POLITECNICO DI TORINO

Master of Science Program in

ARCHITECTURE FOR THE SUSTAINABILITY DESIGN

Final Thesis Report

Sustainable Mobility and Resilient Infrastructure

A Case Study in Regio Parco Region, Torino

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Abstract

Most countries have witnessed rapid urbanization and growing use of automobiles for more than half a century. This has resulted in increased urban expansion and increased demand for motorized transportation, with a variety of environmental, social, and economic effects. Urban transportation is a major source of greenhouse gas emissions and a health hazard owing to air and noise pollution. Commuters and goods transporters bear enormous economic and productivity losses as a result of traffic congestion caused by unsustainable transportation infrastructures. These issues are more acute in cities in developing countries. In the following decades, this region will account for over 90% of world population growth. These communities are already straining to fulfill the rising demand for transportation investment.

In this thesis, we analyze the region of Regio Parco in Torino, Italy on its mobility aspects and redesign the system to mitigate and resist the changes that are occurring in the environment by using different passive techniques. We emphasize on the soft mobility aspects and encourage people through architecture and planning. This is done in 4 parts. We first build a background in Mobility and understand different aspects of the concept. Then, there is an emphasis on climate change and strategies to adapt, mitigate and resist it. During these parts we go through case studies that have been through such processes to give us a better understanding on the topics. Then we analyze the region of Regio Parco focusing on the mobility and green infrastructure. This level of detail begins with some background on the intervention city, Turin. After locating it and briefly framing it from a historical/social standpoint, the resident population and its evolution over the previous few years, the climate and the effects of climate change it is experiencing are all discussed. We use the software of EnviMET to get information on the micro climate situation of the zone. Moving down the degree of detail, we arrive at the identification of problem areas and its Regio Parco district, on which the individual places under investigation insist, which are explored both from a geographical and historical standpoint.

Introduction

Many international examples suggest that expanding infrastructure for private vehicles is not the answer. Rather, the solutions lay in reshaping our towns and cities in ways that make it easier for more people to get around and create lively spaces for people to enjoy. These kinds of improvements in our streets can be difficult to adopt, but cities are discovering that experimenting with them can help people envision their streets, resulting in project implementation being sped up.

Every day, European cities show that reducing the use of personal automobiles is not only desired, but also doable. Incentives for public transportation, car-sharing, and bicycles are used in Amsterdam, Barcelona, Bremen, Copenhagen, Edinburgh, Ferrara, Graz, and Strasbourg, as well as restrictions on the use of private cars in respective city centers.

These cities' economic growth and access to retail malls are unaffected. They actually support them because they recognize that unrestricted car use for individual travels is no longer compatible with simple mobility for the majority of inhabitants.

Their strategy is completely consistent with the European Union's worldwide commitments to reduce greenhouse gas emissions and European air quality legislation. This mandates the implementation of local strategies to regulate and improve urban air quality, as well as the notification of citizens in the event of major pollution. This has been the situation for ozone for numerous years. The way cities (and, by extension, significant corporations) organize their transportation networks will be a key problem in the coming years, especially since the Commission will publish a list of regions whose air quality does not meet an acceptable level each year.

Aim

The study's goal is to conduct an assessment of urban area in Turin's northern outskirts, specifically in the Regio Parco district, which is close to the Po River and some of the city's most important green infrastructures. The area is characterized by a broad presence of public residential structures, which are managed by the ATC (Territorial Agency for the Piedmont House Central), and by various types of settlement development, including compact and semi-compact courtyards and buildings in line. The purpose is to design a good mobility system that can make a difference in the lives of the car oriented society and push them towards a more environmental friendly and climate supportive Urban Mobility System.

This study determines the thermal comfort performance of various public places in order to plan for a long-term sustainable urban mobility and green development. In order to achieve this, Computational Fluid Dynamics (CFD) model was set up in the ENVI-met environment. The software examines the local environment, taking into consideration the impact of plants on the atmosphere, radiation, and the earth. Building shape, horizontal surface properties, and the quantity and quality of vegetation are all included during the modeling phase. The orthophotos and the thorough Geo-referenced Information System (GIS) of the Municipality were two of the most important resources used to create the 3D models(e.g. building height, tree species). On the other side, by comparing the simulation results, the places with the worst micro-climatic features can be identified. This reality, which is less than ideal in terms of environmental quality, will be exacerbated by a design vision that intervenes through a combination of adaptation and mitigation efforts.

Mobility

1.1
What is Mobility?

The movement of people, animals, and products from one location to another is known as mobility or transportation. People must travel from one location to another on a daily basis for a variety of reasons, including job, recreation, and education. Mobility has a significant influence on our actions and judgments. Mobility influences the type of architecture that is required on a larger scale, but architecture can impact the type of mobility that people use on a smaller scale. For example, if there is a pleasant bicycle path and beautiful scenery along the way to their destination, a person may be more likely to ride a bicycle. Similarly, if there is no parking infrastructure near their destination, a person would avoid driving. The distance between the origin and the destination is another element that determines the form of transportation employed. If I needed to travel to a store in another neighborhood or further out, I would drive, but if the store was only down the street, I would ride my bike or walk.[*1]

Infrastructure, vehicles, and operations are the three components of transportation. Fixed installations such as roads, railways, airways, waterways, canals, and pipelines, as well as terminals such as airports, railway stations, bus stations, warehouses, trucking terminals, refueling depots, and seaports, make up transportation infrastructure. Terminals can be used for passenger and cargo interchange as well as maintenance. By providing the fixed infrastructure that mobility necessitates, architecture plays a critical role. Mobility is one of the world's largest energy consumers, as well as a source of many environmental challenges, particularly in urban areas.

Transportation consumes a significant amount of energy and consumes the majority of the world's petroleum. This causes air pollution, such as nitrous oxides and particles, and contributes to global warming by emitting carbon dioxide, with transportation being the fastest-growing source of CO2. Road transport is the largest contributor to global warming by sub-sector. In affluent countries, environmental rules have lowered individual car emissions; however, this has been countered by growth in the number of vehicles and their use. Some options for significantly lowering road vehicle carbon emissions have been investigated.

1. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved January 7, 2022, from https://www.eea.europa.eu/themes/climate

While Tesla is an automobile manufacturer that builds electric automobiles to reduce CO2 emissions at the point of use, cities throughout the world are increasingly prioritizing public transportation, bicycles, and pedestrian movement.* Vehicle activity is redirected to create 20-minute neighborhoods, which promote exercise while dramatically reducing vehicle dependence and pollution. Some laws impose a congestion tax on cars that travel through crowded regions during rush hour.

The significance of transportation in sustainable development was first explicitly recognized by the United Nations at the Earth Summit in 1992. At the United Nations World Conference in 2012, world leaders unanimously agreed that transportation and mobility are critical to meeting sustainability goals. Data collected in recent years has revealed that the transportation sector accounts for a quarter of global greenhouse gas emissions; as a result, sustainable transportation has been incorporated into several of the 2030 Sustainable Development Goals, particularly those related to food, security, health, energy, economic growth, infrastructure, and cities and human settlements. Meeting sustainable transportation targets is thought to be critical to meeting the Paris Agreement's goals.

Various Sustainable Development Goals (SDGs) promote sustainable transportation in order to achieve the set objectives. SDG 3 on health (improved road safety), SDG 9 on resilient infrastructure, SDG 11 on sustainable cities (transport access and expanded public transportation) and SDG 13 on climate action(reducing the emission of Green House Gases).[*2]

2. United Nations. (n.d.). The 17 goals | sustainable development. United Nations. Retrieved January 7, 2022, from https://sdgs.un.org/goals

1. *SDG 3*

SDG 3 is about ensuring healthy lives and promote well-being for all at all ages. We are achieving these passively through promoting people to use soft mobility which improves the physical activity and social interactions. This is one of the most important milestone in terms of the effect of mobility on lifestyles of people in cities these days. We are also actively hitting target 3.6, which is to half the number of global deaths and injuries from road traffic accidents. We are actively trying to increase the number of micro-mobility options and reduce the use of cars by following the guidelines which promote the 15 min city concept and walkable city concept. These help us move closer to the sustainable development goal 3 which is to ensure healthy lives and promote well-being for all at all ages.[*2]

Image 1. SDG 3 - Good Health and Well Being

Images 1: United Nations Depertment of Economic and Social Affairs - Sustainable development, https://sdgs.un.org/goals, accessed on 16.07.2021

2. United Nations. (n.d.). The 17 goals | sustainable development. United Nations. Retrieved January 7, 2022, from https://sdgs.un.org/goals

2. *SDG 9*

SDG 7 is about building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. We are achieving these passively through the new metro line built in the site and the development of the multi-modal hub in the site. We are ensuring connectivity to the city center and improving on the infrastructure using sustainable and resilient mobility infrastructure. We are also actively hitting target 9.1, which is to develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all. We are actively trying to increase the passenger and freight volumes, by mode of public transport.[*2]

Image 2. SDG 9 - Industry, Innovation and Infrastructure
Image 3. SDG 11 - Sustainable Cities and Communities

3. *SDG 11*

SDG 11 is about Make cities and human settlements inclusive, safe, resilient and sustainable. We are actively hitting targets 11.2, which is to provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons, 11.3, By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries and 11.7, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.[*2]

Images 2,3: United Nations Depertment of Economic and Social Affairs - Sustainable development, https://sdgs.un.org/goals, accessed on 16.07.2021

2. United Nations. (n.d.). The 17 goals | sustainable development. United Nations. Retrieved January 7, 2022, from https://sdgs.un.org/goals

4. *SDG 13*

SDG 13 is about taking urgent action to combat climate change and its impacts. We are achieving these passively through promoting people to use soft mobility. We are ensuring connectivity to the city center and improving on the infrastructure using sustainable and resilient mobility infrastructure. We are also actively hitting target 13.1, which is to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. We are also hitting the target 13.2, by reducing the total green house gases emissions per year. We are actively trying to reduce the people using cars and others forms of motorized transport which will effect the climate.[*2]

Image 4. SDG 13 - Climate Action

Images 4: United Nations Depertment of Economic and Social Affairs - Sustainable development, https://sdgs.un.org/goals, accessed on 16.07.2021

2. United Nations. (n.d.). The 17 goals | sustainable development. United Nations. Retrieved January 7, 2022, from https://sdgs.un.org/goals

1.2
Modes of Transport

A mode of transportation is a transportation solution that makes use of a certain vehicle, infrastructure, and operation. A person or cargo may be transported using one mode or numerous modes, with the latter being referred to as inter-modal or multi-modal transportation. Each mode has its own set of benefits and drawbacks, and will be picked based on price, capabilities, and route. Depending on the country and mode of transportation, infrastructure operations and ownership might be public or private.[*3] Passenger transportation can be public or private, with operators providing scheduled services. Although bulk transport is utilized for huge volumes of durable goods, freight transportation has been increasingly focused on containerization. Although transportation plays a significant part in economic growth and globalization, the majority of modes pollute the air and consume a lot of land.

There are numerous modes of transportation available, ranging from bicycles to rockets, but for the purposes of our study, we will concentrate on four forms of mobility in our urban setting.

1. Walking.
2. Human-powered vehicles (cycling).
3. Use of public transportation.
4. Motorized Vehicles Owned by Individuals.

3. Mobility - Europa. (n.d.). Retrieved July 10, 2021, from https://webgate.ec.europa.eu/greencitytool/resources/docs/guidance/mobility.pdf

1.3
Urban Mobility

Designers have recently focused on improving urban transportation by developing new and expanding infrastructure for automobiles. The cost of such a car-dependent development is enormous. They have varying effects on society and the environment.

1. *Urban Sprawl*

Urban sprawl (also known as suburban sprawl or urban encroachment) is the unfettered growth of housing, commercial development, and roadways across wide swaths of land in many urban areas, with little regard for urban planning. The phrase refers not only to a specific type of urbanization, but also to the social and environmental consequences of that development. Before the emergence of industrial warfare, medieval suburbs suffered from a lack of city wall security. Increased travel time, transportation costs, pollution, and landscape devastation are all modern downsides and costs. The cost of constructing urban infrastructure for new developments is rarely recouped through property taxes, thereby subsidizing developers and new inhabitants at the expense of existing property taxpayers.

The term Peri-urbanization is commonly used in Continental Europe to describe similar processes and occurrences, however the European Environment Agency now uses the term urban sprawl.[*4] There is a lot of debate over what constitutes sprawl and how to measure it. Some commentators, for example, use the average number of residential units per acre in a specific area to calculate sprawl. Decentralization (spread of people without a well-defined center), discontinuity (leapfrogging development, as described below), segregation of uses, and other concepts are associated with it by others.

4. Encyclopædia Britannica, inc. (n.d.). Urban Sprawl. Encyclopædia Britannica. Retrieved August 16, 2021, from https://www.britannica.com/explore/savingearth/urban-sprawl

The word “urban sprawl” has a strong political meaning and is almost always associated with negative connotations. It has been chastised on aesthetic grounds for contributing to environmental degradation, growing segregation, and dilution of the vibrancy of existing metropolitan areas. Because of the negative connotation of the term, few people actively support urban sprawl. The phrase has become a rallying cry for the management of urban growth. Urban sprawl is linked to a slew of harmful environmental consequences.[*4]

Land loss, habitat loss, and eventual biodiversity loss are some of the key environmental issues linked with sprawl. According to a study by Czech and colleagues, urbanization endangers more species and is more geographically widespread than any other human activity in the continental United States. Native flora and animals are disrupted by urban sprawl, which also introduces exotic species into their ecosystems. Despite the fact that the consequences can be lessened via careful conservation of natural plants, the ecological succession process, and public education, sprawl is one of the most serious threats to biodiversity. As a result of uncontrolled urban growth and developing megacities like Kolkata, regions with high birth rates and immigration suffer environmental issues.

There are also the following issues:

Expanded temperatures from heat islands, which come from increased impervious surfaces for roads and parking (see urban runoff), lead to a dramatically increased risk of mortality in senior populations.

At the same time, the metropolitan centers of these and practically all other large cities in the United States, Western Europe, and Japan that did not annex new land witnessed dropping household sizes and, particularly in the United States, resulting in population losses.

4. Encyclopædia Britannica, inc. (n.d.). Urban Sprawl. Encyclopædia Britannica. Retrieved August 16, 2021, from https://www.britannica.com/explore/savingearth/urban-sprawl

This tendency has halted in recent years as more people have rediscovered their desire to live in cities.

More agriculture and wildlife habitats are displaced per inhabitant due to the bigger area occupied by expanding suburbs compared to urban districts. Rainfall is less effectively absorbed into groundwater aquifers as forest cover is destroyed and covered with impermeable surfaces (concrete and asphalt) in the suburbs. Both the quality and quantity of water sources are jeopardized as a result of this. Rainwater gathers up gasoline, motor oil, heavy metals, and other pollutants in runoff from parking lots and highways, increasing water contamination.

2. *Air and Noise Pollution*

Air pollution is defined as the presence of pollutants in the atmosphere that are damaging to human and other living species' health, as well as to the climate and materials. People who are exposed to air pollution suffer from a variety of health problems. Short-term effects and long-term effects are two types of effects. Infections such as pneumonia or bronchitis are examples of short-term consequences. They can also cause irritation to the nose, throat, eyes, or skin. Headaches, dizziness, and nausea are all symptoms of air pollution. Air pollution includes unpleasant odors produced by factories, waste, and sewer systems.[*5] These odors aren't as bad, but they're still unpleasant. Air pollution's long-term impacts can continue for years or even a lifetime. They have the potential to kill a person. Heart disease, lung cancer, and respiratory disorders like emphysema are all long-term health repercussions of air pollution. Air pollution can harm people's nerves, brains, kidneys, livers, and other organs over time. Some scientists believe that pollution in the air causes birth abnormalities.

5. National Geographic Society. (2012, October 9). Air Pollution. National Geographic Society. Retrieved August 16, 2021, from https://www.nationalgeographic.org/encyclopedia/air-pollution/

Every year, almost 2.5 million people die as a result of the consequences of outdoor or indoor air pollution around the world. Air pollution's long-term impacts can continue for years or even a lifetime. They have the potential to kill a person. Heart disease, lung cancer, and respiratory disorders like emphysema are all long-term health repercussions of air pollution. Air pollution can harm people's nerves, brains, kidneys, livers, and other organs over time. Scientists believe that pollution in the air causes birth abnormalities. Every year, almost 2.5 million people die as a result of the consequences of outdoor or indoor air pollution around the world. Varied types of air pollution have different effects on people. Pollution is frequently more sensitive in young children and older adults, whose immune systems are weaker.[*6] Exposure to air pollution can aggravate conditions like asthma, heart disease, and lung illness. The time of exposure, as well as the amount and kind of pollutants, are all important considerations.

Noise pollution is the spread of noise that has a variety of effects on human or animal activities, the majority of which are damaging to some degree. On a daily basis, millions of people are affected by noise pollution. Noise Induced Hearing Loss is the most common health condition it causes (NIHL). Loud noise can also lead to high blood pressure, heart disease, sleep problems, and stress. These health issues can impact people of all ages, but notably children. Many children who live near noisy airports or streets have been reported to be stressed and to have additional issues, such as memory, attention, and reading difficulties. Wildlife's health and well-being are also affected by noise pollution. Caterpillars' hearts beat quicker and bluebirds have fewer offspring when they hear loud noises, according to studies. Animals utilize sound to navigate, obtain food, attract mates, and avoid predators, among other things. Noise pollution makes it difficult for them to do these activities, which has an impact on their survival abilities.

6. National Geographic Society. (2019, July 15). Noise pollution. National Geographic Society. Retrieved August 16, 2021, from https://www.nationalgeographic.org/encyclopedia/noise-pollution/

3. *Climate Change*

Climate change now encompasses both human-caused global warming and its effects on Earth's weather patterns. Climate change has occurred in the past, but the current changes are more fast than any known occurrence in Earth's history. Emissions of greenhouse gases, mostly carbon dioxide (CO 2) and methane, are the primary reason. The majority of these emissions are caused by the burning of fossil fuels for energy. Additional sources include agriculture, steel-making, cement production, and forest loss. Climate feedbacks such as the loss of sunlight-reflecting snow cover and the release of carbon dioxide from drought-stricken forests influence temperature rise. These factors, taken together, accelerate global warming.[*7]

Temperatures on land have risen twice as quickly as the worldwide average. Heat waves and wildfires are getting more prevalent, and deserts are growing. Melting permafrost, glacial retreat, and sea ice loss have all been attributed to increased heat in the Arctic. Intense storms and other weather extremes are becoming more often as temperatures rise. Many species are forced to relocate or become extinct as their environment changes in areas like coral reefs, mountains, and the Arctic. Food and water scarcity, higher flooding, extreme heat, more disease, and economic loss are among threats posed by climate change. It has the potential to cause human migration. Climate change, according to the World Health Organization, is the greatest threat to world health in the twenty-first century. Even if attempts to reduce future warming succeed, some consequences will last for centuries. Sea level rise and warmer, more acidic waters are two examples.

7. NASA. (2021, August 26). The effects of climate change. NASA. Retrieved September 15, 2021, from https://climate.nasa.gov/effects/

4. *Traffic Accidents*

A traffic accident is defined as an incident involving at least one vehicle on a public road that results in the injury or death of at least one person. Since 2017, Istat has disseminated the previous year's final data on road accidents in July, on the eve of the summer exodus and the peak traffic volume on the roadways. The timely and early sharing of data aims to aid decision-making, improve road safety, and raise awareness of responsible driving behavior. This result was achieved thanks to an ongoing effort involving ACI (Automobile Club d'Italia) as a partner, the Road Police, Carabinieri (special military body), Local Police, Statistical offices and Monitoring Centers of Municipalities, Provinces, Autonomous Provinces and Regions, who agreed to a Memorandum of Understanding for the national coordination of activities related to statistics. In 2018, there were 172,344 traffic accidents in Italy that resulted in deaths or injuries, with 3,325 victims and 242,621 injured.[*8] Traffic accident mortality declined (-1.6 percent) from the previous year, following an uptick in 2017; road accidents and injuries also decreased (respectively -1.5 percent and -1.7 percent). Between 2017 and 2018, the road accident mortality rate increased from 55.8 to 55.0 deaths per million people. In comparison to 2010, the number of road victims has decreased by 19.2 percent.

5. *Community Severance*

The term "community severance" refers to when transportation infrastructure or motorized traffic creates a physical or psychological barrier to pedestrian movement. Multi-lane roadways with physical barriers that restrict pedestrians from crossing generate the most severe occurrences of community severance. Crossing may be problematic even in the absence of these barriers due to road design characteristics such as median strips or high motorized traffic volumes or speeds. If there is a lack of basic pedestrian infrastructure, such as pedestrian pavements, severance can also occur on small roads with low traffic volumes.

8. Road accidents 2019 en - automobile club d'italia. (n.d.). Retrieved August 20, 2021, from https://www.aci.it/fileadmin/documenti/studi_e_ricerche/dati_statistiche/incidenti/Road_accidents_2019_EN.pdf

Despite mounting evidence of the phenomenon's potential public health consequences, there is a lack of methods to detect and quantify the problem, limiting the breadth of policy responses.[*9] This could be because scholars from a variety of fields have looked into community severance, including public health, economics, geography, and urban studies. To identify and analyze the topic, these scholars used a variety of concepts and approaches. Local communities, road users, and practitioners in a variety of sectors, including not only transportation and health, but also urban planning and local economic and social policy, are all affected by the issue.

9. Anciaes, P. R., Boniface, S., Dhanani, A., Mindell, J. S., & Groce, N. (2016). Urban Transport and Community Severance: Linking Research and policy to link people and places. Journal of Transport & Health, 3(3), 268–277. https://doi.org/10.1016/j.jth.2016.07.006

1.4
Sustainable Mobility

In terms of climate, social, and environmental implications, the term "sustainable mobility" refers to a vast topic. This is determined by looking at the vehicles that will be used on the road, by sea, or by air, as well as the energy source and the infrastructure that will be needed to support the module. Due to the high rate of urbanization in many developing countries in recent years. The world's population has grown fivefold, and by 2030, nearly 60% of the world's population will be living in cities. Every year, 73 million people migrate to metropolitan areas, with 90% of them living in developing countries. This has resulted in an increase in the demand for mobility and the use of motorized vehicles, which has resulted in an increase in energy consumption that has exceeded estimates. One of the major contributors to anthropogenic greenhouse gas emissions is the transportation industry. Transportation accounted for the greatest percentage of GHG Emissions in 2019, according to the inventory of Greenhouse Gas Emissions and Sinks.[*10] Transportation end-use sector emissions are produced by a variety of sources, including automobiles, trucks, commercial aircraft, and railroads, among others. In wealthy countries, environmental rules have lowered individual automobile emissions. However, a growth in the number of automobiles and increasing use of each vehicle has offset this. Noise pollution and carbon monoxide emissions, for example, have direct and detrimental consequences on the ecosystem, as well as indirect effects. Because it is commonly assumed that initial impacts inflict the greatest damage, indirect consequences are often of greater consequence, leading to the mis-perception that it is the contrary. Particulates, for example, which result from incomplete combustion in an internal combustion engine, are not connected to respiratory and cardiovascular issues because they contribute to other variables. Even though environmental effects are normally addressed one at a time, there are also cumulative effects to consider. The synergistic impacts of transportation operations, which consider both direct and indirect effects on an ecosystem. Climate change is the outcome of a combination of natural and human influences. The transportation industry is responsible for 15% of global CO2 emissions. A variety of innovative mobility trends, such as shared mobility and providing people with inexpensive and sustainable transportation options, can help the world reach its sustainability goals.

10. What is sustainable mobility? Neste worldwide. (2021, December 15). Retrieved December 18, 2021, from https://www.neste.com/media/sustainable-mobility/what-is-sustainable-mobility

1. *Shared Mobility*

Shared mobility has the potential to reduce emissions and congestion. We can avoid owning vehicles sitting idle for the majority of the day by sharing various modes of transportation (cars, scooters, e-bikes) and optimize the use of vehicles by accomplishing more with less by sharing various modes of transportation (cars, scooters, e-bikes). 'NOwnership,' in which people do not own vehicles but pay per use, has already begun to alter our habits, particularly in urban areas.[*3]

According to MIT research on the benefits of shared mobility, this mode of transportation may cut the need of parking spots in cities by 86%, freeing up valuable public space and forcing a radical reconsideration of how space is used.

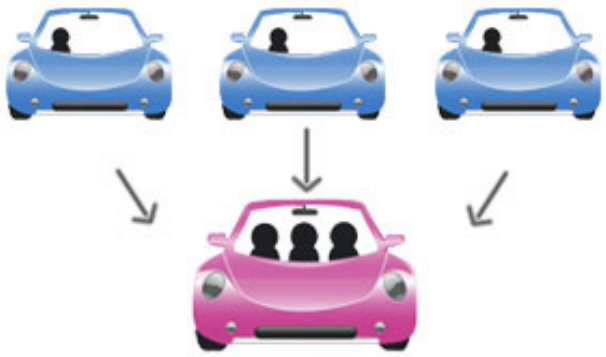


Image 5. Illustration showing how car pooling can be effective.

2. *Public Transport*

One of the most effective strategies to reduce emissions and congestion is to improve the quality and quantity of public transportation services. Individual transportation is the true competitor of communal transportation, hence providing high-quality, frequent services is critical. The countries or localities that invest the most in public transportation systems also have the highest modal split percentages. A recent study, for example, found that train infrastructure and services had a direct impact on modal split and greenhouse gas emissions.

Image 5: https://www.altrapsicologia.it/regioni/veneto/vota-re-assieme-in-car-pooling/

3. Mobility - Europa. (n.d.). Retrieved July 10, 2021, from https://webgate.ec.europa.eu/greencitytool/resources/docs/guidance/mobility.pdf

3. *Smart Mobility*

Automated mobility and smart traffic management are made possible by digital technologies, making transportation more efficient and lowering emissions. Intelligent transportation technologies will be critical in improving mobility on our roads, in the water, and in the air. Peer-to-peer, vehicle-to-vehicle, and vehicle-to-infrastructure connectivity, for example, can encourage sustainable journey options, allow for multimodal transportation, increase public transportation access, and minimize traffic and fuel consumption.[*3] Connectivity can improve traffic flow and save fuel consumption by optimizing travel mode and route selection. Vehicle control that is automated has the potential to improve energy efficiency, safety, and convenience. Fuel usage decreases with each level of automation and greater connectivity.

4. *Access to Mobility*

Access to mobility, regardless of wealth or location, is a crucial aspect of sustainable mobility. Equity in accessibility is a key component of sustainable mobility, with a focus on more vulnerable populations and geographical locations at danger of social exclusion. Soft mobility promotion, particularly in urban areas, is an easy strategy to cut emissions and improve quality of life.

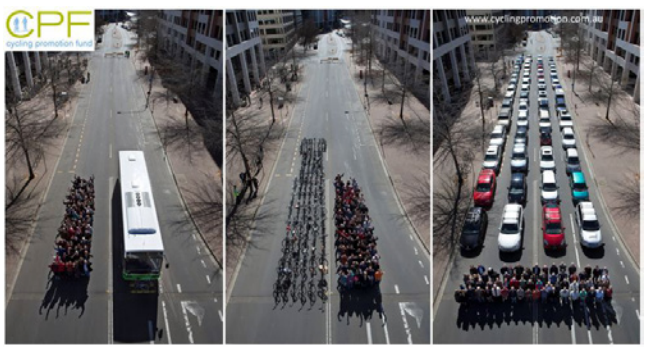
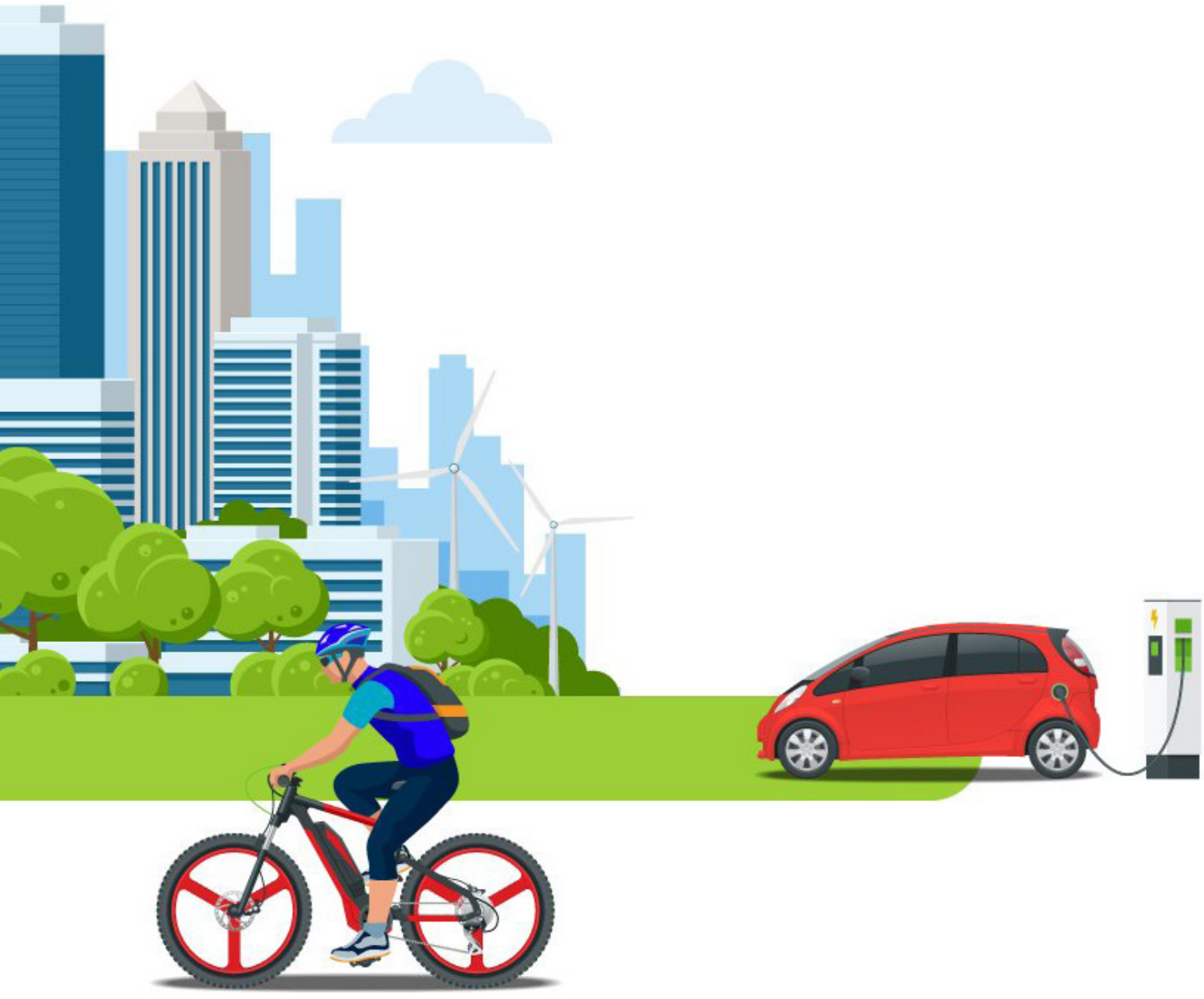


Image 6. Space Occupied on road by different means of transport with reference to the number of people served

Image 6: https://humantransit.org/2012/09/the-photo-that-explains-almost-everything.html

3. Mobility - Europa. (n.d.). Retrieved July 10, 2021, from https://webgate.ec.europa.eu/greencitytool/resources/docs/guidance/mobility.pdf

Soft Mobility



2.1
Cyclability

Sustainable mobility is a major goal of transportation policy at all levels of government: municipal, regional, national, and European. The fight against climate change, for example, is one of the bright spots in European transport policy, and air pollution, particularly in terms of particulate matter concentrations, is an increasing source of concern. Since 2015, when the European Commission issued the Declaration on Cycling as a Climate-Friendly Transport Mode, European policies have focused on the importance of cycling and specific infrastructure design that might improve this mode of transportation, particularly at the urban level. One of the key reasons for this research is that soft mobility (especially cycling) is a "climate friendly method of transportation" that enhances residents' health.

Why do we need to Cycle?

Emissions sources differ each city, but in the vast majority of situations, transportation – notably on-road vehicle transportation – accounts for a significant portion of greenhouse gas emissions. Transportation contributes for 28 percent of emissions in New York City, 53 percent in Mexico City, and 30 percent on average among the C40 cities.

Outdoor air pollution kills about 4.2 million people each year around the world, and many more suffer from major health problems like premature birth, low birth weight, and asthma.[*12] Urban air pollution, including non-greenhouse gas pollutants, is primarily caused by traffic. It is responsible for around a quarter of the particulate matter in city air around the world.

Cycling is one of the most energy-efficient forms of transportation. Cycles also lessen the need to manufacture, maintain, and dispose of automobiles. Bicycles save space on the road and in the home, allowing us to eliminate concrete and expand green space. In a single car lot, we can fit ten bicycles. Cycling consumes 200 times less energy than driving a car and 5 times less energy than walking.

12. Walking and Cycling Transformation. C40 Knowledge Community. (n.d.). Retrieved September 15, 2021, from https://www.c40knowledgehub.org/s/article/How-to-achieve-a-walking-and-cycling-transformation-in-your-city?language=en_US

Benefits of Cycling?

Congestion relief increases municipal production. Our economy are hampered by traffic congestion due to lost time and production. Prior to the introduction of London's Congestion Charge zone in 2002, time lost due to congestion cost the city's economy up to £4 million each week. Traffic congestion in Lagos is having a significant impact on businesses, costing the city more than $9 billion each year.

There is a compelling economic rationale for walking and cycling. Local employment, footfall, shop sales, and rents can all benefit from more walkable regions. A drastic reduction in vehicle space on a downtown boulevard, combined with simple changes in street design to prioritize walking and cycling, has sparked economic and social activity in Lancaster, California, attracting $130 million in private investment and generating $273 million in economic output over four years. The city's original investment was $11.5 million. An £80 million investment in active travel resulted in a £724 million economic benefit for London, according to research. Footfall in the city center grew by 10% when Oslo decreased automobile parking, boosted cycling and public transportation, and pedestrianized streets, and there is greater demand for store space on the car-free streets.[*12]

Depression, anxiety, stress, obesity, and chronic disease are all reduced by active travel. Physical and mental health concerns, lower productivity, higher absenteeism rates, and higher healthcare expenditures all arise from a lack of physical activity. Today, it kills more people than smoking. Getting people out of cars and into active transportation – especially walking and cycling, but also public transportation, which often leads to more exercise – reduces these hazards dramatically. Mick Cornett, the former mayor of Oklahoma City from 2005 to 2018, credited investments in people-centered streets with helping to turn around the city's economic fortunes and address its obesity problem in just five years.

12. Walking and Cycling Transformation. C40 Knowledge Community. (n.d.). Retrieved September 15, 2021, from https://www.c40knowledgehub.org/s/article/How-to-achieve-a-walking-and-cycling-transformation-in-your-city?language=en_US

When traffic is reduced, the air is cleaner and there is less noise. In over 90% of cities around the world, people breathe polluted air, posing a serious threat to public health. Meanwhile, noise pollution can cause sleep disturbances, cognitive impairment in children, and cardiovascular illness, and it is Europe's second-largest environmental health hazard after air pollution. Motor vehicles are responsible for the vast majority of noise in cities.

Car parking is a waste of valuable city space that is both wasteful and harmful. Private cars are parked for over 95% of the time on average. Parking coverage ranges from 15% to 30% in cities such as New York, London, Paris, Vienna, Boston, and Hong Kong. Parking spaces separate buildings, making it more difficult to walk and encouraging more driving. It also reduces the vibrancy and sense of community in neighborhoods, while wide swaths of asphalt contribute to the urban heat island effect and flood risk. Cities offer a significant opportunity to convert parking into residences, as well as productive uses such as stores and office buildings, as well as for walking, cycling, and public transportation stations.

Fewer cars on the road may result in safer streets. In 2008, Kansas City police reported that crime in the city's Kessler Park reduced by 74% when a 2.6-mile byway was made car-free on weekends. In London's Walt-ham Forest, the introduction of low-traffic neighborhoods in 2015 was linked to an 18 percent fall in crime in three years, with significantly bigger reductions for violent and sexual offenses.[*12] Less traffic also means fewer pedestrian and bicycle deaths on city roads - for the first time in 2019, Oslo recorded zero pedestrian and cycling deaths after implementing steps to reduce car traffic (by comparison, in the same year London and New York City recorded 79 and 149 pedestrian and cyclist deaths respectively).

12. Walking and Cycling Transformation. C40 Knowledge Community. (n.d.). Retrieved September 15, 2021, from https://www.c40knowledgehub.org/s/article/How-to-achieve-a-walking-and-cycling-transformation-in-your-city?language=en_US

Is cycling practiced only in flat countries?

Cycling is frequently connected with two countries and cities: the Netherlands and Denmark, specifically Amsterdam and Copenhagen.

Cycling necessitates a muscular effort, which necessitates its practice in flat countries.

Bicycles, on the other hand, are commonly used practically everywhere in Europe. The image of the bicycle, which is sometimes considered as an antique method of transportation, a toy for children, or a piece of sporting equipment, is one of the main reasons why cycling is not as popular in southern nations. Who'd have guessed that a southern Italian town like Parma would have a cycling rate comparable to that of Amsterdam? 19% of all journeys are performed by bicycle in Parma (176 000 inhabitants), while 20% of all journeys are made by bicycle in Amsterdam (a little less than a million residents). Bike travels account for 31% of all trips between home and work in Ferrera (population 160 000).[*11]

Sweden is a land of extreme cold. Despite this, bicycles account for 33% of all journeys in Västers (population 115 000). While extreme heat in southern countries may make cycling difficult at times, the mild climate means that cycling may be done for lengthy periods of time throughout the year.

Although Switzerland is not a flat country, bicycles account for 23% of all journeys in Basle (230 000 residents), which is constructed on both banks of a Rhine curve, and 15% of journeys in Bern, where a number of roads have a 7% gradient.

Despite the fact that the United Kingdom is a wet country, 27 percent of journeys in Cambridge (population 100 000) are still performed by bicycle.

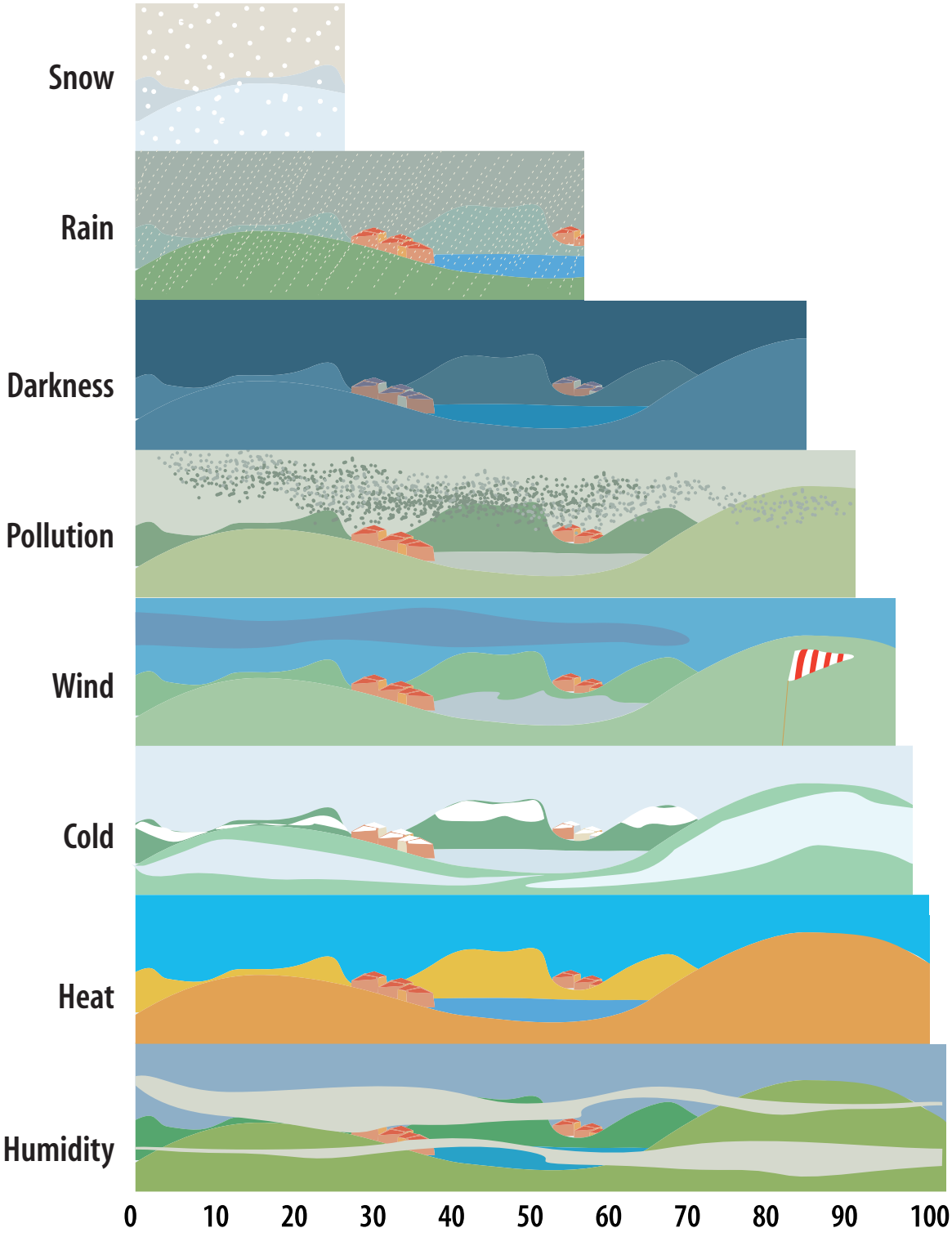
11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

Bikes are frequently utilized extensively as soon as the weather permits (no rain or snow, see the example of Sweden). In truth, there aren't many instances where riding a bicycle isn't an option. The only weather conditions that are truly dissuasive to bikers are torrential rain or scorching heat. However, the short lengths of excursions in town, appropriate clothing, and good infrastructure upon arrival considerably mitigate the detrimental impact of atmospheric conditions that are far less conducive to daily cycling than is commonly assumed.

In towns where slopes with a greater than 5% gradient are long and numerous, hills constitute a substantial impediment for slightly unskilled bikers using outdated and inadequate bicycles. Even in such conditions, there remains possibility for riding, as the following hilly towns demonstrate: Trondheim (Norway), which hosted the Velo Borealis Conference in 1998, has an 8% riding rate and was the first city in the world to have bicycle lifts.[*11]

In addition to the Netherlands' and Denmark's relatively flat natures, both countries are frequently buffeted by strong winds, which may necessitate substantial effort on the part of cyclists confronted with this difficulty.

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf



Graph 1. Graph describes the percentage of people willing to take a bicycle on certain weather conditions

Graph 1: Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

Safety

Bicyclists, like pedestrians, face serious safety issues. Cyclists are at the mercy of car drivers because they are riding amid cars that are often traveling much faster. Statistics, on the other hand, reveal that popular opinion is not always correct. If you assess risk by age group and make reasonable statistical corrections, you'll find that cycling has a reduced overall accident risk for people aged 18 to 50.[*11] There is no escaping the fact that young bikers (particularly boys) are the most vulnerable if they have not adequately understood the regulations, which are necessary to keep adolescents' passion in check.

It's important to remember that moped and motorcycle riders face greater risks because they travel at even higher speeds without any more protection than cyclists (the helmet only protects the head, which is ineffective at high speeds, and the rest of the body is vulnerable to fatal or disabling injuries whose severity increases with speed). It is important to note that cyclists and riders of mopeds and motorcycles are not interchangeable and should never be lumped into the same statistical group as 'two-wheeled' vehicle users. Motorists are, without a doubt, the best protected of all road users. They are particularly hazardous to pedestrians and bikers. With increasing speed, the danger that motorists pose to others grows exponentially.

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

Age group	Motorists (drivers)	Cyclists
12 - 14	-	16.8
15 - 17	-	18.2
18 - 24	33.5	7.7
25 - 29	17.0	8.2
30 - 39	9.7	7.0
40 - 49	9.7	9.2
50 - 59	5.9	17.2
60 - 64	10.4	32.1
> 64	39.9	79.1
Total	20.8	21.0

Table 1. The table describes the Risk of accident per million kilometers according to age groups

Table 1: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

2.2
Walk-ability

What is a Walkable City?

The term “walkability” was used to characterize how welcoming a city or neighborhood is to pedestrian movement. The Walkable and Livable Cities Institute defines walkable communities as places where “people, not their automobiles, are at the center of the design scale.” We create areas that are socially, ecologically, and economically vibrant when we plan communities around the human foot.”

Image 7. Advantages of increasing walkability in a City

The capacity to walk is critical to an urban area’s effective ground transportation system. Walking is still the most cost-effective mode of transportation for everyone. As a result, the creation of a walkable city provides the most cost-effective and equitable mode of transportation, which every community can plan, design, construct, and manage. For resource sustainability, walkable cities restore scale, pattern, and mix to urban landscapes (both natural and economic).[*13] Through social connection, physical fitness, less crime, and increased wellness, they help to solve many social and economic problems. Walkable cities are livable constructed environments that enable residents to live full, happy, and healthy lives. They maintain employment while attracting young adults, families, and children.

Image 7: Walk Score, https://www.walkscore.com/walkable-neighborhoods.shtml, accessed on 12.11.2021

13. Walkable neighborhoods. What Makes a Neighborhood Walkable. (n.d.). Retrieved November 12, 2021, from https://www.walkscore.com/walkable-neighborhoods.shtml

Why Cities are Less Walkable?

It's not so much that we don't want to walk; it's more that we can't. As a result, it's critical to recognize that city walkability is hampered by a number of issues. First, the automobile and major investments in highway systems made it possible to live hundreds of miles distant from work. Unfortunately, most of our cities are built for automobiles, which makes walking difficult. A physical environment designed for cars may make it difficult for residents to age in place.[*14]

Second, land outside of the city is less expensive and provides a blank canvas for development. As a result of the decentralization of metropolitan populations and employment hubs to suburban areas, travel distances to work, school, and other everyday duties have grown. As a result, people have become increasingly reliant on automobiles.

Benefits of Walkable City

Our health, the environment, our money, and our communities all benefit from walkability.

Health: People who live in walkable neighborhoods weigh 6-10 pounds less than those who live in expansive areas. Happiness is enhanced in cities with strong public transportation and easy access to facilities.
Environment: Fossil fuel combustion accounts for 87 percent of CO2 emissions. Your feet are pollutant-free transportation vehicles.
Finances: Cars are the second most expensive household item in the United States. A single point of Walk Score can add up to $3,250 to the value of your home.
Communities: Walkability is linked to higher levels of arts groups, innovation, and civic participation in communities.

14. The ten steps to walkable cities. Smart Cities Dive. (n.d.). Retrieved November 12, 2021, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-steps-walkability/96836/

Walkable City

There are ten steps to creating walkability, according to Jeff Speck's great new book, Walkable City. Most of them also have something to do with redressing the negative consequences of decades of permitting automobiles to dominate urban settings. I may not agree with every detail, and my own list may differ in some ways based on my own experiences and ideals. But it's a great menu to get municipal officials and thinkers thinking about how to make their neighborhoods more walkable.

Step 1*: Put cars in their place*

"Traffic studies are a load of nonsense." Isn't it an interesting quote? Jeff argues that a car-first approach has harmed American cities, and I tend to agree. This is partly due to traffic engineers' failure to recognize that increasing roadway traffic capacity can result in more cars on the road, not less. The related phenomena of "generated demand" has unintended ramifications not only for traffic on freeways but also for traffic in neighborhoods and downtowns, where streets are sometimes considered as conveyances for motor cars rather than as important public places for invigorating city life. Jeff is a supporter of congestion pricing in general, but cautions against assuming the virtues of pedestrian-only zones.[*14]

Step 2*: Mix the uses*

"Cities were built to bring people and ideas together." According to the findings, neighborhoods with a variety of uses - locations to walk to – have substantially more walking than neighborhoods without. Jeff points out that housing – or, to put it another way, locations to walk from – is in notably short supply in most American downtowns. He also accurately points out that affordability is not an issue in most (still-disinvested) downtowns because reasonably affordable

14. The ten steps to walkable cities. Smart Cities Dive. (n.d.). Retrieved November 12, 2021, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-steps-walkability/96836/

housing is all that there. Inclusionary zoning and “granny flats,” or auxiliary dwelling units, are two solutions he advocates for gentrifying downtowns. Streets are sometimes considered as conveyances for motor cars rather than as important public places for invigorating city life. Jeff is a supporter of congestion pricing in general, but cautions against assuming the virtues of pedestrian-only zones.

Step 3*: Get the parking right*

“Ample parking encourages driving that would not happen otherwise.” Jeff, like many progressive city thinkers, points out that we have a vast surplus of low-cost parking, thanks in part to development and company minimum parking regulations. Because there isn’t enough space to develop parking for the buildings’ new purposes, adaptive reuse of historic assets may be hindered as a result.[*14] Jeff suggests centralized parking for various buildings and companies, as well as higher charges, particularly for curb parking, and provides several examples.

Step 4*: Let transit work*

“While good transit promotes walk-ability, walk-ability is absolutely necessary for good transit.” Insufficient residential densities, too much downtown parking, routes distant from the busiest sections, inconsistent service, and a lack of mixed-use, walkable neighborhoods near the stops are all examples of what not to do to assist transit, according to Jeff. Jeff suggests focusing on those transportation lines that can be enhanced to handle ten-minute headways, and working to improve both transit and the urban fabric at the same time. Jeff also reminds us, quoting transportation planner Darrin Nordahl, that public transit is a “mobile type of public space” that should be treated with respect and made enjoyable.[*14]

14. The ten steps to walkable cities. Smart Cities Dive. (n.d.). Retrieved November 12, 2021, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-steps-walkability/96836/

Step 5*: Protect the pedestrian*

"The safest roads are the ones where you don't feel safe." It's all about driving once more. According to Jeff, "improvements" to the road that facilitate car traffic, such as bigger lanes or one-way streets, encourage higher speeds; instead, we should employ narrow lanes and two-way streets. Intriguingly, he advocates – as have other new urbanists – for the removal of signs and mode separation from some roadways. The notion is that if drivers believe they are about to hit someone or something, they will slow down or modify their course. On-street curbside parking, which Jeff and I both support, protects the walkway from driving vehicles.

Step 6*: Welcome bikes*

"On any given day, roughly 400,000 people in Amsterdam, a city of 783,000, are out riding their bikes."[*14] Except for the fact that bike traffic slows car traffic, this step is only tangentially concerning walkability. It's all about making cities more cycling-friendly, which many communities in the United States are now doing. Although drivers grumble, data and my personal experience as a driver suggest that when bike infrastructure is thoughtfully added, automobile traffic isn't really inconvenienced much, if at all. New Orleans Jeff makes the fascinating point that some expert cyclists prefer to ride in the main road rather than a dedicated lane.

Step 7*: Shape the spaces*

"If you design it well enough, people will walk in nearly any weather." I'll admit that, as much as I enjoyed this book, I wondered when, if ever, my urban designer friend would get around to urban design. This chapter is mostly concerned with creating the sensation of enclosure that we require in order to feel safe when walking. The major villain is the car once again, this time in the form of surface

14. The ten steps to walkable cities. Smart Cities Dive. (n.d.). Retrieved November 12, 2021, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-steps-walkability/96836/

parking lots along the sidewalk. Jeff, on the other hand, takes some shots at blank walls (which he does well) and look-at-me buildings (I somewhat, but not entirely, agree). He, like myself, feels that the level of density required to maintain good city walkability does not have to be in the form of big buildings.

Step 8*: Plant trees*

"It's best not to pick favorites in the walkability debate—every single point matters—but I think the humble street tree will win my vote."* Despite the fact that street trees are linked to fewer car accidents, several public transit organizations want to limit them because they obstruct view. However, Jeff points out that trees provide a variety of public benefits, including natural cooling, reduced emissions and energy demand for air conditioning, and reduced stormwater pollution, in addition to contributing to auto safety.

Step 9*: Make friendly and unique [building] faces*

"Pedestrians require a sense of security and comfort, as well as the opportunity to be entertained." This is the stage that is most about design, or at least design of things other than roadways, out of the 10. It reminded me of Steve Mouzon's great "walk appeal" hypothesis[*14], which states that how far we walk is determined by what we encounter along the way. Stores and businesses with street-level windows, as well as hidden or lined parking, vertical building lines, and architectural elements, all help. Jeff, on the other hand, isn't fond of parks or green infrastructure that absorbs stormwater.

Step 10*: Pick your winners*

"Where can the smallest amount of money make the biggest difference?" "In the actual world, you can't do everything," may be the subtitle. That is correct. Jeff advocates putting a priority on downtowns and small corridors that connect walkable areas.

14. The ten steps to walkable cities. Smart Cities Dive. (n.d.). Retrieved November 12, 2021, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-steps-walkability/96836/

Sustainable Urban Mobility Plan

3.1
What is SUMP?

"A Sustainable Urban Mobility Plan is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life. It builds on existing planning practices and takes due consideration of integration, participation, and evaluation principles."[*15]

What distinguishes a mobility strategy as "sustainable"?

A Sustainable Urban Mobility Plan aims to develop an urban transportation system by addressing – at a minimum – the following goals:

• Ensure that all citizens have access to transportation options that allow them to reach key destinations and services;
• Improve safety and security;
• Reduce air and noise pollution, greenhouse gas emissions, and energy consumption;
• Improve the efficiency and cost-effectiveness of people and goods transportation;
• Contribute to improving the environment.

A Sustainable Metropolitan Mobility Plan more effectively addresses transportation-related issues in urban settings. It is the outcome of a structured process that includes status analysis, vision development, goal and target setting, policy and measure selection, active communication, monitoring and evaluation – as well as the identification of lessons learned.* The following are the basic characteristics of a Sustainable Urban Mobility Plan, which build on existing practices and regulatory frameworks:

• Long-term vision and clear implementation plan;
• Participatory approach;
• Balanced and integrated development of all modes of transportation;
• Horizontal and vertical integration;
• Assessment of current and future performance;
• Regular monitoring, review, and reporting;
• Consideration of external costs for all modes of transportation.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

1. *Long-Term Vision and Clear Implementation Plan*

A Sustainable Metropolitan Mobility Plan is based on a long-term vision for the entire urban agglomeration's transportation and mobility development, which includes all modes and forms of transportation: public and private, passenger and freight, motorized and non-motorized, moving and parking. It includes a plan for the strategy's short-term implementation, which includes an implementation date and budget, as well as a clear distribution of duties and resources needed to carry out the plan's objectives and measures.[*15]

2. *Participatory Approach*

People are at the center of a Sustainable Urban Mobility Plan, which focuses on addressing their basic mobility needs. It takes a transparent and participatory approach to planning, involving people and other stakeholders from the start and throughout the process of developing and implementing the plan. Citizens and stakeholders must engage in participatory planning in order to take ownership of the Sustainable Urban Mobility Plan and the policies it promotes. It increases the likelihood of public acceptance and support, reducing risk for decision-makers and facilitating plan implementation.

3. *Balance Integrated Development of All Transport Modes*

A Sustainable Urban Mobility Plan promotes the balanced growth of all key forms of transportation while advocating a transition toward more environmentally friendly modes. In terms of the stated aims and objectives, the plan

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

proposes an integrated set of measures to increase performance and cost effectiveness. Technical, commercial, and market-based measures and services, as well as infrastructure, are among these actions. Public transportation, non-motorized transportation (walking and cycling), intermodality and door-to-door mobility, urban road safety, flowing and stationary road transport, urban logistics, mobility management, and Intelligent Transport Systems are all topics covered in a Sustainable Urban Mobility Plan (ITS).[*15]

4. *Horizontal and Vertical Integration*

The development and execution of a Sustainable Urban Mobility Plan takes an integrated approach with high levels of cooperation and consultation among government levels and relevant authorities.

a) A dedication to sustainability, i.e. balancing economic development, social fairness, and environmental quality in integrated planning and implementation.

b) At the local level, consultation and collaboration between ministries to ensure consistency and complementarity with policies in linked sectors (transport, land use and spatial planning, social services, health, energy, education, enforcement and policing, etc.).

c) Consistent communication with relevant authorities at all levels of government (e.g. district, municipality, agglomeration, region, and Member State).

d) Activities coordination between authorities in neighboring urban and Peri-urban areas (encompassing the whole 'functional city' characterized by main commuter flows).

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

5. *Assessment of Current and Future Performance*

The creation of a Sustainable Urban Mobility Plan focuses on reaching ambitious, measurable targets generated from short-term objectives, which are connected with a mobility vision and embedded in a larger sustainable development strategy. A comprehensive assessment of the current and future performance of the urban transportation system is the foundation of a Sustainable Urban Mobility Plan. It gives a thorough assessment of the current condition as well as a benchmark against which progress can be measured. A study of the current institutional set-up for planning and implementation is included in the status analysis. To describe the current state of the urban transportation system, appropriate indicators should be established. A Sustainable Metropolitan Mobility Plan defines particular performance goals that are both achievable in light of the current state of the urban area as determined by the status analysis and ambitious in terms of the plan's goals. A Sustainable Urban Mobility Plan establishes quantifiable goals based on a realistic assessment of the starting point and resources available. To track progress toward goals, specific indicators are employed.[*15]

6. *Regular Monitoring, Review and Reporting*

Implementation of a Sustainable Urban Mobility Plan is regularly monitored. The indicator framework is used to assess progress towards the plan's objectives and reaching the targets on a regular basis. To that purpose, the necessary steps must be taken to ensure prompt access to essential data and statistics. The evaluation of the Sustainable Urban Mobility Plan and its implementation may result in target changes and, where necessary, remedial actions.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

The progress in designing and implementing the Sustainable Urban Mobility Plan is reported in a Monitoring Report that is publicly shared and communicated with people and stakeholders.

7. Consideration of External Costs for all Transportation Modes

A cost-benefit analysis of all means of transportation should be included in the construction of a Sustainable Urban Mobility Plan.[*15] This should take into account the broader societal costs and benefits, as well as cross-sectoral costs and benefits, in order to influence action choices.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

3.2
Benefits of SUMP

The ability to persuade decision makers of the value of a Sustainable Urban Mobility Plan is a recurring difficulty for planners in local governments. The following are 10 significant arguments in favour of this strategy:

1. *Improving Quality of Life*

Sustainable urban mobility planning has been shown to improve the quality of life in urban areas. A Sustainable Urban Mobility Plan defines well-coordinated policies that result in a wide range of benefits, including more appealing public areas, enhanced road safety, better health, and reduced air and noise pollution.[*15]

2. *Saving Costs - Creating Economic Benefits*

Mobility is a critical enabler for a community's economy. A cleaner environment and less traffic contribute to lower expenses for the local community and the attraction of new enterprises. A well-organized and sustainable city is also more attractive to investors in the global and national competitiveness of metropolitan centers. A city with a clear forward-looking mobility policy simply has a lot superior "business case" than one without.

3. *Contributing to Better Health and Environment*

Better air quality and less noise are directly related to more sustainable mobility. It is beneficial to citizens' health to travel more actively (by walking and

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

cycling more frequently).er health, and reduced air and noise pollution. In the medium to long run, investing in less noise and better air quality certainly pays off for a city. Cities must contribute to the reduction of greenhouse gas emissions in the transportation sector. Any climate policy must include sustainable urban mobility planning.

4. *Making Mobility Seamless and Improving Access*

Sustainable urban mobility planning is a great way to come up with multimodal door-to-door transportation options. Bringing multiple players together guarantees that residents' and enterprises' specific access demands are met efficiently.[*15]

5. *Making Effective Use of Limited Resources*

At a time when financial resources are scarce, it's even more critical to make sure that the solutions chosen make the most use of the cash available. The focus of sustainable urban mobility planning shifts away from road-based infrastructure and toward a balanced mix of solutions, including lower-cost mobility management. Adopting the polluter-pays principle also creates a new money stream that may be used to fund alternative modes of transportation.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

6. *Winning Public Support*

Stakeholder and citizen participation is a fundamental concept of a Sustainable Urban Mobility Plan. A municipal administration that demonstrates that it cares about what its citizens want and needs, and that appropriately engages its stakeholders, is in a much better position to gain a high level of "public legitimacy,"[*15] which decreases the danger of opposition to ambitious policies being implemented.

7. *Preparing Better Plans*

When planners receive early feedback, they can better grasp the mobility demands of different user groups, especially when they are traditionally focused on creating infrastructure. Because they are better familiar with a certain scenario, stakeholders can sometimes come up with very effective ideas. An integrated and interdisciplinary planning strategy (with diverse departments contributing their skills) aids in the implementation of a mobility plan on a larger scale. It guarantees that the plan promotes a balanced development of all key modes of transportation while supporting a transition toward more environmentally friendly modes. As a result, it meets the needs of all users in terms of access and mobility.

8. *Fulfilling Legal Obligations Effectively*

Cities must comply with a plethora of legislative obligations, some of which are at odds with one another. The legal duties for improving air quality and

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

reducing noise are just two examples of a plethora of national and European legislation. A Sustainable Urban Mobility Plan provides an efficient approach to respond by combining multiple strategies into one.

9. *Using Synergies, Increasing Relevance*

Problems with urban mobility frequently cut over administrative lines, involve many policy areas, and affect a wide range of agencies and institutions. Sustainable urban mobility planning aims to provide solutions for the "functioning city" and its ties to the national and European transportation networks. Within the "functioning city," a Sustainable Urban Mobility Plan fosters a collaborative planning culture across different policy areas and sectors, as well as between different governance levels. The development of solutions that reflect the interconnected character of urban transportation is aided by this collaborative planning culture.[*15]

10. *Moving Towards a New Mobility Culture*

As many cities have demonstrated, the result of continued sustainable urban mobility planning is a shared vision of a new mobility culture: a vision that is shared by major political groups, institutions, and citizens of an urban society; a vision that transcends electoral cycles and can include less appealing elements when they provide long-term benefits.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

3.3
Process of SUMP

The fundamental goal to be attained, namely increasing urban transportation and mobility, should not be viewed as a destination, but rather as part of a larger picture aiming at improving inhabitants' quality of life and well-being in general. Starting with this last goal, the European guidelines specify 11 critical steps for preparing a successful SUMP, which are briefly described below.

Phase 1 - Determining the potential for a successful SUMP

It is critical to determine the feasibility of producing a solid, effective, and long-term plan from the start of the planning process. This first phase is devoted to the description of the essential tasks for planning the development process that will result in a successful Plan. There are six activities:

Step 1*: Commit to Overall Sustainable Mobility Principles*

To create a truly sustainable transportation strategy, it is vital to include all of the components in a sustainable manner, including those that are not strictly related to transportation and mobility, such as economic, environmental, and social factors. This can be accomplished by analyzing the sustainable components of the political agenda through tables of comparison and checks with stakeholders and political decision makers, or by analyzing the sustainable principles of the political agenda through tables of comparison and checks with stakeholders and political decision makers.[*15]

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 2*: Assess the Impact of Regional/National Framework*

The SUMP focuses on urban mobility, although it is part of a larger planning environment, such as regional or national planning. To minimize conflicts that may arise even in later phases, it is necessary to review the local regulatory structure to verify that it is consistent with the new Plan. Documentation, identification, and assessment of legal requirements, regional and national financing criteria, and higher-level plans, strategies, and objectives that may have an impact on SUMPs.[*15]

Step 3*: Conduct Self Assessment*

The phase will be carried out at the start of the project to determine the characteristics of present planning, as well as its strengths and shortcomings, in order to define the Sustainable Mobility Plan's true success potential. An evaluation of the phases will be required, for example, through peer review, which is presently used for local transportation planning processes to see if they depart from the European Guidelines. Determine any institutional hurdles, as well as restrictions impacting the entire planning process or checking the needs of the community, and assess if there are weaker categories or features of social exclusion as a result.

Step 4*: Review Availability of Resources*

Resource evaluation, which is closely related to the preceding activity, covers both human and financial resources, without which it will be difficult to determine a plan's success. Employee talents are rarely employed to support the formulation of the Plan in local governments, thus it is far more common than necessary to assign the task to outside professionals. After assessing the

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

institution's internal resources and maybe entrusting the assignment to a third party, it is required to draft a concise "Management Plan" in order to establish a successful approach. After that, political support for the budget must be gained in order to carry out the process, and ultimately, an assessment of the budgetary framework must be completed in order to carry out the measures.

Step 5*: Define Basic Timeline*

The key to success is defining a rough timeline; in doing so, it is necessary to consider all ongoing or planned activities, the timing of drafting the Plan, the period (elections, changes in political decision-makers, changes in regulations, etc.) And, in general, all those components that may have a negative impact on the timing of drafting. It will be required to pick an opportune period for defining the strategy framework operational for the planning process and putting the measures in place.

Step 5*: Identify Key Actors and Stakeholders*

The identification of diverse stakeholders and their roles in the planning process is a crucial exercise. Who are the most important players? What do the key actors entail? What kinds of conflicts might occur?[*15] By answering these questions, you will be able to form a complete picture and lay a solid and long-lasting basis among all of the specified groups of interest. Using tools like the influence-interest matrix to assess the value of each stakeholder and, as a result, assigning them a unique function.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Phase 2 - Define the development process and Scope of Plan

The Plan's creation process must be consistent with the context in which it will be implemented, so determining the territorial area of application is critical. Additional features such as policy integration and stakeholder participation are included in this phase, which should be completed with a broad agreement on the Plan and its modalities.

Step 1*: Looking beyond the Boundaries and Responsibilities*

The initial action of phase two is to choose the most appropriate territorial dimension, which must be agreed upon by all stakeholders. Once you've found the planning perimeter, you'll need to decide which institution or institutions will be in charge of the process, and then get political approval for the geographic coverage and organization.[*15]

Step 2*: Strive for Policy Coordination and an Integrated Planning Approach*

The goals of this activity are to ensure that transportation is integrated and that it is not treated separately; to identify relationships between changes in urban architecture and mobility; and to think of mobility as a shared discipline. These goals have been set in order to address one of the major flaws in present planning, namely the lack of connectivity between policies and institutions.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 3*: Plan Stakeholder and Citizen involvement*

Stakeholder participation aids in the development of more effective and efficient planning, which must:

- Ensure organized participation of all interested parties;
- Create a transparent culture based on communication and consultation;
- Encourage citizens to participate;
- Improve efficiency, quality, and transparency throughout the process.

Step 4*: Agree on Work Plan and Management Arrangements*

The development and implementation of a SUMP are extremely complicated processes that necessitate political backing, a process coordinator, and the creation of an operational program and tactics.

Phase 3 - Analyze the mobility situation and develop scenarios

The examination of the current situation and the construction of certain alternative scenarios representing future opportunities are found in this final step of the SUMP preparation. This is an important phase because it establishes a thorough and rational foundation for the objectives and scenarios that can be produced in the future. The beginning point is undoubtedly an examination of present events in order to determine the criticality and go deeper into the issues surrounding the reference context's mobility.[*15]

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 1*: Prepare an analysis of problems and opportunities*

Before taking any measures or making decisions about future policy, it is necessary to have a thorough understanding of the existing situation. In this regard, a study of the current situation is required, which can be done by reviewing iPlan papers and research on area accessibility, for example. Select a selection of congruous indicators characterizing the existing condition and mobility in the reference city from a document that highlights all of the criticalities present. It is also recommended to recover and evaluate the quality of accessible data, summarize them, and where gaps emerge, integrate them; identify prospective events that may occur, both known and unexpected, that necessitate a strengthening of the urban transportation system's resilience.[*15]

Step 2*: Develop scenarios*

The goal of this activity is to help stakeholders better understand the potential effects of drafting a Sustainable Mobility Plan. In particular, it is necessary to describe the various possible scenarios in both qualitative and quantitative terms, to evaluate the interrelationships that can be created between the various sectors concerned (e.g., mobility with the territory or with demographic development), and to use appropriate techniques such as the use of a graphical representation.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Phase 4 - Develop a common vision and engage citizens

The development of a shared “Vision” serves as a springboard for the subsequent phases, which will establish concrete projects and goals.[*15]

Step 1*: Develop a common vision of mobility and beyond*

Phase four’s first action emphasizes the need of developing a single strategic vision that is consistent with future prospects and regulatory frameworks. Starting with the assumption of the SUMP’s long-term vision, a representative group responsible for the development of the strategy “ vision,” arrange stakeholder meetings, construct the future vision project, and eventually publish it in a form that everyone can comprehend is required.

Step 2*: Actively inform the public*

Citizenship information is a crucial activity for establishing a foundation for the development of concrete initiatives. If citizens cannot always be included in the planning process, it is critical to keep them informed and up to speed on the various stages of the process. This can be accomplished through polls, local media involvement, or the distribution of process papers.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Phase 5 - Set priorities and measurable targets

The previous phase's "Vision" is insufficient unless it is backed with precise objectives that specify the type of change intended. Any change must be quantifiable using certain indicators that will be determined based on specific industries.

Step 1*: Identify the priorities for Mobility*

The formulation of the objectives is critical for determining the SUMP's strategic level and concentrating and coordinating operations. As a result, it will be important to assess the priorities for mobility options in collaboration with stakeholders, as well as to plan workshops, round-table discussions, and meetings to allow for consensus on major issues. Finally, in order to guide the selection of measurements and specifics for the Plan, identify precise, quantifiable objectives and specify the timeline of their implementation.[*15]

Step 2*: Develop SMART targets*

The level of change that one wanted to achieve in a specific period of time is indicated by a target. They are required to determine whether a change has truly produced the expected outcomes, and hence serve as the starting point for later monitoring and assessment phases. SMART targets must be: described in detail and including qualitative terms and quantities that are understandable to all parties involved; described in detail and including qualitative terms and quantities that are understandable to all parties involved; described in detail and including qualitative terms and quantities that are understandable to all parties They must be able to be stated numerically or referred to as a progress indicator to be considered measurable or quantifiable. Achievable, in light of the agreements reached, in terms of technical,

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

operational, and financial skills; Relevant in the sense that they must be significant in terms of guiding mobility and being consistent with other goals; Timings that are clearly established for the achievement of the goal.

Phase 6 - Develop effective packages of measures

There are four questions that must be answered briefly in this phase, What? Why? Where? When? The selection of size packages will have to be based on comparison tables, consultations with various stakeholders, and other administrations' experiences. They mark an important turning point in the Plan's development.

Step 1*: Identify the most effective measures*

The major objectives to be met in this activity are to identify packages of specific measures and to ensure that they are both cohesive and effective with the objectives.

Step 2*: Learn from others' experience*

It is advisable to learn from prior experiences, from the analysis of accessible sources, and from the know-how of the major local actors in order to determine the most successful approaches. Not only that, but it can also be beneficial to draw on the experiences of those who have implemented or are implementing measures in diverse circumstances in order to avoid making mistakes or to gather ideas and use them as best practices.[*15]

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 3*: Consider best value for money*

Not just efficacy, but also efficiency, is a key factor for selecting actions in order to ensure that they are financially feasible and to increase the credibility of their execution. This is accomplished by using financially viable criteria that incorporate both the flow of people and commodities, environmental implications, and the fact that all means of transportation are equally treated when analyzing costs and revenues.

Step 4*: Use synergies and create integrated packages of measures*

Phase six's final exercise emphasizes the need of identifying measures that can accomplish numerous goals. The goal is to group themin "packages" in order to integrate them and maximize their synergy and, as a result, the measure's effectiveness; for example, by integrating the planning of measures with other larger sectoral issues such as the environment, the economy, and health.

Phase 7 - Agree on clear responsibilities and allocate funding

This phase is inextricably linked to the preceding one; in fact, the development of an operational plan and associated budget is crucial and requires the approval of the process's key players. At this point, the main questions that need to be answered are: Who? How much?.[*15]

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 1*: Assign responsibilities and resources*

The designation of resources and responsibilities to assure priorities and implementation of the measures themselves is the next step in determining the set of measures. This exercise includes the validation of a reasonable plan, provide effective coordination between all the many means of financing, which can be:

- Municipal taxation;
- Direct financing;
- Community funds;
- Private operators;
- State or local funding;
- Fundraising.

Step 2*: Prepare an action and budget plan*

This plan must include a synopsis of priorities, objectives, resources, and work program implementation. As a result, a schedule measurement and budgeting technique for the next five years must be established, as well as a plan that identifies the contributions of each subject, the time schedule for the design conclusion, financing sources, risks, and emergencies.[*15]

Phase 8 - Build monitoring and assessment into the plan

These are essential actions that should be included as part of the overall strategy. Monitoring and evaluation must be integrated as a tool to review and measure all aspects of the planning process.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 1*: Arrange for monitoring and evaluation*

These are key actions for the Plan's effectiveness; they are able to identify and anticipate critical issues in the design and drafting of the SUMP thanks to this method. This is where monitoring and evaluation indicators are "linked" to the smart objectives of the earlier activity, with a focus on the most easily quantifiable indications in order to prevent overloading the system. The in-itinerant evaluation ensures continuous control by assessing the activities taken, their impact, and the measures' execution. It will also be necessary to establish duties and allocate them to the most qualified individuals (preferably, an independent body), define and measure interim results to verify progress, and anticipate stakeholder involvement.[*15]

Phase 9 - Adopt Sustainable Urban Mobility Plan

It is the culmination of all preceding phases; following quality assurance, the Plan is formally endorsed (containing activities and a financial plan) by political representatives.

Step 1*: Check the quality of the plan*

The team in charge of drafting the Plan will have to draft a document that must be controlled both internally and by stakeholders; as a result, in order to ensure a quality Sustainable Urban Mobility Plan, the draft Plan will need to be examined in its entirety and, if necessary, changes made with stakeholders.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 2*: Adopt the plan*

The Plan is only adopted after it has been legitimized by the Entity's political representatives or the entities in charge of execution. The process can take a few months in some cases, and the particular procedure for adoption is determined by the regulatory structure in place in each country.

Step 3*: Create ownership of the plan*

The activity immediately following the adoption is to ensure that the Urban Sustainable Mobility Plan is widely accepted and shared by providing information and involving stakeholders and residents. As a result, all of the process's outcomes must be communicated in a precise and transparent manner planning, explaining in detail what the objectives will be will achieve (expectations management), and ensuring that the Plan is the subject of debates and discussed as a goal achieved and shared with citizens.[*15]

Phase 10 - Ensure proper management and communication (when implementing the plan)

The Plan is implemented after the adoption phase, and because it is strategic, it deals with providing a framework of reference rather than going into the specifics of the actions or individual measures. The implementation phase follows a defined process to manage, communicate, and implement measures; implementation management cycles are significantly shorter than the planning cycle, and they must be flexible in order to effectively adapt to unexpected conditions.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Step 1*: Manage plan implementation*

A SUMP does not guarantee positive results, but it is critical to monitor its execution on a regular basis in order to handle any risks or hazards that may occur. The implementation cycle involves tasks such as deciding on and implementing management practices, implementation and reporting techniques with all stakeholders involved.

Step 2*: Inform and engage citizens*

The goal of this activity is to ensure higher acceptability of the measures and actions, as well as to raise awareness of opportunities while also limiting implementation. It will be necessary to assess how the negative impacts can be more pronounced than the favorable ones, and to reduce them in this situation. Inform the public on advances and how to put them into action, get them involved, and celebrate triumphs with them.[*15]

Step 3*: Check progress towards achieving the objectives*

Evaluation and monitoring are carried out during the implementation phase to ensure that progress toward the attainment of objectives is tracked on a regular basis. Any issues should be identified, and stakeholders and residents should be kept up to date on the development.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Phase 11 - Learn the lessons

To profit from the strategic process and drive future planning decisions, all of the results must be shared, reviewed, and analyzed.

Step 1*: Update current plan regularly*

In this action, areas where the objectives are unlikely to be met are identified, and modifications must be made with the individuals involved. At least every 5 years, a review and update is required to adapt to new needs that may arise over time.

Step 2*: Review achievements – understand success and failure*[*15]

It is essential to review the results achieved in order to, Analyze the planning process, the operational plan and implementation; Improve understanding of the planning process and overall measure its impact; Learn for subsequent revisions. Once a sufficiently useful number of results has been acquired, it will therefore be advisable to evaluate them (through meetings, interviews, focus groups), analyze critical issues and positive aspects and draw up a list of objectives that will hardly be achieved despite being still foreseen.

Step 3*: Identify new challenges for next SUMP generation*

Experiences from around Europe demonstrate how each planning cycle helps to strengthen abilities and raise awareness for future planning. This last activity's objectives are to "prepare" for the future planning by recognizing new difficulties that may develop and involving subjects and stakeholders to discuss with in order to respond effectively.

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Planning Cycle for a SUMP

Image 8. Comprehensive chart describing all the steps and substeps of SUMP

Image 8: Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

Best Practices

4.1
Urban Transport Systems

1. *Singapore*

General Information

Singapore has one of the best public transportation networks in the world, as well as one of the safest and most environmentally friendly. The city, on the other hand, is still changing. The government is improving the existing transportation network by building a new terminal and runway at Changi Airport, extending and improving the reliability of the MRT system, opening more cycling paths, and launching EV sharing and taxis, among other initiatives, as the population is expected to grow to more than six million people by 2030.

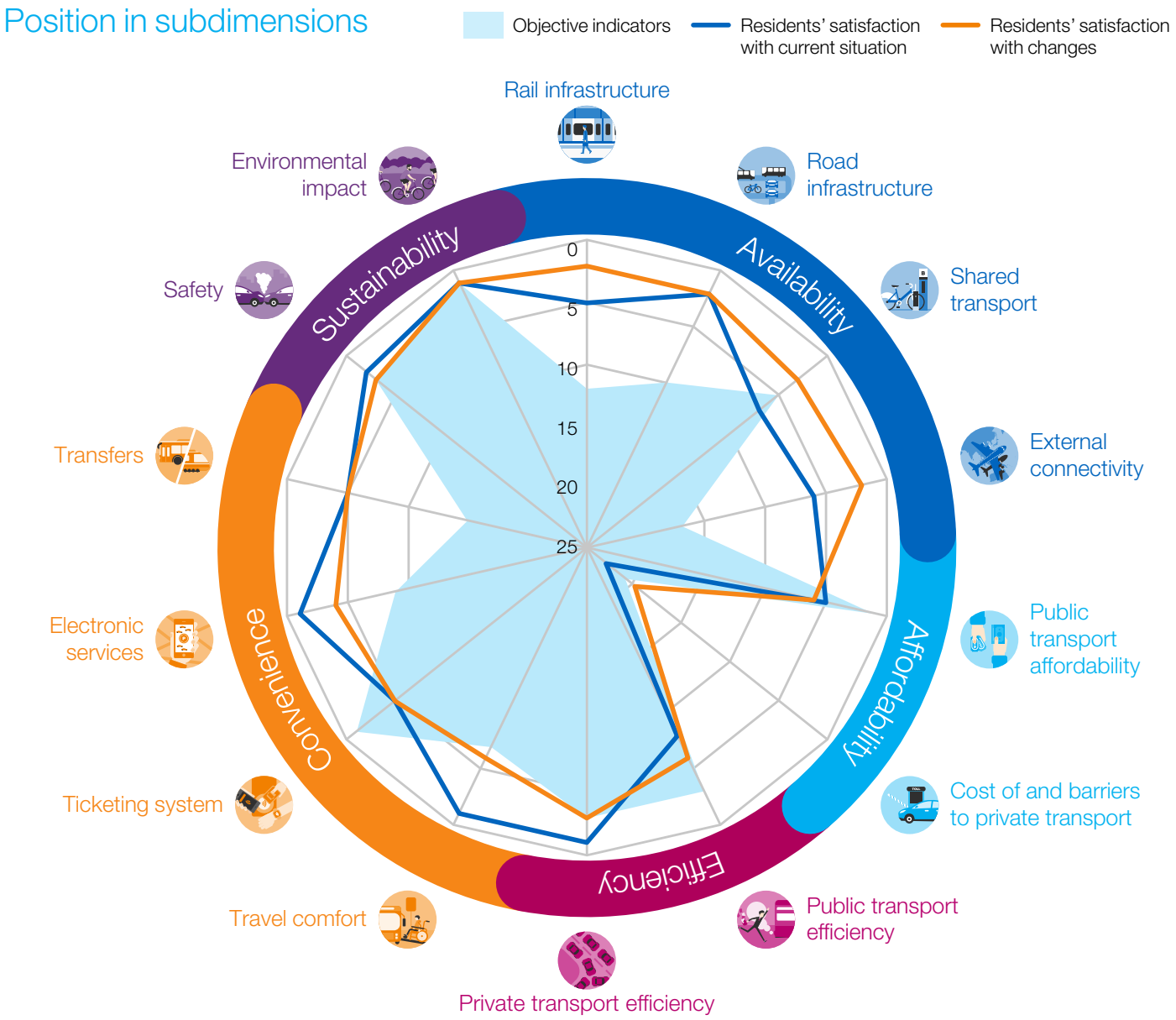
City population, millions	5.6
GRP per capita, in US$ thousands, PPP	66.9
Population density, people per km²	8,100
Cars per 1,000 people	101

People satisfied with overall situation in public transport, %	86
People satisfied with recent changes in public transport, %	83

People satisfied with overall situation in private transport, %	71
People satisfied with changes in private transport, %	73

Number have been rounded

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.



Objective Accomplishments

Singapore has developed a world-class public transportation system that is easy to use, efficient, convenient, sustainable, and economical.

- Singaporean public transportation is known for its efficiency, and the country's Land Transport Authority (LTA) is now focusing on building a predictive maintenance system.

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

- Another benefit is the low cost. In 2013, the fares were reassessed and additional measures were implemented, including a 15% discount on adult fares for low-wage workers, free transportation for children, and seven other concessions. As a result, the new program benefited almost one million people who use public transportation.
- Another notable element of the Singaporean ticketing system is its convenience and flexibility. The EZ-link card is a contact-less stored-value card that was first presented in 2002 for public transportation. The system successfully combines the primary ticketing advances—it can be filled up via the multipurpose EZ-Link App, and it allows users to earn and redeem reward points for any EZ-Link card transactions, including non-transport services. In 2017, the LTA began testing the use of credit cards to pay for bus and rail rides.

Residents' Perception

People are extremely content with their transportation system and how it has changed over the previous few years—they are the most satisfied in 13 of the 14 criteria evaluated, both in terms of the current state of their transportation and its changes, when compared to residents worldwide.
- Electronic services and their evolution are among the most popular modes of transportation among people. In 2016, the LTA began working with four top technology companies, City-mapper, Google, Hugo, and Quantum Inventions, to produce new enhanced trip planners that incorporate transfers into the planning of multi-modal public transportation routes.
- Singaporeans are generally pleased with their city's external connectivity, despite the fact that it lags behind that of other cities. Given its status as an island/city-state, the city's lack of internal flights is unsurprising, despite the amount of foreign flights available.
- The citizens' primary issue is the cost of private transportation, which corresponds to objective indicators. However, this is the result of an intentional car-limiting policy, which includes relatively high prices for new cars (over $74,000 for a modest SUV), the demand for a special government permit to begin driving (up to $37,000), and a fee to drive to the city center.

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

Aspects where Singapore is in the Top 10 Cities

LTA is currently working on a predictive maintenance solution. The Rail Enterprise Asset Management System would centralize and combine data from all train lines into a single database. This would allow for the prediction of possible defects, improved prevention, and the selection of the best maintenance strategy.

Image 9. Train line under Rail enterprise Asset Management System in Singapore

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

2. *Paris*

General Information

Paris boasts one of the best public transit networks and is one of the most developed cities in the world. Paris, which is dedicated to pedestrian and bicycle-centric programs, has already established a suitable infrastructure for non-motorized transportation and plans to expand it by establishing more car-free zones and supporting public transportation. Paris stands out in terms of maintaining passenger safety due to the city's concentration on preventing road accidents and making passenger safety the top priority of the public transportation network.

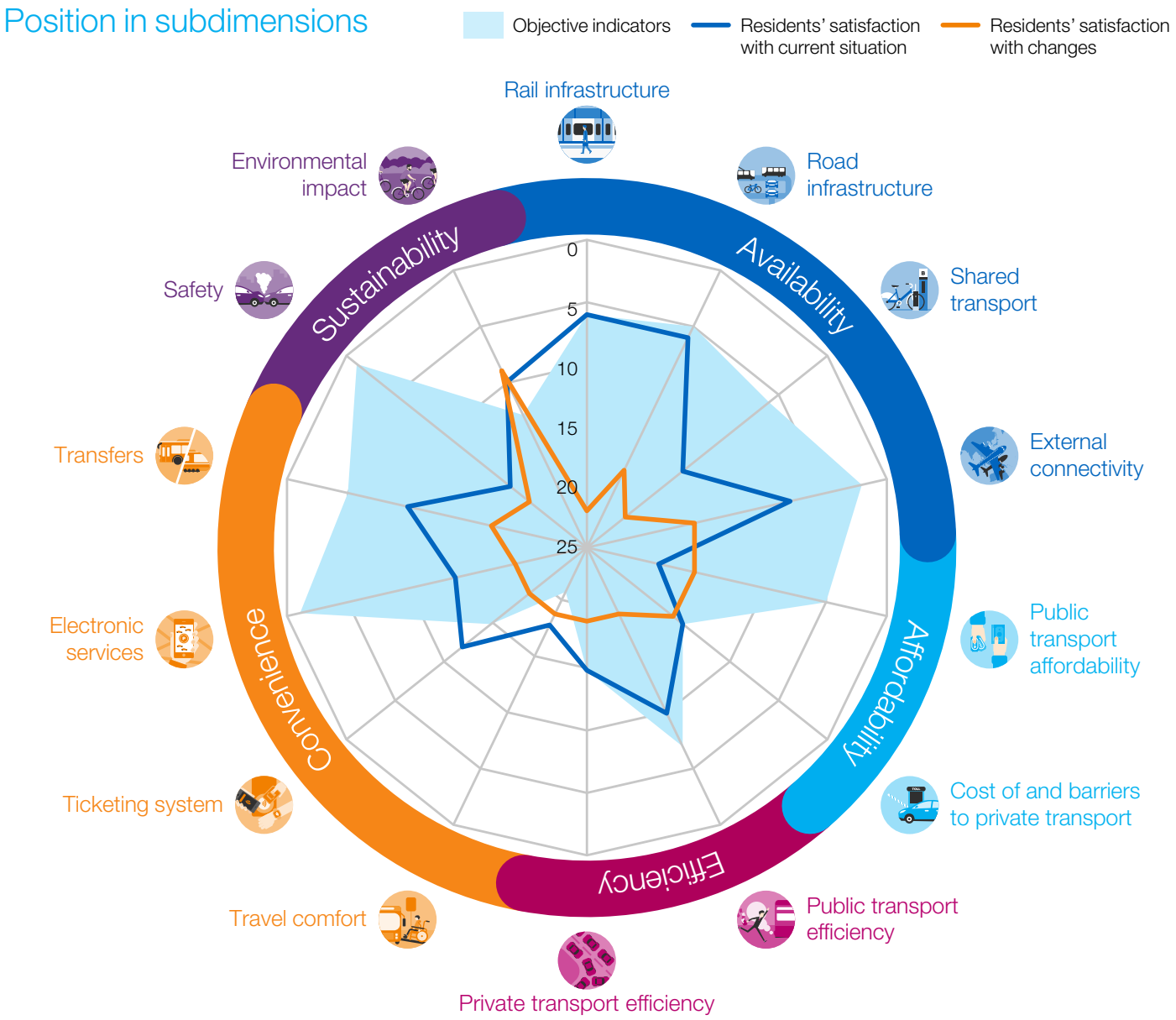
City population, millions	7
GRP per capita, in US$ thousands, PPP	57.2
Population density, people per km^2	9,200
Cars per 1,000 people	530

People satisfied with overall situation in public transport, %	68
People satisfied with changes in public transport, %	67

People satisfied with overall situation in private transport, %	60
People satisfied with changes in private transport, %	56

Number have been rounded

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.



Objective Accomplishments

Paris features a unique and user-friendly transportation system that prioritizes public transportation and non-motorized means of movement. - Although the established road infrastructure is one of the hallmarks of the Parisian transportation system, the mayor of Paris, Anne Hidalgo20, has consciously launched a transition away from vehicles and toward pedestrian and bicycle friendliness.

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

The city has already made a lot of districts and streets car-free, and it has no plans to stop. For example, in 2016, 2.4 kilometers of the Seine River quayside—a major thoroughfare—were declared car-free, with plans to expand car-free zones and limitations.

- Since 2010, Paris has also maintained best-in-class transportation safety, reducing traffic fatalities by 40%21. Because public transportation safety is one of the RATP's top concerns, it implements a variety of safety-related projects, ranging from metro track maintenance and replacement programs to more than 40,000 cameras that ensure passenger safety onboard and at stations.
- Another notable element of the Parisian public transportation system is its emphasis on passenger-friendly service, particularly through advanced computerized systems. 2,400 real-time information screens, for example, assist Parisians and visitors in navigating the multi-modal public transportation network.

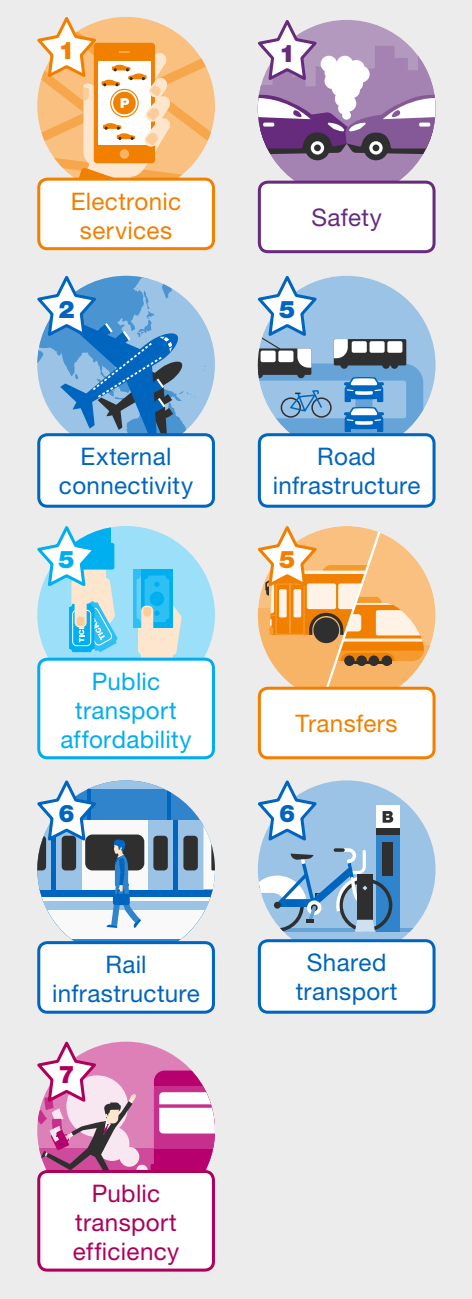
Residents' Perception

Although Paris boasts one of the most modern transportation networks in the world, its citizens are more dubious of it and its recent changes—resident satisfaction is lower across the board.

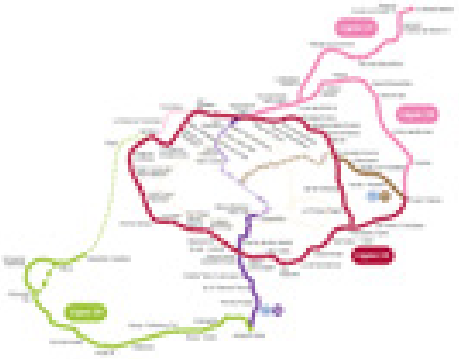
- Residents, on the other hand, are enthusiastic about transportation sustainability, particularly the Eco-friendly efforts that Paris has aggressively undertaken in recent years. One of the most notable is the launch of the world's first fully electric bus line, as well as a plan to outfit two other lines with a different battery technology. By 2025, the city intends to have a 100% "green bus" fleet.
- Residents like how efficient public transportation is right now, as well as how well-developed the train system is. This sounds fair, given that the Parisian metro system has 245 stops, making it one of the densest in the world. With the Grand Paris Express project, it also wants to expand to the suburbs by building new routes and stations.
- One of the biggest problems is the lack of transit comfort, as the Parisian metro is difficult to use for the disabled. Because the metro is very old and was built without elevators, it is currently difficult to build them. The city, on the other hand, is attempting to make public transportation more accessible to the disabled.

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

Aspects where Paris is in the Top 10 Cities



The Grand Paris Express is a huge public transportation network extension project designed to providing high-quality rapid transit to over two million passengers each day. The project entails the construction of four new automated metro lines in and around Paris, as well as the extension of two existing lines, totaling more than 200 kilometers of new track and 72 stops. The first stations are projected to debut in 2020, with a full deployment in 2030.



Map 1. Map of the Giant Paris Express

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

3. *Hong Kong*

General Information

Paris boasts one of the best public transit networks and is one of the most developed cities in the world. Paris, which is dedicated to pedestrian and bicycle-centric programs, has already established a suitable infrastructure for non-motorized transportation and plans to expand it by establishing more car-free zones and supporting public transportation. Paris stands out in terms of maintaining passenger safety due to the city's concentration on preventing road accidents and making passenger safety the top priority of the public transportation network.

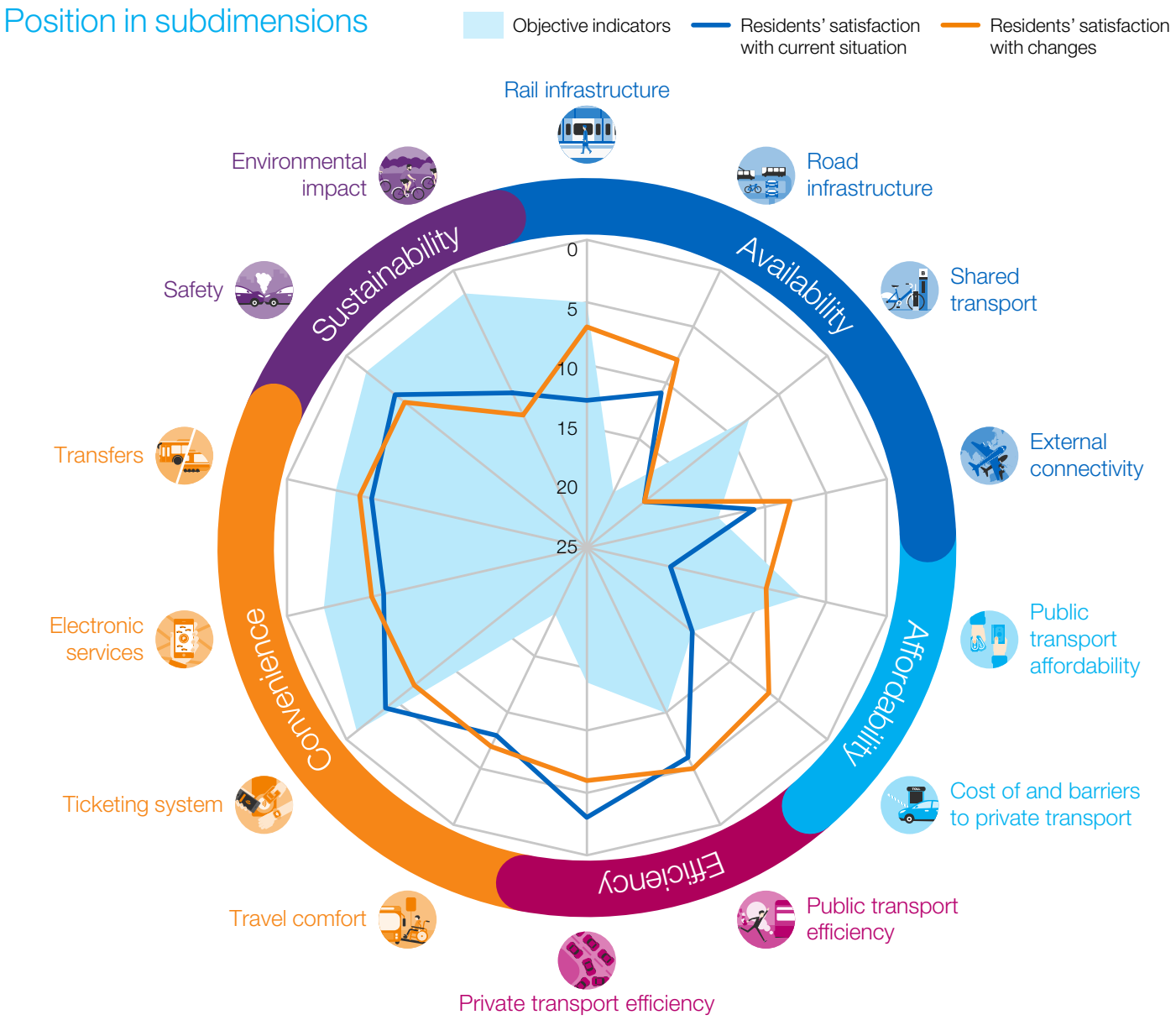
City population, millions	3.3
GRP per capita, in US$ thousands, PPP	57.2
Population density, people per km^2	36,300
Cars per 1,000 people	63

People satisfied with overall situation in public transport, %	83
People satisfied with changes in public transport, %	81

People satisfied with overall situation in private transport, %	72
People satisfied with changes in private transport, %	77

Number have been rounded

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.



Objective Accomplishments

Hong Kong's transportation system is well-developed, ranking among the best in the world in terms of train infrastructure, safety, environmental impact, ticketing system technologies, and electronic services. - Hong Kong is unique in that it has one of the best public transportation coverage areas in the world, with 75 percent of the population and 94 percent of

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workplaces within one kilometer of a metro station. Heavy rail is the backbone of public transportation, accounting for 37% of trips, and it is supplemented by light rail in the Northwest New Territories and trams mostly on Hong Kong's northern side.

- Hong Kong is a technology leader, actively implementing current technologies. Octopus chip card, the city's smart ticketing system, is well known around the world as an example of inventive solutions. It is used by 99 percent of residents and can be used not just to pay for transportation and non-transport services, but also for non-payment reasons such office building access control.
- In recent years, Hong Kong has made significant progress in terms of sustainability and safety. The city is a global pioneer in the adoption of electric vehicles, with more than 10,000 on the road now, compared to only 69 in 2011. In terms of safety, the number of fatal traffic accidents has reduced by about 15% in the last ten years.

Residents' Perception

Residents of Hong Kong are pleased with their current transportation system and recent advancements, particularly in terms of safety, convenience, and efficiency.

- Residents praise the ticketing system, as well as electronic service and safety, as being among the best in the world.
- Notably, Hong Kong citizens are generally content with the dynamics of public transportation expenses, whereas all other cities' perceptions are often negative. Hong Kong is taking steps to make public transportation more affordable by offering a variety of fee discounts for frequent riders, the elderly, and disabled passengers.
- Residents tend to underestimate the long-term viability of their transportation infrastructure, despite Hong Kong's position as a leader in this area. Furthermore, change perception is lower than one may think.
- According to people, the main potential for Hong Kong is transportation sharing systems, which are just getting started. The sharing is already a part of the city's long-term vision, with plans to build bicycle lanes and public parking spaces at major transportation hubs.

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Aspects where Hong Kong is in the Top 10 Cities

The MTR (Mass Transit Railway) is Hong Kong's primary public transportation system, handling around 4.8 million passengers per day. Over the previous 20 years, the network has tripled in length, reaching 231 kilometers with 91 stations. Its length will be increased by 25%, which will include the construction of additional stations and lines.

Image 10. Mass Transit Railway in HongKong

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4. *London*

General Information

Over the previous decade, London has seen significant population expansion, with more than a million people expected to move to the city in the next 20 years. The London transportation system faces a difficulty as a result of the city's fast growth. The city is spending roughly US$11.8 billion in 2015-16 to expand and improve the transportation network, making it more efficient and passenger-friendly. More improvements are on the way: London prioritizes public transportation, cycling, and walking, with the goal of increasing their use to 80% by 2041.

City population, millions	8.4
GRP per capita, in US$ thousands, PPP	57.2
Population density, people per km^2	5,200
Cars per 1,000 people	213

People satisfied with overall situation in public transport, %	85
People satisfied with changes in public transport, %	79

People satisfied with overall situation in private transport, %	69
People satisfied with changes in private transport, %	61

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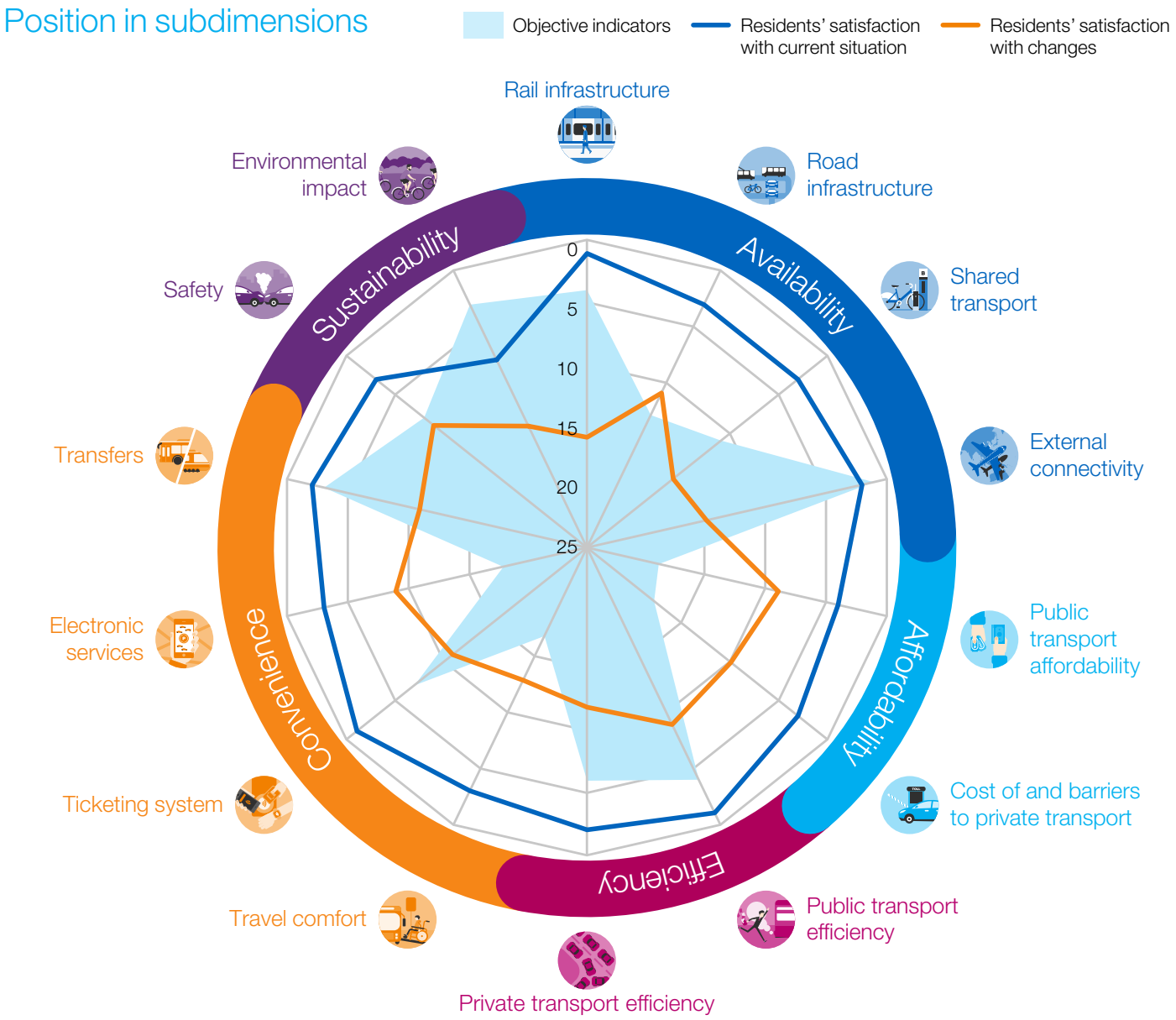

Objective Accomplishments

London's private and public transportation systems are well-developed; they are among the most efficient, safe, and sustainable in the world, and they are still evolving. The London public and private transportation systems are both extremely efficient. One of the top responsibilities of Transport for London (TFL), the government agency in charge of transportation in Greater London,

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is to ensure the reliability of public transportation. TFL's current activities include routine maintenance, track renovation, and boosting the number of trains running during peak hours. Advanced ITS, which allows for improved traffic monitoring and management, drives the efficiency of private automobiles, while congestion charges and high parking fees assist limit the number of cars in the city center.
- One of London's distinguishing qualities is intermodality, or mixed-mode transit: in 2006, the city created Legible London, a single navigation system, to make the streets more convenient for inhabitants and visitors. More than 1,700 signage have been put throughout the city since 2006. Legible London has won numerous honors and is widely regarded as one of the best wayfinding systems in the world. Another notable feat of London is its public transportation system. Following the adoption of Vision Zero, London has implemented a variety of safety efforts in recent years, resulting in a 45 percent reduction in fatal road accidents between 2005 and 2009. By 2041, the city wants to be completely free of fatalities and serious injuries on London's public transportation system.

Residents' Perception

Residents are quite satisfied with practically all aspects of the transportation system, according to the poll, while objective indicators and qualitative feedback indicate that there are a few areas that may be improved. The recent changes have also pleased Londoners, though to a lesser extent than their overall impressions of the system.
- Londoners are particularly grateful for recent adjustments in public transportation costs, as the city is now attempting to make public transportation more affordable. The mayor agreed to freezing public transportation fares at 2016 levels until 2020, saving an average household up to US$280 over the four-year period. One of the most popular elements among residents is ticketing. The Oyster card, which can be used on almost all of London's public transportation, makes payments easier by offering a variety of Online capabilities. Although London's transportation system is one of the most environmentally friendly in the world, citizens believe there is still room for improvement and are wary of recent modifications.

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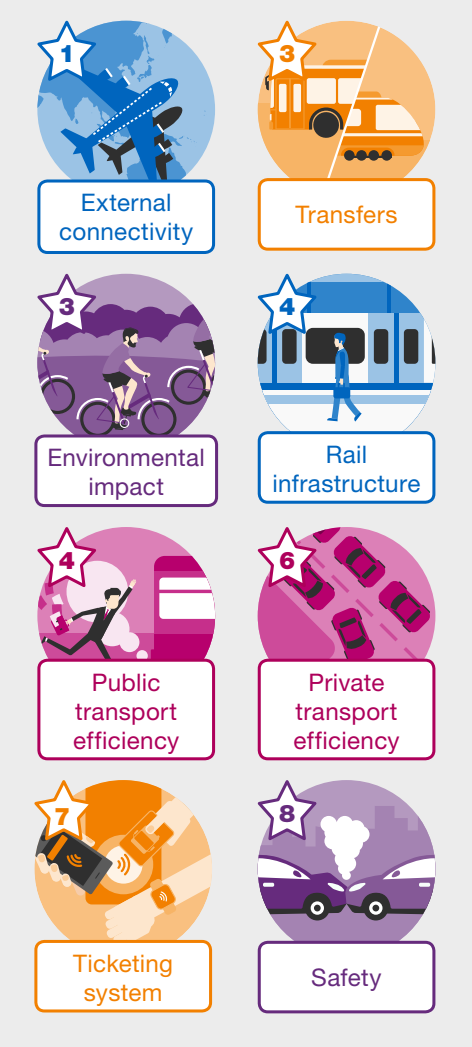
Aspects where London is in the Top 10 Cities



The London Underground, sometimes known as the Tube, is the world's third-longest metro system at 402 kilometers. The Northern and Bakerloo lines are slated for major expansions by the Tube. 45,000 dwellings and 30,000 jobs might be supported by the new stations. The expanded capacity would reduce peak travel times in the morning and evening, as well as congestion on local bus and rail services.

Image 11. London tube, i.e., the underground subway system in London

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5. *Madrid*

General Information

Despite its specific problems, Madrid puts forth an amazing effort. Although the Madrid Central Almond region covers only 0.5 percent of the city's surface area, it is home to more than 35 percent of the city's jobs. On a typical workday, almost 1.25 million commuters visit the city as a result of this imbalance. They use the built radial highways as arteries, but such high passenger traffic eventually causes congestion. The city, on the other hand, has a strategy in place to deal with the problem.

City population, millions	3.2
GRP per capita, in US$ thousands, PPP	39.3
Population density, people per km^2	5,200
Cars per 1,000 people	563

People satisfied with overall situation in public transport, %	76
People satisfied with changes in public transport, %	79

People satisfied with overall situation in private transport, %	61
People satisfied with changes in private transport, %	64

Number have been rounded

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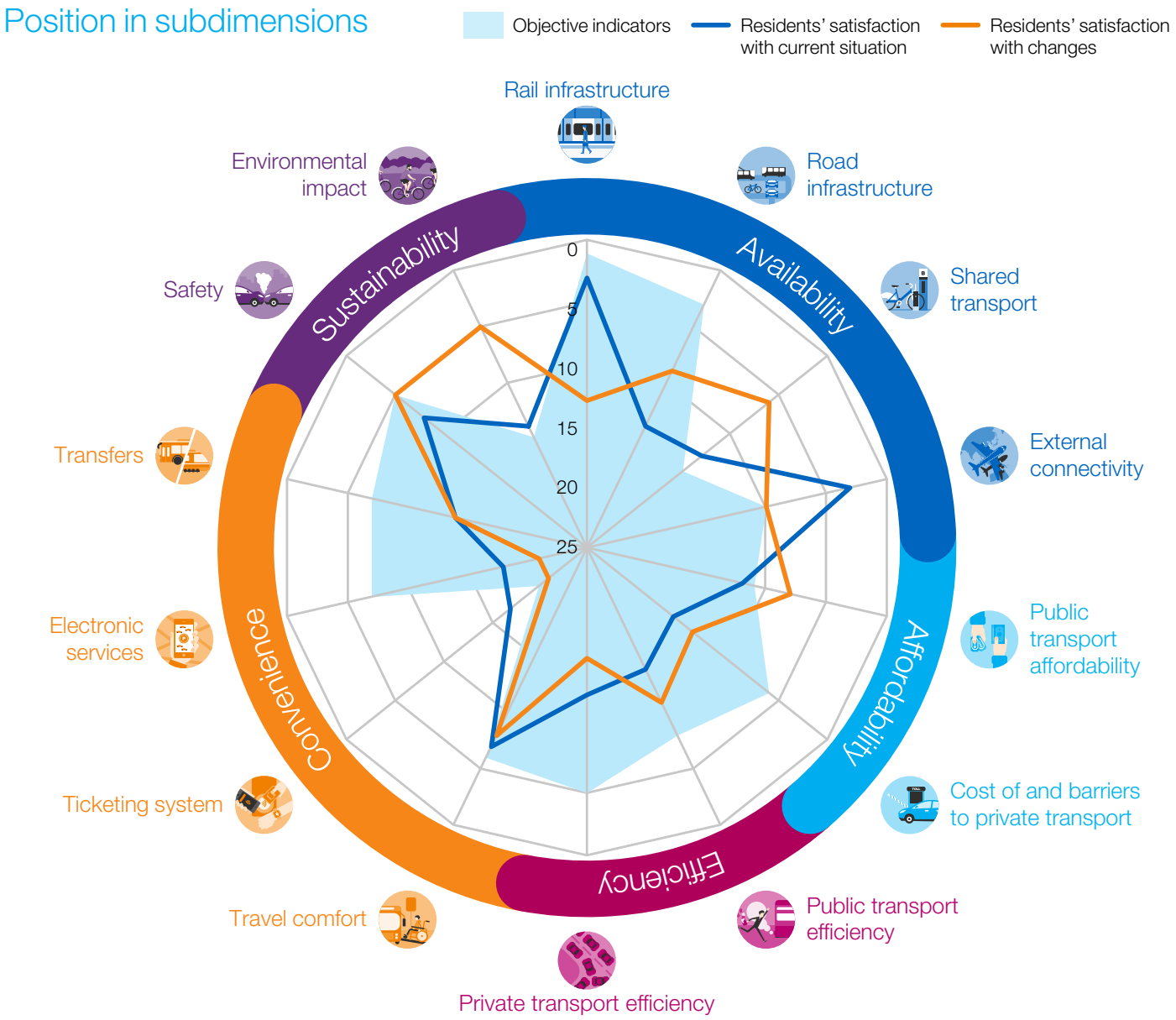

Objective Accomplishments

Madrid has created a well-balanced transportation infrastructure that allows for best-in-class mobility for both private and public transportation. Madrid's transportation system is known for its efficiency and extensive coverage. In compared to other metro and subway rail networks studied.

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- The Madrid underground has the most coverage—over 89 percent of the population and 97 percent of jobs are within a one-kilometer radius of a station. The Metro de Madrid has a 294-kilometer network with 13 lines and 301 stops. Between 2004 and 2007, a number of additional sections of M-30 (inner ring) highways with a total length of 99 kilometers were installed to offer better availability for private transportation. These make it easier to connect the city and the suburbs. - One of the best aspects of Madrid transportation is its efficiency, which is constantly improving. By enhancing maintenance and operations management, replacing the bus fleet, increasing the workforce of drivers, and extending bus lines, the Municipal Transport Company of Madrid has lately improved bus service and cut average waiting time. Madrid is a one-of-a-kind case in terms of private transportation efficiency, as it manages to provide extremely efficient private transportation without imposing large prices or limitations to limit cars.

Residents' Perception

Residents of Madrid are pleased with the current quality of some components of their transportation system and welcome the recent modifications in the majority of others.

The rail infrastructure and travel comfort, both of which are well-developed, are the aspects that passengers love the most. In terms of travel convenience, Madrid's public transportation is very accessible; 60% of metro stations and 100% of bus stations are wheelchair accessible, and the quality of the service is continually monitored. Shared schemes, safety, and environmental effect are the three primary changes that consumers value the most. Madrid is tripling the number of shared bikes to 4,000 and expanding dock stations beyond the M-30 circle in order to improve shared transportation. The city plans to promote non-motorized transportation to make transportation more environmentally friendly, such as by extending walkways for walkers and building separated bike lanes. In 2018, the city also intends to establish zero-emission zones in the city core. - Residents are worried about convenience features like ticketing, electronic services, and the flexibility to switch between modes of transportation, both in their current state and as the system evolves. This could be interpreted as an indication that there is room for improvement.

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Aspects where Madrid is in the Top 10 Cities

Gran Va, a major six-lane shopping boulevard in Madrid's centre, will be car-free until May 2019. There has been much discussion about its future, and in early 2017, it was decided to restrict access to walkers, bicycles, buses, and taxis. During the Christmas vacation, Gran Va was already partially closed to non-residents' cars for nine days.

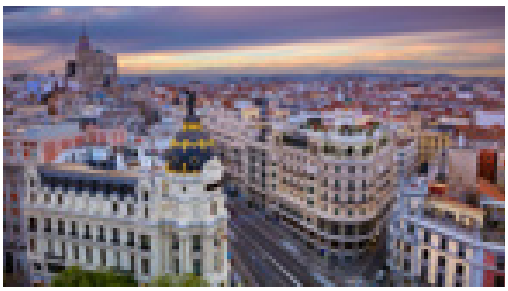

Image 12. Madrid City Center

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6. *Moscow*

General Information

The Moscow transportation system faces three major challenges: 1) inflow of residents from across Russia, 2) rapidly increasing numbers of commuters from the greater Moscow region, where job growth is outpacing population growth, and 3) residents' desire to own a car, which remains a symbol of success and luxury. In response to the issues, Moscow revised its transportation policy in 2012, emphasizing public and non-motorized modes of transportation. The goal of the policy was to increase public transportation use and reduce traffic congestion.

City population, millions	12.4
GRP per capita, in US$ thousands, PPP	45.8
Population density, people per km^2	11,300
Cars per 1,000 people	341

People satisfied with overall situation in public transport, %	75
People satisfied with changes in public transport, %	79

People satisfied with overall situation in private transport, %	48
People satisfied with changes in private transport, %	64

Number have been rounded

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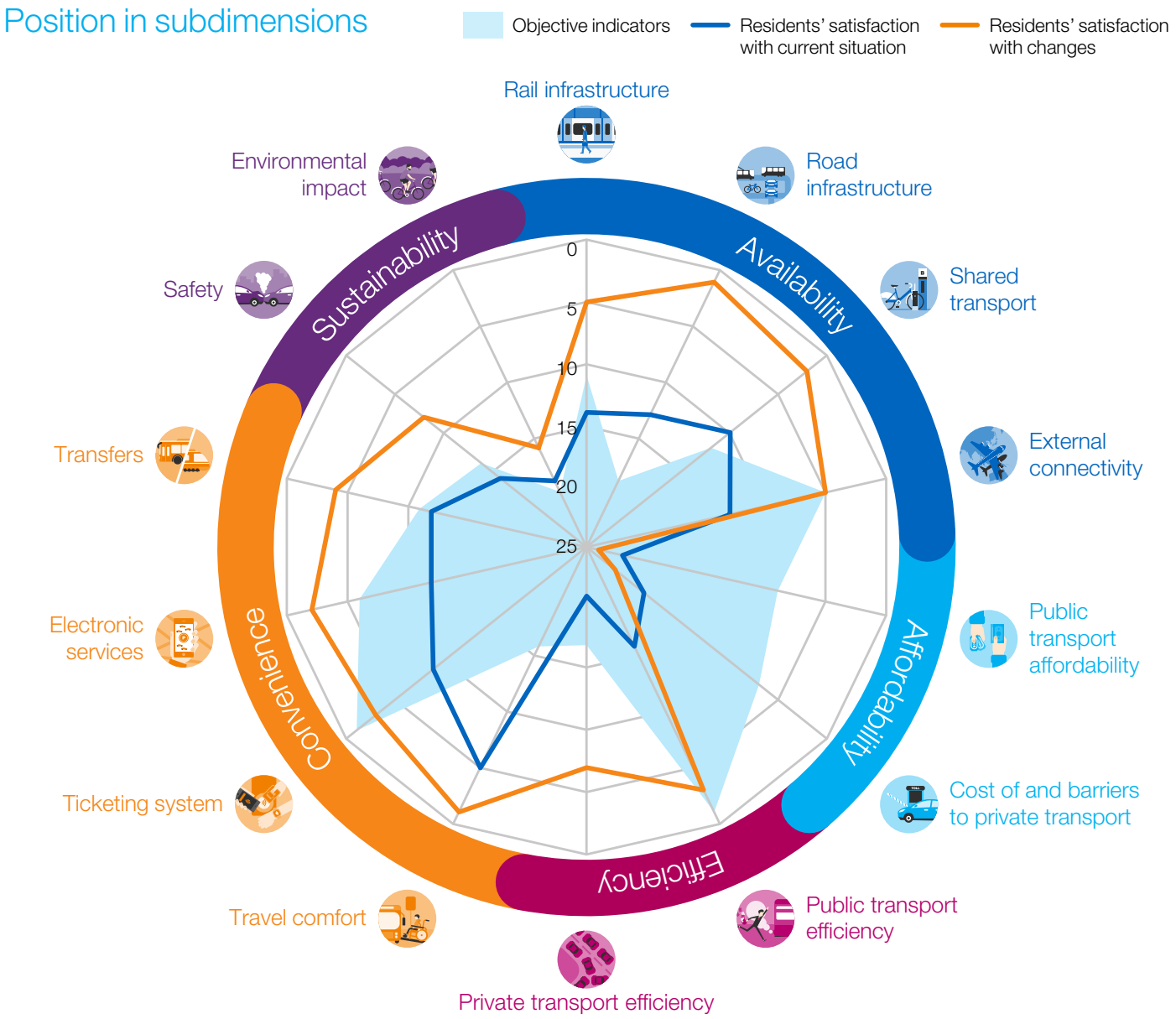

Objective Accomplishments

Moscow is notable for having one of the best public transportation systems in the world: it is extremely efficient, reasonably economical, and convenient, and its use as a percentage of total transportation has climbed by 10% since 2010. - Rail infrastructure has improved substantially in recent years. A large-scale metro extension was one of the important steps: 61 metro stations were built between 2010 and 2017, including the opening of Moscow Central Circle.

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- The efficiency of public transportation has improved dramatically as a result of route optimization, a major increase in dedicated bus lanes (an addition of roughly 285 kilometers since 2010), and the replacement of the bus fleet. These initiatives aided in the prevention of unanticipated breakdowns, the acceleration of ground transportation, and the increased reliability of the service.
- Moscow's best features in terms of ease are its ticketing system and electronic services. Adoption of a unified chip card with remote top-up and payments for activities other than transportation services, such as museums, is one of the advancements. Also available are a variety of other payment methods, such as mobile ticketing and Pay-pass/Apple Pay/Android Pay, which are currently being implemented. In addition, the Moscow government has lately digitized the majority of its services and created a number of popular transportation apps.

Residents' Perception

Despite the fact that most of the reforms done in recent years have been met with enthusiasm by Moscow residents, the city's transportation system remains undervalued in comparison to other cities.
- The availability and convenience dimensions, particularly the ticketing system, electronic services, intermodality, and shared transportation, have the highest levels of current satisfaction and contentment with modifications. The latter is the consequence of the active growth of a municipal bike-sharing program, "Velobike," as well as booming car-sharing programs, which today operate over 6,500 cars. The success of intermodality appears to be largely due to the creation of handy transfer hubs, the addition of over 8,000 intercept (commuter) parking lots, and the implementation of a single wayfinding system throughout the city.
- The affordability and long-term viability of the transportation system are top priorities for residents. While sustainability may be a future point of development, the system's genuine affordability is grossly underestimated, which may be due to recent economic stagnation. The efficiency of public transportation is a source of dissatisfaction. While residents agree that recent beneficial changes have been significant, their satisfaction trails well behind objective criteria.

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Aspects where Moscow is in the Top 10 Cities

Moscow Central Circle, a circular rail line with 31 stations that encircles ancient Moscow and connects 11 radial lines, launched in September 2016. On working days, an increased number of Lastochka trains ply the Moscow Central Circle, transporting about 430,000 passengers per day.

Image 13. Moscow Central Circle railways

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7. *Chicago*

General Information

Chicago is one of the top 10 cities in the world. Despite having a well-developed public transportation infrastructure, inhabitants rely heavily on private vehicles—77 percent of trips are made by car, which is high for a top ten city but typical of most US cities. The city recognizes the difficulties of heavy motorization and is working to improve public transportation, cycling, and pedestrian infrastructure in the future to ensure sustainable and efficient transportation.

City population, millions	2.7
GRP per capita, in US$ thousands, PPP	58.9
Population density, people per km²	4,400
Cars per 1,000 people	436

People satisfied with overall situation in public transport, %	77
People satisfied with changes in public transport, %	71

People satisfied with overall situation in private transport, %	65
People satisfied with changes in private transport, %	57

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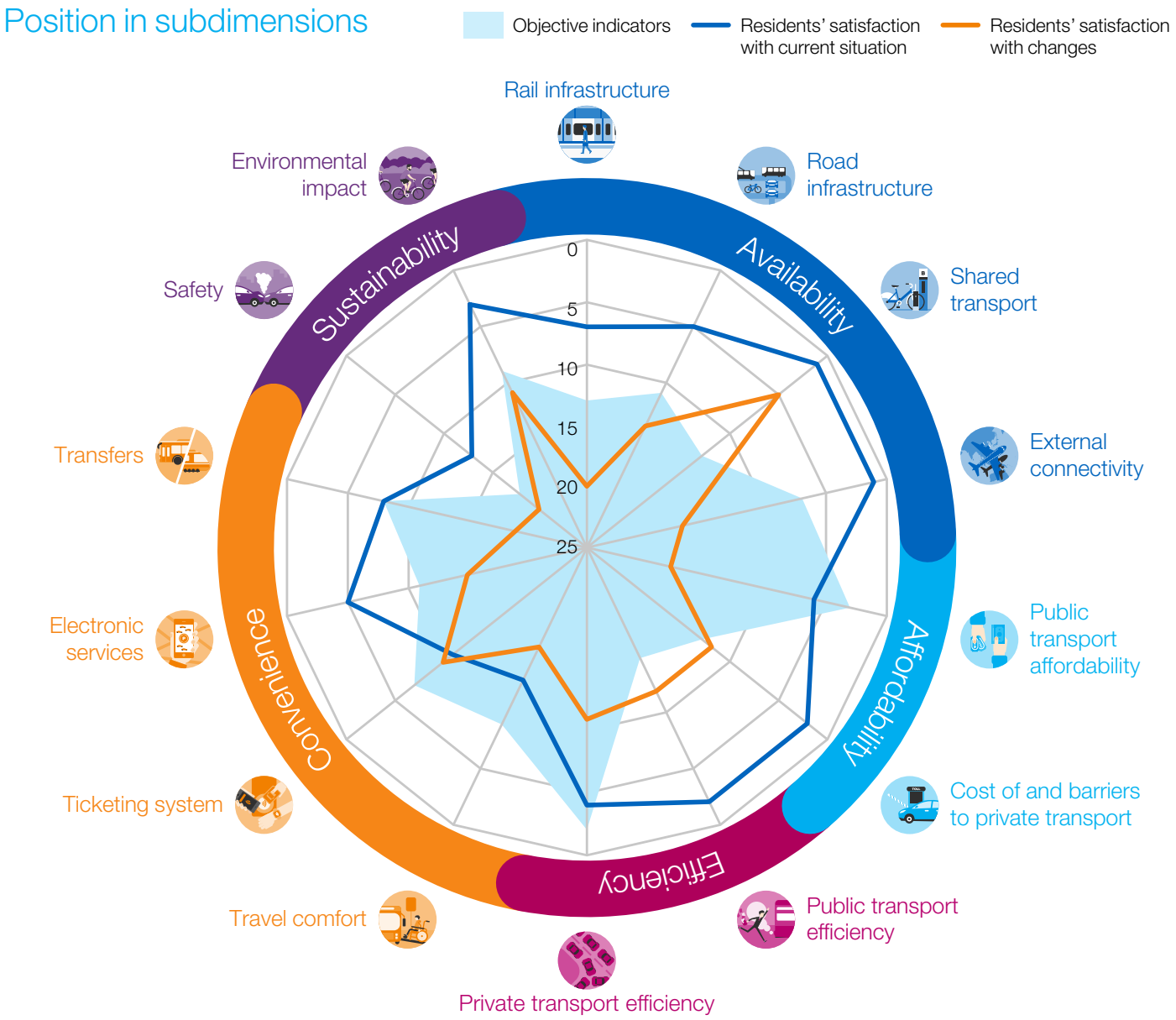

Objective Accomplishments

The Chicago public transportation system is both convenient and economical. Because there are no significant car limits in Chicago, private transportation is fairly affordable: the city only has paid parking and numerous toll highways within the area as constraints. Congestion charges, charged admissions to the city area, preventive taxes on car acquisition, and other similar techniques of discouraging private car use do not exist in the city.

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Although a monthly ticket is expensive in absolute terms, the city's public transportation is also among the most economical. This is due to the city's comparatively high average income. Furthermore, since 2013, the cost of a Chicago transit pass has remained consistent, and a variety of reduced-fare and free-ride schemes (for disabled individuals, military members, and elderly) are available. Another distinguishing element of Chicago transportation is its convenience; the city provides high levels of travel comfort, innovative ticketing and electronic services, and many modes of transportation. The Chicago Transit Authority (CTA) has made it a priority to make public transportation accessible to everyone; now, 100% of buses and railcars, as well as 70% of metro stations, are accessible. In terms of technical advancements, travelers have access to more than 20 applications with features ranging from real-time bus arrival information to maintaining a chip card account.

Residents' Perception

Residents are pleased with the public transportation system, particularly its accessibility, cost, and efficiency. Residents also value recent improvements in environmental friendliness, road infrastructure, and shared transportation.

- Despite the city's relatively high level of motorization, citizens are satisfied with environmental sustainability and changes. Chicago has made sustainability a priority and has handled the issue in a variety of ways. For example, since 2007, all new buses have had clean-diesel engines and specific filters to comply with US EPA emissions guidelines. In addition, the city intends to expand its electric bus fleet in the future. CTA upgraded its buildings with more energy-efficient lighting, including LED lighting, to make them more environmentally friendly.
- The city has also pushed cycling and walking as part of its sustainability-oriented agenda, and Chicago people like the shared schemes and road infrastructure, both in terms of their current development and recent adjustments. The city inaugurated Divvy bike sharing in 2013, with roughly 6,000 bikes available at 580 stations. Bike infrastructure has also been greatly improved, with more than 400 kilometers of dedicated bike lanes and a proposal to establish a continuous riding network of more than 1,000 kilometers by 2020.

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Aspects where Chicago is in the Top 10 Cities

The Chicago Loop Link, which opened in 2015, was an enhancement to bus service in the central business district, allowing for more reliable and quick travel. Six bus lines, dedicated bus lanes, bus-level stations/stops, and improved pedestrian and bicycle facilities were all part of the project. More than 30,000 bus passengers gain from greater frequent and reliable service, not to mention bikers and pedestrians who benefit from increased safety and more space.

Image 14. Chicago Roads showing buses, indicating the improvement of bus services in the Chicago Loop Link

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8. *Seoul*

General Information

Motorization has steadily expanded over the last decade, and with over 1.5 million people traveling to Seoul for work from adjacent regions, the transportation infrastructure is naturally under strain. Seoul recognizes the problem and has been concentrating on improving and promoting public and non-motorized transportation since 2004. Seoul's transportation system and its continuous progress are built on this people-centered approach.

City population, millions	10.1
GRP per capita, in US$ thousands, PPP	34.4
Population density, people per km²	16,700
Cars per 1,000 people	308

People satisfied with overall situation in public transport, %	84
People satisfied with changes in public transport, %	90
People satisfied with overall situation in private transport, %	65
People satisfied with changes in private transport, %	89

Number have been rounded

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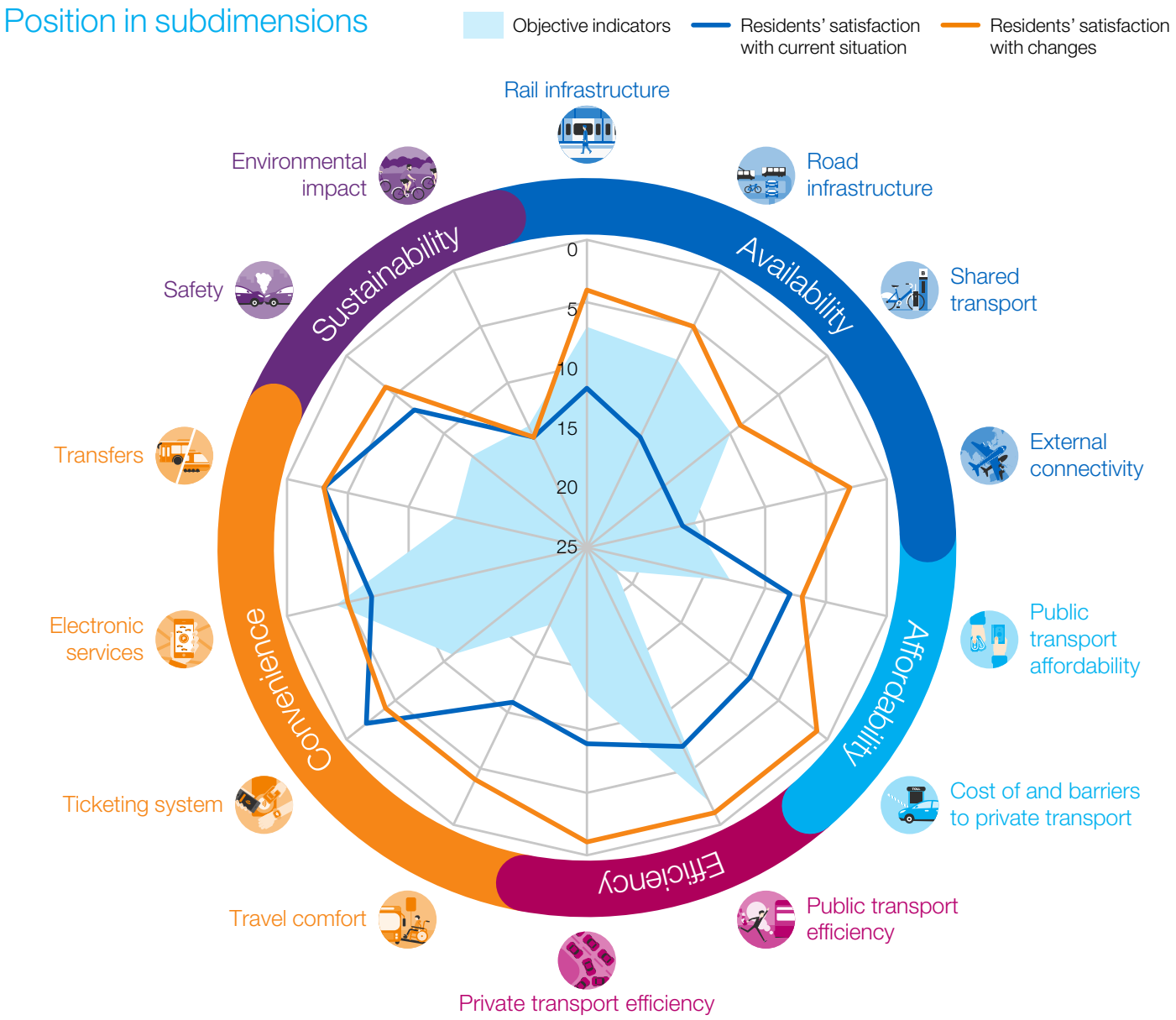

Objective Accomplishments

With a focus on public and non-motorized transportation, Seoul was able to construct a highly public transportation system with a wide coverage and well-developed technical solutions.

- Seoul's public transportation system provides some of the best rail coverage in the world. The Seoul Metropolitan Subway, which consists of 21 lines that

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connect city districts and provide connections to the suburbs, is the network's backbone. Furthermore, the bus network is well-developed, accounting for around 28% of all journeys. Inter-regional, trunk, feeder, and circular buses are four different types of buses with different functions.

- Seoul has also made tremendous progress in terms of public transportation efficiency, ranking among the top three cities in the world in this regard. The optimization of bus routes and the building of special median bus lanes, which enhanced bus speeds by an average of 30%, have fueled this success. The development of an intelligent Bus Management System was also critical in optimizing bus headway and staying on schedule, resulting in more reliable bus service.
- The enhancement of TOPIS, an integrated data center that allows the regulation and administration of road traffic, is driving the efficiency of private transportation, which is another of Seoul's relatively developed qualities. TOPIS' performance was recognized on a global scale when it was awarded the International Association of Public Transportation award in 2011.

Residents' Perception

In particular, Seoul residents are enthusiastic about the majority of recent transportation modifications and are particularly pleased with the convenience of their existing transportation system.

- Residents place a high importance on technology advancements, such as electronic services and improved tickets. Residents can get real-time information about public transportation arrivals both online and at stations, use multipurpose transportation apps, and connect to Wi-Fi in buses, metro stations, and bus stations.
- Locals consider recent improvements in shared transportation and road infrastructure to be a success. Seoul has been expanding its pedestrian and bicycle infrastructure in recent years, and it plans to build "special pedestrian zones" in Seochon and the Eulji Road region in the near future. A total of 8,400 shared bikes and 262 dock stations will be added to the city's public bike sharing program.

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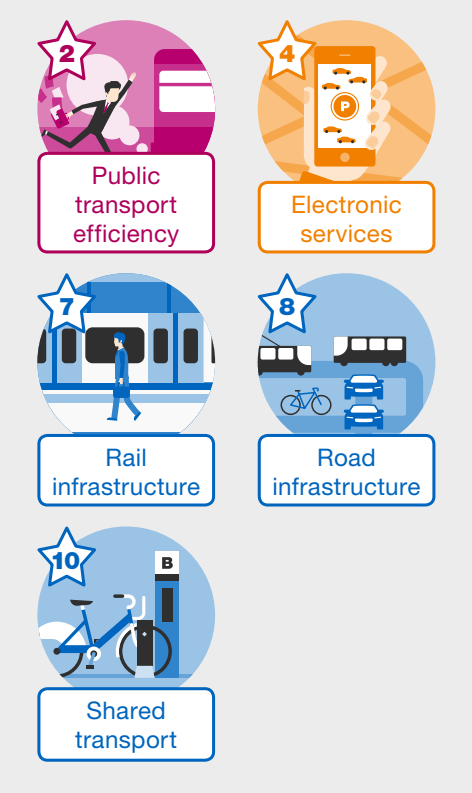
Aspects where Seoul is in the Top 10 Cities



After a $900 million renovation, the Cheonggyecheon Stream reopened to the public in September 2005. The creek had been covered by a busy elevated expressway for nearly 30 years. The park has helped to restore the area's natural identity and is now a popular tourism attraction for both inhabitants and visitors.

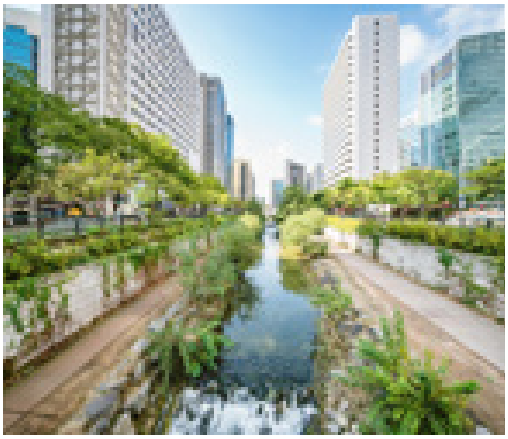


Image 15. Cheonggyecheon Stream, Seoul

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9. *New York*

General Information

The city's population surpassed 8.5 million for the first time in 2016 and continues to rise, putting further strain on its transportation network. Moreover, New York attracts hundreds of thousands of commuters from New Jersey and other nearby locations who visit the city on a regular basis for work. New York is one of just a few top cities in the ranking that has successfully built excellent public transportation networks while simultaneously maintaining strong private transportation.

City population, millions	8.5
GRP per capita, in US$ thousands, PPP	69.9
Population density, people per km^2	10,600
Cars per 1,000 people	305

People satisfied with overall situation in public transport, %	77
People satisfied with changes in public transport, %	72

People satisfied with overall situation in private transport, %	57
People satisfied with changes in private transport, %	57

Number have been rounded

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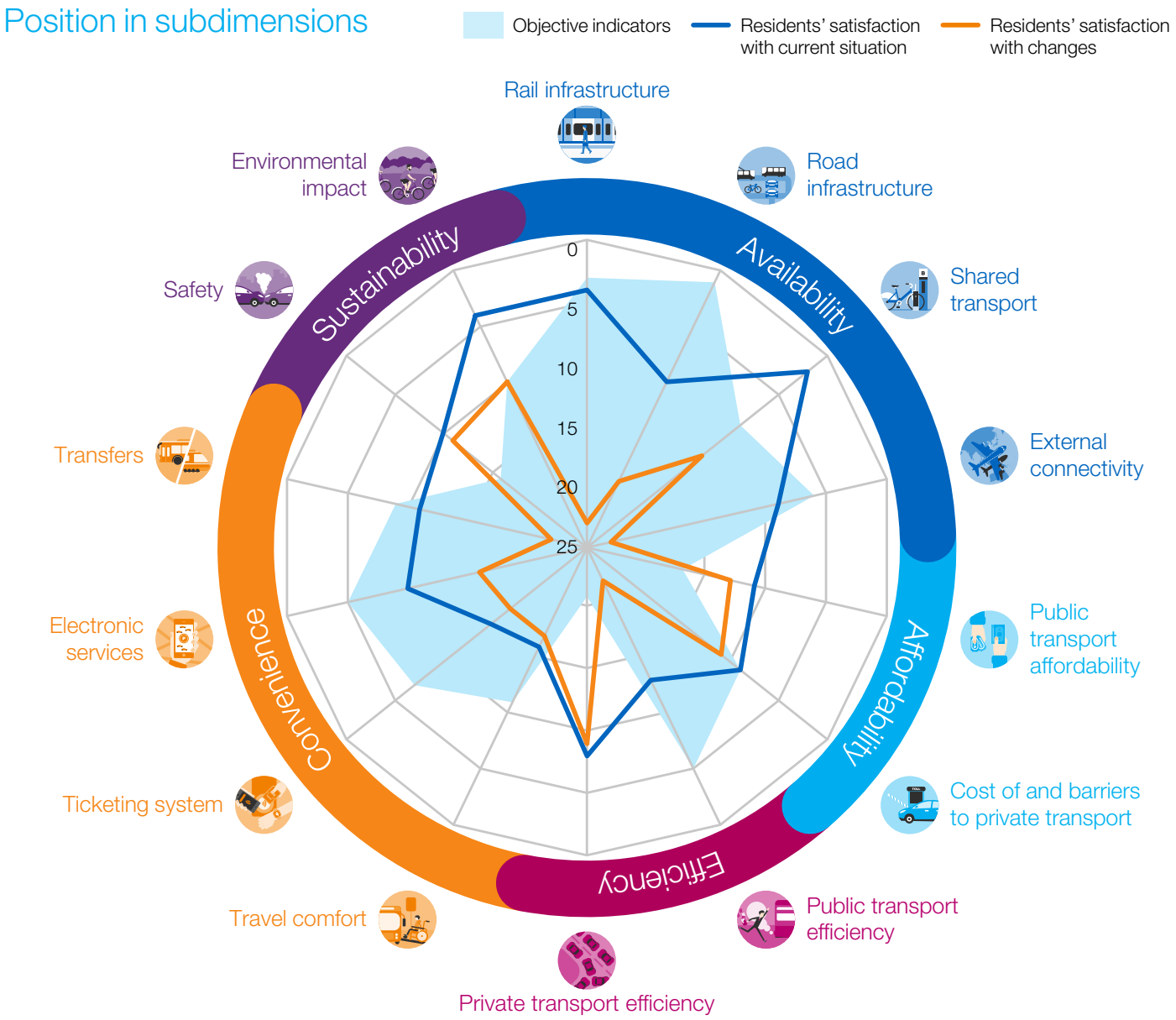

Objective Accomplishments

Public transportation and well-developed infrastructure for cycling and walking are two of New York's most notable transportation characteristics.

-New York features a unique transportation system that includes the world's largest metro network (472 stations), a comprehensive bus system, and over 13,000 taxi cabs. The metro and suburban rail lines encompass 73 percent of the population.

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and 93 percent of the jobs in the city. The city intends to extend the service by adding 21 new bus routes, which will cover new areas while also improving service.
- In the previous ten years, New York has improved cycling and pedestrian infrastructure, converting around 60 plazas and squares to pedestrian-only zones, adding more than 10,000 square meters of pedestrian space, and adding 600 kilometers of bicycle lanes. In recent years, the city has developed automated traffic signal management and off-board fare collecting, as well as dedicated bus lanes, which have cut average travel time by 12% during peak periods.

Residents' Perception

The citizens of New York value the city's transportation system, particularly its accessibility and efficiency. Residents, on the other hand, are less enthusiastic about recent changes in transfer convenience, external connectivity, and rail and road infrastructure availability. The city is considering providing more shared bikes with a dock less sharing scheme and is piloting a new car-sharing scheme in 2018. The residents' favorite feature is the sharing services, which are well-developed and actively being enhanced—the city is considering providing more shared bikes with a dock less sharing scheme and is piloting a new car-sharing scheme in 2018. Residents also appreciate New York's environmentally friendly transportation, which is a result of the city's Department of Transportation's dedication to decreasing its own carbon footprint and expanding sustainable travel options for New Yorkers.
- Safety programs are also popular among New Yorkers. New York was the first city in the United States to implement Vision Zero in 2014. In just three years, New York has seen significant progress, with road fatalities down 28 percent and pedestrian fatalities down 45 percent. Residents like the efficiency of private transportation as well, and they are pleased with recent changes in the city. To minimize traffic congestion, New York has used a number of new technologies in recent years, including sensor technology, data analytics for more efficient traffic management, and road rules enforcement.

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Aspects where New York is in the Top 10 Cities

In 2017, the final portion of the Manhattan Waterfront Greenway, a 51-kilometer waterfront for walking and cycling, was opened in New York. The project began in 1993 and has steadily progressed since then. The Greenway's last phase, which will include a continuous waterfront esplanade and a bikeway for nearly 100 blocks along Manhattan's east side, is slated to be completed in 2022.

Image 16. Manhatten Waterfront Greenway

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10. *Milan*

General Information

Milan is one of the most motorized European cities, with an estimated 850,000 daily commuters, which is a large number given the city's tiny population. These are significant obstacles for the transportation system to overcome. However, the city is tackling the problem, attempting to realign its transportation network toward more environmentally friendly means of transit, and has already made great headway.

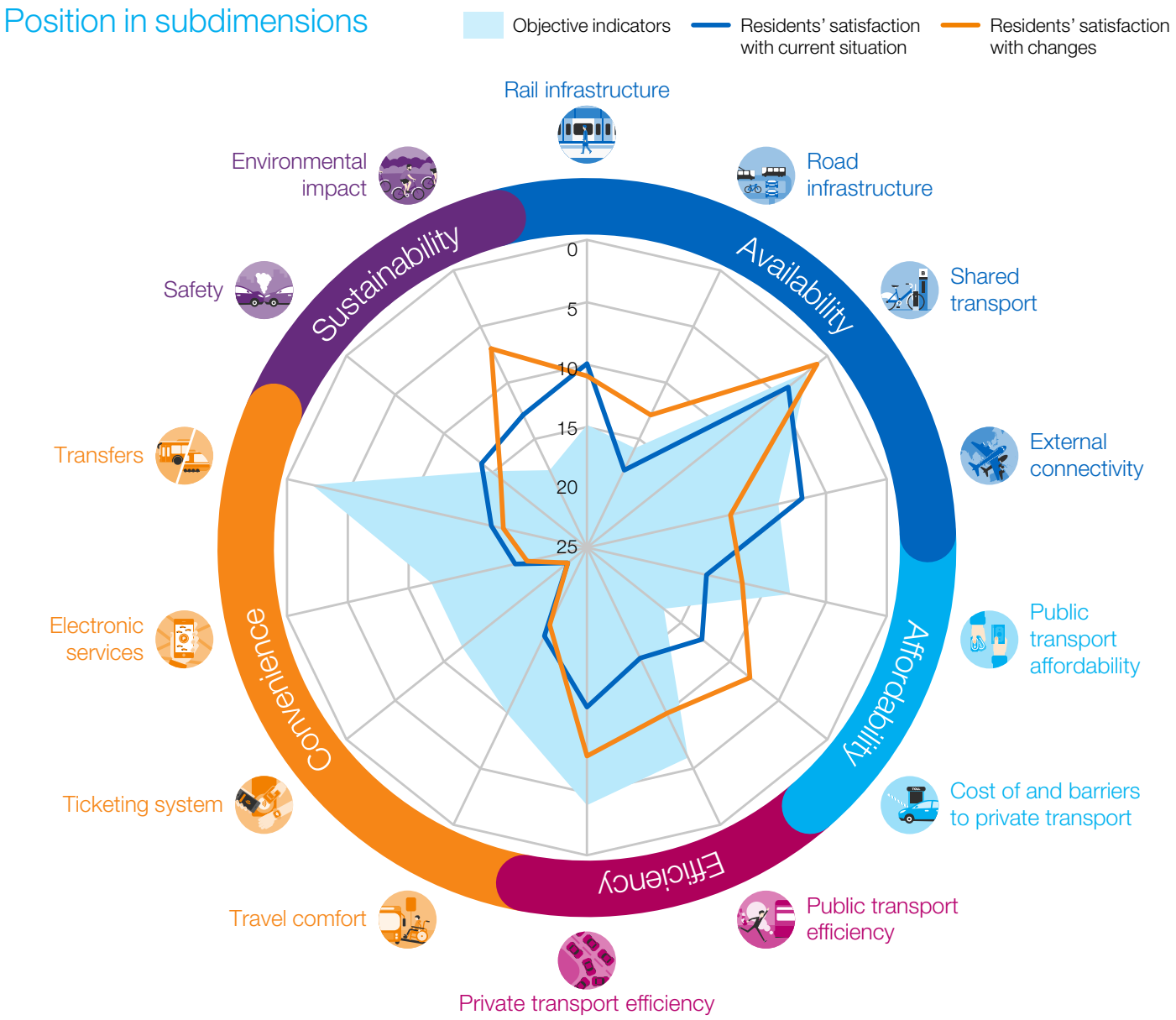
City population, millions	3.2
GRP per capita, in US$ thousands, PPP	41.1
Population density, people per km^2	2,000
Cars per 1,000 people	518

People satisfied with overall situation in public transport, %	70
People satisfied with changes in public transport, %	77

People satisfied with overall situation in private transport, %	57
People satisfied with changes in private transport, %	68

Number have been rounded

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.



Objective Accomplishments

Milan manages to cope with its relatively high rate of motorization by providing excellent private transportation. In addition, the city provides best-in-class shared schemes and is very transfer-friendly.

- Despite its high level of motorization, the city manages to maintain efficient private transportation, although at the sacrifice of its affordability. Milan implemented "Area C," a congestion charge in the city center, in 2012.

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

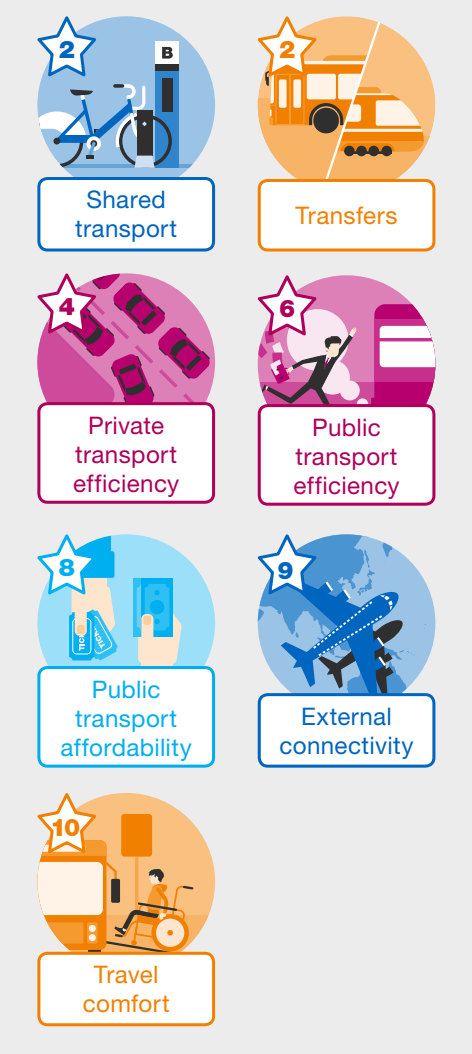
In the first month, the program reduced traffic by 33 percent, or about 40,000 cars each day. The long-term effect was similarly significant, resulting in a 28 percent reduction in the number of cars on the road. Vehicles that do not satisfy the required emission criteria are likewise prohibited from entering the system.
- Shared transportation is one of the most prominent elements of Milan's transportation system; since shared mobility is one of the pillars of Milan's sustainability plan, it has grown dramatically in recent years. Approximately 3,000 shared automobiles, nearly 30% of which are electric, 4,650 dock-sharing bikes, 1,000 of which are electric, 12,000 dock-less shared bicycles, and even 100 fully electric scooters are currently available in the city. The improvement of shared transportation has already yielded results: roughly 12% of respondents have decided to give up their individual automobile, with another 8% planning to do so in the near future.

Residents' Perception

Residents are content with the current status of train infrastructure as well as increases in efficiency, shared transportation, and environmental impact, while being cautious about other elements.
- Residents of Milan are grateful for the speedy rail service. Its network, which includes four metro lines and 12 suburban rail lines, covers 75 percent of jobs and 54 percent of the population, and serves more than 1 million passengers daily.
- People also prefer the recent modifications adopted under the city's Sustainable Mobility Plan in terms of sustainability. Popularization of shared transportation and upgrading of pedestrian and cycling infrastructure are its mainstays; the city has created more than 70 kilometers of bike lanes since 2011 and expects to add 250 more by 2024.
- The main concern of residents, both in terms of the current status and the changes, is convenience, particularly ticketing, which is comparatively well established.

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

Aspects where Milan is in the Top 10 Cities



Milan's metro rail network is currently being expanded, with Line 4 set to begin in 2022. The line would be 15 kilometers long and feature 21 stations, with all trains being automated. This would improve service frequency and capacity to up to 24,000 people per hour.

Image 16. Milan Duomo Metro Stop

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

4.2
Cyclable Cities

1. *Ferrerra*

Image 17. Ferrerra City Center

Ferrara is home to 140 000 people and 100 000 bicycles. Bicycles account for more than 30% of all journeys. Despite this, the town has maintained and even increased its efforts to promote cycling and limit vehicle use. The pedestrianized central area (5 acres) is also accessible to bikes. A 50-hectare area surrounding the centre is open to car traffic, albeit with a number of restrictions.

Ferrara is gradually expanding its cycling network to include major traffic routes, increasing the number of residential streets where cyclists and pedestrians have priority over automobile traffic, opening all one-way streets to cyclists traveling in both directions, and improving bicycle parking (2 500 places free of charge, 330 supervised places and parking for 800 bicycles at the station).[*11]

Image 17: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021
11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

The town was glad to replace outdated, uncomfortable pavement stones with flat, 80 cm broad ones to make cycling and walking more appealing propositions in the historic center! Even better, since the goal was to establish a bike track in both directions, some of Ferrara's one-way streets were created not to aid automobile traffic or to make more space available for parking, but to reclaim land allocated for bicycles. In other streets, through-traffic has been limited to allow cyclists to circulate in the now-strictly localized car traffic.

Tourism and leisure activities have been boosted thanks to the creation of a 163-kilometer cycling route along the Po River and the organization of bicycle tours of Ferrara. In terms of the local economy and small and medium-sized businesses that employ technical laborers, the popularity of cycling has allowed for the coexistence of no less than 31 repair shops.

2. *Bilbao and Biscay*

In the Basque country, the province of Biscay includes several important cities, notably Bilbao. The province has just begun development on a 200-kilometer bike network that, once completed, will connect all of the region's major urban centers as well as rural towns and villages. The project's major goal is to improve the environment (by reducing car use) and the quality of life (by providing infrastructure for a recreational activity), but it will also have economic benefits (tourism).

This network is based on a broad plan for the province's territory, from which the links to be created have been drawn. Nine itineraries have been created as a result of this process. These make use of former railway lines (50 km), as well as walks and asphalted roads (80 km), woodland paths, and other comparable routes (40 km). About 20 kilometers of cycle/pedestrian pathways will be built specifically for the missing linkages. These routes were created for daily bikers (since they connect close conglomerations and give numerous connections to the public transportation network), but they can also be used for recreational purposes (walking or cycling).[*11]

Image 18. Cycling Road, Bilbao and Biscay

Image 18: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

3. *Dublin*

Image 19. Dublin

The bicycle is the primary means of transportation for 11% of persons who commute to work in Dublin. Bike travel accounts for 5% of all journeys (corresponding to about one-fifth of the cycling rate in 1960). The use of bicycles decreased between 1987 and 1991, according to statistics. However, the opposite goal has been set, namely to double bicycle usage during a 10-year period to a level of 10%.

According to a market research, 18% of Dublin residents said they would be willing to pedal on a regular basis if there were facilities for bicycles. Furthermore, 16 percent of Dubliners who now cycle on occasion said they would ride their bike more often if more cycling facilities were available. A total of 34% of the population believes the administration will take steps to encourage cycling. To promote cycling, the Department of Transport in Dublin has studied a network of cycle paths as part of its research of a future mobility policy for the city. The recommendation of a EUR 3 million annual budget has received political approval. The total budget for the period 1994-99 will be EURO 18 million, support from the European Union being provided under the cohesion policy.[*11]

Image 19: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

The city has established a section to promote cycling, where city officials and bikers meet on a regular basis. A five-year plan is in place to construct 120 kilometers of cycle routes. In 1996 and 1997, 50 kilometers of cycling-friendly routes were built. In addition, Dublin intends to give 15% of the total number of parking places in public car parks for cyclists. Furthermore, Dublin can count on encouraging tourists to ride their bicycles to the airport; every year, 10,000 tourists arrive with their bicycles at the airport, and this figure is steadily increasing.

4. *Cyprus*

The European Union is funding the investigation of a bike network in four Cypriot cities: Nicosia, Larnaca, Limassol, and Paphos, as part of the LIFE initiative. The main goal is to alleviate traffic congestion and improve the quality of travels as well as the quality of life in these towns. The project is spaced out over three years and includes a program to encourage cycling among the general public (with conferences, debates, meetings with pressure groups, etc.). Two surveys on how cyclists are viewed are also in the works. The initiative has a total expenditure of EURO 330 000, with each municipality paying around EURO 18 000.[*11] The project began with a bike tour around Nicosia, which included the mayors of the towns involved.

Image 20. Cyprus

Image 20: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

5. *Freiburg*

Freiburg (Germany's Black Forest) has increasingly pedestrianized its downtown area. Despite vehement opposition from shops at first, there was a fundamental shift in thinking as soon as the first pedestrian streets were opened, and eventually the shopkeepers themselves pushed that pedestrianization should be implemented more swiftly. Similar steps have been used in Strasbourg. The fact that cyclists can access the city centers in both towns has been a strong motivator to pedal.

Pedestrianisation and the general mobility strategy have benefited Freiburg's 1976 cycling program (a 135 km cycle path network, investments totaling EURO 13 million, 30 km speed restriction zones over a wide area of the town). Between 1976 and 1992, cycling doubled in popularity, accounting for more than 20% of all journeys.[*11]

Image 21. Freiburg

Image 21: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

6. *Strasbourg*

The number of bicycle trips in Strasbourg has increased from 8% in 1988 to 13% in 1994, as the city promotes cycling while also limiting the center to cars and reinstalling trams. Trips to shops in the core have increased by 33% overall, despite the fact that the commercial surface area has remained unchanged. According to a recent poll of motorists, 63 percent believe that vehicles in cities are a thing of the past. Even better, 80% feel that car use should be reduced in order to enhance traffic circulation in the city.

Strasbourg offers 77 kilometers of bike routes and tracks, 12 kilometers of one-way streets, and 15 kilometers of pavements for cyclists to use. Bicyclists have access to some bus lanes. The overall plan for managing two-wheeled traffic as well as a cycling charter (which includes cycling infrastructure, an anti-theft campaign, communication, and service bicycles) have been adopted with the goal of achieving a lofty goal of 25% of journeys being conducted by bicycle.[*11]

Image 22. Strasbourg

Image 22: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

7. *Geneva*

Geneva's network of 13 cycling lanes, which was established in 1987, is expected to cover 100 kilometers and cost over EUR 4 million. Cycling's percentage of total journeys has increased from 2% to 4% in ten years. Cycling's annual growth rate is roughly 0.5 percent per year. Cycling's progress is slowed in areas where routes have yet to be built, demonstrating the value of cycling amenities. In 1995 and 1996, the town ran a promotion campaign that cost EUR 100,000. Every year, a new edition of the cycle route map is released.[*11]

Image 23. Geneva

8. *The region of Wallonia*

Image 24: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

Cycling has a stronghold in Belgium's north, with at least 4 million bicycles in Flanders out of a total of around 5 million in the country.

Whatever the case may be, the Wallonia region has recently taken an unprecedented step by funding pilot studies of cycle route networks in four of its major cities (Liège, Charleroi, Namur, and Mons) as well as several rural communities.

As a result, the local governments concerned have been given a road-map to follow for the next few years. It is up to them to actually build the networks based on this idea, with the help of the regional authority, which will fund the work at the local level and is in charge of regulating the regional roadways utilized or crossed by cycling routes.

Wallonia is also working on establishing a network that would mostly utilize canal and river towpaths as well as abandoned railway lines. While the 'RAVEL' (autonomous network of slow paths) will be useful for daily travel, it is primarily intended for leisure pursuits and will connect most of the major cities.[*11]

Image 24. The region of Wallonia

Image 23: Cycling, the way ahead for towns and cities, European Commission, accessed on 18.09.2021

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

4.3
Walkability

1. *Copenhagen, A City for People*

Copenhagen is known around the world for its one-of-a-kind design of bustling pedestrian streets. It's also known for its laid-back outdoor cafe and diverse international culture. Copenhagen did not spring up out of nowhere with buildings, roads, and streets. Stroget, for example, is a city in the heart of Copenhagen. It is made up of a 3,500-foot-long linear arrangement of four medieval streets. This region is defined by winding, somewhat small streets with historic, long streets, which create a mysterious feeling due to the tightness and high structures. Stroget experienced a watershed moment in 1962, when its main commercial streets were converted into a pedestrian promenade. Approximately 96,000 square meters were set aside for pedestrian zones, with cars allowed to pass through.[*17]

Image 25. Walkable Roads, Copenhagen

17. Ariza, M. C. (2020, March 17). Public space for all: What makes Copenhagen the city for the people? Ciudades Sostenibles. Retrieved November 11, 2021, from https://blogs.iadb.org/ciudades-sostenibles/en/public-space-for-all-what-makes-copenhagen-the-city-for-the-people/

Stroget's pedestrian-friendly attributes are due to a number of factors. The open, stopping spaces for formal and informal entertainments, restaurants or coffee shops, as well as food vendors and attractions, are what distinguishes the street to the human sight. Furthermore, because the natural anatomy and structure of buildings operate as wind barriers, the street gives physical comfort and protection. One of the best things about Stroget is that it is designed for all types of people and audiences. On the same street, it brings people from all backgrounds, cultures, and nationalities together. People love going through Stroget because of the presence of people and activity, as well as the peaceful, carefree ambiance and the presence of varied historical architecture.

Furthermore, there is a large number of bicyclists. In the summer, half of the individuals who work in central Copenhagen arrive by bicycle. Despite the wet and occasionally icy conditions, almost 70% of those who cycle to work do so during the winter months. Furthermore, bike riders do not appear to be discriminated against; they range from business executives and trendy women to the elderly, students, and parents with toddlers.[*17]

Image 26. Walkable Roads, Copenhagen

17. Ariza, M. C. (2020, March 17). Public space for all: What makes Copenhagen the city for the people? Ciudades Sostenibles. Retrieved November 11, 2021, from https://blogs.iadb.org/ciudades-sostenibles/en/public-space-for-all-what-makes-copenhagen-the-city-for-the-people/

2. *Alexandria, Violation of Pavements*

On the other hand, some cities, such as Alexandria, are inaccessible by foot (Egypt). Roads and streets are primarily used for automobile transit, with pedestrian paths defining their boundaries. Pedestrians are thus relegated to second place behind autos. Streets do not always occupy sidewalks and pavements. Sidewalks do not govern pedestrian flow, nor do they give comfort

Image 27. Alexandria, Egypt

39. EL-ZEMRANY, A. Y. M. A. N. M. A. H. M. O. U. D., & ABDELKADER KANDIL, R. A. N. A. A. S. H. R. A. F. (2019). Quality of life in Egypt: Walkability Assessment in El-Mansheya Square, Alexandria, Egypt. WIT Transactions on The Built Environment. https://doi.org/10.2495/cc190031

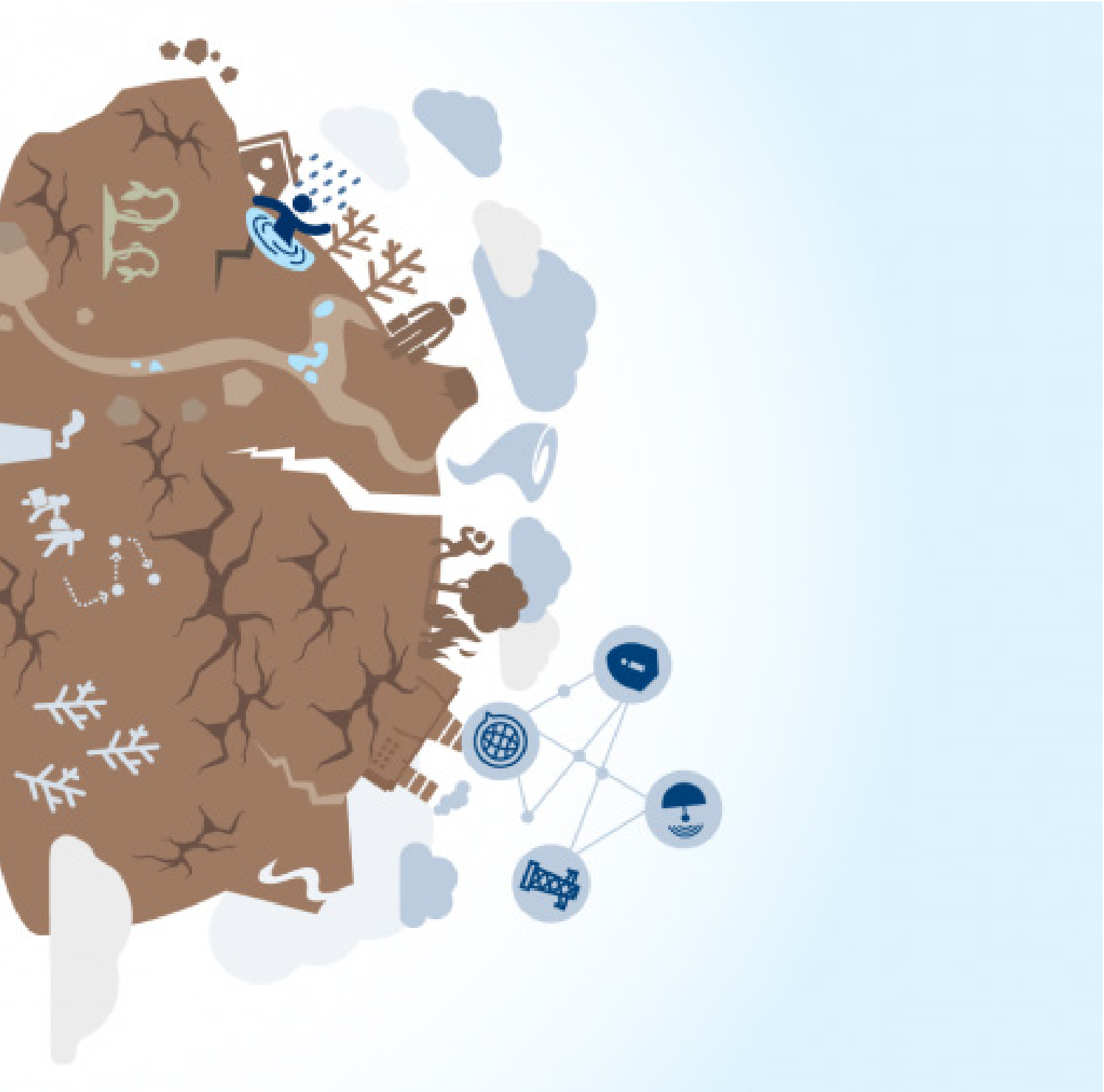
or ease of mobility. Furthermore, there are no pedestrians in the center or even along the sidelines. This is because, when it comes to new streets, the majority of planning considerations are centered on automobile circulation. For pedestrians, roads can be too large, uncomfortable, and dangerous, but they must satisfy the needs of automobile traffic. Pedestrians are put in a risky situation as a result of this.[*39]

I regret to inform you that the existence of sidewalks in Egypt is a violation of everyone's rights. The street is lined with numerous types of stalls, barriers and impediments, and various sorts of advertising. There are no rules or standards for displaying materials, construction, or real estate on the pavement or sidewalk. Unfortunately, this can be witnessed at places like Ramel Station (city center) and El Manshya, to name a few. It is important to note that all of these infractions are the result of a shortage of specialists. Some infractions are done for the purpose of decoration, such as planting trees that obstruct movement.

Image 28. Roads Occupied by Hawkers and Others.

39. EL-ZEMRANY, A. Y. M. A. N. M. A. H. M. O. U. D., & ABDELKADER KANDIL, R. A. N. A. A. S. H. R. A. F. (2019). Quality of life in Egypt: Walkability Assessment in El-Mansheya Square, Alexandria, Egypt. WIT Transactions on The Built Environment. https://doi.org/10.2495/cc190031

Mobility and Micro-Climate



5.1
Impacts of Mobility on Climate

Carbon dioxide, a greenhouse gas, is released into the atmosphere when fossil fuels like gasoline and diesel are burned. Carbon dioxide (CO2) and other greenhouse gases such as methane (CH4), nitrous oxide (N2O), and hydrofluorocarbons (HFCs) are causing the Earth's atmosphere to warm, resulting in climate changes that we can already experience.

Transportation-related greenhouse gas (GHG) emissions account for around 29% of total GHG emissions, making it the greatest source of GHG emissions. GHG emissions in the transportation industry increased more than any other sector in absolute terms between 1990 and 2019.

Land temperatures have risen twice as fast as the global average. Deserts are expanding, and heat waves and wildfires are becoming more common. Increased heat in the Arctic has been linked to melting permafrost, glacier retreat, and sea ice loss. As temperatures rise, intense storms and other weather extremes are becoming more common. As the climate changes in places like coral reefs, mountains, and the Arctic, many species are forced to relocate or become extinct. Climate change poses a number of challenges, including food and water scarcity, increased flooding, extreme heat, increased disease, and economic loss. It has the ability to drive people to migrate. Climate change is the greatest threat to global health in the twenty-first century, according to the World Health Organization.[*7]

Another side effect of the industry of mobility is the presence of contaminants in the atmosphere that are harmful to human and other living species' health, as well as the climate and materials. People who are exposed to air pollution experience a wide range of health issues. There are two types of effects: short-term and long-term. Short-term complications include infections like pneumonia and bronchitis. They can irritate the nose, throat, eyes, and skin as well. The symptoms of air pollution include headaches, dizziness, and nausea. Unpleasant odors produced by factories, trash, and sewer systems are examples of air pollution. Around the world, almost 2.5 million people die each year as a result of the effects of outdoor or indoor air pollution.

7. NASA. (2021, August 26). The effects of climate change. NASA. Retrieved September 15, 2021, from https://climate.nasa.gov/effects/

5.2
Climate Adaptation

The term “adaptation” refers to the response of a human or natural system to stimuli or their effects (present or predicted / foreseeable) resulting from ongoing climate change, with the goal of minimizing damage or maximizing benefits. To avoid tertiary consequences, adaptation strategies concentrate on secondary climatic effects. For example, more rainfall (primary effect) can result in a surplus of water in lower places (secondary effect), resulting in flooded streets (tertiary effect). To deal with shifting climatic risks and uncertainties, adaptation strategies must include “flexible” actions. Incorporating the essential requirement of flexibility in architectural, environmental, urban, and transportation design, as well as all other types of infrastructures, the same adaptation process must be flexible and allow room for ongoing reviews, monitoring of results, and potential actions adaptation.

The intervention modalities at the local level should be capable of allowing for an overall adaptation that incorporates technology measures, ecosystem-based measures, and behavioral and lifestyle modifications in light of the changed environmental conditions. Such procedures are required to mitigate the primary effects of meteorological phenomena (heat waves, heavy rain, drought, and windstorms) as well as various harmful substances in the atmosphere.[*18]

The measures may be combined with the provision of green and blue infrastructures, urban greening, and water management actions, as well as solar radiation control and natural urban ventilation, resulting in a reduction in pollutants and the presence of more dilated and articulated spaces to contain social concentrations.

Reduced physical travel, such as limiting heavy usage of public transportation during peak hours and discouraging the use of polluting private vehicles, is critical to reducing potential health concerns. These models have the potential to alter work and leisure activity behavior and structure. Decongestion, de-intensification, polycentrality, self-sufficiency, and the provision of

18. Environment, U. N. (n.d.). Climate adaptation. UNEP. Retrieved November 20, 2021, from https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation

ecosystem services are all goals that have been advocated for the conversion of Paris into a “Ville du quart d’heur,” or a “15-minute city,” as proposed by Carlos Moreno.[*18]

The new design experiences highlight the need for an approach to urban design that addresses multiple aspects at once, as evidenced by the combination of environmental risks and vulnerabilities that characterize urban systems, in order to allow adequate adaptation to today’s multi-risk environmental scenario. Losasso states that adaptation necessitates a restructuring of knowledge in regards to environmental challenges and their effects on the architectural project.

“How do climate adaptation measures connect to a specific urban context and how do they apply?” Can be an issue that emerges. There are many various sorts and shapes of cities, and different design measures have varied effects on each of them. Due to the limited space available, it is difficult to regulate the local climate in a densely built-up area with a vast system of green and water, but it is much easier in a wider neighborhood.

18. Environment, U. N. (n.d.). Climate adaptation. UNEP. Retrieved November 20, 2021, from https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation

5.3
Climate Resilience

The idea of resilience, which is closely related to that of adaptation and has gained particular importance for cities, is generally hypothesized as extremely complex adaptive systems originating from the interplay of several subsystems: physical, functional, and socio-economic.

Climate change, exacerbated by the high rate of urban development in the last century and the resulting increase in greenhouse gas production, necessitates the capacity for "resilient development," defined as development based, in addition to mitigation actions, on codes of adaptation to respond quickly and flexibly to shocks and stress caused by changing environmental, social, and economic needs. A priority and cross-cutting goal of the Sustainable Development Goals is to transform urban settlements and infrastructure into resilient systems.[*19]

The resilience of territories, cities, and buildings represents a new challenge in today's risk society, in which it is necessary to combine planning and innovation in relation to adaptive, reactive, and regenerative capacities in order to minimize the impacts and vulnerabilities resulting from extreme events.

Producing territorial and urban resilience entails using the environmental balance as a primary (qualitative-quantitative) planning reference, to be preserved by acting directly on the metabolism, through a project capable of managing waste flows, to minimize production, support reduction and recycling, and regenerate the territory, in line with circular economy concepts.

The reduction of urban systems' vulnerability to extreme atmospheric events, the increase in the adaptability of buildings and open spaces, the use of bioclimatic criteria, and the increase in safety and environmental comfort are all examples of resilience and adaptation to macroclimatic changes and their microenvironmental impacts.

19. Climate resilience and adaptation to climate change. European Commission - European Commission. (2021, February 24). Retrieved November 20, 2021, from https://ec.europa.eu/info/research-and-innovation/research-area/environment/climate-action/climate-resilience-and-adaptation-climate-change_en

The ability of the built environment to react to the evolution of ecological impoverishment and natural capital, of impoverishment of material and physical resources, and of the energetic threat, with its inefficiencies and non-renewability of its sources, to the detriment of the long, including the quality of life, is invested in resilience and adaptation to problems related to progressive limited and non-renewable natural resources.[*19]

The available “green” solutions for interventions targeted at strengthening the built environment’s resilience, mitigation, and adaptation capacity can be divided into three categories:

- Strategic “gray” structural activities, or types of “physical” interventions in the built environment based on technical design services to carry out deep rehabilitation operations of buildings and infrastructures.

- Strategic “green” infrastructural actions, i.e., categories of “biophysical” interventions in the built environment that help increase ecosystem resilience and that, while aiming to halt biodiversity loss and degradation and restore water cycles, use the functions, services, and resources offered by ecosystems to deliver more effective resilience and adaptation solutions under the economic profile.

- Non-structural “soft” strategic actions, such as the definition and implementation of built environment policies and procedures, information disclosure, and Green Economy incentives, aimed at reducing or preventing vulnerability, not only of urban elements subject to “gray” footprint interventions or “green,” but of the entire system and to environmental changes (climate change) and chronic problems (resource scarcity).

19. Climate resilience and adaptation to climate change. European Commission - European Commission. (2021, February 24). Retrieved November 20, 2021, from https://ec.europa.eu/info/research-and-innovation/research-area/environment/climate-action/climate-resilience-and-adaptation-climate-change_en

5.4
Urban Heat Island Effect

Temperatures in densely populated regions are greater than those outside, both day and night: this is known as Urban Heat Island (UHI). In many cities, the intensity of the heat island reaches 10K, depending on urban features and local meteorological circumstances. This phenomena is caused by a number of variables, including a decrease in vegetation, which results in poorer evapotranspiration, a higher predominance of dark surfaces with low albedo, and increased anthropogenic heat output. As a result, urbanization is assumed to be the primary cause of the urban heat island. The effect of the UHI and its intensity in cities is mostly determined by regional atmospheric and topographical conditions. Geographical qualities, meteorological circumstances, and seasonal variations of a city's specific location all have an impact on the effect. Furthermore, the strength of the UHI is strongly influenced by the time of day.

The urban heat island increases energy consumption for cooling and electricity peak demand during the summer, increases the concentration of harmful secondary pollutants such as ground level ozone and Volatile Organic Compounds (VOCs), increases CO2 emissions in the atmosphere, worsens internal and external thermal comfort during hot periods, has an impact on health, and increases mortality.[*20]

Urban heat islands can be found on the ground (surface heat islands) as well as in the sky both within and above the metropolis (atmospheric heat islands). The latter is separated into two types: "canopy-layer" and "boundary-layer." When the temperature of urban surfaces is higher than that of rural surfaces (natural) surrounds, a "surface" heat island (SHI) is generated. This form of heat island is widespread in cities surrounded by moist soil or vegetation, as these locations are cooler than waterproof and dry urban surfaces.

Within cities, the heat island of the "canopy-layer" (CLHI) is detected in the layer of air closer to the surfaces, extending upwards, roughly to the average height of the structures.

20. Urban heat island: What it is and why it matters to construction. DOZR. (n.d.). Retrieved November 20, 2021, from https://dozr.com/blog/urban-heat-island

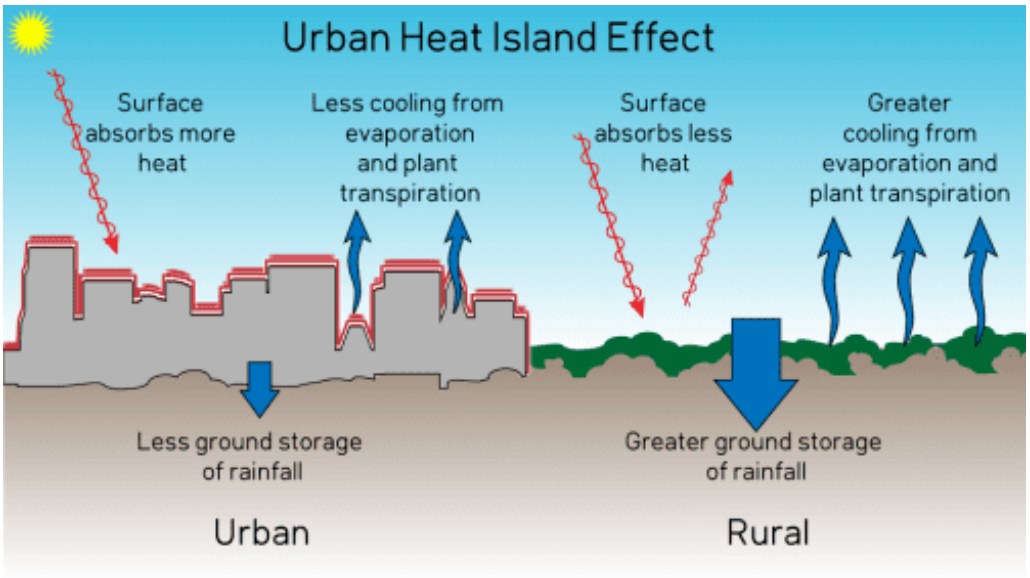


Image 29. Urban Heat Island Effect

Finally, the “boundary-layer heat island” (BLHI) generates a single dome of warmer air that extends downwind. During the day, it can be a kilometer thick or more, while at night, it can be hundreds of meters thick or less. The wind frequently transforms the dome into a plume.

To mitigate the effects of urban warming, mitigation and adaptation methods must be implemented. However, the two are inextricably linked because many adaptation measures contribute to and are preconditions for mitigation.

20. Urban heat island: What it is and why it matters to construction. DOZR. (n.d.). Retrieved November 20, 2021, from https://dozr.com/blog/urban-heat-island

5.5
Mitigation

The term mitigation, which in daily language refers to a set of measures for reducing and acting on the risks of any activity, can be described as «the reduction of risk through the decrease of the probability and/or impact of a societal hazard and/or vulnerability».” Mitigation is frequently linked to a variety of challenges, including technological advancements, global warming, health, and system physical vulnerability. Climate change is defined as “a human intervention to reduce the sources of greenhouse gases and/or improve their absorption, lowering their concentrations in the atmosphere.”[*21]

The EU has established a binding, short-term objective to cut emissions in the EU by at least 40% below 1990 levels by 2030 as part of a climate and energy policy framework. Furthermore, it aspires to reduce greenhouse gas emissions by 80-95 percent by 2050 compared to 1990 levels, with each of its Member States setting and pursuing national emission reduction objectives.

The combustion of fossil fuels for the production of energy, products, and transportation; agriculture and changes in land use; landfills; and the usage of industrial fluorinated gases are the main sources of greenhouse gases produced by humans. The phrase “mitigation,” on the other hand, has evolved to encompass all of the preceding difficulties. Climate change, socioeconomic development, greenhouse gas emissions, impacts, and vulnerabilities in many sectors have a relatively tight link. As a result, climate change mitigation is a worldwide strategy that must be implemented through international agreements and policies and is capable of reducing a major portion of the damages that would otherwise occur. Implementing effective mitigation techniques necessitates significant socioeconomic changes.

21. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved December 20, 2021, from https://www.eea.europa.eu/themes/climate

5.6
Strategies for Adaptation and Mitigation

1. *Green Infrastructure*

Evaporation and transpiration (evapotranspiration) cool the surroundings, whereas shade reduces the absorption of short wave radiation by the surfaces. The typical cooling effect of vegetation on air temperature is 1 to 6 degrees Celsius, but this is highly dependent on the amount of water available to the plant or tree. In urban settings, vegetation is used in a variety of ways, including urban forests (parks), road trees, lawns, private green in gardens, and rooftops or green facade.

1.1*: Urban Forest*

An urban forest or park is a green space in a densely populated region. As a result of the lower air and surface temperatures in these places, they form a so-called PCI (Park Cool Island). For a cooling impact, a green area does not have to be particularly large. It's vital to note that, because to evapotranspiration, trees have a higher cooling impact than the shadow cast by buildings alone.[*21]

The effect on the perimeter when utilizing a PCI for cooling is quite essential and varies depending on air flow and other climatic factors. The park's layout also plays a role: many trees give shade while also impeding the flow of air. Small, diffuse vegetation has the capacity to chill a larger region of the city than huge parks of similar overall dimensions.

1.2*: Tree Lined Avenues*

Although roadside trees may appear to have little impact on the temperature inside the city due to their dispersion, they have a significant impact due to their abundance. These, in reality, have the best cooling performance in terms of thermal comfort. The evapotranspiration of a single tree cools the air with a power of 20-30 kW in a single day of sunlight, which is comparable to

21. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved December 20, 2021, from https://www.eea.europa.eu/themes/climate

the power of more than ten air conditioning units. In a high-emission scenario, a 10% reduction in urban greenery resulted in a rise in maximum surface temperatures of up to 8.2 ° C. [*21]

The surrounding constructed environment is not necessarily fresher than the vegetation. In the winter, trees (and other objects such as buildings) provide shelter and impede the dispersion of heat into the atmosphere by breaking the wind and obstructing long wave radiation. After sunset in the summer, the same process happens, resulting in slower cooling in regions with numerous trees than in areas without trees due to reduced radiative exchange towards the sky.

1.3*: Urban Gardens*

Urban agriculture could be a viable strategy for increasing vegetation in cities. Because of the irrigation of cultivated fields, the disparity in effect on UHI and thermal comfort has risen. When the crops are also harvested, the effect of greenery is lessened; nonetheless, the behavior of bare soil in connection to the microclimate is even better than a waterproofing of the pavement. Another benefit of producing crops in and around cities is that it reduces the carbon footprint of cities by reducing food transportation.[*21]

1.4*: Green Facades and Roofs*

Vegetation on a roof or facade has a rejuvenating influence on the urban environment as well as the structure. The evapotranspiration of the leaves, the conversion of heat into latent heat via evaporation from the ground, and the avoidance of short wave radiation absorption by low albedo materials and shadowing are the cooling mechanisms responsible for a green roof or a facade. The internal temperature is lowered as well, thanks to the green package's high insulation value, which keeps the heat outside in the summer and inside in the winter. Roof greening is one of the most successful adaptation responses

21. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved December 20, 2021, from https://www.eea.europa.eu/themes/climate

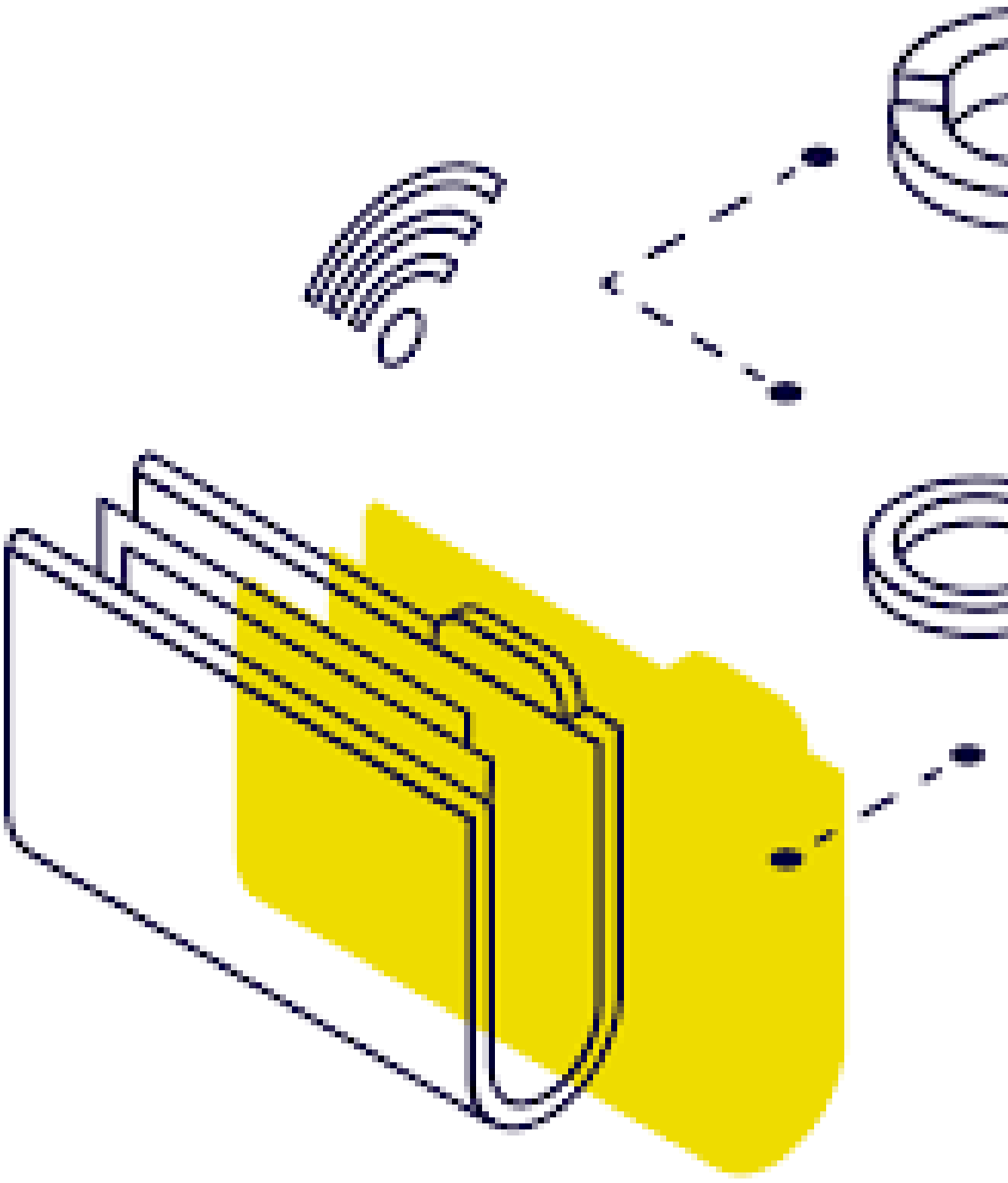
because it can store water during extreme weather, allowing water management to be decentralized. Simultaneously as a mitigating tool: effective for lowering long-wave radiation, which determines the urban thermal field, as well as improving air quality. Based on the characteristics of use, vegetation, and building techniques used, green roof systems can be divided into two categories: extensive green roofs and intensive green roofs.

In terms of green facades, the shade of windows and walls facing west saves the most energy in terms of cooling. Numerous studies have demonstrated the usefulness of green facade irrigation: one liter per day per m2 is sufficient for optimal cooling. These adaptable solutions work best in buildings that are less than 10 meters tall.[*21]

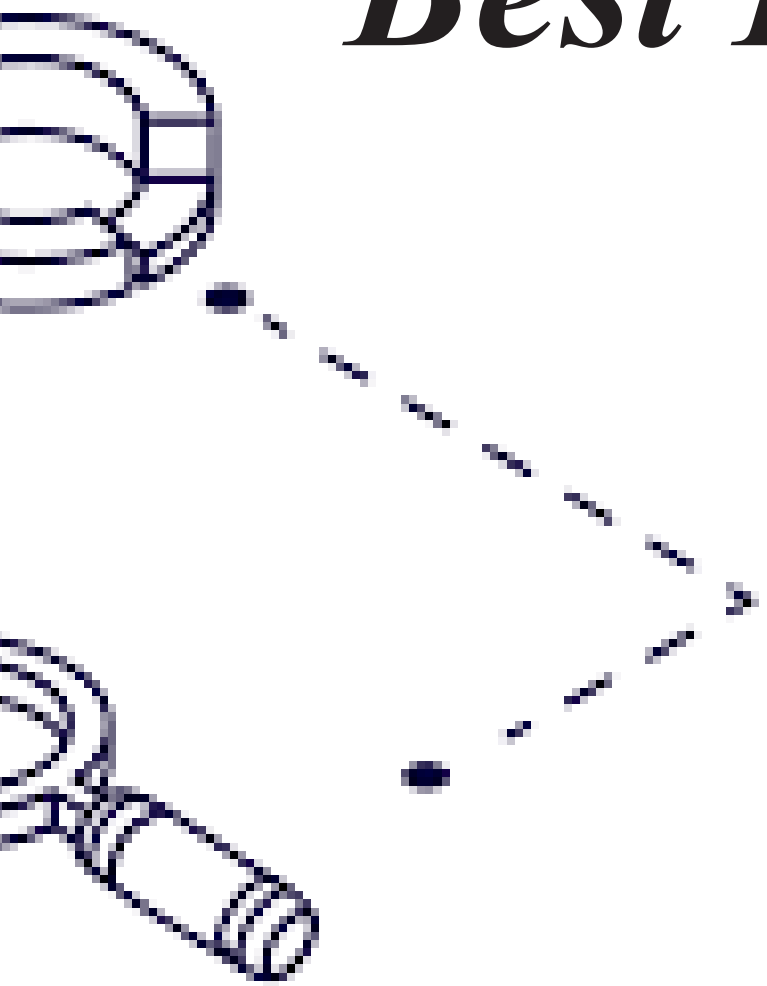
2. *Blue Infrastructure*

Water cools the air by evaporating, absorbing heat (when there is a huge body of water acting as a heat pad), or transmitting heat by sliding (as in rivers). Water applications are more successful in general when they have a broad surface area or when the water flows or disperses, such as from a fountain. The effect of evaporative cooling is also influenced by the flow of air through the city. Water cooling, like PCI, is dependent on the atmospheric and urban conditions. Water does not always act as a coolant. Water serves a dual purpose, as it can cool the city through evaporation or heat it through the release of stored heat from stagnant water bodies. Water disseminated by a fountain provides a larger cooling impact than stagnant water, despite the fact that flowing water has a greater cooling effect. Water can also be used on roofs since it can significantly reduce internal air temperatures by storing heat. In this instance, it's critical to utilize a shade device, preferably one with a low emissivity, to prevent excessive and quick heating.

21. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved December 20, 2021, from https://www.eea.europa.eu/themes/climate



Best Practices



6.1
Case Studies, Green and Blue Infrastructure

1. *Green Acre Park, New York City*

This modest New York City Modernist park is a rare respite among the hustle and bustle of Midtown Manhattan. Hard surfaces, movable furniture, water features (typically to block out the city's noise), and potted displays of annual flora are common design elements in small-scale urban parks.

The honey locusts' canopy gives dappled shade and relief from the mid-afternoon sun in the summer, but their lack of leaves allows the park to trap in sunshine in the winter months, while the park's three walls and high entrance provide shelter from winter winds.

A stunning, 25-foot-high waterfall created from massive sculpted granite slabs with a mass of cascading water is the showpiece of the Park, which is divided into three levels. A granite-faced wall also drips water, which flows into a tranquil creek that runs alongside the Park's entrance.

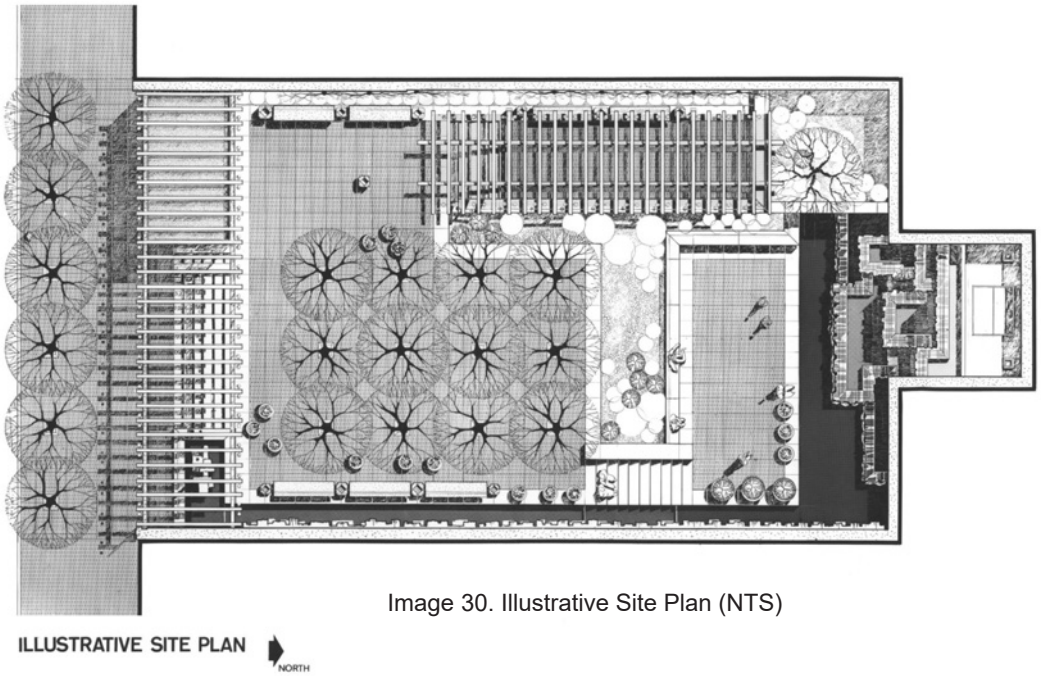


Image 30. Illustrative Site Plan (NTS)

Image 30: Greenacre Park, https://greenacrepark.org/about/, accessed on 30.11.2021
22. Greenacre park • New York City. Greenacre Park New York City. (n.d.). Retrieved November 30, 2021 from https://greenacrepark.org/about/

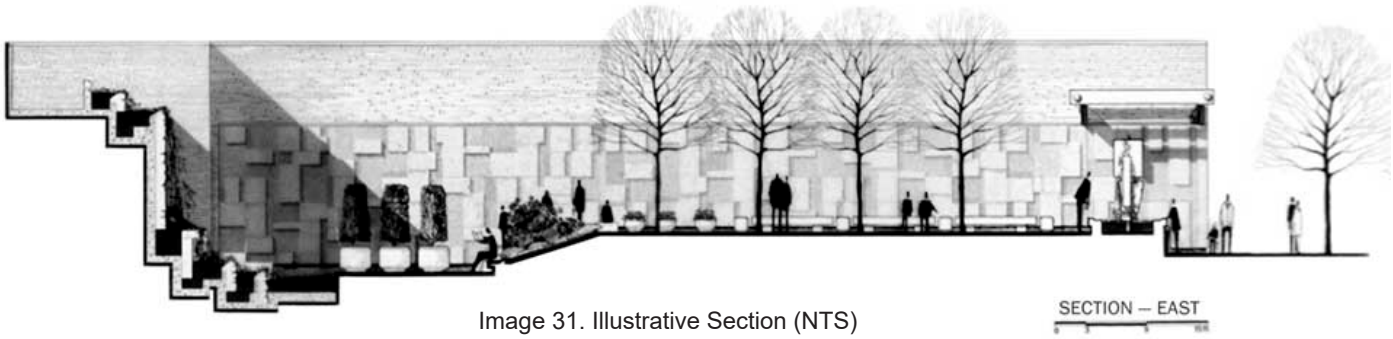


Image 31. Illustrative Section (NTS)

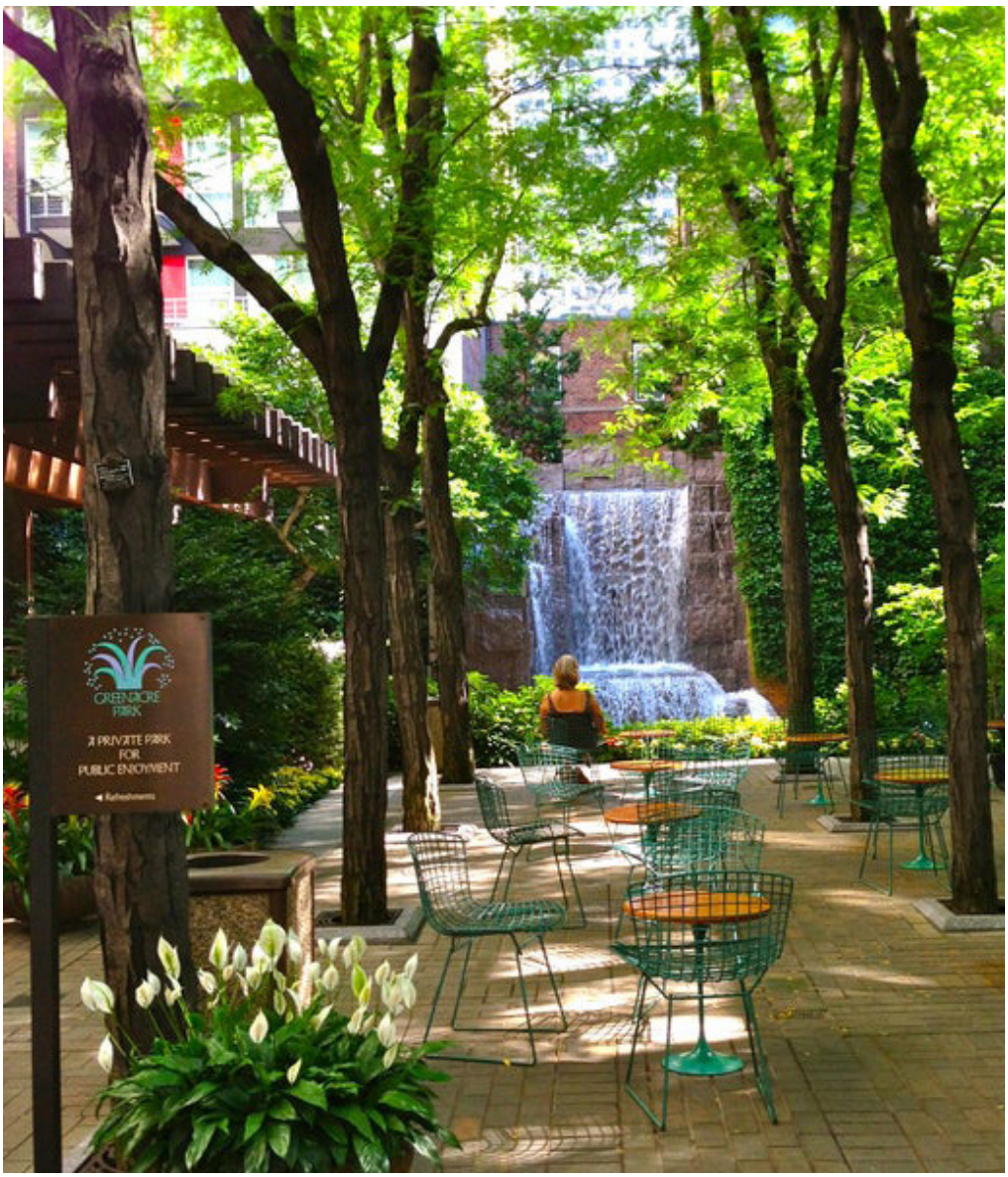


Image 32. Green Acre Park, New York

Image 31,32: Greenacre Park, https://greenacrepark.org/about/, accessed on 30.11.2021
22. Greenacre park • New York City. Greenacre Park New York City. (n.d.). Retrieved November 30, 2021, from https://greenacrepark.org/about/

2. *Philadelphia Pocket Parks*

One of the first cities to construct pocket parks within its neighborhoods was Philadelphia. These were built on the site of vacant or abandoned lots that had become eyesores, and they were in low-income districts that needed local open space in addition to the minimal facilities that were already available. These parks incorporated community input into their design and construction, with a particular emphasis on children's play spaces.

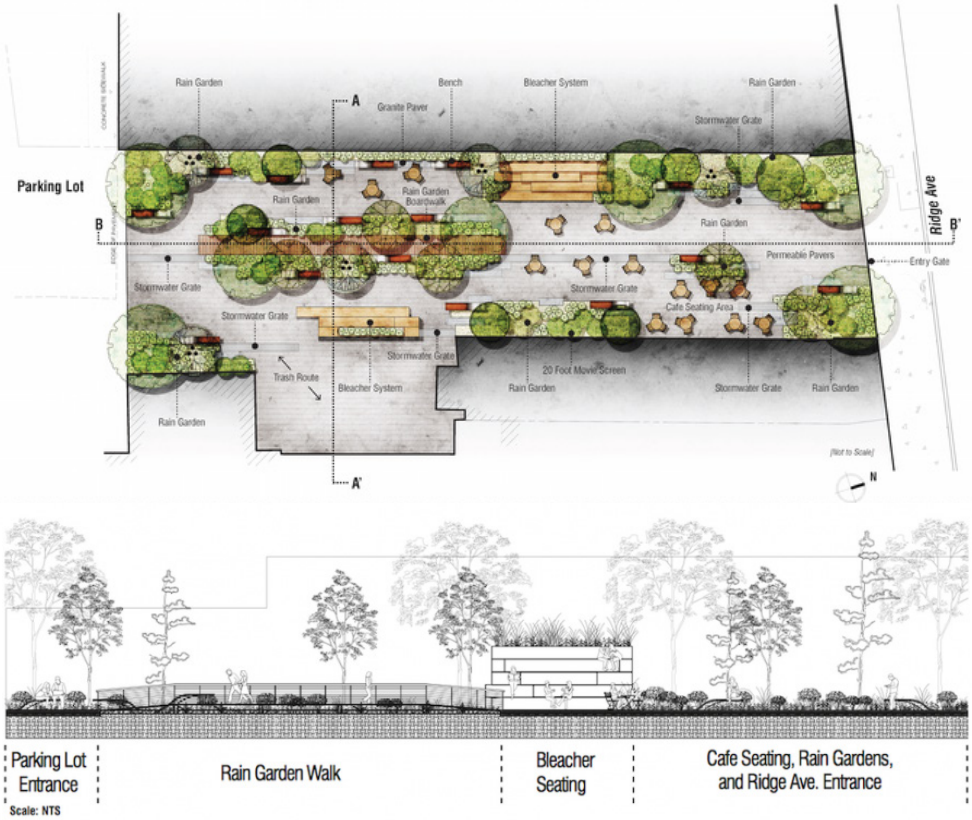


Image 33. Illustrative Plan and Section (NTS)

Image 33. Roxborough: A place with roots. https://roxboroughpa.com/enjoy-the-outdoors/roxborough-pocket-park 26. Roxborough: A place with roots. Roxborough Pocket Park | Roxborough, Philadelphia. (n.d.). Retrieved November 30, 2021, from https://roxboroughpa.com/enjoy-the-outdoors/roxborough-pocket-park

Image 34. Illustrative Axonometry

Image 35. Roxborough Pocket Park

Image 34,35: Roxborough, https://roxboroughpa.com/enjoy-the-outdoors/roxborough-pocket-park, accessed on 30.11.2021
26. Roxborough: A place with roots. Roxborough Pocket Park | Roxborough, Philadelphia. (n.d.). Retrieved November 30, 2021, from https://roxboroughpa.com/enjoy-the-outdoors/roxborough-pocket-park

3. *Paley Park, New York*

Because of the high population of workers, shoppers, and tourists in the region, while serving to a small user group, it is incredibly busy and popular. The park in midtown is intended for adults, including office workers, shoppers, tourists, and passers-by. Its purpose is to provide a place for the office worker who has finished lunch to spend the remainder of the lunch hour; for the shopper, an opportunity to set down packages, recline in a comfortable chair, and perhaps sip a coffee before continuing; and for the tourist or passerby, an opportunity to be visually refreshed by the scale of the place, by the dense green growth, and, hopefully, by the quiet of the small space.

Image 36. Paley Park

Image 36, 37, 38, 39: Cultural Landscape Foundation, https://www.tclf.org/landscapes/paley-park, accessed on 30.11.2021
23. Paley Park | The Cultural Landscape Foundation. (n.d.). Retrieved November 30, 2021, from https://www.tclf.org/landscapes/paley-park

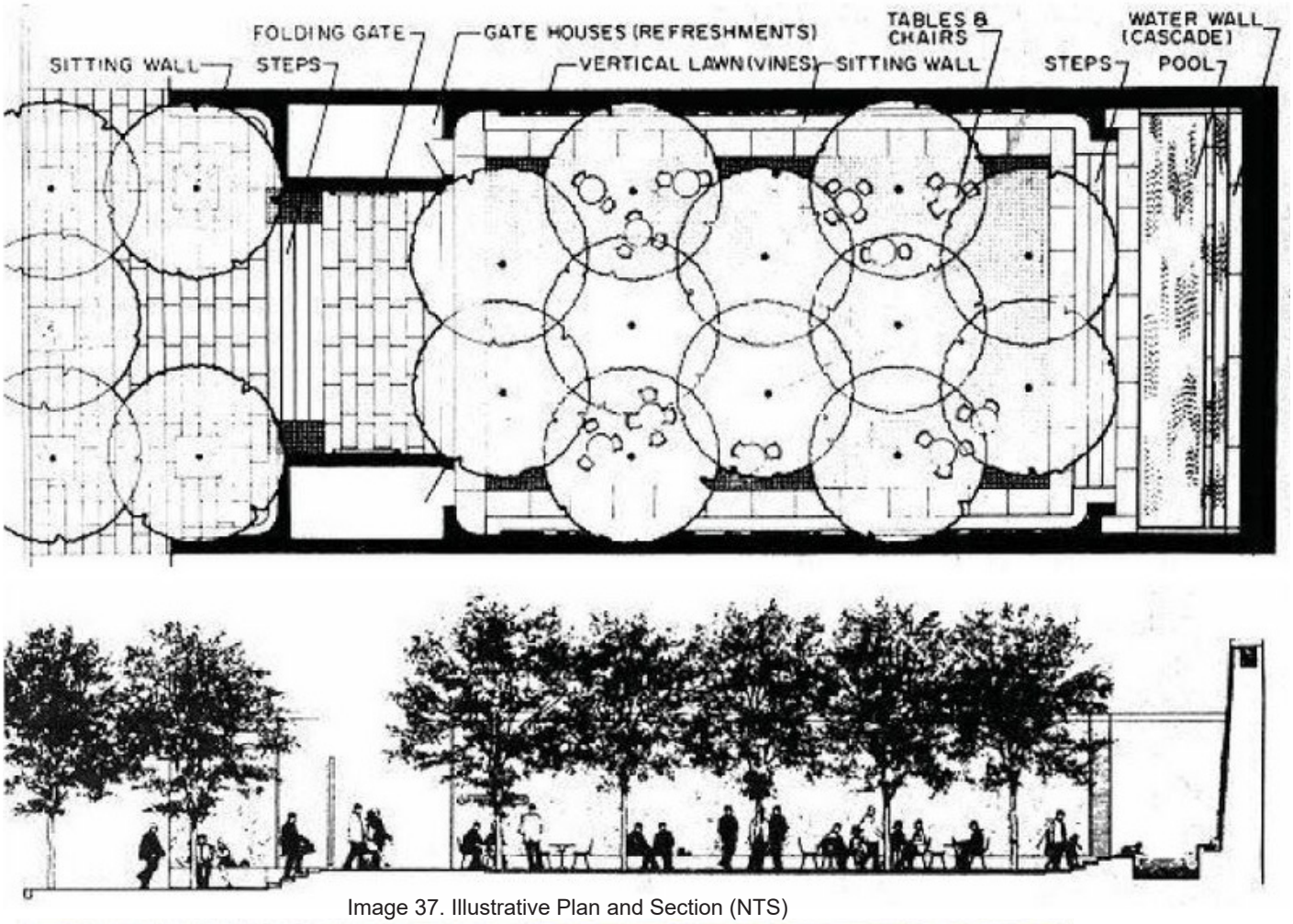


Image 37. Illustrative Plan and Section (NTS)

Image 38. Paley Park

Image 39. Grass Pavers

23. Paley Park | The Cultural Landscape Foundation. (n.d.). Retrieved November 30, 2021, from https://www.tclf.org/landscapes/paley-park

3. *Downtown Squares, Savannah*

Savannah's squares and parks are the city's most well-known landmarks. Originally constructed with 24 squares, only 22 survive today for the millions who visit these green utopias each year to enjoy. Although the largest of Savannah's downtown squares is slightly larger than a standard pocket park, the squares are renowned as a comprehensive system of small parks that serve a variety of functions while also molding the city's character and image. Residents and visitors alike benefit from the parks' central location, which encourages frequent use and exploration. The system's interconnectedness also encourages pedestrians to stroll rather than drive throughout the community.

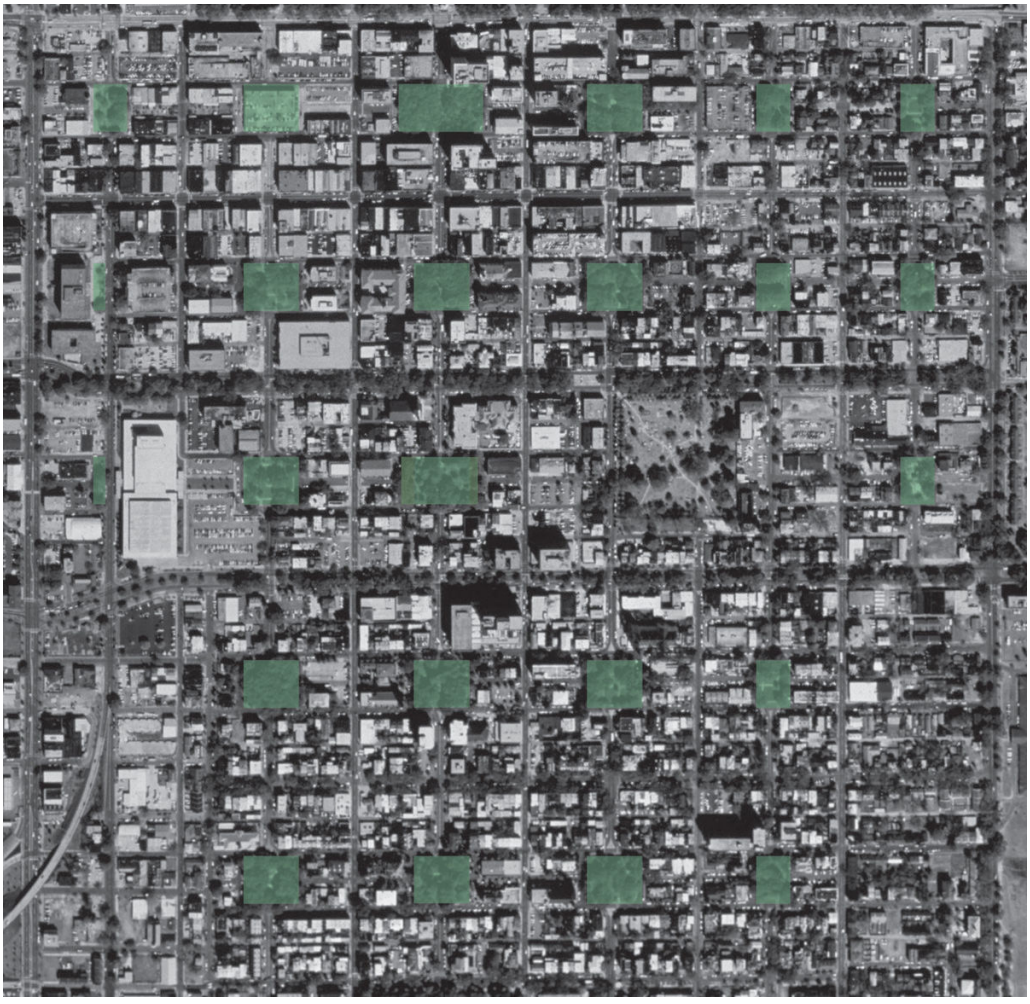


Image 40. Savannah Pocket Parks Plan

24. Visit Savannah. (2018, March 22). Savannah's squares and Parks. Visit Savannah. Retrieved November 30, 2021, from https://www.visitsavannah.com/article/savannahs-squares-and-parks

Image 41. Savannah Pocket Parks

Image 42. Savannah Pocket Parks

Image 43. Savannah Pocket Parks

Image 40, 41, 42, 43: Visit Savannah, https://www.visitsavannah.com/article/savannahs-squares-and-parks, accessed on 30.11.2021
24. Visit Savannah. (2018, March 22). Savannah's squares and Parks. Visit Savannah. Retrieved November 30, 2021, from https://www.visitsavannah.com/article/savannahs-squares-and-parks

4. *The pearl of Hangzhou Water Garden*

Hangzhou's Pearl is an interesting water pearl on the famous West Lake's shoreline. The rainwater plan for Phase 1, the park island, is to collect run-off from the roofs and use it for park irrigation and toilet flushing in the amenities. The pedestrian-only Phase 2 is the urban shopping village. Water is collected from the village's pedestrian streets and roofs and utilized to supplement water cascades and walls, which are designed to improve the village's indoor/outdoor climate comfort. The remaining rainwater will be kept and used to clean the pedestrian streets, which will be wiped down up to twice a day due to predicted visitor numbers.

A 'pearl' in the middle of a dynamic spiral sprays refreshing water during the day and sparkles with seductive colors at night. A demonstration fountain removes unclean water from West Lake, cycles it through purifying biotopes, and then returns it to the lake. The first impressions from the pedestrian tunnel's egress are of a dynamic, dazzling water cascade. The cascade and water plaza's well calibrated water systems continuously circulate and cleanse gathered rainwater.

Image 44. Illustrative Plan (NTS)

27.Hesson, R. (2021, April 11). The pearl of hangzhou water garden hangzhou - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/the-pearl-of-hangzhou-water-garden-hangzhou.html

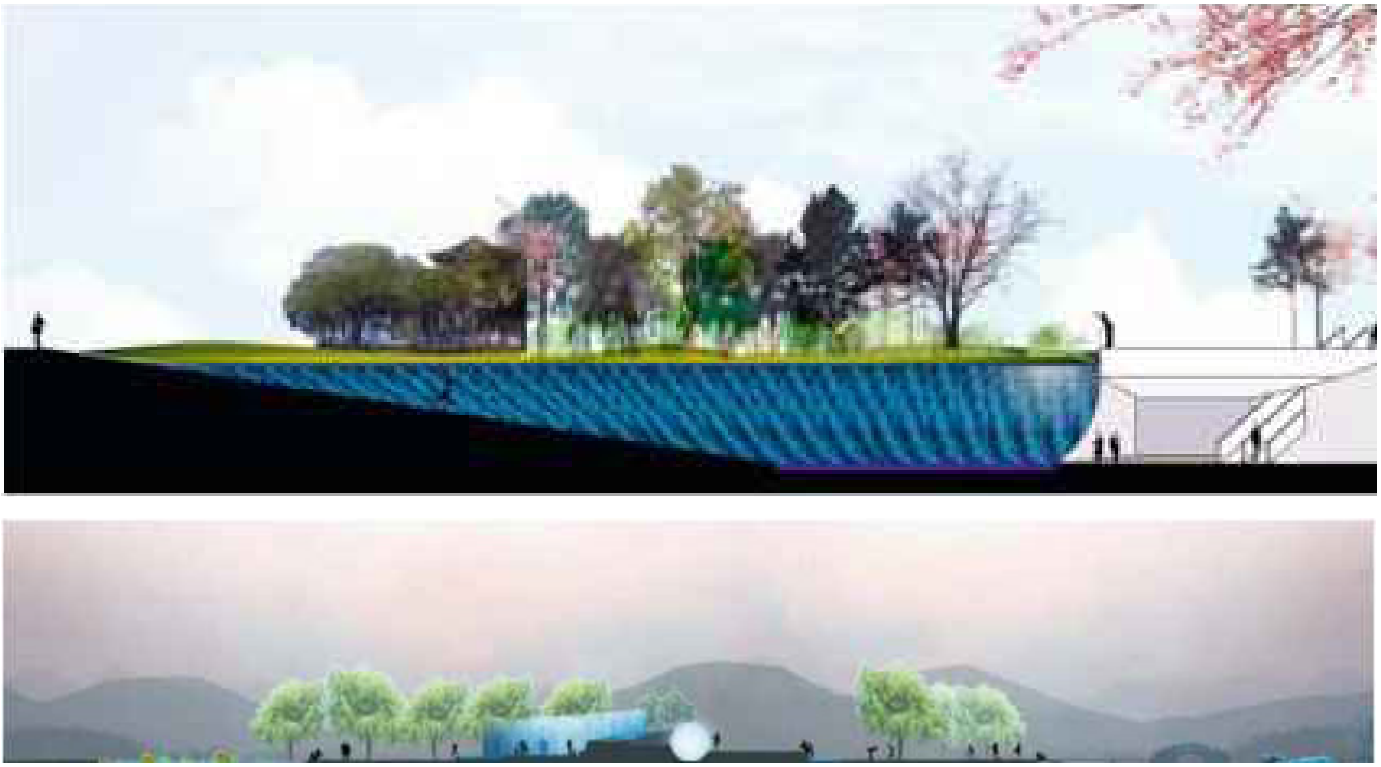


Image 45. Illustrative Section (NTS)

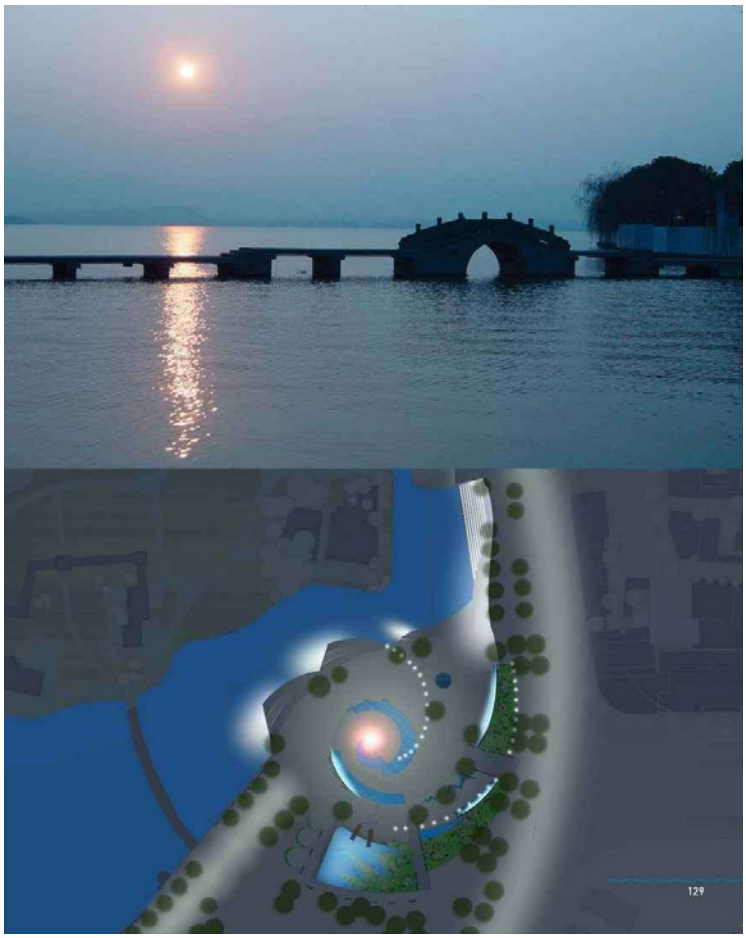


Image 46. The Pearl of Hangzhou

Image 44, 45, 46: Northern Architecture, https://www.northernarchitecture.us/water-management/the-pearl-of-hangzhou-water-garden-hangzhou.html, accessed on 30.11.2021

27.Hesson, R. (2021, April 11). The pearl of hangzhou water garden hangzhou - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/the-pearl-of-hangzhou-water-garden-hangzhou.html

6. *'Water-traces' in Hannoversch Münden*

Hann.Münden is surrounded by three rivers, hence water is a vital part of the town. The town contains three connected squares in the centre of the ancient quarter, in addition to three rivers. People developed the notion of renovating and reviving the three squares as people spaces when it became practically difficult to walk this region as a pedestrian. "Watertraces" are the pathways that watercourses take.

People can also put their own imprints here. When people simply step into the pool, the character of the flow changes. The wave-making devices positioned around the carpet can also be used to adjust the flow pattern. V-shaped glass elements that stand roughly 5 meters tall and are lit obliquely after dark on a steel platform. The pool of water is illuminated, and then the town hall's wall is illuminated. As a pattern of urban noise, loudspeakers mounted in the steels project artistically detached voices or water sounds into the scene.

Image 47. Water Traces, Hannmunden Hesson

Image 47, 48, 49, 50: DREISEITL Consulting, https://www.dreiseitlconsulting.com/watertraces-hannmunden, accessed on 30.11.2021
28. Water traces hann munden. DREISEITLconsulting. (n.d.). Retrieved November 30, 2021, from https://www.dreiseitlconsulting.com/water-traces-hannmundenHesson, R. (2021, February 25).

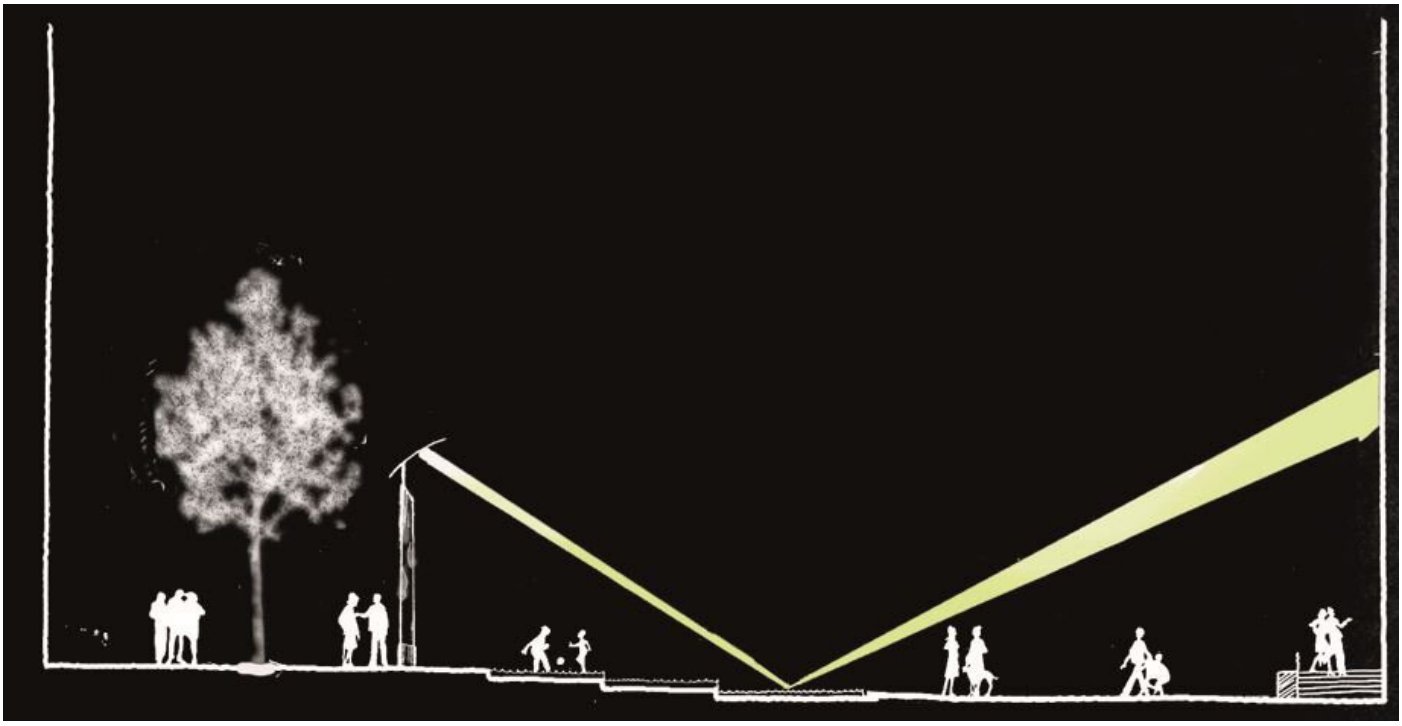


Image 48. Light Element at Water Traces, Hannmunden Hesson
Image 49. Ariel View of Water Traces, Hannmunden Hesson
Image 50. Water Element at Water Traces, Hannmunden Hesson

28. Water traces hann munden. DREISEITLconsulting. (n.d.). Retrieved November 30, 2021, from https://www.dreiseitlconsulting.com/water-traces-hannmundenHesson, R. (2021, February 25).

7. Heiner-Metzger Plaza, Neu-Ulm

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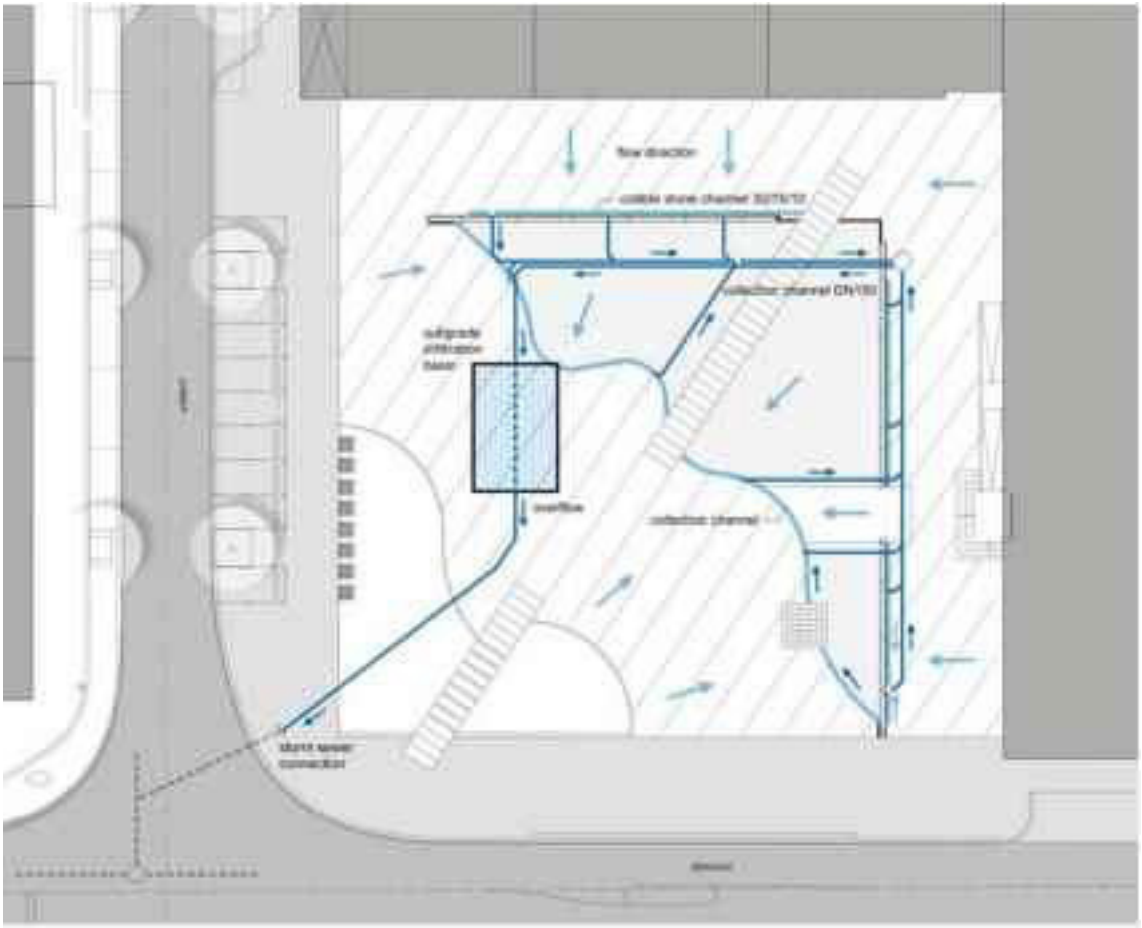
Image 51. Heiner Metzger Plaza Neu Ulm

40. Heiner Metzger Plaza Neu Ulm - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/heinermetzger-plaza-neuulm.html



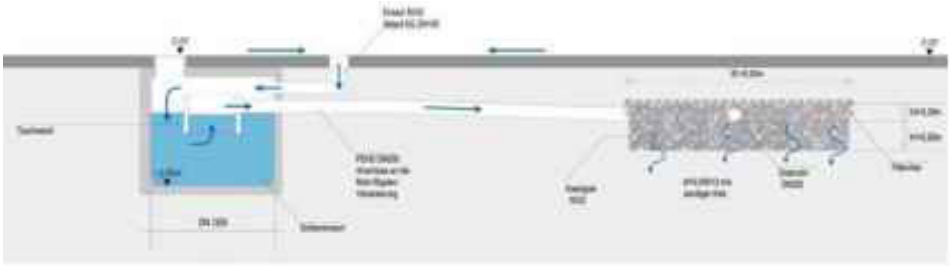


Image 52. Illustrative Plan and Section
Image 53. Heiner Metzger Plaza Neu Ulm

Image 51, 52, 53: Northern Architecture, https://www.northernarchitecture.us/water-management/heiner-metzger-plaza-neuulm.html, accessed on 30.11.2021
40. Heiner Metzger Plaza Neu Ulm - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/heinermetzger-plaza-neuulm.html

8. *Water playground in Pforzheim*

Water is always on the go, carving its own route, rising to the surface, collecting, seeping away, and posing questions. Pforzheim, a small town in southern Germany, has a water park that aims to answer some of these problems. It is located on the outskirts of the Black Forest and hosted the regional horticultural show in 1992, with a 4,000-square-meter landscape showcasing all aspects of water. 'Learning through play,' as the saying goes.

At various play stations, visitors can learn about the history of technological evolution by playing with ancient water-raising devices (the Egyptian shadoof), Archimedean Screws, a medieval well-shaft, and a rotary pump. Water emerges in naturalistically built brooks running across meadows and eventually into the river Enz in the park's quieter areas.

Image 54. Water Playground in Pforzheim

29. Water playground. DREISEITLconsulting. (n.d.). Retrieved November 30, 2021, from https://www.dreiseitlconsulting.com/water-playground

Image 55. Illustrative Plan (NTS)

Image 56. Small Fountain Water Playground in Pforzheim
Image 57. Water based Play element Water Playground in Pforzheim

Image 54, 55, 56, 57: DREISEITL Consulting, https://www.dreiseitlconsulting.com/water-playground, accessed on 30.11.2021
29. Water playground. DREISEITLconsulting. (n.d.). Retrieved November 30, 2021, from https://www.dreiseitlconsulting.com/water-playground

6.2
Synthesis

Summary

For such parks to contribute effectively to city life, they must be readily available. Further, they should not be looked upon as mere amenities. They have become necessities, and necessities must, by definition, be close at hand, easily come by. Their presence must be felt everywhere throughout the area.

Influences of Pocket Parks on the Community

Social Life and Health Benefits: Improve mental health of users, Allow local residents to construct decisions that imitate their community, Create societies more friendly by involving people in the same neighborhood, Strengthen connections with local authorities and communities, Diminish crime percentages.

Environmental Benefits: Decrease pollution, traffic and exploitation of resources, Re-generate neglected areas,Expansion of the amount of permeable surfaces across the city.

Considerations for design of Miniparks

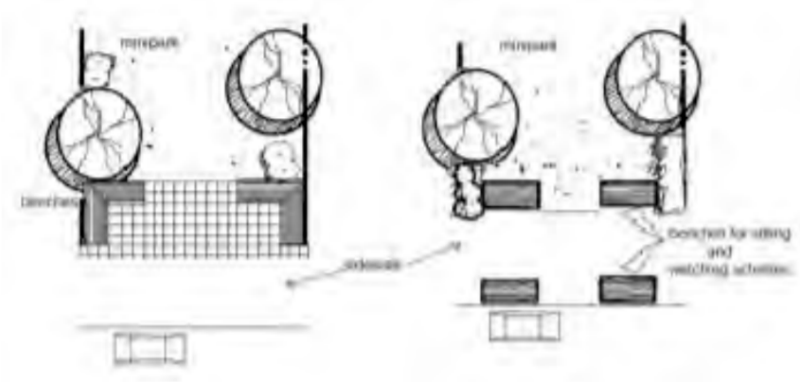


Image 58. Entries to mini-park should be carefully designed to allow passing pedestrians to watch the activity

Image 58. Pocket Parks for people – a study of park design and use. https://doi.org/10.1016/j.ufug.2012.11.003
41. Nordh, H., & Østby, K. (2013). Pocket Parks for people – a study of park design and use. Urban Forestry & Urban Greening, 12(1), 12–17. https://doi.org/10.1016/j.ufug.2012.11.003

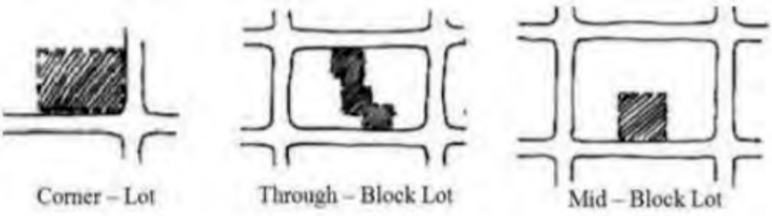


Image 59. Three typical pocket park locations.

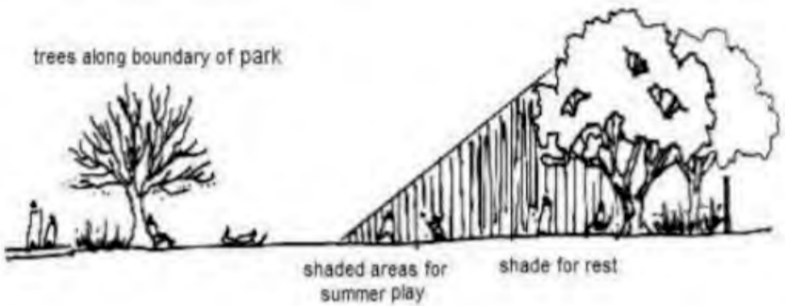


Image 60. Plant materials for shadow and play.

Patterns

4-Block Radius User Group: People Places states that “few minipark users will walk more than four blocks, and most will come from a one-totwo-block radius. Thus, the design of a pocket park should attempt to serve the needs of this immediately local community.

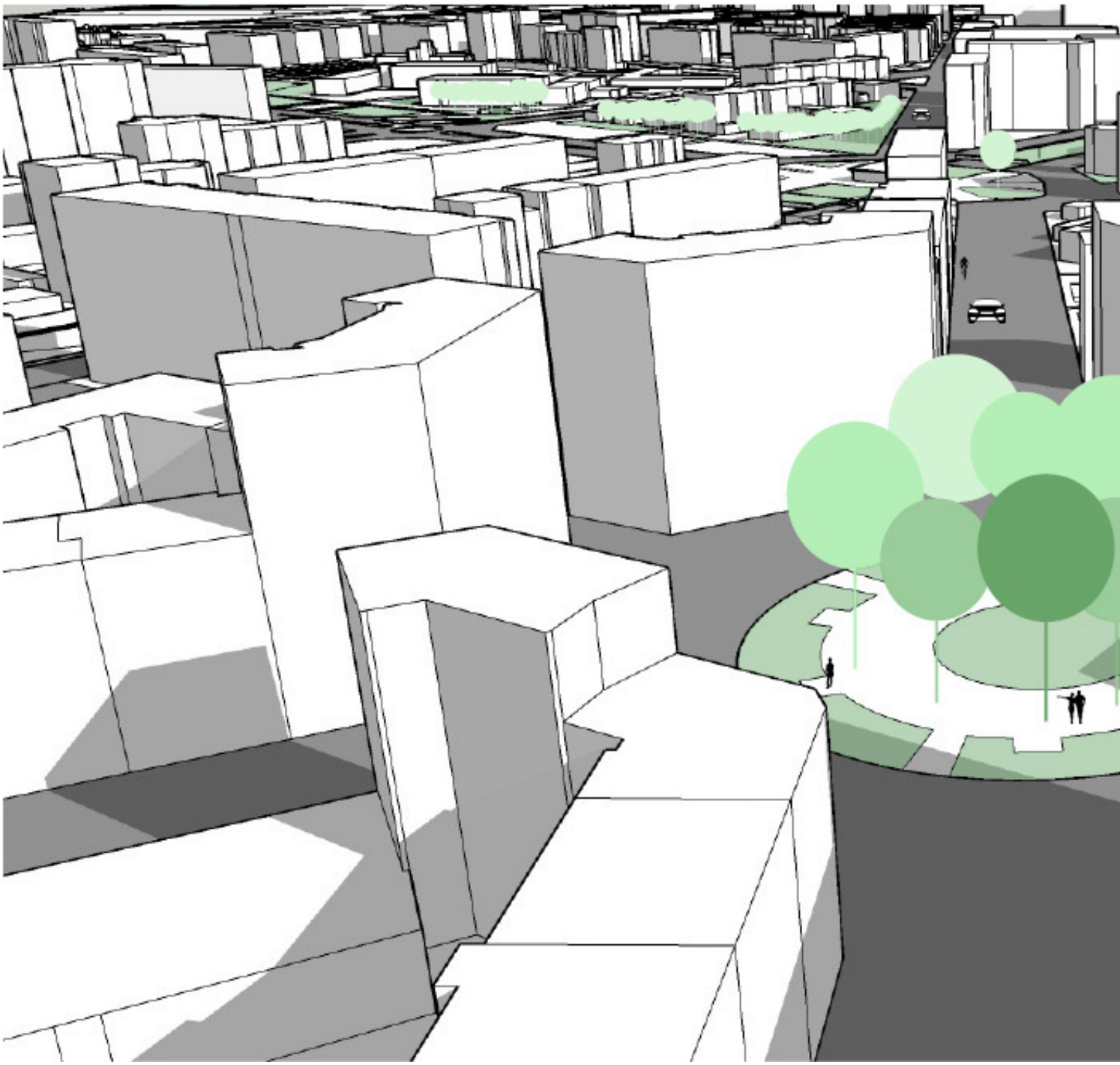
Frequency: Ideally, there will be one small park sited within every city block in order to meet the range of user group needs without causing conflict between groups.

Microclimates: Pocket parks should be appropriately sited and arranged so as to respond to the local microclimate, thereby encouraging use.

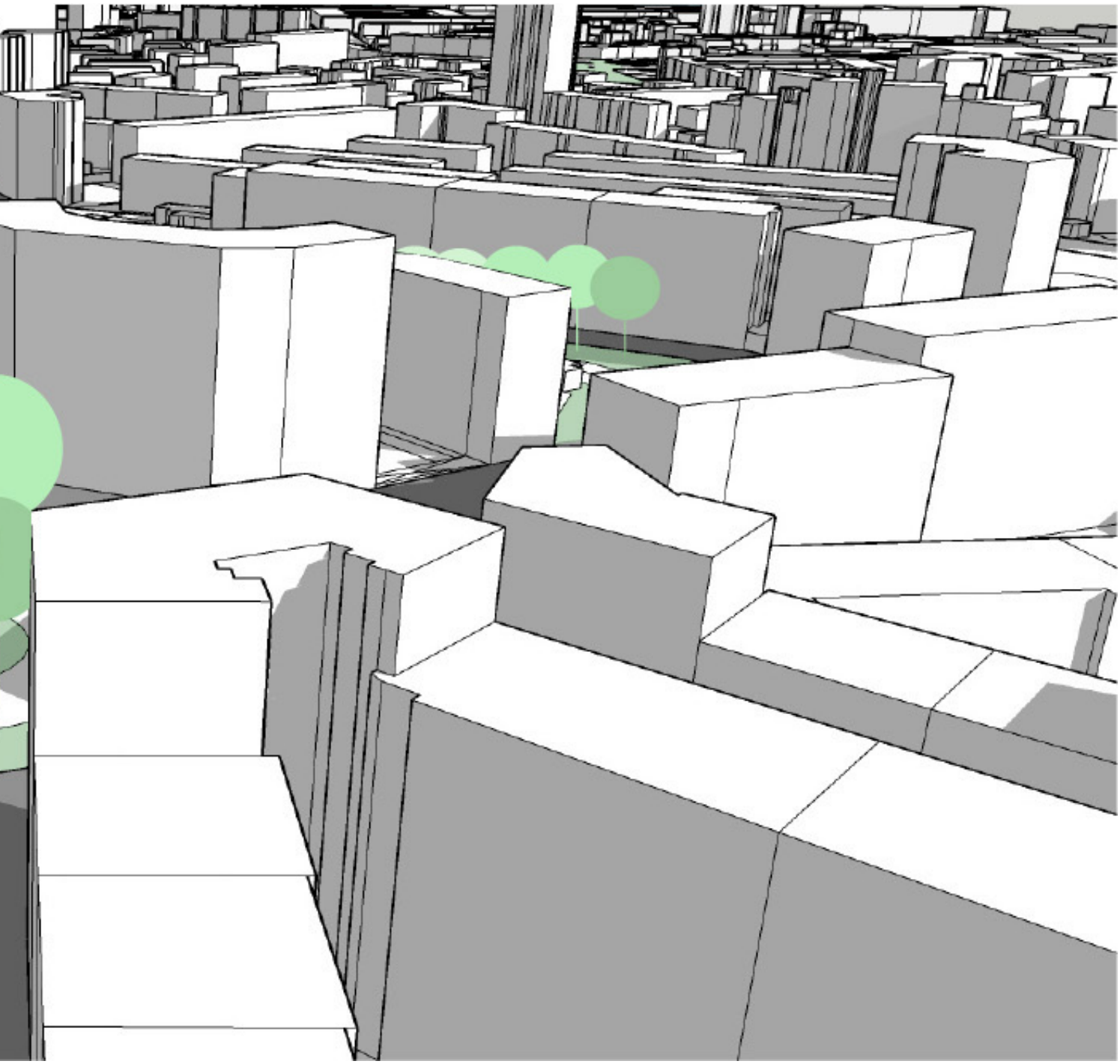
User Needs: Accommodate as many different users as possible, according to neighborhood needs; however be careful not to pack too many uses into such a small space that conflicts are inevitable.

Location: Parks should be sited in areas of heavy pedestrian traffic so that they are convenient to get to and pass through. They can be sited on block corners, mid block, or may even transect a whole block to create a pedestrian corridor.

Image 59, 60. Pocket Parks for people – a study of park design and use. https://doi.org/10.1016/j.ufug.2012.11.003
41. Nordh, H., & Østby, K. (2013). Pocket Parks for people – a study of park design and use. Urban Forestry & Urban Greening, 12(1), 12–17. https://doi.org/10.1016/j.ufug.2012.11.003



Case Study Regio Parco, Torino



7.1
Site Analysis

1. *Context*

Torino is a significant industrial and cultural city in Northern Italy. It was the first Italian capital in the nineteenth century and is the capital of Piemonte. The city is mostly located on the western bank of the Po River, below the Susa Valley, and is bounded by the western Alpine arch and Superga Hill. The city proper has a population of 852,223 people as of September 30, 2021, whereas the urban area has a population of 1.7 million people, according to Eurostat. The OECD estimates that the Turin metropolitan region has a population of 2.2 million people. The city is noted for its numerous art galleries, restaurants, churches, palaces, opera houses, piazzas, parks, gardens, theatres, libraries, museums, and other venues, as well as its rich culture and history.

Turin's architecture includes Baroque, Rococo, Neoclassical, and Art Nouveau styles. Between the 16th and 18th centuries, many of Turin's public squares, castles, gardens, and beautiful palazzi, such as the Palazzo Madama, were created. Under the designation Residences of the Royal House of Savoy, a section of Turin's historical core was inscribed on the World Heritage List. In addition, museums such as the Museo Egizio and the Mole Antonelliana, which houses the Museo Nazionale del Cinema, are located in the city. Turin is one of the top 250 tourist destinations in the world, and the tenth most visited city in Italy in 2008.

The Turin Polytechnic and the University of Turin are among Italy's greatest universities, colleges, academies, lycea, and gymnasia. Turin is known around the world for icons such as the gianduja, the Holy Shroud, FIAT automobiles, and Juventus football club, which competes against Torino in the Derby della Mole, the city's derby.

42. Power, A. (2016). Torino City Story. La Fabrique De La Cite.

The city preserves the ancient Roman road network, which was developed and updated by the Savoy dynasty, who, beginning in the sixteenth century, gave their city a rational and strict urban design arrangement, which was then perfected and completed in the following centuries. The urban and architectural renewal of the nineteenth and twentieth centuries saw the establishment of new key streets and tree-lined avenues, as well as the construction of new buildings and green places, like the Valentino park. Piazza Castello lies at the heart of the city, surrounded by the city's most important historical landmarks and ending in Via Roma.

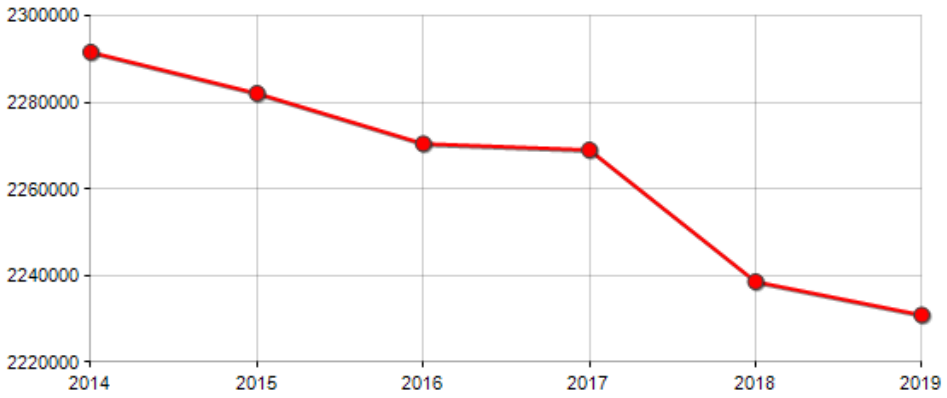
Along the Po and the hills on the right bank of the river, residential districts have grown, joined by huge bridges that connect the two banks: Ponte Balbis, Isabella, Umberto I, Vittorio Emanuele I, Regina Margherita, Sassi bridge. The industrial areas, on the other hand, are located on the outskirts of the city, to the north, west, and, most importantly, to the south.

Turin, which became the capital of a key mechanical and textile region in the nineteenth and twentieth centuries, is the driving force behind a big urban agglomeration, the second largest after Milan among the major Italian industrial cities. The mechanical industry, particularly in the automobile sector, shines out, as does metallurgy. The crisis that hit the Fiat car industry, a pillar of the city's economy, and yes, spread to all related industries, as well as the various restructuring processes underway in various other industrial sectors (mechanical and electronic), had serious ramifications on the level of employment, resulting in a progressive reduction of resident population in the 1980s and 1990s.

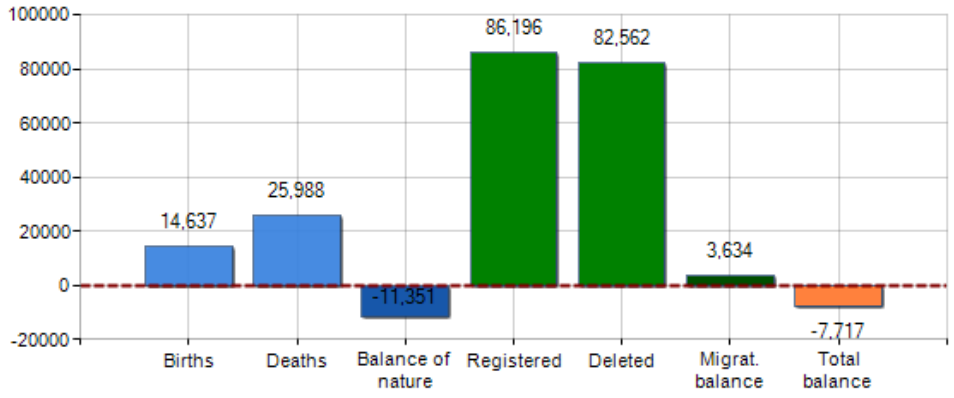
42. Power, A. (2016). Torino City Story. La Fabrique De La Cite.

2. *Demographics*

Turin's population peaked in 1974, when the city's population reached 1.2 million people. Following that, the population began to shrink gradually, with a drop of 3% from 1995 to 2015. The population is currently 848,196 (ISTAT statistics as of 15 September 2021), and the downward trend has persisted in recent years.



Graph 2. Shows the demographics of the Metropolitan Area of Torino

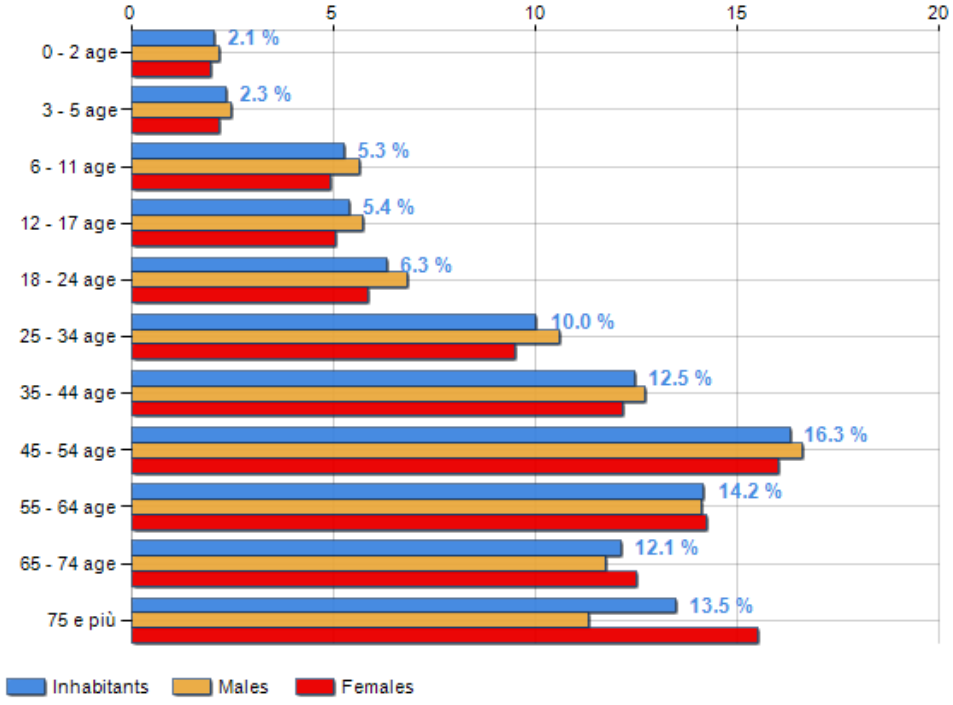


Graph 3. Shows the Population and Migration Statistics

Graph 2, 3: https://ugeo.urbistat.com/AdminStat/en/it/demografia/popolazione/torino/1/3

30. Demographic indicators - ISTAT. (n.d.). Retrieved November 30, 2021, from http://dati.istat.it/Index.aspx?QueryId=18462&lang=en

Demographers' projections show a likely evolution of population structure, with a significant increase in the over 60s and a drop in minors. In addition to demographic aging, there has been a gradual drop in the population in the working age group, traditionally defined as 15 to 64 years old, in recent years.



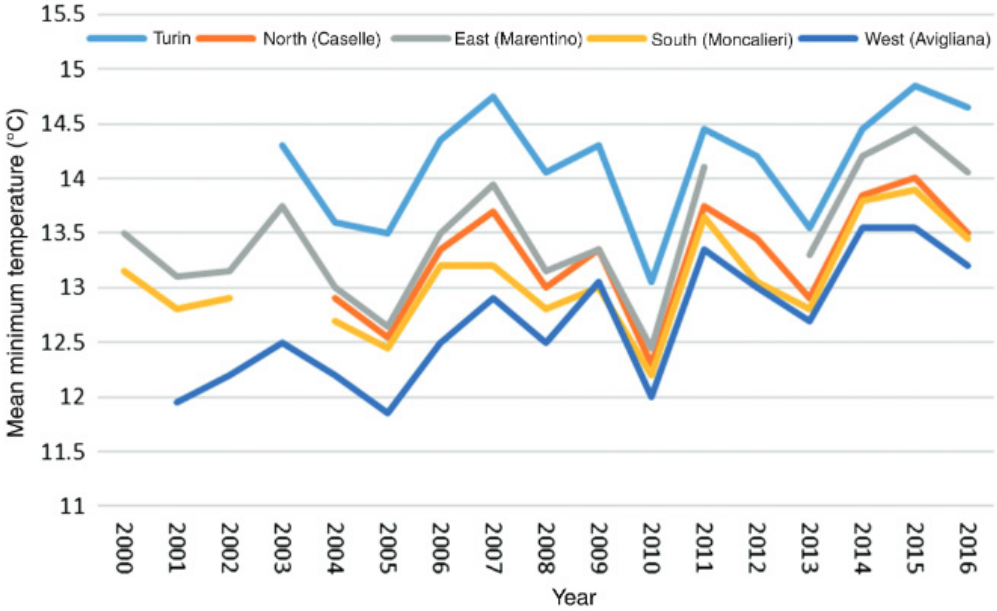
Graph 4. Shows the Age to Gender rations

Graph 4: https://ugeo.urbistat.com/AdminStat/en/it/demografia/popolazione/torino/1/3

30. Demographic indicators - ISTAT. (n.d.). Retrieved November 30, 2021, from http://dati.istat.it/Index.aspx?QueryId=18462&lang=en

3. *Climate*

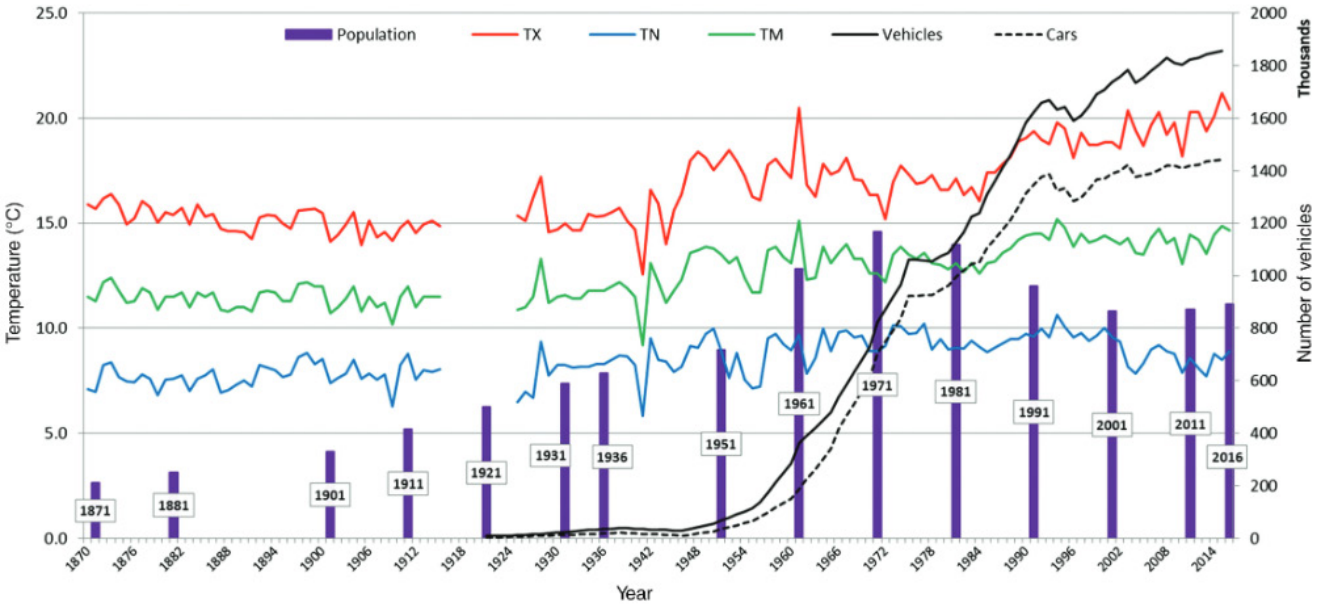
In the case of Torino's metropolitan area, temperature differences between artificially dense or diffused areas and rural areas reach values of more than 6°C, a value that is significantly higher than that of other metropolitan areas, which have ranges of less than 2°C. The density of the consumed fuel has an impact on the phenomenon of urban heat islands, but it is also influenced by other factors such as the presence of vegetation, the location of the urbanized area, and the circulation of the wind. In the last few decades, the average temperature has risen by 0.15 degrees Celsius per ten years. In particular, it is noted that the temperature average has always been higher than the norm of the reference thirty years (1971-2000), implying a 50-year increase of about 1° C. The effects of hot weather on human health are felt in metropolitan areas, resulting in an increase in mortality and morbidity.



Graph 5. Mean Minimum Temperation in different regions of Piedmont with Time

Graph 5: Garzena, D., Acquaotta, F., & Fratianni, S. (2018). Analysis of the long-time climate data series for Turin and assessment of the city's Urban Heat Island. Weather, 74(10), 353–359. https://doi.org/10.1002/wea.3292

31. Garzena, D., Acquaotta, F., & Fratianni, S. (2018). Analysis of the long-time climate data series for Turin and assessment of the city's Urban Heat Island. Weather, 74(10), 353–359. https://doi.org/10.1002/wea.3292



Graph 5. Relation between the temperature and number of vehicles with time

Graph 6: Garzena, D., Acquaotta, F., & Fratianni, S. (2018). Analysis of the long-time climate data series for Turin and assessment of the city's Urban Heat Island. Weather, 74(10), 353–359. https://doi.org/10.1002/wea.3292

31. Garzena, D., Acquaotta, F., & Fratianni, S. (2018). Analysis of the long-time climate data series for Turin and assessment of the city's Urban Heat Island. Weather, 74(10), 353–359. https://doi.org/10.1002/wea.3292

7.2
EnviMET Analysis

This program could be viewed as a necessary step in precisely analyzing the comfort indices's of a given location, or, to put it another way, in a way that produces reliable results. The program's digitizing/modeling process is simple to use, but the software as a whole necessitates a thorough understanding of the program's interface. This software may be beneficial in the pre-production of an architecture project or any other project using comfort indices's. Particularly in bioclimatic strategies, micro-climate analysis, and other areas. One of the best aspects of this software is the ability to customize your workspace, allowing you to control the real thermal conditions you wish to view in that region. As a result, you'll be able to extract numerical and visual information regarding the simulation you performed.

Cities are particularly sensitive to the consequences of climate change. When temperatures rise, the effects of urban heat islands are amplified, with potentially disastrous consequences such as excessive energy demand to cool buildings, poor air quality, and health consequences. Architects play a key role in encouraging sustainable action and ecological responsibility by identifying construction and urban planning solutions to prevent global warming and climate change. While staying cost-effective, modern structures must be environmentally mindful and have verifiable positive effects on urban micro climate. ENVI-met is the only program that assists architects at every stage of the design process. It allows you to model the environmental consequences of construction projects in detail and compute micro climate down to the square meter.

Image 61: Envimet Logo

37. Analysis - Envi-met. com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf

1. *Functionality*

Envimet is a complex application and considers various factors while making the simulation.

- When estimating short and long-wave radiation fluxes from surfaces, structures, and plants, it takes into account shading, multiple reflections, and back radiation.

- The surface and wall temperatures of each façade and roof element are dynamically evaluated using up to three material layers and seven calculation sites in the wall.

- Water and heat exchange models in the soil system, as well as plant water supply simulations.

- Particles (including sedimentation and deposition on leaves and surfaces), as well as inert and reactive gases from the NO-NO2 ozone reaction cycle, are all taken into account in the model.

Fluid dynamics, thermodynamics, plant physiology, and soil science are among the scientific fields covered by the models' computation modules. The ENVI MET model concept is based on integrating all of these different techniques into a unified model so that all parts can interact with one another and mirror the synergies we observe in the real world.

Because of its holistic approach, ENVI MET stands out among other environmental simulation models. There are several models that calculate airflow between buildings or solar input on facades, but there are few, if any, that look at the complete system in one picture and take into account the various interactions that occur between the elements.

37. Analysis - Envi-met. com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf

2. *Procedure*

ENVI-met software assists you in establishing sustainable living conditions in a dynamic environment. With the help of its interactive modules, it is possible to define surface types and construction materials, as well as green walls and green roofs, in order to objectively assess the effects of design actions on the local environment and help eliminate problems such as urban heat stress. The simulation has to be carried out in the worst climatic condition possible for us to make an analysis that can help us design for it.

There are five key phases to the program, all of which are interconnected at the same time. The first step in the process is to construct a new plane, which can be seen in the program's "space" area. While working on the Envi-met, we must input all of the data that we need to evaluate. To begin, we must first establish a basis to define our work area. We inject a bitmap that represents our project region in this step, and this data will be used as our geometric data in the software. This procedure gives us with a workspace and a layout in which we can pixelate our modeling area. Following this phase, you must begin modeling your area using the geometrical data you've entered. The climatic data of the area, which you may collect from many agencies that specialize in meteorological elements, is another vital piece of information that we require.

We obtained it from the ARPA station for this purpose. Temperature, relative humidity, wind speed and direction, and solar intensity must be provided hour by hour for (at least) 24 hours. You'll need to change the place where you'll be working.

After you've completed these procedures, navigate to the 2.5D area of the software and begin customizing your workspace. Despite the fact that most 3d modeling software is digital, you will be working on a digitized modulation space in Envi-met.

37. Analysis - Envi-met. com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf

2.1*: DEM*

You must appropriately generate the DEM level of your model, which is one of the most critical steps in the modeling process. Which is your area's terrain/ground level? You must thoroughly inspect your surroundings to recognize the differences between streets, courtyards, train tracks, and so on. The soil for the roadways will be created in this step. When you've finished with the DEM surfaces, move on to the next step.

There are various aspects of this stage that you must be aware of in order to appropriately digitize your terrain and achieve better outcomes. In the illustration below (an example from the modeling phase of this project). The lowest height of the landscape should be your starting point, however the contrary process will also work. Once you've started digitizing your work area, the software will let you choose different levels of height to create hills and plains. There are two important points in this project. One of them was create a river bed on the north-eastern part of the site and the other was to build a former train line that divides the urban morphology into two halves.

2.2*: Soil and Surface*

After you've finished with the DEM modeling, you'll need to set up the database. You'll need to define the materials you'll be working with in your area. This stage allows you to enter the inputs for your region and model surfaces so that the software can analyze them and match them to the meteorological data you've provided to complete the simulation. Additionally, the software allows you to design materials with a variety of characteristics such as roads, pavements, natural surfaces, plants, walls, soils, roofing, and so on. You must double-check each piece of information you enter into the software in between these phases. You must correctly assess your area so that the results you obtain are lot closer than they are now.

37. Analysis - Envi-met. com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf

2.3: *Buildings and Vegetation*

The buildings will be the following step. The software simply converts the digitized areas you've specified as a building into 3-dimensional data in the workspace you're working in. By simply shifting your model view to 3D, you can visualize and continue your modeling at the same time. For your simulation to work properly, you'll need to follow these steps.

To make landings, you should use the bitmap that you have on your workspace. When working on an urban size, the modeling procedure for buildings is a little more difficult than typical. It should be noted that this tool is not designed to provide 3-dimensional views in the way that architects and other construction professionals are used to. The goal is to have accurate data and knowledge on the microclimate of the area you want to work in. Because the modeling is done through a digitalization process, it's not always easy to generate actual forms of houses, roads, flora, and so on.

2.4: *Simulation*

You must launch the Envi-guide application from the Headquarters software. "The simulation should be run for 48 hours, taking into account the previous 24 hours, to eliminate inaccuracies caused by the simulation's starting inertia." You must provide the right numbers for wind direction, temperature relative humidity, and solar adjustment for your area based on your climate data and set the date to the appropriate one for the climatic condition. In our case, it is set to June 27, 2019. Finally, before you start the simulation, the program allows us to double-check all of these procedures for you. It will notify you automatically if something is amiss, and one of the software's advantages is that it will notify you if you made a mistake while digitizing the region or doing something else. If the software finds an issue that the program can resolve on its own, it will do so for you. To imitate without encountering any difficulties. After the simulation is complete, you may extract/visualize the comfort indices using "Leonardo," a linked application to the Headquarter software. We will now be able to retrieve our results thanks to the help of this application.

37. Analysis - Envi-met. com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf

2.6: *Date and Time*

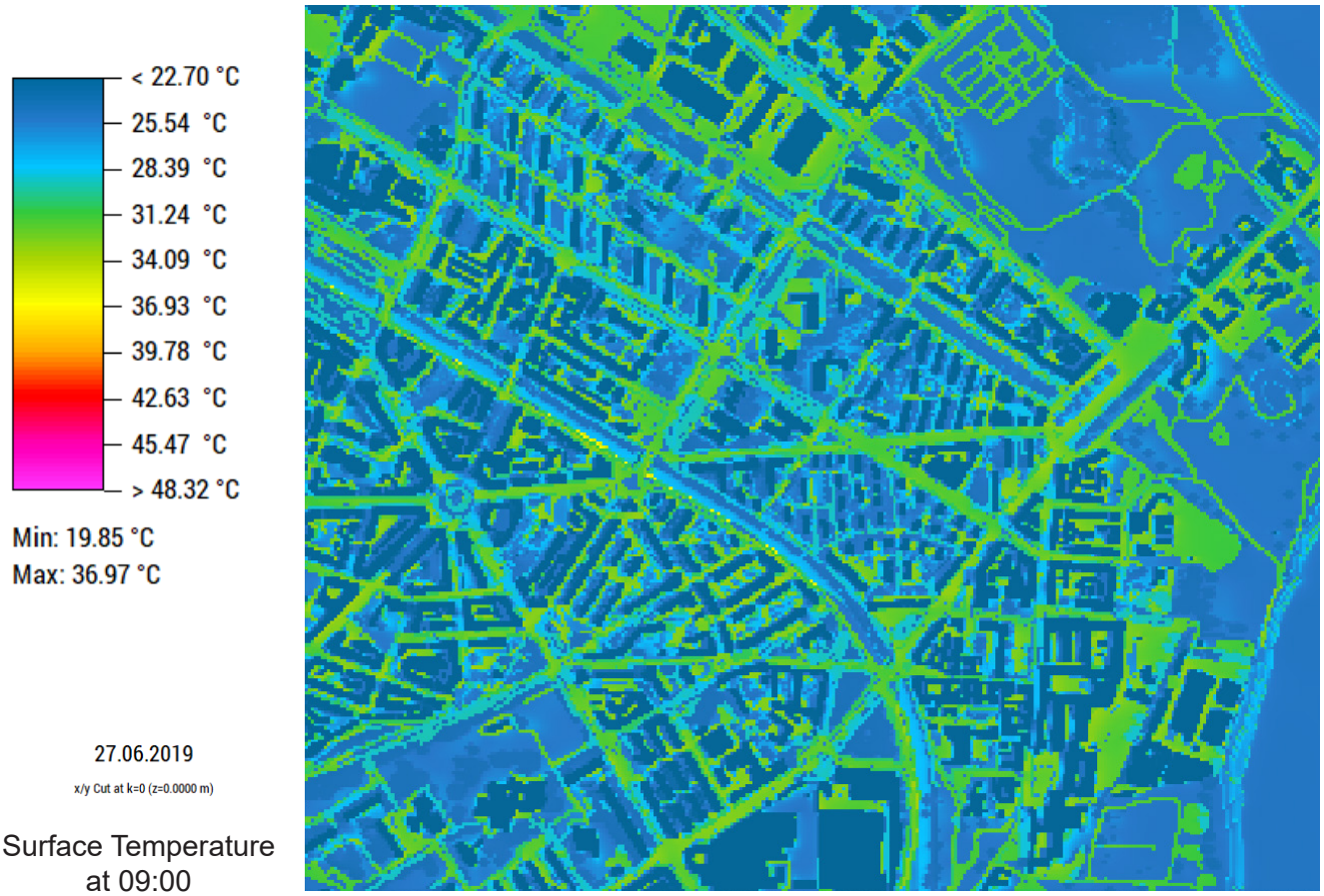
Now we've reached the final phase; All of the data shall be gathered at various periods of the day, including 09:00, 12:00, 15:00, and 18:00 on the June 27, 2019. These hours were chosen based on the amount of solar radiation that would be present in our location at the time. This is done because this day holds one of the critical conditions which will help us get the analysis which can help us design for a better suited neighborhood to deal with it.

2.6: *Results Extraction*

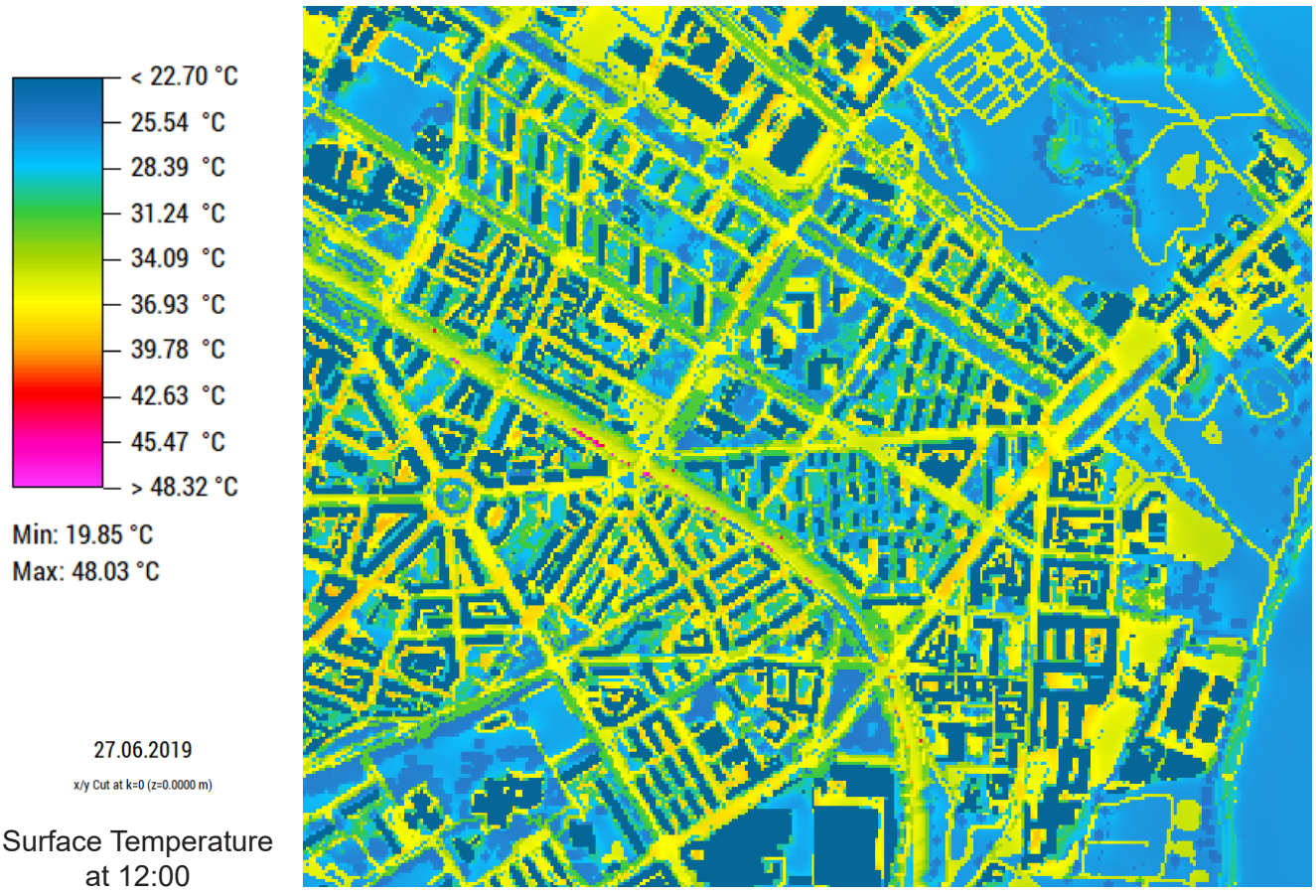
We could quickly find the most affected places during daytime when looking at the extractions that are about surface temperature. While the inner courtyards and closed surrounds of the buildings are between 25.54 and 28.39 degrees Celsius, the asphalt roadways and pedestrian walkways are over 31.24 degrees Celsius (according to T surface extractions). (At 9.00 a.m., the simulation will begin.) The substance of the surfaces is most likely to blame for the degree gap between these two sections. Furthermore, there is a difference in the material's phenomena reflectance and utilization % for these places, which could be the primary cause of temperature differences.

The topic of The rate of heat transfer through a structure is known as thermal transmittance, or U-value, and there is a variation in thermal transmittance between different materials, such as concrete pavement, asphalt road, and so on. The existence of urban green areas is also highly helpful for the thermal comfort that we experience in these regions, according to the surface temperature outputs from Envi-met. When we look at the extraction in figure T, which is related to the surface temperature simulation outputs, we can see that places with vegetation have lower surface temperatures than areas with the same material but no greenery.

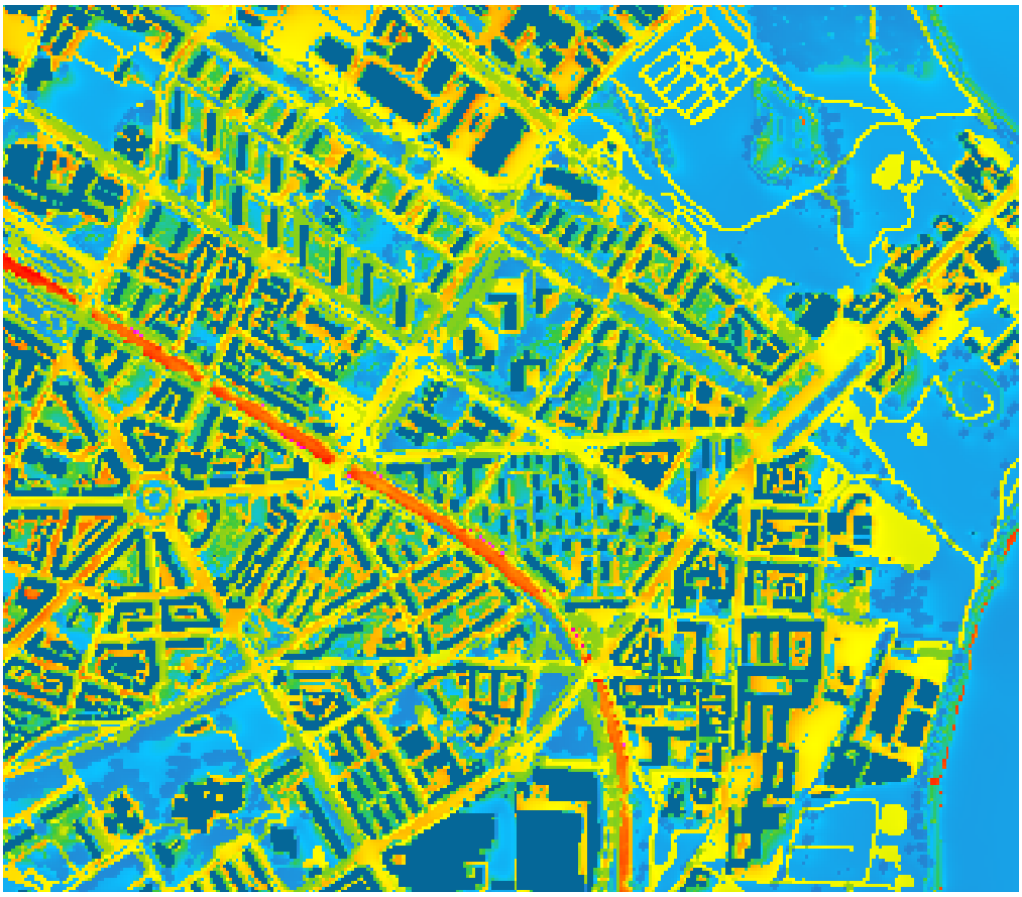
37. Analysis - Envi-met. com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf



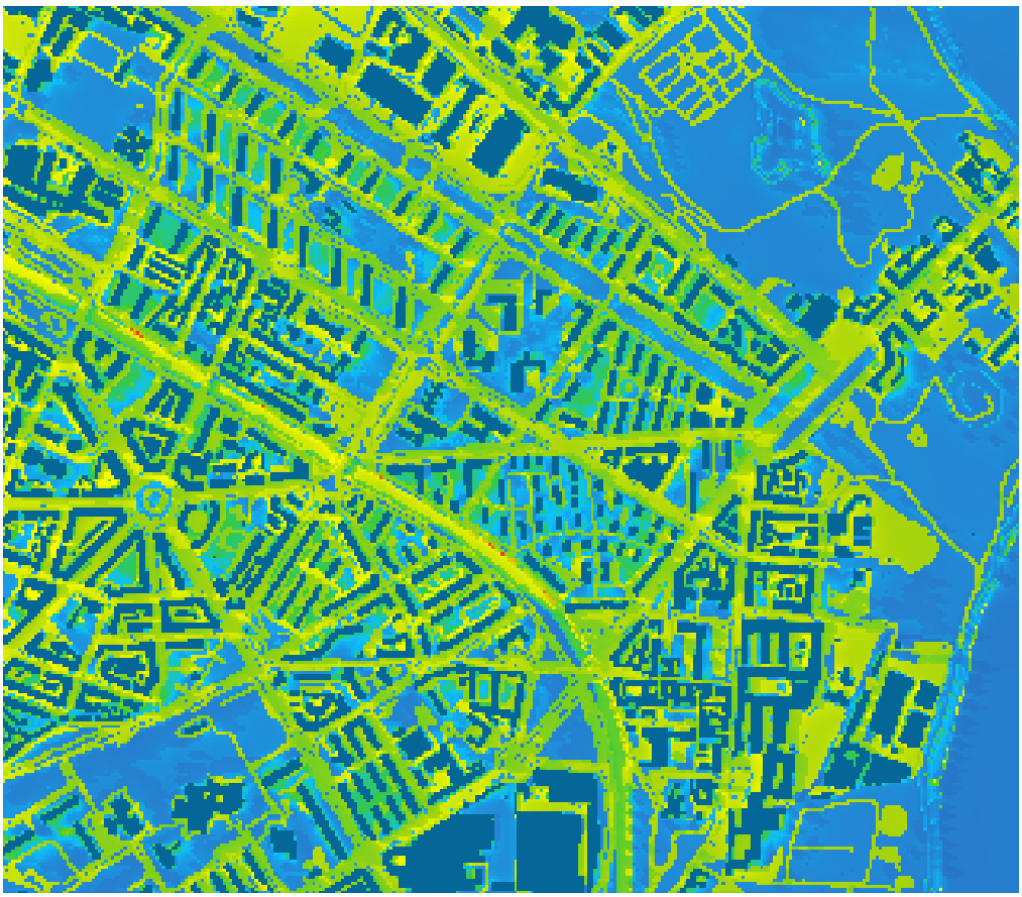
Surface Temperature at 09:00



Surface Temperature at 12:00



Surface Temperature
at 15:00



Surface Temperature
at 18:00

There is a noticeable difference in the T surface between different times of the day. The maximum surface temperature for the entire area is 45.86 degrees Celsius, which is observable during the hours of 12.00 and 15.00. It was lowered to 41.76 C° about 3 p.m.

Surface temperature extraction is depicted in the image (15.00). From the first extraction time of 9.00 a.m., we can see that some locations have significant temperature variations. Higher temperature values have been observed in several regions of the urban morphology of the area, such as inner courtyards and areas surrounded by construction blocks.

The following factors may have contributed to this phenomena.

- There could be insufficient space between the structures, preventing the wind from passing through the site/area. A dense building typology could be present in the area.

- Because of the heights of the structures, the ombre values have a crucial influence. High buildings may be altering shadows and sun direction in an unfavorable way.

-The amount of vegetation in the region may be insufficient; / tree kinds may have been chosen incorrectly.

- The surface materials have been installed incorrectly and may be impacting the region.

We can obtain wind speed data from our modeled area using the software. When we look at the data for wind speed, we have a final extraction. We can see that there are no significant variances in wind speed across the entire urban region as the hour changes. Each hour's maximum speed has increased by 0.03 m/s.

38. Höppe, P. (1999). The physiological equivalent temperature - A Universal index for the biometeorological assessment of The thermal environment. International Journal of Biometeorology, 43(2), 71–75. https://doi.org/10.1007/s004840050118

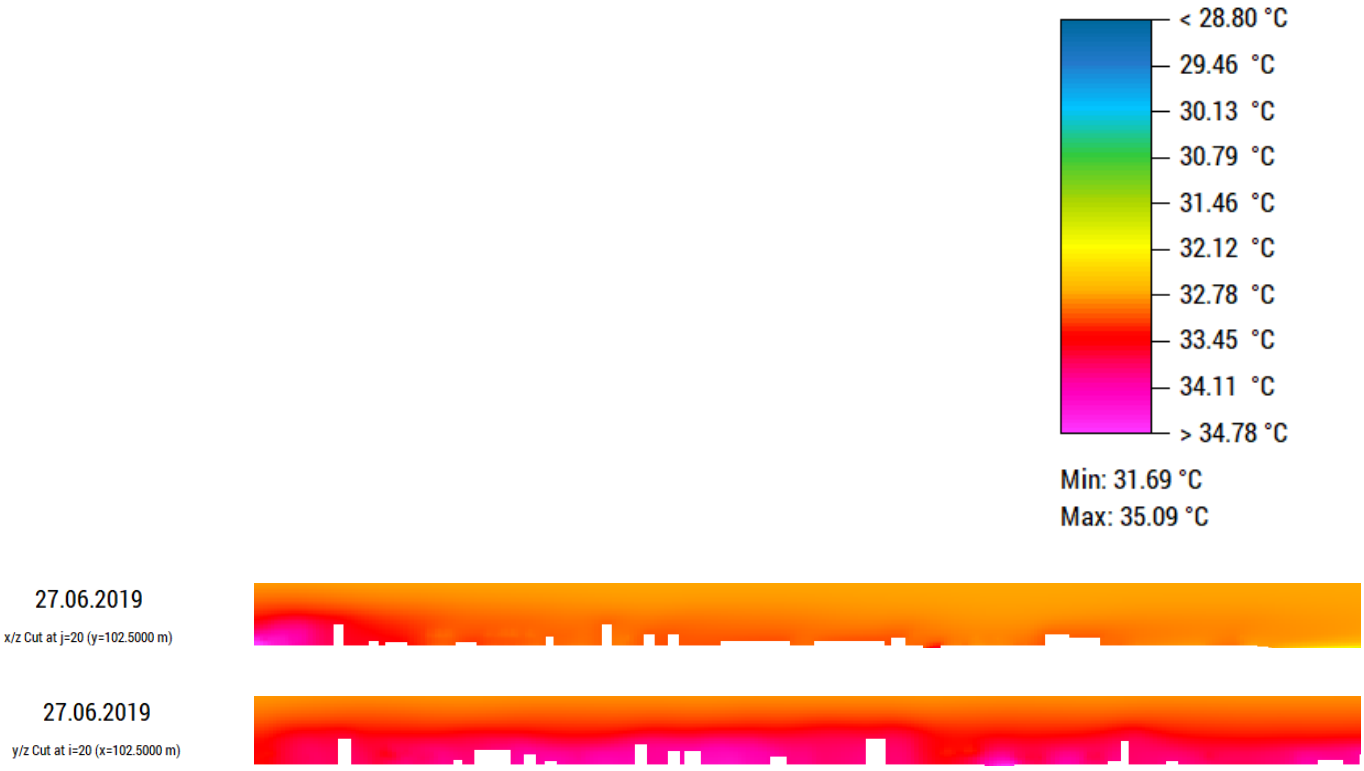
With all of this data, we were able to detect a difference in wind speed throughout the three distinct times of the day; but, because the urban variant had the same pattern, we were unable to discover large differences throughout the area. The buildings appear to be shielding the region from the strong gusts. On the other hand, when we look at locations with water and vacant landscapes, we see that these areas are considerably more affected by the wind blowing from the northeast.

Regarding the wind speed analysis, due to the large spaces that our buildings have, the inner courtyards receive no wind at all (below 0.32m/s), whereas the roads and pedestrian walkways are exposed to the wind (at 1.28m/s). Despite this, we can observe that trees and greenery are useful and play a protective role in terms of wind speed. The most crucial element is to combine these data with surface temperature extractions to see how wind affects microclimate variables.

Temperature is the quantity of heat in a substance, whereas wind speed is the rate at which the air moves. A temperature gradient arises when two areas have differing temperatures, resulting in differences in air pressure between them. As the atmosphere seeks to equalize the air pressure at these two places, wind is generated. In general, the bigger the temperature disparity, the stronger the ensuing winds are. The surface temperature values and the wind-exposed areas have an inverse relationship. Due to the cooling influence of the wind, the place with the most wind has substantially cooler temperatures. The wind transfers heat away from the body as it gains up speed, lowering skin temperature and, eventually, inner body temperature. As a result, it feels colder as a result of the wind. When the temperature is -17°C and the wind speed is 15 mph, the wind chill is -28°C. It has the same impact on the built environment and the microclimate of cities.

We may say that the same situation has occurred for potential air temperature and solar radiation values in some specific places as a result of the wind.

38. Höppe, P. (1999). The physiological equivalent temperature - A Universal index for the biometeorological assessment of The thermal environment. International Journal of Biometeorology, 43(2), 71–75. https://doi.org/10.1007/s004840050118



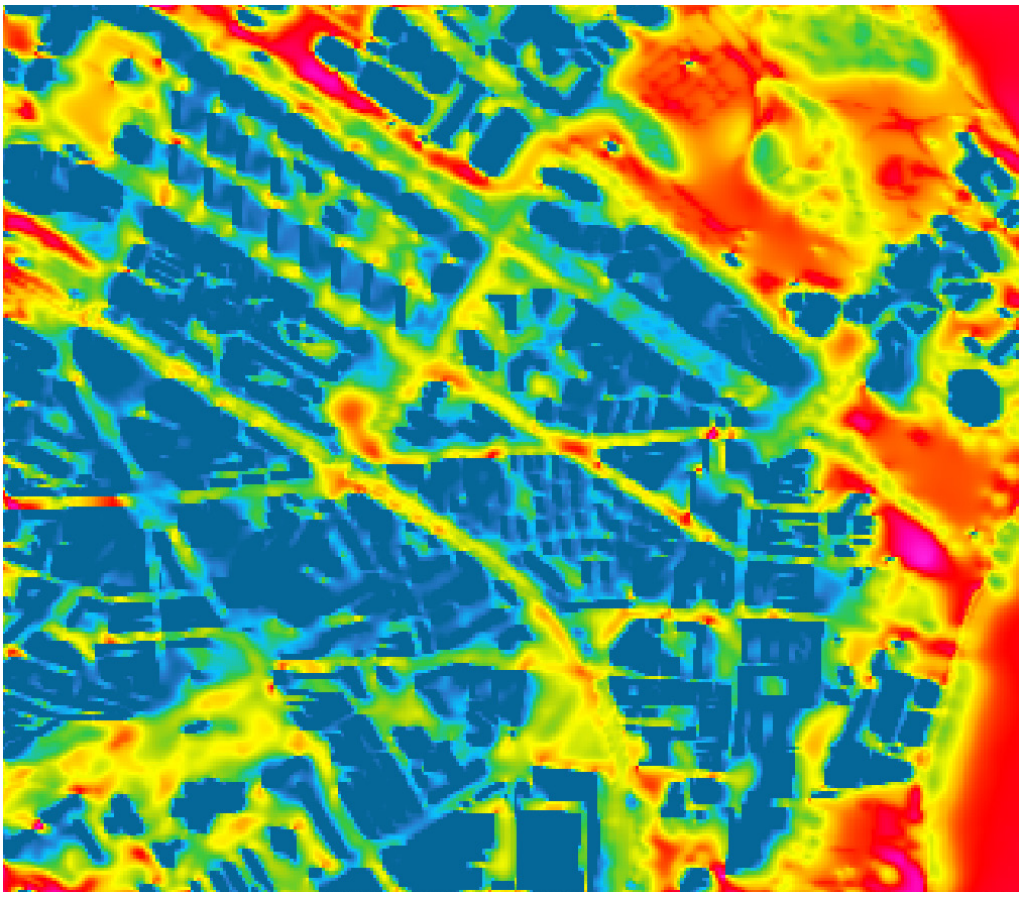
Air Temperature Sections
at 15:00

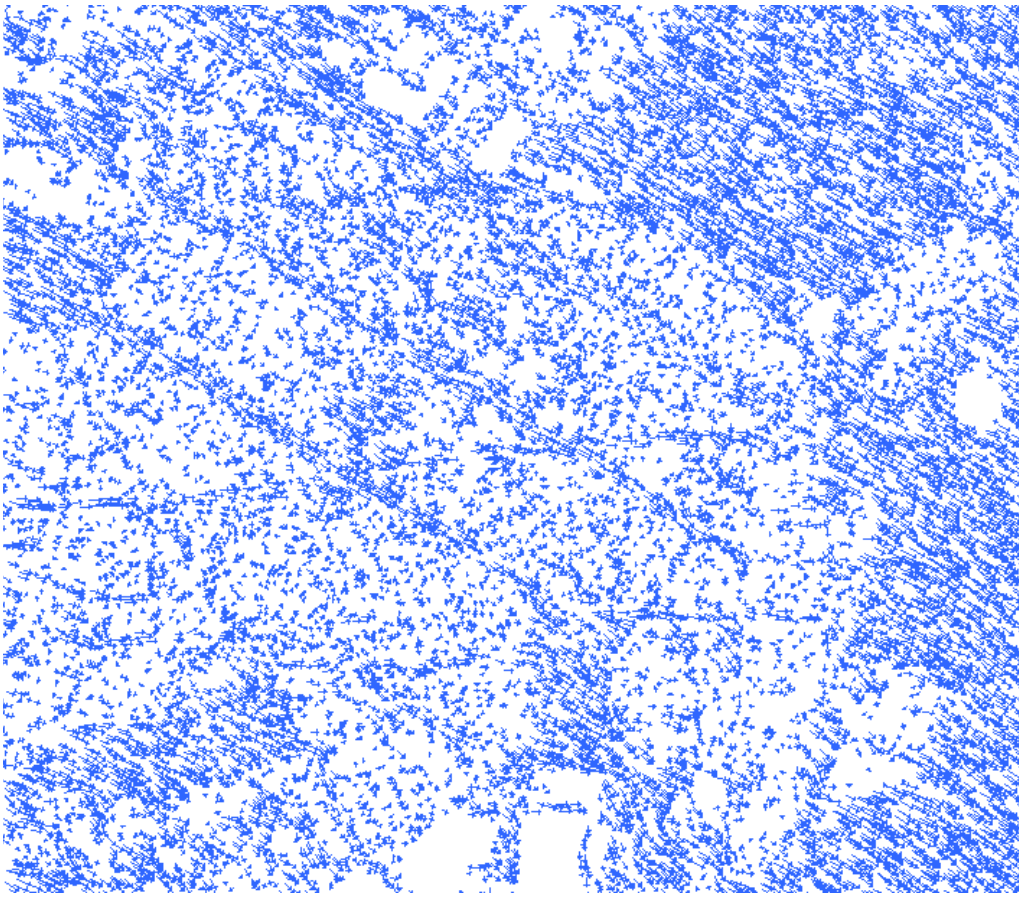
On an urban scale, the wind's effect on building density was investigated. Building density may have an impact on pedestrian comfort in the following ways when it comes to residential area planning and design:

Because of the tube effect seen throughout the buildings that have been created and oriented longitudinally, pedestrians may feel uneasy going around those regions as the wind surface value rises throughout the roadways and pedestrian ways.

Wind speed is low in the inner courtyards of denser residential neighborhoods, restricting natural ventilation; nonetheless, wind surface values are often high throughout the corners of these buildings. As a result, people's activities in these locations may be less pleasant. The existing ty-orientation pology's may have an impact on comfort levels, however natural ventilation values are more acceptable.

Excessive building density will affect the overall outdoor ventilation of residential districts, lowering air quality and limiting pedestrian comfort during the planning and design phase.


< 0.32 m/s
0.64 m/s
0.96 m/s
1.28 m/s
1.60 m/s
1.93 m/s
2.25 m/s
2.57 m/s
2.89 m/s
> 3.21 m/s
Min: 0.00 m/s
Max: 3.13 m/s
27.06.2019
x/y Cut at k=7 (z=7.0000 m)
WindSpeed
at 09:00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27.06.2019
WindSpeed
at 09:00

< 0.32 m/s
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2.57 m/s
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> 3.21 m/s

Min: 0.00 m/s
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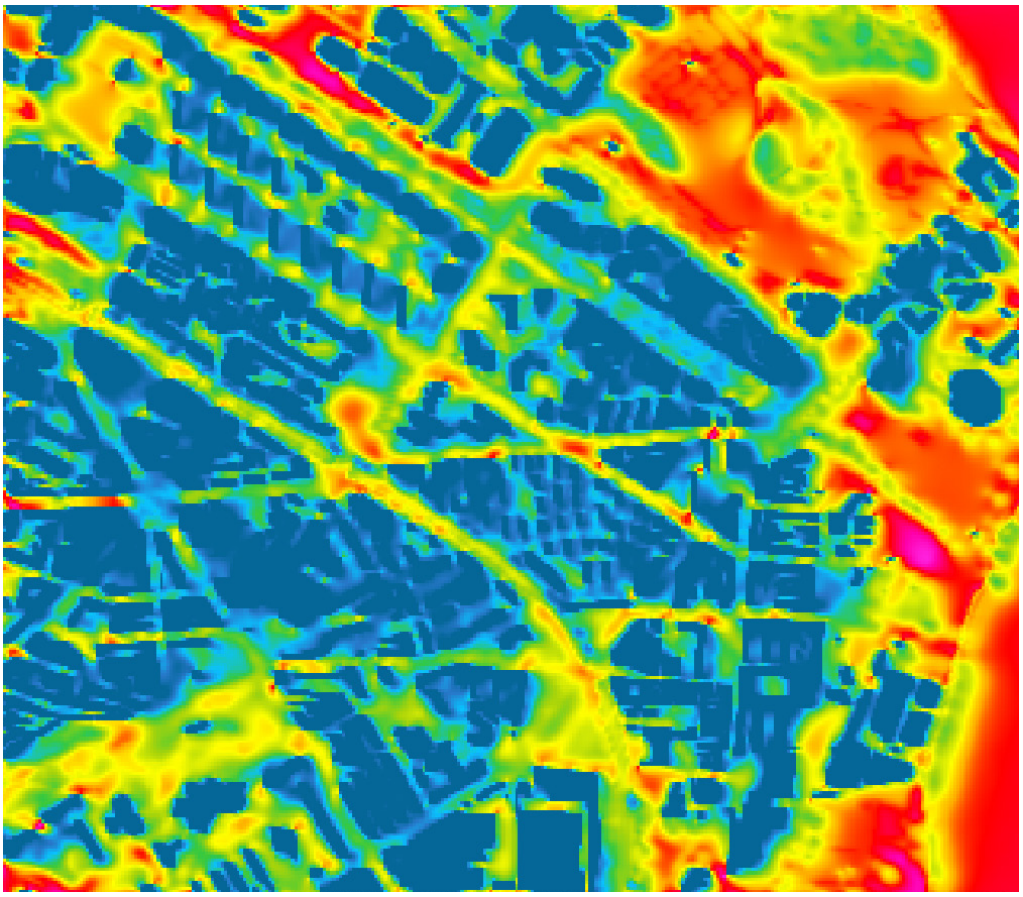

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x/y Cut at k=7 (z=7.0000 m)

Wind Speed
at 12:00

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2.00 m/s
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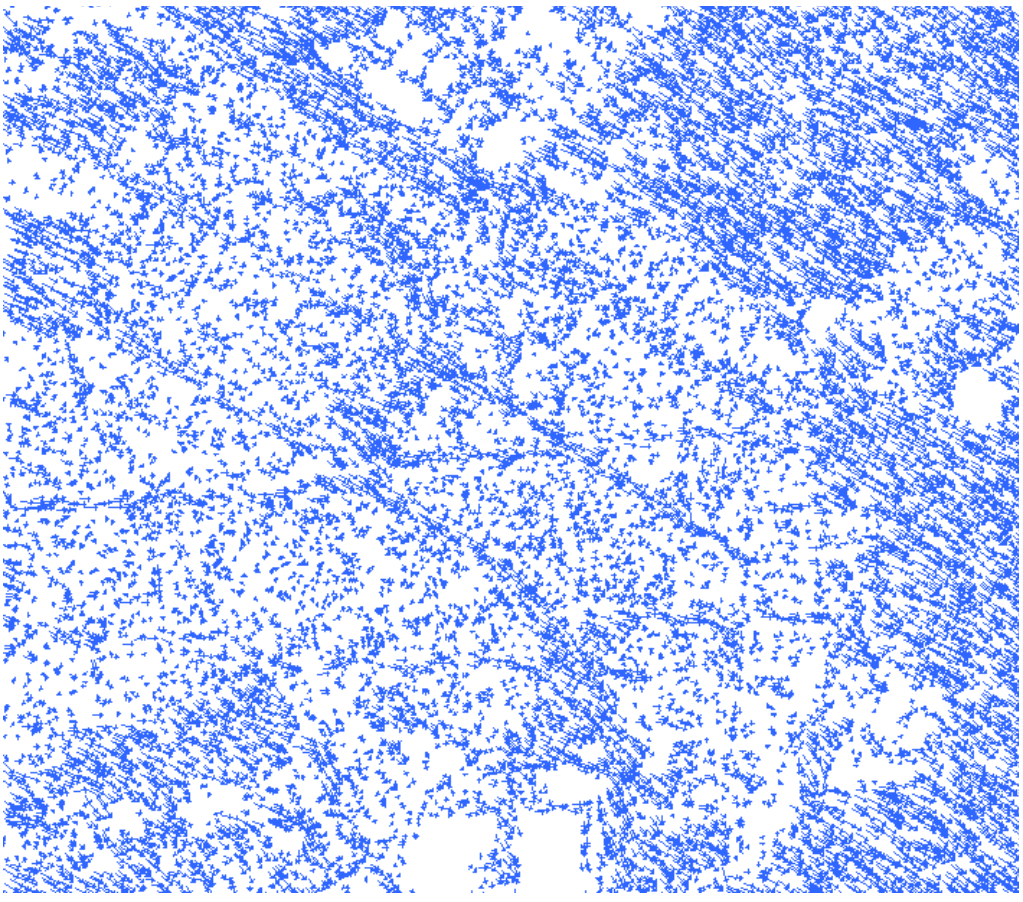

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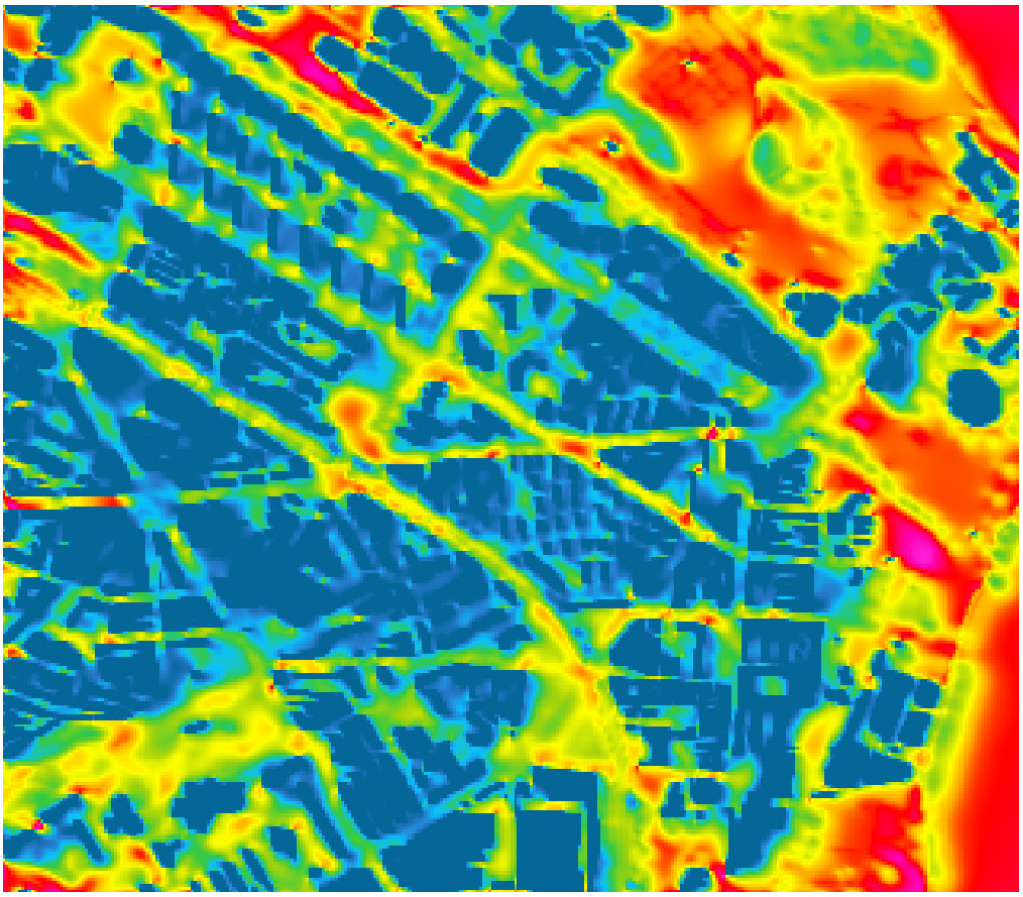
Wind Speed
at 12:00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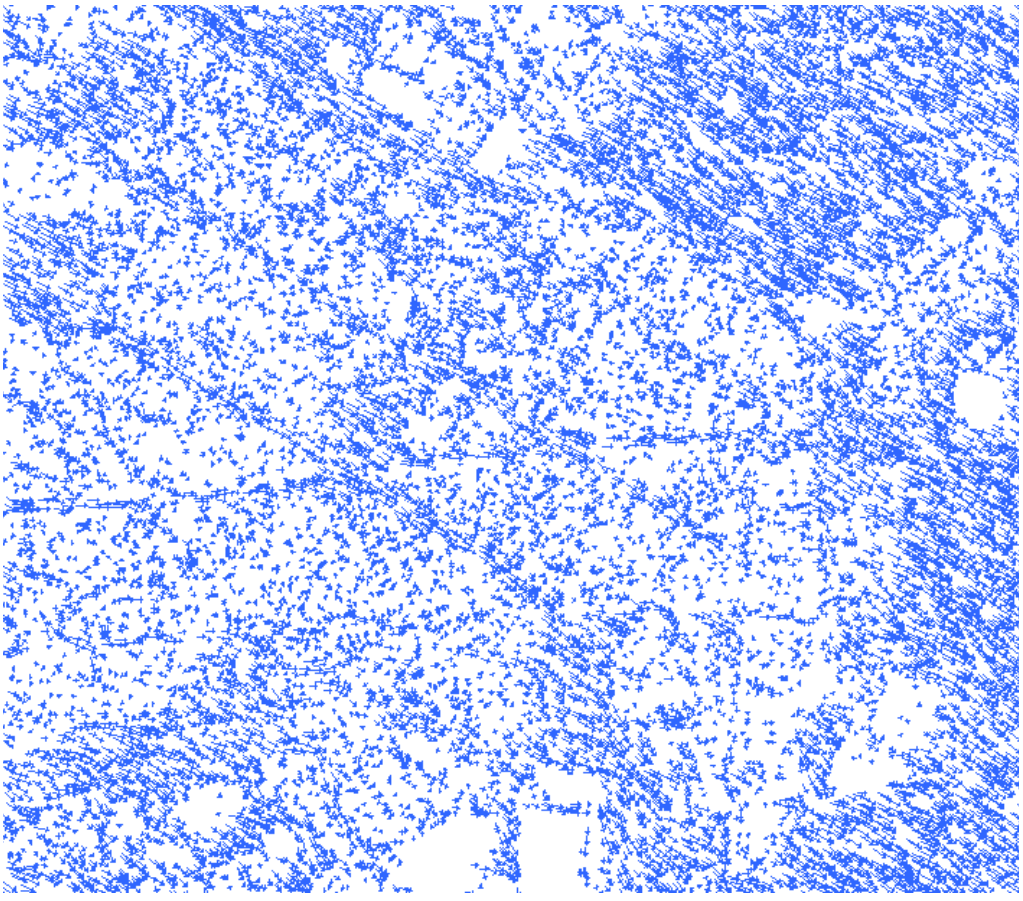
0.64 m/s
0.96 m/s
1.28 m/s
1.60 m/s
1.93 m/s
2.25 m/s
2.57 m/s
2.89 m/s
> 3.21 m/s
Min: 0.00 m/s
Max: 3.19 m/s
27.06.2019
x/y Cut at k=7 (z=7.0000 m)
WindSpeed
at 15:00


Flow v
1.00 m/s
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3.00 m/s
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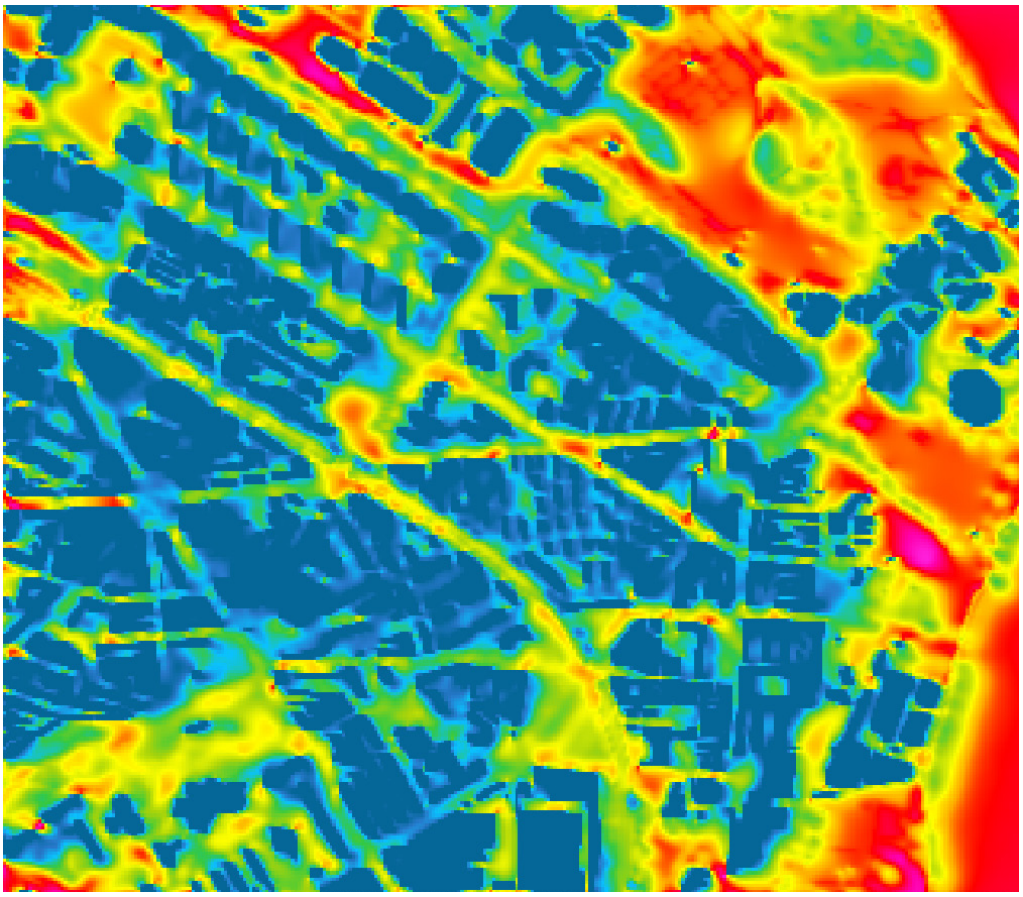
27.06.2019
WindSpeed
at 15:00

< 0.32 m/s
0.64 m/s
0.96 m/s
1.28 m/s
1.60 m/s
1.93 m/s
2.25 m/s
2.57 m/s
2.89 m/s
> 3.21 m/s

Min: 0.00 m/s
Max: 3.21 m/s

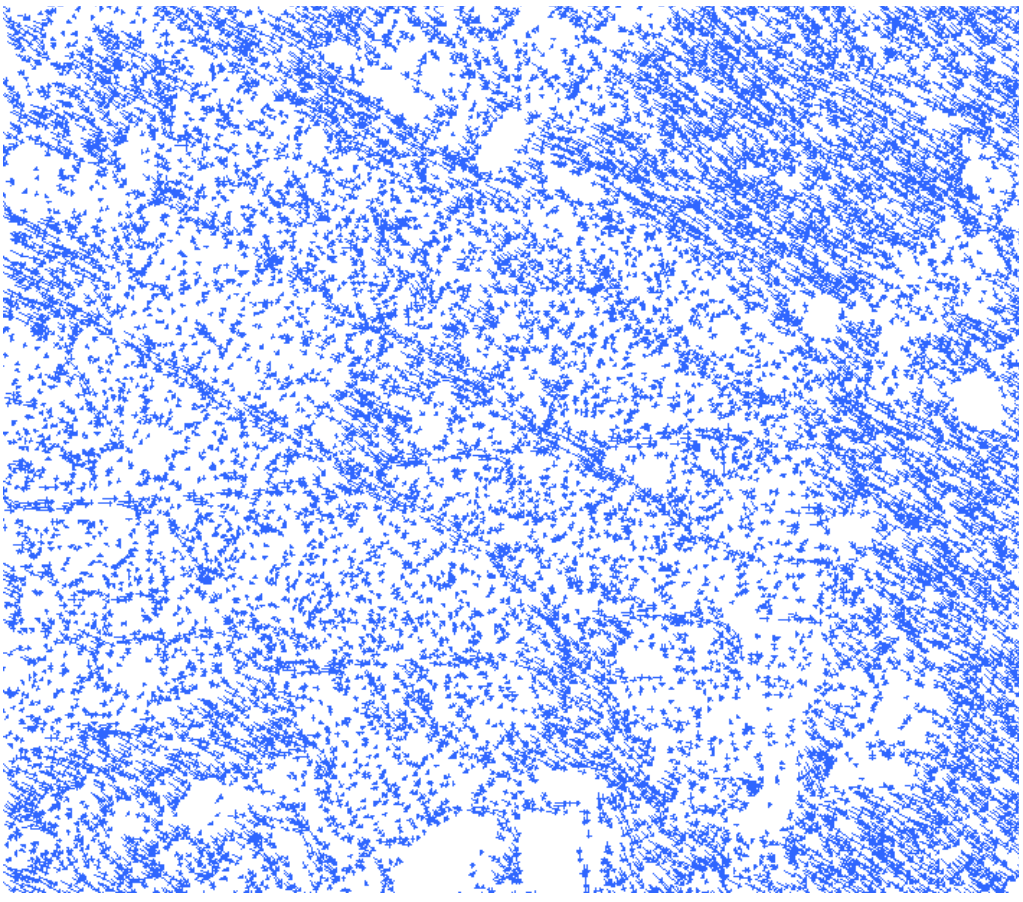


27.06.2019
x/y Cut at k=7 (z=7.0000 m)

Wind Speed
at 18:00

Flow v

1.00 m/s
2.00 m/s
3.00 m/s
4.00 m/s
5.00 m/s



27.06.2019
x/y Cut at k=7 (z=7.0000 m)

Wind Speed
at 18:00

PET is a thermal comfort index that calculates skin temperature, body core temperature, perspiration rate, and, as an auxiliary variable, garment temperature using a predictive model of the human energy balance. It is based on the 2-node model proposed by Gagge et al, which Höppe integrated and expanded into the Munich Energy Balance Model for Individuals (MEMI). Although the core model can be utilized in both in-stationary and stationary modes, PET only uses the stationary solution of the body parameters.

The Physiological Equivalent Temperature (PET) is defined as the air temperature at which the human body's heat budget is balanced in a normal indoor setting (without wind or solar radiation) with the same core and skin temperature as in the challenging outdoor conditions to be assessed. The key differences between ENVI-met Biomet and original PET are as follows:

Instead of using the outdoor air velocity, the turbulent exchange coefficients for heat and vapor for the indoor context are calculated using the inside air velocity. The perspiration rate and amount of sweat on the skin are both set to zero when computing the inside environment. PET (and other outdoor thermal comfort indices) is based on the idea that we may express a human body's thermal comfort by using skin and core temperature as reference markers.

So, in an outside scenario, the essential principle of PET is as follows:

• The human body's entering and outgoing fluxes must be defined.

• Determine a skin and core temperature that corresponds to all of the fluxes.

• Place the person in a confined space.

• Reset any data that isn't accessible when you're inside (direct sun radiation, forced wind movement). Find an internal air temperature (as the single parameter) that provides the same skin and core temperatures as the outdoor temperature.

We were able to easily discover the issue locations in the urban area using PET extractions. The “PET” temperatures in the project area are acceptable and good for the thermal comfort levels because we used greenery and permeable soil on the ground surfaces that we have. We can also see how the shadow has a beneficial influence in some regions.

In terms of the extraction that we performed, we discovered that we have certain high limits in some places that are exclusive to PET extractions. When we investigate. The majority of the troublesome regions are in close proximity to the buildings. The areas most affected are pedestrian paths and motor roads.

Some values are incompatible with human comfort. The temperature in these places ranges from 48.56 to 51.64 degrees Celsius. These temperatures may have developed as a result of the following factors.

- The building’s direction, which has a direct impact on sunshine, wind, and shadow variables.

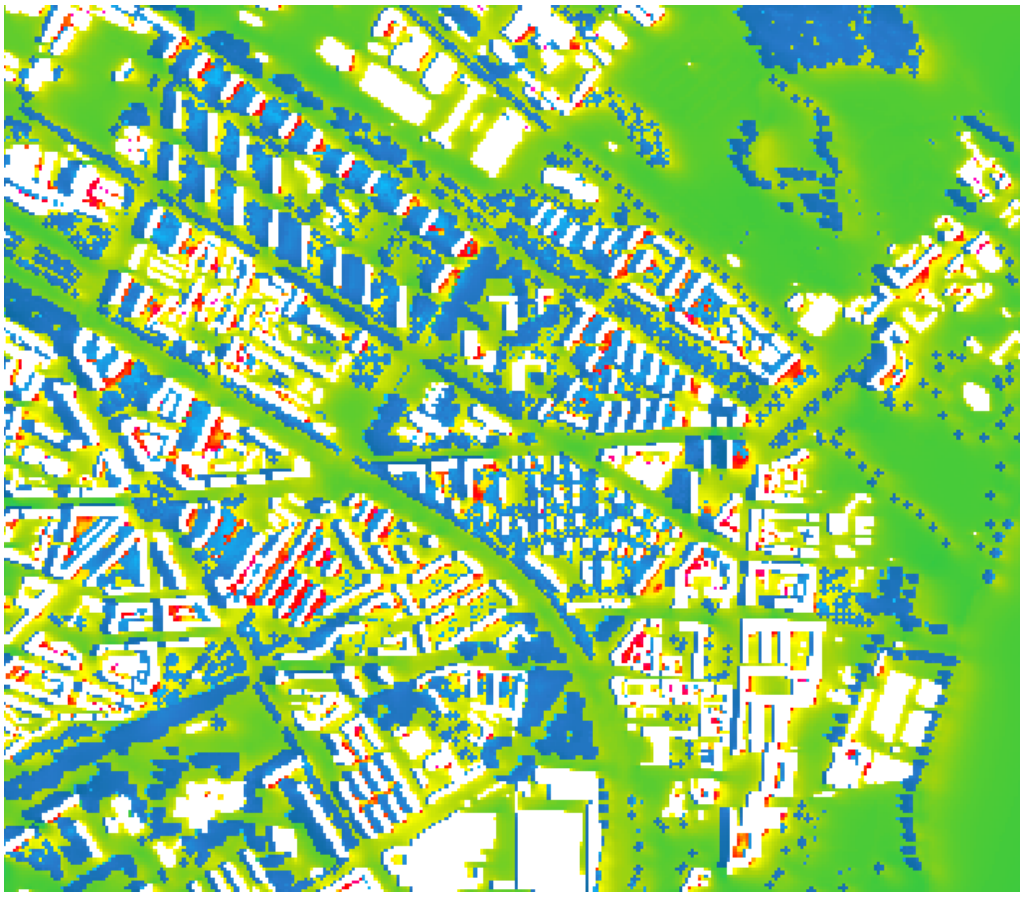
- The materials utilized in these structures were chosen wrong, which may be impacting the PET results.

- It’s possible that there isn’t enough greenery in these regions. Because of the shade they cast on their surroundings, trees have a good impact on the PET value.

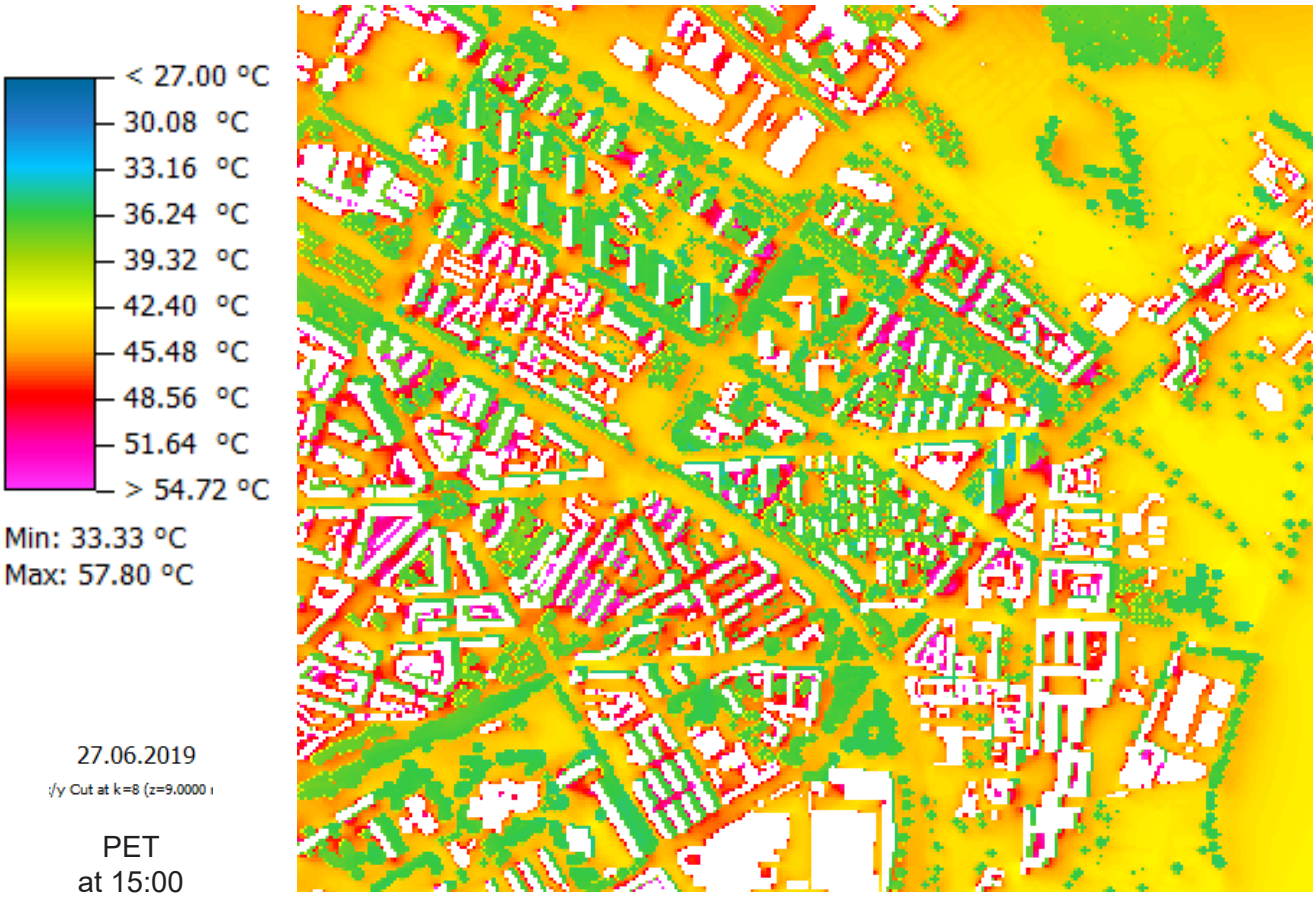
We may deduce these results based on all of the facts and adding the last part, which is PET calculations and diagrams, that the thermal component of the outdoor micro-climate is dependent on the changes that we as human beings make. The thermal comforts in metropolitan regions are directly affected by urbanization.

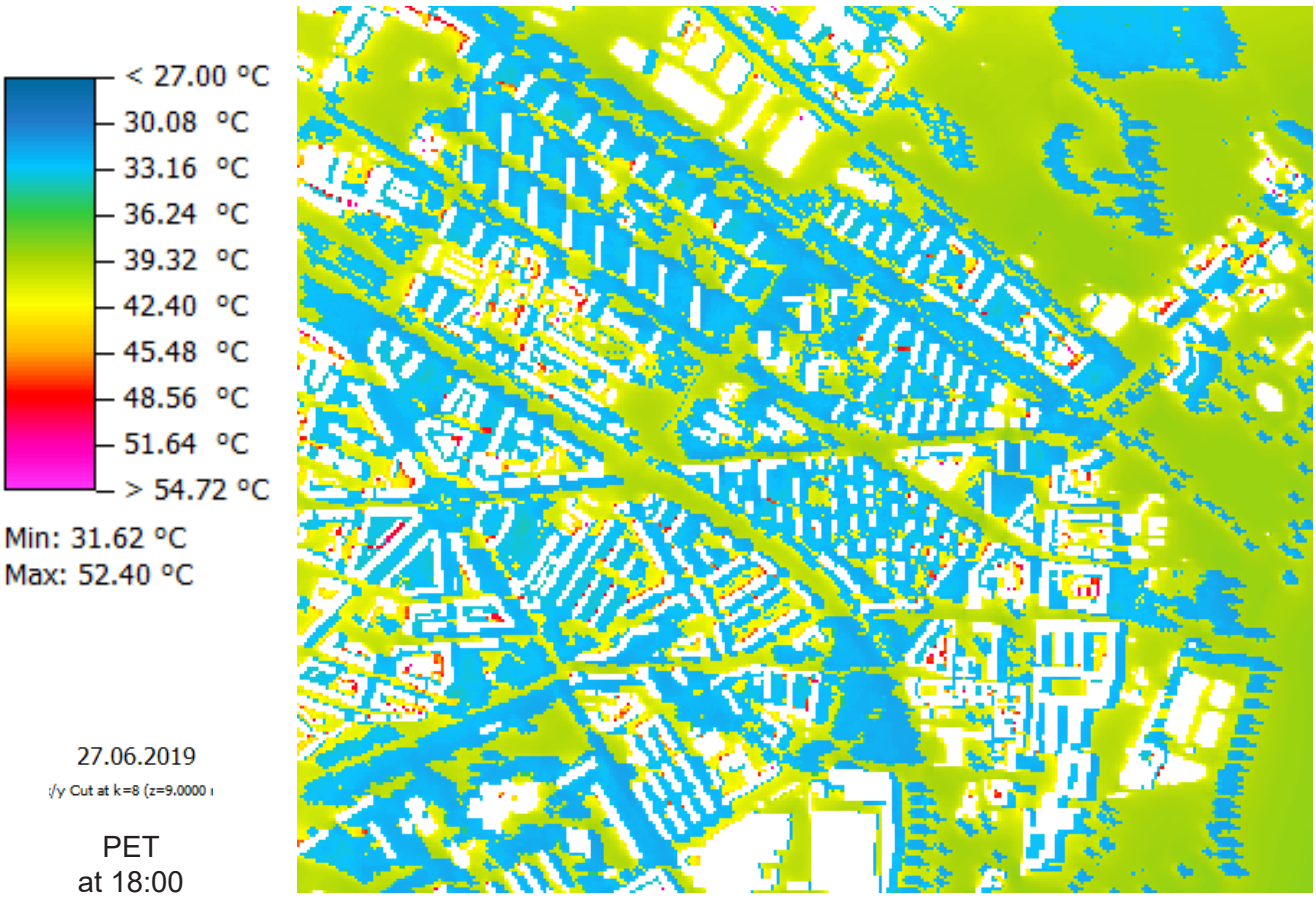
Before we establish our general network, we must consider the micro-climatic effects that we can have on these areas while controlling areas and constructing complex networks, buildings, and environments for human activity.

38. Höppe, P. (1999). The physiological equivalent temperature - A Universal index for the biometeorological assessment of The thermal environment. International Journal of Biometeorology, 43(2), 71–75. https://doi.org/10.1007/s004840050118


< 27.00 °C
30.08 °C
33.16 °C
36.24 °C
39.32 °C
42.40 °C
45.48 °C
48.56 °C
51.64 °C
> 54.72 °C
Min: 27.00 °C
Max: 53.20 °C
27.06.2019
PET
at 09:00


< 27.00 °C
30.08 °C
33.16 °C
36.24 °C
39.32 °C
42.40 °C
45.48 °C
48.56 °C
51.64 °C
> 54.72 °C
Min: 31.60 °C
Max: 53.40 °C
27.06.2019
PET
at 12:00


< 27.00 °C
30.08 °C
33.16 °C
36.24 °C
39.32 °C
42.40 °C
45.48 °C
48.56 °C
51.64 °C
> 54.72 °C
Min: 33.33 °C
Max: 57.80 °C
27.06.2019
PET
at 15:00


< 27.00 °C
30.08 °C
33.16 °C
36.24 °C
39.32 °C
42.40 °C
45.48 °C
48.56 °C
51.64 °C
> 54.72 °C
Min: 31.62 °C
Max: 52.40 °C
27.06.2019
PET
at 18:00

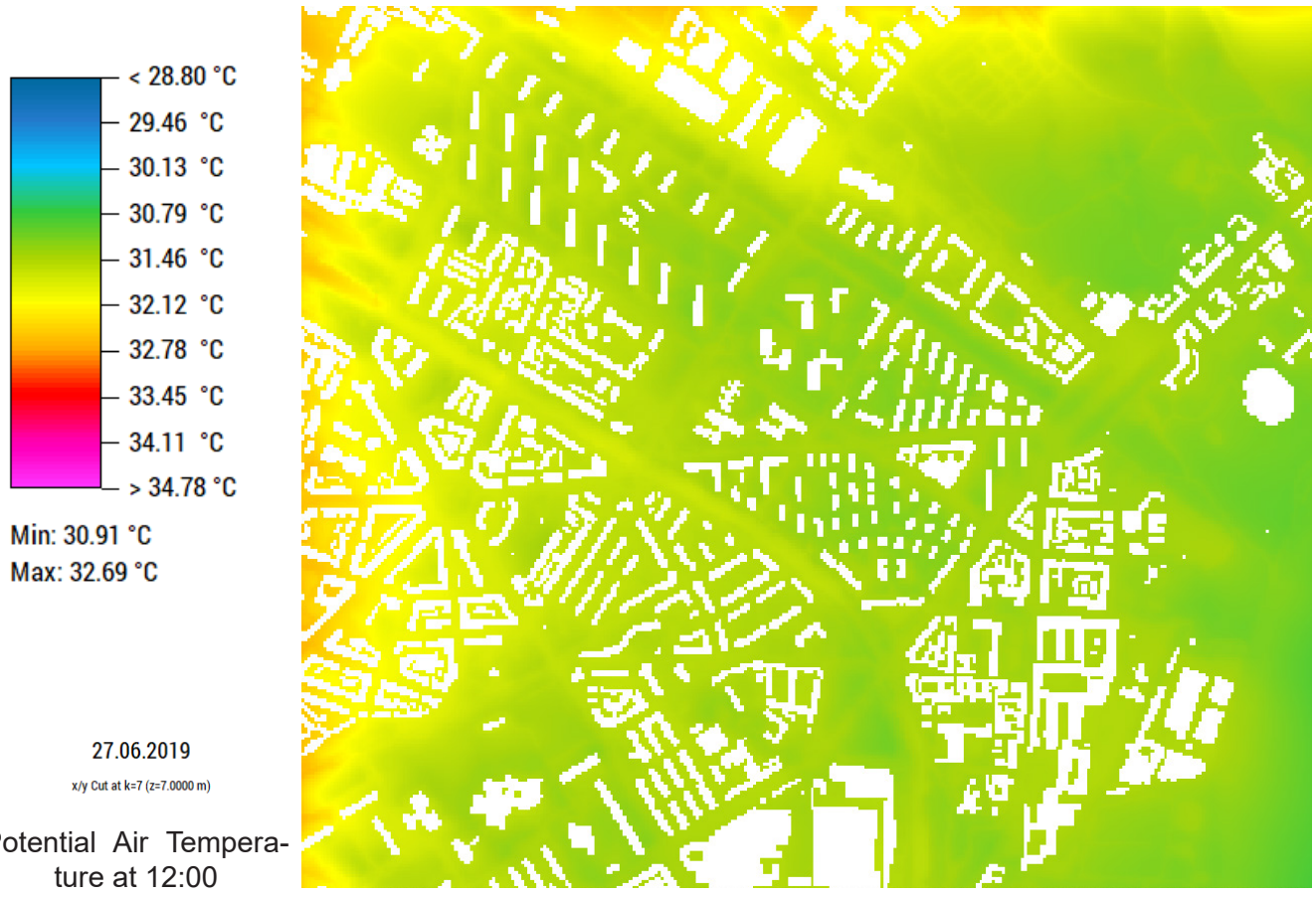
Thermal comfort is a useful statistic for describing people's subjective temperature experiences in open spaces in urban microclimates. The influence of the sun, wind, air temperature, and humidity on thermal sensation is crucial. When the human body is unable to compensate for hot or cold ambient conditions through heat generation, and the actual environment is either warm or cold, thermal discomfort ensues. The unfavorable weather conditions are one of the key reasons why society prefers to live in the suburbs of cities rather than in the city center.

As a result, the design of sustainable urban open spaces must strike a balance between potential users' aspirations and the city's actual requirements. As a result, determining how people feel under varied climatic conditions, particularly their thermal and wind comfort, and how this influences behavior inside the urban structure is part of evaluating the microclimate characteristics of an urban place.

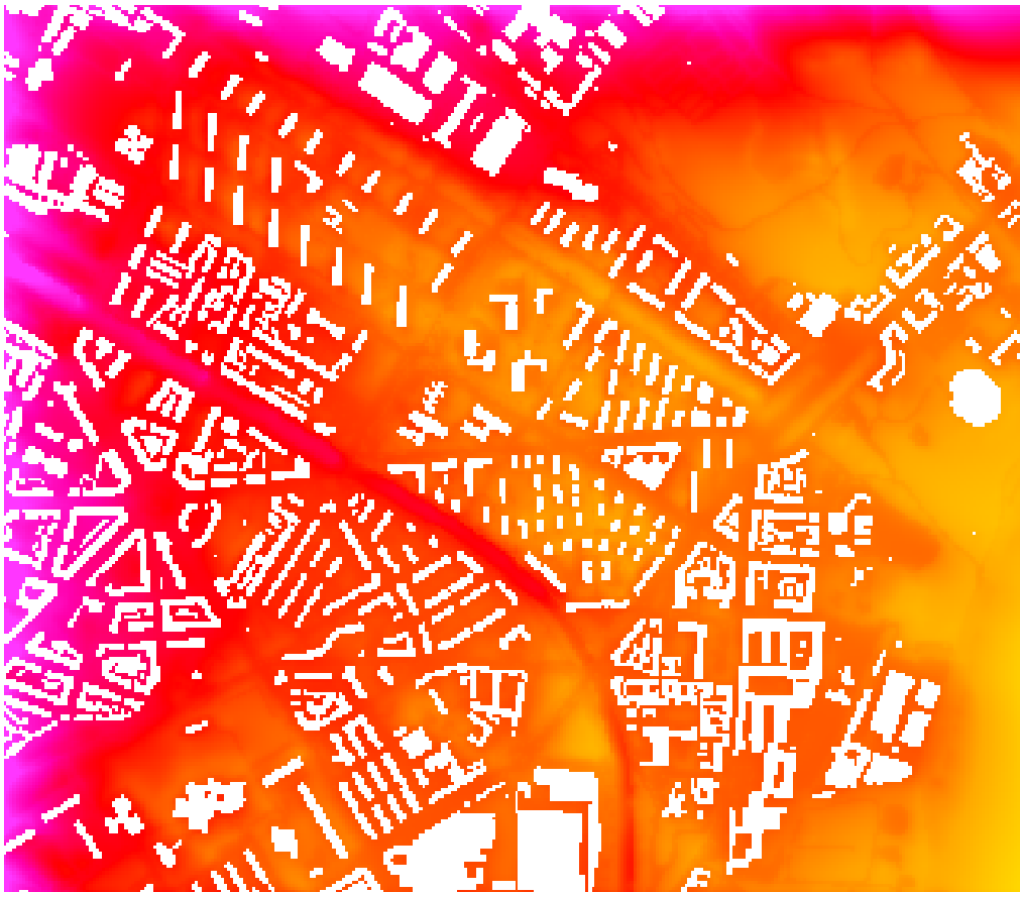
"An urban heat island is a phenomenon that affects anything from a few hot patches on a street to entire city districts." A full and dynamic simulation of all causative components of the urban heat island is required to understand the thermal performance of a city at the block or district level.

38. Höppe, P. (1999). The physiological equivalent temperature - A Universal index for the biometeorological assessment of The thermal environment. International Journal of Biometeorology, 43(2), 71–75. https://doi.org/10.1007/s004840050118

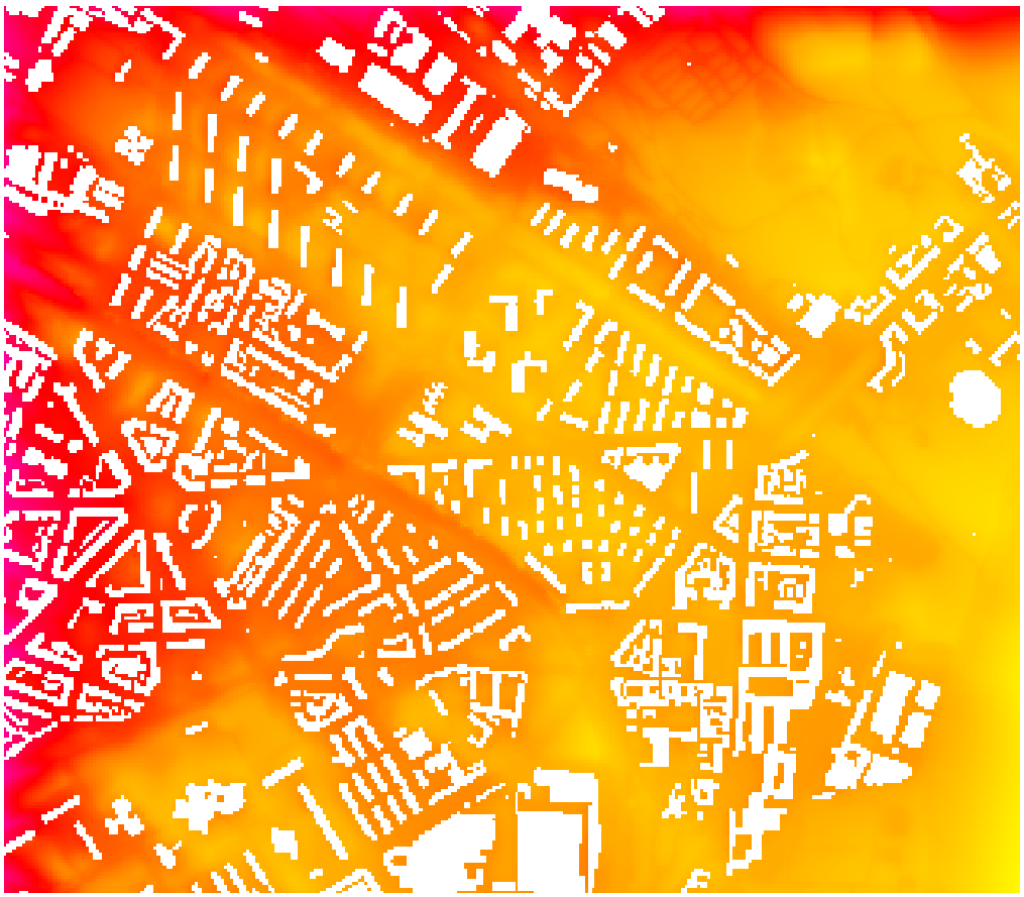
Potential Air Temperature at 09:00



Potential Air Temperature at 12:00



Potential Air Temperature at 15:00



Potential Air Temperature at 18:00

7.3
Mobility in Site

The public transportation system in Turin is run by GTT, Gruppo Transporti Torinese.

Metro Lines – 1 – 15.1km

Tram Line – 8 – 200km

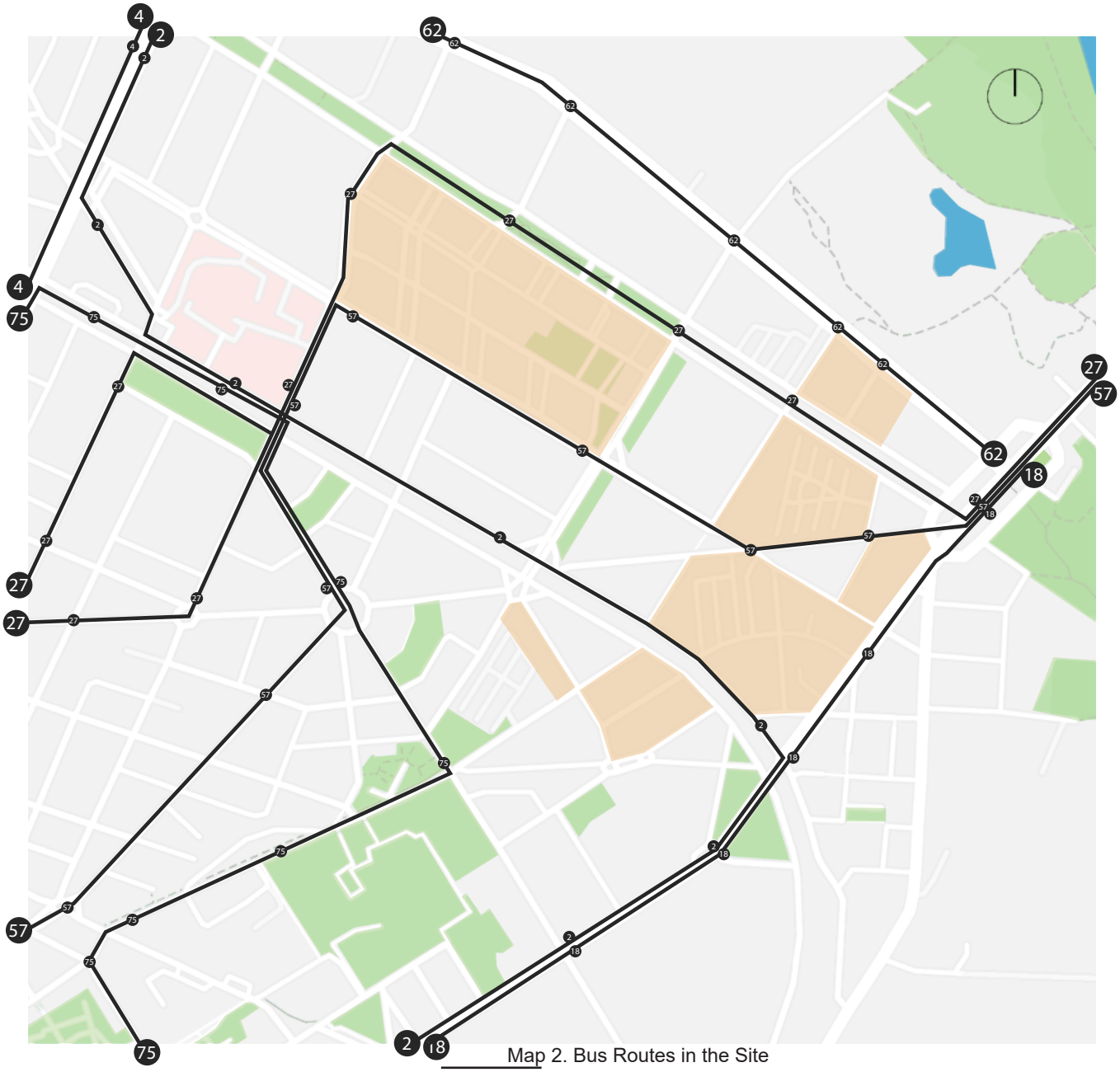
Bus Lines – 83 – 1200km

Out of Town Bus Lines – 80 – 3600km

Rail Lines – 2 – 79km

Rail Lines (Managed on behalf of Trenitalia) – 1 – 36km

SFM A Line – Turin – Caselle Airport – Ceres GTT Line

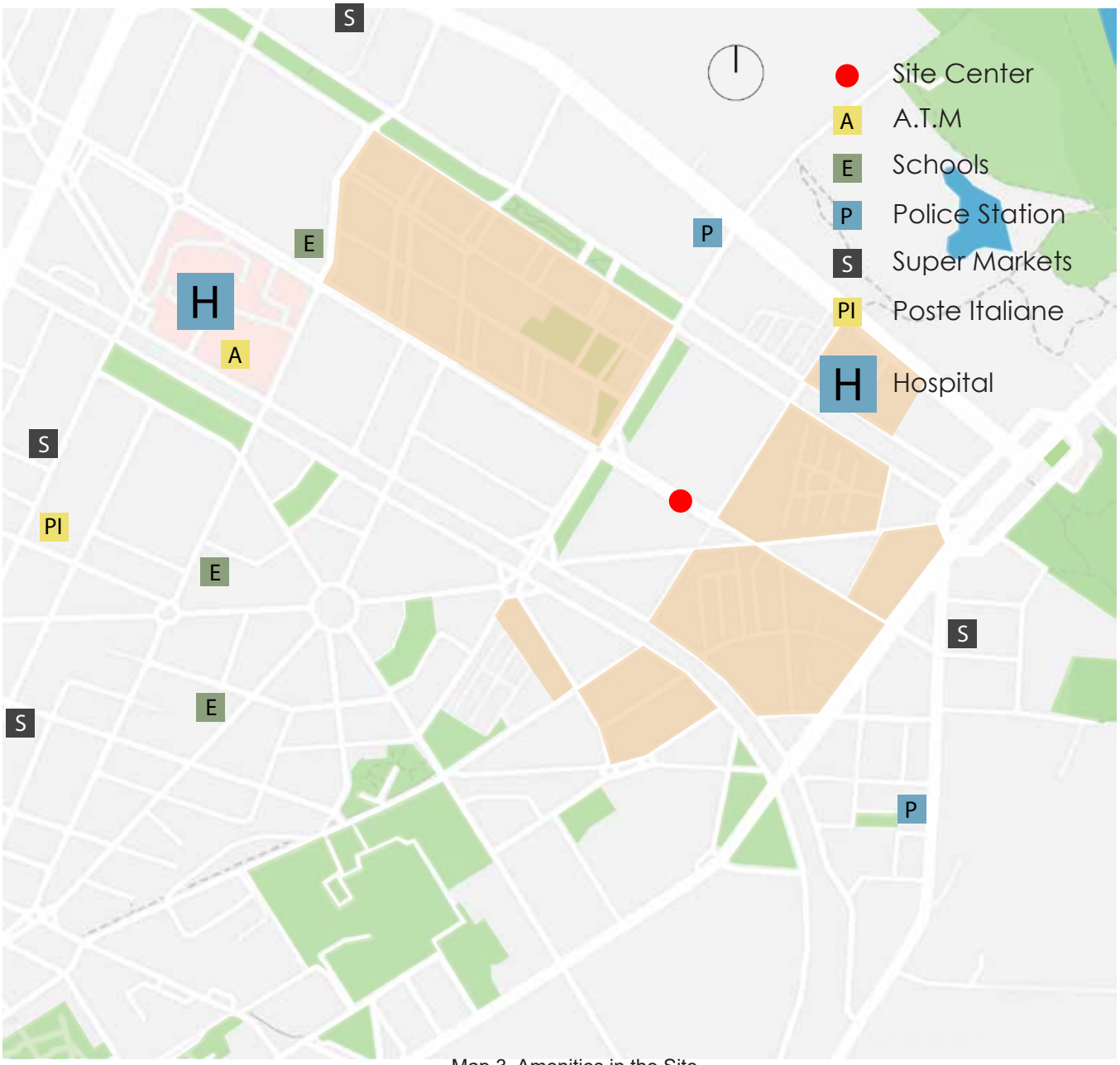


Map 2. Bus Routes in the Site

Proximity of Basic services around the Site

The Site is located near the Northern Border of the City. It has good connectivity to basic facilities as shown in the map. All the basic amenities are within the radius of 1km. That being said, because it is quite far from the city center, it has no bike sharing services near by. The closest service is across the river at a walking distance of about 3.5km.

Distance To
Caselle Airport – 13.7 km
Porta Nouva – 6.6 km
Porta Susa – 5.7 km
Metro Station – 5.1km
(XVIII Dicembre)



Map 3. Amenities in the Site

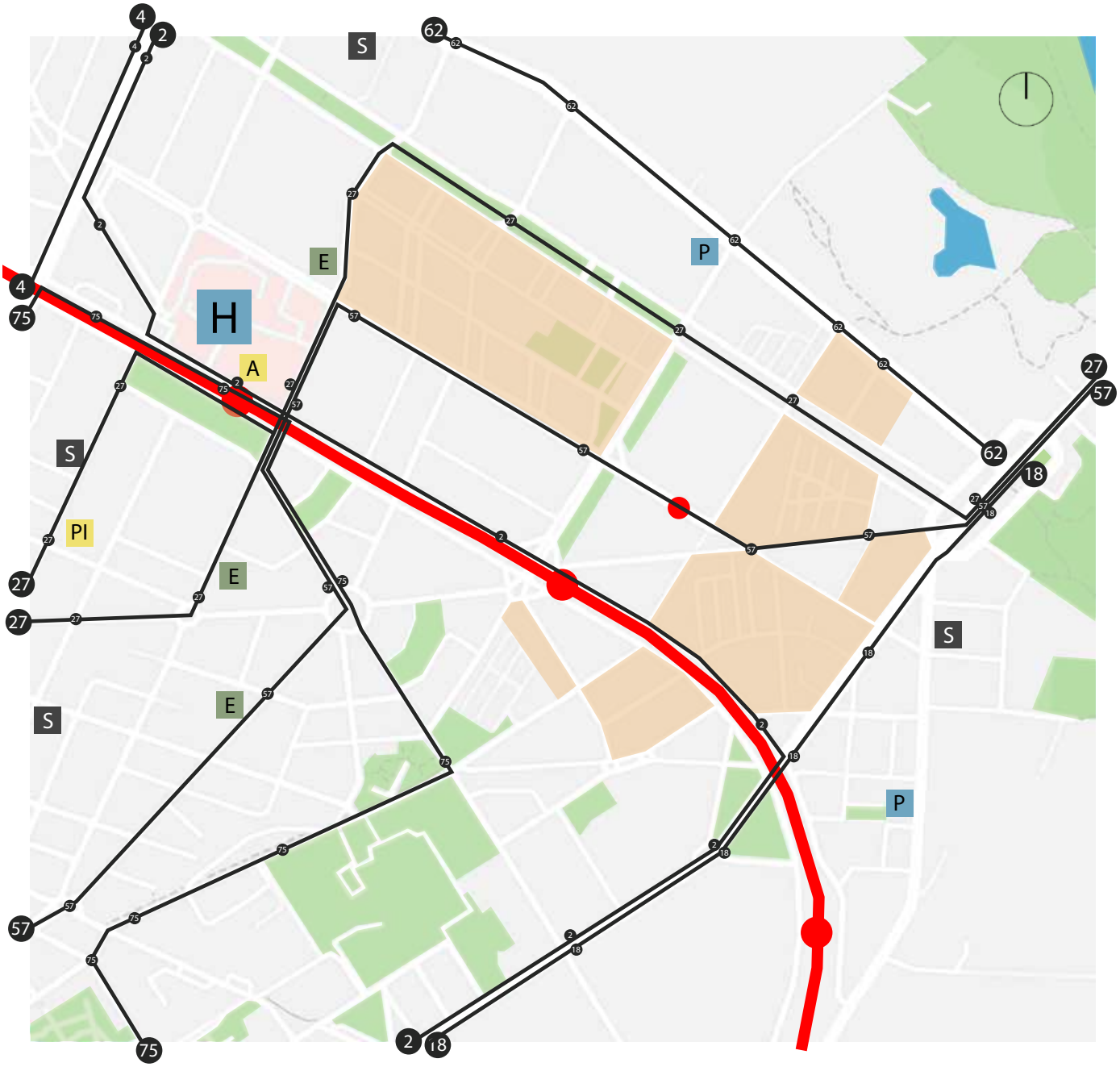
New Metro Line

Line 2 will run along Turin's northeast-southwest metropolitan axis. The trucks will operate automatically to cut wait times and boost service availability across all time windows. The "Y" shaped Line 2 will connect 32 stations over a total of 27 km of track, divided into three main stretches: a central one, 16 km long, connecting 23 stations from Rebaudengo to Anselmetti; a soutward extension, 6 km long, connecting 5 stations from the former station to Orbassano; and a northward extension, 4 km long, connecting 4 stations and bringing to Pescarito/S.Mauro.

The facility will help to strengthen connections between the city's important hubs, including the FCA in Mirafiori, university hubs like Campus Einaudi and the Politecnico di Turin, the city center, and the Giovanni Bosco Hospital. Line 2 will connect to the current public transportation network through three interexchange points: it will connect to the Metro Rail Transit System in Zappata and Rebaudengo stations, and it will intercept Line 1 of the Underground in Porta Nuova Station, which is an intermodal hub of excellence. In addition, four interchange parking lots for public and private vehicles in the Orbassano, Anselmetti, San Mauro, and Rebaudengo stations will help to improve the intermodal transportation system. In order to facilitate the use of bicycles by commuters or residents who live far from the subterranean track, bike parking and bike-sharing stations will be positioned near the stops, and covered and safe facilities for long stopovers will be incorporated in the line's key stops.

The preliminary plan for Line 2 was funded by Resolution "Sblocca Italia," which set aside 90 million for the completion of Line 1's westward extension and ten million for the basic planning of Line 2. The Turin City Council awarded the responsibility of drafting up the preliminary draft of Line 2 central stretch and the Feasibility Study for the northward and southerly extensions through public bidding in December 2017. The center stretch's technical and economic feasibility project was completed in May 2019, while the extensions to Orbassano in the south and San Mauro in the north were completed in June of the same year.

25. Metro Line 2. InfraTo. (n.d.). Retrieved November 30, 2021, from https://www.infrato.it/metro-line-2/



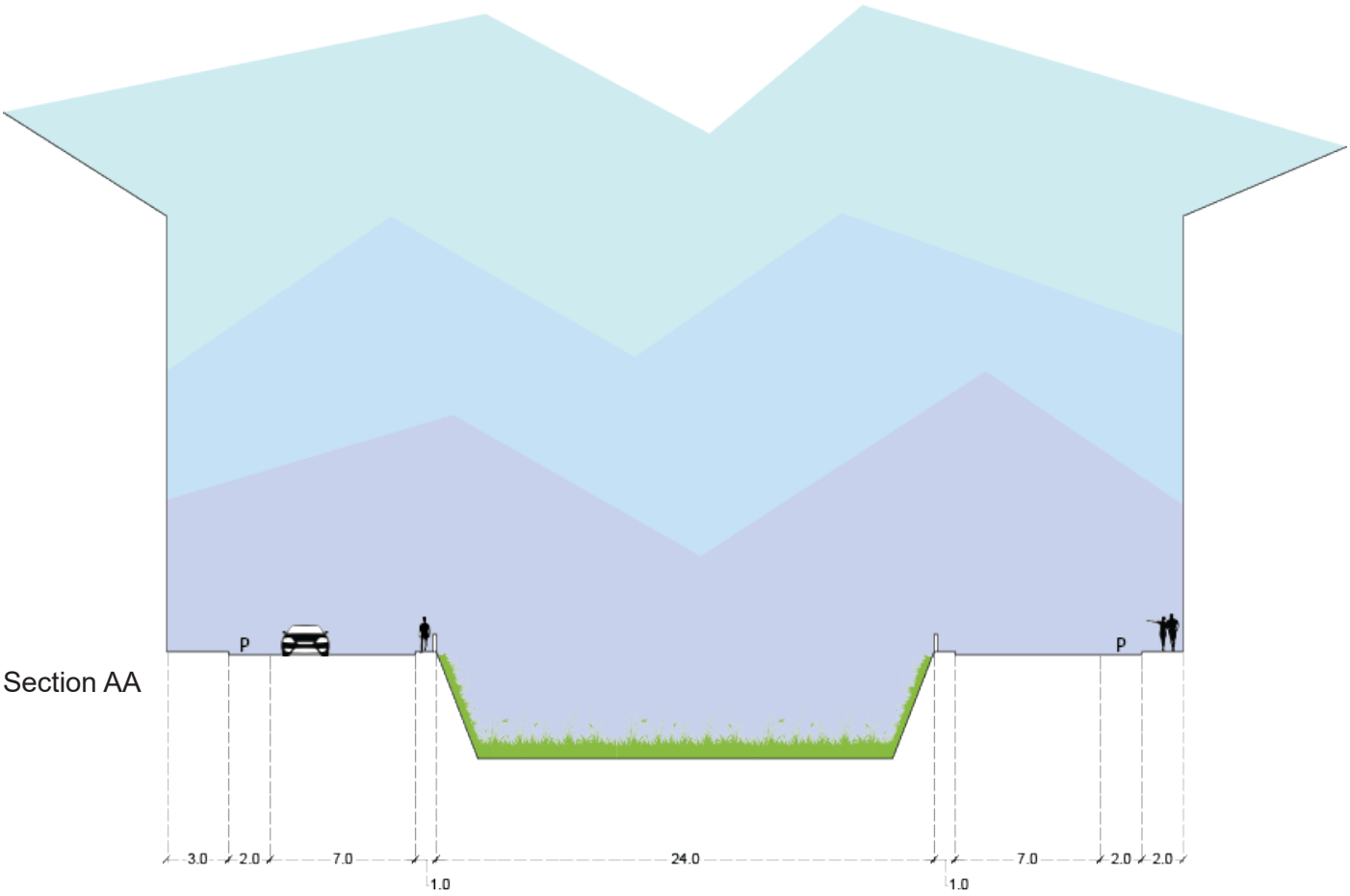
Map 4. Position and Stops of the New Metro Line

Existing Roads

Via Gottardo – Via Sempione

The existing road has a big trench in between the two one-way roads. These roads are 9.5m wide but one of the lanes is always left out for parking as seen in the images below.

Section AA



Photograph 1

Photograph 2

Photograph 3

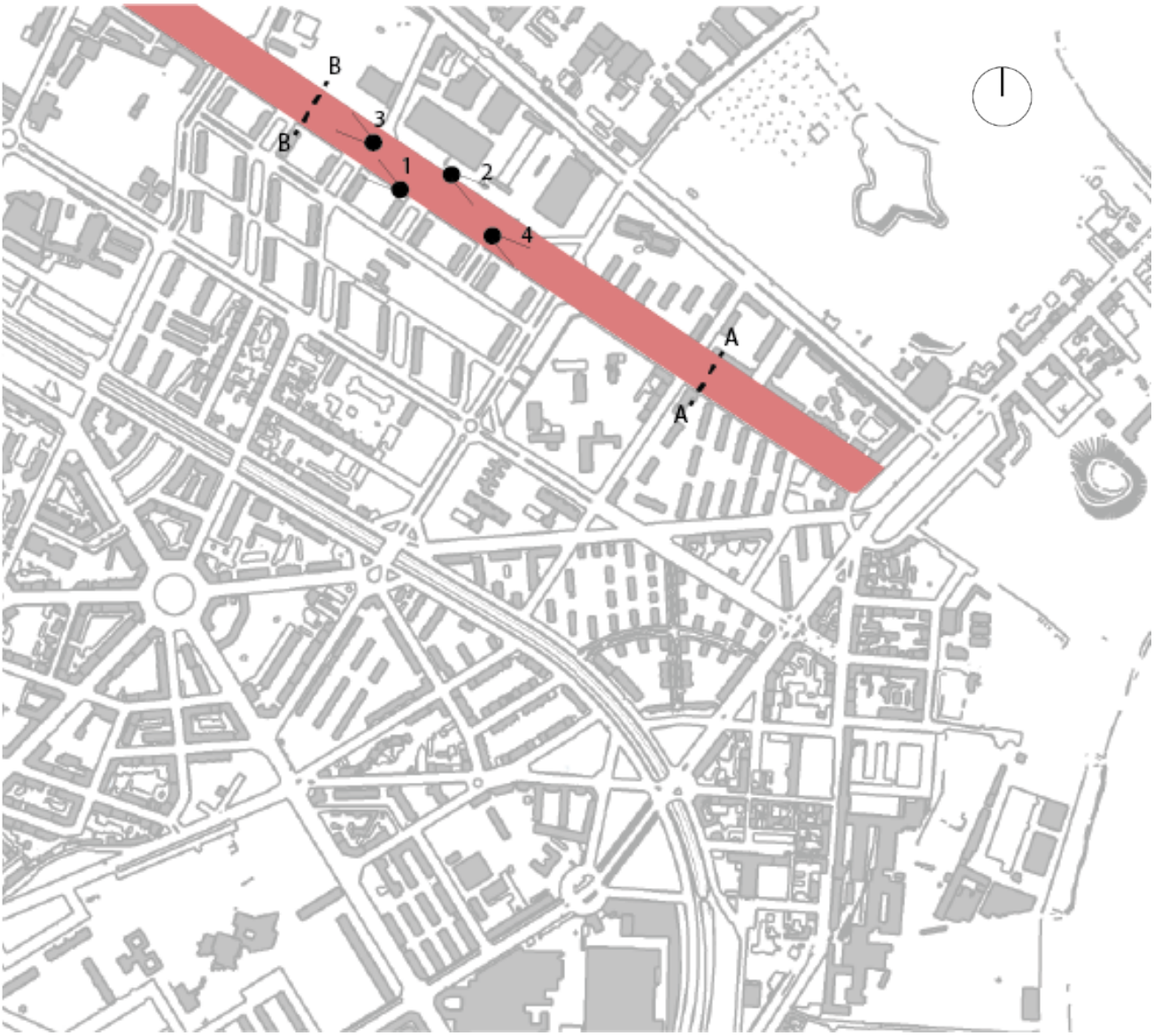
Photograph 4

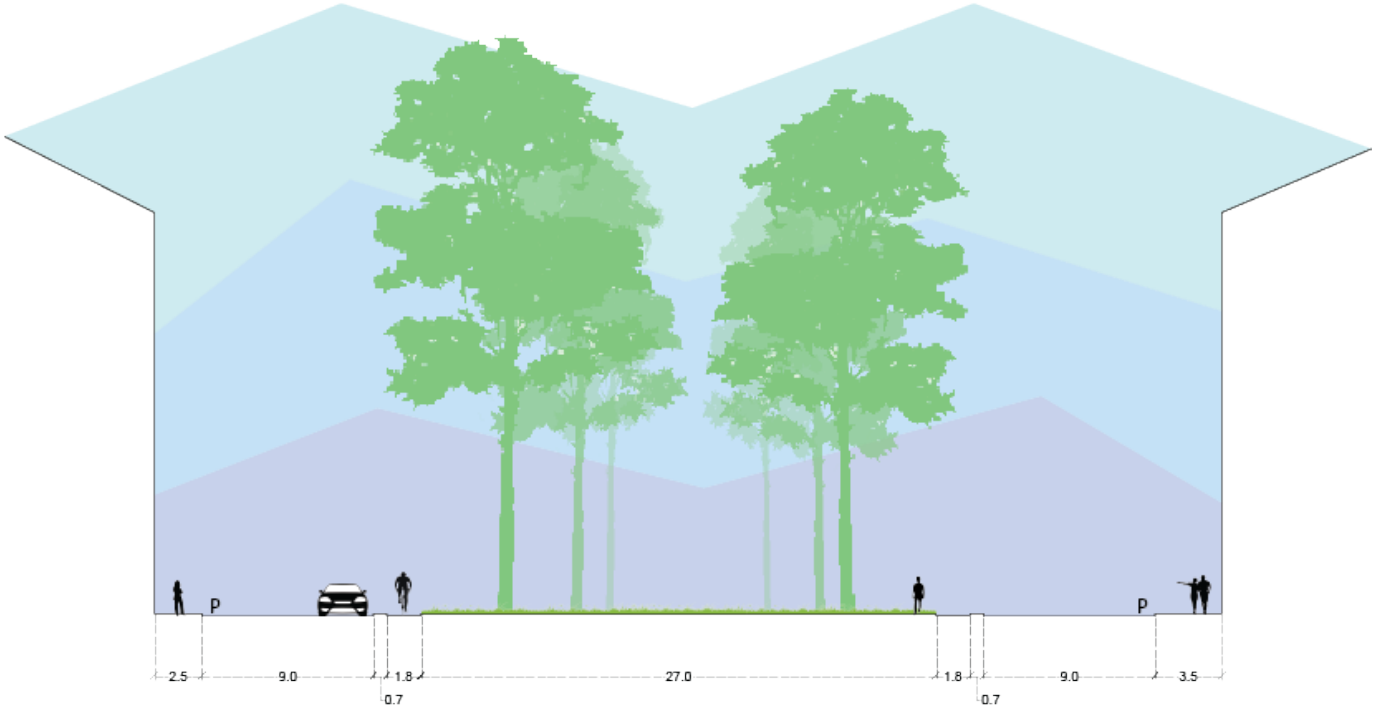
Photograph 5

Existing Roads

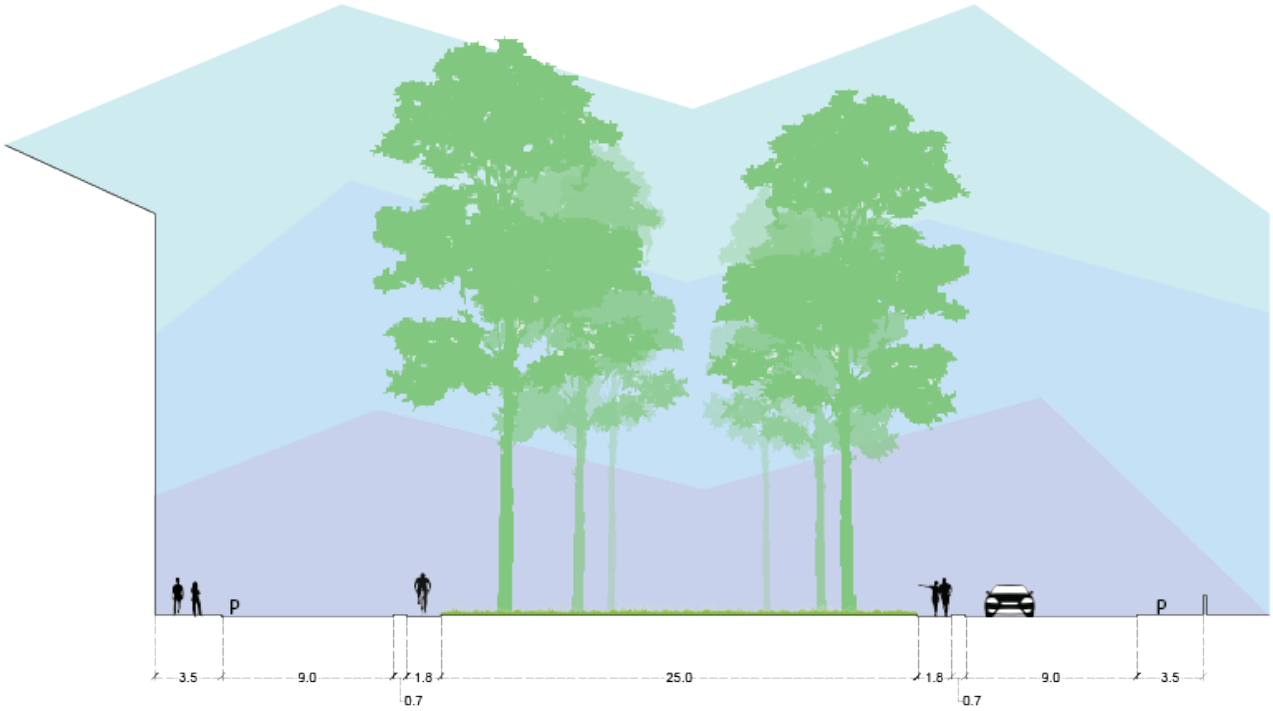
Corso Taranto

The existing road has bicycle lanes in between the two one-way roads along with a park. These roads are 9.0m wide but one of the lanes is always left out for parking as seen in the images below.





Section AA



Section BB

Photograph 1

Photograph 2

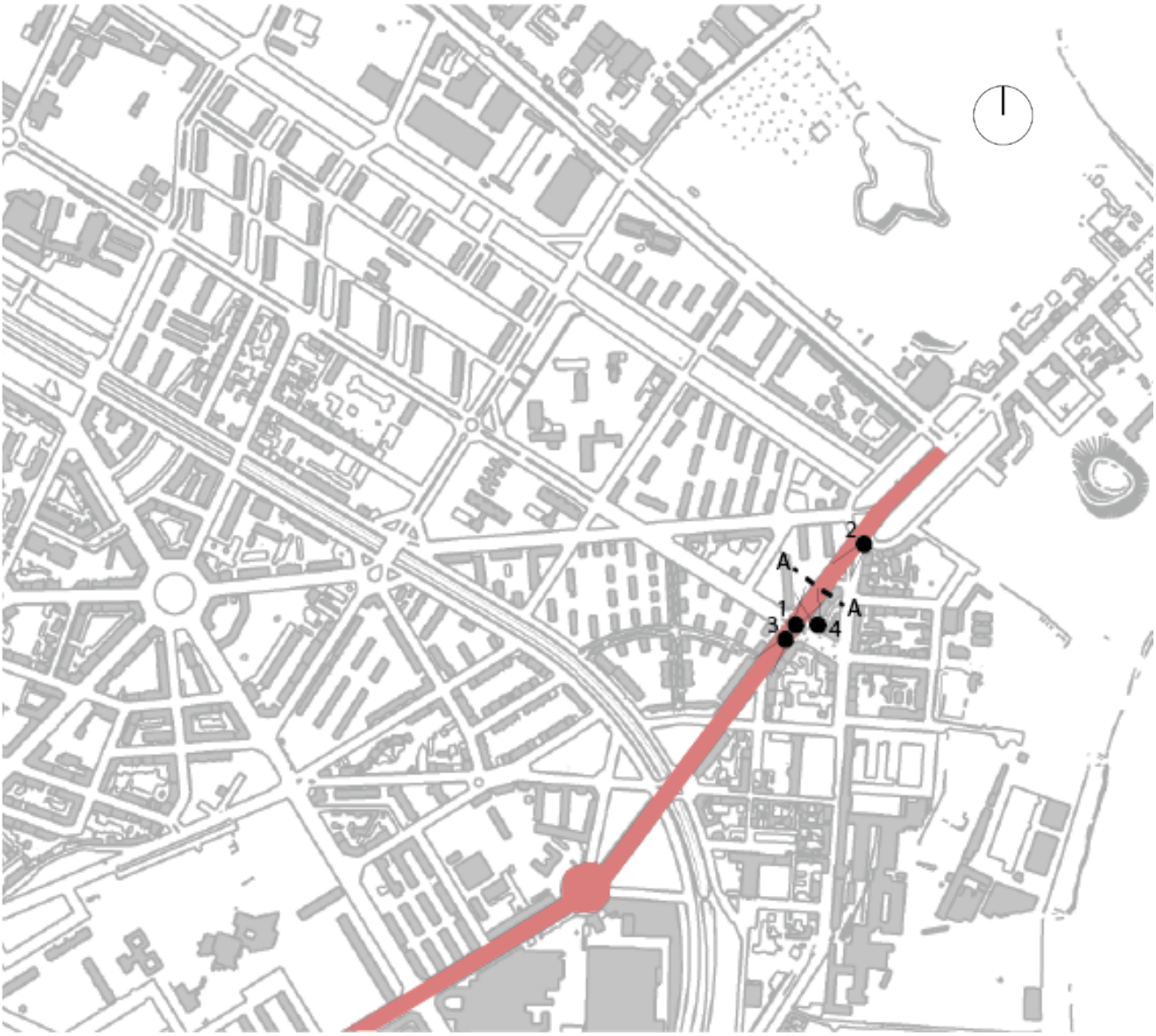
Photograph 3

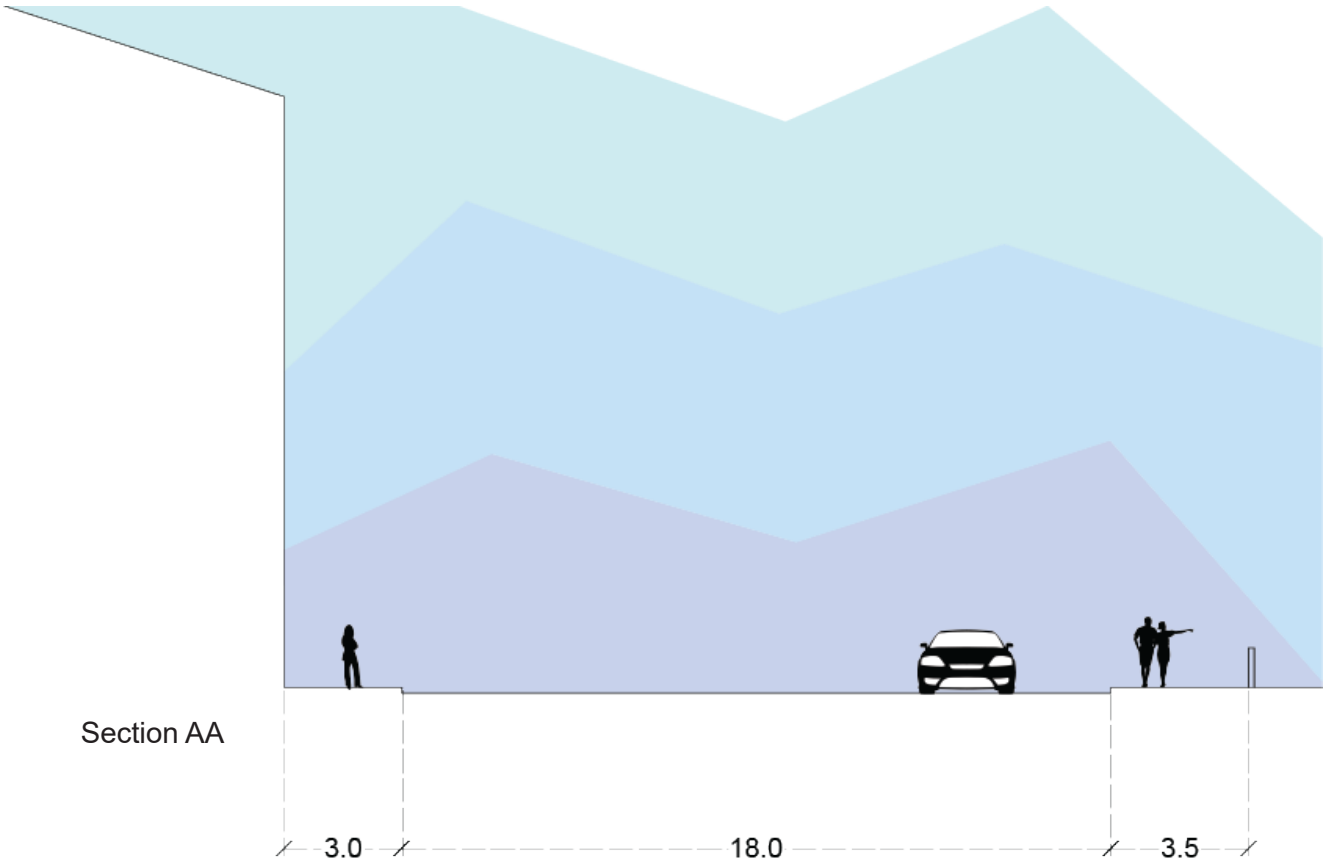
Photograph 4

Existing Roads

Via Bologna

This is one of the main roads to the site. It hosts the Route 8 which goes from the northern end of the city to the southern. It has pedestrian paths on both sides of the road.





Photograph 1

Photograph 2

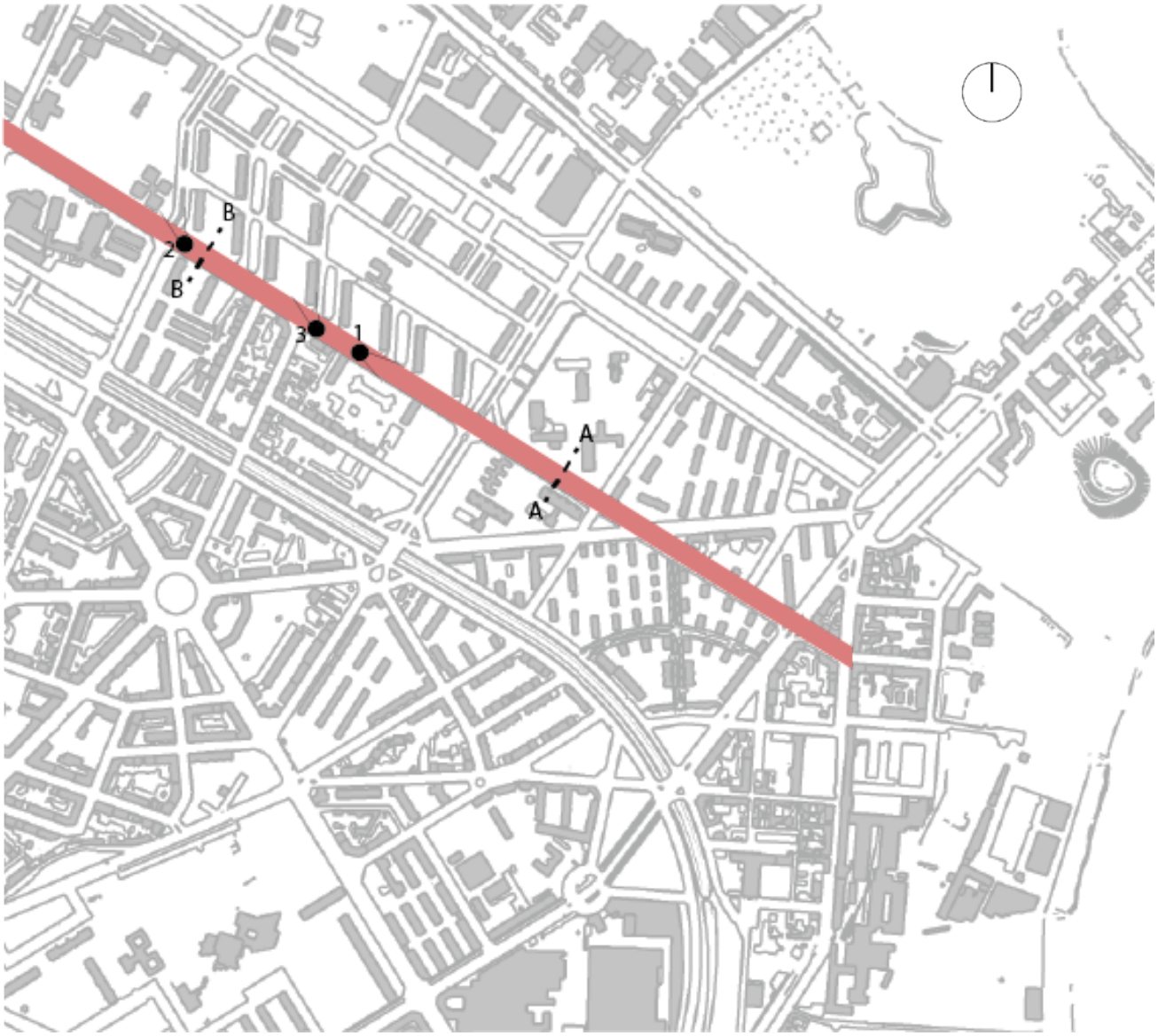
Photograph 3

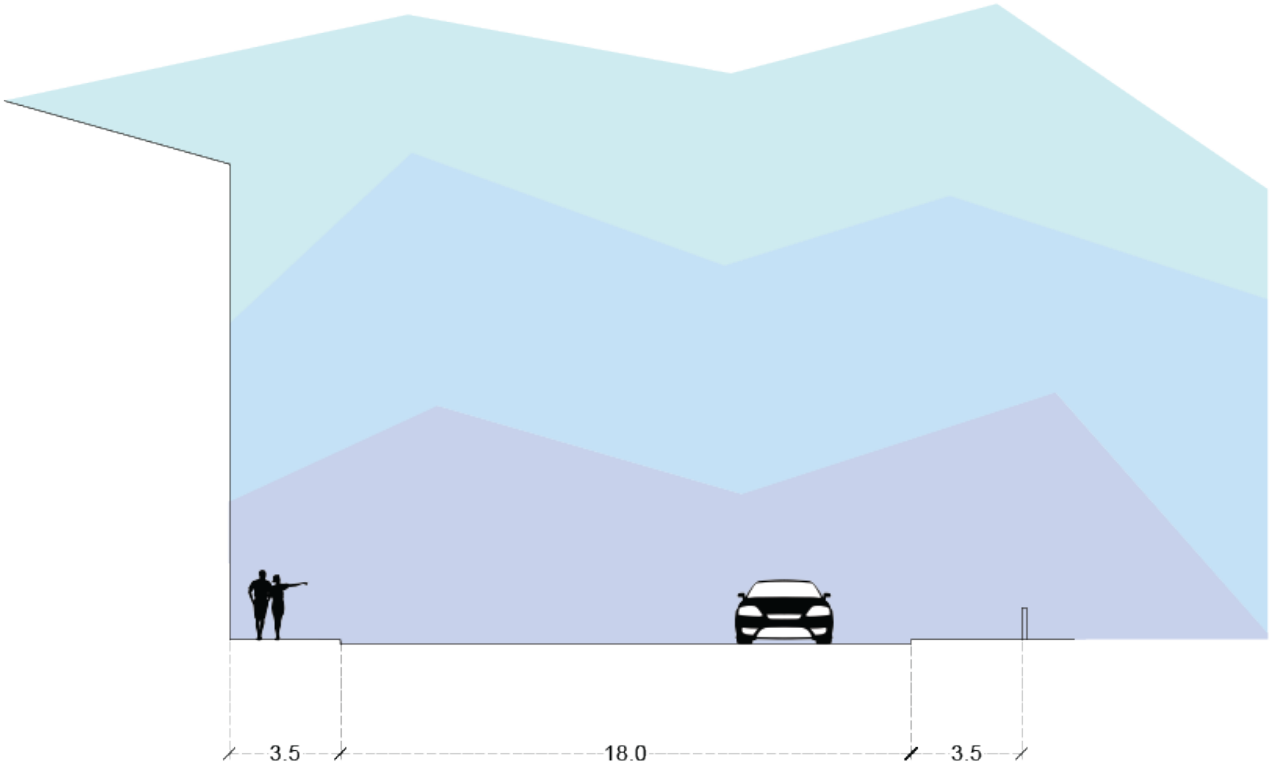
Photograph 4

Existing Roads

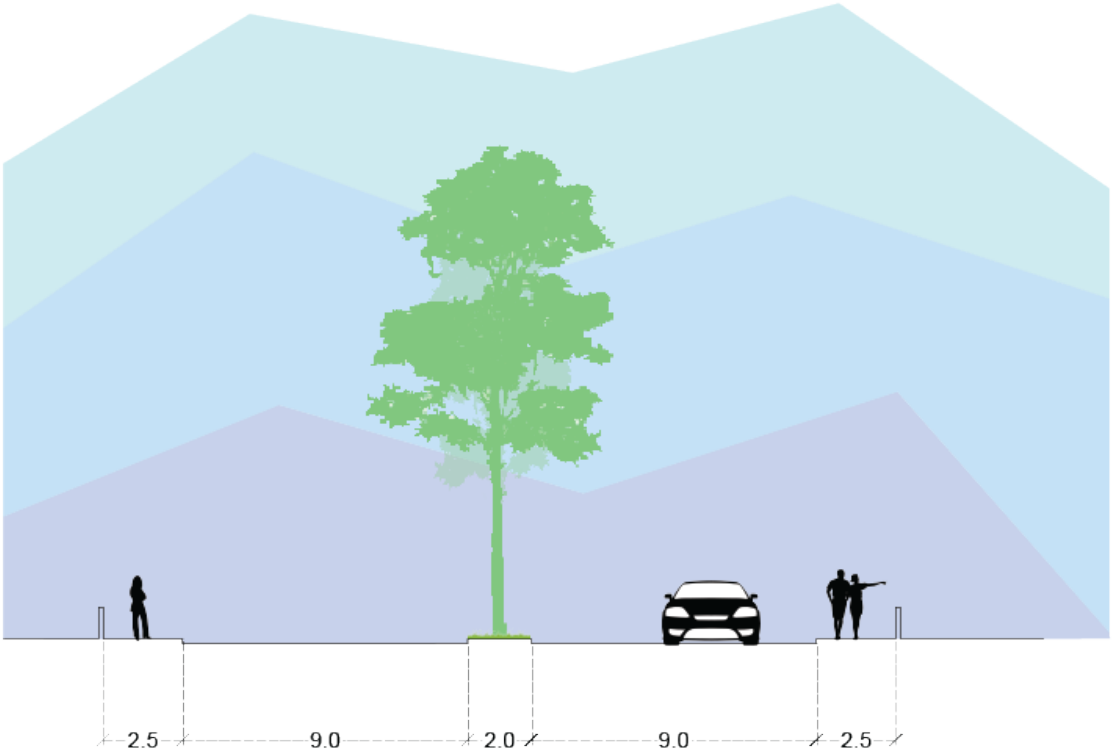
Via Giambattisa Pergolesi

This road is one of the wider roads with the tree paths. It provides access to one of the schools in the region.





Section AA



Section BB

Photograph 1

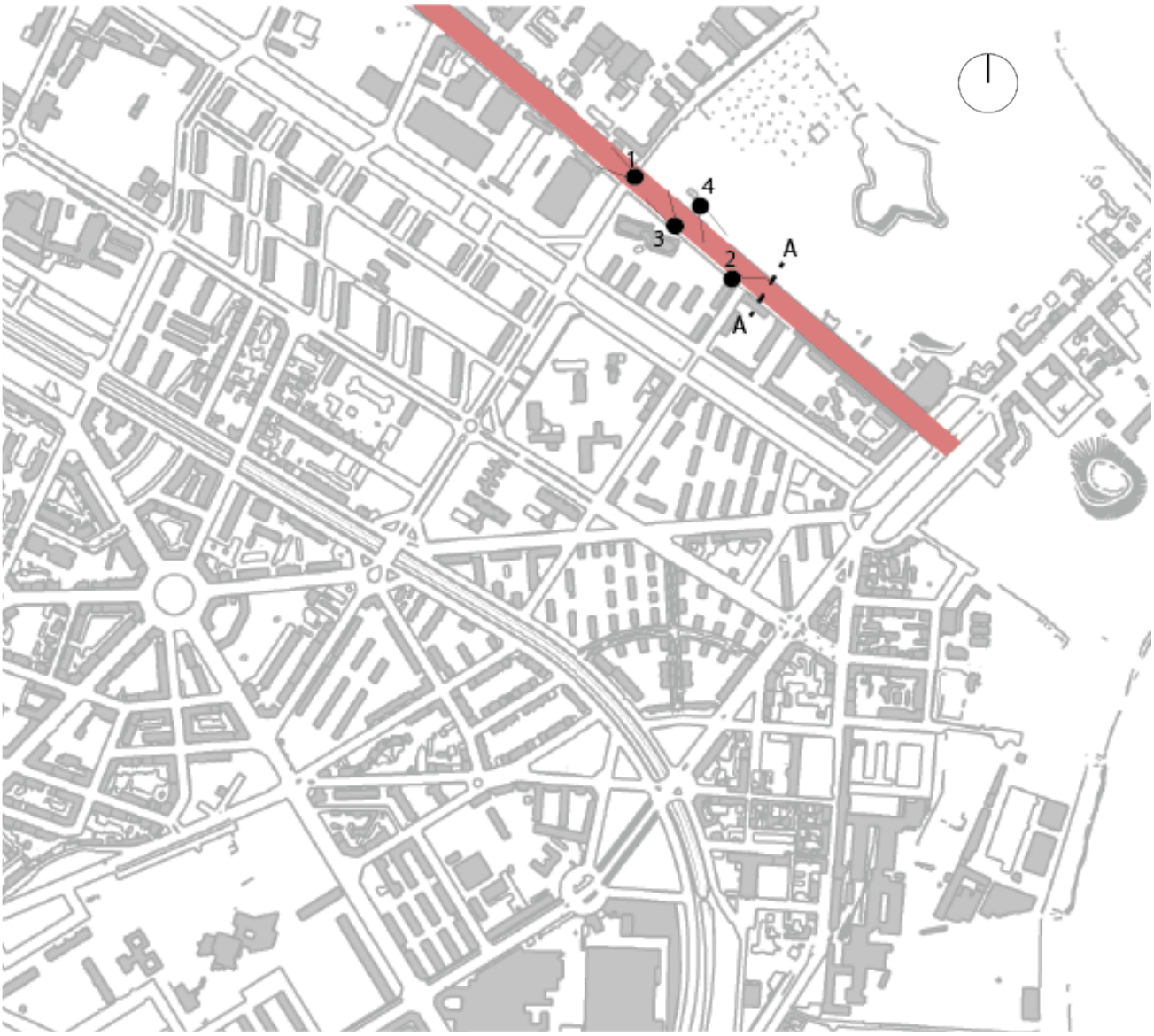
Photograph 2

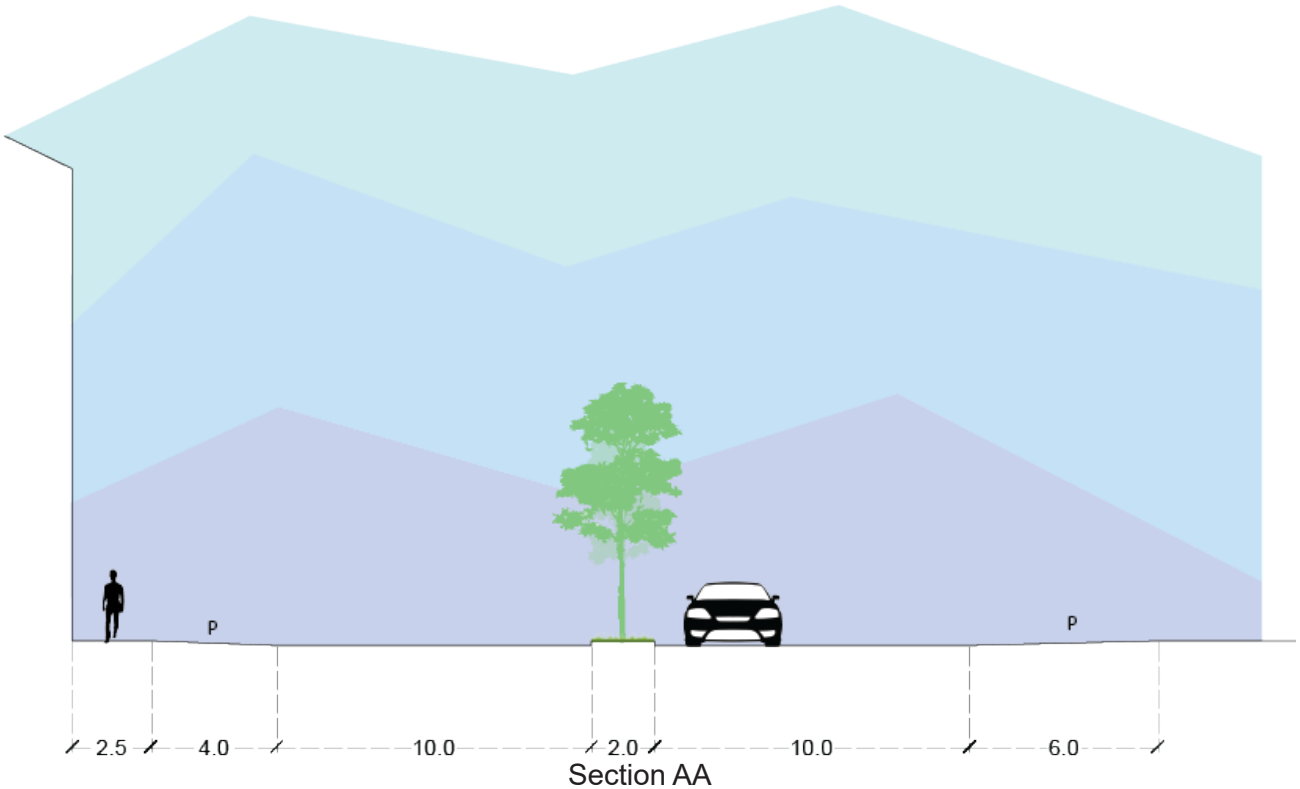
Photograph 3

Existing Roads

Via Sandro Botticelli

This is one of the roads with parking lanes on both the sides of the road. It is relatively free/empty during most of the daytime.





Section AA

Photograph 1

Photograph 2

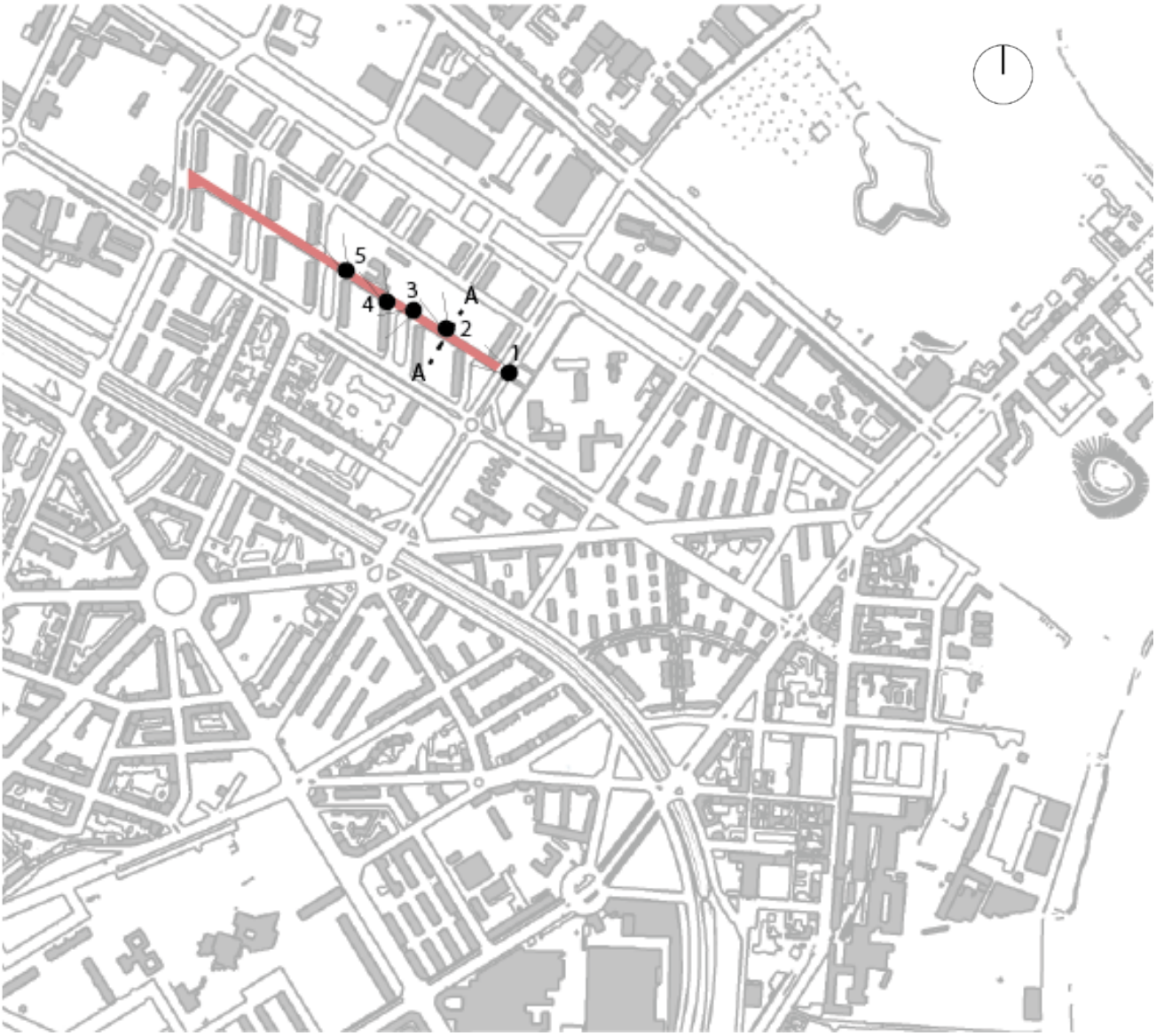
Photograph 3

Photograph 4

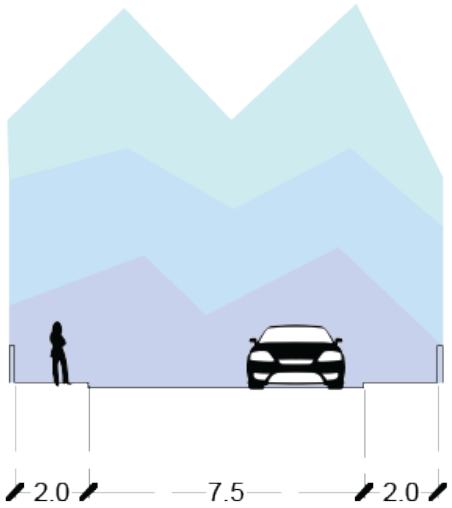
Existing Roads

Via Lorenzo Perosi

This road connects the main roads to the smaller streets in between buildings. It hosts the high-rise colony in the site.



Section AA



Photograph 1

Photograph 2

Photograph 3

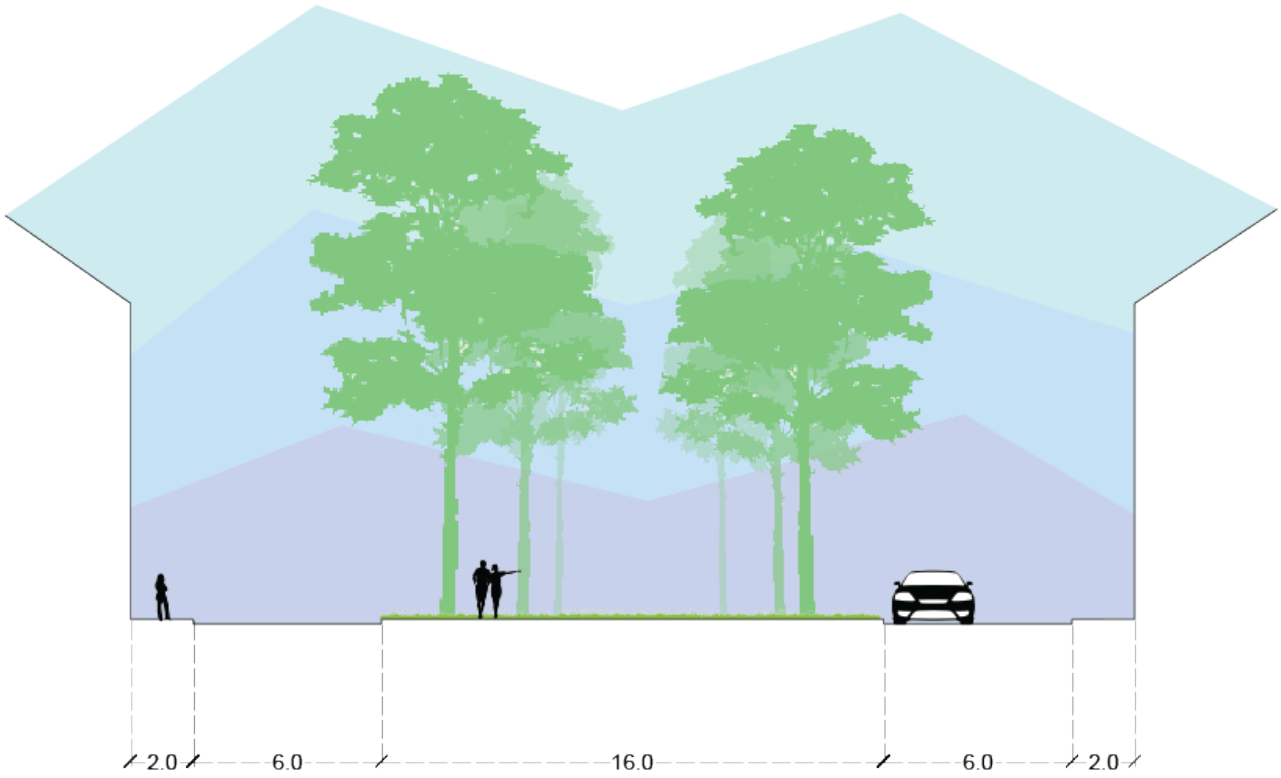
Photograph 4

Photograph 5

Existing Roads

Via Francesco Celia

This is the street road in the Highrise region of the site. It has a small park in between but is mostly used for parking.



Section AA

Photograph 1

Photograph 2

Photograph 3

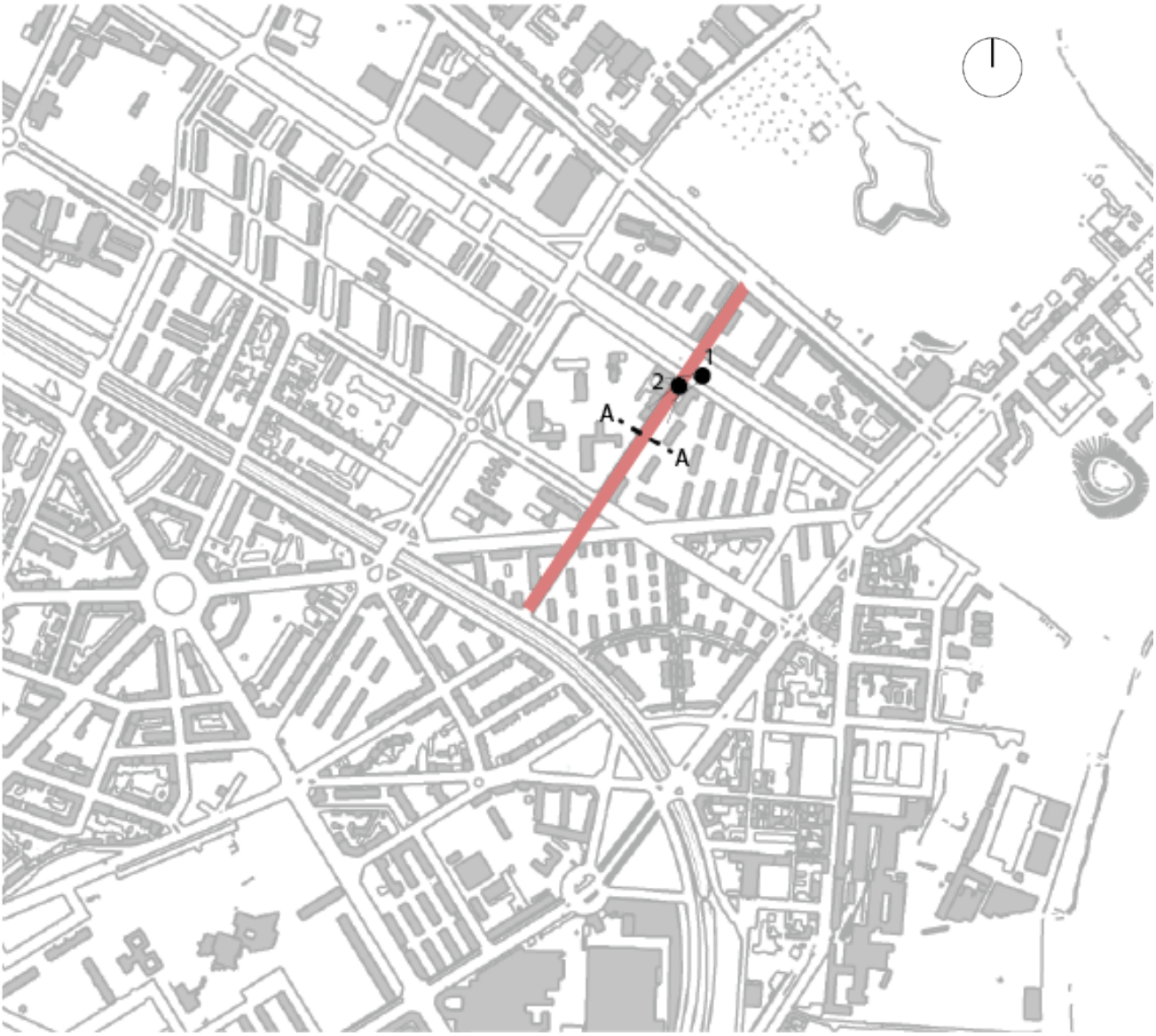
Photograph 4

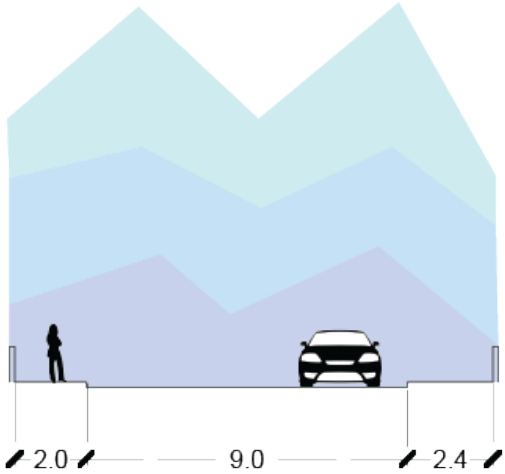
Photograph 5

Existing Roads

Via Giovenale Anacia

This is the road behind the rural Village. It is also mostly used for parking.





Section AA

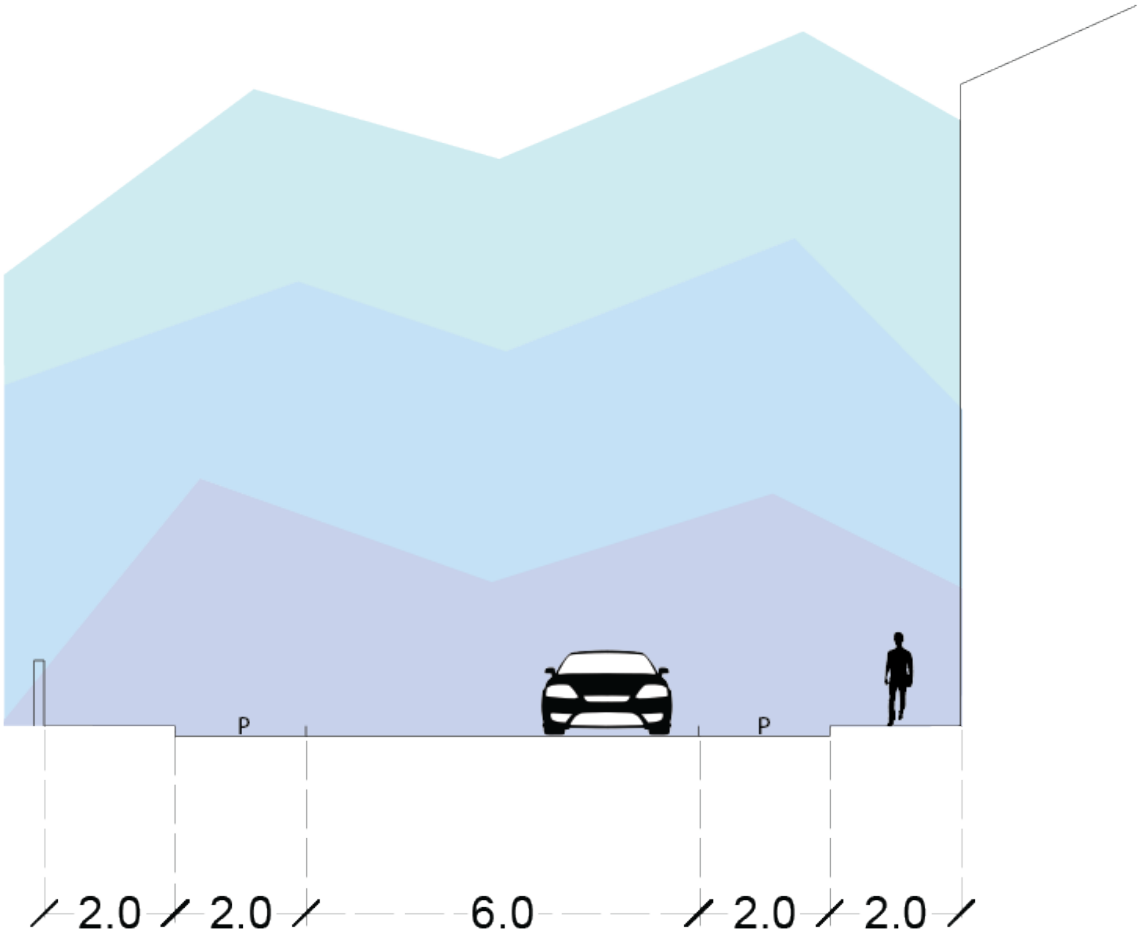
Photograph 1

Photograph 2

Existing Roads

Via Errico Petrella

This is kind of like the continuation to the Via Giovenale Anacia across the Trench. It is also mostly used for parking.



Section AA

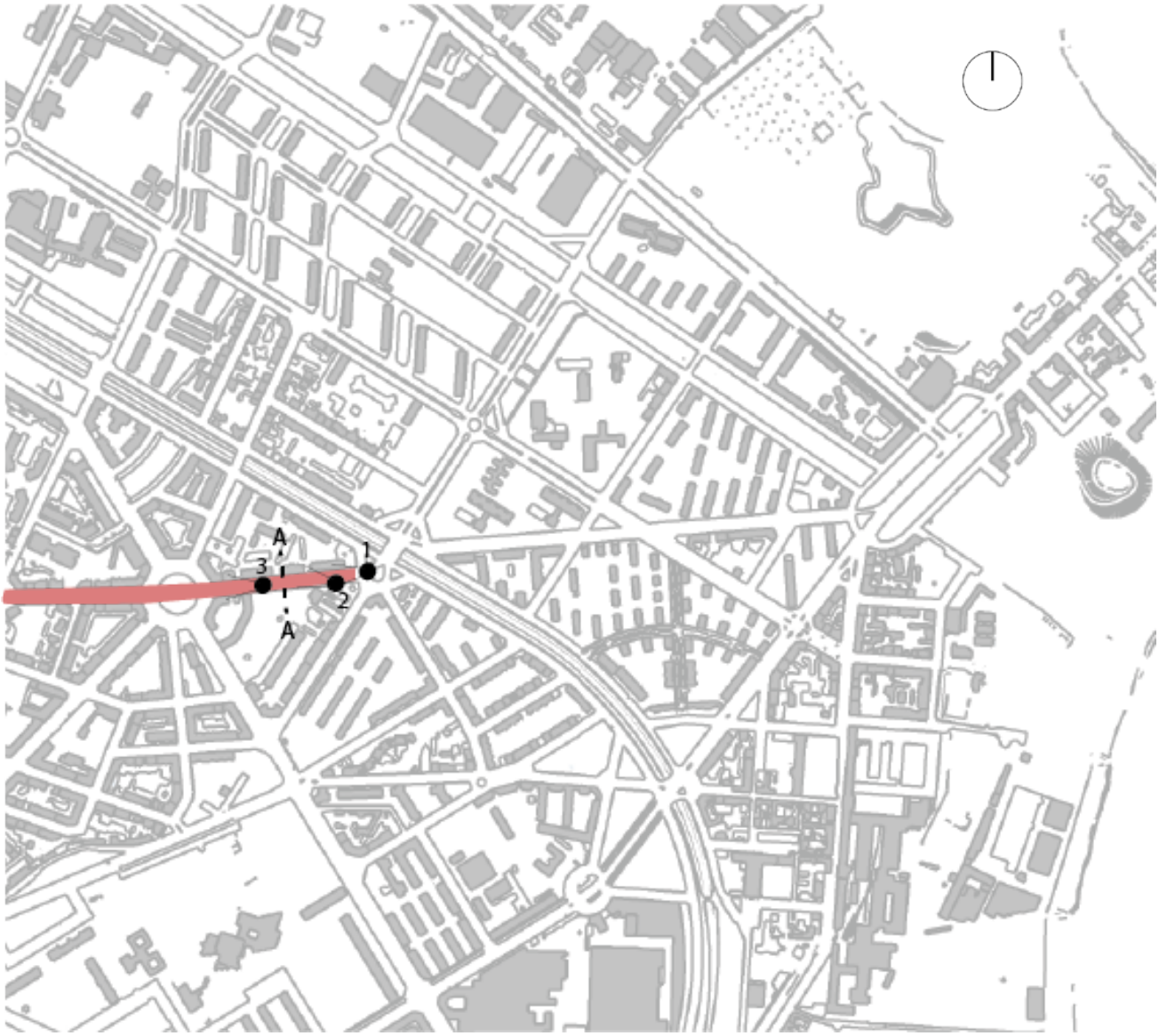
Photograph 1

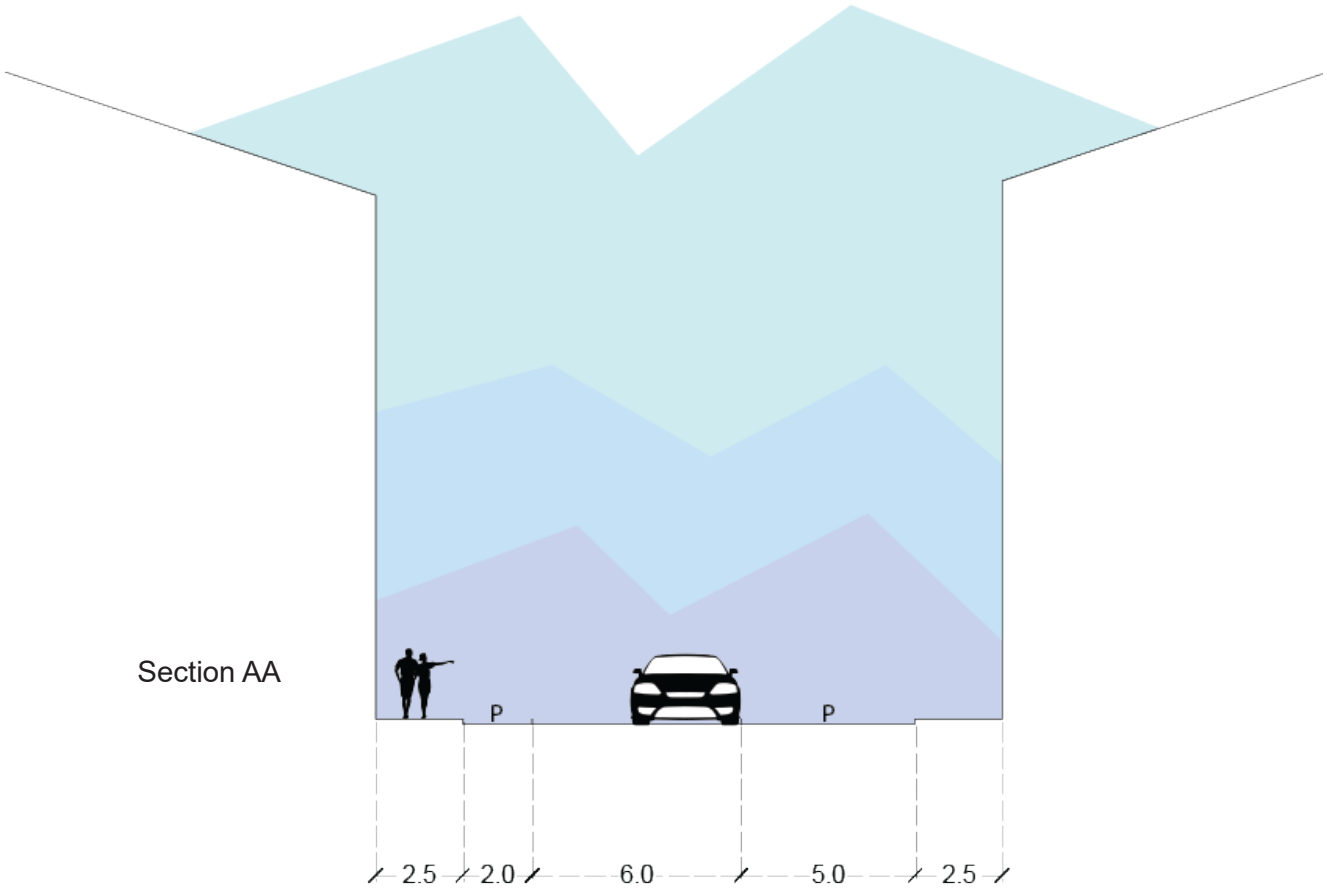
Photograph 2

Existing Roads

Via Luigi Salvatore Cherubini

This road is generally used for parking and is one of the streets with two lane parking. It has a small park attached to it.





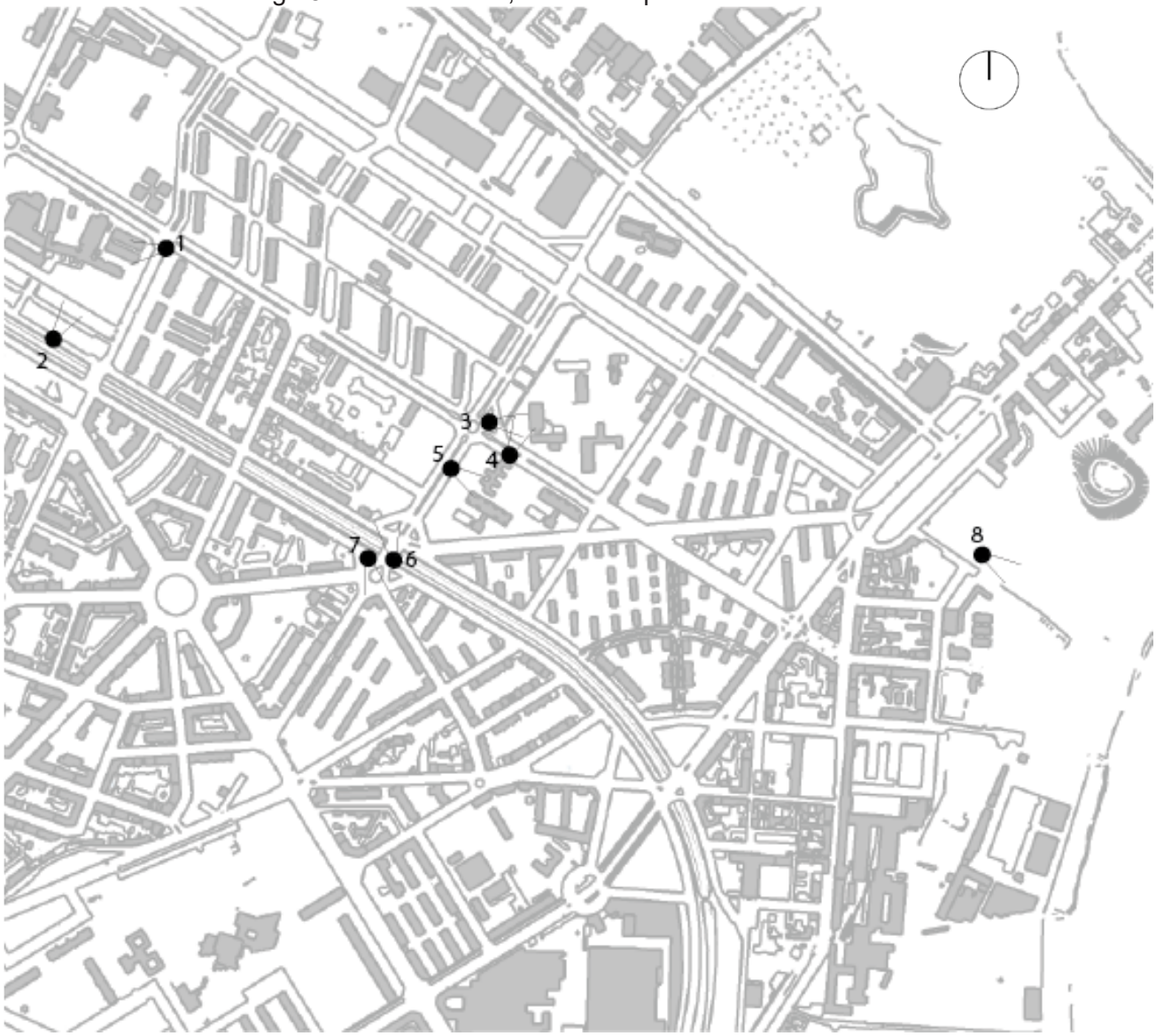
Photograph 1

Photograph 2

Photograph 3

Other Images Around the Site

The other major landmarks around the site, are shown in the images below. The images 1 and 2 are of the Ospadale San Giovanni Bosco, the ones in 3,4 and 5 are of the school and the pictures 6 and 7 show the area of the new metro station. The final image 8 is near the river, where the park starts.



Photograph 1

Photograph 2

Photograph 3

Photograph 4

Photograph 5

Photograph 6

Photograph 7

Photograph 8

Design

8.1 *Vision, Objectives and Guidelines*

Following the identification of the areas with the worst microclimatic performance, we move on to establish a design vision that sets itself the goal of increasing urban thermal comfort through a combination of adaptation and mitigation efforts. The rehabilitation of public space is thought to be within the purview of environmental design, as it is primarily responsible for mitigating the urban heat island and determining how a city can react to increasingly unpredictable events.

As a result, the intervention aims to intervene by mending the city, which has been cut in half for a long time by railway grounds, shortening distances, promoting a “city of 15 minutes,” and encouraging sustainable mobility through green areas, cycle paths, and lanes reserved for public transportation. Reduced traffic and improved pedestrian conditions, as well as the inclusion of cyclists, can help to foster social cohesion. Cleaner fuels for transportation and energy production can also help to minimize local pollution, which disproportionately affects the poorest members of society. In reality, research suggests that children who live near green spaces are less stressed, have less social problems, and have a stronger feeling of personal worth. Green spaces encourage social contact and improve one’s overall well-being. These are some of the reasons why you want to create a “Green corridor” with various functions throughout its length, as well as the task of reducing the local urban microclimate. This reimagined urban length will be a methodical approach that is repeatable and scalable, as well as a starting point for improving green and blue infrastructure while avoiding yet another asphalted road part that is unusable and in need of redevelopment.

The design process begins with the identification of significant concerns relating to the intervention area, as determined by the previous study. These criticalities are crucial in laying the groundwork for achieving environmental improvement goals. The following five goals have been established: to improve the usability of urban greenery by diversifying functions; to enhance sustainable mobility; to promote “the city of 15 minutes” by increasing accessibility to various services and their connections; to connect the area with the center city, river,

and parks; and to mitigate the urban microclimate. These goals, in turn, serve as the foundation for developing strategies for implementing urban improvements and achieving the predetermined goal. Although the tactics are typically interchangeable and cause several changes, they have been classified by perspective. In addition, certain axonometric schemes combine them and make them more accessible. A Masterplan intervention will be used to collect the overarching design vision and will outline the numerous alterations that will be accomplished. In addition, an axonometry of the region will demonstrate a new way of thinking about the city's section, using the same process representation that was previously utilized for the analysis of the individual lots. The use of point views will then be used to highlight the many techniques that have been applied and to better comprehend the design vision.

The main objectives of the design are

1. Enhance Sustainable Mobility.

2. Promote "15-Minute City" concept.

3. Improve the usability of Urban Greens.

4. Control the Urban Microclimate.

Guidelines

Based on the above analysis, we establish a few guidelines for the design that will regulate it to achieve our vision. We are going to focus on some of the below points for this design.

1. We have observed that our region is filled with wide roads but most of it is used for parking. We have to re-purpose this space and use it for providing better infrastructure for pedestrians and cyclists to promote soft mobility.

2. There are a lot of under used green spaces which can be transformed into sports fields or playgrounds.

3. Priority lanes to be given to the public transport vehicles on the roads that they are running for example the Corso Taranto.

4. Insertion of cycle paths on the appropriate roads which connect the existing city cycle path.

5. Creation of public spaces for people, rather than connection between two points.

6. Development of the new Metro Stop in the site, into a hub for multiple modes and pertaining some commercial zones for the enhancement of the concept of 15-minute City.

7. Improving the access of micro-mobility rentals in the site, to reduce the usage of cars.

8. Developing the trench into a green-blue ecological infrastructure through nature based solutions.

9. Introduction of a swale system to collect storm water and refilling the water table but also working as a preventive measure against urban flooding.

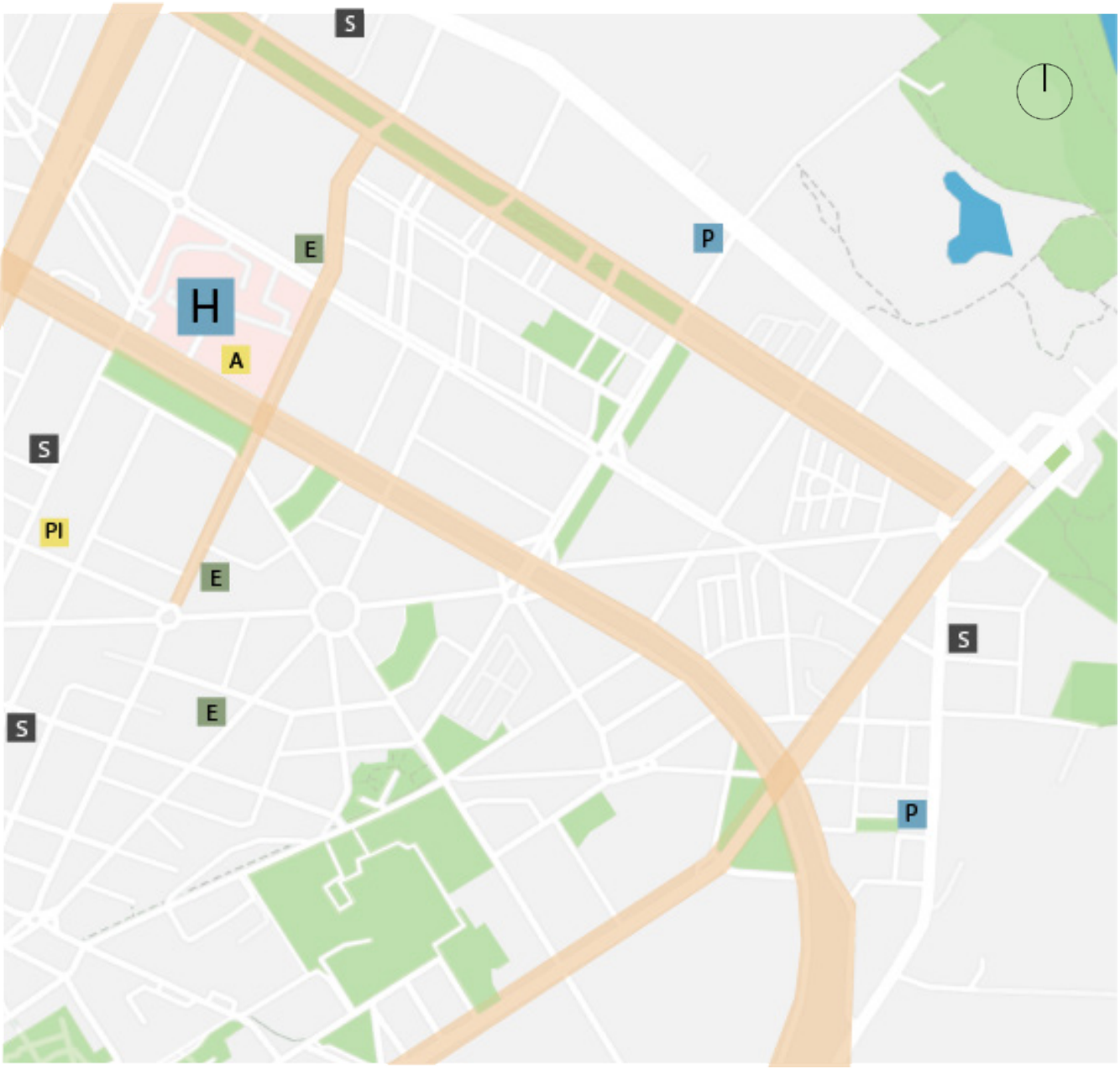
8.2
Roads

Road Architypes

The road architypes and layouts have been reworked to provide a better condition for people to experience the area, while following the guidelines. We have introduced swales to many of the roads and have created major architypes in the roads. The architypes include

1. Bus Route Roads
2. Cyclying Matrix Roads
3. Parking Inroads.

Map 6. Existing Condition



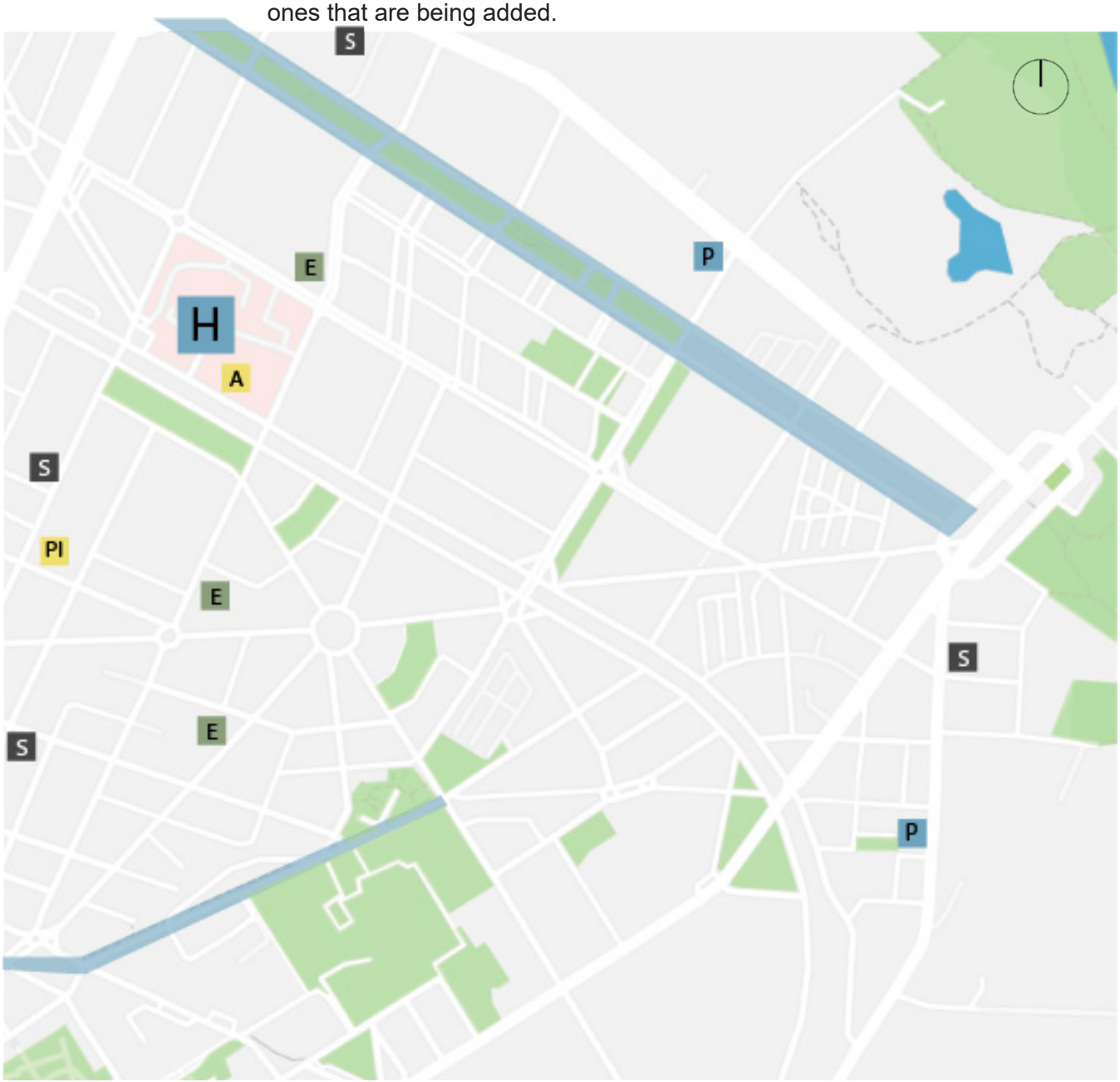
Map 7. Designed Bus Route Roads

Bus Route Roads

As the name suggests, the roads consist a separate lane for public transport. We have rerouted some of the buses and made a few adjustments to improve the quality of public transport and the lane systems.

Cycle Matrix Roads

As the name suggests, the roads consist a separate lane for bicycles. These are connected to the existing lanes while creating the new lanes to give comfortable continuous flows. Map 1 shows existing and Map 2 shows the new ones that are being added.



Map 8. Existing Cycle Routes

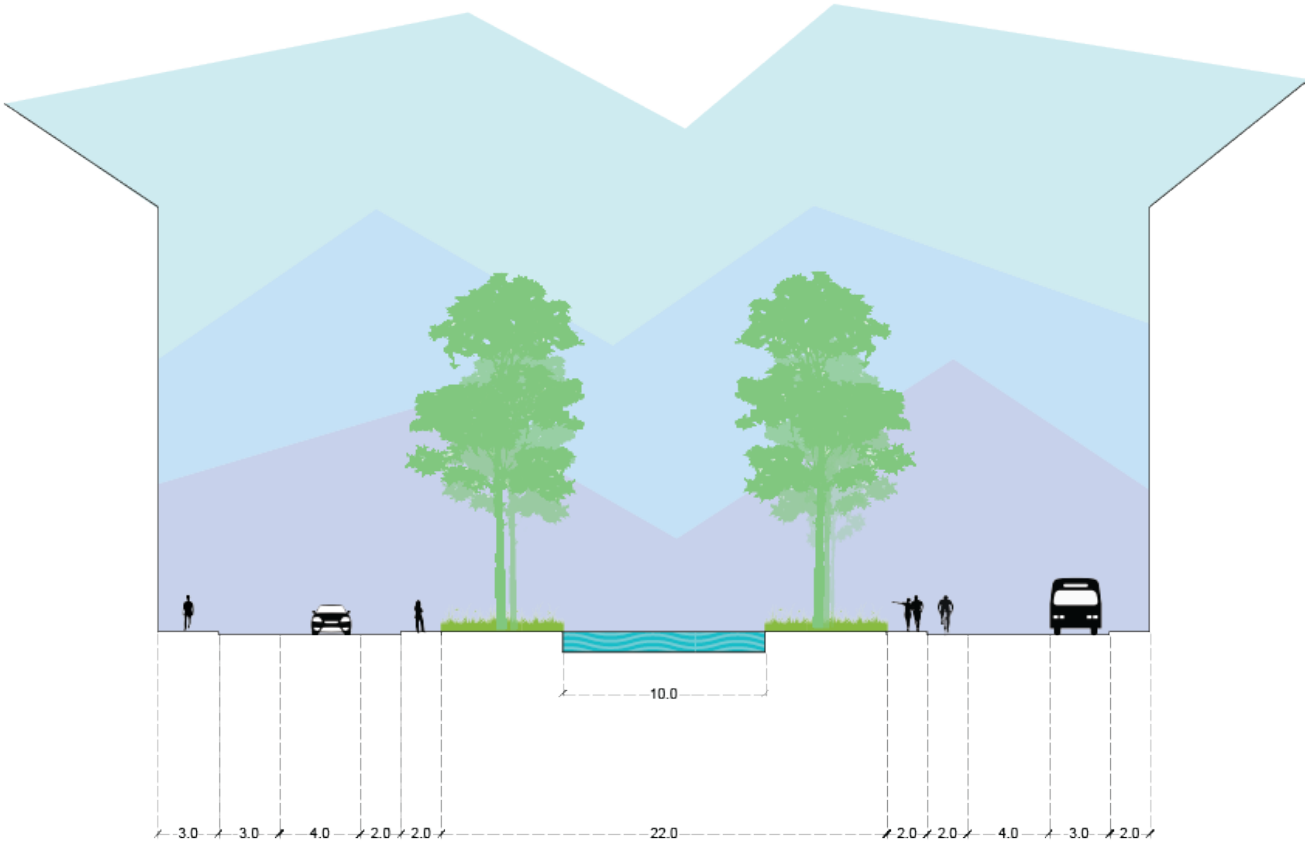
Map 9. Designed Cycle Routes

Parking Inroads

Many of the roads in the site are being changed in a way, where on street parking is being removed. So, a few of the inner roads are getting dedicated parking, so that the residents don't have to go far to park their cars.

Via Gottardo – Via Sempione

In the following, we demonstrate the designed section and the changed percentages of road use, through our design.



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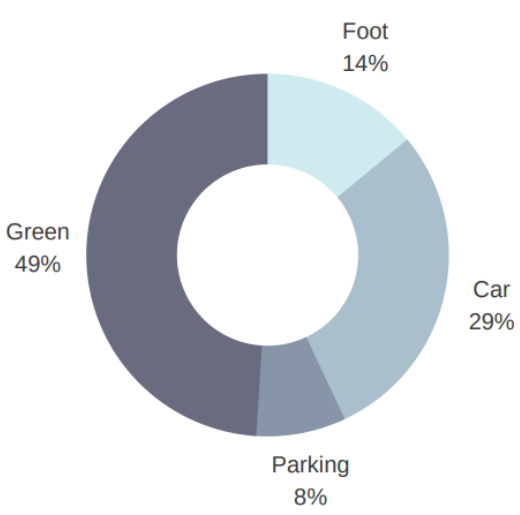

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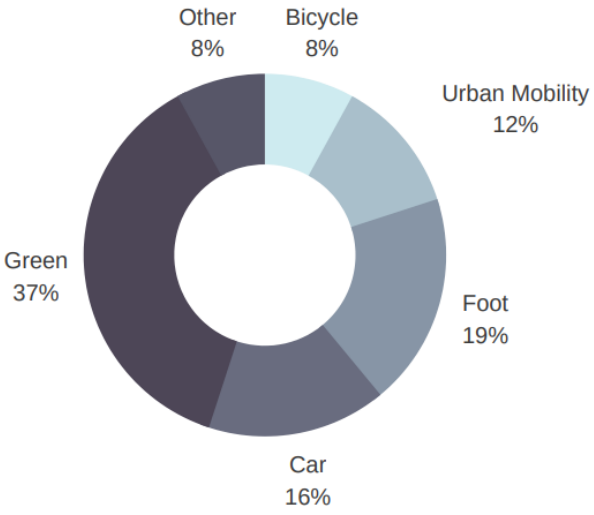

Updated

Corso Taranto

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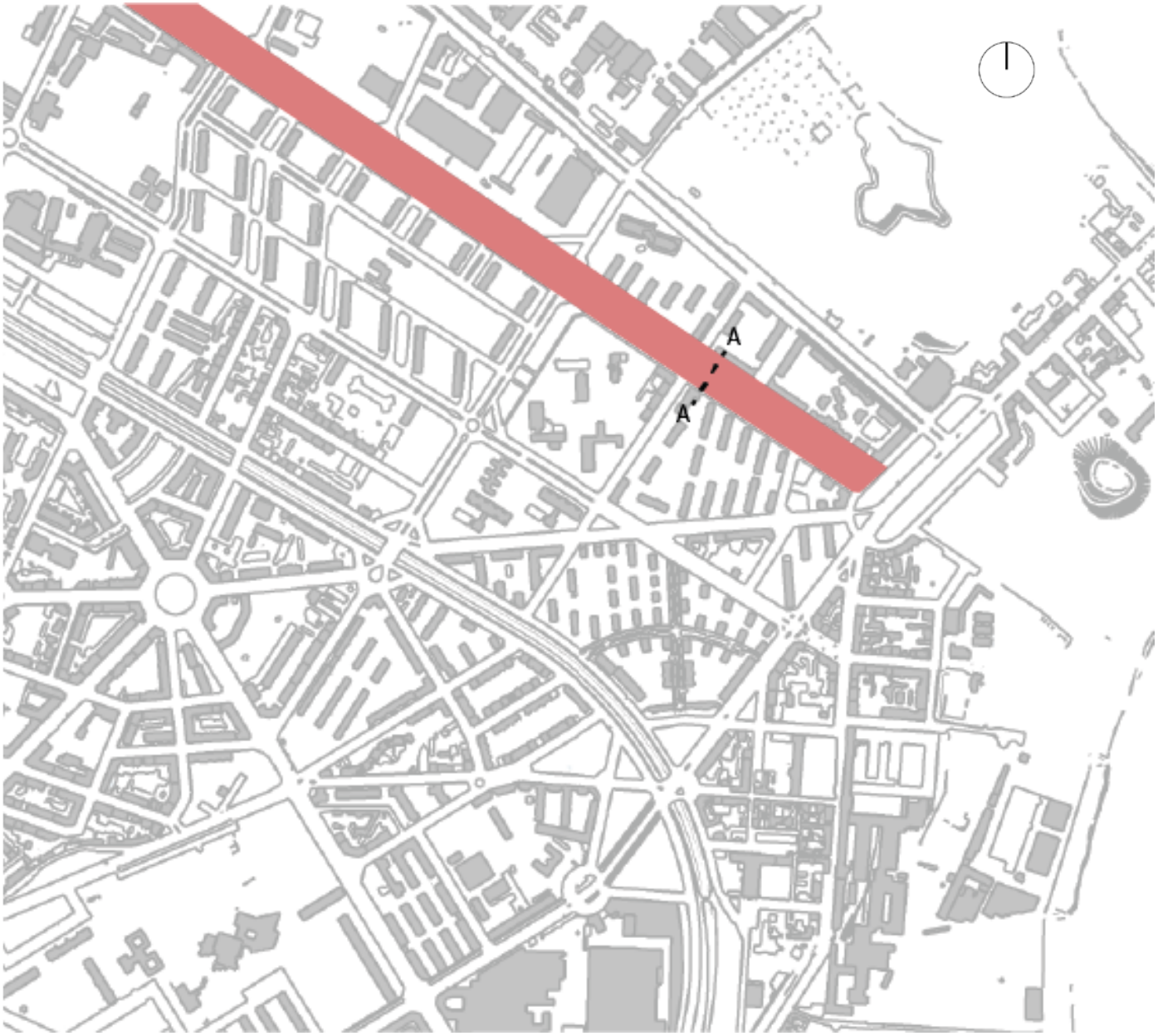

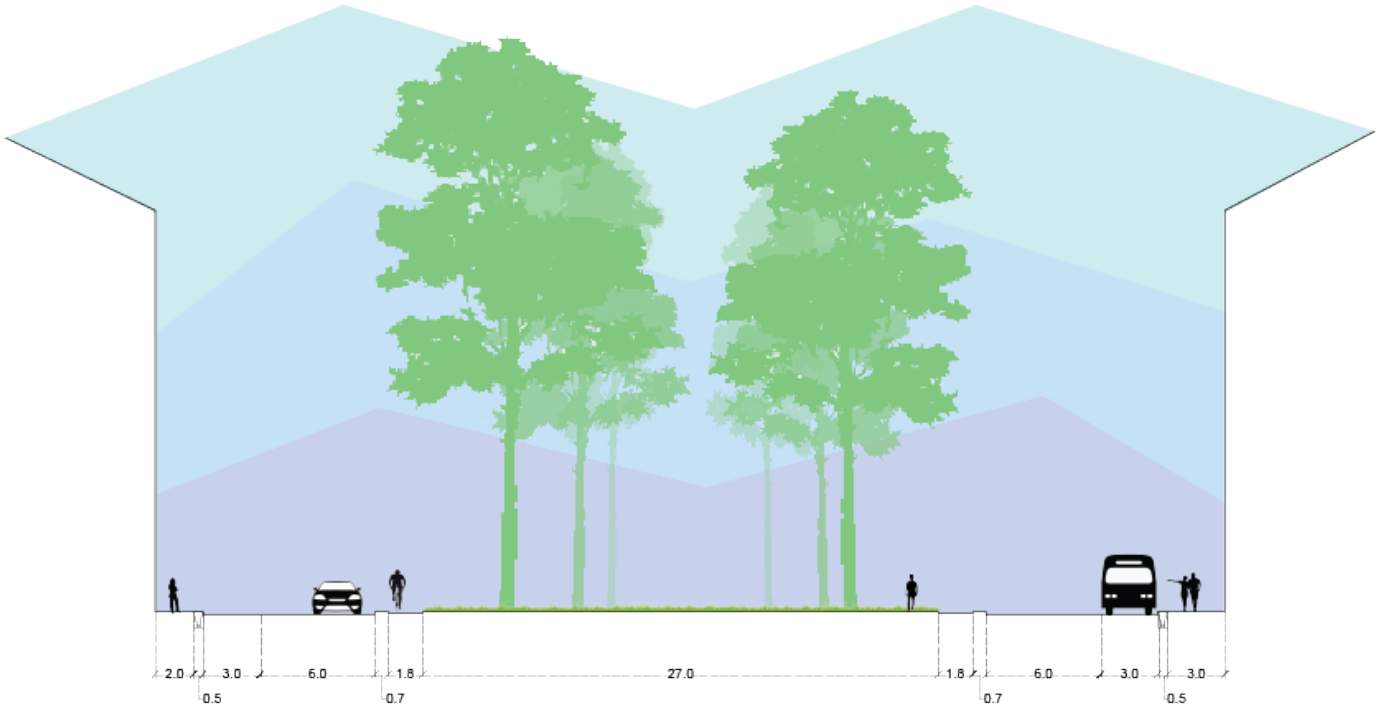

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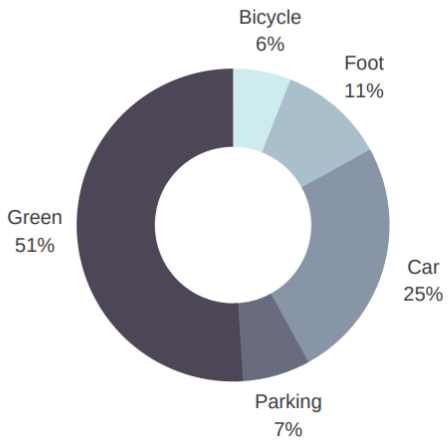

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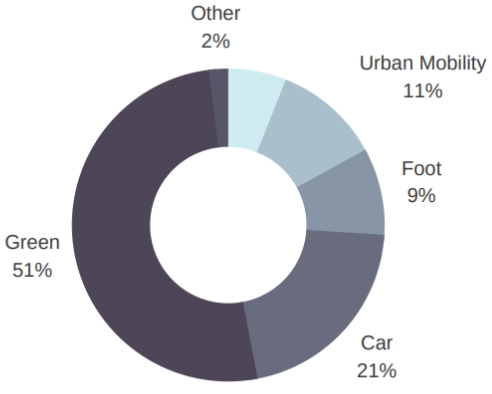

Updated

Via Bologna

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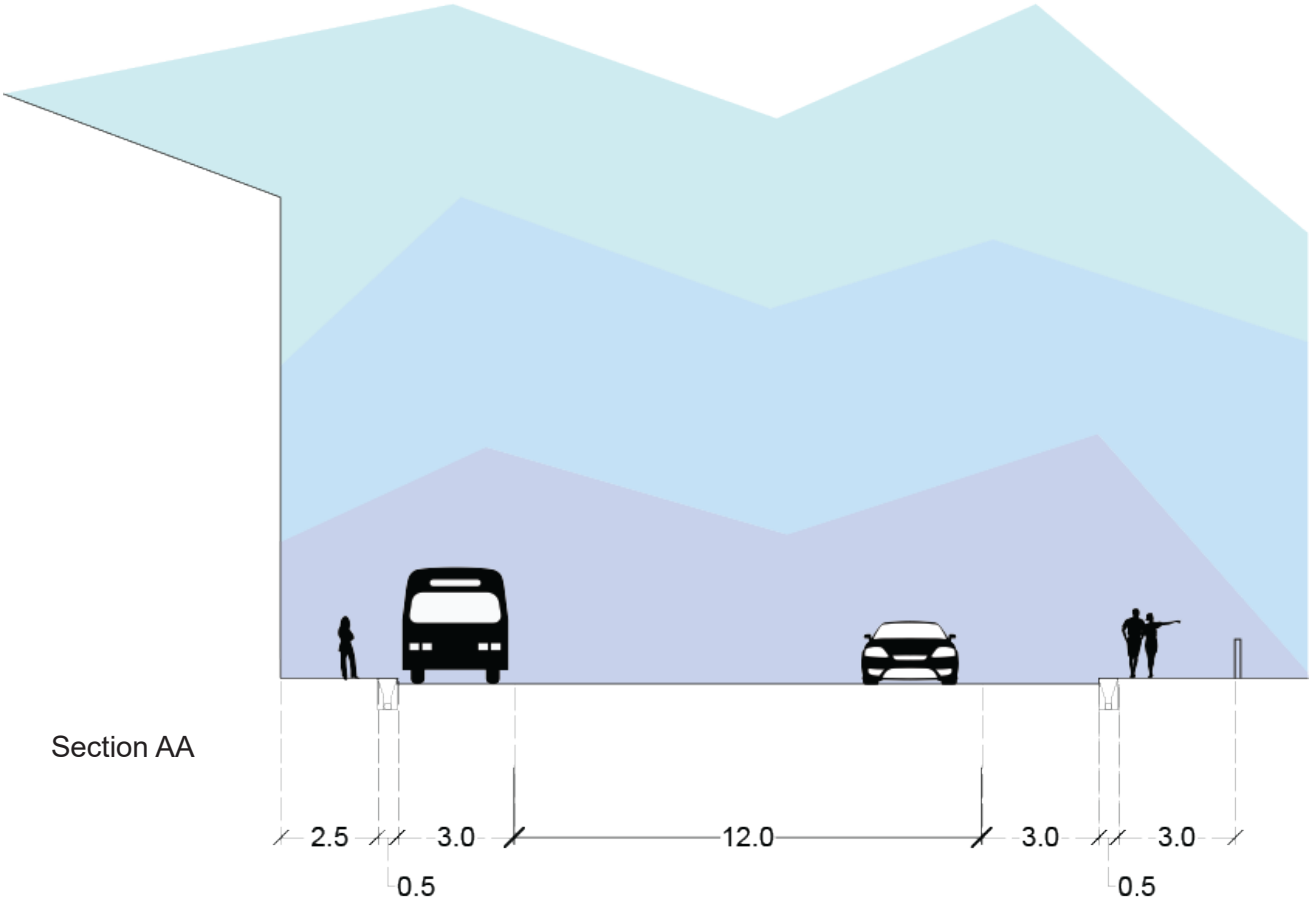

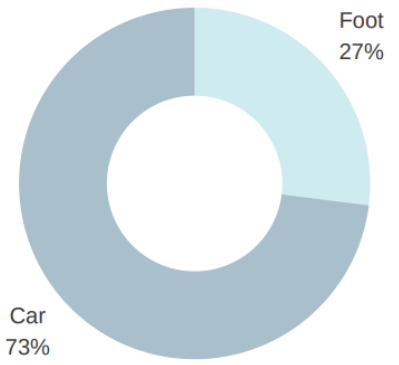

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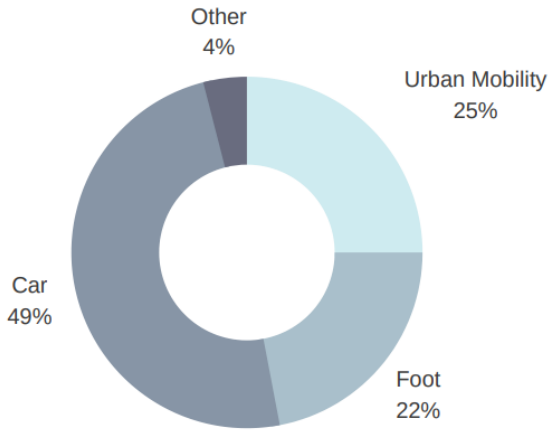

Updated

Via Giambattista Pergolesi

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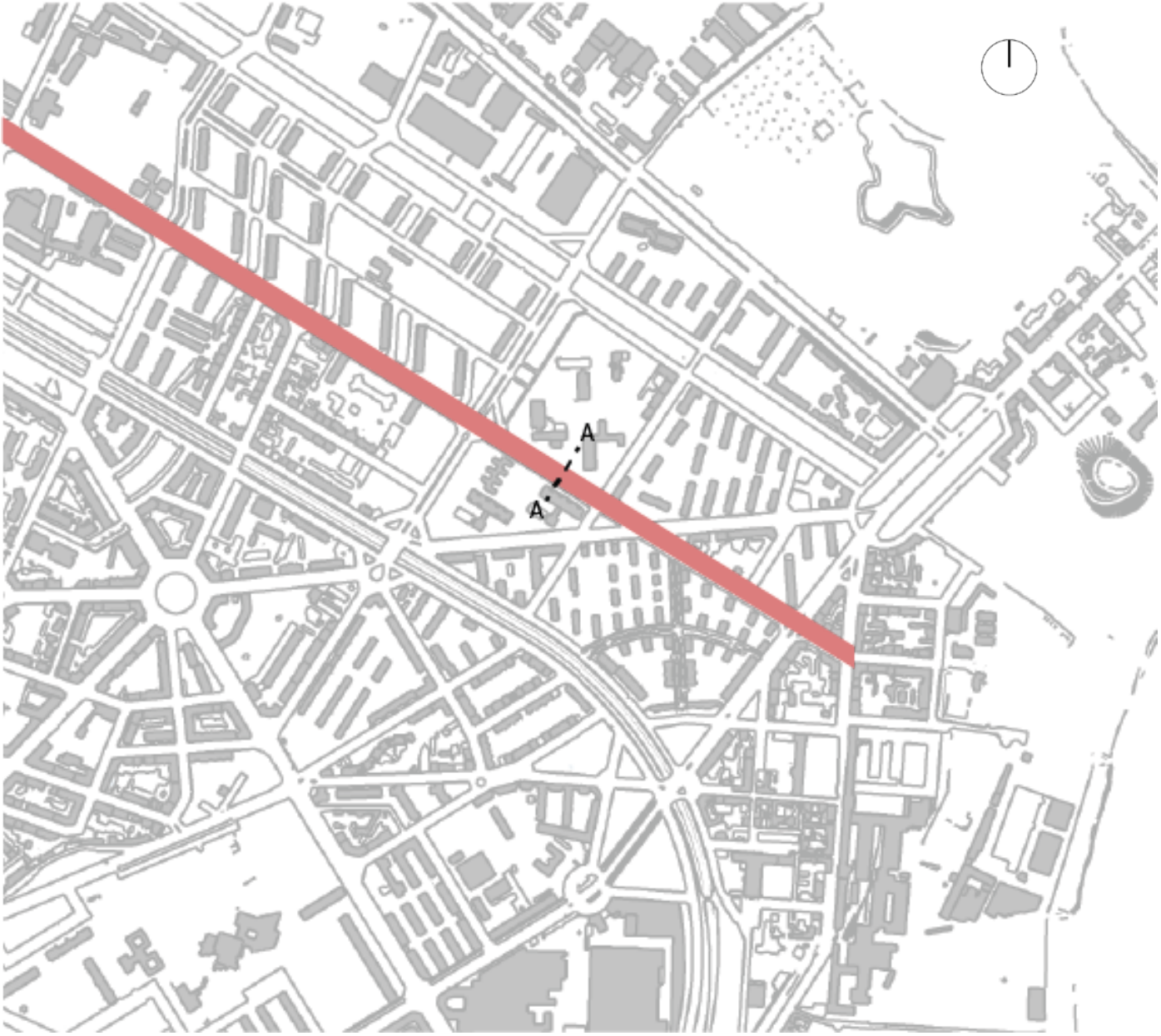

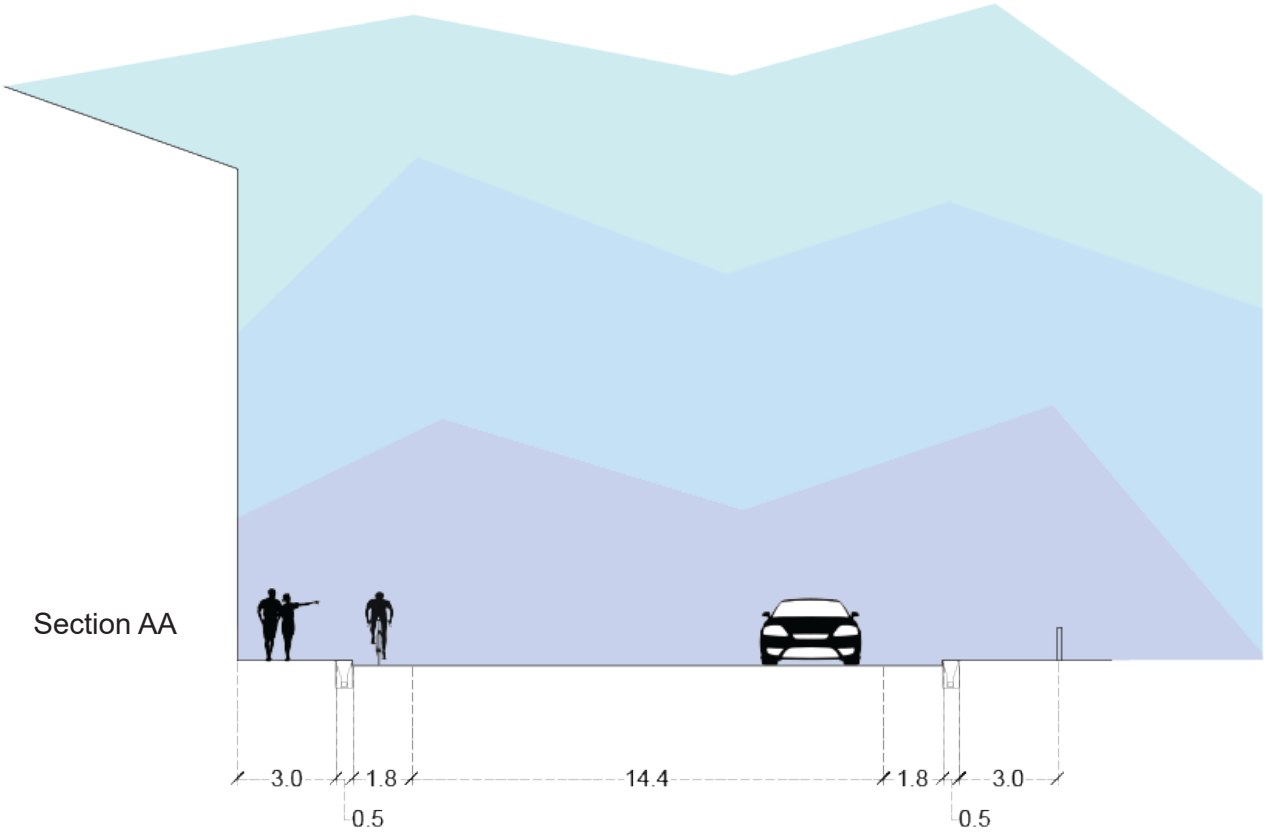

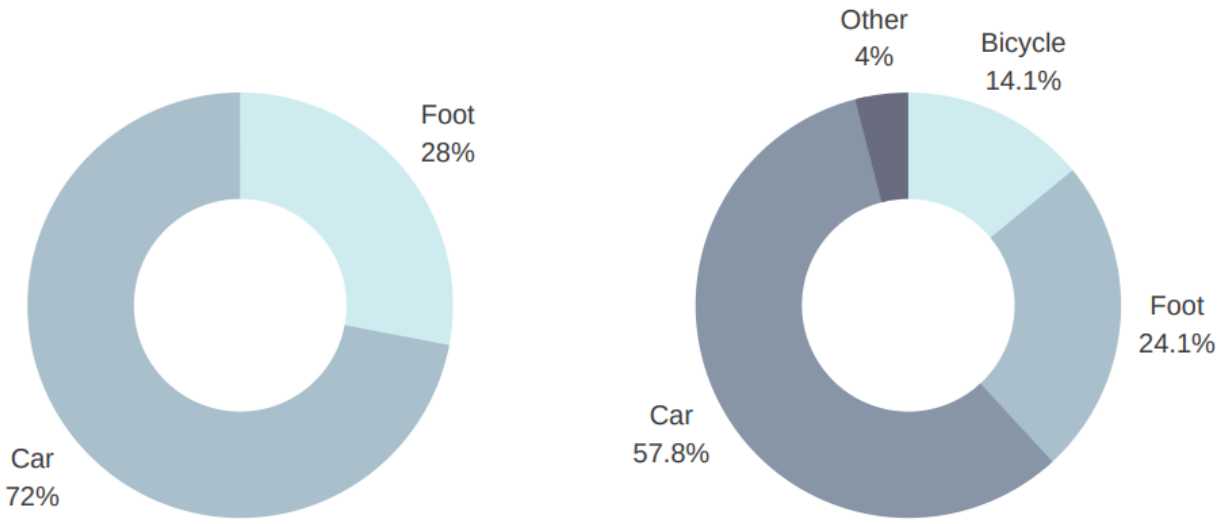

Existing

Updated

Via Sandro Botticelli

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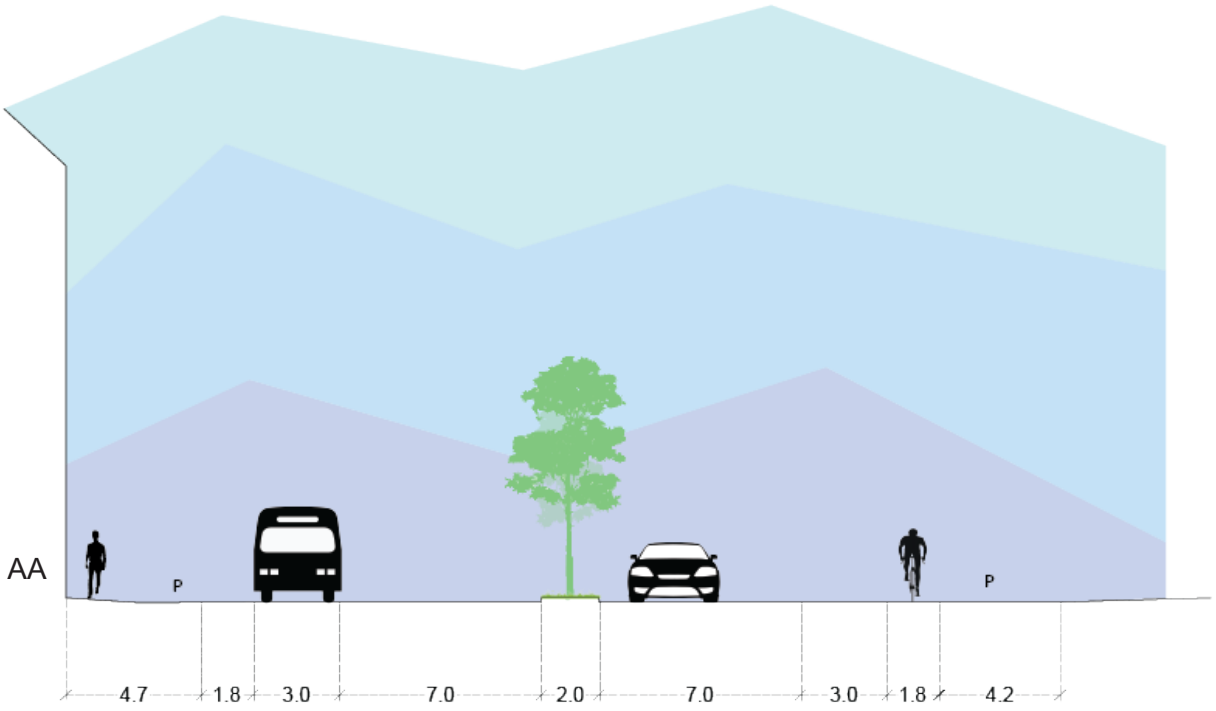

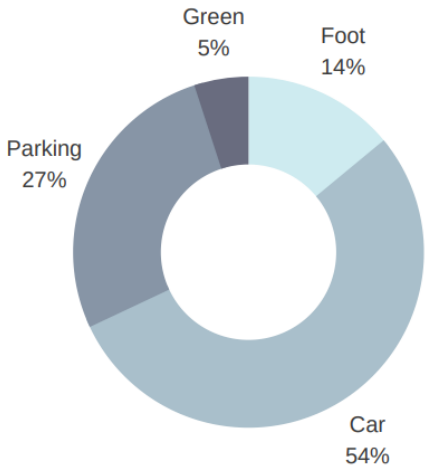

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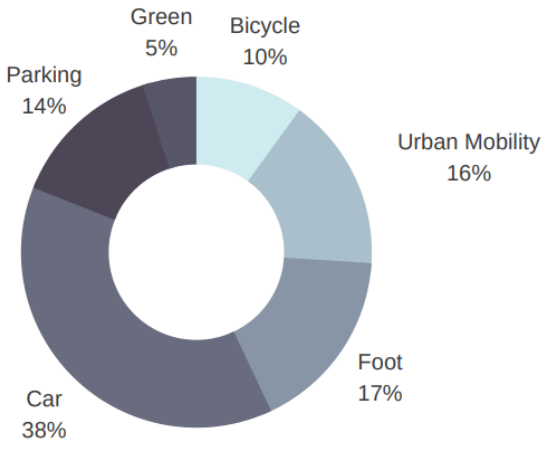

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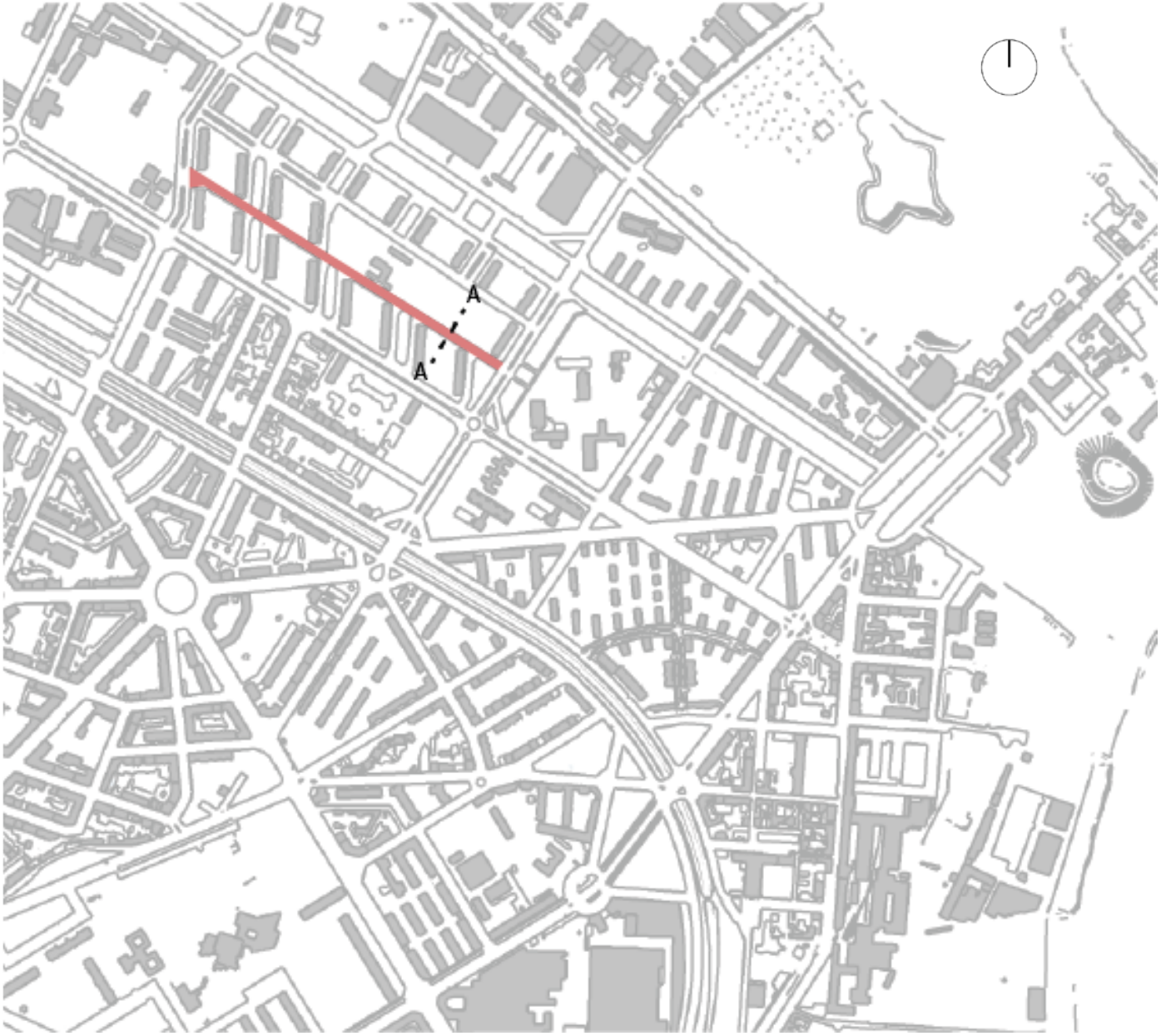

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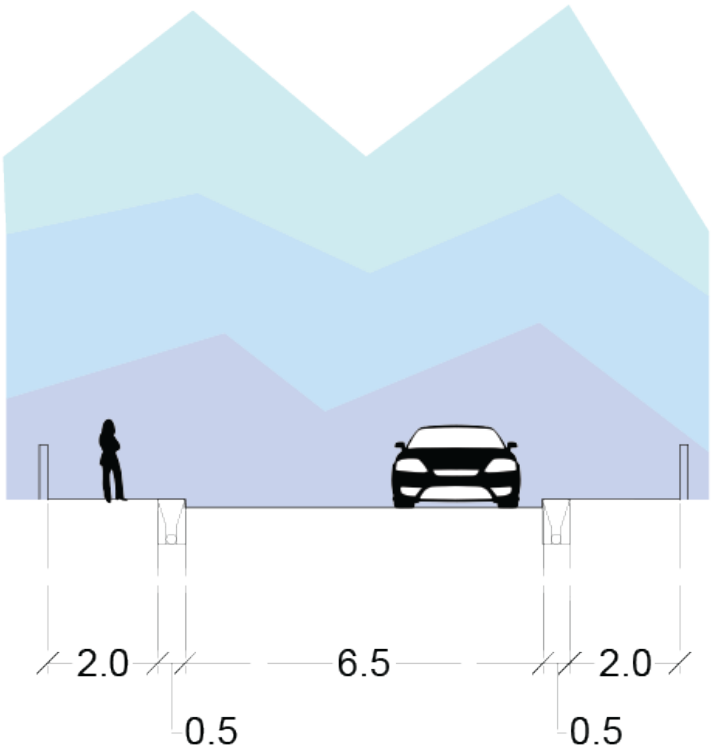

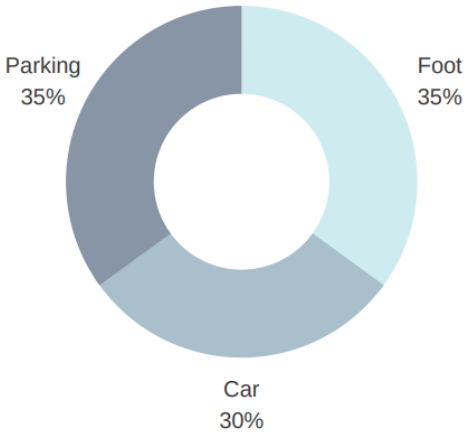

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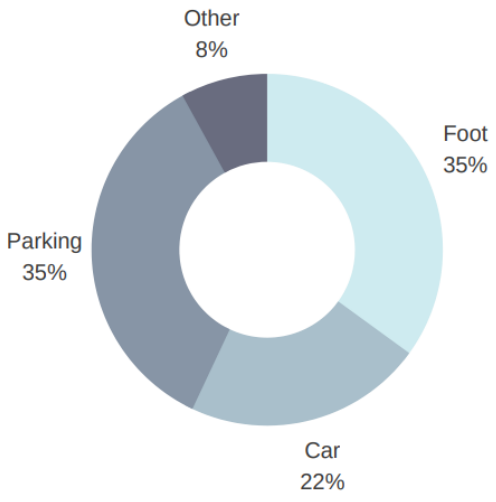

Updated

Via Francesco Celia

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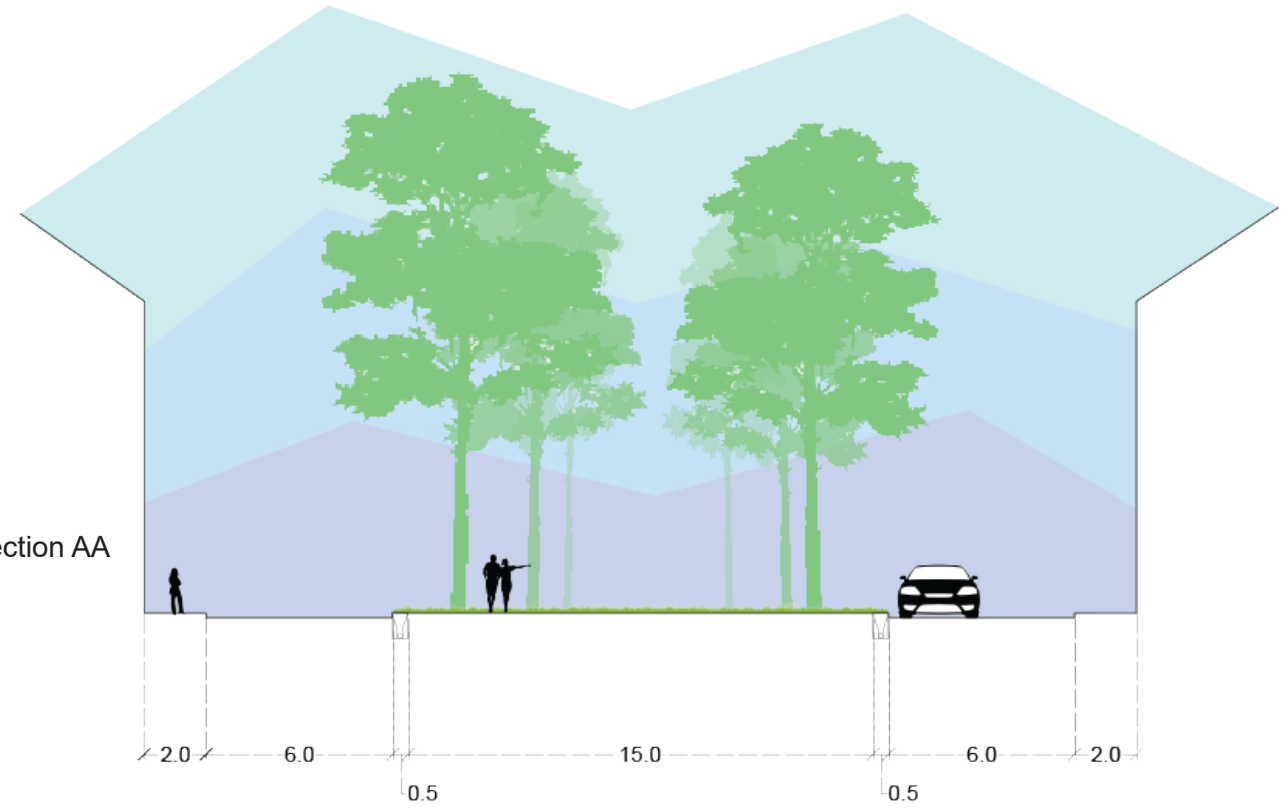

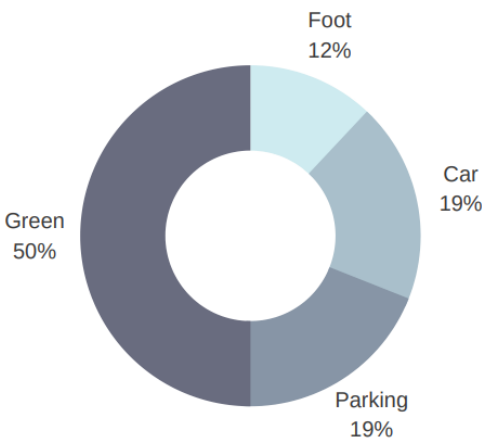

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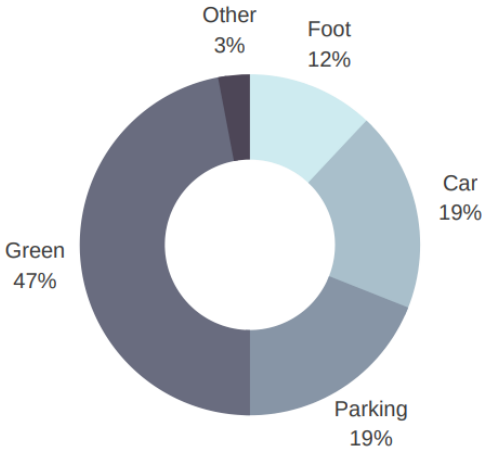

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Via Giovenale Ancina

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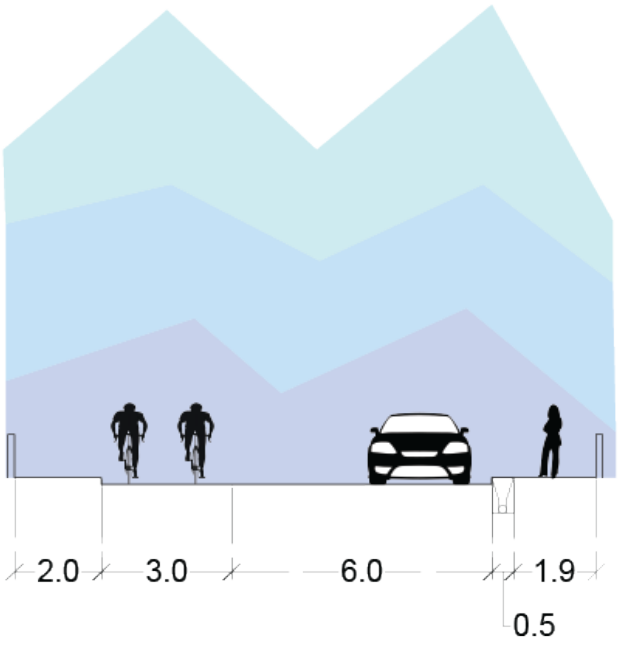

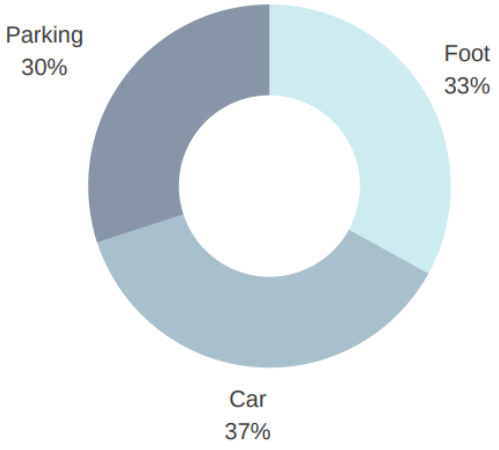

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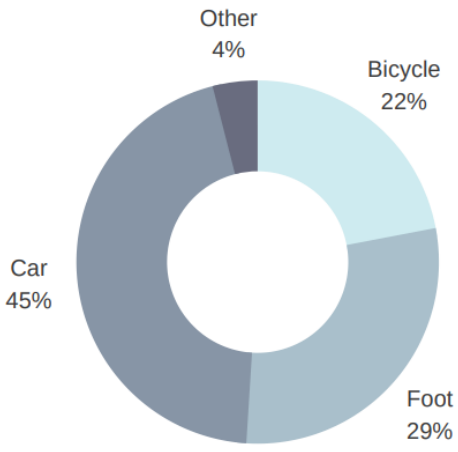

Updated

Via Errico Petrella

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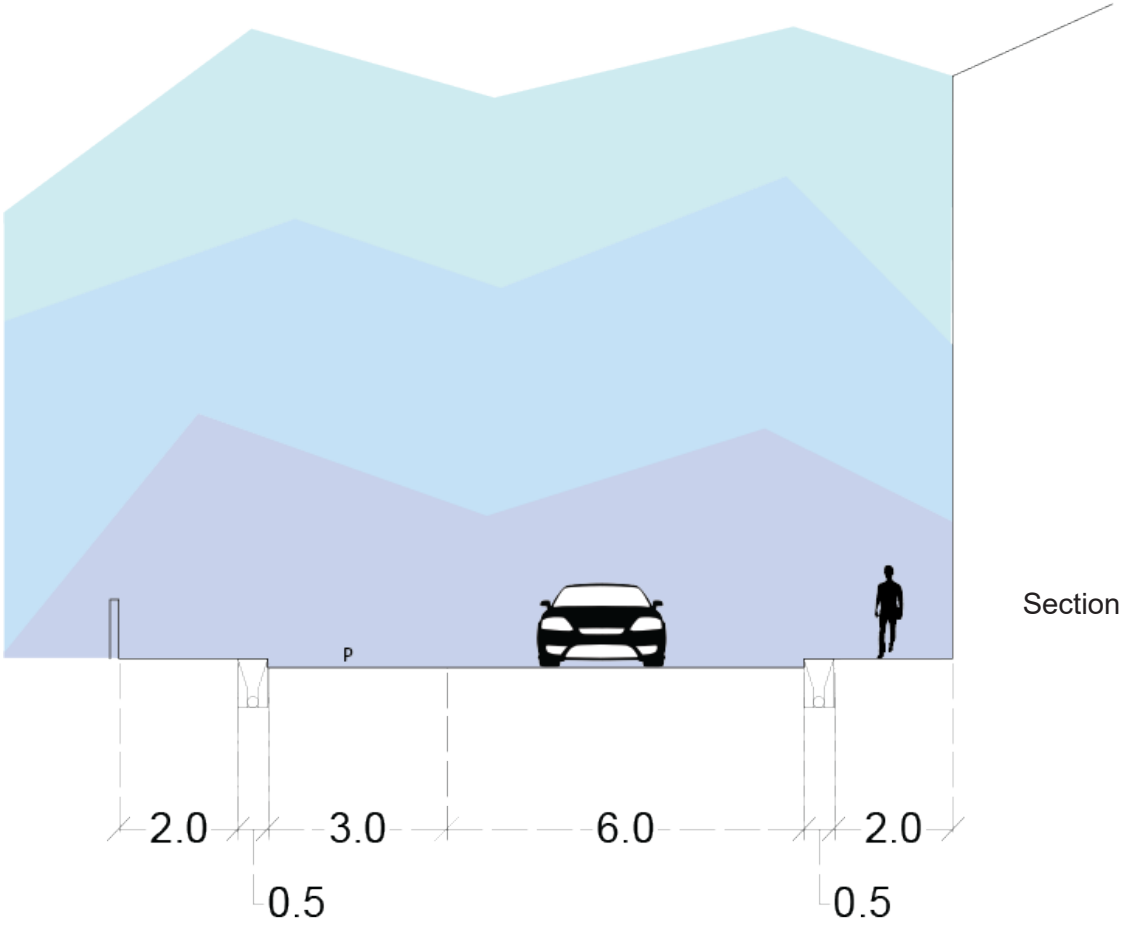

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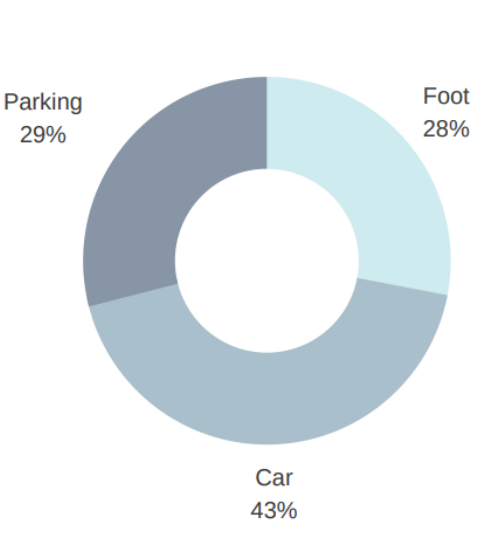

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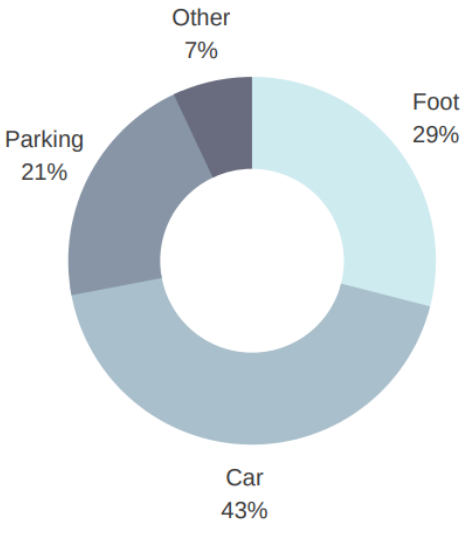

Updated

Via Luigi Salvatore Cherubini

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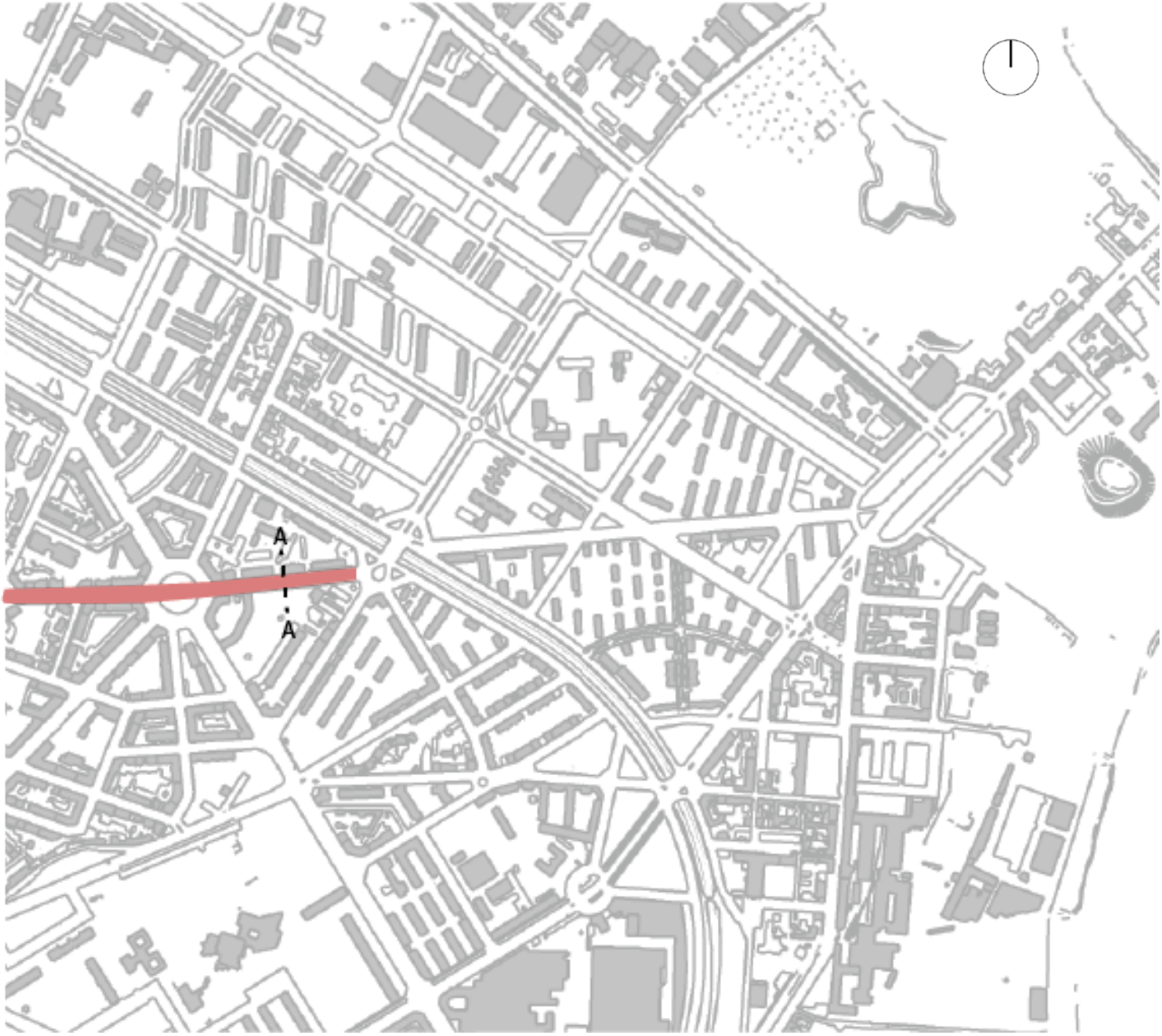

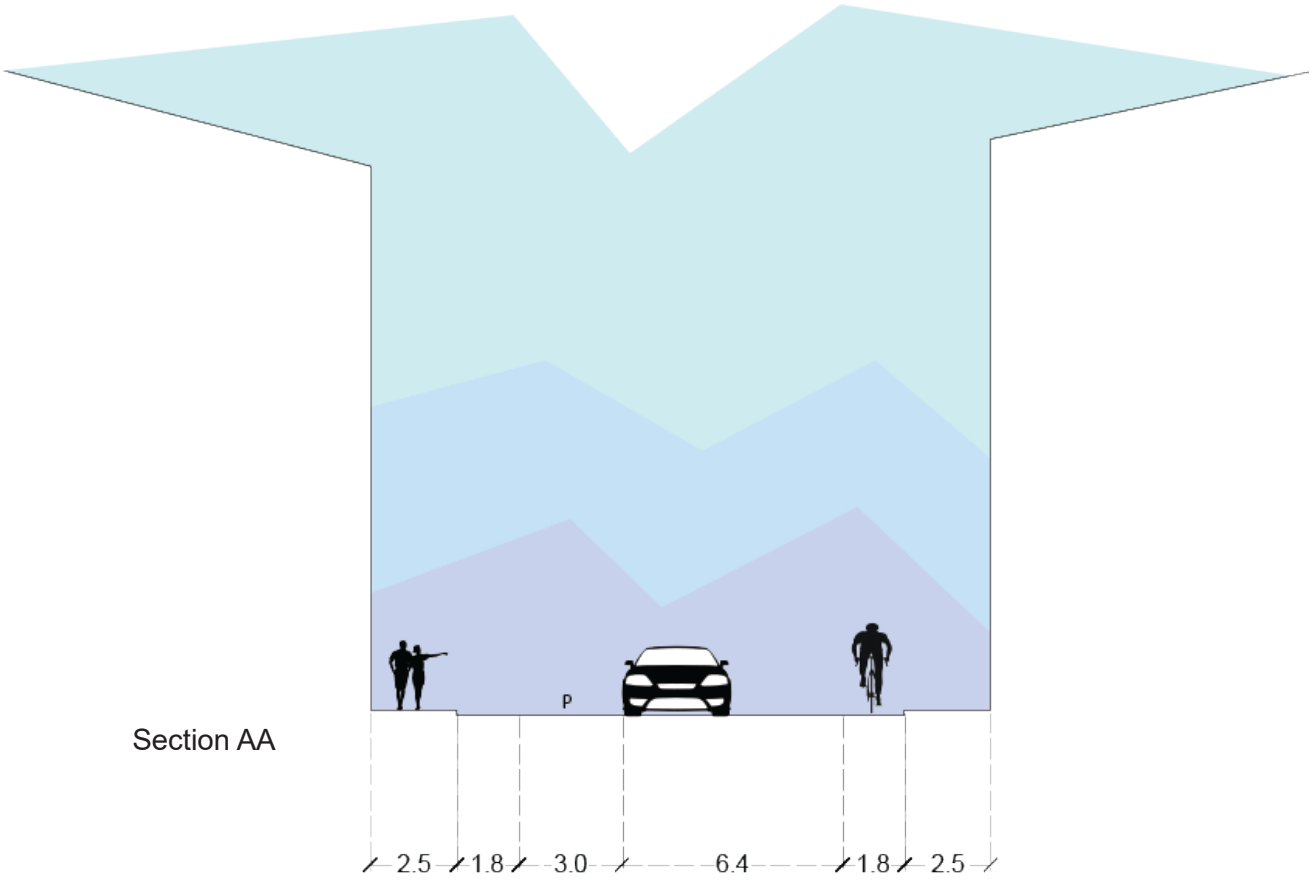

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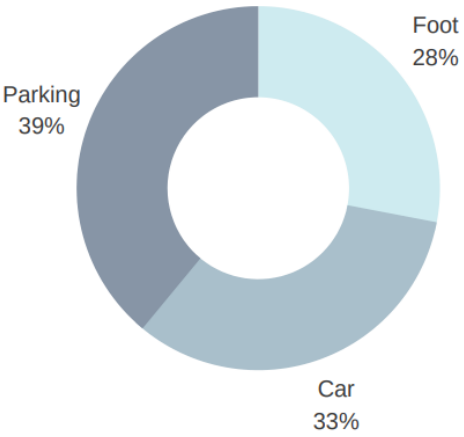

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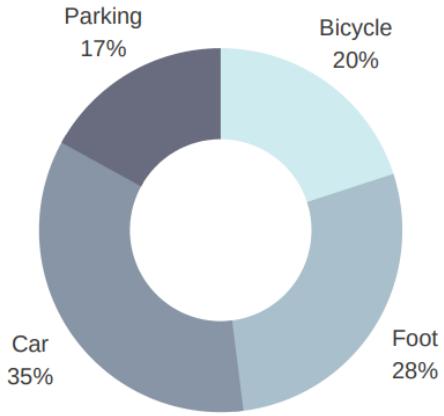

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8.3
Before - After

Via Gottardo - Via Sempione

Image Source: Google Maps

Corso Taranto

Image Source: Google Maps

Via Bologna

Image Source: Google Maps

Via Giambattista Pergolesi

Image Source: Google Maps

Via Sandro Botticelli

Image Source: Google Maps

Via Lorenzo Perosi

Image Source: Google Maps

Via Francesco Celia

Image Source: Google Maps

Via Giovenale Ancina

Image Source: Google Maps

Via Errico Petrella

Image Source: Google Maps

Via Luigi Salvatore Cherubini

Image Source: Google Maps

9
Conclusion and Way Forward

The purpose of this thesis is to analyze the Urban Mobility Concept and its effects on a city. The research began by understanding what mobility is and how it is affecting the different points of sustainability. We went through different mobility options that can help us mitigate the effects. Some of these options include public transportation, soft mobility, and even electric mobility. We have observed that we can influence the choice of people using Architecture. As a result, quality of life in neighborhoods can be improved, hence resulting in happier, sustainable, flourishing cities and communities.

The concept of 15 min city is an approach which can give out amazing results by strengthening the pillars of sustainability which are Environmental, Economic and Social pillars. We can reduce the energy consumption, if we don't have to move more than a couple of blocks to get all the basic amenities which results in positive environmental effects due to reduction in the consumption of fuels and it also makes it economically sustainable by reducing costs of transportation. It also similarly encourages the social aspect by increasing the communication between people. People are more observant and involved when they walk/cycle when compared to motorized transport. If people need to come out of the neighborhoods, they are provided with well connected public transport systems which in turn enhances the above pillars.

The main limitation to this project is the time frame of change. If it occurs gradually and with time, it gives time to the people and community to turn towards the positive effect. It is done suddenly; it forces people into something which generally results in people going back to their old habits of using cars. That is why we have gone through minor changes in the design to give people the incentive to start towards a sustainable mobility lifestyle. The process can be continued and improved as mentioned in the guidelines to further the concept of Sustainable Urban Mobility. This will also open the spaces for other infrastructure as it wouldn't have to be invested it into wide roads, parking spaces etc. It is similar to the concept of behavior change from the book Atomic Habits by James Clear. Small changes lead to big impact.

The ENVIMET analysis of the region shows us the zones of trouble due to the wind, asphalt, and others. The analysis of the region after the design isn't a part of this study. This study helps us understand the different variations in temperatures and winds in the location. It gave us information on the zones which suffer from heat accumulation and helped us deal with it. This software guides us in deciding the different strategies that can be used and how they affect the region. The analysis of the region after the design isn't a part of this study.

The current roads are quite wide, which have been re-purposed into cycle lanes, bus lanes etc. These can be further changed into pedestrian spaces and green spaces going forward, if people are able to adapt to the new mobility strategies. If we follow the concept we can get from a stage where there are 674 cars per 1000 people in Torino to under 100 cars per 1000 people by 2050. This shows a positive impact on the climate of the city, as re-purposing the roads into green spaces will reduce the amount of asphalt and heat absorbing elements in the city. Adding green and blue infrastructure will help us cool the environment around. This will also help us reduce the Urban Heat Island effect in the region. Also, by the introduction of swale system along the roads, we can collect the storm-water and replenish the underground water table.

If our vision is successful and we are able to reduce the number of cars, we can re-purpose the roads into public spaces cafe, parks, playgrounds etc. This will help us improve the climatic condition in the area and make the place for people rather than a place for cars as it currently is. As mentioned before the change is slow and needs a change in lifestyle of the residents for it to occur.

As mentioned above going forward, the design can be enhanced by re-purposing the roads into green spaces and pedestrian spaces and adding pocket spaces like playgrounds, cafe etc. An example version of the road Via Sandro Botticelli has been given below to show how it can be upgraded. The road can be turned into a place for people which in the grand scheme implies a city for people rather than a city for cars.

Via Sandro Botticelli
HUMANIZED
CITY FOR PEOPLE

10
Bibliography

1. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved January 7, 2022, from https://www.eea.europa.eu/themes/climate

2. United Nations. (n.d.). The 17 goals | sustainable development. United Nations. Retrieved January 7, 2022, from https://sdgs.un.org/goals

3. Mobility - Europa. (n.d.). Retrieved July 10, 2021, from https://webgate.ec.europa.eu/greencitytool/resources/docs/guidance/mobility.pdf

4. Encyclopædia Britannica, inc. (n.d.). Urban Sprawl. Encyclopædia Britannica. Retrieved August 16, 2021, from https://www.britannica.com/explore/savingearth/urban-sprawl

5. National Geographic Society. (2012, October 9). Air Pollution. National Geographic Society. Retrieved August 16, 2021, from https://www.nationalgeographic.org/encyclopedia/air-pollution/

6. National Geographic Society. (2019, July 15). Noise pollution. National Geographic Society. Retrieved August 16, 2021, from https://www.nationalgeographic.org/encyclopedia/noise-pollution/

7. NASA. (2021, August 26). The effects of climate change. NASA. Retrieved September 15, 2021, from https://climate.nasa.gov/effects/

8. Road accidents 2019 en - automobile club d'italia. (n.d.). Retrieved August 20, 2021, from https://www.aci.it/fileadmin/documenti/studi_e_ricerche/dati_statistiche/incidenti/Road_accidents_2019_EN.pdf

9. Anciaes, P. R., Boniface, S., Dhanani, A., Mindell, J. S., & Groce, N. (2016). Urban Transport and Community Severance: Linking Research and policy to link people and places. Journal of Transport & Health, 3(3), 268–277. https://doi.org/10.1016/j.jth.2016.07.006

10. What is sustainable mobility? Neste worldwide. (2021, December 15). Retrieved December 18, 2021, from https://www.neste.com/media/sustainable-mobility/what-is-sustainable-mobility

11. Cycling: The way ahead for towns and cities. (n.d.). Retrieved September 18, 2021, from https://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

12. Walking and Cycling Transformation. C40 Knowledge Community. (n.d.). Retrieved September 15, 2021, from https://www.c40knowledgehub.org/s/article/How-to-achieve-a-walking-and-cycling-transformation-in-your-city?language=en_US

13. Walkable neighborhoods. What Makes a Neighborhood Walkable. (n.d.). Retrieved November 12, 2021, from https://www.walkscore.com/walkable-neighborhoods.shtml

14. The ten steps to walkable cities. Smart Cities Dive. (n.d.). Retrieved November 12, 2021, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-steps-walkability/96836/

15. Sump Guidelines - eltis.org. (n.d.). Retrieved August 2, 2021, from https://www.eltis.org/sites/default/files/eltis_11th_sump_cg_meeting_06_sump_guidelines.pdf

16. Urban Transportation Systems e-versions | mckinsey. (n.d.). Retrieved September 20, 2021, from https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Elements%20of%20success%20Urban%20transportation%20systems%20of%2024%20global%20cities/Urban-transportation-systems_e-versions.ashx

17. Ariza, M. C. (2020, March 17). Public space for all: What makes Copenhagen the city for the people? Ciudades Sostenibles. Retrieved November 11, 2021, from https://blogs.iadb.org/ciudades-sostenibles/en/public-space-for-all-what-makes-copenhagen-the-city-for-the-people/

18. Environment, U. N. (n.d.). Climate adaptation. UNEP. Retrieved November 20, 2021, from https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation

19. Climate resilience and adaptation to climate change. European Commission - European Commission. (2021, February 24). Retrieved November 20, 2021, from https://ec.europa.eu/info/research-and-innovation/research-area/environment/climate-action/climate-resilience-and-adaptation-climate-change_en

20. Urban heat island: What it is and why it matters to construction. DOZR. (n.d.). Retrieved November 20, 2021, from https://dozr.com/blog/urban-heat-island

21. Climate change mitigation. European Environment Agency. (2017, December 7). Retrieved December 20, 2021, from https://www.eea.europa.eu/themes/climate

22. Greenacre park • New York City. Greenacre Park New York City. (n.d.). Retrieved November 30, 2021, from https://greenacrepark.org/about/

23. Paley Park | The Cultural Landscape Foundation. (n.d.). Retrieved November 30, 2021, from https://www.tclf.org/landscapes/paley-park

24. Visit Savannah. (2018, March 22). Savannah's squares and Parks. Visit Savannah. Retrieved November 30, 2021, from https://www.visitsavannah.com/article/savannahs-squares-and-parks

25. Metro Line 2. InfraTo. (n.d.). Retrieved November 30, 2021, from https://www.infrato.it/metro-line-2/

26. Roxborough: A place with roots. Roxborough Pocket Park | Roxborough, Philadelphia. (n.d.). Retrieved November 30, 2021, from https://roxboroughpa.com/enjoy-the-outdoors/roxborough-pocket-park

27.Hesson, R. (2021, April 11). The pearl of hangzhou water garden hangzhou - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/the-pearl-of-hangzhou-water-garden-hangzhou.html

28. Water traces hann munden. DREISEITLconsulting. (n.d.). Retrieved November 30, 2021, from https://www.dreiseitlconsulting.com/watertraces-hannmundenHesson, R. (2021, February 25). Heiner Metzger Plaza Neu Ulm - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/heiner-metzger-plaza-neuulm.html

29. Water playground. DREISEITLconsulting. (n.d.). Retrieved November 30, 2021, from https://www.dreiseitlconsulting.com/water-playground

30. Demographic indicators - ISTAT. (n.d.). Retrieved November 30, 2021, from http://dati.istat.it/Index.aspx?QueryId=18462&lang=en

31. Garzena, D., Acquaotta, F., & Fratianni, S. (2018). Analysis of the long-time climate data series for Turin and assessment of the city's Urban Heat Island. Weather, 74(10), 353–359. https://doi.org/10.1002/wea.3292

32. Knupfer, S. M., Pokotilo, V., & Woetzel, J. (2018). Elements of Success: Urban Transportation Systems of 24 Global Cities.

33. Unione Europea, SUMPS, Bruxelles, 2013: Http://www.eltis.org/sites/default/files/sump_guidelines_en.pdf

34. Http://civitas.eu/sites/default/files/1st_european_conference_on_sump_-_agendaannouncement.pdf.

35. Https://www.ubc-sustainable.net/events/2nd-european-conference-sustainable-urbanmobility-plans-sumps.

36. Http://civitas.eu/sites/default/files/sump_conference_2017_final_programme4.pdf.

37. Analysis - Envi-met.com. (n.d.). Retrieved August 30, 2021, from http://www.envi-met.com/wp-content/uploads/2021/08/ENVI-met-Case-Study_Vegetation_Analysis.pdf

38. Höppe, P. (1999). The physiological equivalent temperature - A Universal index for the biometeorological assessment of The thermal environment. International Journal of Biometeorology, 43(2), 71–75. https://doi.org/10.1007/s004840050118

39. EL-ZEMRANY, A. Y. M. A. N. M. A. H. M. O. U. D., & ABDELKADER KANDIL, R. A. N. A. A. S. H. R. A. F. (2019). Quality of life in Egypt: Walkability Assessment in El-Mansheya Square, Alexandria, Egypt. WIT Transactions on The Built Environment. https://doi.org/10.2495/cc190031

40. Heiner Metzger Plaza Neu Ulm - water management. Northern Architecture. Retrieved November 30, 2021, from https://www.northernarchitecture.us/water-management/heinermetzger-plaza-neuulm.html

41. Nordh, H., & Østby, K. (2013). Pocket Parks for people – a study of park design and use. Urban Forestry & Urban Greening, 12(1), 12–17. https://doi.org/10.1016/j.ufug.2012.11.003

42. Power, A. (2016). Torino City Story. La Fabrique De La Cite.