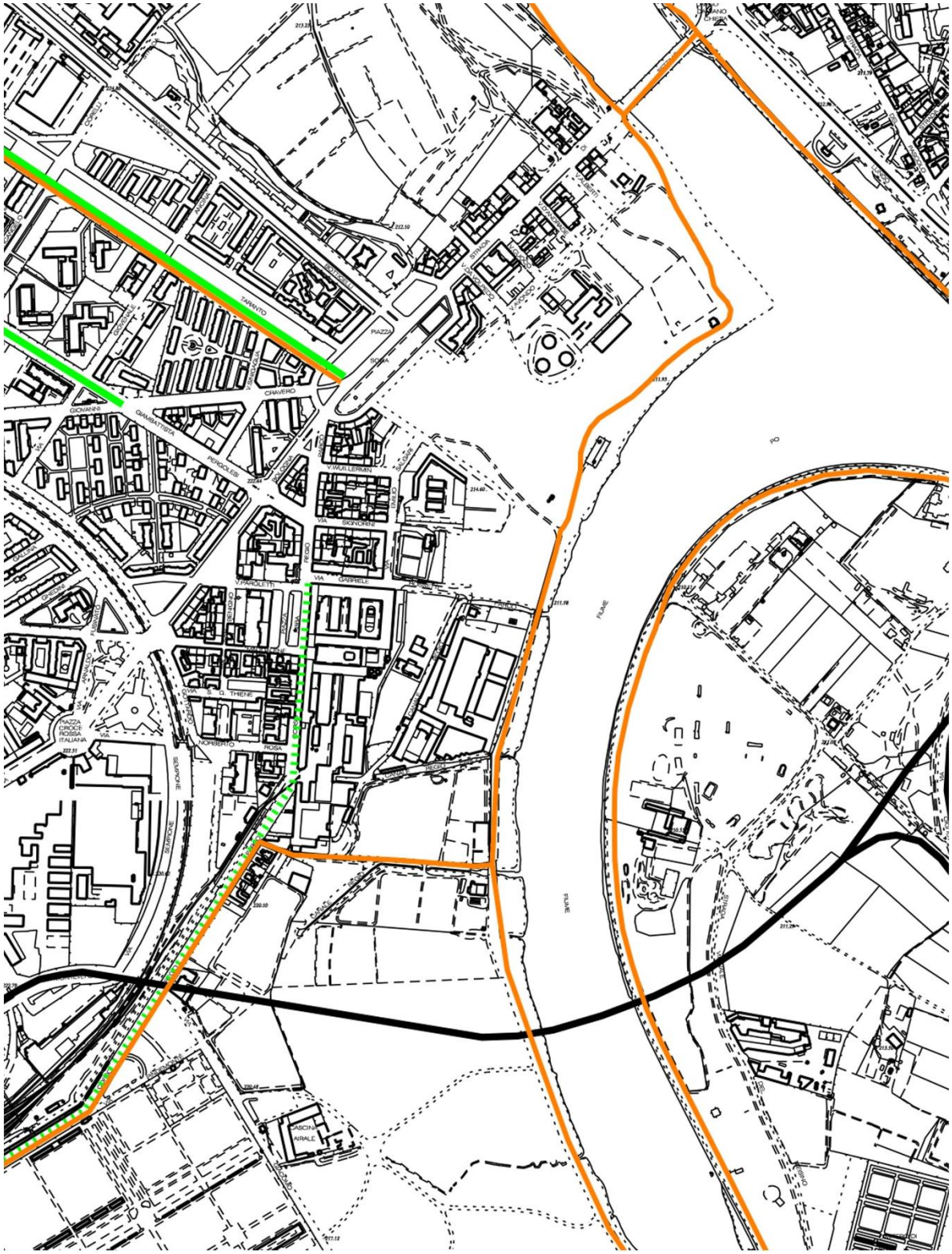


Figure 59: Road System 2024

Source: Geoportale

5.4. INDICATORS OF URBAN RESILIENCE ON THE SITE:

Dimension	Indicator	Representation (Model)
Social Resilience	Social Inclusion	• Inclusive public spaces like parks, and plazas. • Location of community centers and cultural hubs.
	Emergency response services	• Location of fire stations, police stations, and hospitals. • Evacuation route with pedestrian and vehicle flow. • Placement of disaster shelters or relief zones.
	Health and well-being	• Placement of hospitals, clinics, and fitness centers. • Proximity to green spaces and walking trails.
	Communication	• Placement of telecom towers and public communication (kiosks) • Integrating IoT for real-time communication (emergency alerts)
	Community network	• Location of cultural centers, recreational facilities, and meeting spaces. • Community network data
Economic Resilience	Economic Diversity	• Zoning maps with land use (Commercial, industrial, and residential spaces) • Locations of Business clusters and economic activity hubs.
	Employment Rate	• Visualization of employment centers (offices, factories, and co-working spaces)
	Income Inequality	• Location of affordable housing units in high-income neighborhoods.

	Access to financial services	• Locations of banks, credit unions, and microfinance institutions.
	Infrastructure Investment	• Ongoing and planned infrastructure projects (roads, bridges, utilities, etc)
Environmental Resilience	Air and water quality	• Placement of air quality monitoring stations. • Models for improving water quality.
	Green Infrastructure	• Green parks, and urban forests. • Green roofs, rain gardens, Bioswales, permeable pavements, and green walls. • Analysis of green space availability for residents.
	Climate Adaptation	• Location of Flood risk zones • Models of seawalls, levees, and stormwater drainage systems.
	Public transport and eco-friendly mobility	• Routes and stations of public transport (buses, trams, bike-sharing docks) • Walkability maps and pedestrian pathways. • EV charging stations and cycle lanes.
	Renewable energy use	• Location of building integrated with renewable energy systems.
Institutional Resilience	Emergency Preparedness	• Location of emergency facilities (Fire stations, police stations, hospitals). • Evacuation routes and shelters. • Disaster management hubs.

	Governance Quality	• Location of Government buildings and coordination hubs.
	Policy Flexibility and adaptation	• Mixed-use development zones (adaptive buildings). • Flexible land use policies
	Citizen participation in decision-making	• Public engagement spaces (Community centers, cultural spaces and townhalls) • Plazas and parks
	Availability of urban data	• Real-time data integration (traffic, water levels, air quality etc)

Table 6: Indicators of Urban Resilience on the site

5.5. INDICATORS OF URBAN SUSTAINABILITY ON THE SITE:

Dimension	Indicator	Representation (Model)
Economic Sustainability	Economic growth	• Areas of business development, industrial hubs, and commercial spaces. • Mixed-use development. • Traffic density showcasing business vibrancy.
	Jobs/ employment rate	• Location and density of offices, factories, and coworking spaces.
Environment Sustainability	Green infrastructure	• Green parks, and urban forests. • Green roofs, rain gardens, Bioswales, permeable pavements, and green walls. • Analysis of green space availability for residents.
	Energy efficiency & renewable energy	• Location of building integrated with renewable energy systems like solar panels, wind turbines, etc.

	Air and water quality	• Placement of air quality monitoring stations. • Models for improving water quality.
	Waste Management	• Locations of waste collecting points and waste management centers.
	Biodiversity and Ecosystem	• Green spaces, wildlife corridors, urban wetlands, and biodiversity features.
Social Sustainability	Housing	• Affordable housing, mixed-use development, and high-quality residential buildings. • Proximity to essential services like transportation, schools, and hospitals.
	Quality public spaces	• Parks, plazas, and recreational areas with pedestrian pathways.
	Education	• Location of schools, universities, and libraries. • Community centers for extracurricular and after-school activities.
	Sanitation	• Location of public toilets and waste collection centers. • Water treatment plants, water distribution networks, and recycling centers.
	Health	• Location of Hospitals, clinics, wellness centers, and pharmacies. • Fitness centers, mental health facilities, and vaccination sites.

Table 7: Indicators of Urban Sustainability on the site

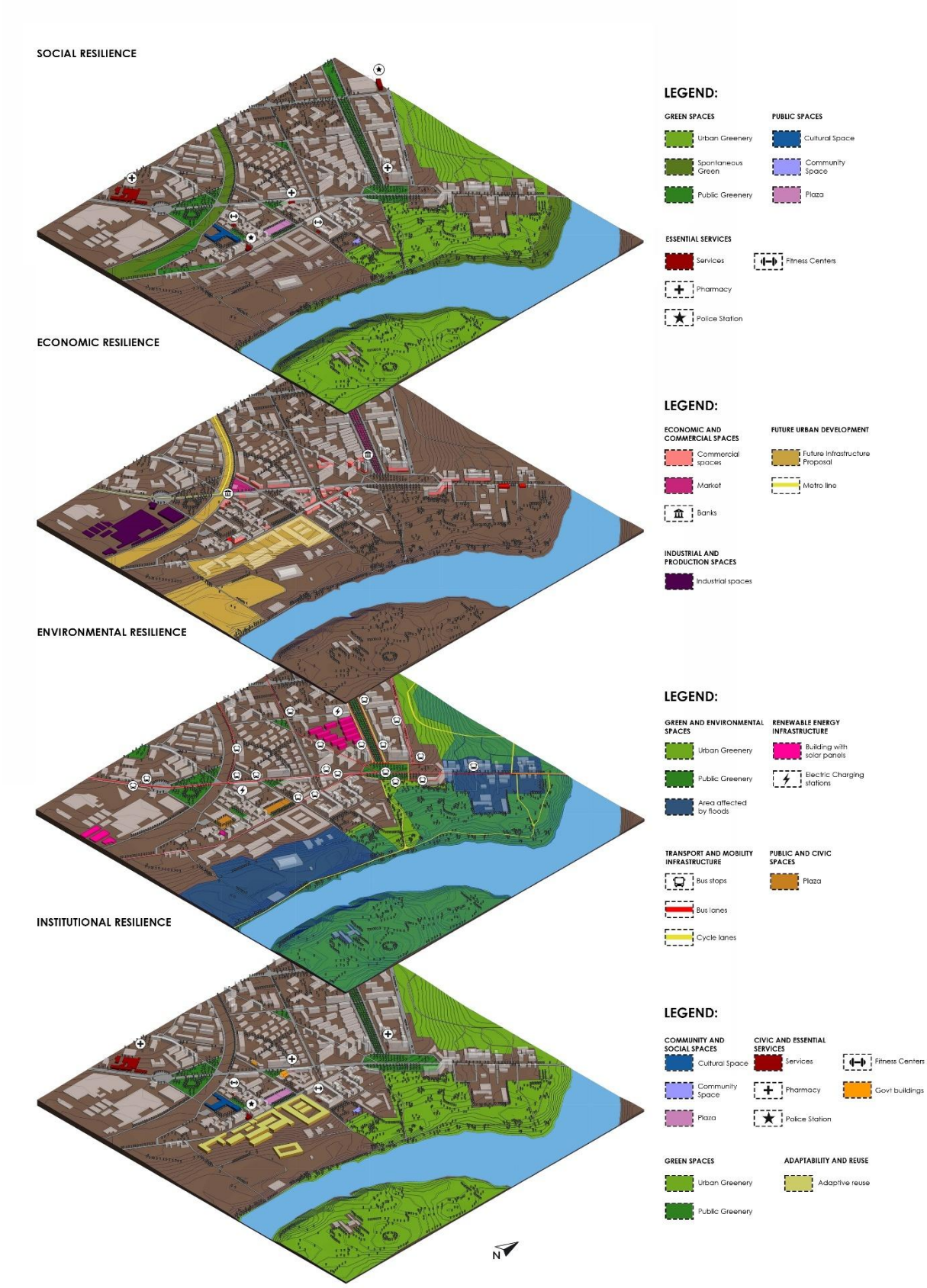


Figure 60: Illustration of Indicators of Urban Resilience on the site

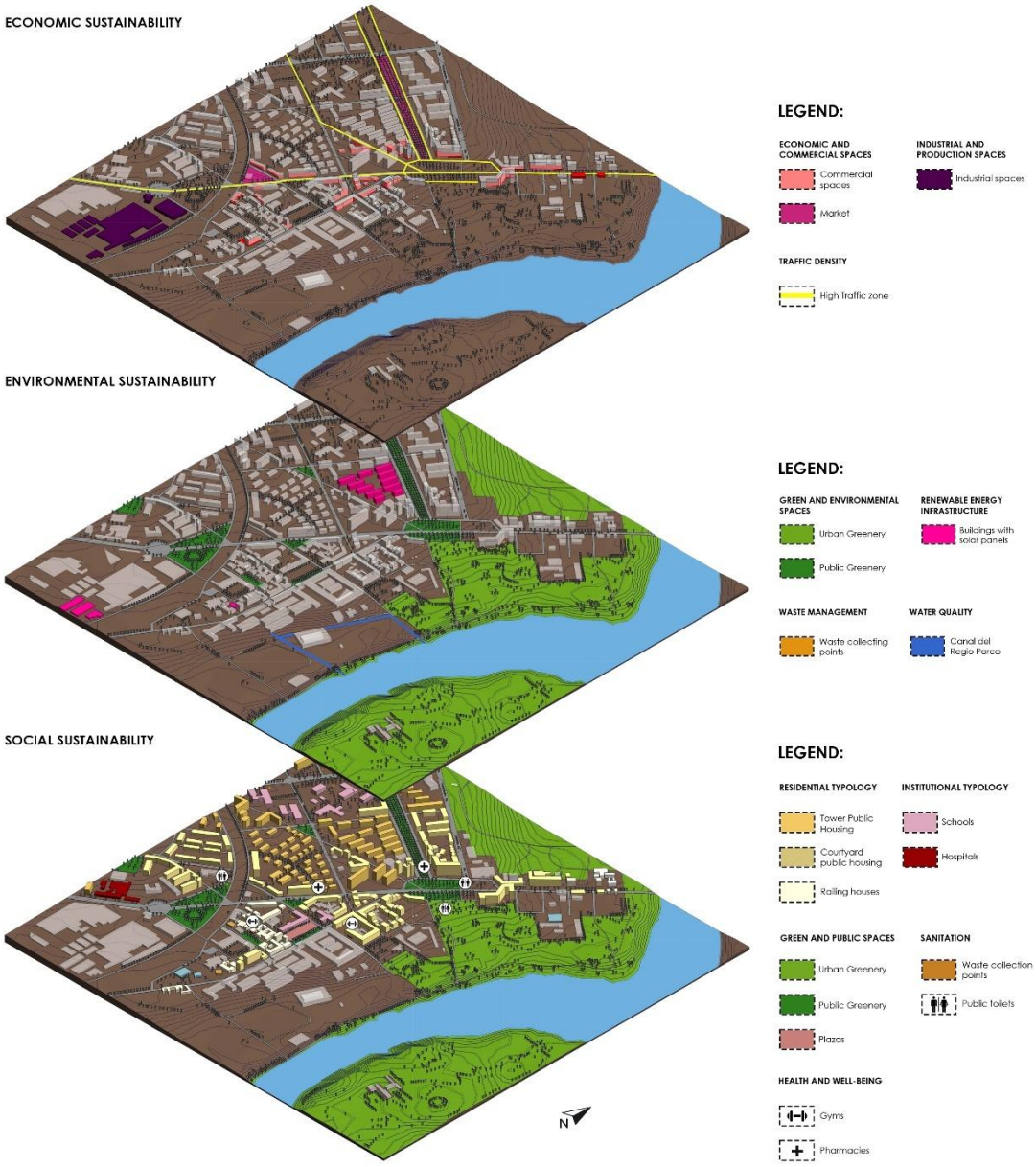


Figure 61: Indicators of Urban Sustainability on the site

Social Resilience:

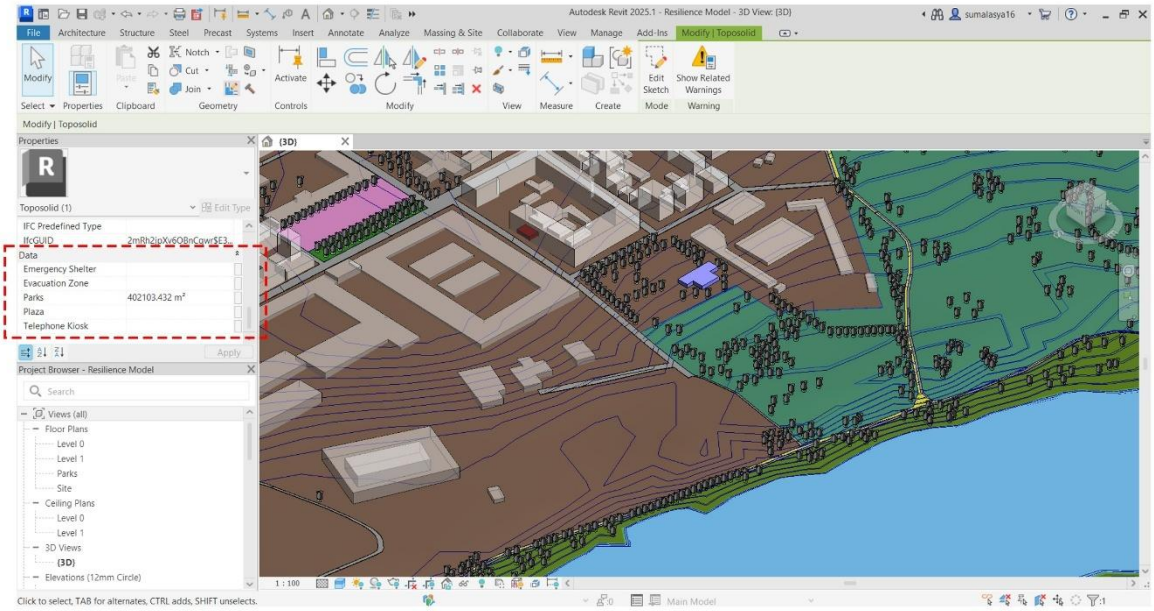


Figure 62: Integration of Social Resilience parameters into the BIM model. The screenshot specifically shows the Area of Parks. Source: Author

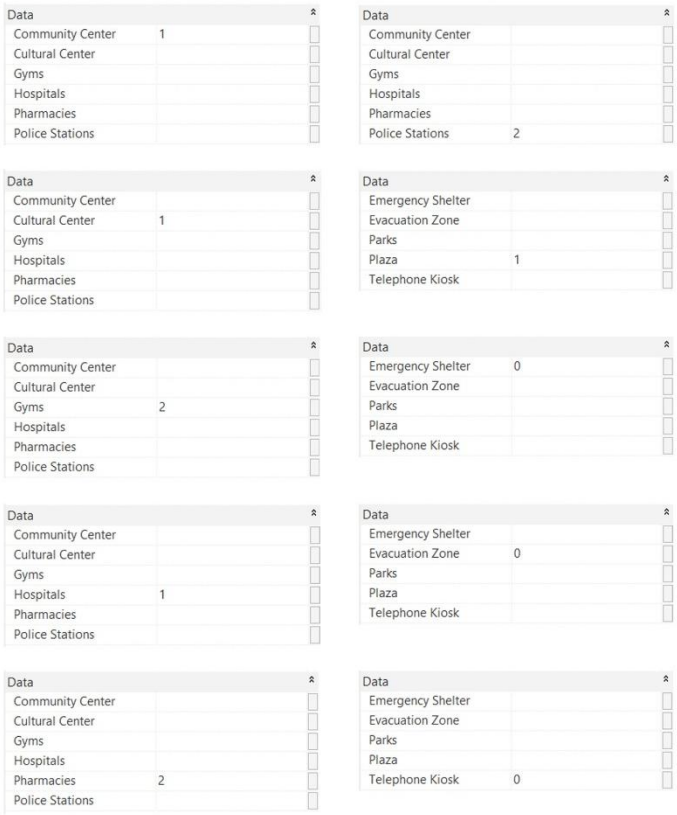


Figure 63: Data of other parameters of Social Resilience from the BIM model. Source: Author

Parameters	Area
Parks	402103.432 m^2
Parameters	Quantity
Community center	1
Cultural center	1
Gyms	2
Hospitals	1
Pharmacies	2
Police stations	2
Plaza	1
Parameter	Yes/no
Emergency shelter	No
Evacuation zone	No
Telephone kiosk	No

Table 8: List of parameters their areas and quantities of Social Resilience. Source: Author

Economic Resilience:

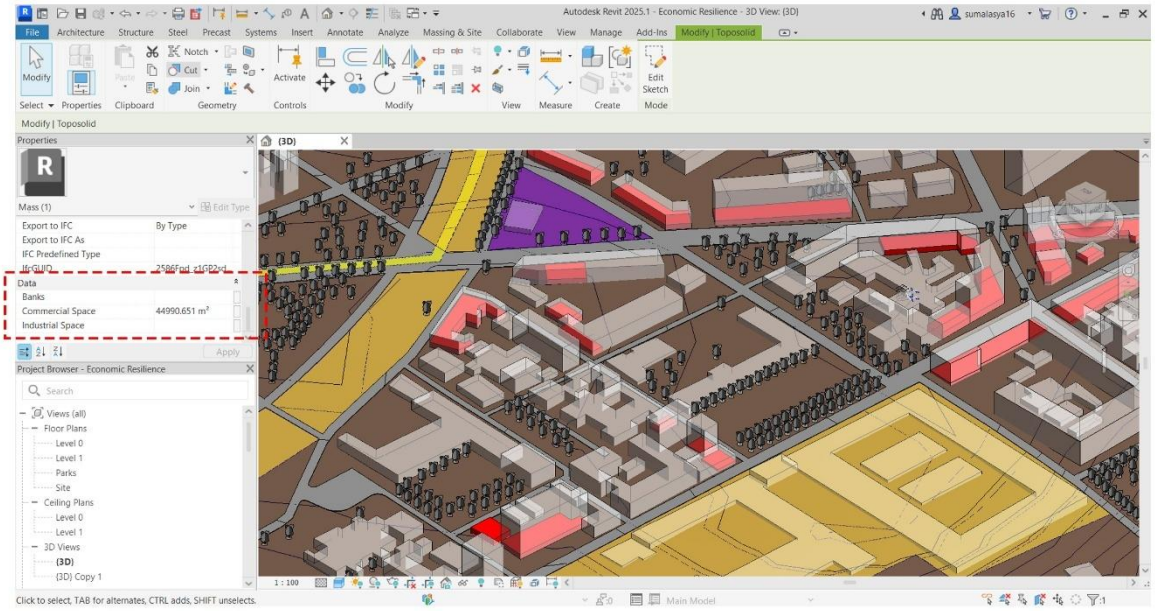


Figure 64: Integration of Economic Resilience parameters into the BIM model. The screenshot specifically shows the Area of Commercial space.

Source: Author

Data	
Banks	
Commercial Space	
Industrial Space	56977.199 m²

Data	
Future Infrastructural Proposal	
Market Space	14174.732 m²

Data	
Banks	2
Commercial Space	
Industrial Space	

Data	
Future Infrastructural Proposal	2
Market Space	

Figure 65: Data of other parameters of Economic Resilience from the BIM model. Source: Author

Parameters	Areas
Commercial space	44990.651 m²
Industrial space	56977.199 m²
Marketspace	14174.732 m²

Parameters	Quantity
Banks	2
Future infrastructure proposal	2

Table 9: List of parameters their areas and quantities of Economic Resilience.

Environmental Resilience:

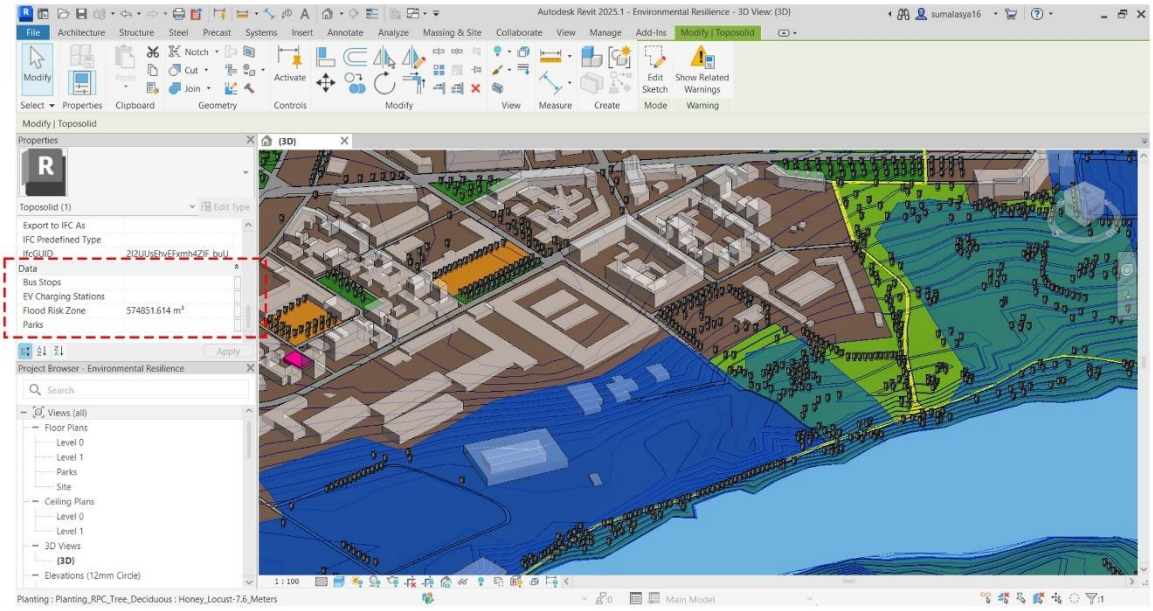


Figure 66: Integration of Environmental Resilience parameters into the BIM model. The screenshot specifically shows the Area of the Flood Risk Zone. Source: Author

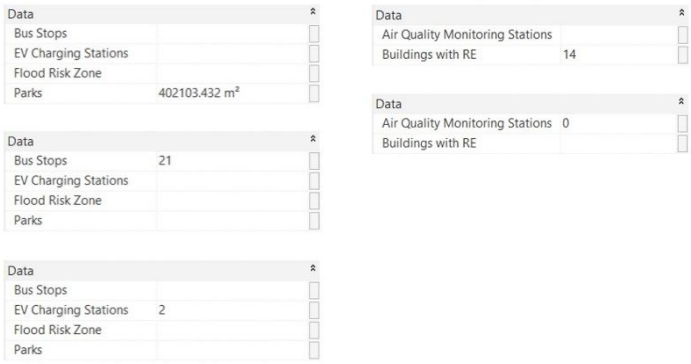


Figure 67: Data of other parameters of Environmental Resilience from the BIM model. Source: Author

Parameters	Area
Flood risk zone	574851.614 m^2
Parks	402103.432 m^2
Parameters	**Quantity**
Buildings with renewable energy	14
Bus stops	21
Ev charging stations	2
Parameters	**Yes/No**
Air quality monitoring stations	No

Table 10: List of parameters their areas, and quantities of Environmental Resilience.

Institutional Resilience:

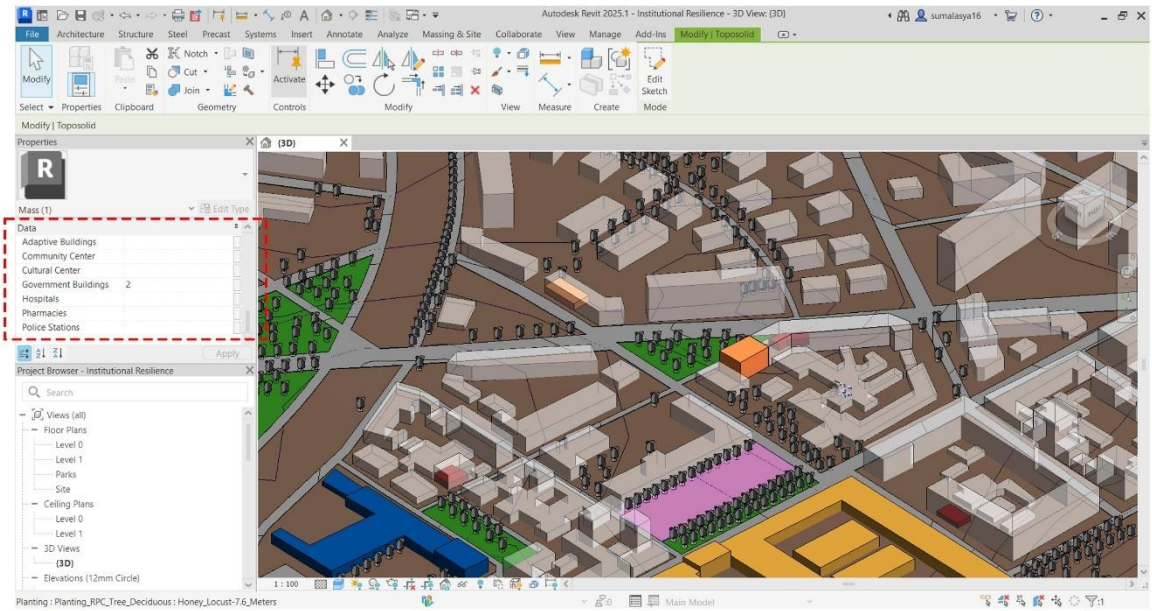


Figure 68: Integration of Institutional *Resilience parameters into the BIM model. The screenshot specifically shows the* number *of* Government Buildings. *Source: Author.*

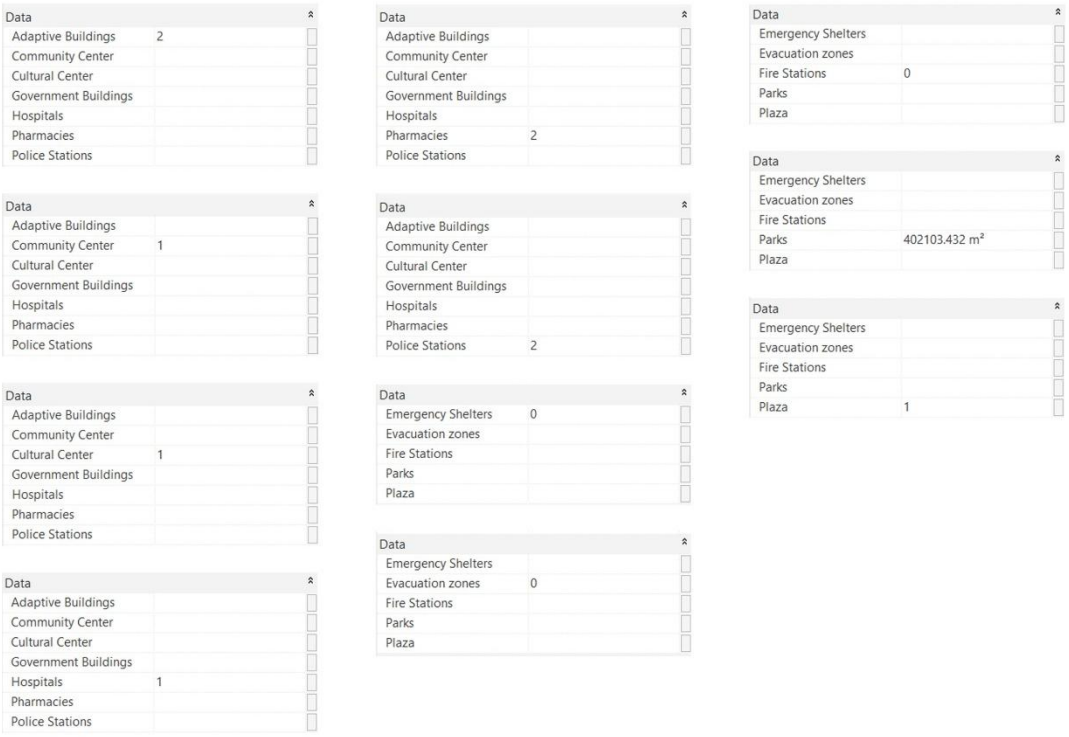


Figure 69: Data of other parameters of Institutional *Resilience from the BIM model. Source: Author.*

Parameters	Area
Parks	402103.432 m²
Parameters	**Quantity**
Adaptive buildings	2
Community center	1
Cultural center	1
Government buildings	2
Hospitals	1
Pharmacies	2
Police stations	2
Plaza	1
Parameters	**Yes/No**
Fire stations	No
Evacuation zone	No
Emergency shelter	No

Table 11: List of parameters their areas and quantities of Institutional Resilience.

Economic Sustainability:

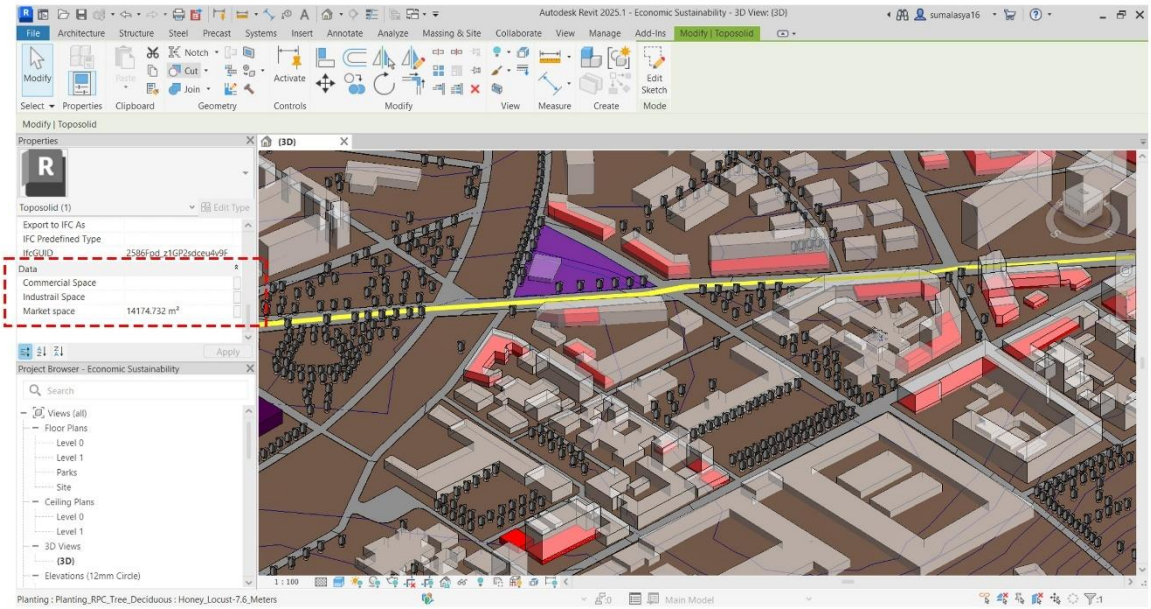


Figure 70: Integration of Economic Sustainability *parameters into the BIM model. The screenshot specifically shows the* area of market space.

Source: Author.

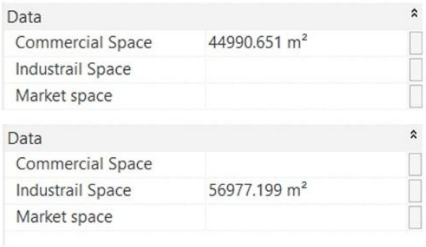


Figure 71: Data of other parameters of Economic Sustainability *from the BIM model. Source: Author.*

Parameters	Area
Commercial space	44990.651 m²
Industrial space	56977.199 m²
Marketspace	14174.732 m²
Parameters	Yes/no
Traffic density	Yes

Table 12: List of parameters their areas and quantities of Economic Sustainability.

Environmental Sustainability:

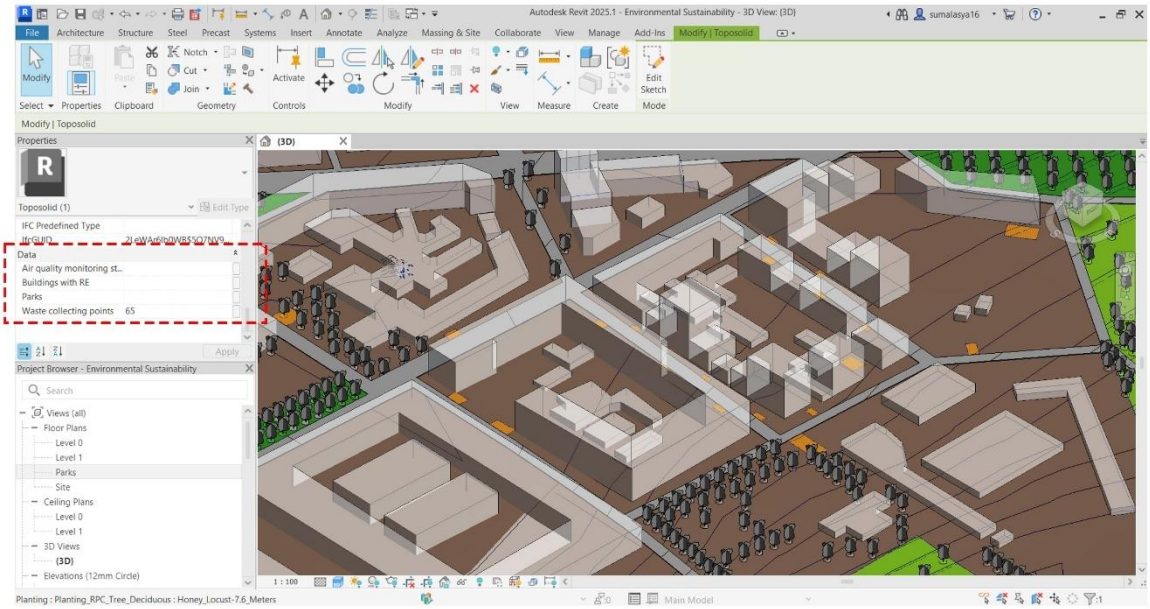


Figure 72: Integration of Environmental Sustainability *parameters into the BIM model. The screenshot specifically shows the* number *of* waste collection spots. *Source: Author*

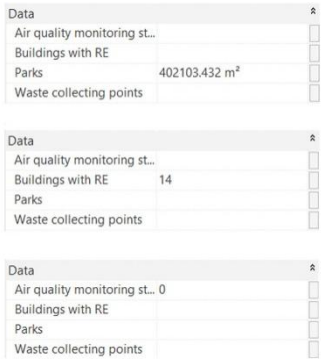


Figure 73: Data of other parameters of Environmental Sustainability *from the BIM model. Source: Author*

Parameters	Area
Parks	402103.432 m^2
Parameters	Quantity
Buildings with renewable energy	14
Waste collection points	65
Parameters	Yes/no
Air quality monitoring stations	No

Table 13: List of parameters their areas and quantities of Environmnetal Sustainability.

Social Sustainability:

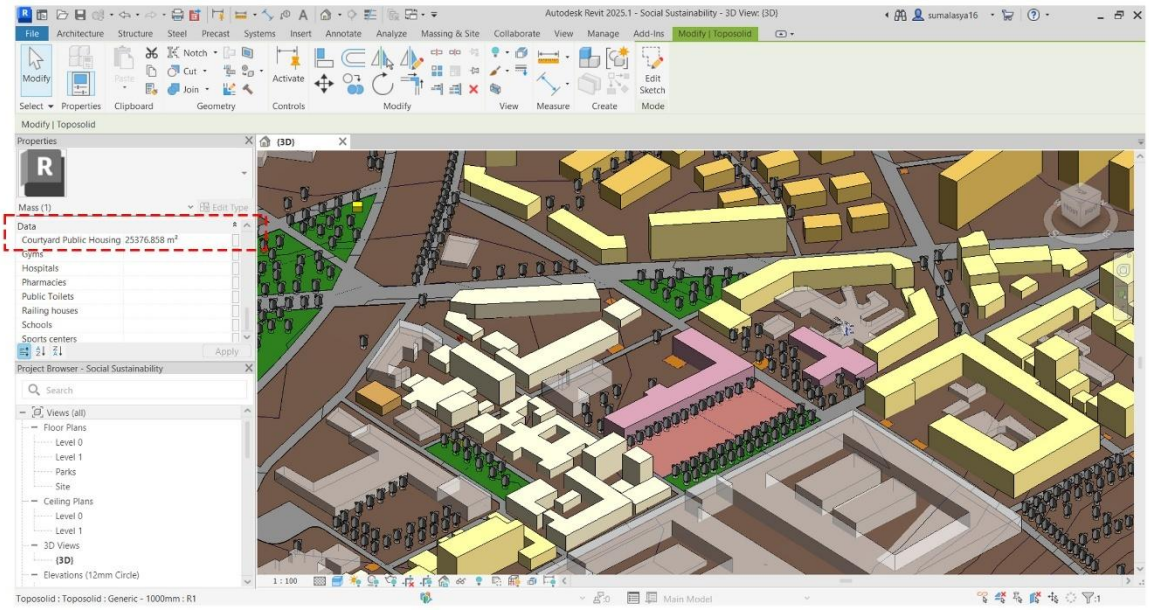


Figure 74: Integration of Social Sustainability *parameters into the BIM model. The screenshot specifically shows the* area of Courtyard public housing. *Source: Author.*

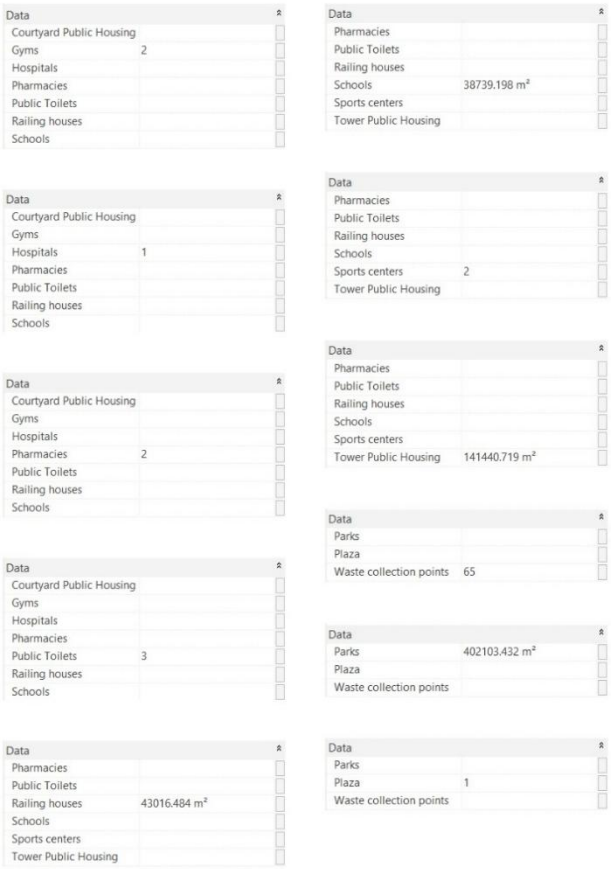


Figure 75: Data of other parameters of Social Sustainability *from the BIM model. Source: Author.*

Parameters	Area
Tower public housing	141440.719 m^2
Courtyard public housing	25376.858 m^2
Railing houses	43016.484 m^2
Schools	38739.198 m^2
Parks	402103.432 m^2
Parameters	Quantity
Plaza	1
Hospitals	1
Pharmacies	2
Public toilets	3
Sports center	2
Waste collection points	65
Gyms	2

Table 14: List of parameters their areas and quantities of Social Sustainability.

CHAPTER

06

APPROACH TO THE DESIGN

6.1. UNDERSTANDING THE SITE:

Figure 76: Site. Source: Author (BIM)

Figure 77: Areas of intervention in site. Source: Author (BIM).

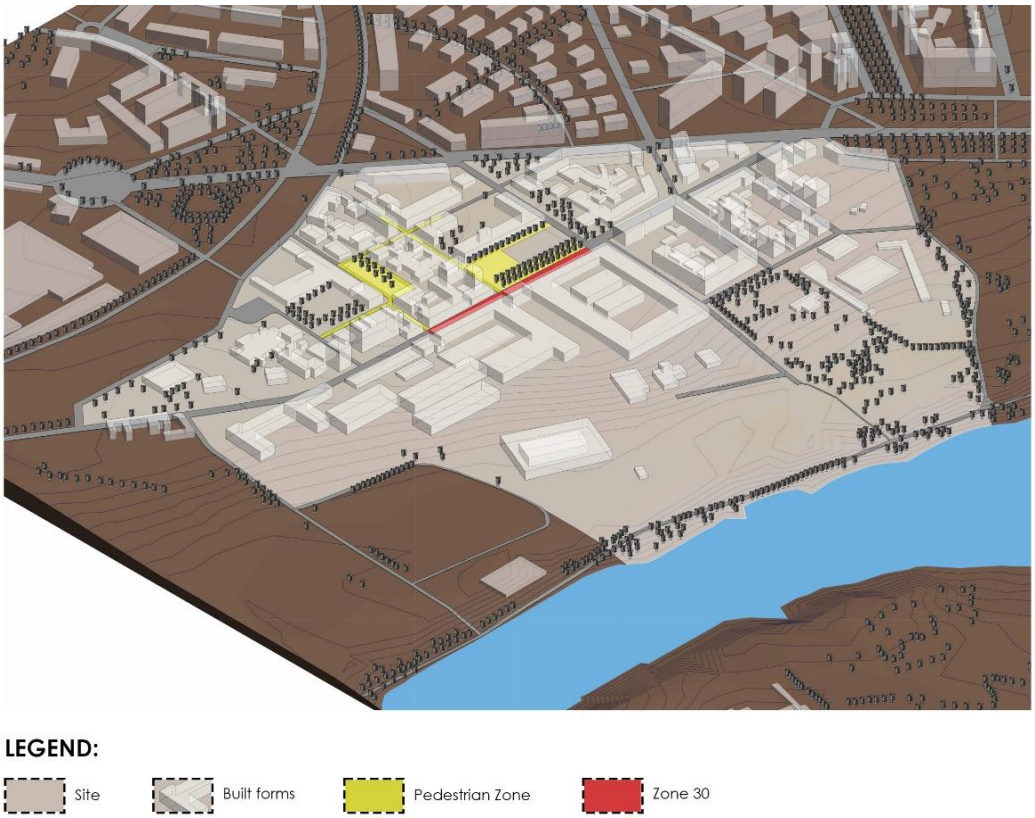


Figure 78: Connectivity in the site. Source: Author(BIM)

Figure 79: Future Proposals around the site. Source: Author (BIM)

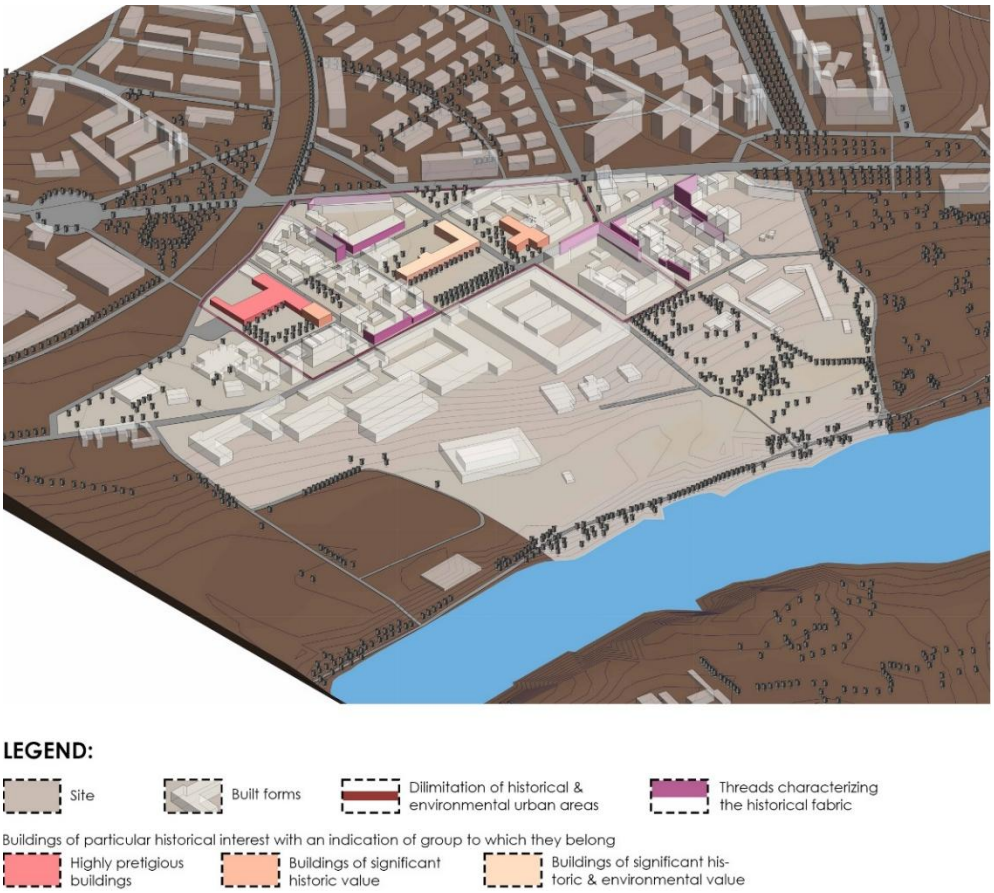


Figure 80:Buildings with Historical Interest. Source: Author (BIM)

Figure 81: Extension of Park. Source: Author (BIM)

Figure 82: Hierarchy of zones. Source: Author (BIM)

Initially the black spots of the neighborhood were identified based on various categories. They have been divided into seven areas. So that a detailed analysis and design can be done.

- Area 1: Space behind Manifacttura Tabacchi, which includes auto mobile garage.
- Area 2: Piazza Abba on Corso Regio Parco
- Area 3: Open space in the Church on Via Norberto
- Area 4: Open space in the Church complex on Via S. Gaetano da Thiene.
- Area 5: Plaza on the intersection of Via Bologna and Via Modesto Paroletti
- Area 6: Intersection of Via Bologna and Corso Regio Parco
- Area 7: Canal of Regio Parco between Corso Terenzio Mamiani and Corso Regio Parco.

6.2. MASTER PLAN:

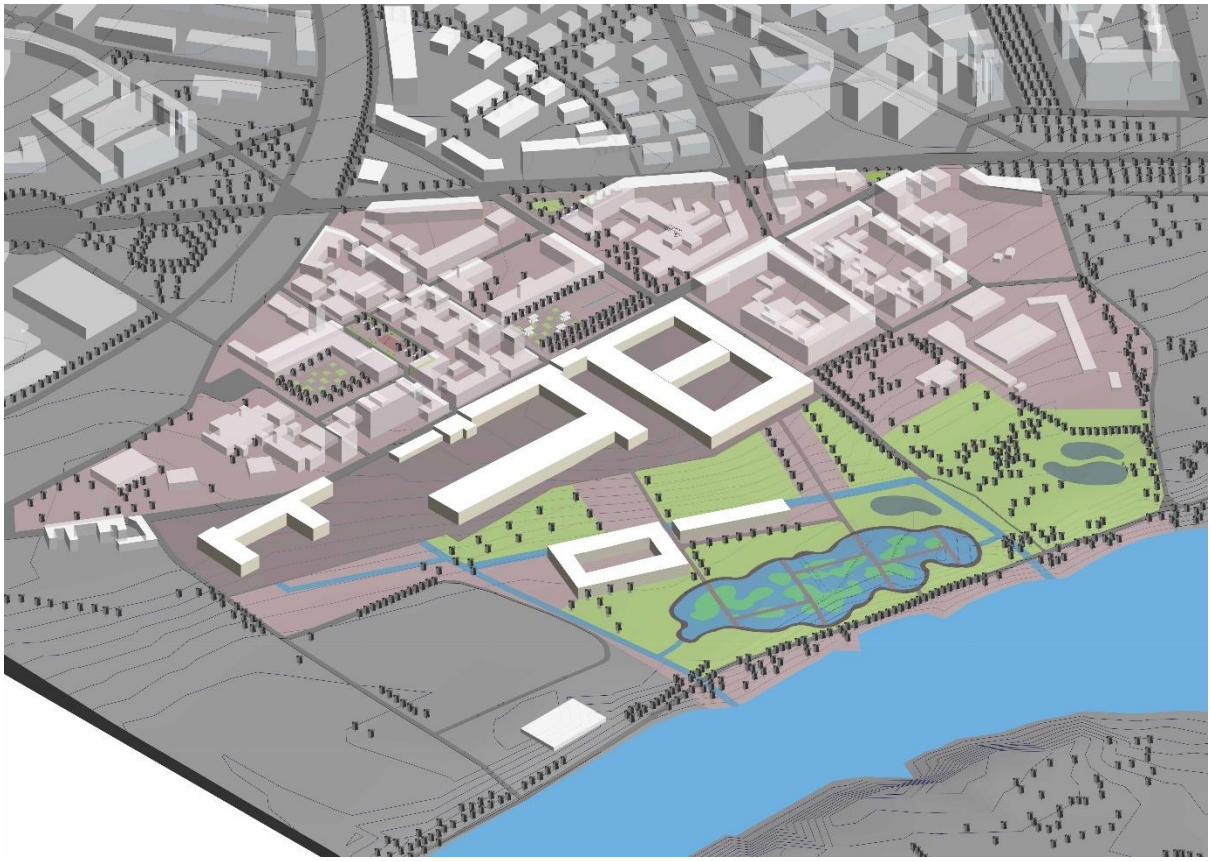


Figure 83: Master plan of the Site

Figure 84: Neighbourhood Key plan.

6.3. THE DESIGN VISION:

Area 1:

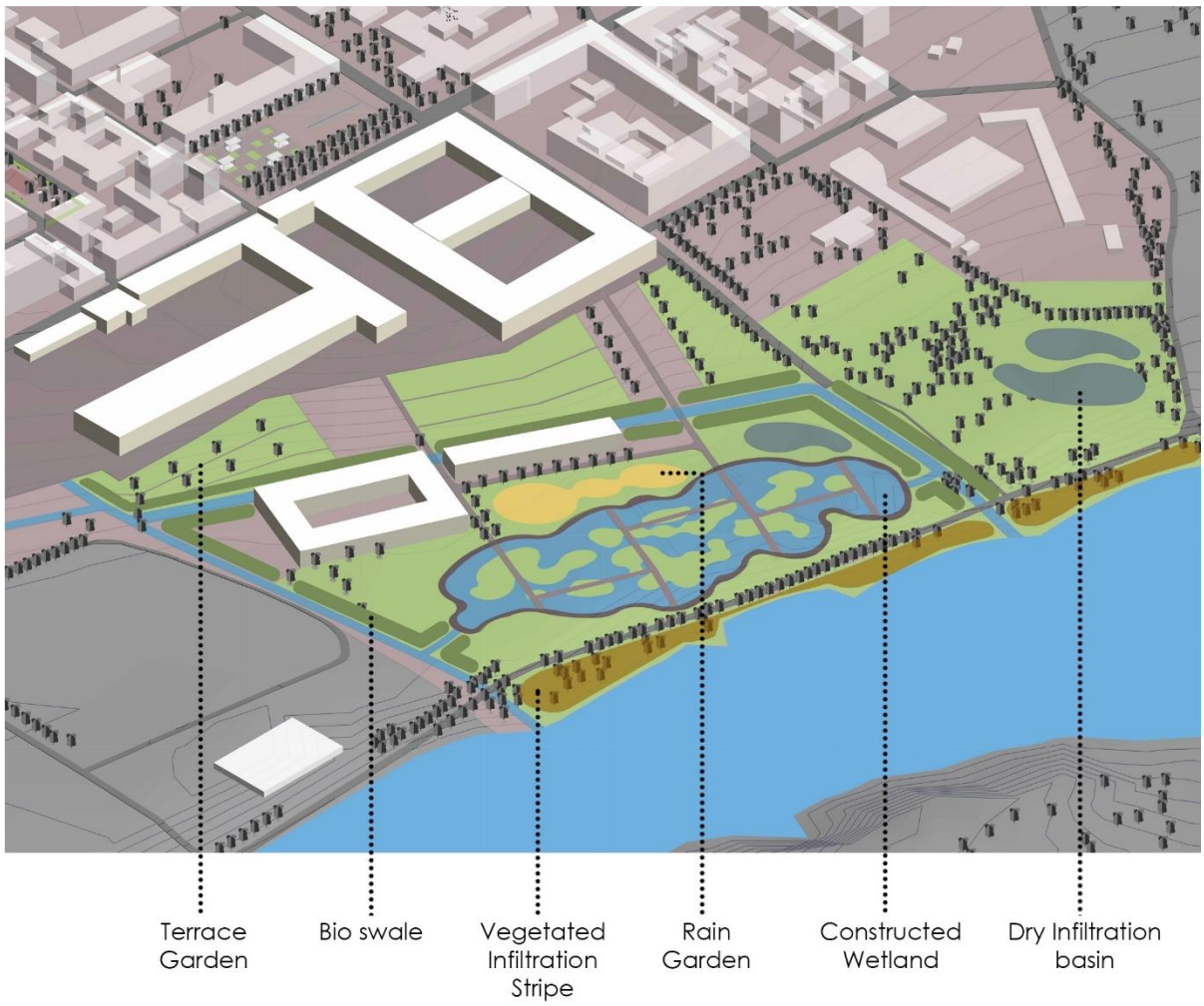


Figure 85: Green infrastructure strategies used in Area 1

Due to the site's vulnerability to floods, the site benefits significantly from the incorporation of nature-based solutions that improve its green infrastructure. Taking advantage of the site's slope terrace garden was adopted into the site as it slows down surface runoff. Bioswales help in filtering the stormwater as well as the water in the canal and encourage soil penetration. Before water enters drainage systems, sediments, and pollutants are captured by vegetated filter strips, which serve as buffers. Rain gardens help in increasing groundwater recharge. As natural retention basins, artificial wetlands enhance water quality by storing and releasing water gradually. When combined these solutions strengthen the

site's resilience, reducing floods, while supporting biodiversity and enhancing overall environmental health.

Area 2:

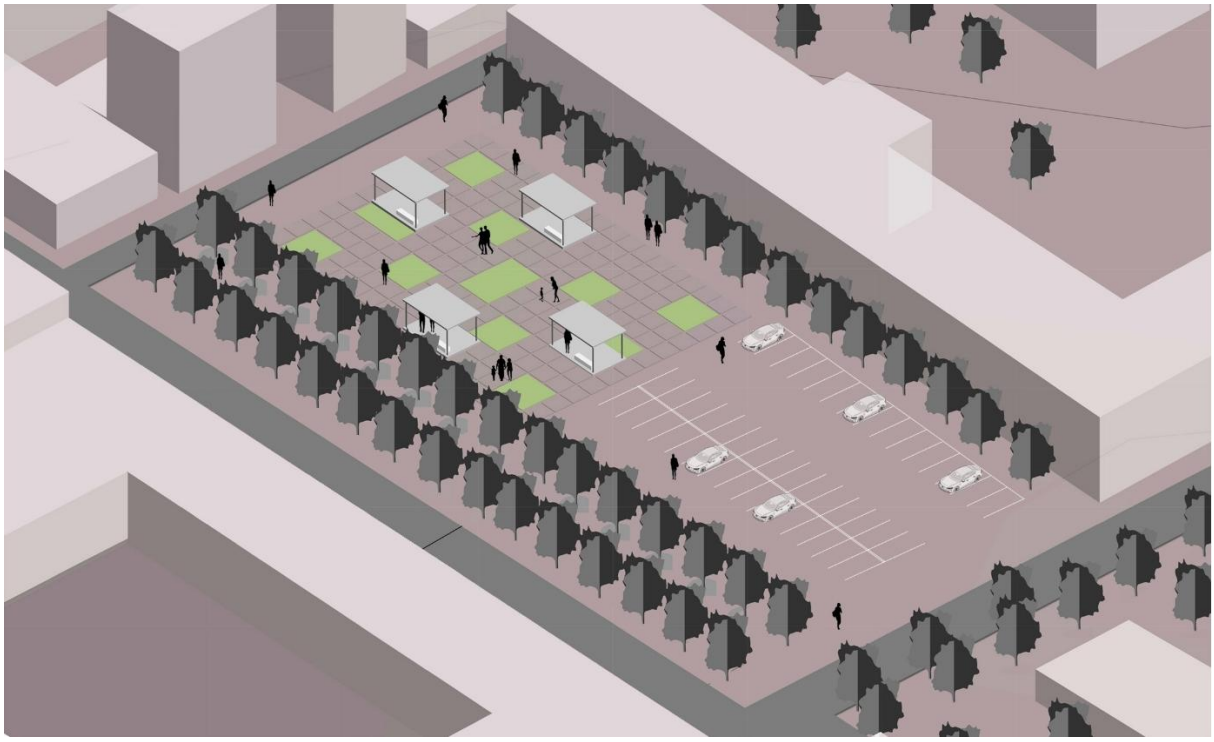


Figure 86: Piazza Giuseppe Cesare Abba

Area 3:

Figure 87: Plaza on Via Norberto

Area 4:

Figure 88: Open space in the Church Complex

Area 5:

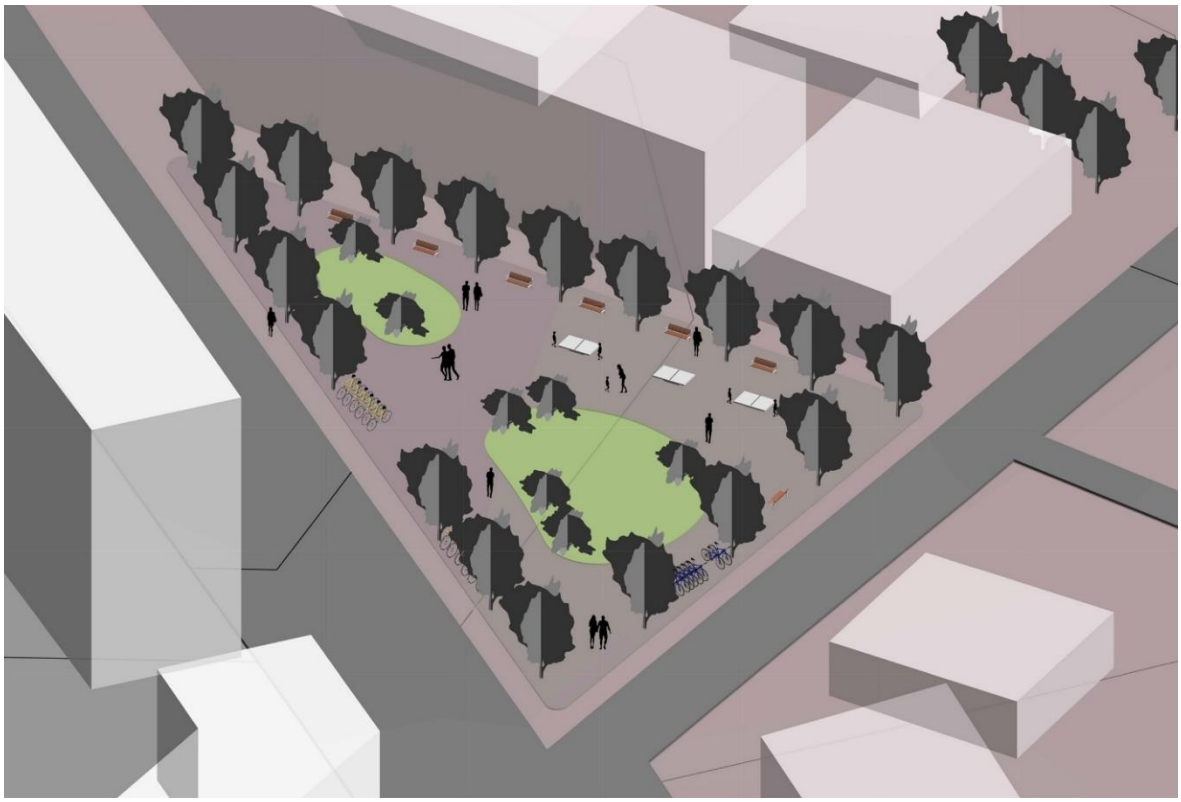


Figure 89: Plaza on the intersection of Via Bologna and Via Modesto Paroletti

Area 6:

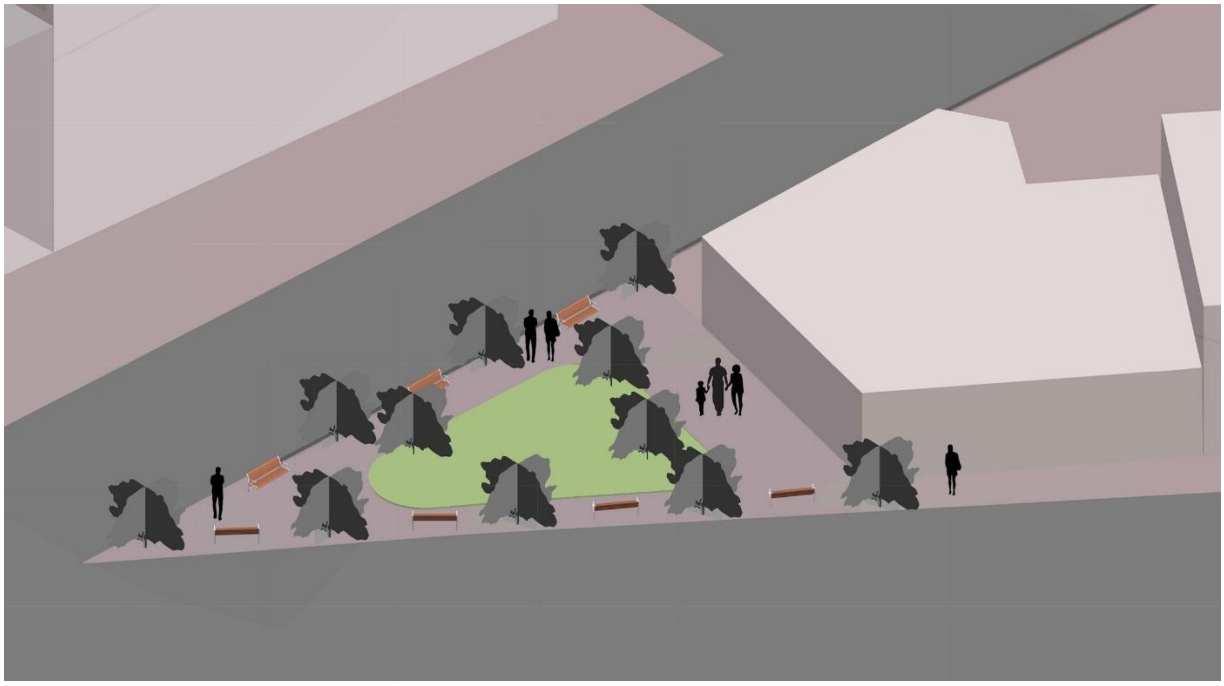


Figure 90: Seating area at the intersection of Via Bologna and Corso Regio

In all the Area 2 to 6, All the green spaces are underutilized and neglected. In order to make them vibrant and sustainable the following strategies are used. Permeable pavement is used throughout to enhance water penetration and lower surface runoff which helps in controlling floods. Additionally, more seating sections are also incorporated to create warm communal areas, and E-bike and bicycle stations are also incorporated to promote sustainable mobility. Table tennis tables are positioned thoughtfully to promote conversation and movement, bringing people together in a lively and engaging environment.

Area 7 is situated in between between Corso Terenzio Mamiani and Corso Regio Parco. It is the Canal of Parco regio, which has currently dried out, and a trench is left remaining beside the street and the bridge. In case of emergency, it might be a dangerous place where people might fall into it. So, to solve this issue vegetation (trees and bushes) is used which acts like a natural barrier to the trench.

6.4. MOBILITY PLAN OF THE NEIGHBORHOOD:

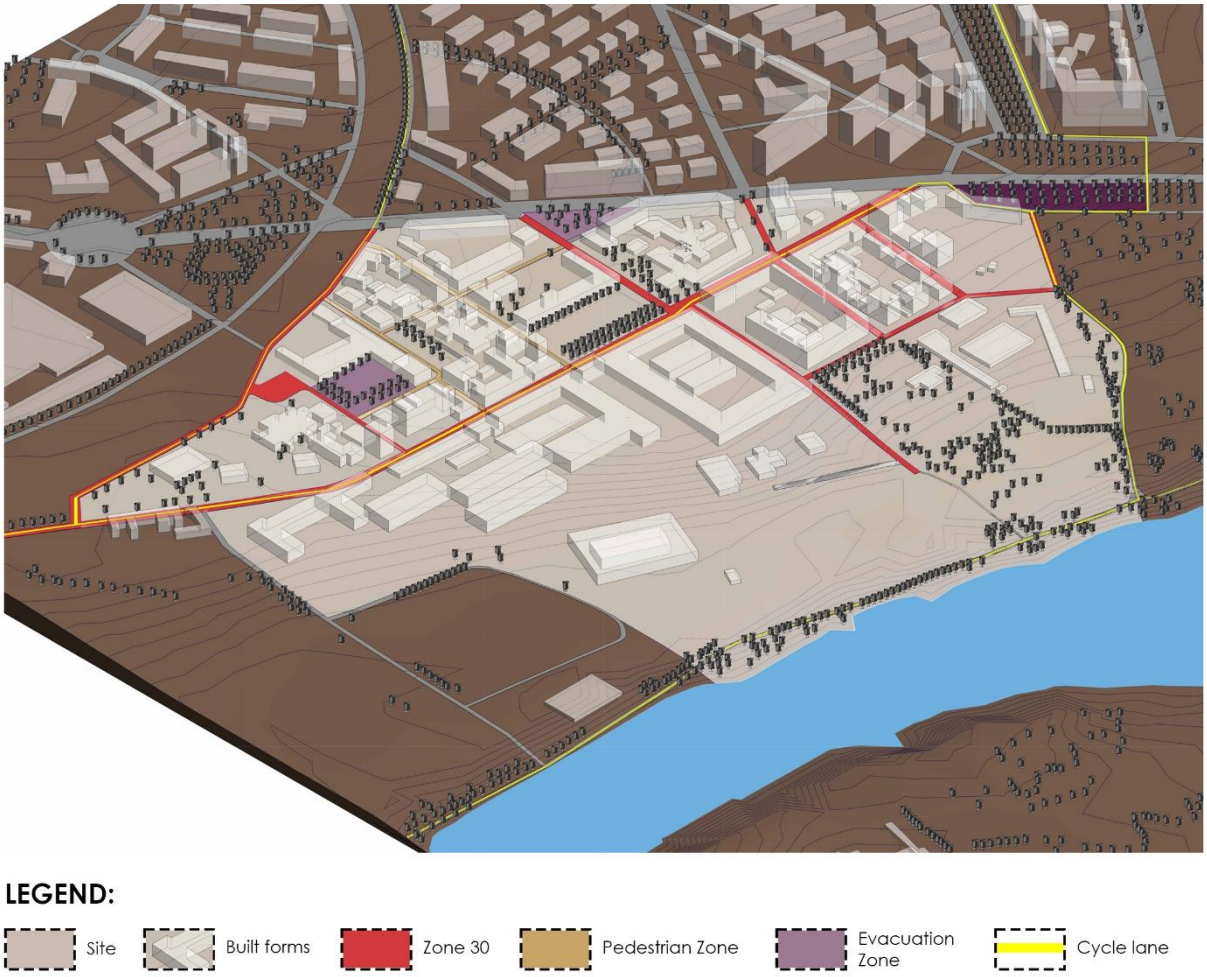


Figure 91: Mobility Plan Proposal. Source: Author (BIM)

Site has historical and environmental significance, so to make the streets safer, more walkable, and environmentally friendly area Zone 30 is adapted. It would foster a pedestrian-friendly area, preserve green infrastructure, and lessen the impact of vehicle traffic.

Two bicycle lanes are added to Corso Regio Parco and Via Gottardo. Three evacuation zone has been placed which are easily accessible and are at a high level topographically so that they are not flooded easily in case of emergency.

6.5. CONCLUSION:

This thesis focuses on understanding the importance of urban resilience and sustainability in revitalizing green infrastructure within a neighborhood. Strategies that promote human and ecological well-being in the face of rapid urbanization, climate change, and environmental degradation must be included. This study shows the green infrastructure can transform a site at risk into a resilient and community-focused urban development.

This research begins with a detailed analysis of urban resilience and sustainability in general. The indicators of urban resilience and sustainability have been applied to the site's BIM model. The resilience indicators include environmental, economic, social, institutional, and cultural resilience. The sustainability indicators include environmental, economic, and social sustainability.

As per the analysis, the site faces several major concerns, but floods are the primary threats. Poor connectivity and accessibility, and open green spaces with low functionality are other major concerns. Additionally, the site also lacks evacuation points, space for emergency camps, and places for the community to conduct workshops and collaborative disaster planning. Poorly designed pathways for pedestrians, lack of shared mobility stations, and absence of cycle lanes are diminishing the vibrancy of the street and discouraging the adaptation of green mobility solutions. Collectively, these factors highlight the weakness of connectivity, accessible and functional green spaces, and disaster preparedness infrastructure.

As the major threat the site faces is floods, nature-based solutions are used to mitigate the floods. As we know nature-based solutions enhance the ecosystem, improve the ecological balance, and offer cost-effective approaches. In the park design features such as constructed wetlands, bioswales, rain gardens, vegetated filter strips, stormwater retention ponds, and planted riparian buffers have been incorporated, arranged in a well-defined hierarchy of zones to manage stormwater, reduce surface runoff, and improve infiltration. These strategies show that urban

landscapes can be used for both the restoration of nature and to prevention of disasters. Through this approach, we can reduce the number of people in the neighbourhood from experiencing environmental shocks.

The pedestrianized superblock, which draws influence from Barcelona's successful urban planning approach encourages people to walk and reduces dependency on vehicles. Pedestrian pathways and cycle lanes have been introduced and shared mobility stations for e-scooters and bikes have been provided in the plazas to encourage sustainable mobility. This makes a city safer and more welcoming to all age groups of people. Evacuation points have been provided which makes it easier for people to gather during emergencies or hazards, showing how important preparedness is to build resilient urban systems. The selection of evacuation zones was based on the topography of the site, if they are on a higher elevation they do not get flooded during the flood events. Spaces for community workshops and collaborative disaster planning have also been allocated along with the evacuation spots.

This study shows how local, customized interpretations can be a solution to climate change and urbanization which are the major problems that the world is facing today. By revitalizing green infrastructure, the project also shows how resilience and sustainability are interdependent, requiring collaboration across different fields of stakeholders. Manifattura Tabacchi's metamorphosis into resilient and sustainable urban development model shows how design can improve resource efficiency, community well-being and environmental health.

This thesis visualizes a neighborhood that not only tackles flooding but also demonstrates sustainable urban living. Through design, the neighborhood has been turned into a place of opportunity and resilience by focusing on environmental health, community well-being, and resource efficiency. Future urban initiatives can be guided by these results to maintain a better balance between nature and human activity which leads to create more adaptable and sustainable cities globally.

Way Forward:

Future studies can explore how real-time data collection through IoT can be integrated into advanced BIM tools. By improving the predictive modeling and automated responses to environmental changes like heat waves or rising water levels etc, we can improve the flexibility of the city's framework.

The principle of the proposed intervention can be applied, tested, and refined to other similar projects that require design interventions to improve the environment, increase livability, and strengthen the bond between the people and their surroundings. The main features of the project can be applied to projects that deal with urban regeneration, bio-diversity enhancement, water-sensitive urban design, sustainable urban mobility, and smart cities. By applying the design framework to different projects with different environmental, social, and economic circumstances, the flexibility and resilience of the method can be evaluated.

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