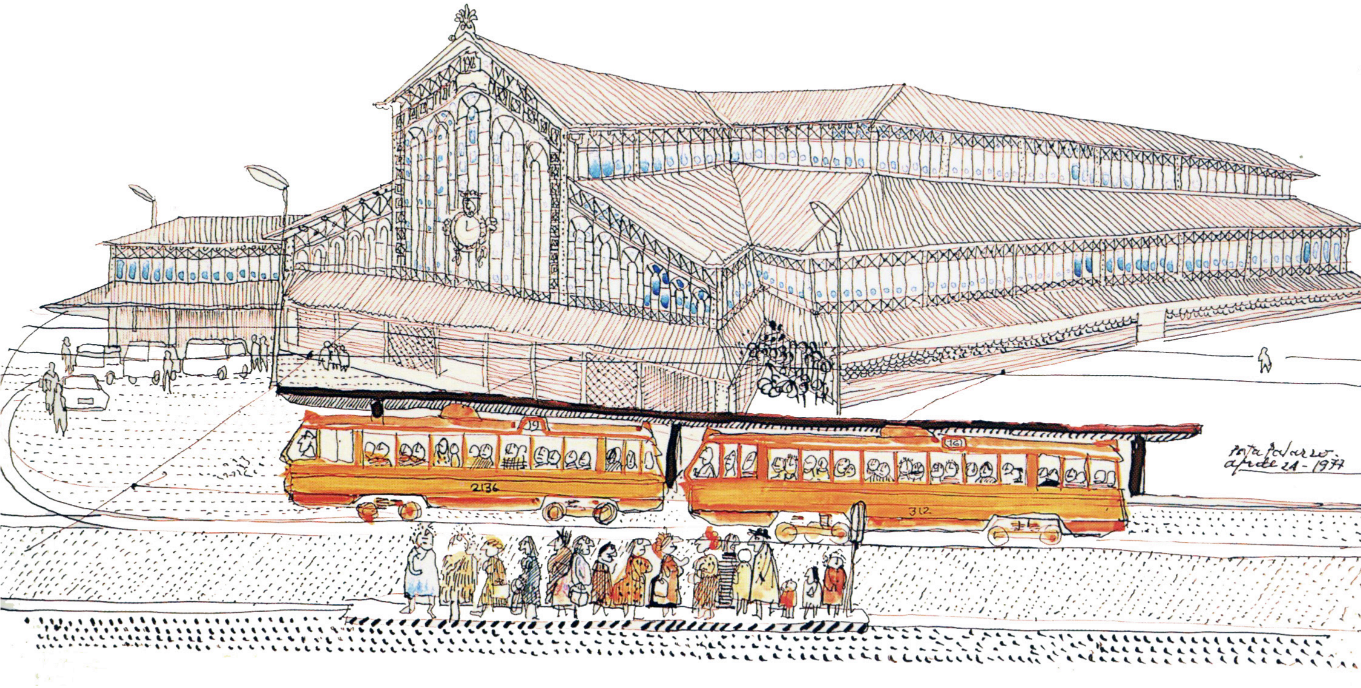
Microclimate Mitigation: Analysis and Design of an Open-Air Market in Porta Palazzo, Turin



Master Thesis
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Microclimate Mitigation: Analysis and Design of an Open-Air Market in Porta Palazzo, Turin

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Master thesis

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source of the cover painting: (Coppo et al ., 2006)

I sincerely thank my thesis supervisor, Riccardo Pollo, for his valuable guidance, and Anja Pejović for her incredible support as co-supervisor.

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0.1 Glossary

Albedo –The ability of a surface that allows it to reflect solar radiation, measured between 0 and 1 (0 being full absorption and 1 being full reflectivity) (Lopez-Cabeza et. al, 2022).

Adaptation – Adaptation is an area of action whose aim is to moderate the damage of the climate change or exploit its benefits (IPCC, 2007). The effect of the adaptation measures is immediately noticeable (Pollo and Trane, 2021).

Microclimate – the suite of climatic conditions of a particular location or a relatively small area, that differ from the one of its surroundings (consisting of environmental variables such as potential air temperature, surface temperature, wind speed and outdoor comfort indicators)
(Martin & Hine, 2008).

Mitigation – interventions that deal with the causes of climate change, such as to reduce the emission sources (Locatelli, 2011).

Mitigative urban Environments and Microclimates (MitEM) - involves urban planning strategies that both reduce greenhouse gas emissions and enhance local resilience to climate impacts

Psychological Equivalent Temperature (PET) – the air temperature at which, in a typical indoor setting (without wind and solar radiation), the heat budget of the human body is balanced with the same core and skin temperature as under the complex outdoor conditions to be assessed (Erell et al., 2011).

Urban heat island (UHI) – an urban or metropolitan area where the temperature is significantly higher compared to that of its surroundings, commonly associated with intense human activities (Taha, 2004)

0.2 Abstract

The impact of urban design on microclimate conditions has long been a topic of interest to the scientific community. This thesis presents an analysis of the microclimate of Porta Palazzo Market in Turin, with the aim of proposing strategies for the area that mitigate Urban Heat Island (UHI) effects at the neighborhood scale. The study incorporates an analysis of the market's architectural and historical aspects, examining the market's timeline and heritage to integrate these elements with urban design principles. Specific software was used to analyze how the microclimate around the market is influenced by UHI and other factors, identifying the areas most impacted.

The thesis is structured into three main phases. The first phase provides a historical and theoretical foundation, covering microclimate concepts, mitigation and adaptation strategies, and relevant analytical software. The second phase includes case studies that illustrate these concepts and enhance the understanding of the thesis scope. In the final phase, a detailed microclimate analysis using ENVI-met software is conducted, focusing on four main parameters: potential air temperature, surface temperature, wind speed, and Physiological Equivalent Temperature (PET).
Based on this methodology, strategies for microclimate mitigation and adaptation in the area are suggested. The effectiveness of the proposed design is evaluated using the same software, demonstrating promising results in improving thermal comfort and positively impacting the climate conditions in the market.

The findings of this research underscore the importance of targeted microclimate interventions in enhancing urban resilience and sustainability.

Key words: microclimate, outdoor thermal comfort, adaptation, mitigation, ENVI-met, open-market

0.3 Introduction

Urban environments are dynamic and complex, constantly evolving to accommodate the needs and aspirations of their inhabitants. As cities grow, the challenges of maintaining a sustainable and livable environment become increasingly pressing. One critical aspect of urban design is the consideration of microclimates and their impact on the well-being of the urban population. Microclimates, defined as the localized atmospheric conditions within an urban area, play a pivotal role in determining the comfort and quality of outdoor spaces. Climatic conditions within the urban area depend not only on the meteorological parameters but also on site-specific condition and features, such as the morphology, the presence of greenery, the surface materials, the use of the public space (Pollo et al., 2020)

The city of Turin, renowned for its rich history, cultural heritage, and vibrant urban fabric, faces numerous challenges in maintaining a favorable microclimate for its residents and visitors. Located in the northwest region of Italy, Turin experiences a continental climate characterized by hot summers and cold winters. Nevertheless, certain regions within the city can experience notable deviations from the overall climate patterns due to localized elements like topography, building density, and land usage.

Porta Palazzo, an historically significant district in Turin, is home to the largest open-air market in Europe. The Porta Palazzo Market serves as a vibrant social and economic drawing a diverse array of individuals and playing a crucial role in connecting the city's residents with local producers.

Recognizing the importance of the Porta Palazzo Market as a cultural and economic asset, it becomes imperative to explore strategies that mitigate the adverse effects of the microclimate, thus enhancing the overall experience and ensuring the market's long-term viability. This thesis aims to investigate the microclimate conditions in Porta Palazzo and propose innovative design interventions that address the challenges associated with the market's open-air setting. To be able to analyze these complex interactions an to evaluate the different outcomes of urban decision-making processes, the need for computer-based tools and numerical simulations is undeniable. (Bruse & Fleer, 1998). Therefore, ENVI-met software has been used for the simulations that have been carried out during the research.

By examining the microclimate parameters, such as temperature, humidity, wind patterns, and solar exposure, in conjunction with a comprehensive analysis of the site's urban context, this research seeks to identify potential design strategies that promote thermal comfort, enhance air quality, and provide suitable shading and ventilation for both vendors and visitors. Furthermore, the study will consider the sociocultural aspects of the market, considering the needs and preferences of different user groups to create an inclusive and enjoyable experience.

0.4 Research question

The main research question that this thesis addresses is:

How can the design of Porta Palazzo Market in Turin be improved to enhance microclimate conditions and people's comfort?

The sub-research questions that this thesis seeks to illuminate are:

- How do microclimate conditions impact the comfort and health of people's in open air markets', and how can these insights be applied to similar markets?

- What design interventions can improve microclimate conditions and enhance thermal comfort and energy efficiency in urban open-air markets?»

0.5 Methodology

This study employs a mixed-methods approach to investigate microclimate conditions and proposes design interventions for the open-air market in Porta Palazzo, Turin. The methodology consists of data collection, data analysis, a review of existing literature, design development, and evaluation.

Background: Includes both historical and theoretical backgrounds. The background for this thesis involved a comprehensive literature review encompassing the historical development of markets in Europe, the evolution of covered markets in Italy, and the scientific principles underlying microclimate analysis. By examining the historical context, including significant periods of market expansion and modernization, the review provided insights into the social and economic roles of markets and their contemporary challenges. Focusing on key Italian cities, particularly Turin and its Porta Palazzo Market, the study explored the historical significance and current conditions of these markets. Additionally, the review delved into the fundamentals of microclimate, the use of ENVI-met software for climate analysis, and the methodologies for microclimate modeling. This thorough review established a robust theoretical foundation, informing the subsequent analysis and design interventions aimed at improving microclimate conditions in urban markets.

Studying the best practices: Studying best practices involved an extensive review of successful strategies and interventions implemented in markets worldwide to improve microclimate conditions. This examination focused on identifying innovative design solutions, material usage, and urban planning approaches that have effectively enhanced thermal comfort, energy efficiency, and overall visitor experience.
By analyzing two kind of case studies including resarch case studies and bulit ones from diverse geographic and climatic contexts, the study highlighted adaptable and scalable practices that can be tailored to specific market environments. These insights not only informed the proposed design interventions for Porta Palazzo Market but also provided a framework for applying these strategies to other urban markets, contributing to a broader understanding of microclimate mitigation in public spaces.

Microclimate analysis and design: The modeling and simulation conducted represent a focused study on the microclimate conditions surrounding the Porta Palazzo Market in Turin. This research involved detailed mapping and analysis of the city block encompassing Piazza della Repubblica, considering various factors such as surfaces, components, and greenery. Utilizing ENVI-met software, simulations were conducted to assess microclimate conditions under both existing and proposed design scenarios. Key parameters including potential air temperature, surface temperature, wind speed, and PET were meticulously analyzed. The outcomes provide insights into how different urban elements influence microclimate variations across market area and surrending streets. Through thorough analysis of the results and the data gathered from the study, the research identifies the significant elements impacting the microclimate and evaluates the effectiveness of different mitigation strategies.
Finally strategies proposed based on research to mitigate the microclimate condition of the Porta Palazzo market.

1. Background

1.1.Market

What comes first: the city or the market? It is not always clear, but historically the development of towns and markets is often linked. (Black, 2012)
According to the Oxford Dictionary of Current English, a market is the "gathering of people for the purchase and sale of provisions, livestock, etc.; space or building used for this; demand (for commodity and service); place or group providing such demand; conditions as regards, or opportunity for, buying or selling; rate of purchase
and sale. (Black, 2013)
This concept examines the market at three levels: as a physical place for exchange, a gathering of people for buying and selling, and an abstract economic concept.
Although markets are economically inefficient compared to supermarkets, they persist in modern European cities due to their social value.
The market is a sort of contained chaos. The location of markets often corresponds to the positioning of political power: in that way, institutional power is transferred to urban structures» (Fligstein, 2002)
Markets foster social interactions, provide a sense of community, and serve as important public spaces. They contrast with supermarkets, which emphasize efficiency and individualism, leading to a loss of social connections.

Market structures can exhibit various configurations, with two common forms being linear and cluster arrangements. As shown in Figure 1, linear market structures are characterized by a direct and predictable correlation between variables, reflecting a clear connection among different market elements. On the other hand, Figure 2 illustrates that cluster formations in markets involve the aggregation of similar entities or behaviors, leading to the emergence of distinct clusters within the market ecosystem. (Coppo et al ., 2006) In real-life contexts, markets adapt to urban spaces and cultural traditions over time and across diverse locations.

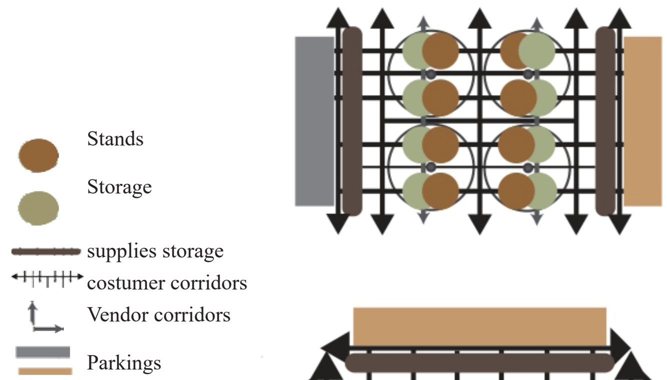


Fig1
Linear Market: This type features a strict separation between the customer walkways and vendor service areas, with stands arranged in straight rows. The space behind the vendors is used for storage and parking.
Source: illustration by author, based on (Coppo et al ., 2006)

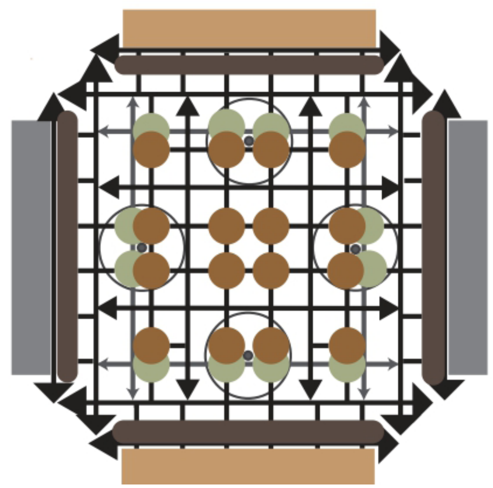


Fig2. Cluster Market: In this layout, customer and vendor spaces overlap, with storage and parking located on the market's perimeter.
Source: illustration by author, based on (Coppo et al ., 2006)

1.2 Historical Background

1.2.1 Development of Markets in Europe

The development of markets and cities is intimately connected; however, while markets can exist without a city, the opposite is unthinkable. Historically, all cities have had markets; indeed, cities formed around markets (Black, 2012)
Food markets as a new form of architecture and town planning were established in urban Europe in the early nineteenth century and spread over the continent thanks to the proliferation of iron and glass markets in the second half of the century, managing to become one of the most obvious expressions of municipal pride, However, in the twentieth century many of them began to decline, some of them falling under the pickaxe and surviving only in people's memory. Contrarily, many others are still standing, their old structures defying new commercial structures. (Guàrdia et al, 2015)

The development of markets has played a significant role in shaping European cities and economies throughout history. This chapter explores the evolution of European markets, tracing their development from ancient times to the present day. By examining the historical context and key factors that have influenced market growth, the aim is to gain a comprehensive understanding of the transformation and significance of markets in Europe.

1.2.2 Evolution of European Markets

The roots of European markets can be traced back to ancient civilizations, where marketplaces served as central hubs for trade and exchange. The Greeks and Romans (fig 3 and fig 4) established vibrant market systems, fostering economic activities and cultural interactions. Over time, the medieval period witnessed the rise of market towns, where local and international trade thrived, shaping the urban fabric and economic structures. (Dijkman, 2011)
To delve deeper into the historical evolution of markets in Europe, (Wahl, 2016) discusses the significance of historical trade centers in shaping contemporary economic development. The study highlights how cities like Nuremberg, Frankfurt, and Cologne owed their importance to their function as trade centers, emphasizing the enduring impact of medieval trade on urban development.

Fig.3 TTrajan's large markets in Rome, dug on the slopes of Mount Quirinale.
source:
(Guàrdia & Oyón, 2015)

Fig.4 The Fish Market, 1807, painting by Nicholas Condy. The new enclosed Pannier Market in Plymouth
source:
(Guàrdia & Oyón, 2015)

Furthermore, (Kallioinen, 2020) quantitatively demonstrates the integration of European markets starting in the late medieval period, with significant advancements occurring in the 16th century. This research sheds light on the gradual evolution of European markets and the pivotal role played by medieval trade in laying the foundation for modern market structures.

In summary, the establishment of markets in ancient civilizations, the vibrancy of market systems in Greek and Roman times, and the rise of market towns in the medieval period collectively shaped the economic and urban landscape of Europe, laying the groundwork for the markets we see today.

Table1. The Timeline of the open air market in europe
source: (Li & Wang, 2022) adapted by theauthor

Medieval Period (5th to 15th Century) Open-air markets originated as local weekly gatherings regulated by local authorities or feudal lords, serving as key centers for trade and social interaction. They primarily sold agricultural produce, livestock, and handmade goods, with some long-distance trade for luxury items.
Renaissance Period (14th to 17th Century) Markets expanded in size and number, with some specializing in particular goods and becoming hubs for cultural exchange. Increased long-distance trade was facilitated by merchant guilds and improved transportation.
Industrialization (18th - 19th Century) Industrialization introduced mass-produced goods to markets, transforming them alongside traditional handmade items. Rapid urbanization and improved transportation expanded markets and often moved them indoors.
Modernization (20th Century) The rise of supermarkets and retail chains led to a decline in traditional open-air markets, which adapted by focusing on fresh produce and specialty items. Increased regulation and focus on hygiene standards improved the quality and safety of market goods.
Contemporary Trends (21st Century) There has been a resurgence in local and farmers' markets driven by consumer interest in fresh, organic, and locally-sourced produce. Modern markets emphasize sustainability, ethical consumption, and digital integration while serving as cultural and social hubs.

1.2.3 Renaissance and Expansion

The Renaissance period in Europe marked a significant cultural and economic shift, leading to the expansion of open-air markets across the continent. These markets became vibrant hubs of trade and social interaction, embodying the essence of the era. Open-air markets were not just places of commerce but also cultural spaces that brought people together, fostering connections between individuals and local biodiversity (Franco et al., 2020). The natural pricing mechanisms in these markets allowed for efficient allocation of goods, even in challenging conditions, contributing to economic growth (List, 2009).

This economic and cultural dynamism in Europe during the Renaissance era was further fueled by the expansion of international new ventures, which leveraged market competition and entrepreneurial culture to adapt swiftly to new environments (Deng et al., 2018).

Furthermore the location of market squares has also changed over time, from central to peripheral positions. Street markets and commercial arteries have also contributed to the development of urban spaces. The market squares have played an important role in shaping the urban environment, leaving material signs that still impact the character of many cities today. (Coppo, 2006).

1.2.4 Industrialization and Modernization

The advent of industrialization in the 18th and 19th centuries marked a significant transformation in European markets, as documented by various scholars (e.g., Pollard, 2005; Berg, 1994).

The proliferation of factories and the adoption of mass production techniques reshaped economic landscapes, resulting in unprecedented urbanization and demographic shifts (Chandler, 1990). This period witnessed the emergence of modern retailing practices alongside traditional market structures (Thompson, 1989). Department stores and chain retailers began to establish themselves as prominent players in the market scene, catering to evolving consumer demands and preferences (Johnston et al., 2006). Thus, the industrial era not only revolutionized production processes but also profoundly influenced the organization and dynamics of European markets, as evidenced by scholarly research and historical analysis.

In recent decades, there has been a resurgence of interest in traditional and specialized markets across Europe. This revival can be attributed to various factors, including a desire for unique and authentic experiences, a focus on local and sustainable products, and the rise of food tourism. Farmers' markets, flea markets, and artisanal markets have become vibrant spaces that connect producers with consumers and foster community engagement.

1.2.5 Market Challenges and Responses

While European markets have evolved and adapted to changing times, they have also faced challenges. Urbanization, globalization, and the growth of online retailing have posed significant competition to traditional markets.
At a very basic level, the concept of the market is dependent on society. Open-air markets are driven by the social and propelled by the economic. If we only looked at the economic aspects of markets, there would not be much reason to continue this form of distribution. Economically speaking, markets are among the least efficient methods of food distribution and retail (List 2009).
However, market operators and policymakers have responded by implementing innovative strategies, These responses include market modernization, revitalization projects, and the integration of technology. . Understanding the historical evolution and current dynamics of markets provides valuable insights into their role as drivers of economic development, cultural preservation, and community cohesion (Morales, 2011)
From ancient marketplaces to modern specialized markets, these spaces continue to be vital components of urban life, fostering social interactions, supporting local economies, and contributing to the overall vibrancy of communities (Karaman, 2012).

Vending stands have slowly modified their shapes over the centuries as they were adapted to more modern needs for hygiene and for the preservatiorWof the merchandise. However, stands have always kept the same fundamental elements over the centuries. The traditional stand consists of a moveable board mounted on wooden trestles and covered by a simple structure with pieces of canvas. Thus the moveable stores in circulation today take many different shapes yet they all remain almost totally self-sufficient vending structures for the preservation, buying, and selling of perishable food products. Gigi Cappa Bava's sketch that is as ironic as it is nostalgic is meant as a tribute to the eternal banchetto, the eternal stand in its most traditional form (fig. 5). (Guàrdia & Oyón, 2015)

Fig.5 Gigi Cappa Bava's sketch for open airmarkets
source:
(Coppo et al ., 2006)

1.3 Markets in Italy

Since the postwar period, supermarkets have become the dominant venues for provisioning in Italy, and they have played an important part in the creation of consumer society (Humphrey 1998).
Markets in Italy are a vibrant and integral part of the country's cultural and economic landscape. These markets, such as those found in the metropolitan area of Turin, offer a diverse assortment of goods, including traditional products like goat dairy-based items (Massaglia et al., 2019)
Italy's rich heritage markets, like the formal high-end menswear sector, reflect the country's traditional industries (Arrigo & Brun, 2021).
Italy's traditional food markets (fig 7- 10) play a significant role in the consumption habits of Italians, with a focus on products like olive oil and wine (Scheidel & Krausmann, 2011; Cembalo et al., 2014). The presence of these markets not only sustains local traditions but also attracts international attention, as seen in the demand for Sardinian bakery products from Italy and Europe (Baire et al., 2019). Furthermore, Italy's open-air markets serve as platforms for small-scale farmers to sell traditional European varieties, contributing to the preservation of local agricultural practices (Manco et al., 2019).

Renato Guttuso's great painting of Palermo's Vucciria market (fig6) is an unequalled illustration of the richness, color, and sensuality that permeates the market life. The various photographs juxtaposed with it show different types of merchandise from different places and different epochs. These are only meant to emphasize the inexhaustible variety of what is offered in the markets and to show how the vendors have been displaying their products using the wisdom and the skill that their own vending traditions have taught them. They certainly need not consult an expert designer to attract their customers' attention to their products. (Guàrdia & Oyón, 2015)

Fig.6 Renato Guttuso's painting of Palermo's Vucciria market
source:
(Coppo et al ., 2006)

Fig.7 Mercato Centrale, Florence, 1870-1874, ca. 1890. Architect: Giuseppe Mengoni
source:
(Guàrdia & Oyón, 2015)

Fig.9 Fish market on San Teodoro, Rome, 1909
source:
(Guàrdia & Oyón, 2015)

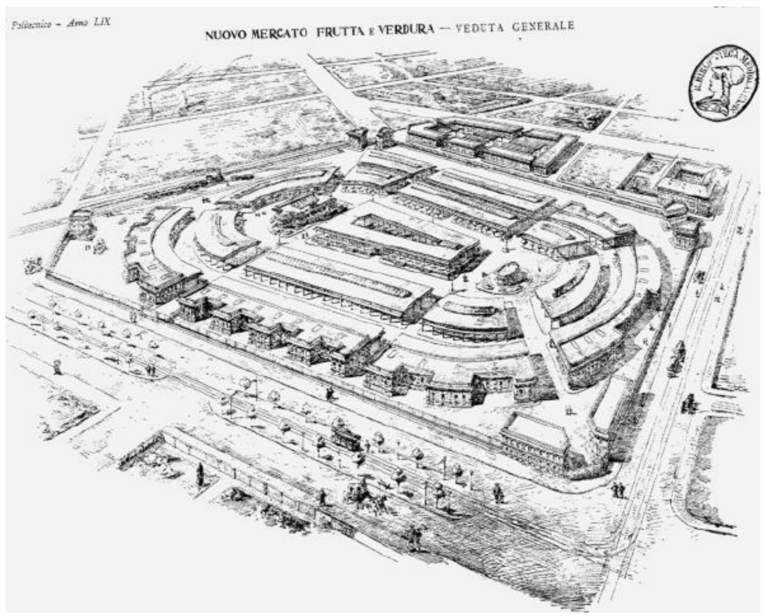
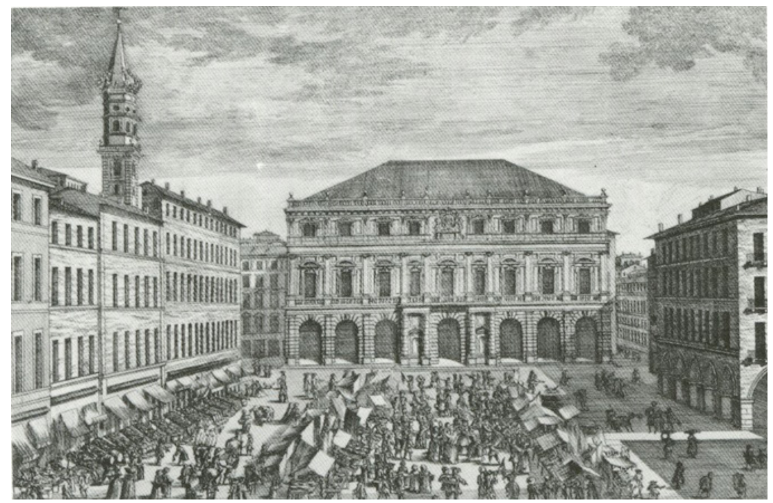


Fig.8 General view of the greengrocery market in Porta Vittoria, Milan
source:
(Guàrdia & Oyón, 2015)

Fig.10 View of Piazza delle Erbe in the engraving by GIAMBATTISTA BORRA, from: Principal views of Torto, 1749
source:ASCT, Simeom Collection, D371



1.3.1 Turin, City of Markets

Turin, a city located in northwestern Italy, is renowned for its rich cultural heritage, historical significance, and architectural marvels. The city boasts a blend of ancient and modern structures that reflect its diverse history and evolution over the centuries. Castex (2008) With a warmer climate compared to northern Europe, Turin offers a unique setting for biodiversity, as evidenced by studies on the breeding dynamics of species like Triturus carnifex in the region (Andreone & Giacoma, 1989).

The evolution of Turin's markets reflects a blend of tradition and innovation, catering to diverse needs while shaping the city's identity (Fregonara et al., 2017). The reorganization of markets in Turin, such as the iconic Porta Palazzo market, highlights the city's adaptability to changing market dynamics and urban landscapes (Barreca et al., 2020).
Turin's markets have been pivotal in shaping the city's narrative, offering insights into urban vibrancy and housing dynamics (Barreca et al., 2017).
The city's market infrastructure, including open-air spaces and covered markets, plays a crucial role in fostering community engagement and economic activities (Taffuri et al., 2021).
Additionally, as illustrated in figure 11, Turin's markets serve as platforms for farmers and small businesses to engage with the community, fostering relationships and supporting local economies.

The markets in Turin also contribute to the city's urban environment, with initiatives like green roofs aimed at mitigating the urban heat island effect and enhancing outdoor thermal comfort (Mutani & Todeschi, 2020).

The market system in a medium-large city like Turin includes wholesale markets for necessities and a distribution network of retail points of sale that covers the entire urban area with an average range of 15-30 minutes on foot. Large commercial outlets also serve as distribution centers for wholesale and retail sales. The displacement of the large fruit and vegetable market in Turin has heavily influenced the balance of individual retail markets in neighboring districts. Markets in Turin are divided into different types, including metropolitan, urban, local, special, and coverage area markets. (Black, 2012)

Figure 11 Piazza delle Erbe, Giovanni Tommaso Borgonio in Theatrum Statuum Regiae. Celsitudinis Sabaudiae Ducis, I, Amstellodami, Blaeu, 1682. ASCT, Collezione Simeom, N.1, tav. 17. Courtesy of the Archivio Storico della Città di Torino.
source:
(Coppo et al ., 2006)

Map1. Boarders around Tax districts, Plans, Markets of Turin. During different years.
illustration by author, based on (Coppo et al ., 2006)

1.3.2 Porta Palazzo

Porta Palazzo is an urban space with a heavy impact on eyes, ears, and nose: the colors of the awnings and produce are dazzling; the vendors cry out trying to capture the attention of potential customers; the smell of freshly baked bread, capers, and anchovies mixes with a subtle undertone of rotting fruit. The sensory experience of the market changes with the seasons as temperatures change along with the goods on sale. Unlike supermarkets, where sensory experience is controlled right down to the smell, open-air markets produce both pleasing and repelling scents, at times simultaneously. (Black, 2012)
Porta Palazzo Market in Turin, Italy,(figure 12) is a bustling hub of activity offering a wide range of commodities such as food products, fabric, clothing, household goods, flowers, and plants. This market serves as an alternative distribution system, providing a unique shopping experience for both locals and visitors. (Bonadonna et al. 2018)
The Porta Palazzo market in Turin, Italy, has two distinct sides or aspects. The first side is characterized by the daily interactions of working-class people who come to the market to buy and sell goods, reflecting the practical, everyday nature of the market. The second side is represented by the weekly Balön flea market, where more affluent people come to browse and purchase items, reflecting a more leisurely and luxurious aspect of the market. (Guàrdia & Oyón, 2015)

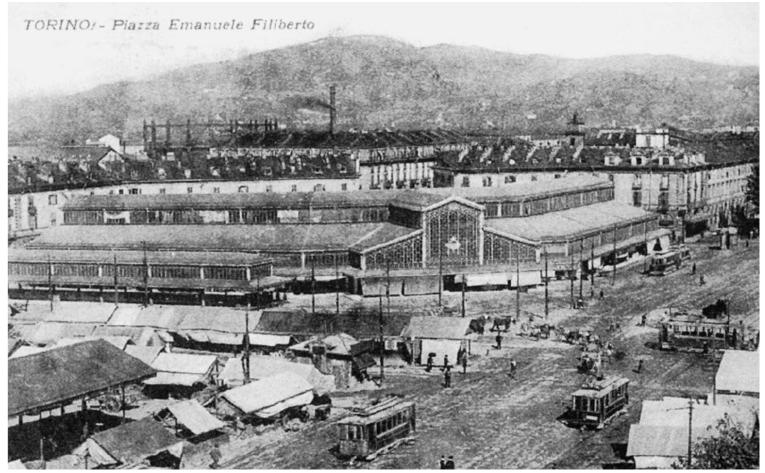
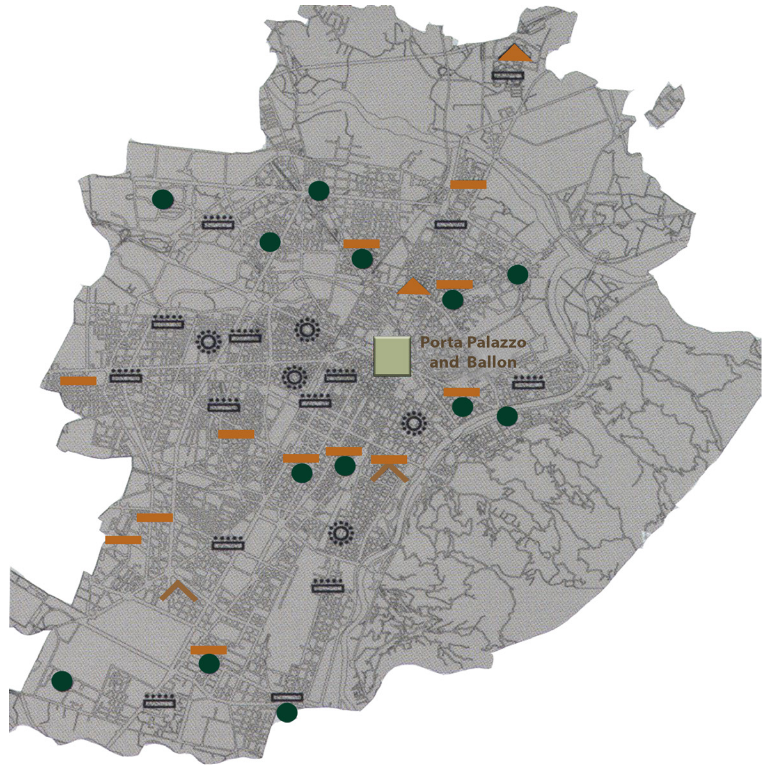


Fig.12 Market on Piazza Emanuele Filiberto (Porta Palazzo), Turin. Postcard, 1919
source:
(Guàrdia & Oyón, 2015)



Map2. Identifying Porta Palazzo and Balôn within the city and their relationship with other markets.
source:
illustration by author, based on (Coppo et al ., 2006)

1.3.2.1 Historical Framework of Porta Palazzo

From a city planning point of view, the history of this area is extremely convoluted, different and heterogeneous.
In examining the historical framework of the Porta Palazzo market in Turin, Italy, it is crucial to consider the market's evolution and significance within the city. The market has been a subject of various studies and projects, such as the RePoPP (The RePoPP project, part of Turin's broader initiative to enhance sustainability, focuses on reducing food waste and promoting circular economy practices within the city's food system. Specifically, the project aims to manage food surpluses in the Porta Palazzo market by collecting unsold food and redistributing it to those in need, as well as converting organic waste into compost. This initiative is aligned with the city's commitment to environmental sustainability and social equity, forming a key component of Turin's urban food policy framework (FUSILLI, 2023)). project, which focuses on circular economy initiatives (Fassio & Minotti, 2019).
This project illustrates how the market has been incorporated into sustainability efforts and circular practices, underscoring its importance in the city's economic and environmental landscape.
The history of Porta Palazzo in Turin traces back to the early 18th century when the city embarked on a comprehensive urban restructuring program. illustrated in the figure13.

During the Napoleonic era, significant changes occurred in urban planning as city walls were dismantled, leading to revisions in the urban layout. The Plan Général d'Embellissements proposed the creation of a grand square at Porta Palazzo, connected to newly constructed peripheral avenues. Gaetano Lombardi's 1819 plan detailed the methods for urban expansion (Collins & Drinkwater, 2016). The dismantling of city walls and the subsequent urban layout revisions highlight the importance of understanding the historical and social contexts of urban development. In the case of Porta Palazzo, the creation of a grand square signifies a deliberate effort to enhance the urban environment and create new focal points within the city (Collins & Drinkwater, 2016).
Such interventions reflect the intersection of politics, architecture, and urban design in shaping the built environment. As Figures 14- 17 illustrate the Porta Palazzo Market both in photos and historical historical 2D plans.

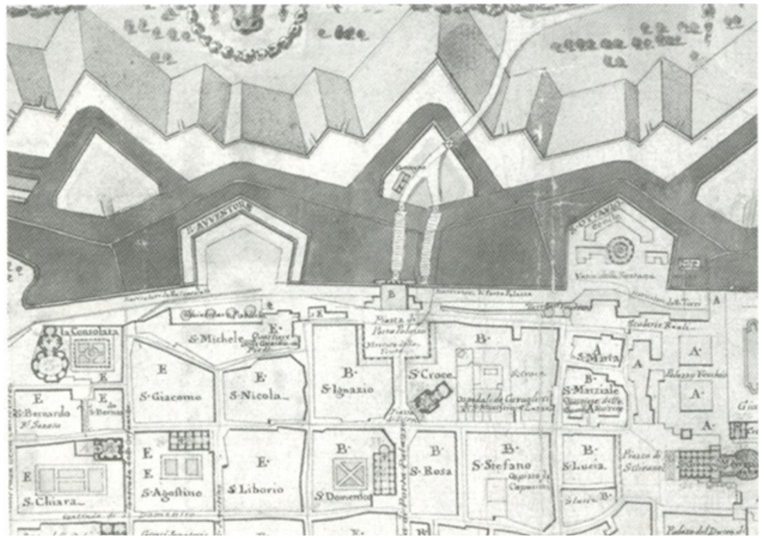


Fig.13 I.A. GALLETTI. Geometric plan of the Royal city and citadel of Torino, with their fortification, 1790 , excerpt (ASCT, Types and drawings, 64-2-13)
source:
(Guàrdia & Oyón, 2015)

Fig.14 17Vintage postcard showing Porta Palazzo in its configuration prior to the thealisation of the «Clock roof», today's food market IV
source: (Coppo et al ., 2006)

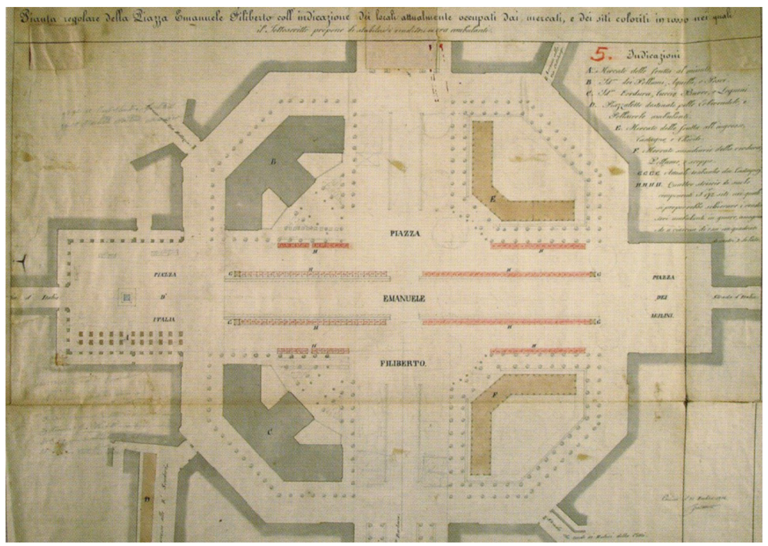


Fig.15 15 G. BARATTINI, Regular plan of Piazza Emanuele Filiberto with indication of the rooms currently occupied by the markets [...], 1854 (ASCT, Types and drawings, 15-5-126/5).
source:
(Coppo et al ., 2006)

Fig.16 Vintage postcard. At the beginning of the twentieth century, the entire square was characterized by numerous canopies. in wood or metal carpentry, for the street vendors market
source:
(Coppo et al ., 2006)

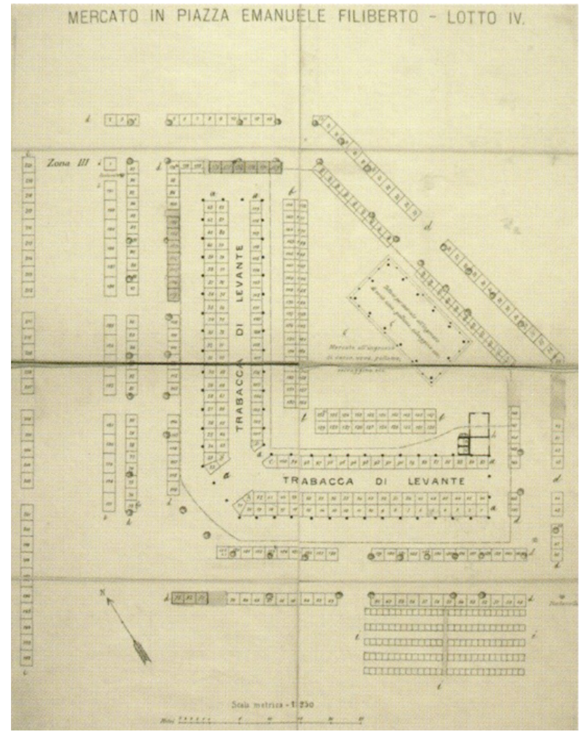


Fig.17 Market in Piazza Emanuele Filiberto, s.d . (ASCT, Collection O XIV, n. 5 lot IV).

source (Coppo et al ., 2006)

Turin, Italy, has a rich historical background as an industrial city, particularly with the establishment of Fiat in the late 19th century, which significantly contributed to its industrial development (Governa & Saccomani, 2009). The industrialization of Turin attracted internal migrants in search of job opportunities, influencing the city's demographic composition (Ugolotti, 2014).

Turin's urban policies have been pivotal in promoting innovation and sustainability, exemplified by experiments with high-performance urban open spaces paving (Mazzotta & Mutani, 2015).

The collaboration between the city's governance coalition and the private sector has been essential in maintaining a consistent urban agenda (Artioli, 2016). Moreover, studies have explored Turin's urban form and building characteristics concerning energy demand and environmental considerations (Mutani et al., 2022).
The city's architectural identity, characterized by the prevalent use of stone materials, reflects its historical heritage and unique urban landscape (Borghi et al., 2016; Borghi et al., 2014). figure 18 and 19 illustrate plan of construction of the piazza.
Research has also focused on Turin's climate, including the urban heat island effect, emphasizing the city's climatic challenges and the significance of sustainable urban planning (Garzena et al., 2018; Mutani & Todeschi, 2020).

In summary, Turin has transitioned from its industrial past to prioritize sustainable urban development, innovation, and the preservation of its architectural and cultural heritage.

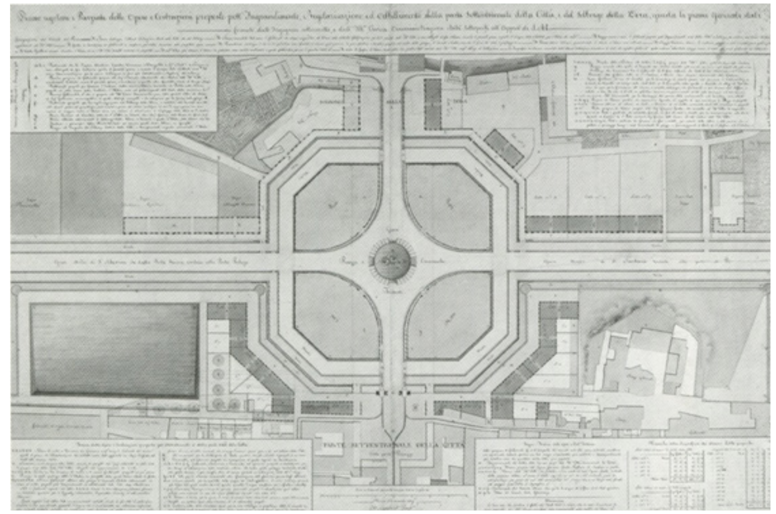


Fig.18 G.LOMBARDI, Regular and Partial Plan of Works and Constructions pro pell Enlargement, Regularization and Beautification of the northern part of the City 1819 (ASCT, Tpi and drawing 29.2 101
source:
(Coppo et al ., 2006)

Fig.19 Porta Palazzo Mercato, circa 1890, photographed by Mario Gabinio, showcases the north-east corner of the fish market.
source:
Alinari Archives, Florence, 1925 - 1935 ca

1.3.2.2 Existing Condition of Porta Palazzo

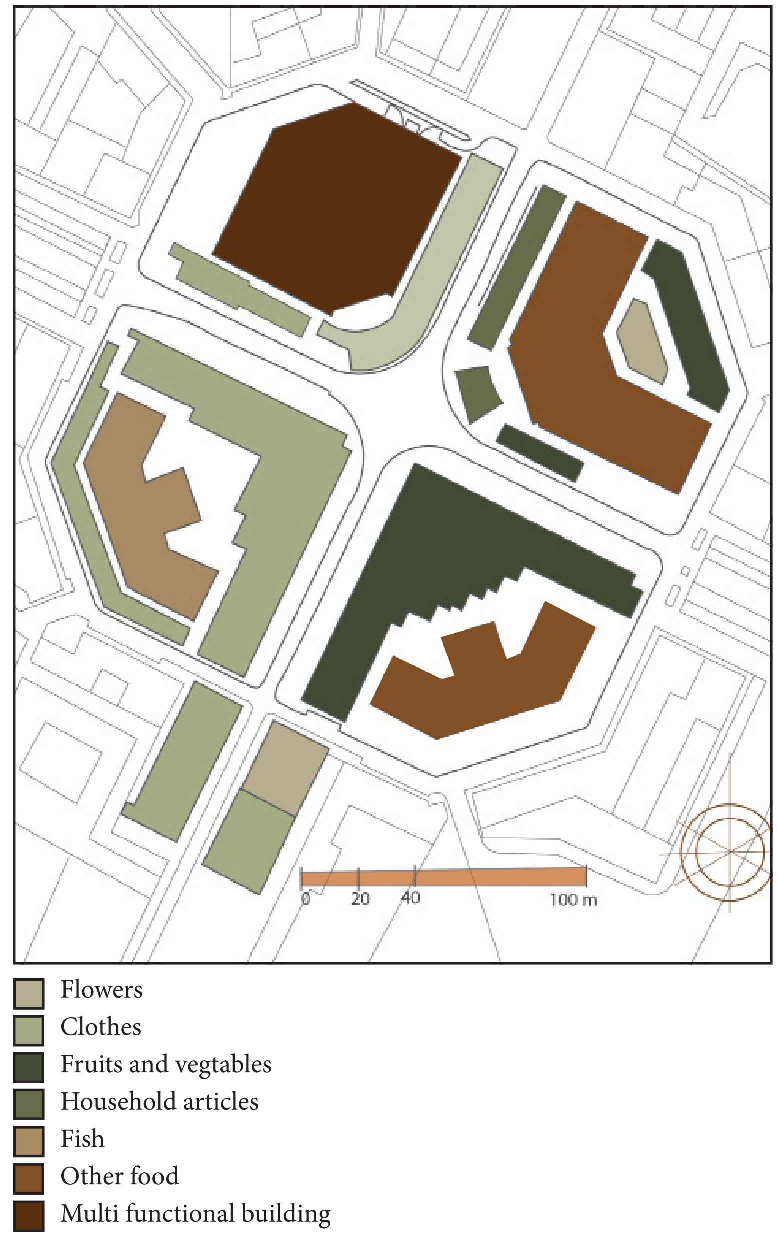
The «economic miracle» and Fiat's rise in the mid-20th century led to another wave of migration, particularly from southern Italy, creating cultural tensions and discrimination against newcomers. Porta Palazzo emerged as a key gateway for migrants, offering a familiar environment where they could find compatriots and traditional foods, eventually influencing Turin's culinary landscape. In recent decades, Porta Palazzo has continued to attract migrants, now primarily non-European, leading to a diverse but often tense community. Despite challenges, the market remains a crucial social and economic hub where food and culture facilitate interaction and integration among diverse groups. (Black, 2012)

Nowadays, Porta Palazzo, is one of the largest open-air markets in Western Europe, covering 51,300 square meters with a significant portion dedicated to commercial activities (Vanolo, 2021). The market hosts numerous vendors, including 756 licensed mobile vendors on average weekdays and 796 on Saturdays, offering a diverse range of products from nonfood items to fresh produce (Vanolo, 2021). Operating from early morning to early afternoon on weekdays and extending its hours until 6 p.m. on Saturdays, the market attracts approximately 100,000 visitors weekly. (Vanolo, 2021)

The market's layout (figuere 20) divided into quadrants by via Milano and corso Giulio Cesare, enhances efficiency, aids in management, and allows visitors to navigate specific areas with ease (Vanolo, 2021).The northern quadrant notably features the iconic «Palafuksas» pavilion, symbolizing the market's blend of tradition and modernity (Vanolo, 2021). Beyond commerce, Porta Palazzo acts as a frontier space for the ongoing gentrification of central and northern Turin (Bourlessas et al., 2021). It serves as a cultural hub, reflecting the city's heritage while embracing innovation and sustainability in its operations (Fassio & Minotti, 2019).

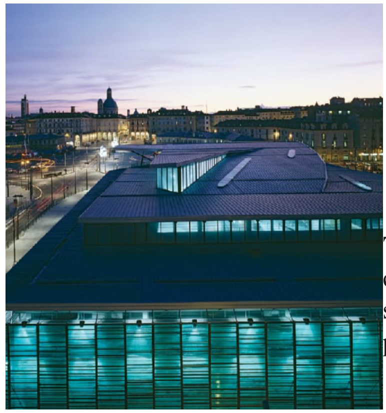
Fig.20 Aerial view of the Porta Palazzo market circa 1998. Photo by Giovanni Fontana.
source:
Progetto the Gate; Port a Palazzo

Porta Palazzo, showcases a distinctive blend of the built environment, urban planning, and microclimate considerations. The market's physical attributes, including its layout and design, significantly influence the interactions within the space. Previous studies have emphasized that analyzing the urban street network can offer valuable insights into the efficiency and functionality of the market area (Porta et al., 2006).
The division of the market into quadrants not only improves operational efficiency but also impacts visitor flow and experience, reflecting principles of sustainable urban forms and design concepts (Jabareen, 2006).
Furthermore, the market's location in Piazza della Repubblica contributes to its dynamic nature, continually shaped by social and economic activities. Understanding how the physical built environment attributes affect activities within the market, such as walking and cycling levels, as discussed in the literature, can provide valuable insights (Wang et al., 2016).
Additionally, given the market's significance as a cultural hub and a space for diverse economic activities,as illustrated in figure19, it is crucial to evaluate the current conditions in terms of urban planning to ensure sustainable development and address concerns related to accessibility, safety, and functionality (Jackson, 2019; Yazar & Dede, 2012).
By examining both the historical and contemporary aspects of Porta Palazzo, encompassing its built environment, urban planning strategies, and microclimate considerations, a comprehensive understanding of this lively market space can be attained, facilitating well-informed interventions and future developments.
figure 22 illustrqtes the important buildings in the porta palazzo area.

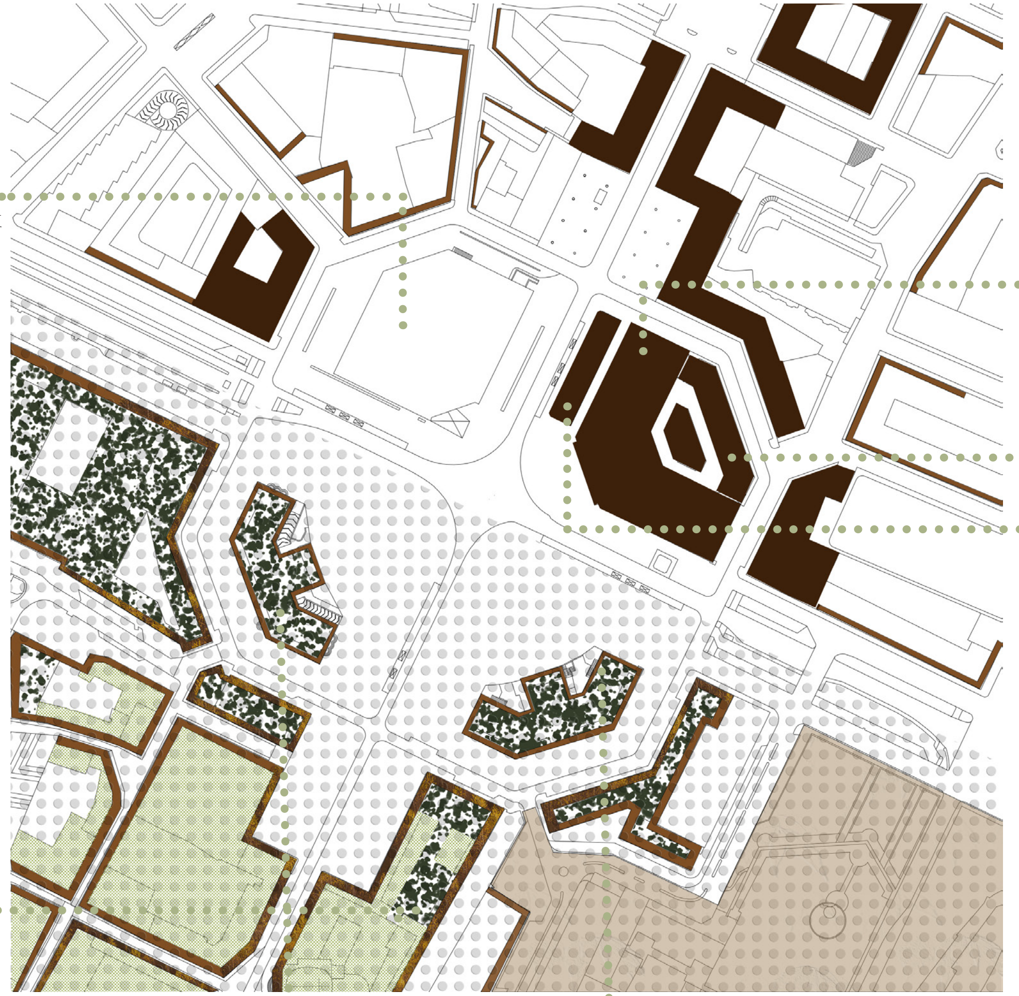


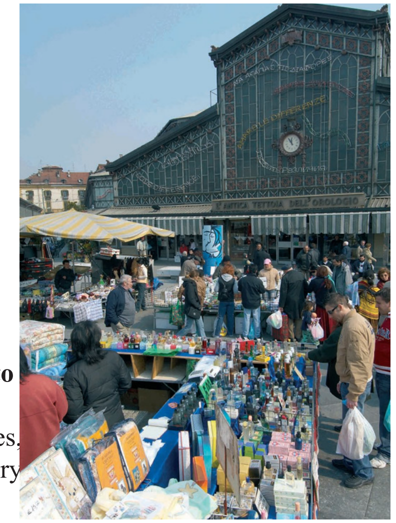
map3 Schematic Plan of Porta Palazzo area with indication of the product sales sectors.
Illustrated by the author

Fig.21 Highlghted areas protected by restriction
source: illustration by author, based on (Coppo et al ., 2006)

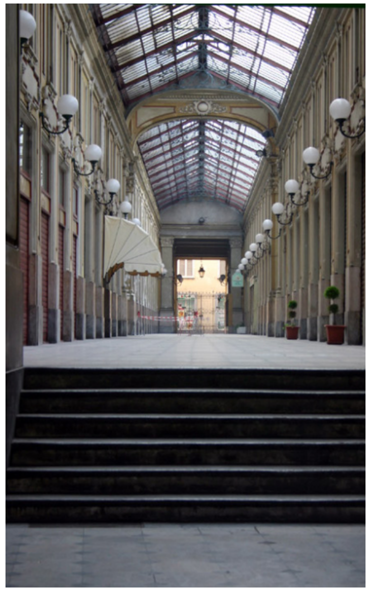


Turin Central Market/ PalaFuksas
clothing, food. also artistic projects, scientific themed meetings, book presentations, cultural workshops





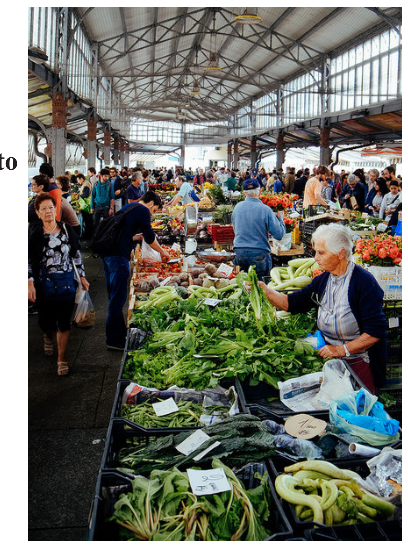
Food Market IV/ Mercato dell'Orologio
meat, cured meats, cheeses, fresh pasta, bakery, pastry shop, seeds, animal food



Galleria Umberto I

Fish Market/Mercato ittico

V Food Market/ Mercatto alimentari V
meat, cured meats, cheeses, fresh pasta, bakery, seeds, food for animals



Farmers' Market/ Mercato dei produttori diretti
Fresh product from farms

- Building of Historical Interest:
- Central urban zone of historical interest
- Building from 19th-century city expansion
- Fronts with high prestige
- Fronts that characterize the urban setting
- The Porta Palatine area
- Urban heritage

1.4 Scientific Background

1.4.1 Microclimate

Microclimate, a term referring to the localized climate conditions within a specific area, is influenced by a variety of factors such as topography, vegetation, and human activities (Taleghani et al. 2015). This micro-scale climate encompasses parameters like temperature, humidity, wind speed, and solar radiation, collectively shaping the environmental conditions experienced within that area (Shamshiri et al., 2018). At this scale, referring to an area of up to one kilometre (Oke, 1987), Individual structures and trees play a crucial role in influencing climate conditions by providing shade, reflecting sunlight, and altering wind flow, which directly impacts people's thermal comfort and the energy efficiency of nearby buildings Carlucci et al. (2018). Urban design plays a significant role in shaping microclimate and thermal comfort outdoors, emphasizing the need for better urban spaces in harmony with microclimate conditions (Chondrogianni & Stephanedes, 2022). Landscape design can impact urban microclimate and thermal comfort, modifying elements like wind, radiation, air temperature, and humidity at the neighborhood or community scale (Wang et al., 2018). The influence of street geometry factors on urban microclimate highlights the necessity of incorporating microclimate knowledge into planning strategies to mitigate negative climatic impacts (Shafaghat et al., 2016).

Microclimate conditions in an urban area impact two main categories: the activities and comfort of people, and the energy performance of buildings, particularly regarding energy conservation. In order to create more comfortable and usable environments for humans, the planners must take into account the microclimatic conditions of the urban space throughout time. Understanding and managing microclimatic conditions in healthcare facilities, workplaces, and residential areas are essential for promoting human comfort and well-being (Zeevi et al., 2017).
Figure 22 illustrates the sub-branch of urban planning in urban climatology studies

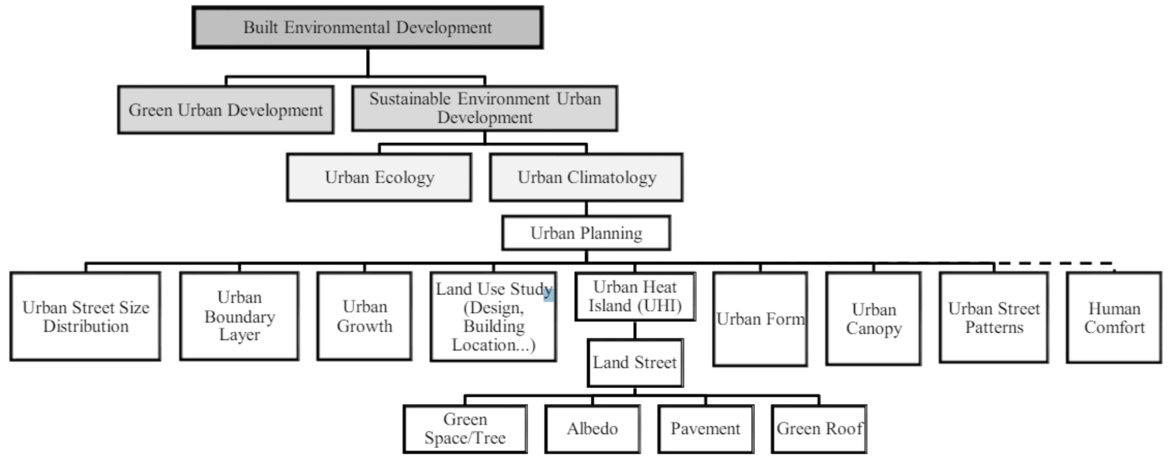


Fig.22 Branch of urban planning in taxonomy of urban climatology studies sectors.
(Shafaghat et al., 2016)

1.4.1.1 Factors Influencing Microclimate

1.Urban Form and Density:
The layout, density, and arrangement of buildings in urban areas impact microclimate conditions, influencing factors such as temperature differentials and air circulation (Chen et al. 2010,Yahia et al., 2017).

2.Urban canyons:
The idealized urban canyon is symmetric, with two long, uniform blocks with flat roofs flanking both sides of the road(figure 24),
Research studies have shown that in deep urban canyons with aspect ratios higher than two (H/W > 2), there may be a lack of coupling between undisturbed airflow above the buildings and flow within the canyon, leading to the development of local airflow phenomena such as double vortices or upward and downward thermal flows along the canyon facades (Giannopoulou et al. 2010).
As iluustrated in figure 23, key features characterizing an urban canyon's impact on micro-climate are geometry, surface properties, and vegetation.
For two-dimensional street canyons, the aspect ratio is considered the most important parameter in defining the flow regime and pollutant dispersion, with higher aspect ratios influencing the velocity field and pollutant dispersion within the canyon (Ibrahim et al., 2023)

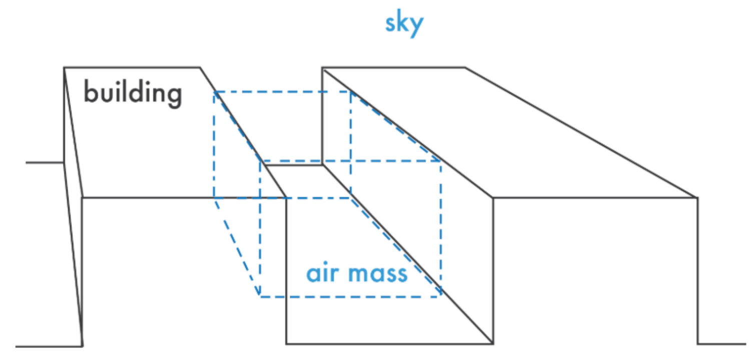


Fig.23 Conceptual diagram illustrating the idealized, or 'regular' urban canyon source:
(Boeters et al., 2012)

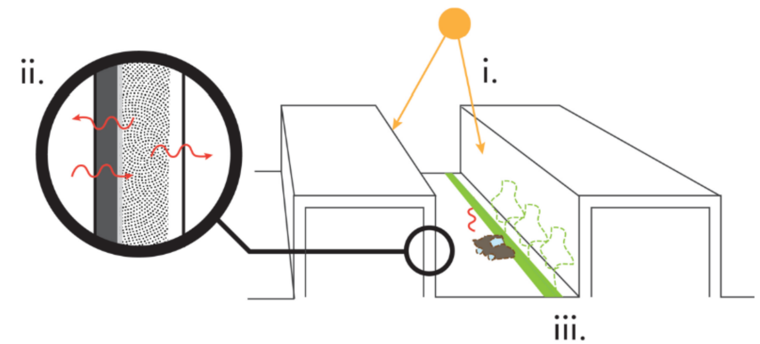


Fig.24 Three overarching features to characterize an urban canyon (i) canyon geometry, (ii) surface properties, (iii) street vegetation and furniture causing mechanical turbulence
Source:
(Boeters et al., 2012)

The sky view factor (SVF):
measures the ratio of visible sky from a specific point to the unobstructed sky dome, plays a significant role in regulating air temperature differences in urban areas . (Chen et al, 2010). The SVF is commonly used to indicate the influence of urban geometry on air temperature differentials, With higher SVF values associated with increased solar radiation exposure and potentially reduced thermal comfort in urban canyons (Li et al., 2021). The SVF has been suggested to have implications on urban heat island effects, daylight availability, and solar radiation exchange.
Figure 25 illustrated the concept and the way of photographing SVF.

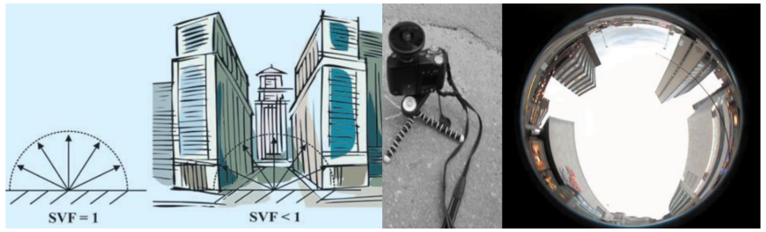


Figure25 Sky-View-Factor Profile ; a typical fish eye photograph
source:
(Gopinath, Singh, et al., 2014)

Cardinal direction:
Studies have highlighted the importance of canyon orientation, such as north-south or east-west orientations, (Figure 26) in impacting factors like air temperature differentials, solar radiation exposure, and thermal comfort in urban environments (Hu et al. 2020). The orientation of urban canyons can affect the distribution of shadows, solar radiation, and airflow patterns, ultimately influencing the thermal conditions experienced within these urban spaces (De & Mukherjee, 2017).
Understanding and optimizing the orientation of urban canyons can lead to improved thermal comfort, reduced energy consumption, and enhanced overall urban microclimate conditions (Grajeda-Rosado et al., 2022).

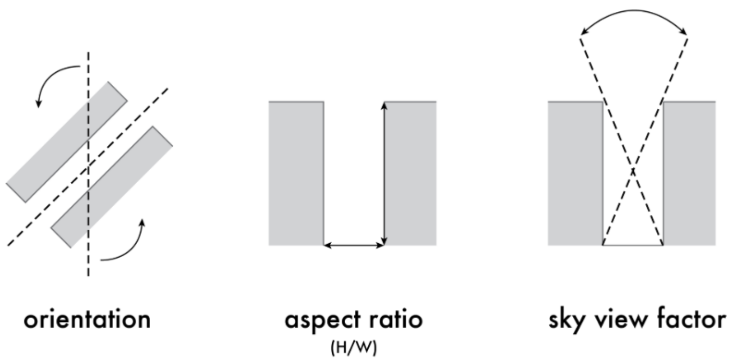


Figure26 The geometry of an urban canyon can be described by orientation, aspect ratio and sky view factor
source:
(Boeters et al., 2012)

Landscape Design:
The integration of green infrastructure, vegetation, and water bodies in urban design plays a crucial role in shaping microclimate conditions, affecting thermal comfort and environmental quality (Lin & Brown, 2021; Wang et al., 2018).

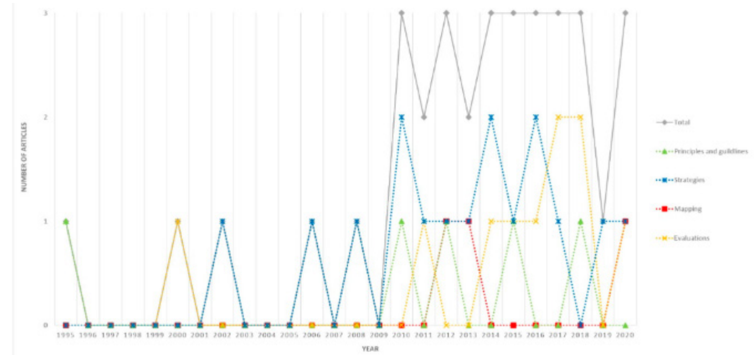


Figure27 Annual number of publications on the way that applying microclimate to landscape architecture from 1995 to 2020.
source:
(Lin et al 2021; Wang et al., 2018).

3. Urban Heat Island Effect:
The urban heat island (UHI) effect is a well-documented phenomenon characterized by significantly higher temperatures in urban areas compared to their rural surroundings (Mohamed, 2024). (figure28) This disparity in temperature is primarily attributed to factors such as increased impervious surfaces, reduced vegetation cover, and heightened anthropogenic heat generation due to urbanization (Mohamed, 2024). As urban areas become more developed, the urban heat island effect intensifies, leading to additional hot days, heat waves, and adverse impacts on human health (Tan et al., 2009).
The phenomenon is exacerbated by the lack of green spaces, high building density, and the heat-retaining capacity of urban surface materials (Sun et al., 2019).

Most urban surfaces are impervious and lack moisture, causing them to heat up. Dark materials like asphalt absorb and release heat, raising temperatures and increasing the urban heat island effect. Multiple studies have shown that the presence of vegetation has negative impact on the intensity of UHI (Erell et al., 2011).

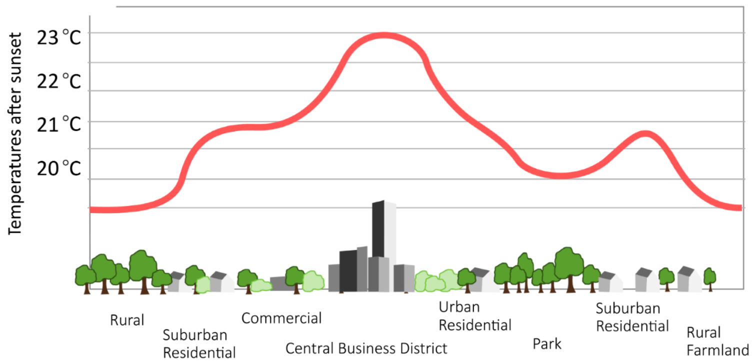


Figure28 The urban heat island effect is greatest in the Central Business District. Local features such as parks can have a big effect.
source:
https://www.metlink.org/fieldwork-resource/urban-heat-island-introduction/

UHI is caused by a combination of heat generation (by anthropogenic sources), heat retention (by increased surface area of materials with low albedo and high heat storage capacity, reduced sky views, lower latent heat flux due to reduced vegetation, and reduced turbulent heat transport), and heat entrapment (Boeters et al., 2012) (Fig29)

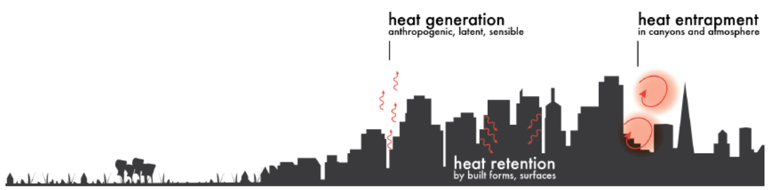


Figure29
Overview of UHI causes
source:
(Boeters et al., 2012)

1.4.1.2. Thermal Comfort and Outdoor Spaces

Thermal preferences could be described as a combination of physical factors which influence thermal sensation (air temperature, humidity, air movement, radiation, clothing and activity) that a person would choose in a specific physical environment when restricted by climate and existing physical, social, cultural and economic influences (Erell et al., 2011).
Designing outdoor spaces for thermal comfort, considering factors like solar exposure, wind patterns, and green infrastructure, is key to creating sustainable and user-friendly urban environments (Tapias & Schmitt, 2014).
Thermal comfort can be measured with different indices:

PET: Various studies have emphasized the significance of utilizing indicators like the Physiologically Equivalent Temperature (PET) to effectively assess outdoor thermal comfort (Rinchumphu et al., 2021; -Hartabela et al., 2021). PET takes into account factors such as mean radiant temperature, clothing, and metabolic rates of individuals to offer a comprehensive evaluation of thermal comfort (Johansson et al., 2017) It has been incorporated into new assessment tools like the Street Walkability and Thermal Comfort Index (SWTCI) to evaluate street design and walkability based on thermal comfort considerations (Sayad et al., 2021).

PPD and **PMV:** The Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) are widely recognized indices used to assess thermal comfort levels (Cheung et al, 2019 -Zhou et al., 2019). The PMV index quantifies the mean thermal sensation of a group of individuals, while the PPD index indicates the percentage of individuals likely to feel dissatisfied with the thermal conditions (Alam & Salve, 2021).

UTCI: Based on a research by Peri (2023) The Universal Thermal Climate Index, is known for its versatility, allowing for precise assessments across different spatial and temporal scales. Studies have emphasized the effectiveness of UTCI in assessing thermal comfort in urban street canyons during hot summer days and nights, highlighting its significance as a primary indicator in such evaluations (Liu, 2024).

SET: The Standard Effective Temperature (SET*) is a crucial factor in evaluating thermal comfort in outdoor and semi-outdoor environments. Based on a Research by Zhou et al. (2013) that the outdoor SET* can vary depending on climatic conditions, with values like 26.2°C identified as indicative of thermal neutrality in humid subtropical climates. Factors such as water bodies can impact the thermal environment and comfort in both indoor and outdoor spaces, influencing the calculation of SET (Reza et al., 2021).

WBGT: is an internationally recognized heat index extensively used across various sectors to assess thermal comfort in challenging environmental conditions (Liu, 2024).

WBGT serves as a thermophysiological index to explore the influence of thermal conditions on people’s perceptions and adaptive behaviors in outdoor urban spaces, highlighting its role in understanding thermal comfort dynamics (Lin et al., 2013). The application of the WBGT model has been valuable in identifying days when outdoor activities should be limited to protect individuals’ health and comfort, particularly in heat-stress-prone environments (Đurić et al., 2022). Studies have shown that shade and airflow can reduce WBGT levels, thereby enhancing labor capacities and reducing heat injury risks in warm to hot climates (Hall & Horta, 2023)

1.4.1.3 Microclimate Mitigation and Adaptation

Mitigation approach means addressing the causes of climate change, with the aim of reducing the greenhouse gas emissions into the atmosphere through prevention and decarbonisation. In the urban areas this mainly refers to the improvement of buildings' energy efficiency, reduction of demand peaks, the use of alternative energy resources, urban densification and implementation of greenery (Pollo and Trane, 2021). (figure29)

Strategies that focus on bioclimatic urban planning can enhance urban resilience and create spaces that promote social interaction while considering microclimate factors (Chondrogianni & Stephanedes, 2022). Urban shading, as studied in Colombo, Sri Lanka, using tools like ENVI-met, demonstrates the influence of different urban design options on air and surface temperatures, as well as outdoor thermal comfort (Emmanuel et al., 2007).

Mitigation policies require short and long term investments and global political agreements (Goklany, 2007). Their effects are visible mostly in the medium-long term and on a national or global scale (Klein et al., 2007).

Microclimate adaptation involves implementing strategies to modify local environmental conditions to enhance resilience and comfort in the face of climate change, such as through the use of vegetation, water features, shading structures, and reflective materials. It means making the built environment resilient to the inevitable events (Pollo and Trane, 2021) and improving the living conditions of people and ecosystems in the current scenario of global warming (Pollo et al., 2020).

Mitigation involves reducing greenhouse gas emissions, while adaptation involves adjusting to minimize climate impacts. Traditionally, mitigation is long-term and global, The effect of the adaptation measures is immediately noticeable (Pollo and Trane, 2021).

However, urban challenges like the Urban Heat Island effect show that many adaptive measures also mitigate climate change. This evolving approach, known as the «mitigation-adaptation lens,» emphasizes that strategies can achieve both goals simultaneously. Improving urban microclimates, for instance, can help cities adapt to and mitigate climate change effects.

There is a profound correlation between climate change mitigation, climate adaptation and microclimate quality (Trane et al., 2021).

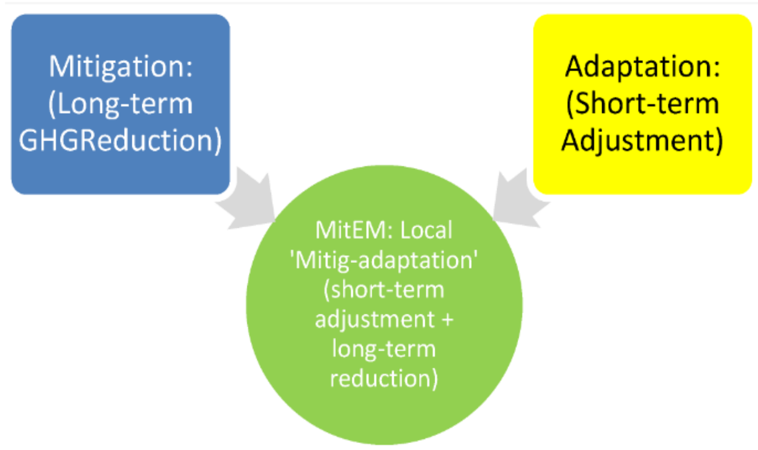


Fig.30 Proposed approach as intersection between mitigation and adaptation. source: (Schiano-Phan et al., 2015).

1.4.1.3 1 Microclimate Mitigation and Adaptation Strategies

To address microclimate mitigation and adaptation strategies, several studies like (Salata et al, 2015) have explored innovative approaches to enhance urban environments and reduce the impact of climate change-related phenomena. Figure 31 presented different urban microclimate mitigation strategies through a PMV analysis, emphasizing the importance of studying and examining mitigation strategies for microclimates. (Berardi et al, 2023) investigated the effect of a denser city on the urban microclimate, highlighting the need to propose strategies to mitigate potential Urban Heat Island (UHI) effects. . (Balany et al, 2020)

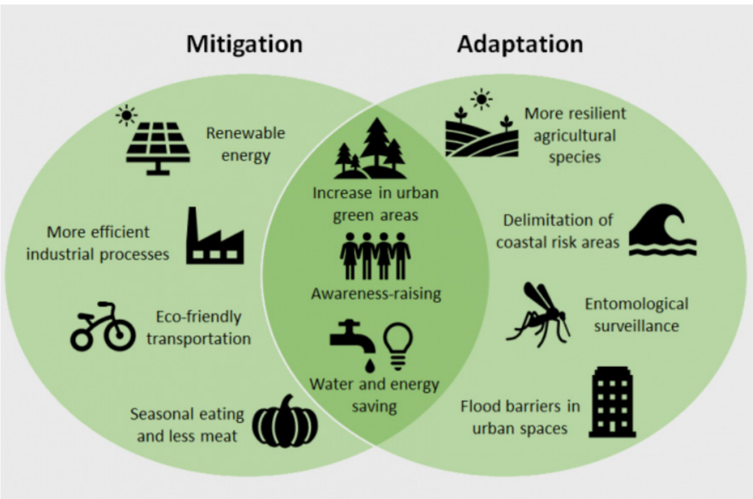


Fig.31 Proposed approach as intersection between mitigation and adaptation. source: https://www.algarveadapta.pt/en/adaptation-or-mitigation/).

1.4.1.3.1.1. Blue- Green Infrastructures

Green infrastructure, including blue-green infrastructure (BGI) and green roofs, plays a crucial role in mitigating and adapting to microclimate changes. Studies have shown that green infrastructure can significantly impact microclimates by regulating temperatures and enhancing human thermal comfort (Balany et al., 2022; Scharf & Kraus, 2019; Cao et al., 2022). For instance, the strategic planning of blue-green infrastructure networks can deliver various ecosystem services, including microclimate regulation (Balany et al., 2022). Additionally, green roofs have been identified as a feasible design strategy for ameliorating microclimates and conserving energy in urban areas (Peng & Jim, 2013).

The effectiveness of green infrastructure in regulating microclimates is influenced by various factors such as plant types, planting configurations, and the ratio of water bodies to green spaces (He & Reith, 2023; Dan et al., 2020; Xu, 2024). Research has indicated that vegetation can reduce wind speed and the change rate of mean radiant temperature, contributing to improved thermal comfort (He & Reith, 2023). Moreover, the microclimate regulation capacity of green infrastructure varies based on planting configurations, with group planting showing higher effectiveness compared to linear or individual planting (Dan et al., 2020).

In urban settings, green infrastructure not only helps in microclimate regulation but also plays a significant role in reducing the urban heat island effect (Balany et al., 2020; Privitera & Rosa, 2018). By providing ecosystem services and regulating microclimates, green infrastructure contributes to mitigating the adverse effects of climate change and enhancing urban sustainability (Privitera & Rosa, 2018). Additionally, the presence of green infrastructure can enhance the microclimate by reducing solar irradiance and replacing dark-colored pavements with reflective surfaces (Elbardisy et al., 2021).
Urban greenery acts to modify shade provision,as shown in figure 32, evapotranspiration and albedo. The combination of these three mechanisms reduces sensible heat gain, thereby, lowering heat gain and surface temperatures. Red boxes indicate warming mechanisms and blue boxes indicate cooling mechanisms. (Wong et al., 2021)

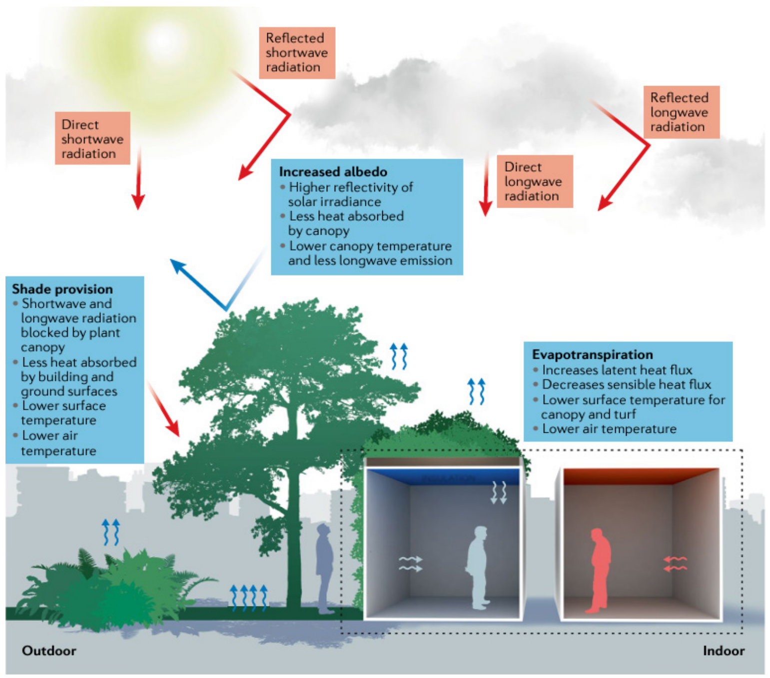


Fig.32 Greenery-related cooling mechanisms in the urban environment
source:
(Wong et al., 2021)

1.4.1.3.1.2. Cool Materials

Cool materials, such as high albedo surfaces and materials characterized by high solar reflectance and emissivity, play a significant role in mitigating the urban heat island effect and reducing indoor temperatures, consequently decreasing cooling loads in warm weather (Alnajaret al. ,2022) Stone et al., 2014; Epstein et al., 2017). The application of cool materials on both buildings and ground has been shown to generate a more pronounced mitigation effect, resulting in a substantial reduction in air and surface temperatures (Zeeshan & Ali, 2022). Cool roofs, which have increased solar reflectance, can lower ambient air temperatures in cities during summer, slowing ozone formation and increasing human comfort (Epstein et al., 2017; Zhang et al., 2016). Additionally, the use of reflective and permeable pavements as cool materials can contribute to improving the urban microclimate by reducing surface temperatures (Ferrari et al., 2019.).
Furthermore, cool materials, when combined with other strategies like shading and greenery, can lead to a holistic approach to local climate mitigation, reducing peak ambient temperatures and total annual cooling loads (Haddad et al., 2020). The use of cool colored concrete tile and asphalt shingle roofing products has been identified as an effective way to save energy, mitigate urban heat islands, and cool urban surfaces (Levinson et al., 2010). Moreover, the design of smart wetting of building materials for evaporative cooling during heat waves can help improve the urban climate (Ferrari et al., 2020).

1.4.1.3.1.3. Solar Access and Airflow

The presence of solar radiation and efficient airflow can significantly influence the thermal comfort and energy efficiency of buildings. Research has indicated that solar radiation and wind effects are vital considerations in effective bioclimatic design applications in urban areas . (Stavrakakis et al, l2012). The orientation of urban canyons and the solar radiation direction can impact microclimates and thermal comfort, underscoring the significance of solar access in urban planning (Yola & Siong, 2018).

In the realm of microclimate mitigation, the utilization of cool materials and strategic vegetation placement can enhance the solar reflectance and thermal emittance of urban surfaces, aiding in reducing urban heat island effects (Pisello et al., 2018; Torchia, 2021). Moreover, positioning trees strategically as windbreaks can help moderate temperatures and enhance energy conservation by obstructing cold winter or warm summer air (Torchia, 2021).
The design of streets that are straight and parallel to each other is highly beneficial for promoting airflow into and within urban areas. This layout enhances air movement, which plays a crucial role in mitigating the microclimate effects often experienced in densely built environments. By allowing for better ventilation, this street design helps to disperse heat, reduce air pollution, and improve overall air quality. (figure 33 and 34)

Furthermore, the assessment of various urban microclimate mitigation strategies through numerical simulations hasbeen carried out to evaluate the impact of factors such as vegetation and albedo on microclimatic variables (Salata et al., 2015). These simulations offer valuable insights into the efficacy of different strategies in managing microclimates and enhancing thermal comfort. Additionally, optimizing microclimate control systems for air-conditioned environments underscores the importance of adjustable airflow rates and inlet temperatures in maintaining comfortable indoor settings (Genco et al., 2017).

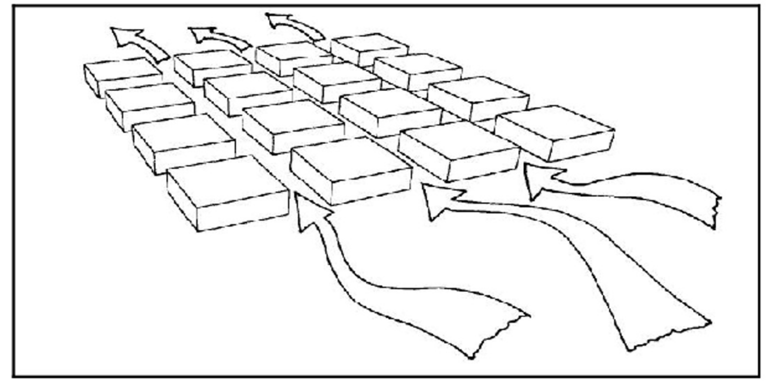


Fig.33 Straight and parallel streets improve airflow into and within a city
source:
(Shishegar, 2013).

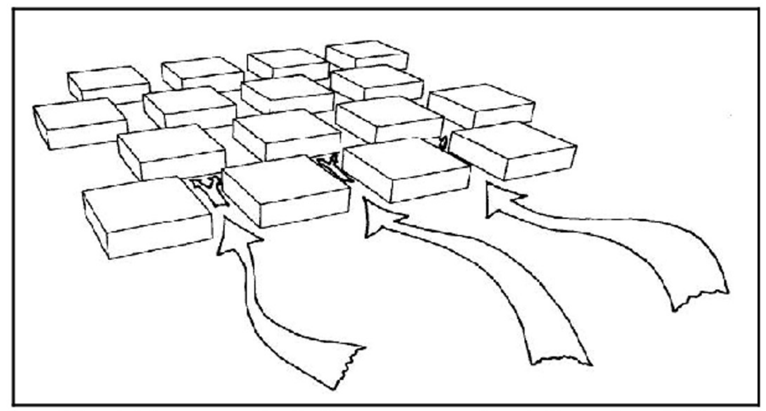


Fig.34 Narrow and winding streets make airflow slow
source:
(Shishegar, 2013)

1.4.1.4 Overview of Climate Analysis

To comprehend and analyze microclimates, various methods such as field measurements, observations, and climate modeling are utilized. Field measurements are crucial for acquiring real data on microclimate parameters to calibrate microclimate-modeling software like ENVI-met (Wang et al, 2018). Observations from weather stations with high spatial resolution are vital for accurately representing microclimatic conditions relevant for ecosystem functions (Aalto et al., 2021).

Climate modeling, which includes simulations integrating urban vegetation, is essential for mitigating climate change by predicting temperature and other meteorological variables at scales pertinent to individual organisms (Xu et al., 2022; Klinges et al., 2022).

Continuous microclimate monitoring in rural, suburban, and urban areas allows for a comparative analysis of different boundary conditions, aiding in assessing the impact of local microclimate on building energy performance (Pisello et al., 2015). Strategies that integrate outdoor microclimate boundary conditions can lead to more livable cities and reduced cooling energy consumption in buildings (Piselli et al., 2020).

1.4.1.4.1 Envi- met

ENVI-met, developed by Michael Bruse and Helge Fleer, is a sophisticated 3D simulation software widely used for modeling microclimatic conditions in outdoor urban and rural spaces. This software can replicate the physical and microclimatic behavior of various environments based on climatic parameters, vegetation cover, surface characteristics, soil properties, and the built environment (Chiri et al., 2020; Berardi & Wang, 2016; Chatzinikolaou et al., 2018).

ENVI-met serves as a valuable tool for assessing the microclimatic behavior of design concepts, evaluating outdoor comfort, and analyzing the impact of changes in urban design on microclimates under different conditions (Chiri et al., 2020; Badache & Alkama, 2021). It enables detailed calculations of parameters affecting the urban thermal environment, such as shortwave and longwave radiation fluxes, shading effects, and heat exchange between building systems, vegetation, and the atmosphere (Berardi & Wang, 2016).

Researchers utilize ENVI-met for microclimatic modeling to predict temperature, wind flow, turbulence, radiative fluxes, humidity, and other meteorological variables at scales relevant to individual organisms and urban settings (Nasrollahi et al., 2017). The software’s ability to simulate the temporal evolution of thermodynamic parameters on a micro-scale range allows for the creation of 3D models that capture the complex interactions between buildings, vegetation, and the atmosphere (Chatzinikolaou et al., 2018).

2. BEST PRACTICE

2.1 Case Studies

2.1.1 Research Oriented Case Studies

2.1.1.1 Mobility Layout in Turin, Italy

2.1.1.2 Microclimate Improvement of an Italian Industrial Distrctct

2.1.1.3 Redevelopment of public space in Granada,Spain

2.1.2 Design Case Studies

2.1.2.1 Skanderbeg Square

2.1.2.2 Albert Cuyp Market

2.1 CASE STUDIES

During the process of gathering the scientific foundation for this thesis, numerous studies and projects focused on the adaptation and mitigation of microclimate, as well as strategies for designing healthier built environments, have been reviewed. Some of these studies are presented as examples to support the scientific background and enhance understanding of the thesis's scope. This chapter will showcase selected prior studies that align with the objectives and perspectives of this thesis. The first section covers research-oriented case studies aimed at understanding the interactions between urban elements and microclimate. The second section highlights built projects in open-air markets, emphasizing applicable sustainability strategies.

2.1.1 Research Case Studies

2.1.1.1 Mobility Layout in Turin, Italy

Research paper: On the Role of Urban Mobility Layout against Urban Microclimate. The Case Study of Turin, Italy
Authors: Anja Pejovic , Matteo Trane * , Matteo Giovanardi , Riccardo Pollo
Posted Date: Published as a preprint on Preprints.org on June 21, 2023

The study investigates the impact of urban mobility layouts on the urban microclimate in Turin, Italy.with a specific focus on mitigating the Urban Heat Island (UHI) effect.
The authors highlight that rapid urbanization and car-centered mobility exacerbate UHI through the reduction of vegetated areas and the increase of impermeable surfaces
The researchers utilized Computational Fluid Dynamics (CFD) models and ENVI-met simulations to analyze six clusters of boulevards with minor lateral roads («controviali») , (figure 34), in Turin.
The study identifies three main strategies for UHI mitigation: increasing vegetation, changing surface materials, and modifying urban morphology.

The data revealed that clusters with a higher emphasis on soft mobility—pedestrian and bicycle-friendly infrastructures—demonstrated significant improvements in microclimatic conditions.

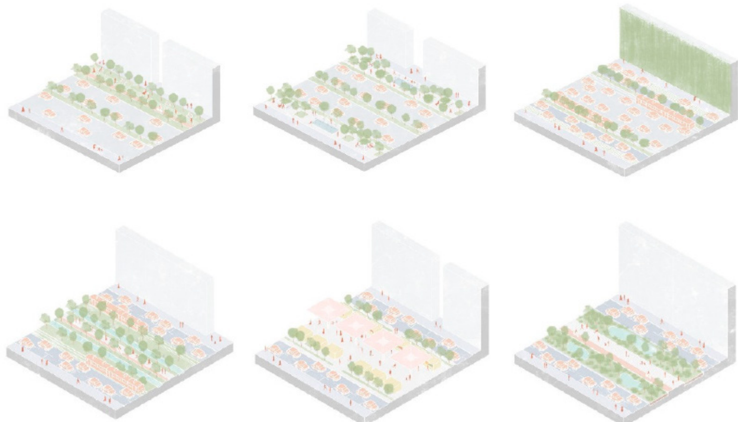


Fig.35 Controviali type of sections and identification. Authors' elaboration.
source:
(Pejovic et al, 2023)

The strategies are focused on:

1. Increasing Vegetation:
Tree Planting
Green Walls and Roofs
Urban Green Spaces

2. Changing Surface Materials:
High-Albedo Materials
Permeable Surfaces
Cool Pavements

3. Modifying Urban Morphology
Pedestrian Zones
Bicycle Lanes
Soft Mobility Infrastructure

4. Integrated Design Approaches
Urban Planning and Zoning
Climate-Responsive Design and Community Engagement

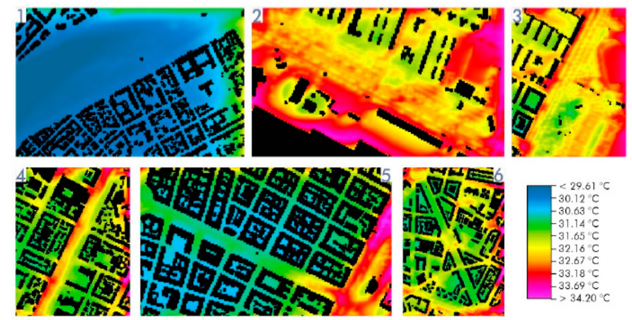


Fig.36 Potential Air Temperature (PAT) at 14:00 h; 1. Corso Casale; 2. Corso Enrico Tazzoli; 3. Corso IV Novembre; 4. Corso Potenza; 5. Corso Guglielmo Marconi; 6. Corso Racconigi. Authors' elaboration via ENVI-met.
source:
(Pejovic et al, 2023)

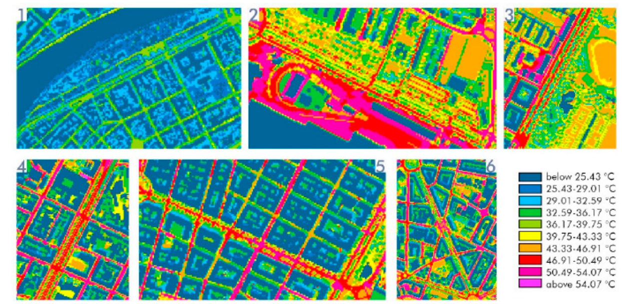


Fig.37 Potential Air Temperature (PAT) at 14:00 h; 1. Corso Casale; 2. Corso Enrico Tazzoli; 3. Corso IV Novembre; 4. Corso Potenza; 5. Corso Guglielmo Marconi; 6. Corso Racconigi. Authors' elaboration via ENVI-met.
source:
(Pejovic et al, 2023)

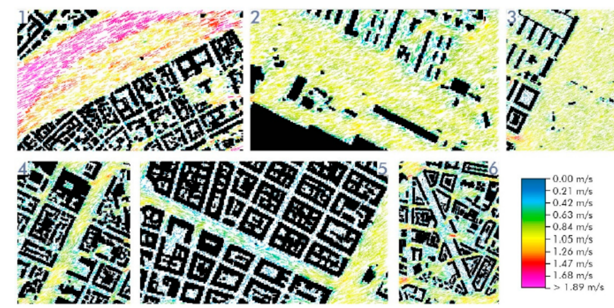


Fig.38 Wind Speed at 14:00 h; 1. Corso Casale; 2. Corso Enrico Tazzoli; 3. Corso IV Novembre; 4. Corso Potenza; 5. Corso Guglielmo Marconi; 6. Corso Racconigi. Authors' elaboration via ENVI-met.
Source:
(Pejovic et al, 2023)

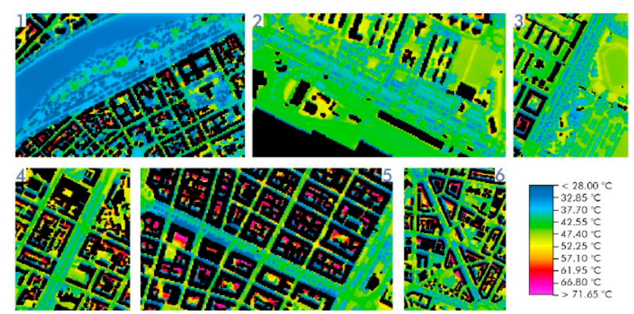


Fig.39 PET at 14:00 h; 1. Corso Casale; 2. Corso Enrico Tazzoli; 3. Corso IV Novembre; 4. Corso Potenza; 5. Corso Guglielmo Marconi; 6. Corso Racconigi. Authors' elaboration via ENVI-met
Source:
(Pejovic et al, 2023)

Results from these simulations figures 35-38, provided crucial insights into the thermal performance and UHI mitigation potential of each cluster. The data revealed that clusters with a higher emphasis on soft mobility—pedestrian and bicycle-friendly infrastructures—demonstrated significant improvements in microclimatic conditions. Specifically, these areas showed reduced air temperatures and improved thermal comfort due to increased shading, evapotranspiration from vegetation, and reduced heat fluxes from vehicular traffic.

2.1.1.2 Microclimate Improvement of an Italian Industrial District

Research paper: Green strategies for improving urban microclimate and air quality: A case study of an Italian industrial district and facility
Authors: Cecilia Ciacci *, Neri Banti , Vincenzo Di Naso , Frida Bazzocchi
Posted Date: published in the journal Building and Environment in 2023 (Volume 244, Pages 110762-110778)

This case study focuses on the implementation of green strategies aimed at enhancing the urban microclimate and air quality within an industrial district located in Caravaggio, Bergamo, in the Lombardy region of Northern Italy. (figure 40) The area is characterized by high air-pollutant concentrations and significant environmental impacts typical of urban settlements. This study examines the efficacy of green roofs in mitigating these issues.

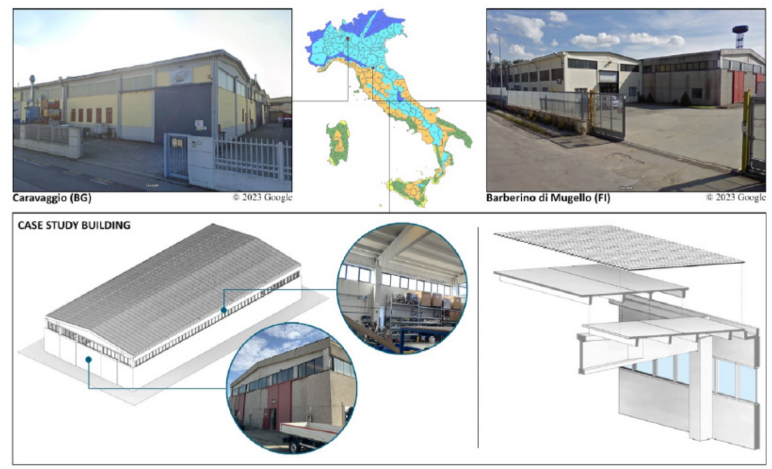


Fig.40 Model of the case study building along with some photographic evidence and the axonometric details of the constructive solution. Source: (Ciacci et al, 2023)

Several green mitigation strategies (figure 41) were evaluated to determine their impact on the microclimate parameters, urban heat island (UHI) effect, air pollutant concentrations (specifically PM10 and PM2.5), and building energy performance. Key strategies included:

Green Roofs: Installation of green roofs on industrial facilities aimed at reducing heat gains and losses, improving energy efficiency, and capturing particulate matter.

Vegetation and Green Spaces: Increasing the green cover within the district to enhance cooling through evapotranspiration and provide additional particulate matter filtration. Urban

Design Improvements: Modifications in urban layout to increase airflow and reduce heat accumulation.

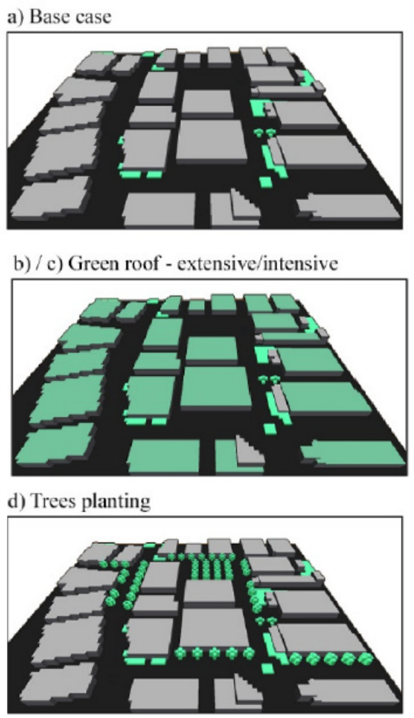


Fig.41 Green strategies applied to the industrial district. In the figure: a) base case, b) extensive green roof, c) intensive green roof and d) evergreen trees planting. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.) Source: (Ciacci et al, 2023)

The research utilized the ENVI-met modeling software to simulate the impact of these strategies on the district's microclimate. Parameters such as outdoor air temperature, (figure 42 and 43), mean radiant temperature, and concentrations of PM10 and PM2.5 were measured. For building-specific impacts, the Design Builder software was used to model a representative facility, focusing on energy performance indicators like heat losses, gains, heating and cooling demands, and surface temperatures.

The simulations compared existing conditions with scenarios incorporating the green strategies to evaluate potential improvements. Data from an on-field air quality monitoring campaign by the Lombardy Region was used to validate the environmental simulations.

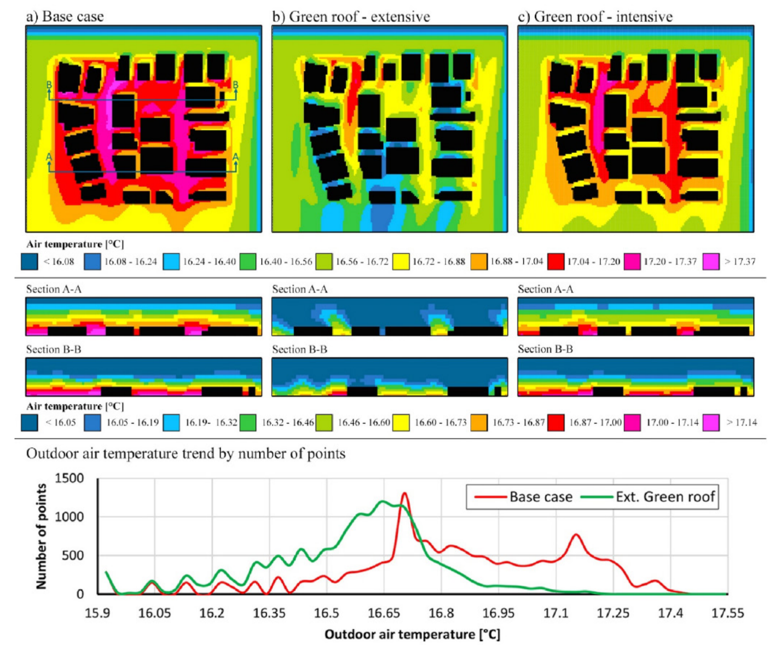


Fig.42 Variation in the outdoor air temperature [◦C]. Month: March Source: (Ciacci et al, 2023)

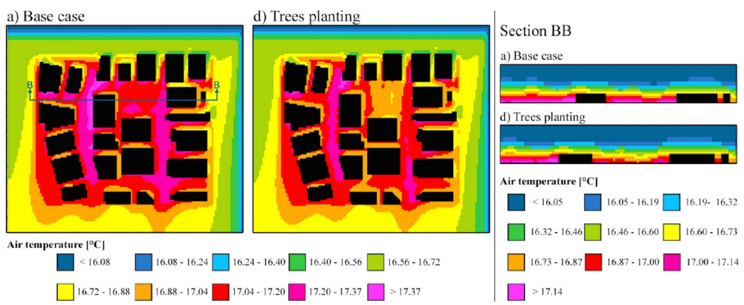


Fig.43 Variation in the outdoor air temperature [◦C] in case of trees planting (d). Month: March. Source: (Ciacci et al, 2023)

Results:

The implementation of green roofs and increased vegetation showed significant positive outcomes:

Temperature Reduction: A noticeable decrease in outdoor air temperature and mean radiant temperature, mitigating the UHI effect.

Improved Air Quality: Reduction in PM10 and PM2.5 concentrations, leading to better air quality.

Energy Savings: Enhanced building energy performance with reduced heating and cooling demands due to the insulating effect of green roofs.

he study demonstrates the effectiveness of green strategies in improving urban microclimate and air quality within an industrial district. These interventions not only enhance environmental conditions but also contribute to energy savings and public health benefits The findings support the broader application of similar green strategies in industrial urban contexts to promote sustainable urban development.

2.1.1.3 Redevelopment of public space in Granada, Spain

Research paper: Microclimate design for micro-urban desing. A case study in Granada, Spain
Authors: Matteo Trane, Matteo Giovanardi, Riccardo Pollo, Chiara Martoccia, 2021
Year: Published in: SMC Magazine, n. 14, 2021

This case study focuses on the redesign of urban public spaces in the Zaidin district of Granada, Spain, (figure 44) with a specific emphasis on improving outdoor quality through microclimatic design.
The study employs a robust modeling and simulation process using ENVI-Met, a Computational Fluid Dynamics (CFD) software widely validated in scientific literature. The methodology includes several steps: modeling the existing conditions and proposed designs using the «Space» application, simulating local climate variables and user comfort with «ENVI-Guide» and «BioMet,» and analyzing the results using the «Leonardo» application. Customization of horizontal surface materials was done through the «Database Manager» application, considering factors like shading and evapotranspiration from trees.
Key climatic parameters assessed included Potential Air Temperature (PAT), Physiological Equivalent Temperature (PET), and Surface Temperatures (ST) .

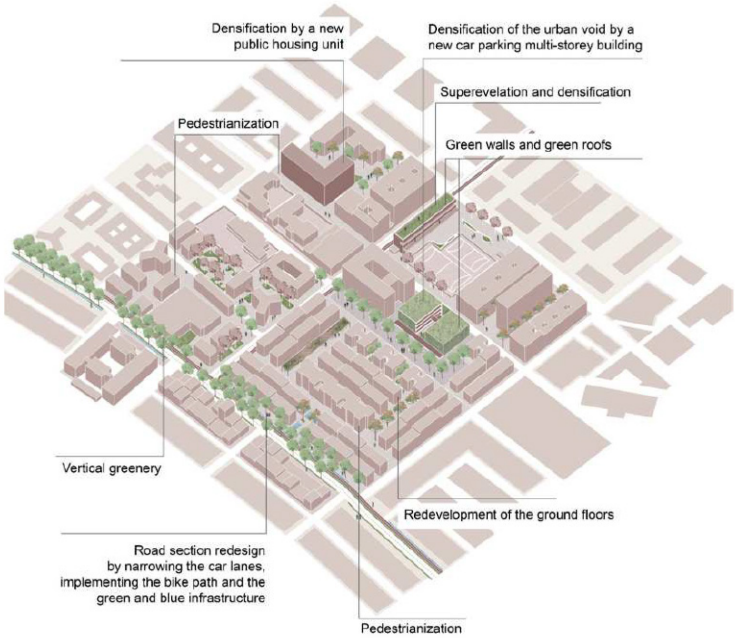


Fig.44 Site-specific redevelopment design strategies
Source:
(Trane et al., 2021)

The analysis focused on the data from July 22, 2019, identified as the hottest day of the year by the weather station. The design proposal encompasses three main target areas, (figures 45- 50) , each with specific strategies:

1. Pedestrianization: Several interstitial spaces were redesigned to favor pedestrians, removing cars from public areas, introducing soft mobility through traffic calming measures, and promoting sustainable public or private transport. The ground floors of buildings were repurposed to meet needs identified during the meta-design phase, offering flexible spaces for co-working, study rooms, temporary residences, commercial activities, services, and bicycle parking.

Fig.45 Design strategies in plot A
source: Trane et al., 2021

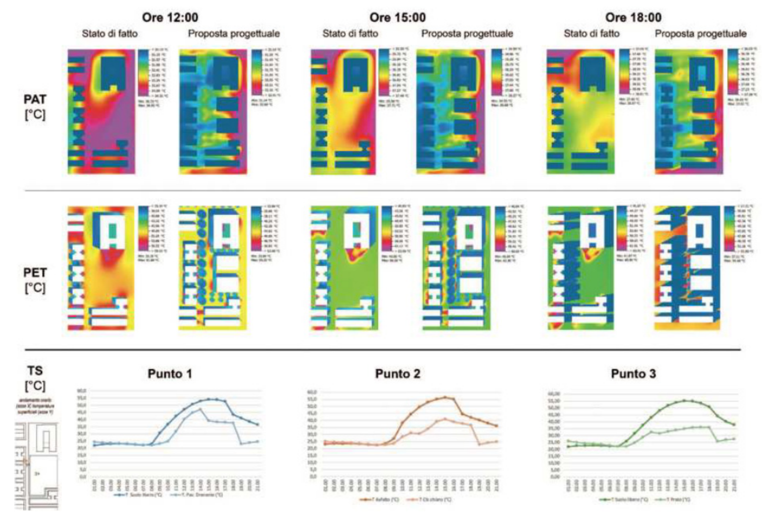


Fig.46 Plot A, outputs of the simulation at 12AM, 3PM, 6PM
source: Trane et al., 2021

2. Densification: An «urban void» was converted into a shared multi-storey car park near the pedestrianized zones. Additionally, ground floor resident spaces were relocated to an industrial area slated for redevelopment in accordance with the Urban Plan of Granada.

Fig.47 Design strategies in Plot B
source: Trane et al., 2021

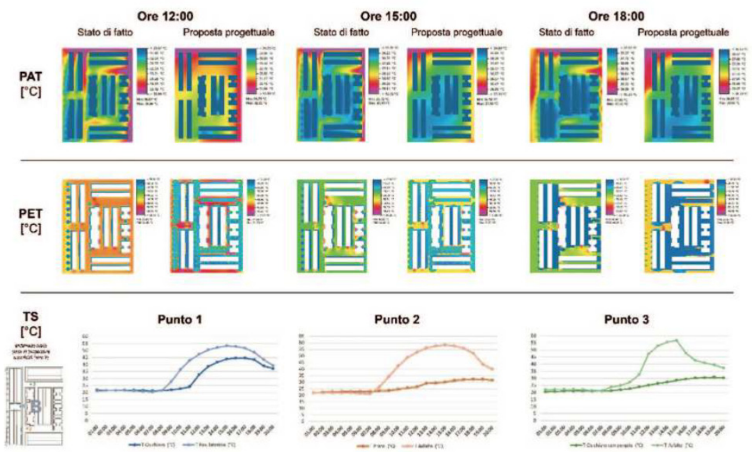


Fig.48 Plot B, outputs of the simulation at 12AM, 3PM, 6PM
source: Trane et al., 2021

3.Green and Blue Infrastructure: Green infrastructure was expanded both horizontally and vertically, with the installation of green roofs and walls. Vehicle road sections were reduced to create space for gardens, water ponds, and cycle paths.

Fig.49 Design strategies in plot C
source: Trane et al., 2021

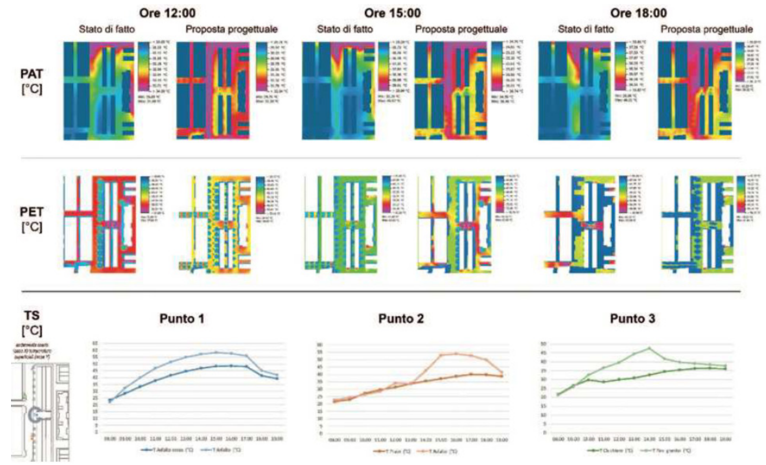


Fig.50 Plot C, outputs of the simulation at 12AM, 3PM, 6PM
source: Trane et al., 2021

Conclusion

The case study demonstrates the effectiveness of integrating microclimatic design strategies in urban planning to combat the adverse effects of climate change. The use of ENVI-Met

for detailed modeling and simulation provided valuable insights into the impact of various design interventions.
The results underscore the importance of a systemic and multi-scalar approach to urban design, combining adaptation and mitigation strategies to create healthier and more resilient urban environments. This approach aligns with the broader goals of ecological transition policies, promoting carbon neutrality and enhancing social and individual well-being through improved environmental quality .

2.1.2 DESIGN CASE STUDIES

2.1.2.1 Skanderbeg Square

The significance of analyzing microclimate conditions on-site is evident in the design solutions, as demonstrated by the representative case studies.

Project: Skanderbeg Square
Architect: 51N4E
Location: Singapore Tirana, Albania
Year: 2017

Fig.51 Skanderbeg square befor and after renovation. source: www.publicspace.com

The main square in Tirana Albania , (figure 51) has been redesigned in a straightforward yet transformative manner, featuring a large pedestrian zone and a green belt that serves as a buffer between the busy city and the square. The square stands out as an open space amid the urban chaos, resembling a flat pyramid surrounded by a densely vegetated perimeter, composed of a mix of historic and new public spaces and gardens. This design mitigates the overpowering presence of Communist-era architecture and enhances Albania's natural environment by incorporating local plant species to bolster the system's resilience to climate change. The green belt includes 12 gardens, each associated with nearby public or private institutions, with careful consideration given to mobility issues and investments in and around the square. The use of local materials was prioritized, revitalizing local stone quarries and boosting the nation's production capabilities.

Design strategies:

Greenery and Vegetation: Introducing more green spaces and planting trees helps to mitigate the urban heat island effect by providing shade, cooling the air through evapotranspiration, and reducing the overall temperature of the square. (figure 52)

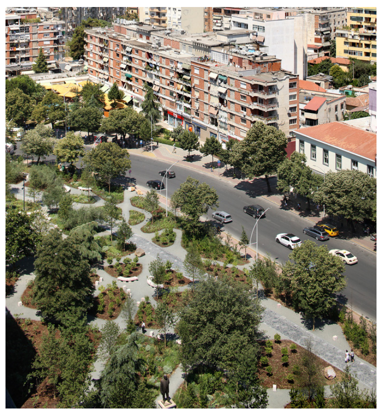


Fig.52 Green belt and improved vegitation in the Skenderbeg square.
souce:
www.51n4e.com/

Porous Pavement: The use of permeable or porous pavement materials allows rainwater to infiltrate into the ground rather than running off into storm drains.(figure 53) This helps to reduce surface runoff and mitigate flooding, while also potentially cooling the area through evaporative cooling.

Fig.53 Permable pavement used in the Skenderbeg square.
Taken by the author

Shading Structures: Installing structures such as pergolas, umbrellas, or awnings can provide shade for pedestrians and reduce direct exposure to sunlight, thereby lowering temperatures in localized areas of the square.

Water Features: Incorporating water features like fountains or small ponds can have a cooling effect through evaporation. They also contribute to aesthetic improvement and create a more comfortable environment for visitors.

Fig.54 Pergola installed in the Skenderbeg square. www..archdaily.com

Urban Furniture and Design: Choosing materials and designs that minimize heat absorption and maximize ventilation can contribute to a more comfortable microclimate. This might include using light-colored materials for pavements and walls, and designing pathways to encourage airflow.

Public Transit and Pedestrianization: Encouraging the use of public transportation and promoting pedestrian-friendly designs reduces vehicular traffic and emissions, which helps improve air quality and reduce heat generation from vehicles.

Energy-Efficient Lighting: Using LED or other energy-efficient lighting systems reduces heat emissions from traditional lighting sources and lowers energy consumption overall.

2.1.2.2 Albert Cuyp Market

The Albert Cuyp Market is located in the De Pijp neighborhood of Amsterdam and is one of the largest and oldest outdoor markets in the Netherlands and is one of Europe's biggest daily markets . It has a rich history dating back to 1904 and has become an integral part of the city's culture.

The 100-year-old, open-air street market features nearly 300 vendors selling everything from fruits, vegetables, fish, meats, spices, chocolate, cheese, flowers and plants to cheap clothes, jewelry, shoes, bike accessories, bedding, fabrics and cosmetics, is comparable to Porta Palazzo market of Turin.
The market stretches along the Albert Cuypstraat, which is closed off to vehicle traffic during market hours. It spans approximately one kilometer and is lined with over 260 vibrant stalls. The market is known for its diverse range of products, including fresh produce, local delicacies, clothing, flowers, household items, and much more.
considering the design of contemporary food markets within urban settings can offer valuable insights into factors influencing the design process, such as social considerations and the heritage of the surrounding neighborhood (Benkő et al., 2021). This approach can help create a market space that resonates with the local community and addresses their needs effectively, which is evident in designing this market.

The design elements:

1. The Entrance Gate Desin: The beginning of the Albert Cuyp market in Amsterdam now has a 10-meter-high entrance gate designed by spatial designers Overtreders W. The gate was built at the request of the market merchants and consists of 258 lanterns, each lantern showing a picture of the products from one of the market stalls. (Figure 55)
Now it features a new entrance gate at the eastern side, making it more accessible and revitalizing the previously overlooked area. This improvement ensures that visitors can easily locate the market from both the western and the newly prominent eastern entrance.

Fig.55 Eterance gate of the Albert Cuyp market
source:
www.archello.com

2. Permeable Surfaces: The market area is surfaced with red-coated asphalt, which helps mitigate microclimate effects.(figure56)

Fig.56 permeable pavement of the Albert Cuyp market
source:
taken by the author.

3.Shading and Shelter: Features retractable awnings and temporary structures to provide shade to vendors and visitors. (figure57)

Fig.57 Permenant and temporary shading structure of the Albert Cuyp market
source:
taken by the author.

4. market layout to improve the airflow and ventilation: market layout is designed to be parallel in order to maximize natural airflow, reducing heat buildup.
The market layout features parallel rows of stalls, organized to streamline visitor traffic and enhance natural airflow, thereby improving ventilation and comfort.

Fig.58 Albery Cuyo market layout
source:
taken by the author.

By adapting these proven strategies from the Albert Cuyp Market, Porta Palazzo in Turin can become a more sustainable, comfortable, and resilient urban market space.

3. MICROCLIMATE ANALYSIS AND DESIGN

3.1. MICROCLIMATE ANALYSIS OF THE EXISTING CONDITION

3.1.1 Survey Analysis

To assess the microclimate conditions at Porta Palazzo market, a comprehensive survey was conducted. The survey targeted two primary groups: permanent shopkeepers within the market and the customers who frequently visit it. (fig 59)
The questionnaire, included in the annex of this thesis, was designed to gather insights into the daily experiences and perceptions of both groups regarding the microclimate.

Survey Structure:

The survey consisted of three main sections including
1. Demographics and Operational Details:
Questions about the respondents' arrival times, hours of operation, and the type of products sold or purchased.

2. Microclimate Perception and Challenges:
Questions focused on perceived changes in the market's microclimate, challenges faced due to microclimate conditions, and any mitigation measures taken.

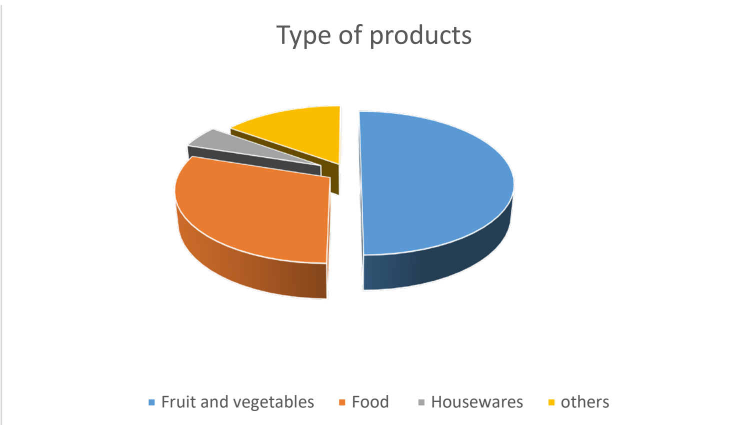
3. Suggestions for Improvement:
Questions aimed at gathering suggestions for improving the market's microclimate, including potential structural changes and policy recommendations.

Fig.59 seller of port apalazzo filling the questionare
source:
taken by the author.

Respondent Demographics

1. Permanent Shopkeepers:
This group included long-term vendors with various types of stalls, from food and groceries to clothing and household items.
2. Customers:
This group consisted of regular shoppers who visit the market at different times of the day and week.

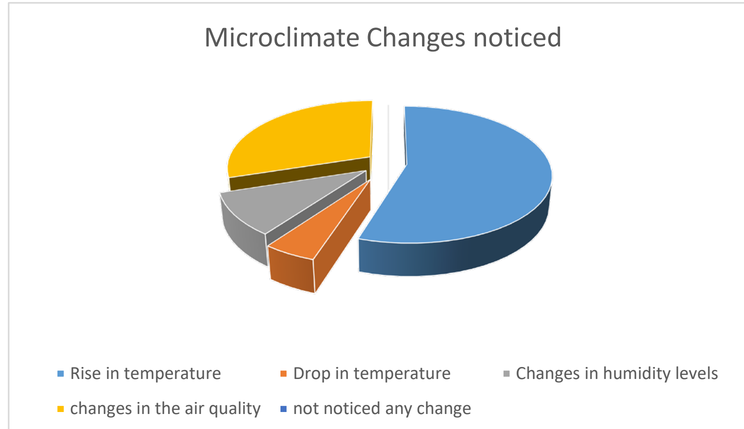
Key Findings:
The results of the survey are presented below, along with graphical representations for clarity.
1. Arrival and Operational Times:
- Most shopkeepers arrive between 5 and 6 AM.
- Shops generally operate for 6-8 hours a day.
2. Microclimate Perception:
- A significant number of shopkeepers (70%) and customers (65%) have noticed an increase in temperature over the years.
- Changes in humidity and air quality were also reported by 40% of the respondents.



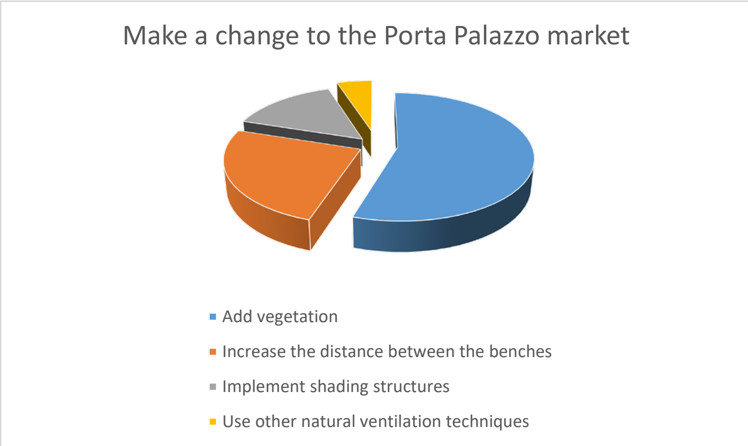
Graph 1 difftent types of products are being sold in port apalazzo based on the the questionare

Graph2 smicroclimate change totice according to sellers and visitors answers in questionare

3. Challenges Due to Microclimate:
- Common issues reported include extreme temperatures and poor air quality.
- Shopkeepers specifically noted difficulties in maintaining product quality and comfort for customers.
4. Mitigation Measures:
- 60% of shopkeepers have installed shading structures or cooling devices.
- Few (15%) have made significant layout changes to improve airflow.



5. Suggestions for Improvement:
- Both groups suggested adding more vegetation and implementing better shading structures.
- Improved ventilation and increased distance between stalls were also recommended.

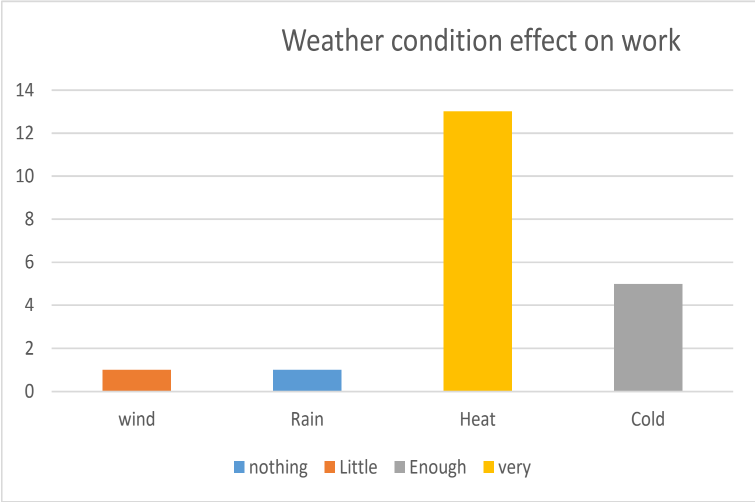


Graph 3 difftent types of products are being sold in port apalazzo based on the the questionare

The data highlights a clear recognition of worsening microclimate conditions in Porta Palazzo market, particularly regarding increasing temperatures and deteriorating air quality. Shopkeepers and customers alike face significant challenges that affect both comfort and business operations.

The majority of respondents support the implementation of sustainable solutions such as additional vegetation, shading canopies, and better ventilation systems. Sustainable materials like timber and bamboo are favored for new structures due to their environmental benefits and effectiveness in carbon capture, which can further enhance the microclimate.

The survey results underscore the necessity for targeted interventions to mitigate the microclimate challenges at Porta Palazzo market. The most significant factor affecting market owners' businesses is heat, making temperature management the most crucial microclimate factor for design considerations.



Graph 4 how the diffrenet weather effect the work of market owners based on the questionare

Implementing the suggestions gathered from the survey can lead to a more comfortable, sustainable, and economically viable market environment. The full questionnaire and detailed responses are provided in the annex for further reference and analysis.

3.1.2 SWOT Analysis

STRENGTHES	WEAKNESSES	OPPURTUNITIES	THREATS
• **Central Location:** easily accessible, enhances its visibility and facilitates connectivity with other parts of the city.	• **Aging Infrastructure:** including roads, sidewalks, and utilities.	• **Redevelopment and Revitalization:** adaptive reuse of historical buildings, creation of new mixed-use developments, and improvement of public spaces to enhance the overall urban fabric.	• **Gentrification and Displacement:** Rising property values and increased demand for housing can lead to the displacement of low-income residents.
• **Cultural and Historical Significance:** Porta Palatina, largest open-air market in Europe, tourists' attractions	• **Limited Green Spaces:** can impact the quality of life and overall well-being of residents.	• **Sustainable Transportation Initiatives:** expanding cycling infrastructure, improving pedestrian walkways, and encouraging the use of public transportation	• **Environmental Degradation:** Pollution, inadequate waste management, and the loss of green spaces may have adverse effects on air and water quality, biodiversity, and overall ecological balance
• **Mixed-Use Development:** combines residential, commercial, and recreational element, create a vibrant and diverse environment.	• **Noise and Air Pollution:** adverse effects on the health and comfort	• **Cultural and Tourism Development:** there is an opportunity to further develop cultural institutions, museums, and tourism initiatives.	• **Inadequate Infrastructure:** Insufficient or aging infrastructure, such as roads, utilities, and public facilities, can hinder the overall livability
• **Public Transportation Accessibility:** reduce reliance on private vehicles	• **High Density and Overcrowding:** resulting in congestion, limited parking options.	• **Green Infrastructure Implementation:** integrate more green spaces, urban parks, and community gardens within the area.	• **Loss of Historical and Cultural Identity:** With ongoing urban development and revitalization, there is a risk of losing the area's unique historical and cultural identity.
• **proximate green spaces**	• **Gentrification Pressures:** which can displace existing low-income residents and disrupt the social fabric of the community.	• **Social Inclusion and Community Engagement:** This can be achieved through initiatives such as participatory planning processes, community-led development projects, and support for local businesses	• **Lack of Affordable Housing**

Table 4 SWOT analysis of Porta Palazzo

3.1.3 Envi- met Input Data

As described in previous chapters, ENVI-met is a 3D microclimate modeling software that utilizes the principles of fluid dynamics and thermodynamics.
This software models the climatological interactions between surfaces, plants, and the atmosphere. Additionally, it evaluates the impact of planning measures on the urban climate.
Being a prognostic model and taking the essential laws of fluid dynamics and thermodynamics as a base, ENVI-met is capable of simulating the flow around and between buildings, exchange processes at the ground surface and at building walls, building physics, impact of vegetation of the local microclimate, bioclimatology and pollutant dispersion (ENVImet,2021).
The software employs a grid-based approach, offering high temporal and spatial resolution. The horizontal resolution typically ranges from 1 to 10 meters, with simulation periods spanning 1 to 5 days. The model area generally encompasses 50x50 to 500x500 grid cells horizontally and 20 to 50 cells vertically.
In this thesis, ENVI-met was used as a tool for the simulation of Porta palazzo market in two stage:

1.A. existing conndition without market stalls
1.B. Existing condition with market stalls
2. After applying design scenarios

Before starting the modeling process, it was necessary to download carta tecnica data from Geoportale Torino.
For modeling the case studies, ENVI-met version 5.5 was utilized.
The software comprises six sections:Monde, Spaces, ENVI-guide, ENVI-core, BIO-met, and Leonardo (figure 60). The Projects/Workspaces module was used to create separate folders and individual settings for each case study. Subsequently, the Spaces module was employed to create the model, starting with adjustments in the «Model Info» section, which contains the base information of the model.

Fig.60 Envi-Met Monde, Spaces , ENVI-guide , ENVI-core , BIO-met , Leonardo

The input data for this specific case of Porta Palazzo is as follows:

.Location Turin
.Geographic coordinates 45.07, 7.683
.Time zone Central European Standard Timereference
.Longitude 15.00
.Number of nesting grids 6
(Extra grids incorporated around the edges of the model to mitigate potential errors near the model's boundaries.)
.Wall material default wall - moderate insulat
.Roof material roofing: tile
.Dominant surfaces asphalt, vegetation, granit, basalt brick, concrete, wood planks

In addition to these parameters, it was necessary to adjust the model's resolution before starting the modeling process. In this thesis, a resolution of 2x2x2 was used for modeling the case study.

Model geometry:

.Grid dimentions: 225x225x50 grids
dx:2 dy:2 dz:2
Core XY domain size: 450m x 450m
Highest building in demain: 45m
Highest of 3D model top: 100m

Table 3 displays the input values for a particular day considered one of the hottest in recent years.

	Hour	T air °C	R.H. %	Wind speed (m/s)	Wind direction
27/06/2019	00:00:00	25,2	82	0,0	-
	01:00:00	24,6	84	1,0	308
	02:00:00	24,2	87	0,9	276
	03:00:00	23,7	90	0,3	272
	04:00:00	23,5	92	0,7	323
	05:00:00	24,0	90	1,5	271
	06:00:00	27,0	75	1,2	247
	07:00:00	30,1	54	2,2	227
	08:00:00	31,1	57	1,2	254
	09:00:00	32,4	53	2,6	181
	10:00:00	32,9	54	2,0	200
	11:00:00	34,1	52	2,9	173
	12:00:00	35,3	47	1,4	188
	13:00:00	36,3	40	2,5	184
	14:00:00	37,1	39	3,0	186
	15:00:00	37,6	35	4,0	199
	16:00:00	38,2	27	4,3	201
	17:00:00	37,4	34	2,6	214
	18:00:00	34,9	43	1,9	245
	19:00:00	31,1	59	1,7	327
	20:00:00	29,4	66	2,6	319
	21:00:00	27,6	69	1,6	309
	22:00:00	26,6	75	1,8	267
	23:00:00	25,6	80	1,7	323

Table 4. 58 Input values source: http://www.arpa.piemonte.it/dati-ambientali/richiesta-dati-orari-meteorologici

Used for simulation
Wind direction **308**
Wind speed **1.7**

The ENVI-guide module was configured with simulation parameters. On June 28, 2019, at ... hours, simulations were initiated, chosen as it marked the hottest day of the year. The simulation duration was ... hours, leveraging all available CPU cores.

The software necessitates meteorological data for accurate modeling, utilizing either simple forcing or full forcing based on available information. For this study, simple forcing was applied. Essential parameters such as air temperature, relative humidity, wind speed, and direction for each hour (refer to Table 3) were sourced from ARPA Piemonte's website, extracted from the nearest meteorological station.

The ENVI-core module conducted simulations, each lasting approximately 7 days due to the area's extensive coverage, resolution requirements, and process complexities.

There are three ENVI-met models: the first without market stalls at Porta Palazzo, the second with market stalls, and the third with market stalls implementing specific strategies. Each model was simulated separately, and the results were compared. (figures 61-66)

3.1.4 Envi- met Outputs

The outputs generated from the simulation were imported into the «Leonardo» section of ENVI-met, which offers capabilities for exporting plan and section views from any plane within the simulation domain. To obtain potential air temperature and wind speed results, data from the «atmosphere» file served as the primary source, while surface temperature results were derived from the «surface» file.

For analyzing Physiological Equivalent Temperature (PET), the «BIO-met» module of the software was utilized. This module not only computes PET but also provides insights into other comfort indices such as Universal Thermal Climate Index (UTCI) and Predicted Mean Vote (PMV). To compute PET values, specific times of the day and heights within the simulation domain were selected.

The results of these calculations were organized into a dedicated «biomet» folder within the simulation output directory. Subsequently, this data was imported back into the Leonardo module to visualize and analyze the distribution of outdoor comfort levels across the simulated area.

The most «critical» hour of the day, characterized by the highest air temperature, is 14:00. Results were collected for three representative hours: 10:00, 14:00, and 18:00. For all parameters except surface temperature, data was recorded at a height of 1.8 meters, representing the average height of a human. To facilitate comparison, the legends for each parameter were standardized to display consistent data across all maps for each specific hour. This approach ensures that variations and trends can be easily identified and analyzed across different times of the day.

3.1.5 Results

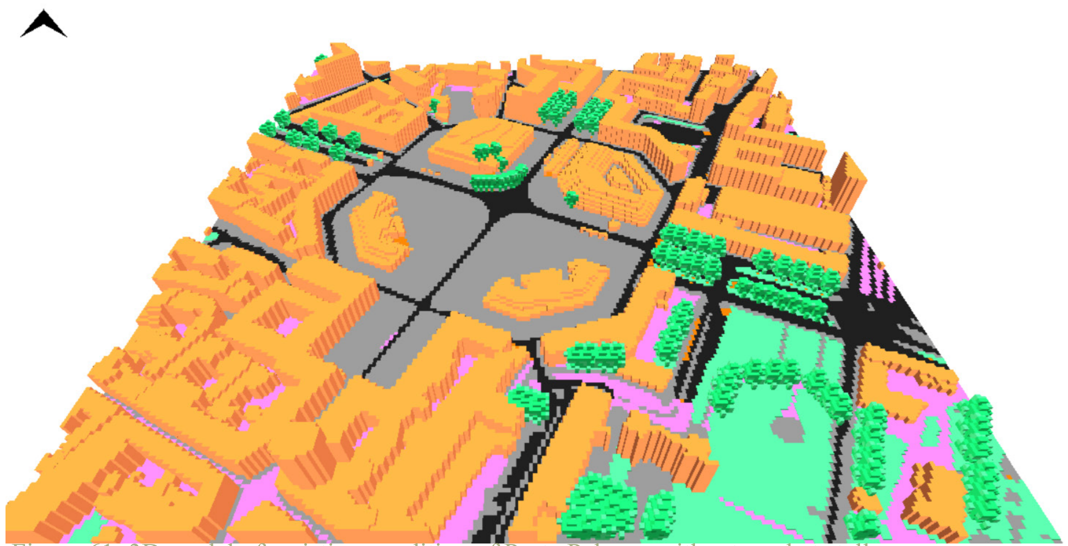


Figure 61: 3D model of existing condition of Porta Palazzo without market stalls.
(Exported from ENVI-met)

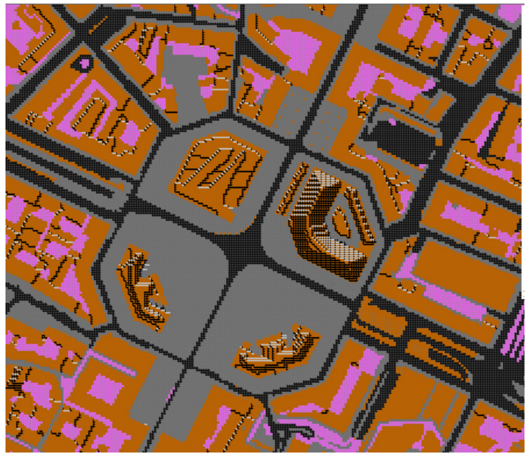


Figure 62: 2D plan illustrating the material distribution in existing condition of Porta Palazzo without considering the market stalls (Exported from ENVI-met)

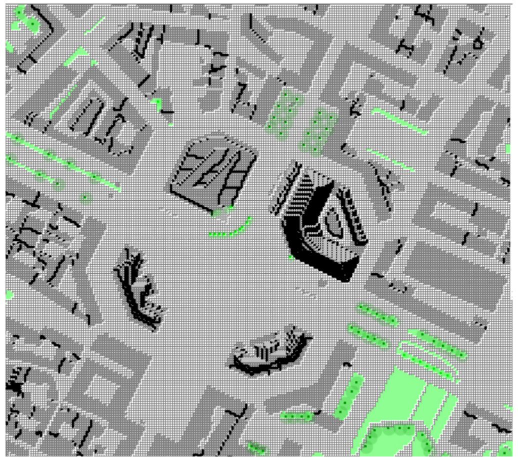


Figure 63: 2D plan illustrating the material distribution in zxisting condition of Porta Palazzo without considering the market stalls (Exported from ENVI-met)

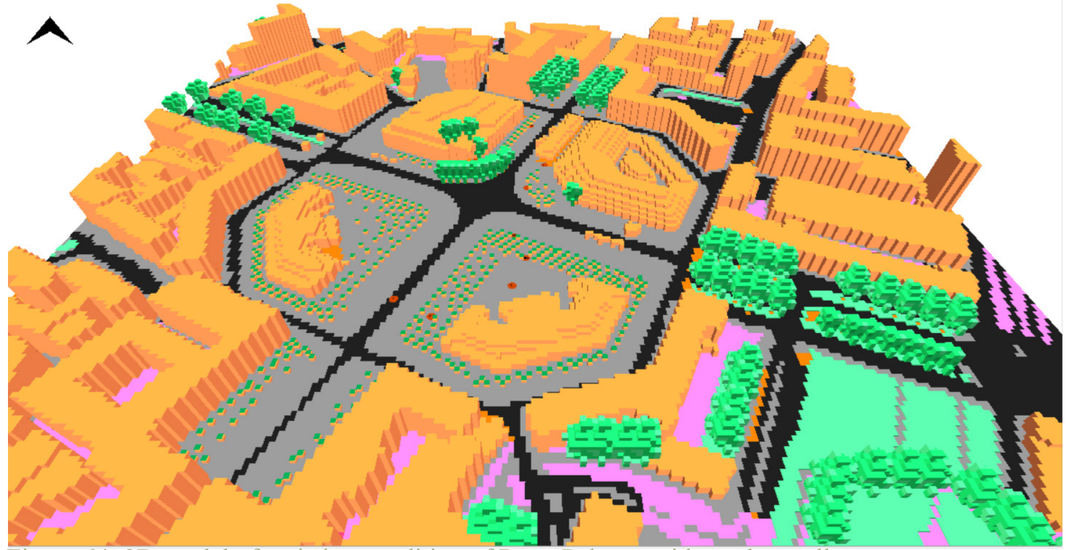


Figure 64: 3D model of existing condition of Porta Palazzo with market stalls.
(Exported from ENVI-met)

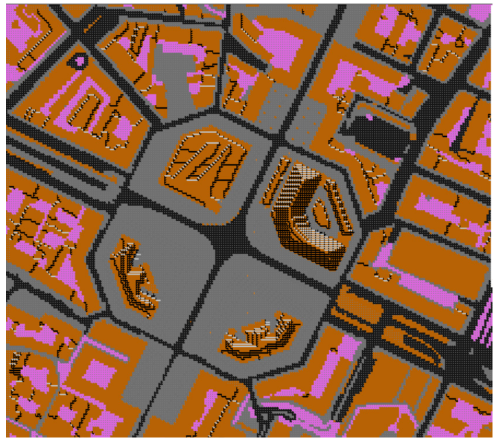


Figure 65: 2D plan illustrating the material distribution in existing condition of Porta Palazzo with considering the market stalls
(Exported from ENVI-met)

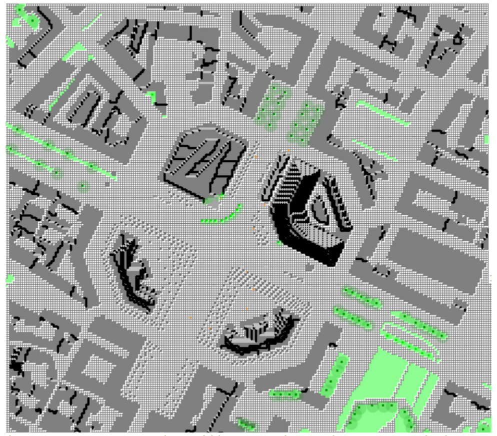
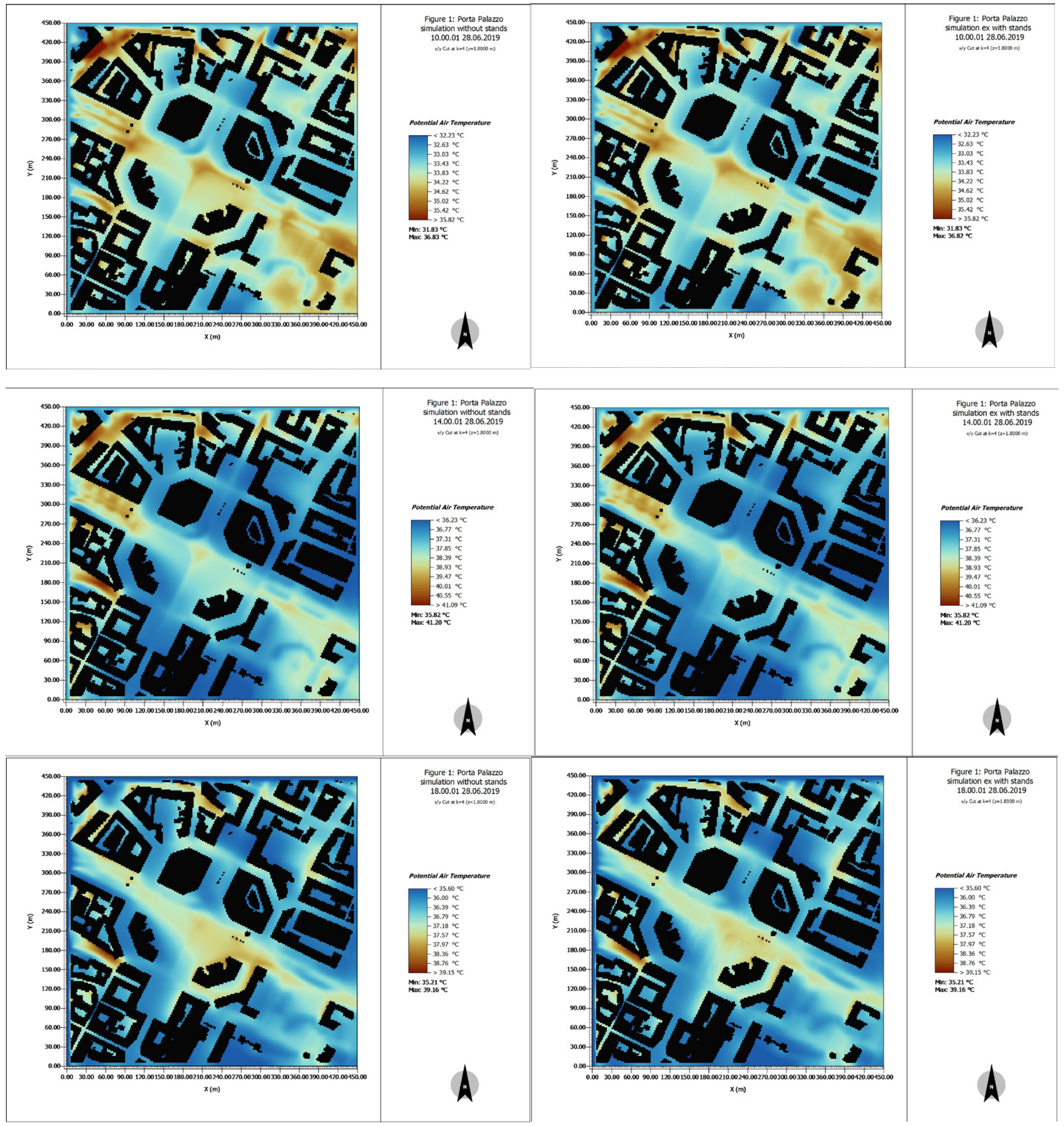


Figure 66: 2D plan illustrating the material distribution in existing condition of Porta Palazzo with considering the market stalls
(Exported from ENVI-met)

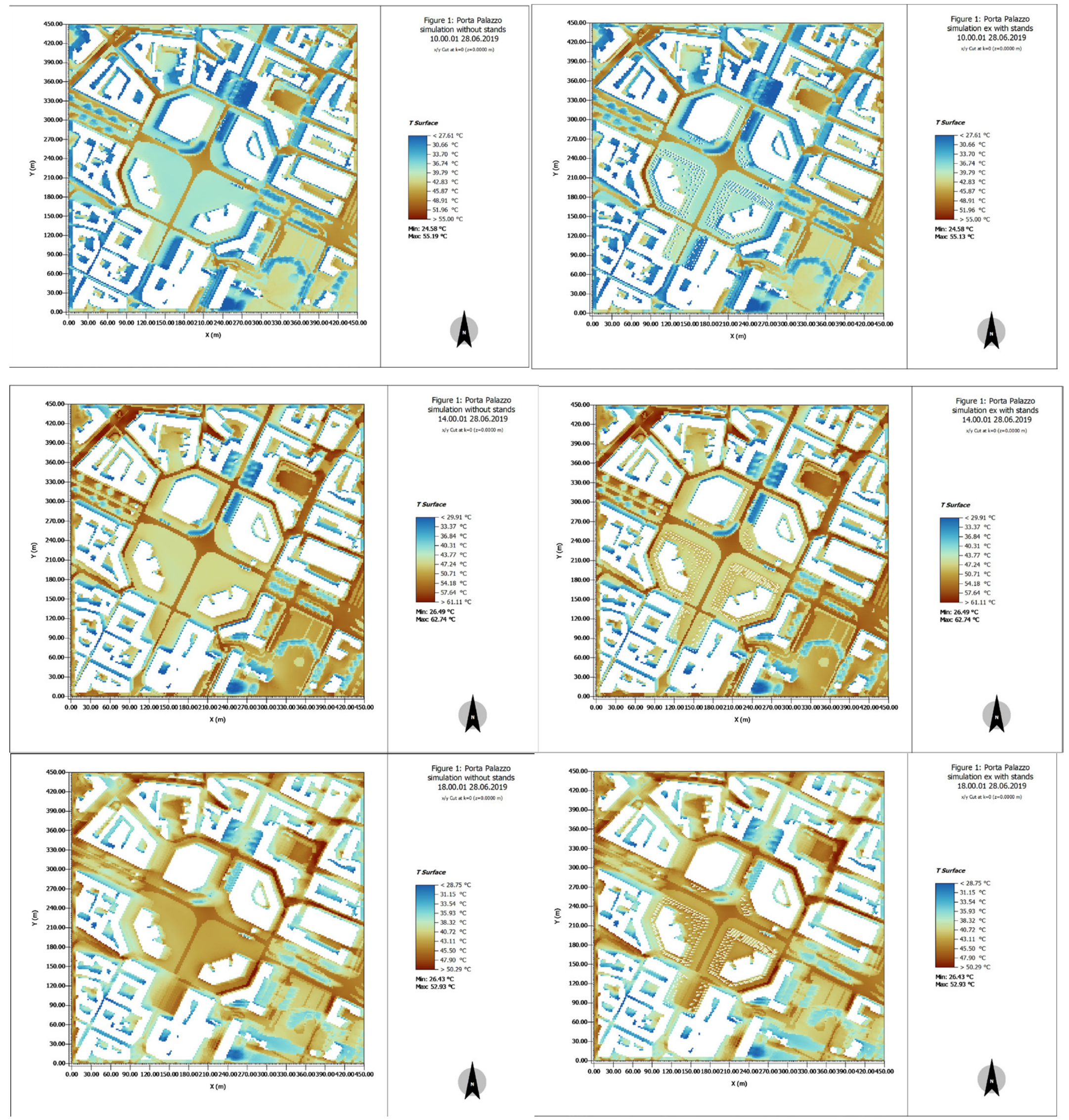
Potential Air Tempreture in existing condition of Porta Palazzo at 10:00, 14:00,18:00

Without market stalls / With market stalls



Surface Tempreture in existing condition of Porta Palazzo

Without market stalls / With market stalls

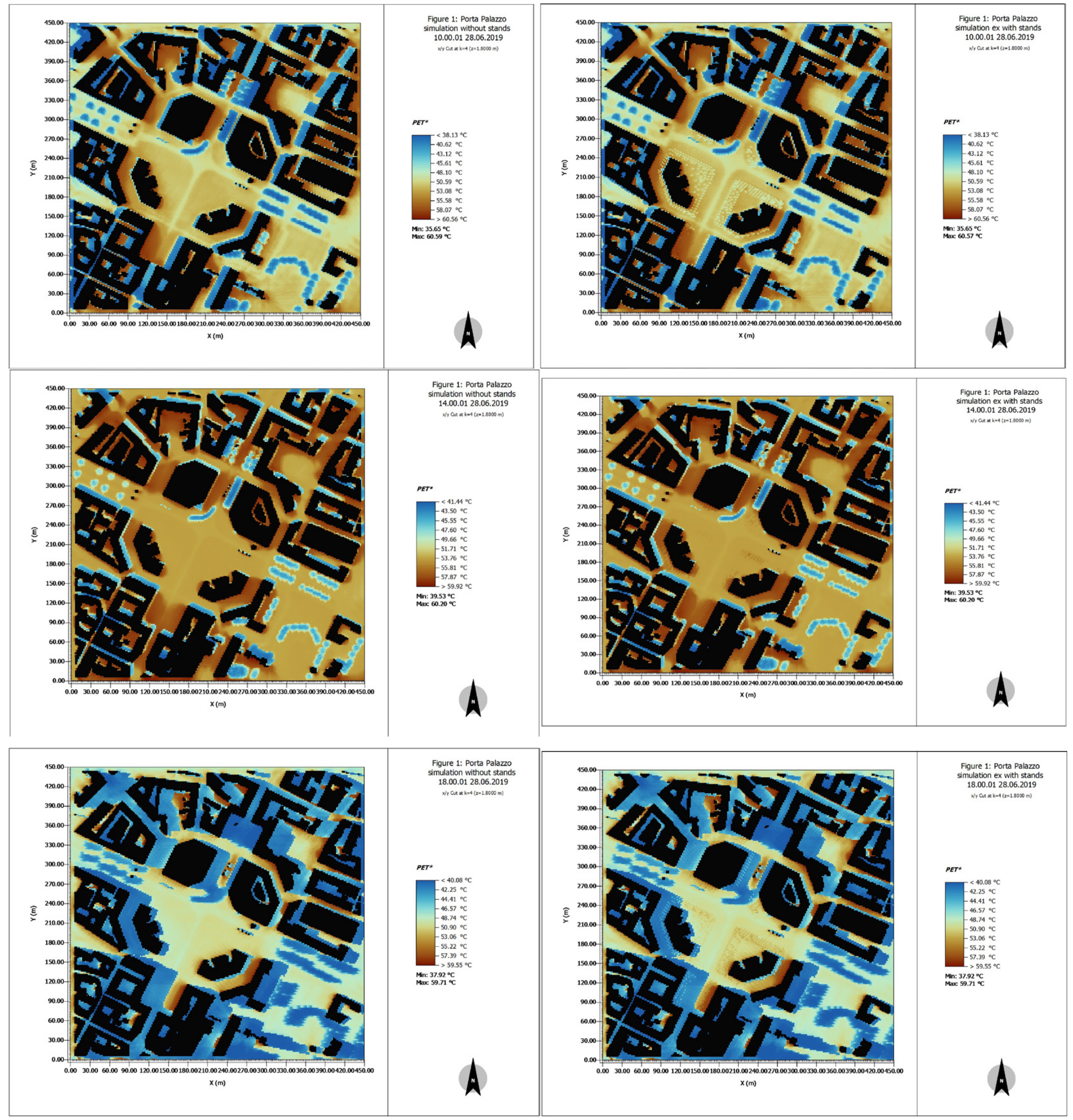


Wind Speed in existing condition of Porta Palazzo

Without market stalls | With market stalls

PET in existing condition of Porta Palazzo

Without market stalls | With market stalls



The tables below, provide detailed information on the minimum and maximum values for each parameter and hour. Additionally, they include the step size used to synchronize the legends, ensuring consistency across all visual representations. This structured approach facilitates a clearer comparison and analysis of the data, highlighting variations and trends effectively.

	PAT(°C)	ST (°C)	WS (m/s)	PET (°C)
min 10:00	31.83	24.58	0.00	35.65
max 10:00	36.83	55.19	4.46	60.59
min 14:00	35.82	26.49	0.00	39.53
max 14:00	41.20	62.74	4.49	60.20
min 18:00	35.21	26.43	0.00	37.92
max 18:00	39.16	52.93	4.51	59.71

Tab. 5 PAT, ST, WS, PET of existing condition without market stalls legend harmonization, extracted from ENVI-met data

	PAT(°C)	ST (°C)	WS (m/s)	PET (°C)
min 10:00	31.83	24.58	0.00	35.65
max 10:00	36.82	55.13	4.46	60.57
min 14:00	35.82	26.49	0.00	39.53
max 14:00	41.20	62.74	4.49	60.20
min 18:00	35.21	26.43	0.00	37.92
max 18:00	39.16	52.93	4.51	59.71

Tab. 6 PAT, ST, WS, PET of existing condition with market stalls legend harmonization, extracted from ENVI-met data

3.2. DISCUSSION

3.2.1 Urban Structure

The urban morphology of Porta Palazzo significantly influences its microclimate. The layout, density, and arrangement of buildings and open spaces create varying microclimatic conditions.
The high density and the arrangement of stalls and awnings in the market can lead to reduced airflow and increased temperature, contributing to a localized urban heat island effect. According to the ENVI-met simulation outputs, the potential air temperature (PAT) ranges from 31.83°C to 41.20°C at different times of the day (10:00, 14:00, and 18:00). This temperature range demonstrates the significant impact of urban morphology on microclimate.

The market's design, characterized by narrow alleys and dense vendor setups, may impede natural ventilation, causing higher temperatures and discomfort for vendors and shoppers alike. To mitigate these effects, it is essential to consider the spatial configuration of market stalls.
By optimizing the arrangement of stalls to enhance airflow, it is possible to create a more comfortable environment. Strategically positioning wider pathways and incorporating open spaces can enhance natural ventilation, reducing temperature buildup. Additionally, integrating semi-open structures that allow for air movement while providing shade can help in maintaining a cooler environment.

Another aspect of urban morphology that impacts microclimate is the height and orientation of surrounding buildings. Taller buildings around the market can create shading effects, reducing the amount of direct solar radiation reaching the market area. However, they can also block prevailing winds, which are crucial for natural ventilation. Therefore, a balance must be struck in urban design to ensure adequate shading without compromising airflow.

map 4 the detailed layout of the Porta Palazzo market and its surrounding road network within the city's broader context.
source: Illustrated by the author

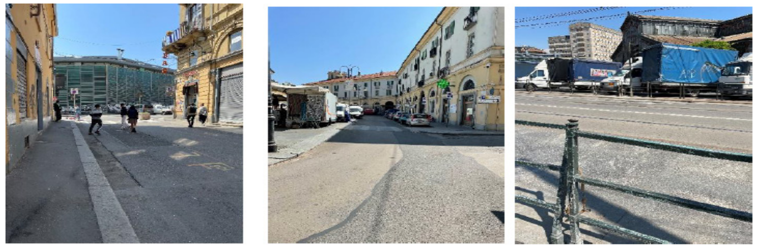
3.2.2 Pavement

The materials used for pavements in the market play a crucial role in thermal regulation. Surfaces with high thermal mass, such as concrete and asphalt, tend to absorb and store heat during the day, releasing it slowly at night, which can elevate nighttime temperatures. The simulation outputs highlight significant surface temperature (ST) variations, with values ranging from 24.58°C to 62.74°C. These variations indicate the different thermal behaviors of various materials under the same environmental conditions.

Areas with lighter, reflective surfaces, such as white tiles or treated asphalt, show lower surface temperatures compared to darker, untreated surfaces. Implementing more reflective or cool materials can reduce surface temperatures and improve overall thermal comfort. The concept of albedo, which refers to the reflectivity of a surface, is critical in this context. High-albedo materials reflect a larger fraction of solar radiation, thereby absorbing less heat. For instance, pavements with a high albedo can significantly lower surface temperatures, enhancing comfort for pedestrians and reducing the urban heat island effect.

It is evident in the 2D maps of surface temperature that there is a vast difference between the materials around the market areas, which include stone tile and asphalt pavement in the streets. To address this, replacing old asphalt areas with colored asphalt coatings can be a good option. These coatings can be designed with high-albedo properties to reflect more sunlight and absorb less heat compared to traditional dark asphalt. figure 67 shows the existing condition of port apalazzo.

Additionally, using permeable materials can aid in managing surface runoff and reducing heat retention. Permeable pavements allow water to infiltrate through the surface, which can cool the pavement through evaporation. This process not only reduces surface temperatures but also helps in managing stormwater, reducing the risk of flooding during heavy rains. Incorporating green infrastructure, such as bioswales and rain gardens, can further enhance the benefits of permeable surfaces, contributing to a more sustainable urban environment.



1.asphalt (albedo 0.1) in the main street and some alleys

2. big tiles (sidewalks and around 4 main buildings) (albedo 0.35)
CLS PIASTRELLE

3. small square grey stones (albedo 0,15-0,54 a seconda del materiale)
3.1. square red stone tiles inside the alleys

5- grass (albedo 0.2)

Fig.67 existing condition of porta palzzo area.
source. taken by the author

3.2.3 Vegetation

Vegetation is a vital component in mitigating microclimate effects. The presence of trees and green spaces within the market area can significantly reduce temperatures through shading and evapotranspiration. The ENVI-met model results demonstrate that areas with higher vegetation density exhibit lower air and surface temperatures. For example, the physiological equivalent temperature (PET) ranges from 35.65°C to 60.59°C, indicating significant variations due to vegetation cover.

Strategically increasing green cover, such as planting more trees along walkways and incorporating green roofs on market stalls, can enhance thermal comfort. Trees can provide shade, reducing the need for artificial cooling, and their evapotranspirative cooling effects can further decrease air temperatures. Large-canopy trees are particularly effective in providing shade over large areas, thus significantly reducing the heat island effect.

Additionally, introducing vertical gardens and green walls can optimize space usage while contributing to microclimate regulation. These green elements can be integrated into building facades and market structures, providing cooling effects through evapotranspiration and improving air quality. Moreover, green walls and vertical gardens can enhance the aesthetic appeal of the market, making it a more pleasant environment for visitors and vendors.

The selection of plant species is also crucial in maximizing the benefits of vegetation. Drought-tolerant and native species that require less water and maintenance can be prioritized to ensure the sustainability of green spaces. Additionally, incorporating a diverse range of plant species can support local biodiversity, providing habitats for urban wildlife and enhancing the ecological value of the market area.

3.2.4 Shading Effect

Effective shading can significantly reduce temperatures by blocking direct solar radiation, which is a primary source of heat gain in urban environments. The introduction of shading elements, such as canopies, pergolas, and large umbrellas, can create cooler, more comfortable spaces for vendors and shoppers. Trees are especially valuable for shading, as they not only block sunlight but also cool the air through evapotranspiration.

According to the ENVI-met simulation outputs, areas under effective shade exhibit lower surface and air temperatures compared to exposed areas. For example, shaded areas show surface temperatures (ST) significantly lower than unshaded areas, with differences of up to 10°C in some instances. The 2D maps of surface temperature illustrate these differences clearly, with shaded zones maintaining temperatures around 24.58°C, compared to exposed areas that can reach up to 62.74°C.

Adding tectonic structures made from sustainable materials like Timber and bamboo are renewable resources that sequester carbon dioxide during their growth, can further enhance the microclimate mitigation effects. These materials not only provide effective shading but also contribute to carbon capture, thus reducing the overall carbon footprint of the market.
By strategically placing these shading devices and enhancing tree cover within the market, the overall thermal comfort can be greatly improved. This reduces the reliance on artificial cooling methods and promotes a more sustainable and pleasant shopping environment. This approach not only mitigates the urban heat island effect but also enhances the aesthetic appeal and usability of the market space throughout the day.

3.3 DESIGN SCENARIOS

The findings presented in this chapter identified the elements with the greatest influence, which should be incorporated into mitigation strategies to enhance the thermal conditions on the Porta Palazzo.

By examining various approaches, the chapter identifies and categorizes the most impactful elements into three distinct areas:
market layout optimization, green/blue infrastructures and pavement replacement, and shading structures.
The goal is to create a more comfortable and sustainable environment for both vendors and visitors.

Overall, the strategies presented in this chapter are geared towards creating a more resilient and enjoyable urban environment in Porta Palazzo. By integrating market layout improvements, green/blue infrastructures, and shading solutions, the aim is to transform the market into a cooler, more inviting space for all its users.

The scenarios can be divided to three main part incluidng:

1. Green/Blue infrustructures/
. Implementing Trees in the Square Based on Historical Locations and creating a Green Belt around the square
. Red coating asphalt + Permeable pavements
. Developing Pocket Parks

2. Improving market layouts based on grids on the ground

3. Shading structure with sustainble materials
timber Pergolas both for pedestrain and car parking

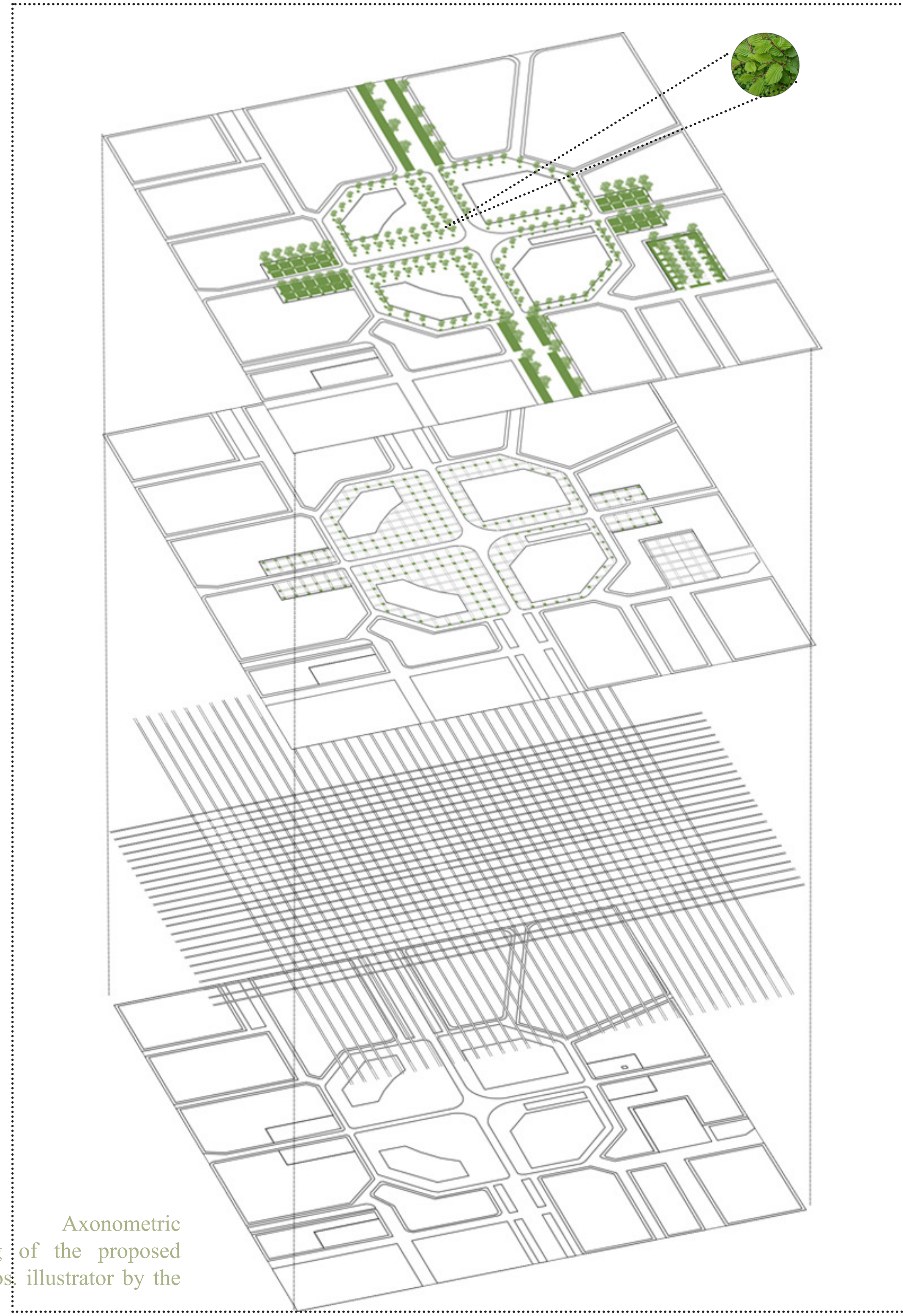


Fig.68 Axonometric drawing of the proposed scenarios illustrator by the author

Implementing Trees in the Square Based on Historical Locations

Reintroducing trees in Porta Palazzo based on their historical locations can significantly enhance the microclimate by providing natural shade, reducing heat absorption, and improving air quality.
Historically, trees played a vital role in urban cooling and creating comfortable public spaces. By carefully selecting and planting tree species that were historically present, we can restore the square's ecological heritage while addressing modern climate challenges.
These trees will offer shade to market visitors, reduce the urban heat island effect, and create a more inviting environment.

figure 69 The steady reduction of green areas over the centuries.
Source: (Coppo et al ., 2006)

Historically, Porta Palazzo was adorned with an array of trees strategically planted around its buildings, Historical documents and archival photographs reveal that these trees were not only ornamental but also functional, providing much-needed shade and cooling for market vendors and visitors. The one/two-lined pathways and squares offered natural canopies that shielded the bustling market from the harsh sun, creating comfortable public spaces that encouraged social interaction and commerce.
The H**ornbeam tree** was chosen for the Porta Palazzo market's microclimate mitigation design due to its adaptability to the climate of Turin and its deciduous nature, providing seasonal shade and cooling

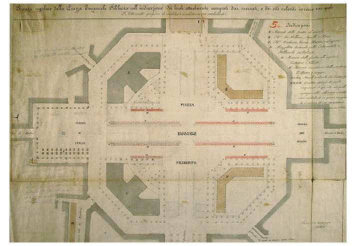
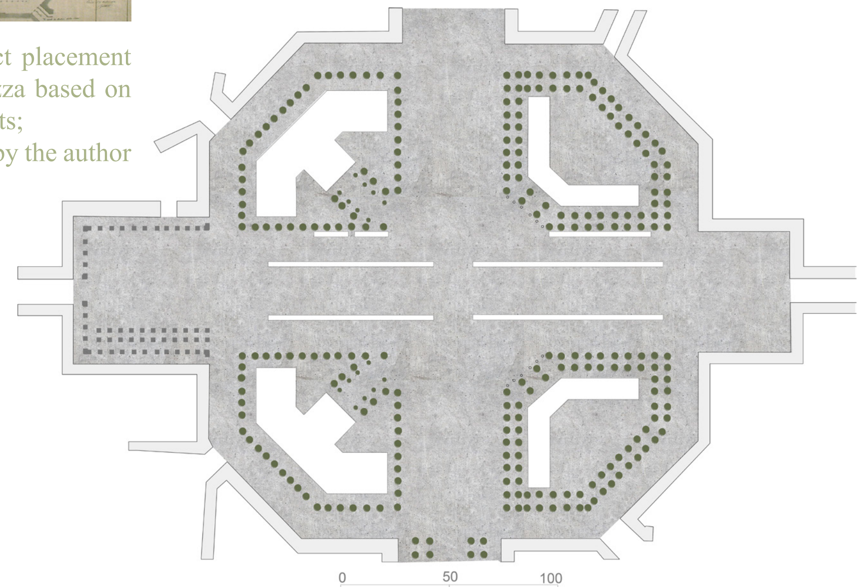


figure 70 The exact placement of trees in the piazza based on historical documents;
source: Illustrated by the author



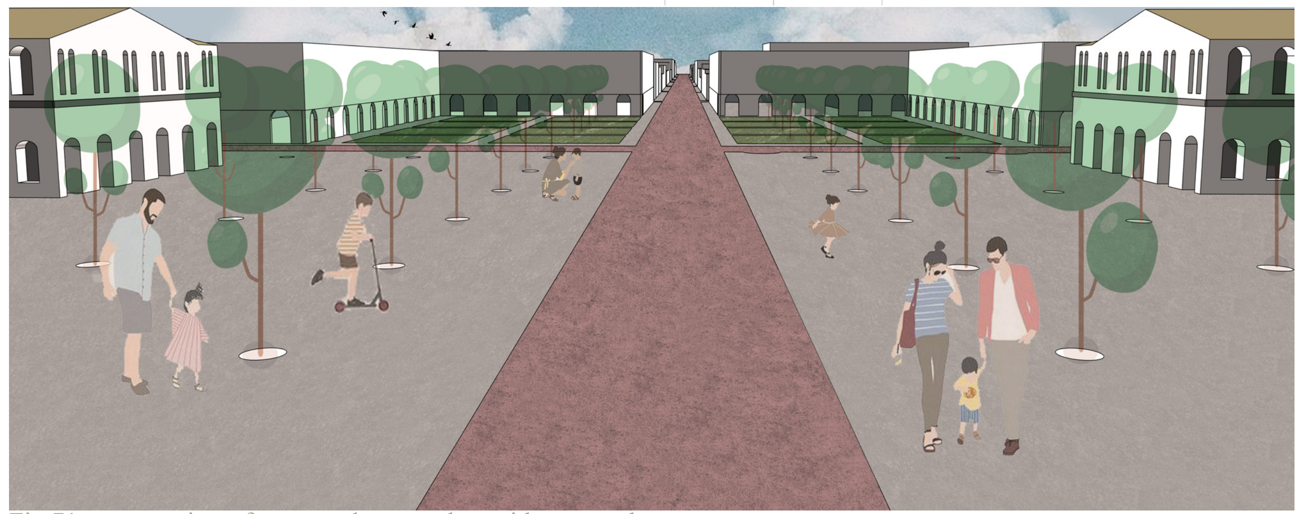
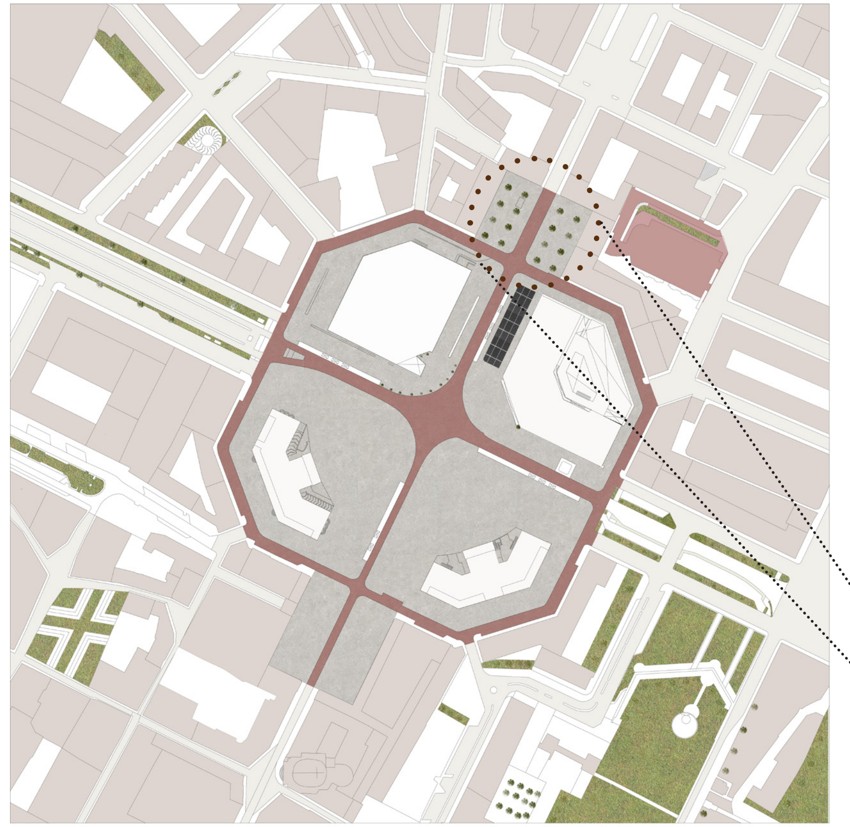


Fig.71 perspective of port apalzzo market with propoed greenary design illustrator by the author

Replaceing asphalt pavement with pavements with higher albedo like «Red coating asphalt» and Permeable pavements in streets around the market and parking area

Fig.72 existing and design pavement of porta palazzo illustrator by the author

Fig.73 red coating asphlat replacement and developing pocket parks as a green infrustructure of porta palazzo illustrator by the author



Developing Pocket Parks:

Pocket parks within Porta Palazzo can provide essential green spaces where visitors can rest, enjoy shade, and eat street food from the market. These small parks can be strategically located to maximize their cooling effects and accessibility. Equipped with seating, greenery, and possibly water features, pocket parks offer a retreat from the bustling market, promoting social interaction and relaxation. They can also act as green oases that break up the urban landscape, contributing to the overall cooling and aesthetic improvement of the square.
The northern and southern parts of the piazza have the potential to develop small greenery and shading areas, where people can rest and eat street food from the market or enjoy the nearby cafes and restaurants.

3.3.2 Second Strategy: Market Layout Optimization Grid

The module for Porta Palazzo is designed based on a square shape that aligns with the two main cross axes formed by Corso Regina Margherita and Corso Giulio Cesare This modular approach creates a coherent and organized ground layout that enhances the spatial structure of the market.

. Indicate the two main axes in the palazza
. Make a Grid Module on the ground bse on these axes
. Place the new trees along side the grid
. Orgnize Market layout based on the grid

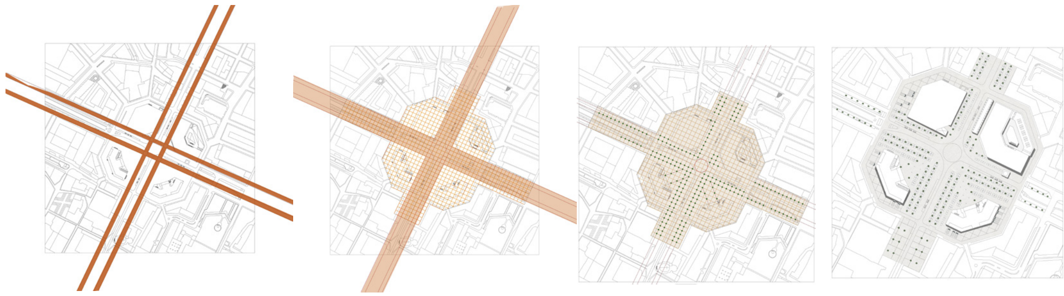


Fig.74 market layout based on grids made of two main axes of porta palazzo, illustrator by the author

In alignment with the historical and ecological aspects of Porta Palazzo, new trees will be planted precisely along the axes of this cross-pattern.
By positioning the trees according to this module, the design pays homage to the historical layout of the piazza while introducing green infrastructure that mitigates the urban heat island effect.
These trees will provide essential shade along the main pathways, enhancing the comfort of market visitors, especially during the warmer months. The systematic placement of trees ensures even distribution of shade and cooling, contributing to a more pleasant and sustainable market environment.
These pathways also provide logical divisions for market stalls, ensuring a balanced distribution of vendors and products across the space. Additionally, the cross-pattern establishes central meeting points and open areas that can host special events, performances, and gatherings, further enriching the market experience for both vendors and shoppers.

Tree A 12 meters Tree B
|<---------------------------->|
|<------ 12 meters ------>|

Hornbeam trees are known for their dense canopies and can grow quite large when fully mature. To ensure that two fully grown hornbeam trees do not intersect and have sufficient space for healthy growth, it is important to consider their mature canopy spread and root system.
Mature Size of Hornbeam Trees
•Height: 12-18 meters
•Spread: 7.5-12 meters

To avoid intersection of their canopies and to ensure proper air circulation, sunlight, and root space, the following spacing is recommended:
•Minimum Distance: The minimum recommended distance between two hornbeam trees is equal to their mature canopy spread. For hornbeam trees, this would be at least 12 meters

The Space Needed
To ensure the canopies do not intersect:
•Tree A: Mature spread = 12 meters
•Tree B: Mature spread = 12 meters

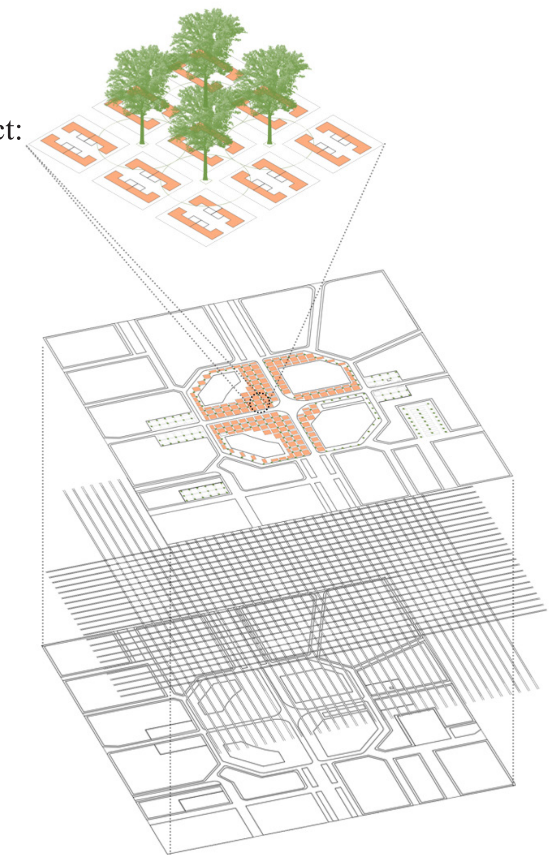
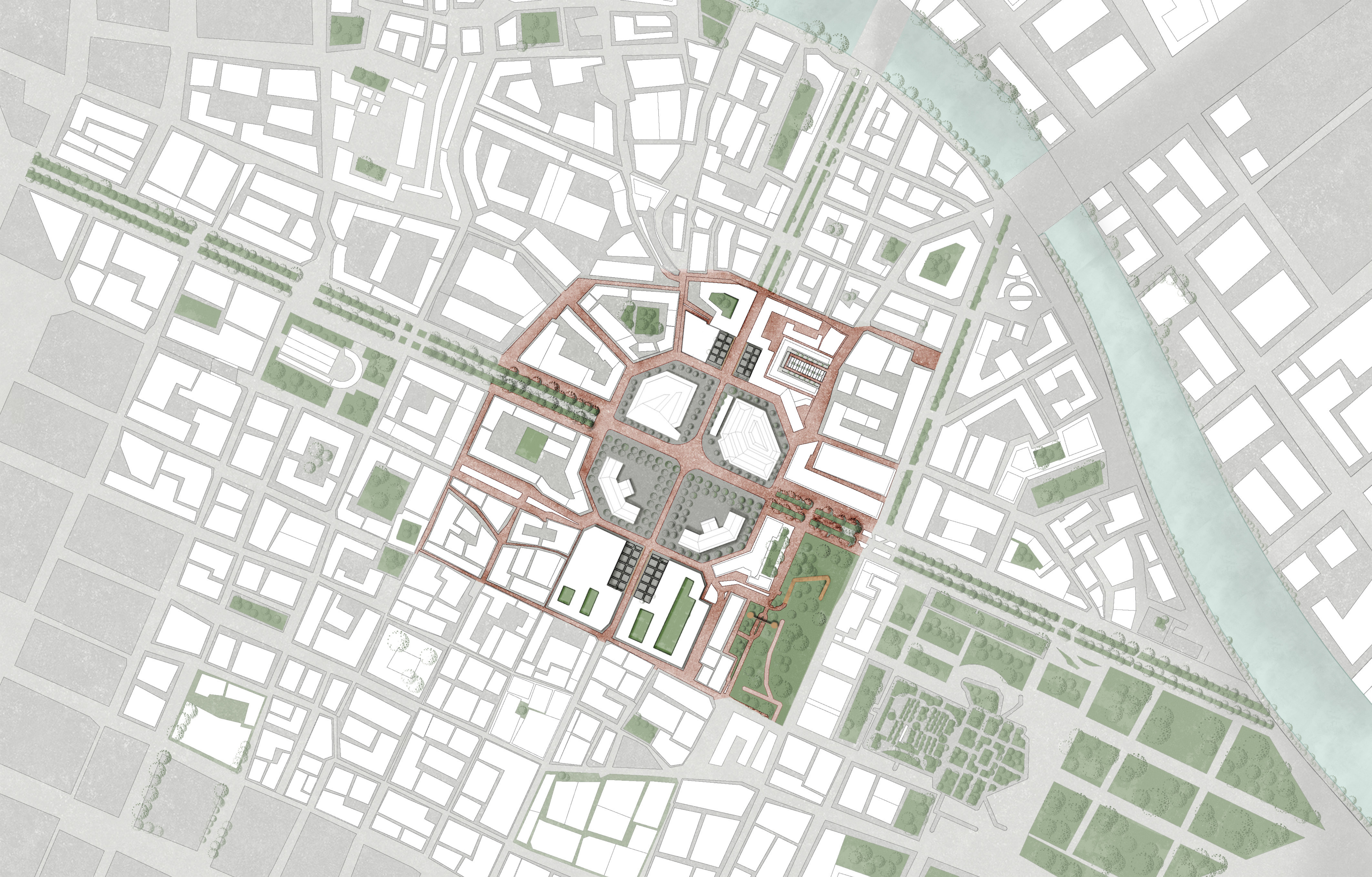


Fig.75 axonometric view of grid module and market layout based on it, illustrator by the author



3.3.3 Thirds Strategy: Integrating Timber Pergolas

Incorporating timber tectonics into the design of Porta Palazzo market can create lightweight, sustainable structures that support vegetation and contribute significantly to microclimate mitigation. These timber structures, such as pergolas and shaded parking areas, can enhance the market environment by providing shade, reducing heat absorption, and integrating greenery. This module can include:

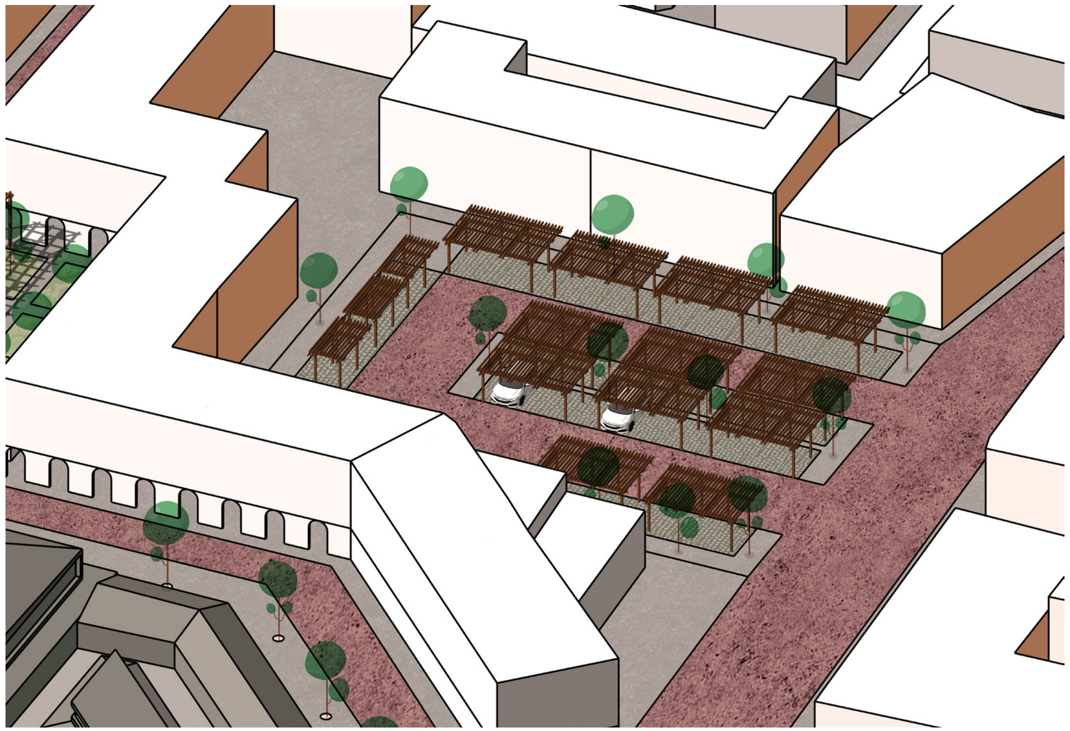
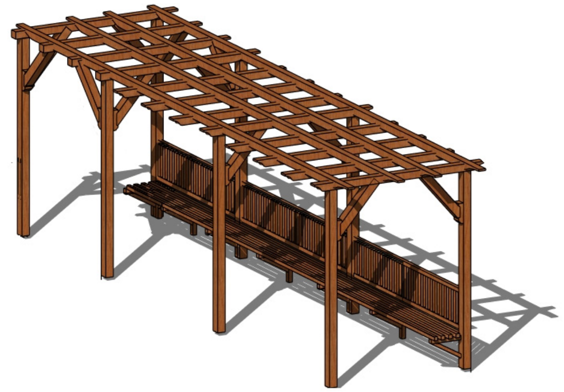
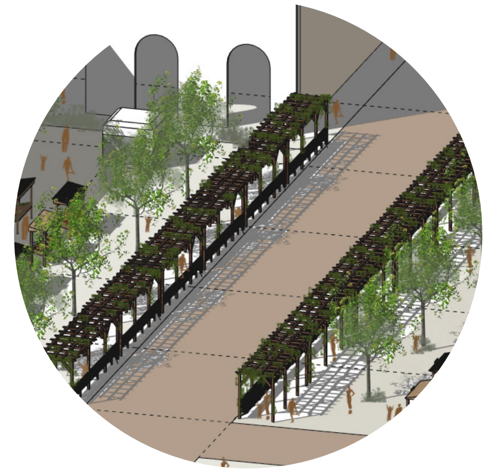
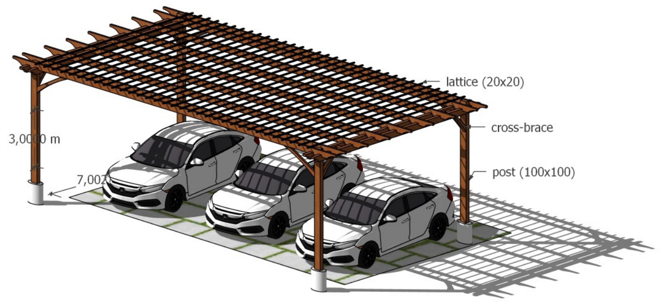
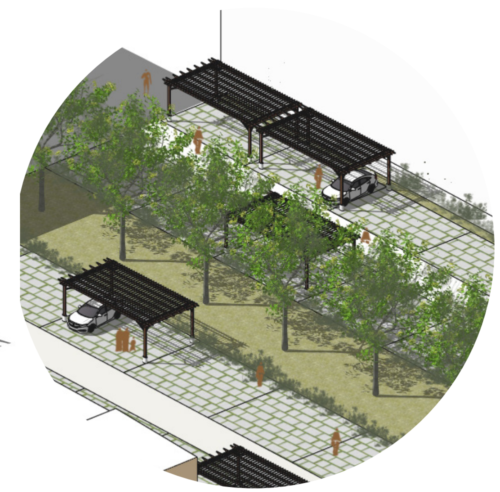


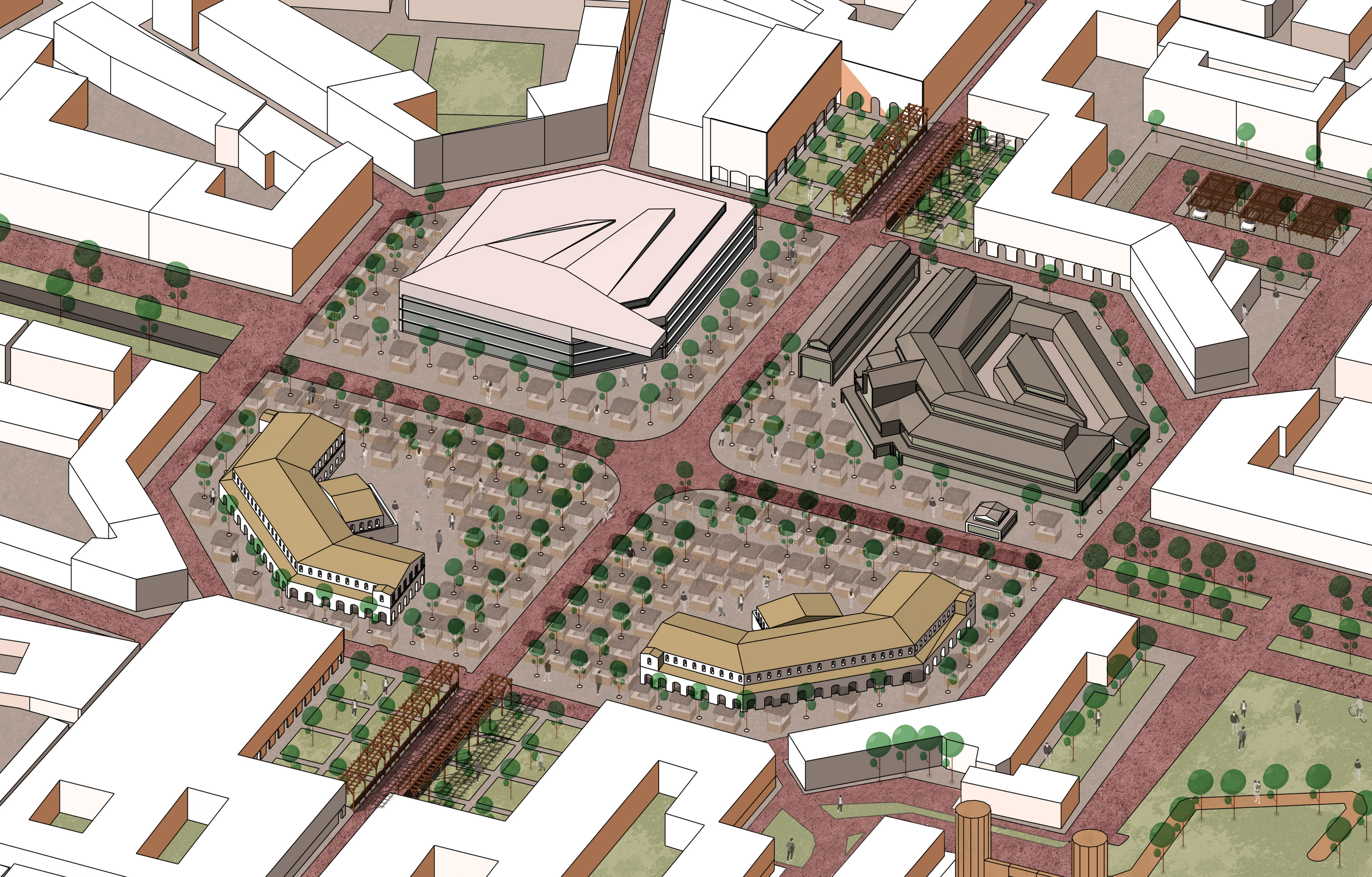
Fig.76 open parking illustration with permable pavements and timber pergolas





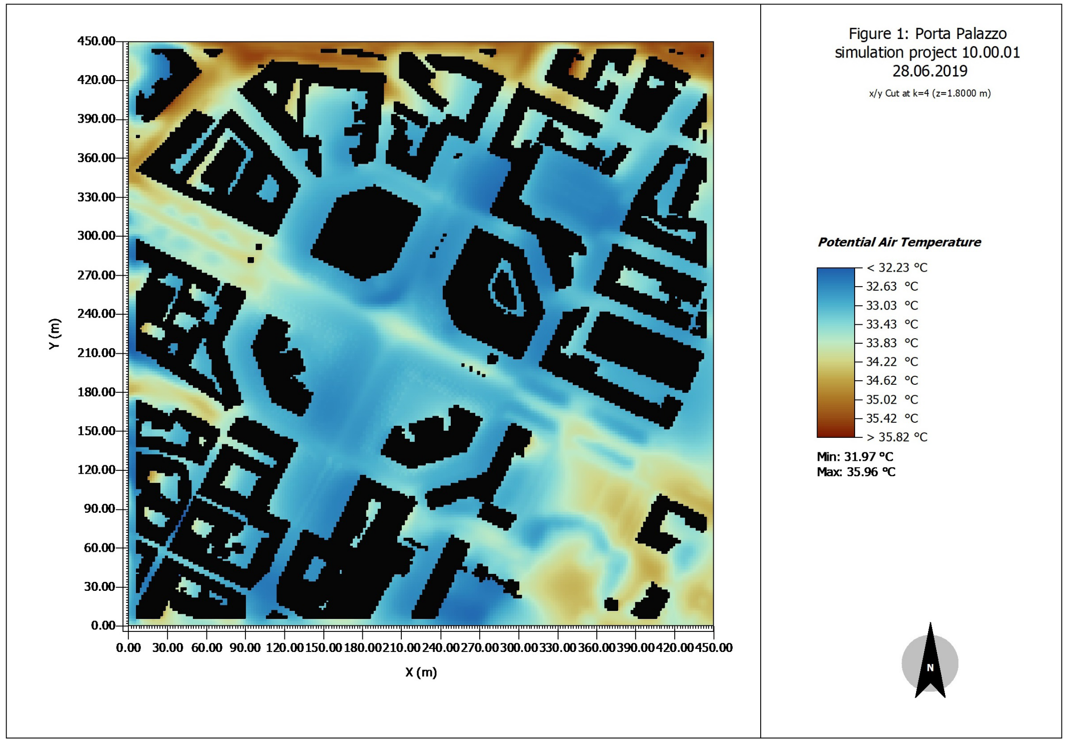


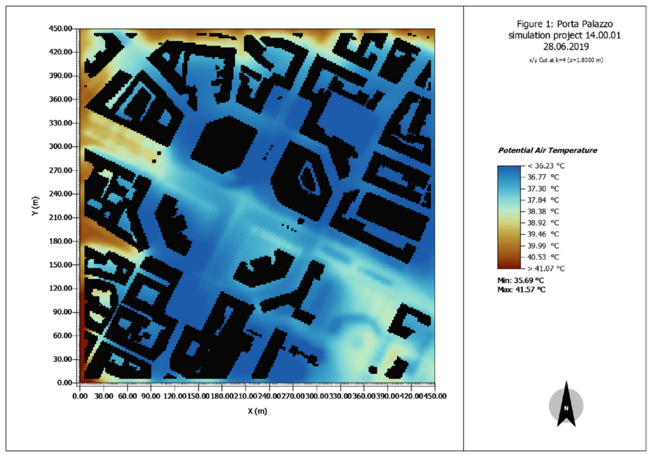


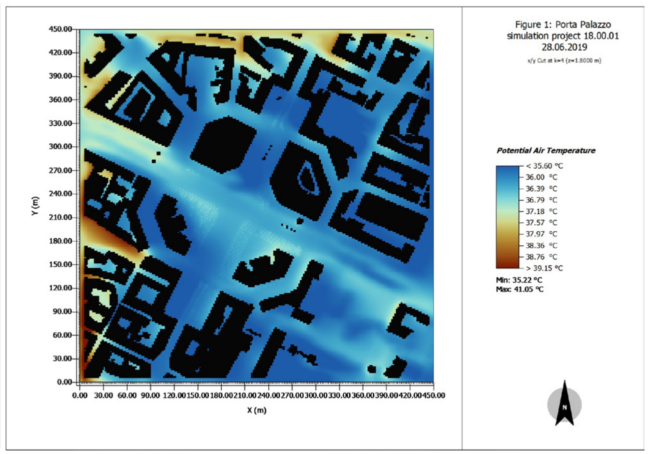


3.3.4 Envi- met results after applying the scenario

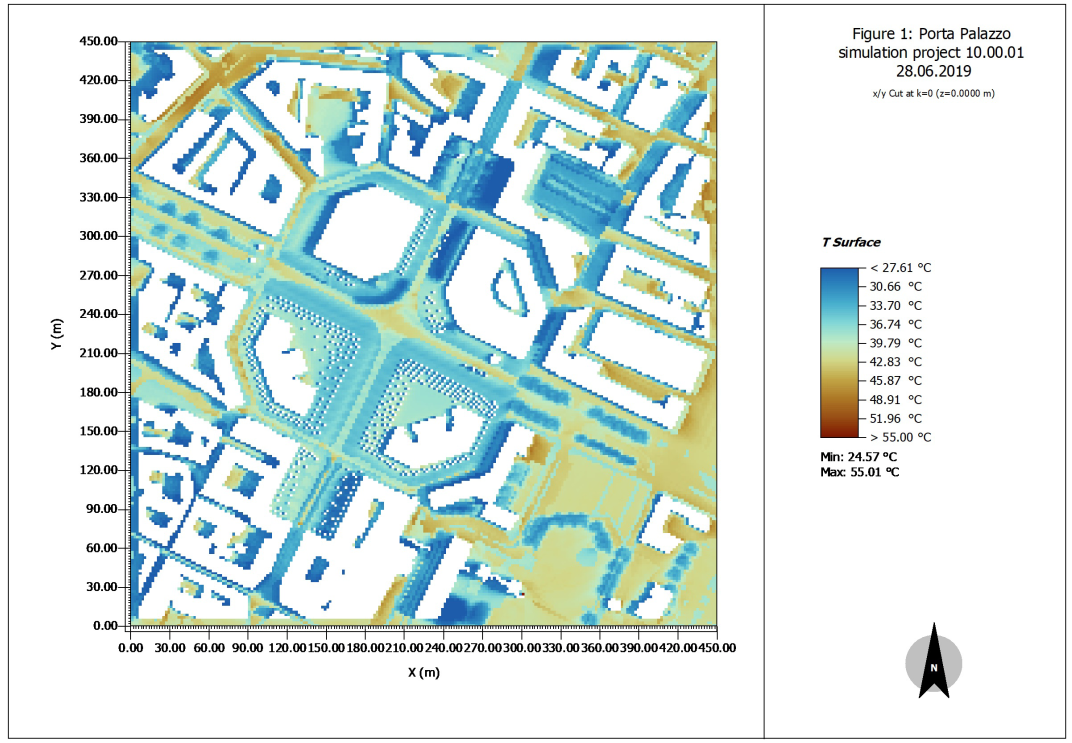
Potential Air Tempreture in Proposed design of Porta Palazzo at 10:00, 14:00,18:00

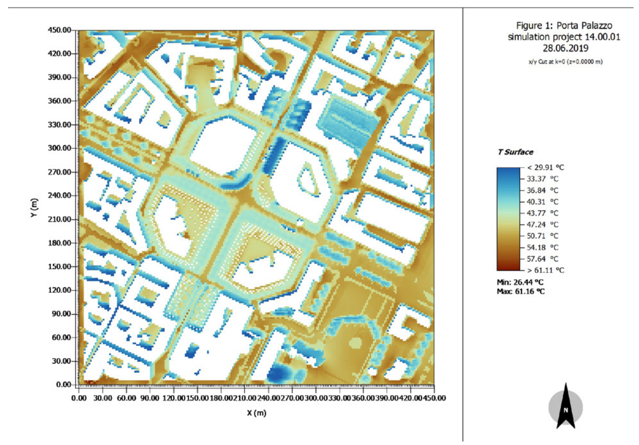


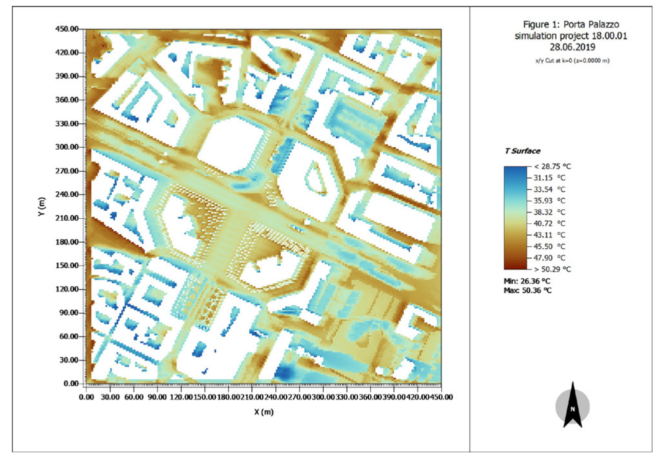




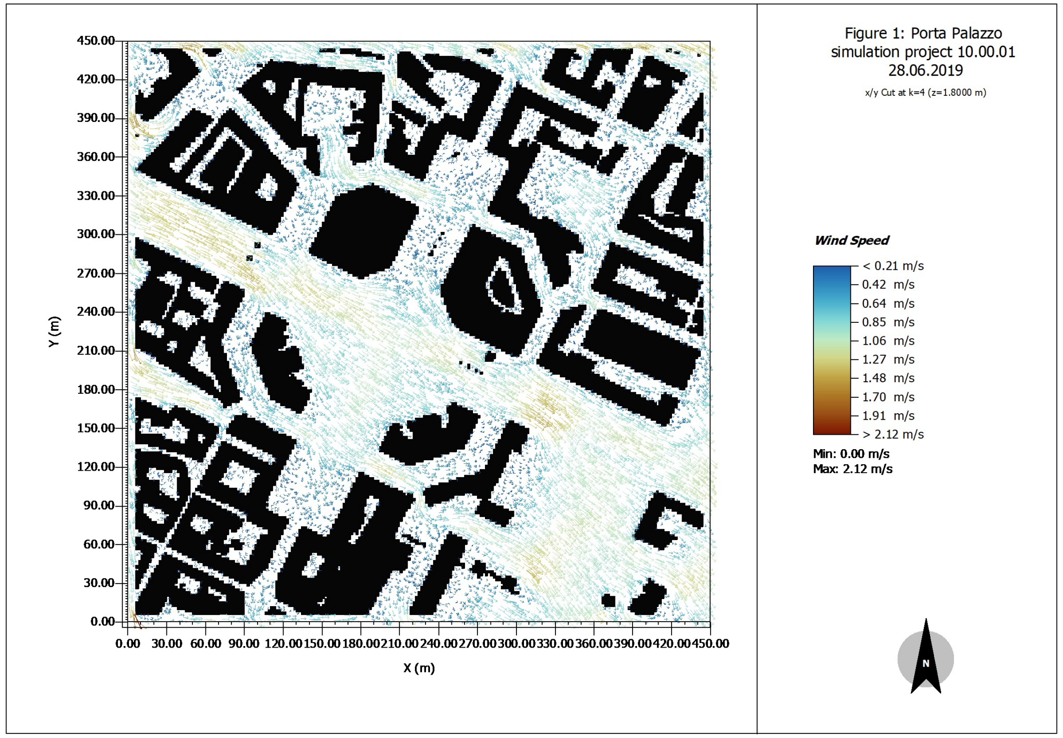
Surface Tempreture n Proposed design of Porta Palazzo at 10:00, 14:00, 18:00

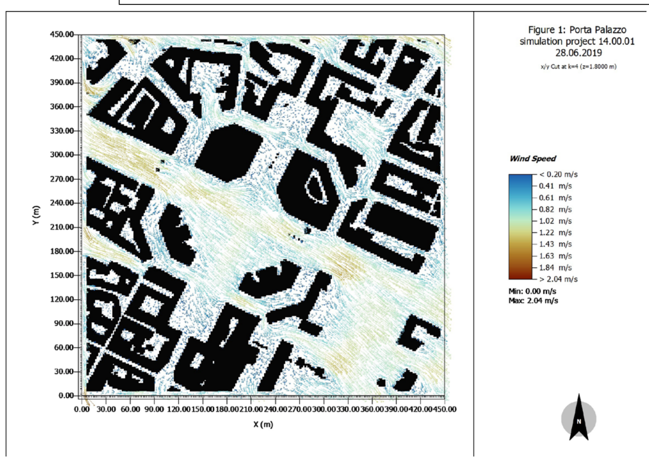


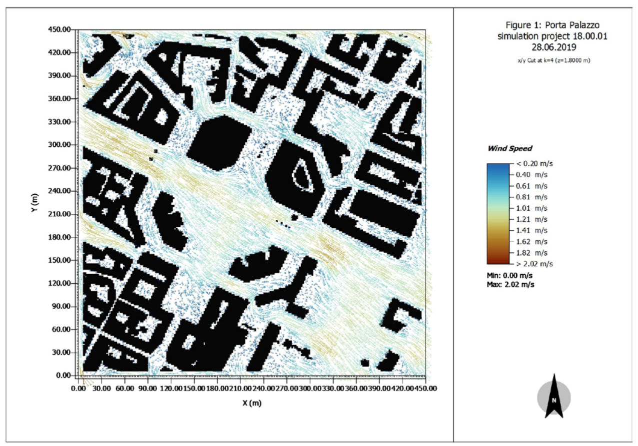




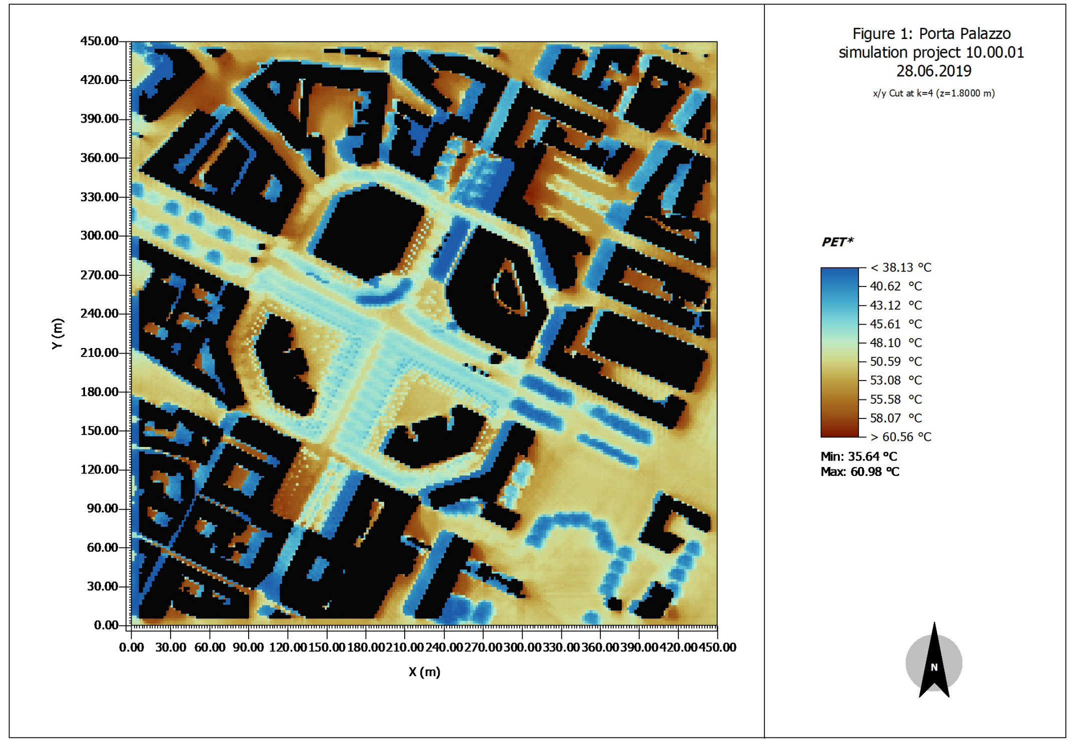
Wind Speed in Proposed design of Porta Palazzo at 10:00, 14:00,18:00

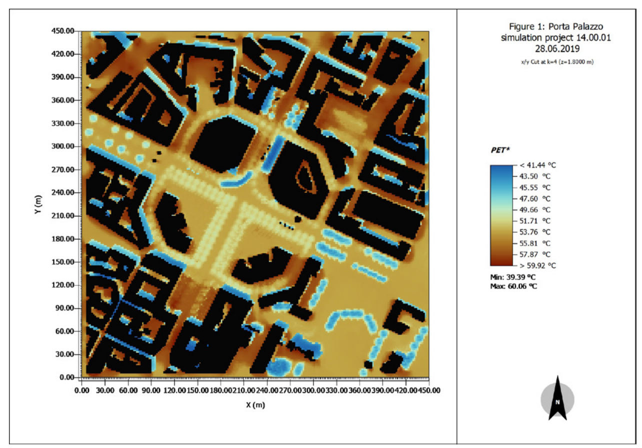


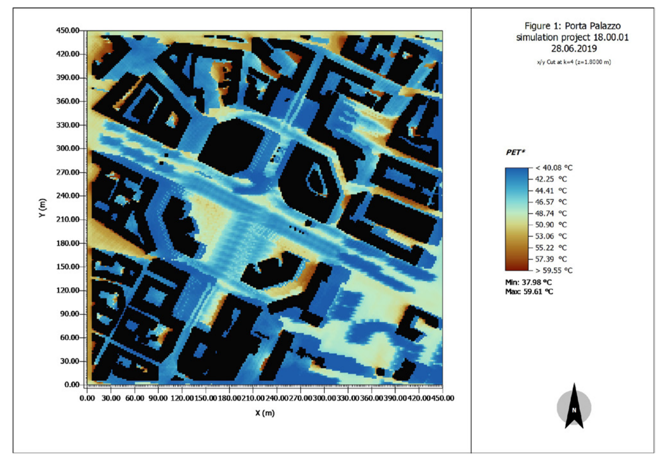




Surface Tempreture n Proposed design of Porta Palazzo at 10:00, 14:00, 18:00







4. Conclutsion

The research conducted for this thesis has provided valuable insights into the microclimate conditions of the Porta Palazzo Market in Turin. Through a comprehensive analysis using ENVI-met software, coupled with historical context and case studies, several key conclusions can be drawn.

The microclimate of the Porta Palazzo Market is significantly influenced by surface materials, shading elements, and urban design features. The simulation outputs revealed substantial variations in surface temperatures across different materials, with values ranging from 24.58°C to 62.74°C. Lighter, reflective surfaces like treated asphalt or white tiles demonstrated lower surface temperatures compared to darker, untreated surfaces. This indicates the critical role of surface albedo in regulating thermal conditions.

One of the most impactful factors on the market environment is the high thermal mass of materials like concrete and traditional asphalt, which absorb and retain heat, exacerbating nighttime temperatures. The adoption of more reflective materials and permeable pavements can mitigate these effects by lowering surface temperatures and enhancing thermal comfort. The 2D maps of surface temperature vividly illustrate the temperature differences between stone tile areas and asphalt-paved streets, underscoring the potential benefits of material selection and design interventions.

Furthermore, the survey conducted with shopkeepers and market visitors highlighted heat as the most significant microclimate factor affecting business operations and visitor comfort. This emphasizes the necessity of addressing heat mitigation in urban design strategies to enhance the overall market experience.

Additionally, implementing shading solutions such as pergolas or canopies made from sustainable materials like timber or bamboo can effectively reduce solar exposure and improve comfort. These structures not only provide immediate relief from the sun but also contribute to carbon capture, promoting environmental sustainability.

In conclusion, the findings of this thesis underscore the importance of targeted microclimate interventions to improve thermal comfort and sustainability in urban markets. The insights gained from the Porta Palazzo Market can serve as a blueprint for similar markets facing microclimate challenges, demonstrating that thoughtful design and material choices can significantly enhance urban resilience and livability.

Future Studies

Future research on microclimate mitigation in urban markets could explore several avenues to build upon the findings of this thesis.

Long-Term Monitoring: Implementing long-term monitoring of microclimate parameters would provide a more comprehensive understanding of seasonal variations and the effectiveness of different mitigation strategies over time.

User Behavior Analysis: Investigating how market users adapt their behavior in response to different microclimate conditions could offer deeper insights into the practical implications of design interventions.

Innovative Materials: Exploring the use of innovative, sustainable materials with high albedo and permeability can further enhance thermal comfort and environmental benefits. For example, colored coatings for asphalt that reflect more solar radiation while maintaining aesthetic appeal could be a focus area.

Green Infrastructure Integration: Examining the integration of green infrastructure such as green roofs, vertical gardens, and urban forests within market environments can offer additional cooling benefits and enhance biodiversity.

Cross-Disciplinary Approaches: Collaborating with experts in fields such as climatology, urban planning, and environmental psychology can enrich the research, leading to more holistic and effective microclimate mitigation strategies.

By pursuing these research directions, future studies can contribute to more sustainable and comfortable urban markets, ultimately fostering healthier and more vibrant urban communities.

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Appendix

Carissimi visitatori e proprietari del mercato di Porta Palazzo,

Sono uno studente di architettura al Politecnico di Torino e attualmente sto lavorando alla mia tesi sul tema della mitigazione del microclima a Porta Palazzo. Il mio obiettivo è raccogliere dati e analizzarli per sviluppare un progetto di design che possa contribuire a risolvere i problemi di microclima presenti nel mercato.

Il vostro contributo è fondamentale per il successo del mio progetto, e sarei molto grato se poteste aiutarmi compilando questo questionario. Non ci sono risposte giuste o sbagliate, e la vostra privacy sarà garantita. Le vostre risposte saranno mantenute confidenziali e utilizzate solo per scopi di ricerca.

Vi ringrazio anticipatamente per il vostro tempo e contributo al mio progetto.

Proprietari del mercato:

1- A che ora arrivi di solito al mercato?

a. Prima delle 5 del mattino

b. Tra le 5 e le 6 del mattino

c. Tra le 6 e le 7 del mattino

d. Dopo le 7 del mattino

2- Qual è la tua media giornaliera di lavoro? (Seleziona tutte le opzioni applicabili)

a. Mattina presto (dalle 5 alle 8 del mattino)

b. Mattina tarda (dalle 8 del mattino alle 12 del pomeriggio)

c. Pomeriggio (dalle 12 alle 4 del pomeriggio)

d. Sera (dalle 4 alle 8 di sera)

e. Notte tarda (dopo le 8 di sera)

3- A che ora chiudi il tuo banco/attività al mercato di Porta Palazzo?

Prima delle 14

Tra le 14 e le 16

Tra le 16 e le 18

Tra le 18 e le 20

Dopo le 20

Dipende dal giorno

Altro (specificare): ____________

4- Quanti giorni alla settimana lavori al mercato?

a. 1-2 giorni

b. 3-4 giorni

c. 5-6 giorni

d. Tutti i giorni

5- Quante ore al giorno lavori di solito al mercato?

a. Meno di 4 ore

b. Da 4 a 6 ore

c. Da 6 a 8 ore

d. Più di 8 ore

6- Quali prodotti vendi nel tuo negozio?

a. Frutta e verdura fresca

b. Prodotti alimentari come carne e latticini

c. Abbigliamento e accessori

d. Prodotti per la casa e elettrodomestici

7- Da quanti anni vendi al mercato?

a. Meno di 5 anni

b. Da 5 a 10 anni

c. Da 10 a 15 anni

d. Più di 15 anni

8- Quali sono le maggiori sfide che incontri come proprietario di un banco al mercato? (Seleziona tutte le opzioni applicabili)

a. Concorrenza da parte di altri venditori

b. Costi di affitto elevati

c. Spazio limitato per l'esposizione dei prodotti

d. Difficoltà nell'ottenere permessi o licenze

e. Problemi di gestione dei rifiuti o di igiene

f. Condizioni meteorologiche (ad esempio vento, pioggia, temperature estreme)

g. Preoccupazioni per la sicurezza (ad esempio furto, vandalismo)

h. Mancanza di passaggio o domanda dei clienti

i. Altro (specificare): _______________

9- Quali fattori influenzano la tua decisione su quando iniziare e finire a commerciare al mercato?

Disponibilità di prodotti da vendere

Domanda dei clienti

Condizioni meteorologiche

Attività dei concorrenti

Preferenze personali o stile di vita

Regolamenti o linee guida del mercato

Disponibilità di personale o lavoratori

Altro (specificare): ________________________

10- Hai notato dei cambiamenti nel microclima del mercato nel corso degli anni? In caso affermativo, quali sono?

Sì, ho notato un aumento della temperatura

Sì, ho notato una diminuzione della temperatura

Sì, ho notato cambiamenti nei livelli di umidità

Sì, ho notato cambiamenti nella qualità dell'aria

No, non ho notato alcun cambiamento nel microclima

11- Hai adottato misure per mitigare gli effetti del microclima sul tuo banco/attività commerciale nel mercato?

Sì, ho installato ventilatori o altri dispositivi di raffreddamento

Sì, ho installato dispositivi di riscaldamento

Sì, ho installato strutture o ombrelloni per l'ombreggiamento

Sì, ho apportato modifiche alla disposizione del mio banco/attività commerciale per ottimizzare la circolazione dell'aria

No, non ho adottato alcuna misura per mitigare gli effetti del microclima

Altro (si prega di specificare): ________

12- Quanto è importante il mercato per la tua attività commerciale e il tuo sostentamento?

Estremamente importante

Molto importante

Abbastanza importante

Non molto importante

Per niente importante

13- Quanto sei soddisfatto delle condizioni attuali del mercato in termini di microclima? In scala da 1 a 5

1

2

3

4

5

14- Pensi che il governo locale dovrebbe adottare maggiori misure per mitigare gli effetti del microclima nella zona del mercato?

Sì

No

15- "Se ti fosse data l'opportunità di apportare un cambiamento al mercato di Porta Palazzo per migliorare il microclima, su quale delle seguenti opzioni ti concentreresti? Seleziona tutte quelle pertinenti:

Aggiungere più vegetazione

Aumentare la distanza tra i banchi

Implementare strutture di ombreggiamento

Utilizzare tecniche di ventilazione naturale"

negozianti permanenti nel mercato di Porta Palazzo:

1- A che ora di solito apri il tuo negozio?

a. Prima delle 8 del mattino

b. Tra le 8 e le 9 del mattino

c. Tra le 9 e le 10 del mattino

d. Dopo le 10 del mattino

2- Quanti giorni alla settimana tieni il tuo negozio aperto?

a. 1-2 giorni

b. 3-4 giorni

c. 5-6 giorni

d. Tutti i giorni

3- Quante ore al giorno è di solito aperto il tuo negozio?

a. Meno di 4 ore

b. 4-6 ore

c. 6-8 ore

d. Più di 8 ore

4- Che tipi di prodotti vendi?

a. Alimentari e prodotti agricoli

b. Abbigliamento e tessuti

c. Prodotti per la casa e gli elettrodomestici

d. Altro (specificare): ________

5- Da quanti anni operi in questa posizione?

a. Meno di 5 anni

b. 5-10 anni

c. 10-15 anni

d. Più di 15 anni

6- Quali sono le principali sfide che affronti come proprietario di un negozio permanente nel mercato? (Selezionare tutte le opzioni applicabili)

a. Concorrenza dagli altri negozi nel mercato

b. Difficoltà economiche

c. Difficoltà nell'ottenere prodotti di qualità

d. Difficoltà a mantenere i clienti

e. Altro (specificare): _______

7- Come promuovi la tua attività ai potenziali clienti? (Selezionare tutte le opzioni applicabili)

a. Social media

b. Volantini o brochure

c. Passaparola

d. Sconti o promozioni

e. Altro (specificare): _______

8- Quali sono i giorni e gli orari più frenetici per la tua attività?

Lunedì

Martedì

Mercoledì

Giovedì

Venerdì

Sabato

Domenica

Mattina (dalle 8 alle 12)

Pomeriggio (dalle 12 alle 16)

Sera (dalle 16 alle 20)

9- Quali sono le principali sfide che affronti come proprietario di un negozio permanente nel mercato?

Concorrenza dagli altri negozi

Cambiamenti nella domanda o nelle preferenze dei clienti

Difficoltà nell'ottenere forniture o inventario

Affitti o costi di gestione elevati

Difficoltà nel mantenere i dipendenti

Sfide di marketing o pubblicità

Questioni di regolamentazione o licenze

Preoccupazioni di sicurezza

Altro (specificare): _______

10- Come ottieni i tuoi prodotti?

Produttori locali

Mercati all'ingrosso

Importatori

Produzione propria

Altro (specificare): _______

11- Come determina i suoi prezzi?

In base al costo di produzione

In base al prezzo di prodotti simili sul mercato

In base alla domanda e all'offerta presenti sul mercato

In base alla margine di profitto desiderata

In base alla negoziazione con il cliente

In base alla stagionalità del prodotto

In base alla qualità e all'unicità del prodotto

In base alla strategia di prezzo del business.

12- Ha notato cambiamenti nel mercato nel corso degli anni in cui ha operato qui?

Sì

No

13- In caso affermativo, quali cambiamenti ha notato nel mercato nel corso degli anni? (Risposte multiple)

Aumento del numero di clienti

Cambiamenti nella demografia dei clienti

Cambiamenti nella concorrenza tra i venditori

Cambiamenti nei tipi di prodotti in vendita

Cambiamenti nell'infrastruttura o nelle strutture del mercato

Cambiamenti nella disposizione o nell'organizzazione del mercato

Cambiamenti nelle regole o nelle politiche che influiscono sul mercato

Aumento o diminuzione dei prezzi dei prodotti

Cambiamenti nelle strategie di marketing o negli sforzi pubblicitari

Altro (specificare): _______________

14- Come ha influenzato la pandemia COVID-19 la sua attività?

Diminuzione del traffico pedonale nel mercato

Riduzione delle vendite e del fatturato

Cambiamenti nel comportamento dei clienti (ad es. maggiore acquisto online)

Difficoltà nel reperire prodotti

Aumento dei costi operativi (ad es. misure igieniche)

Limitazioni e regolamentazioni governative che influiscono sulle operazioni commerciali

Altro (specificare): _______________

15- Come interagisce con i clienti e costruisce rapporti con loro?

Offrendo raccomandazioni o consigli personalizzati

Fornendo un'eccellente assistenza clienti

Creando un'atmosfera accogliente e amichevole

Offrendo programmi di fedeltà o di ricompensa

Interagendo con i clienti sui social media

Partecipando ad eventi o iniziative comunitarie

Offrendo sconti o promozioni

Fornendo campioni o demo dei prodotti

Altro (specificare): _________________

16- Quanto è soddisfatto delle condizioni attuali del mercato in termini di microclima? Su una scala da 1 a 5

1

2

3

4

5

15- "Se ti fosse data l'opportunità di apportare un cambiamento al mercato di Porta Palazzo per migliorare il microclima, su quale delle seguenti opzioni ti concentreresti? Seleziona tutte quelle pertinenti:

Aggiungere più vegetazione

Aumentare la distanza tra i banchi

Implementare strutture di ombreggiamento

Utilizzare tecniche di ventilazione naturale"

persone che vengono a fare la spesa al mercato:

1- **Quanto spesso vai al mercato?**

a. Una volta alla settimana

b. 2-3 volte alla settimana

c. Una volta al mese

d. Raramente o mai

2- A che ora del giorno solitamente vai al mercato?

a. Mattina presto

b. Mattina tardi

c. Pomeriggio presto

d. Pomeriggio tardi

3- Quali tipi di prodotti solitamente acquisti al mercato?

a. Alimenti e prodotti agricoli

b. Abbigliamento e tessuti

c. Prodotti per la casa e elettrodomestici

d. Altro (specificare)

4- A che ora del giorno solitamente visiti il mercato? (Seleziona tutte le risposte pertinenti)

a. Mattina presto (5-8am)

b. Mattina tardi (8am-12pm)

c. Pomeriggio (12-4pm)

d. Sera (4-8pm)

e. Notte tarda (dopo le 8pm)

5- Come solitamente arrivi al mercato?

a. A piedi

b. In bicicletta

c. Trasporto pubblico

d. In auto

6- Quanto sono importanti i seguenti fattori nella tua decisione di fare acquisti al mercato? (Seleziona tutte le risposte pertinenti)

a. Prezzo

b. Qualità dei prodotti

c. Variedade dei prodotti

d. Prossimità da casa o dal lavoro

e. Altro (specificare) __

7- Preferisci fare acquisti al mercato o in un supermercato tradizionale? Perché?

Preferisco fare acquisti al mercato perché:

a. Posso trovare prodotti unici e di origine locale

b. Offre un'atmosfera più vivace e animata

c. Posso interagire direttamente con i venditori e ottenere maggiori informazioni sui prodotti

d. Preferisco sostenere le piccole imprese e l'economia locale

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8- Preferisco fare acquisti in un supermercato tradizionale perché:

a. Offre più varietà e scelta di prodotti

b. È più conveniente e efficiente in termini di tempo

c. I prodotti sono più standardizzati e prevedibili in termini di qualità

d. Posso trovare offerte e sconti migliori sui prodotti

9- Ritieni che il mercato offra una migliore selezione di prodotti rispetto ad altri luoghi di acquisto nella zona?

Sì, il mercato offre una più ampia varietà di prodotti rispetto ad altri luoghi di acquisto

No, posso trovare tutto ciò di cui ho bisogno in altri luoghi di acquisto

A volte, dipende da ciò che cerco

Non sono sicuro/a

10- Hai notato qualche cambiamento nel mercato nel corso degli anni? Se sì, quali sono?

Aumento del numero di clienti

Cambiamenti nella demografia dei clienti

Cambiamenti nella concorrenza tra i venditori

Cambiamenti nei tipi di prodotti venduti

Cambiamenti nell'infrastruttura o nelle strutture di mercato

Cambiamenti nel layout o nell'organizzazione del mercato

Cambiamenti nelle normative o politiche che influenzano il mercato

Aumento o diminuzione dei prezzi dei prodotti

Cambiamenti nelle strategie di marketing o negli sforzi pubblicitari

Altro (specificare)

10- Quanto è importante il mercato per la comunità locale?

Estremamente importante

Molto importante

Moderatamente importante

Poco importante

Non importante affatto

11- Quanto sei soddisfatto/a delle condizioni attuali del mercato in termini di microclima? Scala da 1 a 5

1

2

3

4

5

12- Saresti disposto/a a pagare di più per prodotti o servizi eco-sostenibili che contribuiscano a mitigare gli effetti del microclima nella zona del mercato?

Sì

No

15- "Se ti fosse data l'opportunità di apportare un cambiamento al mercato di Porta Palazzo per migliorare il microclima, su quale delle seguenti opzioni ti concentreresti? Seleziona tutte quelle pertinenti:

Aggiungere più vegetazione

Aumentare la distanza tra i banchi

Implementare strutture di ombreggiamento

Utilizzare tecniche di ventilazione naturale