WHOLESALE MARKET +

a transformation of the wholesale market munich in a water sensible mixed district

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Master Thesis | Sustainable Urban Design
September 2023

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ASBM01: Degree Project in Sustainable Urban Design

Sustainable Urban Design Programme
School of Architecture and the Built Environment, LTH
Lund University, Sweden
September 2023

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Abstract

There is always talk of climate change in the future, but climate change is already present in all its facets.
Intense droughts, water scarcity, severe fires, rising sea levels, floods, melting polar ice, catastrophic storms, and the decline of biodiversity are already visible. The city of Munich is no exception, as problems like heat, drought, and heavy rain increasingly have to be dealt with.
We as urban designers are planning the cities of tomorrow, but climate adaptation of cities should have happened yesterday. Therefore, it is important not to wait any longer, but to adapt cities to the consequences of climate change.
The wholesale market in Munich is a monofunctional area in the middle of the metropolis. It is characterized by large areas of sealed surfaces, little green infrastructure, and buildings in need of renovation. At the moment, the wholesale market area is not accessible to the public, so it is even more important to make an area in such a central location tangible for everyone.
The aim is to transform this mono-functional area into a multifunctional, vibrant, sustainable district, without losing its character and identity as a wholesale market. In this process, the wholesale market is to find its place and interact with places of interaction in addition to residential, commercial, and retail buildings. To counteract climate change, elements of the blue-green infrastructure will be implemented across the entire site. As water is a valuable resource, it is to be made tangible and visible in different ways to draw attention to it simultaneously.
In the end, the goal is to bring positive climatic changes and minimize heat islands, as well as relieve the burden on sewers and avoid inner-city flooding.

Guiding Questions:
What influence does urban develeopment have on the climate and what problems arise in the process?
How can cities adapt their infrastructure to better withstand heavy rainfall events and droughts?
How can an efficient blue-green infrastructure, as well as social infrastructure be maintained and integrated even in growing, denser cities?

Content

00

INTRODUCTION

CLIMATE CHANGE

Climate change is happening now and since the 1800s it's known that the human activities have been the main driver for it. Emissions of greenhouse gases trap the sun's heat and raise global temperatures. The main sectors causing greenhouse gases are energy, transport, industry, buildings, agriculture and land use. In 2020 China, the United States of America, India, the European Union, Indonesia, the Russian Federation, and Brazil were considered as the biggest emitters alone for the emissions. But it is not these states that suffer most from climate change. The most vulernable people are those with the fewest resources. They are not the problem but they need to be prioritized by thinking of climate adaptation.

The Earth's surface is now about 1,1°C warmer than before the industrial revolution (late 1800s) and the last decade (2011-2020) was the warmest on record. The global warming is happening faster than any time in the past years.
There is a misconception that climate change is mainly associated with warmer temperatures. But on Earth, everything is interconnected and can influence each other. Which means the rise of the temperatures is only the beginning. The main consequences now, among others, are intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity.
There is an urgent need for action on climate change that transcends national borders. This issue requires international cooperation at every level as well as coordinated solutions. Therefore, world leaders at the UN Climate Change Conference (COP21) in Paris agreed on limiting global temperature rise to no more than 1.5°C.
Which means everyone needs to take action on climate adaptation to maintain a liveable future. Adaptation will be required on current impacts and those that are likely to occur in the future. Because the actions protect people, homes, businesses, livelihoods, infrastructure and natural ecosystems (cf. United Nations 2023).

The Intergovernmental Panel on Climate Change (IPCC) was established to provide policy makers with options for adapting to and mitigating climate change, and to identify impacts and future risks. It was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme. The IPCC identified key climate-driven impacts such as heatwaves, extreme precipitation and storms in combination with rapid urbanisation and lack of climate-sensitive planning (cf. IPCC 2021).

These global problems also occur in Munich, so this paper focuses on adaptation to climate change on the local level. With a focus on water-sensitive urban development of the Wholesale Market in Munich.

01

BACKGROUND

CLIMATE CHANGE IN THE URBAN CONTEXT

Munich, as a metropole faces several challenges regarding climate change.
What influence does urban development have on the climate and what problems arise in the process?
The ongoing urbanization with growth and the densification of inner cities are further exacerbating the changing climatic conditions.
The main problems are thermal changes and **extreme weather** events such as heavy rain, floods, droughts and heat.
These are caused mainly by traffic, heavy sealing as well as building structure and building density. Another factor is heat storage capacity and thermal conductivity of artificial surfaces as well as anthropogenic heat sources. And the lack of greenery and ventilation in the urban fabric exaberates the problems. This leads to phenomena such as the **urban heat island**.

The term „**extreme weather**“ event refers to an event that is unusual or rare in a particular location at a particular time of year.
Although definitions of „rare“ vary, extreme weather events are typically as rare or rarer than the 10th percentile or 90th percentile of the observed probability distribution (cf. Deutscher Wetterdienst 2023a).

URBAN HEAT ISLAND

Especially in densely built cities such as Munich, the climate is different compared to the climate in natural landscapes. It's usually 1,5C° warmer than the surroundings and the phenomenon reaches its maximum in cloudless and windless weather conditions at night. The City of Munich for example can be 10 C° warmer than the rural areas when the city is heated during the summer period. That phenomenon is called an **urban heat island**. This is mainly due to the fact that the city is heavily sealed and there's not enough greenery in the urban environment to cool off during heat waves (cf. Deutscher Wetterdienst 2023b).

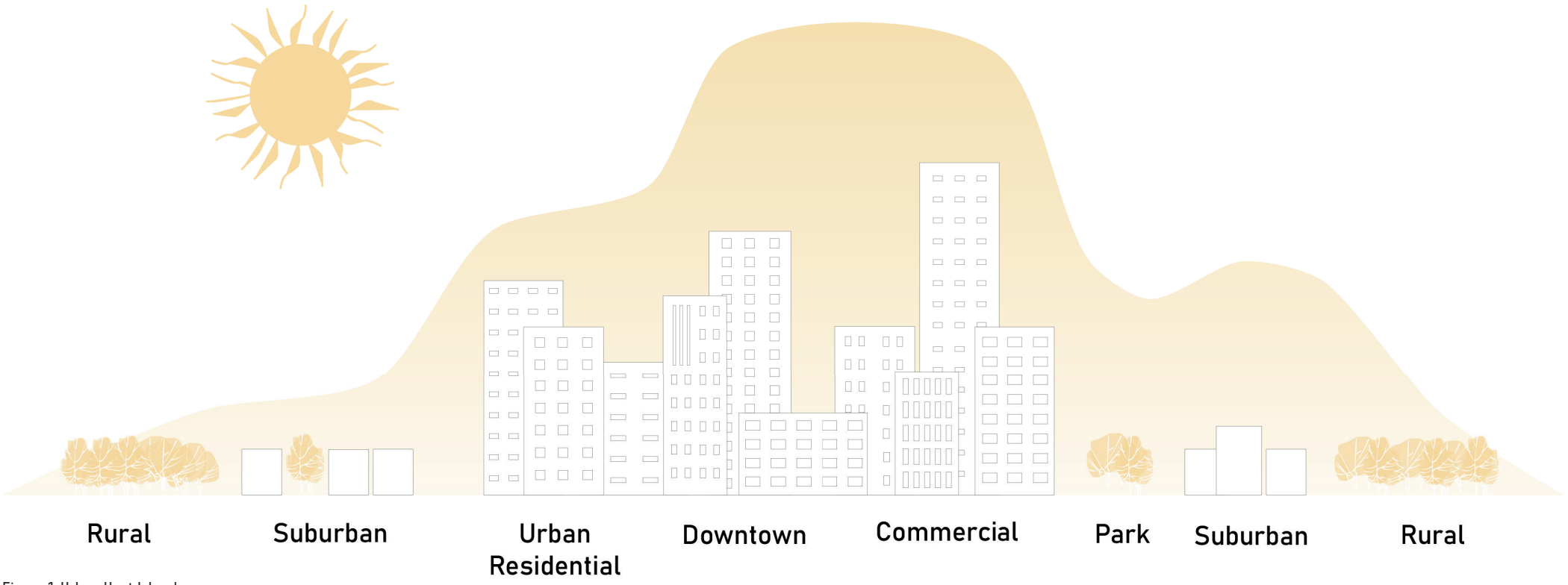


Figure 1: Urban Heat Island

The urban heat island is caused by a number of processes which are influencing the atmosphere[1]:

1. A combination of short-wave radiation absorption and multiple reflections between buildings and street surfaces from the sun.

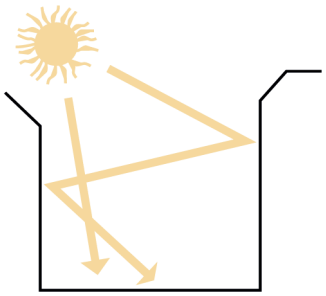


Figure 2: Short-wave radiation

2. Long-wave radiation in the urban environment is absorbed and reemitted by air pollution.

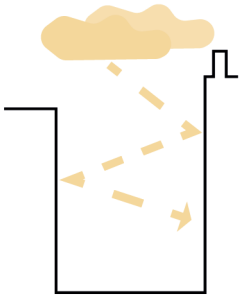


Figure 3: Long-wave radiation

3. When buildings obstruct the sky, long-wave radiant heat is trapped by the surfaces and radiated back into the urban fabric.

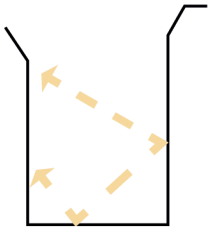


Figure 4: Building reflection

4. Combustion processes, such as traffic, space heating, and industrial processes, release anthropogenic heat.

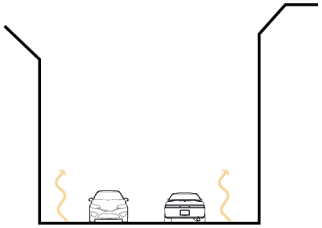


Figure 5: Combustion processes

5. Cities have a larger surface area including materials with high thermal admittance compared to rural areas and therefore more heat can be stored.

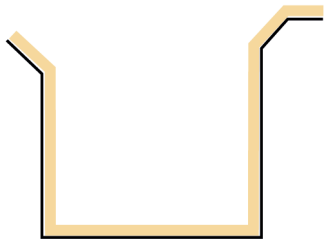


Figure 6: Large Surfaces

6. Evaporation from urban areas is lower compared to rural areas due to less permeable materials and less vegetation. The result is that more energy is put into sensible heat and less energy into latent heat.

Figure 7: Sealed surfaces

7. Wind speed reduction decreases heat transport from streets.

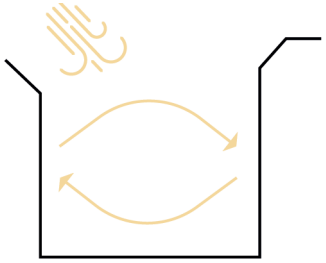


Figure 8: Reduced wind speed

1. Cf. Kleerekoper et al. 2012: 30f.

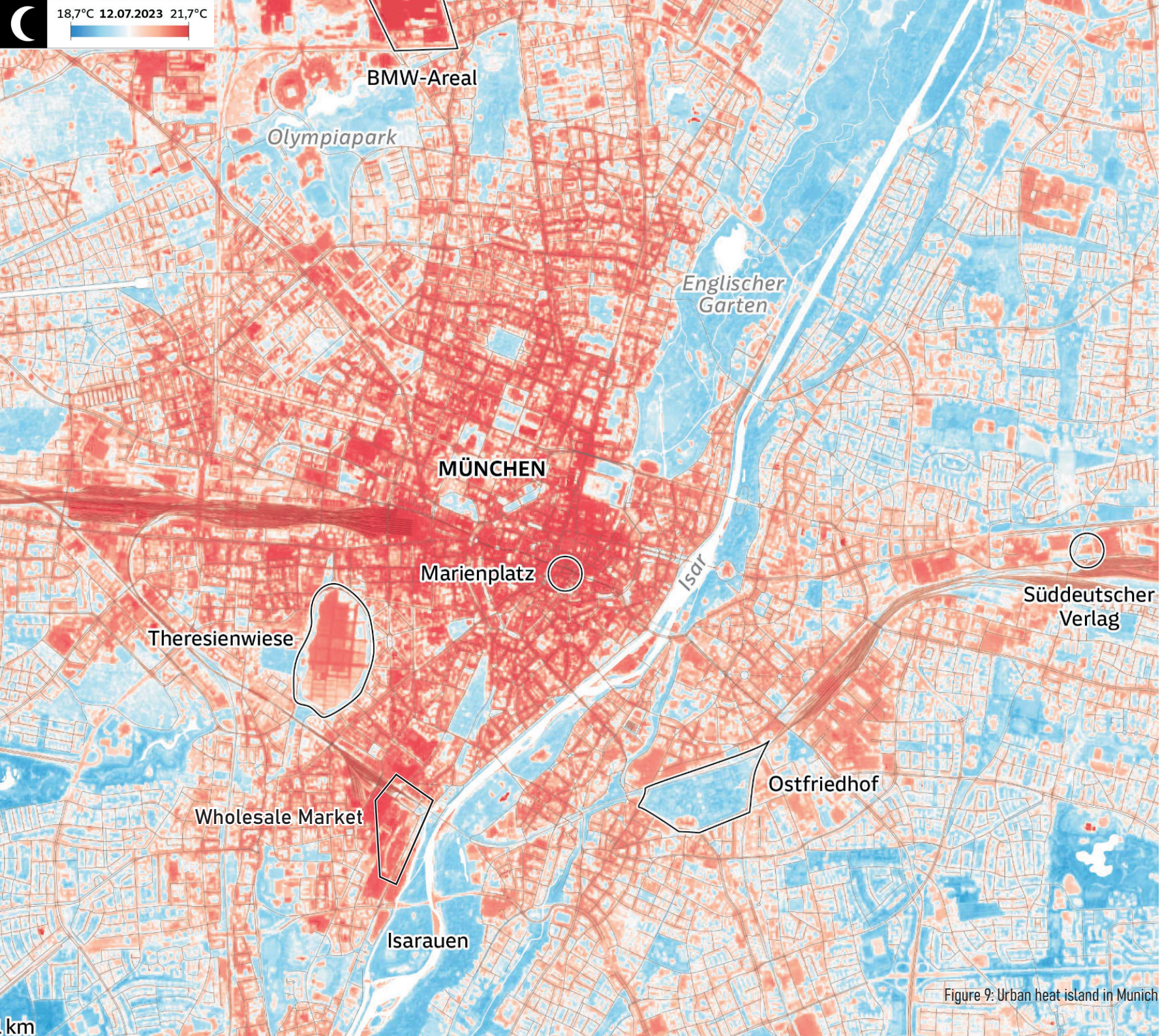


Figure 9: Urban heat island in Munich

This graphic shows the various heat islands in Munich. Here, the temperatures were measured at four o'clock in the morning, after the hottest day of the year so far until July.

This mainly affects the heavily sealed city center and various industrial locations, including the Munich wholesale market. Only sporadically it cools down a bit at night through so-called fresh air corridors.

When it comes to thermal changes the hot spells will increase in both intensity and frequency. By now the average yearly temperature and the hot days are rising steadily. In 2050 the average temperature will rise from about ten degrees today to more than 12 degrees. Sustained high air temperatures during hot spells can have a negative impact on human health. The body is experiencing heat stress and is unable to cool down sufficiently, which can cause problems with the cardiovascular system (cf. Stadt München 2023b).

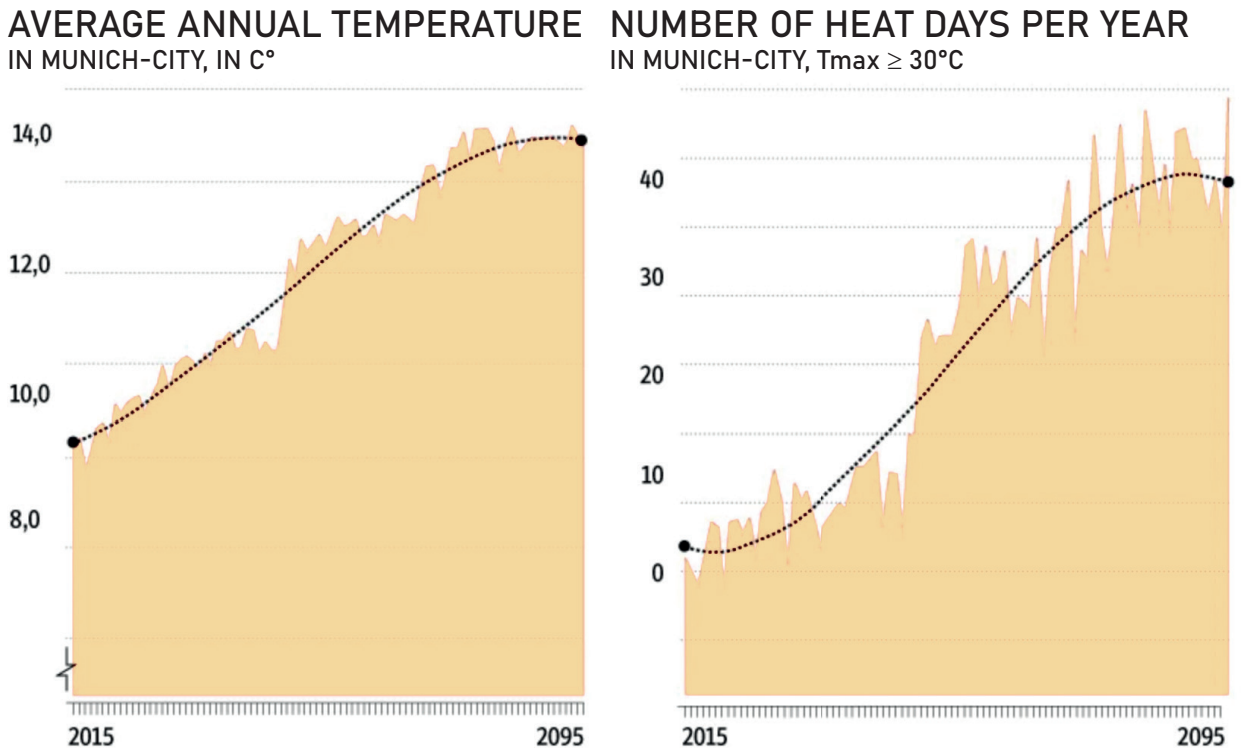


Figure 10: Average annual temperature/ heat days per year

Prolonged periods of heat and drought are not only problematic for the people and their health. It is also a problem for agriculture, forestry, and urban greenery when they suffer from drought and heat stress.
In Munich with a growing population and increasing water demands, water supply may also be affected in the future if the groundwater level drops due to prolonged drought. It is therefore imperative that technical and precautionary measures are taken as soon as possible to irrigate urban green spaces and protect the water supply. On the other hand heavy rainfalls are are becoming more frequent and dry surfaces are problematic in that case.

HEAVY RAINFALL

Urban development inevitably has an impact on the thermal changes but also on the environment. Roads and buildings significantly alter the hydraulic properties of an area. As a result, pervious layers become less permeable or even impermeable.

Meanwhile, **heavy rainfall** events are becoming more frequent. The reason for this is that the warmer atmosphere can absorb more water. This is causing an „excess of water“ and raising the question of what to do with it.
Precipitation can‘t soak into the ground naturally when impervious surfaces like pavement and roofs are present in urban areas and built-up areas. Even on natural surfaces, it becomes difficult when the soil is too dry due to dry periods. The dry and crusted soil surface cannot absorb the rainwater. This is called hydrophobia. The water then only seeps into the cracks and root paths.

In contrast, water flows rapidly into storm sewers, sewer systems, and drainage ditches, causing flooding, erosion, turbidity (or muddiness), overflowing storm and sanitary sewer systems, and damage to infrastructure.

Topics like sealing and infiltration, floodplains, multifunctional areas, changing fire brigade deployment patterns, or increasing chlorination of drinking water to kill germs that can become hazardous after heavy rainfall have been on the agenda for years (cf. EEC Environmental 2023).

The term "**heavy rainfall**" refers to a large amount of precipitation falling within a short period of time. In most cases, it falls from convective clouds (e.g., cumulonimbus clouds). A heavy rainstorm can occur anywhere and cause rapid water levels to rise and (or) floods to occur. In many cases, soil erosion occurs as a result of heavy rain (cf. Deutscher Wetterdienst 2023c).

MORE DAYS WITH HEAVY RAINFALL IN GERMANY

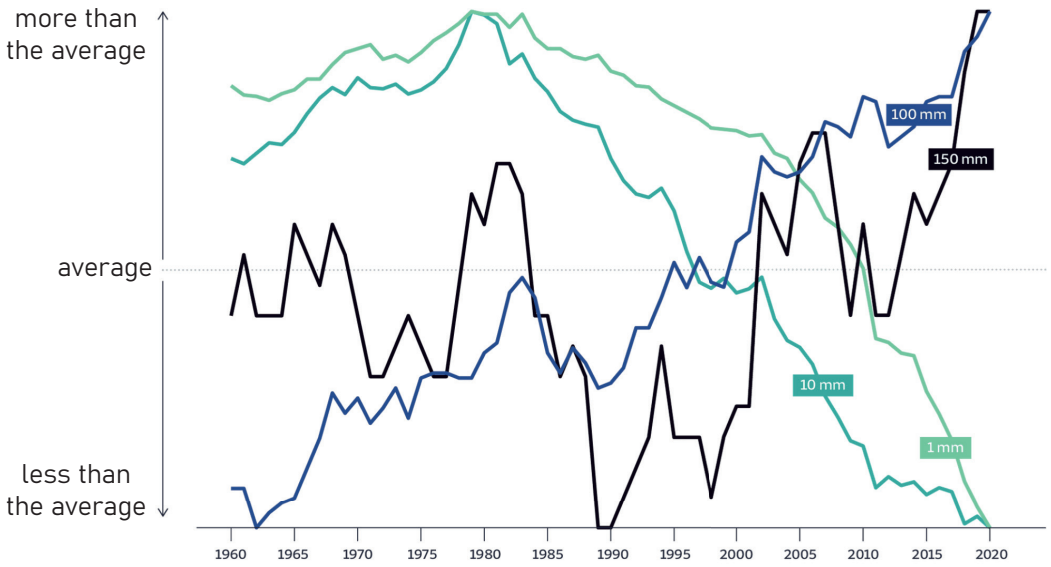


Figure 11: Graph of heavy rainfall days in Germany over the years

DAYS WITH HEAVY RAINFALL (> 20MM) IN 2050

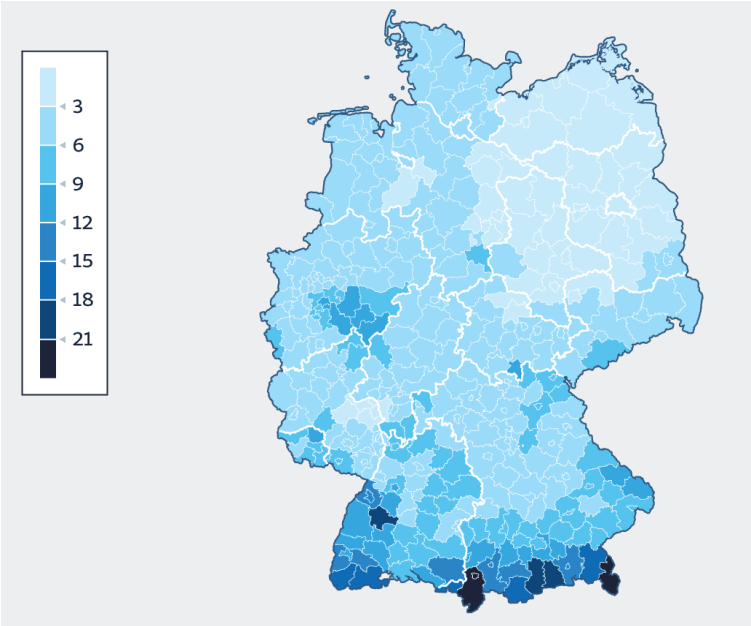


Figure 12: Map of Germany of heavy rainfall days in 2050

This graph shows that normal precipitation in Germany is decreasing, i.e. there are more dry phases, but heavy rainfall events are increasing in return. It is estimated that for each degree of warming, the atmosphere can absorb about seven percent more water vapor and rain it back down again. Between 1881 and 2019, Germany warmed by an average of 1.6 degrees Celsius (cf. Süddeutsche Zeitung 2023).

DEVELOPMENT'S EFFECT ON URBAN WATER CYCLES

The majority of rainwater evaporates in natural environments, is absorbed by plants, or soaks into the ground. This process is drastically altered by urban development, which removes vegetation and covers land with ‚hard' or impervious surfaces. As a consequence, rainwater runs off these surfaces, into stormwater drains, and into our waterways as polluted stormwater very rapidly. It affects water flow timing, speed, and volume, affecting our waterways and bays.

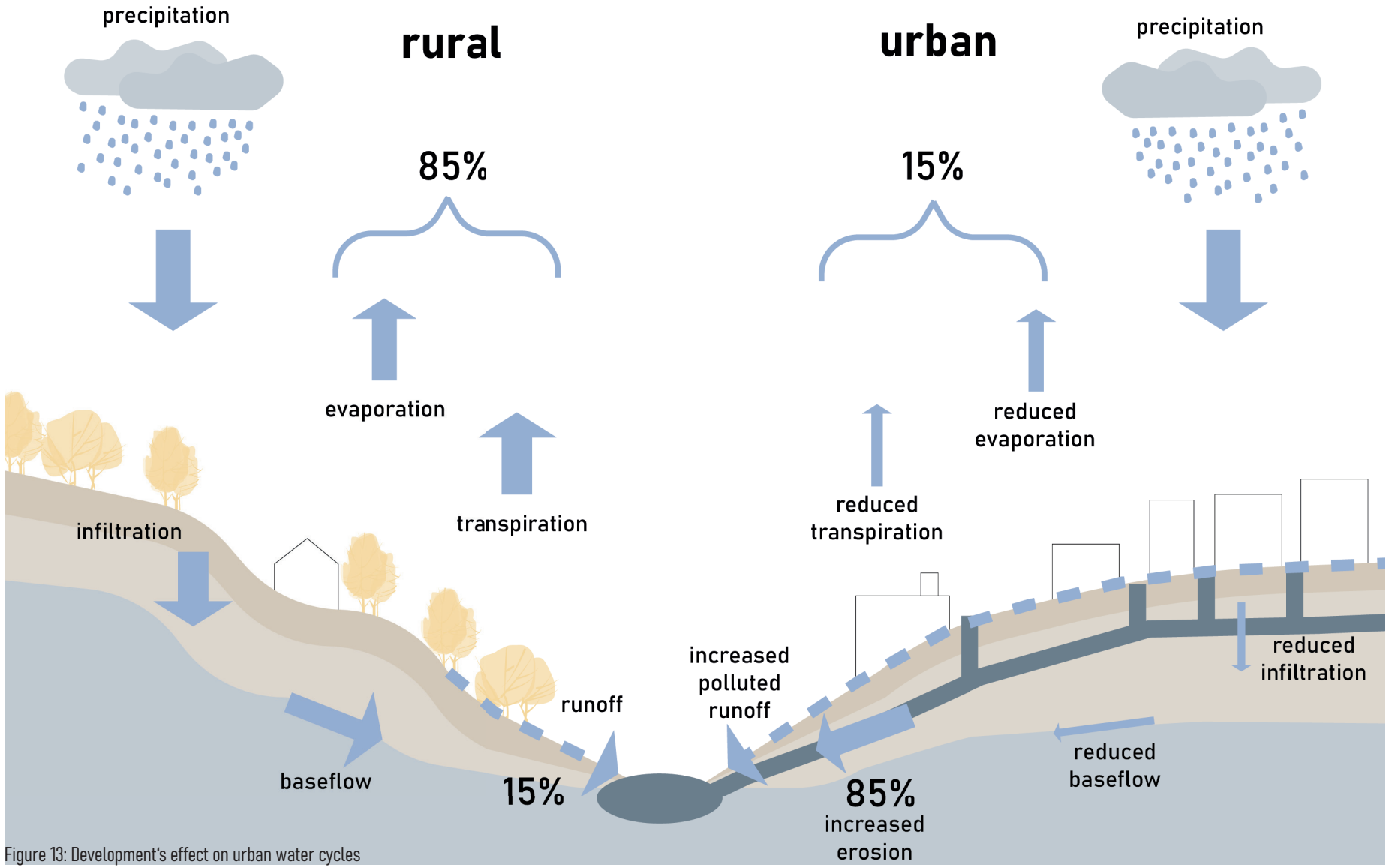


Figure 13: Development's effect on urban water cycles

POPULATION GROWTH AND HOUSING SHORTAGE

The problems of urban growth and housing shortage go hand in hand with the problems of climate change. On the one hand, there are efforts to create and unseal more open spaces and green spaces, on the other hand, to create more living space and increase density.

The population of Munich is growing by about 0.7% annually. This means that by 2040, the population will increase from 1.588 million today to 1.812 million. That is an increase of 14%. The combination of economic opportunities, a high standard of living, and a strong labor market has attracted people from other parts of Germany and around the world to Munich. With the influx of more people to Munich, the demand for housing has increased significantly, which leads to various challenges, especially about the availability and affordability of housing (cf. Landeshauptstadt München Referat für Stadtplanung und Bauordnung I/22 2023: p. 8f.).

POPULATION GROWTH
2022-2040, MUNICH

1.5M
2022

+223,217
RESIDENTS (EQ. +14%)

1.8M
2040

~0.7%
PER YEAR

Munich is geographically constrained by natural features, such as the river Isar and the surrounding Bavarian Alps. As well as the city has strict zoning laws and building regulations, which aim to preserve its historical and architectural heritage.
While these measures protect Munich's unique character, they also make it difficult to create new housing developments.
This leaves limited land for urban expansion, making it challenging to accommodate the growing population, and is responsible for a price increase in the limited real estate.

A lot of people have problems affording the rent which, on average, has been the highest in a German city comparison for years. According to the latest figures, Munich charges 20.70€ per square meter, while in the other two German metropolises Berlin and Hamburg, the rent per square meter is significantly lower (cf. Statista 2023).

As a result of the very high residential property prices and real estate rents more than 500,000 people commute to work in the Munich urban area every day (cf. Bayerisches Landesamt für Statistik 2023).

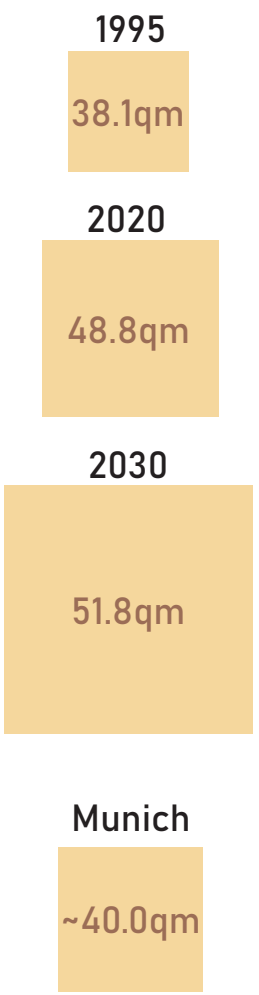
AVERAGE RENT IN GERMAN CITIES 2023

AVERAGE LIVING SPACE PER PERSON

More and more people are living in single households (Munich, 55%). This leads to more square living space per inhabitant on average. In 1995 people in Germany lived on an average of 38.1 qm per person but by 2030 it will be 51.8 qm per person (cf. Dr. Deschermeier/ Henger 2020).

However, compared to the general statistics the average square meter per inhabitant in Munich was estimated to be about 40.0 square meters. It's important to note that this number may vary depending on the specific area or neighborhood within the city. The low square meter per inhabitant ratio in Munich has been a significant concern due to the housing shortage and the resulting high property prices and rental costs. The city is working on various measures to address this issue, such as the promotion of urban densification, the development of affordable housing projects, and the implementation of sustainable urban planning practices (cf. Landeshauptstadt München Referat für Stadtplanung und Bauordnung 2022: p. 13f.).

However, due to the challenges posed by limited space and high demand, finding a solution to improve the square meter per inhabitant ratio remains a complex and ongoing process. As a result, in the following, an approach is provided as to how densification in urban spaces can be reconciled with water-sensitive development, as well as how housing shortages can be addressed in addition to climate change.



02

RESEARCH SUSTAINABLE URBAN DEVELOPMENT

Munich is taking action towards climate change and has drawn up an adaptation action plan. It was developed in 2016 by the Department of Climate and Environmental Protection. It includes expected future changes in the climate in Munich, such as an increase in average temperature, in the frequency and intensity of heat extremes, in the number of climatic days of knowledge, as well as the change in the annual precipitation pattern and increase in the intensity and frequency of local heavy rainfall events.

Munich is particularly sensitive to climate change because its population and infrastructure are concentrated in a small area. Over the years, the municipality has further developed its climate adaptation goals and has arrived at the following lines (cf. Landeshauptstadt München Referat für Gesundheit und Umwelt 2016: p. 29):

- Safeguarding and improving the overarching climatic balancing function
- Securing and developing climate-effective open spaces
- Securing and creating a good quality of stay, especially in public spaces at the neighborhood and property level.
- Consideration of changing climatic conditions, especially extreme events in spatial planning
- Promotion of climate-resilient development through green-blue infrastructure in existing areas
- Continuous expansion and updating of the climate database
- Expansion and consolidation of the interdepartmental information and cooperation platform
- Raising awareness and building knowledge on the topic of climate adaptation
- Integration of climate adaptation in affected areas of life and work
- Reducing the health burdens caused by climate change and promoting well-being, especially for vulnerable groups

The process of adapting to the problems and climate change involves taking action to prepare for and adapt to both the current and predicted impacts of climate change. While we intend to reduce net global emissions by 2050, the concentration of greenhouse gases in the atmosphere will increase for the coming decades , and the average global temperatures will rise. The heated climate is also accompanied by all sorts of risks that need to be solved. There are various strategies that all fall under the topic of **sustainable urban development**, which are described in more detail below.

The term **„sustainable urban development“** means taking the city as a whole into account when making changes. It is important to determine whether decisions are sustainable. As well as to consider all aspects of sustainability, including economic, social, cultural, and environmental dimensions. Sustainable urban development therefore encompasses a wide range of activities. Most of the aspects are shown in the graphic to fulfill a sustainable development (cf. BMUV 2016).

Figure 14: Aspects for sustainable district development

BLUE AND GREEN INFRASTRUCTURE

Known as „**blue and green infrastructure**," these new strategies emphasize water management, reducing urban heat island effects, improving air quality, and promoting economic development.
By incorporating vegetation or making hard surfaces permeable, green infrastructure offers an attractive alternative to traditional concrete or gray infrastructure.
The permeable pavement and the green roof , as well as other strategies have been proven to capture and store rainwater, preventing the stormwater system overload and preventing flooding during heavy rain fall.
Additionally, green infrastructure reduces greenhouse gas emissions and provides wildlife habitat.
In this way, different strategies can be combined to form a local solution for surfaces, as well as squares, parks, or roofs. The water cycle should be kept as natural as possible.
Depending on where the water is diverted from, it may also be necessary for the water to flow through a filter circuit before it can be reused (cf. Georgetown Climate Center 2023).

The strategies can be differentiated into **vital tree sites**, **elements of evaporation**, **elements of infiltration**, **elements of water use**, **elements of water purification**, and **elements of heavy rainfall prevention**.
These are gonna be explained in more detailed in the following chapter (cf. BlueGreenStreets 2022).

1 Vital tree sites
2 Elements of evaporation
3 Elements of infiltration
4 Elements of water use
5 Elements of heavy rainfall prevention
6 Elements of water purification

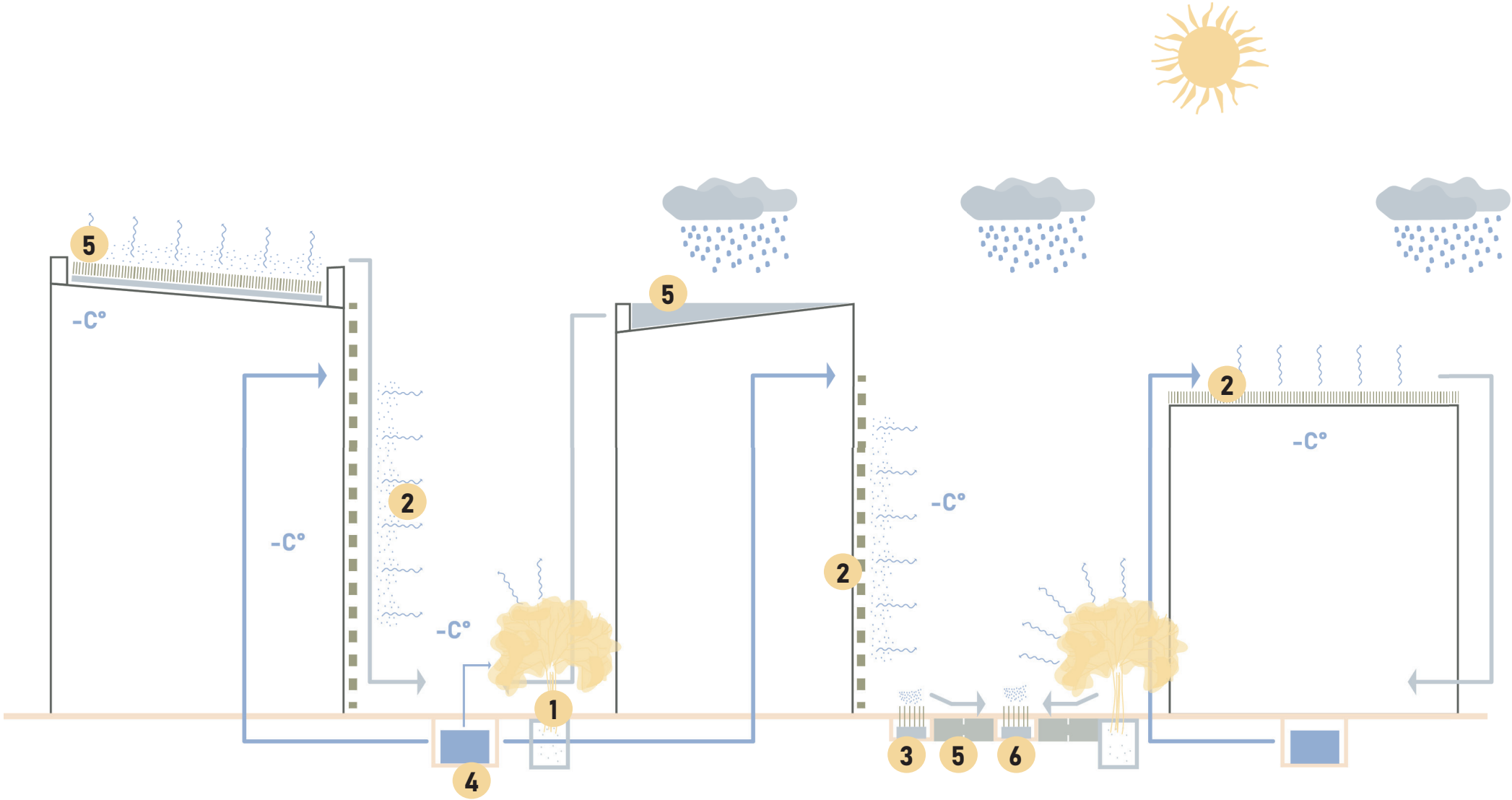


Figure 15: Blue and Green Infrastructure

1 VITAL TREE SITES

The aim is to reduce the drought risk and urban flash floods.
That can be reached by active drainage of rainwater from neighboring areas.
To achieve higher infiltration volume, the substrate for the trees needs to be adapted as well as implementing an infiltration trench for long-term retention of rainwater so that the water is also available during dry periods. Some other positive aspects are that the tree growth and vitality are increased as well as the irrigation effort minimised.

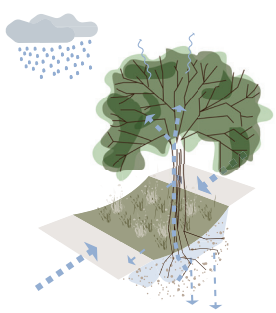


Figure 16: Hydrological optimised tree site

Hydrological optimised tree site

- Conduction of adjacent water
- Improvement of the infiltration capacity of the tree pit
- Water supply secured in the long term

Adaptive trees are:
- American amber tree, Liquidambar styraciflua
- American Gleditschie, Gleditsia triacathos
- Swamp oak,
- Quercus palustris
- Small-leaved lime, Tilia cordata
- Elm, Ulmus resista
- Turkey oak, Quercus cerris

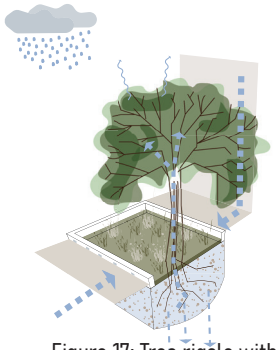


Figure 17: Tree rigole without reservoir

Tree rigole without reservoir

- Conduction of adjacent water and precipitation water inflow
- Filled with a substrate that is rich in structure
- Optimized water and air balance
- Ensures seepage capacity
- Prevents compaction
- Stores rainwater
- Improves water availability

Rainwater inlet:
Above ground
- Open/ lowered curbs
- Drainage channels
- Levelling with adjacent areas

Underground
- Extension of downpipes in the area of the tree pit
- Street drains

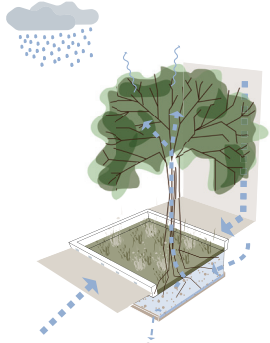


Figure 18: Tree rigole with reservoir

Tree rigole with reservoir

- Properties equal to tree rigole without reservoir
- Sealed underground
- Infiltration only via sides
- Water reservoir

2 ELEMENTS OF EVAPORATION

The effectiveness of evaporation and cooling depends on the water supply of the planting, if possible, even during dry phases. To achieve this, an efficient water reservoir in the soil is required. In addition, a plant species is needed that is well adapted to changing humid site conditions. Taller plantings that shield paved traffic areas and building surfaces can achieve additional cooling effects.
The elements also have a positive influence on flora and fauna by filtering pollutants, as well as on the aesthetic diversity and quality of stay in the cities.

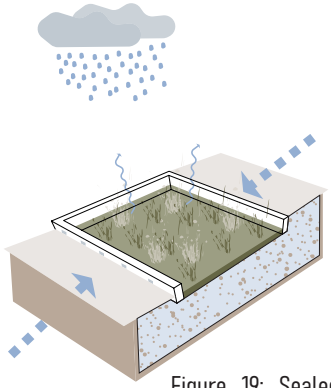


Figure 19: Sealed evaporation basin-structurally enclosed

Sealed evaporation basin – structurally enclosed

- Designed as a deep bed with sufficient underground storage
- Water is stored by natural building materials (loam, clay) or plastic sealing
- Water supplied is stored and made available for evaporation during dry periods
- Two-layer structure consisting of a readily available water reservoir at the top and a hard-to-reach reservoir at the bottom ensures root penetration for a higher purification capacity
- Water with pollutants can be discharged by prior purification
- Purification by infiltration via topsoil, filters in street inlets, gutter systems, or filter beds
- Planting with predominantly low vegetation structure of grasses and perennials

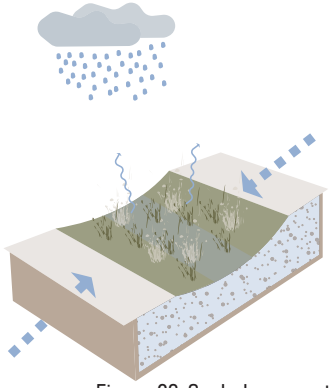


Figure 20: Sealed evaporation basin-naturally enclosed

Sealed evaporation basin – naturally enclosed

- Properties equal to sealed evaporation basin-structurally enclosed
- Impoundment by natural building materials (clay, loam)
- Edging is kept natural

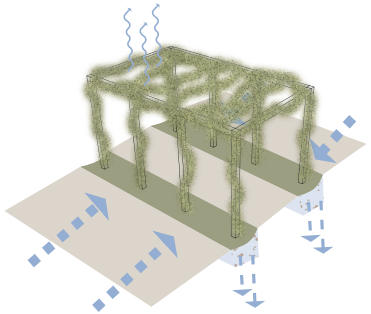


Figure 21: Pergolas

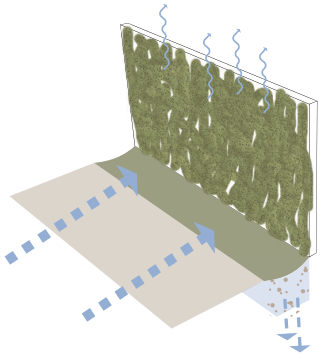


Figure 22: Green walls

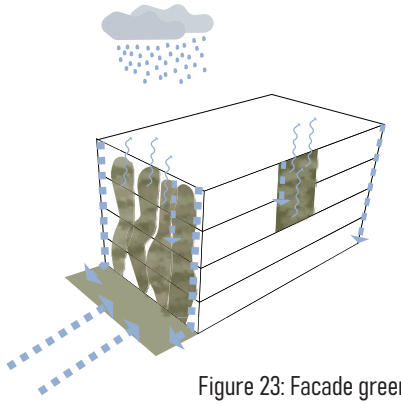


Figure 23: Facade greening

Pergolas

- Protection from the sun
- Used on squares and wide streets
- Water retention limited
- Rainwater should be collected in cisterns and used for irrigation

Green walls – noise protection/evaporation walls

- Noise reduction
- Dust filter
- Air purification
- Oxygen production
- Privacy screen
- Route guidance
- Limited water retention
- Rainwater should be collected in cisterns and used for irrigation

Facade greening

- Properties equal to green walls
- Energy saving (insulating effect due to air cushioning)
- Facade protection (UV, heavy rain/hail, wind, temperature extremes and strong temperature fluctuations, pollutants, dirt)

3 ELEMENTS OF INFILTRATION

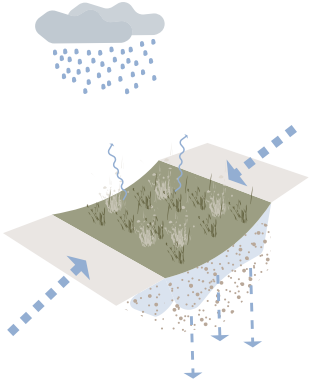


Figure 24: Infiltration swale

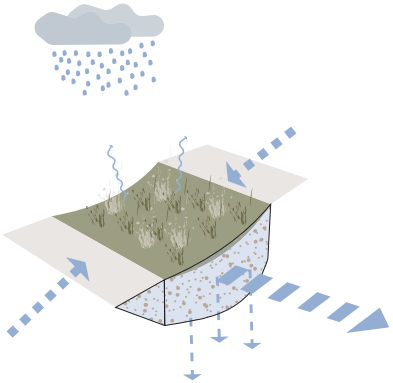


Figure 25: Infiltration swale with infiltration trench

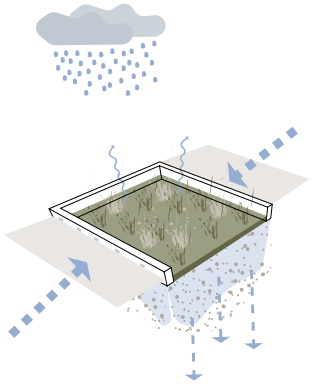


Figure 26: Low bed

With the elements of infiltration, flooding caused by heavy rainfall events can be prevented, as the water is discharged decentrally.

Infiltration swale

- Water is stored for a short time (1-3 days) in permanently green, randomly shaped swales
- Decentralized infiltration via well-drained humus-rich soils
- Part of the water evaporates through planting

Infiltration swale with infiltration trench

- If the existing soil is not sufficiently capable of percolation
- Rainwater is temporarily stored on the surface (1-3 days)
- Infiltrated through topsoil layer into underground storage space (infiltration trench)
- Renewed intermediate storage before final infiltration

Low bed

- In an urban confined space
- Temporary retention
- Decentralized infiltration framed by concrete and natural stone frames to allow for larger volumes

4 ELEMENTS OF WATER USE

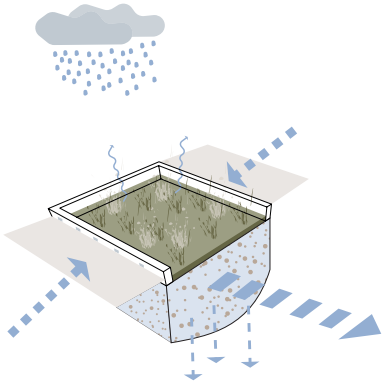


Figure 27: Low bed with infiltration trench

Figure 28: Water-permeable paving

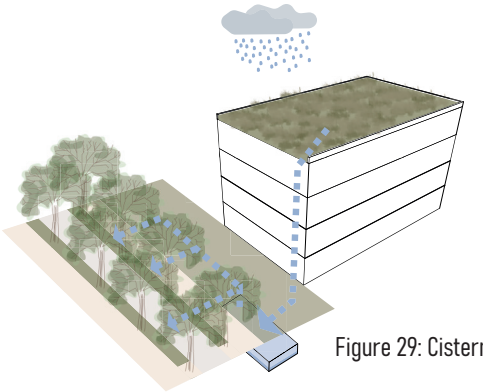


Figure 29: Cistern

Low bed with infiltration trench

- If the soil is not sufficiently capable of seepage rainwater is temporarily stored on the surface (1-3 days)
- Seepage through topsoil layer into underground storage space (infiltration trench)
- Renewed intermediate storage before final infiltration

Water-permeable paving / pavers

- Porous surface coverings
- Greenable, partially permeable pavements
- Absorb precipitation water and infiltrate it over large areas
- Without waterlogging

The elements of water use help to partially purify and collect precipitation water, to make it usable as a substitution for drinking water. It is also used as an intermediate storage tank and helps reduce the amount of rainwater that flows directly into the sewer system.

Cistern for rainwater harvesting

- Underground buried water tank
- Water runs through piping systems into a tank instead of the sewer system
- Various purification stages to filter out dirt and sediments
- To ensure the irrigation of the blue-green infrastructure even in dry periods
- For green spaces, street trees, vertical greening

5 ELEMENTS OF HEAVY RAINFALL PREVENTION

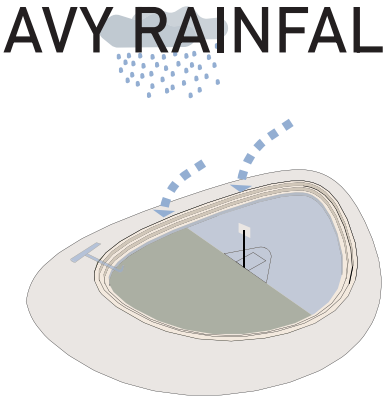


Figure 30: Retention in open space

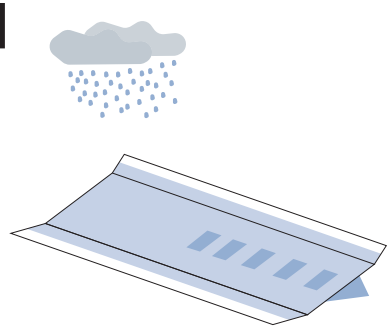


Figure 31: Emergency waterway

Heavy rainfall causes the design case of the drainage systems to be exceeded and precipitation water cannot drain off. In consequence, the water runs off on the surface following the topography and can cause damage. To prevent flooding planned joint use of traffic and open spaces can be used for controlled temporary emergency drainage and retention. The water can be retained and discharged for a moment and can then flow with a delay into the drainage system. It helps to counteract the overloading of the drainage infrastructure.

Retention in open space

- Multifunctional use
- Can be used as parks, sports, or play areas
- Make the element of water a tangible experience
- Possibly integrate precipitation water into regular use

Retention and/or drainage (emergency waterway) in the road space

- In areas with a high proportion of sealed surfaces
- Traffic areas such as roadways between curbs or areas of stationary traffic
- Targeted retention or emergency drainage in the road space
- Avoidance of damage to traffic infrastructure especially in urban areas with high building density
- Generously dimensioned gutter systems
- Raised curbs or thresholds guide runoff over a wide area
- Use of central gutters (V-profile of the carriageway
- Increase of cross-slope
- Road spaces with gradients use speed bumps to cascade

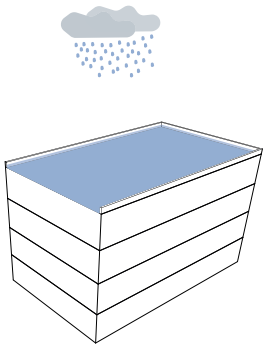


Figure 32: Blue roof

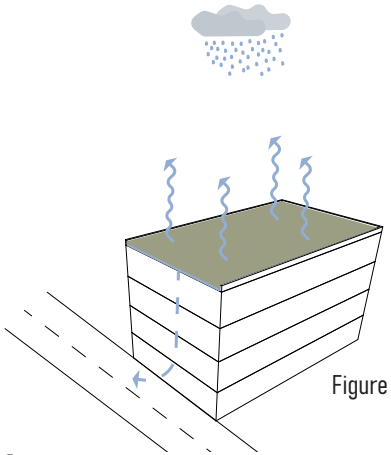


Figure 33: Green roof

Retentionroof („Blue roof“)

- Exclusively for retention function and throttling of precipitation peaks
- Rainwater is collected and retained openly or in gravel beds
- Following a heavy rainfall event, it is then discharged to the sewer in a throttled form (cf. Freie und Hansestadt Hamburg, BUE 2023: p. 10f.)

Retention green roof

- Drainage layer and artificial storage space under green roof construction
- Drainage layer absorbs incidental water
- Artificial storage space can retain water
- Water discharged to the sewer in a throttled form
- When the maximum retention capacity of the fill is exceeded the excess rainwater is discharged via emergency overflows into the adjacent open spaces or traffic areas
- Reduction of sealed surfaces
- Cooling of buildings through evaporation and shading
- Avoidance of heated roofs/ interior through shading/ evaporation of the plants
- Ambient cooling and improvement of the local climate
- Noise reduction through reflection and absorption capacity
- Good for biodiversity
- Carbon storage/oxygen production (cf. Freie und Hansestadt Hamburg, BUE 2023: p. 10f.)

6 ELEMENTS OF WATER PURIFICATION

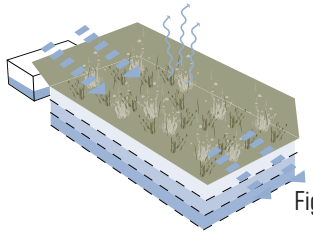


Figure 34: Filter bed

Elements of water purification are used to limit pollution caused by precipitation-induced runoff or when an adjacent body of water has special requirements.

Filter bed

- System of pre-treatment for sedimentation of solids and bottom filter basin
- Retention area for intermediate storage
- The pre-cleaned wastewater passes vertically through a substrate filter body and is then discharged through a drainage system
- Plants such as reeds for higher purification efficiency and prevention of blockage or loosening of the filter substrate

DENSIFICATION

The city is the solution, not the problem, and **density** is good for the eco-balance. But why? The city meets all the needs of daily life in a small space, saving resources and reducing pollution. People who live, work, shop, and spend their leisure time in cities mitigate commuter flows, land consumption, and urban sprawl (cf. Stadt München 2023c).

Since there is not much open space left in most cities, and if it should be preserved to strengthen the urban green, cities are usually densified. There are several options. One option is the **top-up**. In this case, more stories are added to existing buildings and no more space is used. The other option is the **add-on**. This means adding new buildings to existing ones. For example, to create an inner courtyard.

TOP-UP Figure 35: Top-Up

ADD-ON Figure 36: Add-On

Another part of redensification is the mix of uses.

MIXED USE

More than a hundred years ago, during the time of industrialization, the focus was already on mixed-use and differentiated urban structures, as well as communal and public space. However, there was a shift away from the ideal of density, a trend towards disentanglement and a turn towards functionalist urban planning.
Despite much criticism, the principle of spatial separation of the functions of living, working, transport, leisure, etc. was often retained in the implementation. Today mixed-use plays a very important role concerning several programmatic goals such as resource conservation, climate protection, reduction of traffic volume, and equality (e.g. between genders, between the majority society and minority groups, between rich and poor).
The mixing and interweaving of functions is the most inconspicuous characteristic in urban space, but along with density, size, and cultural diversity, it is the most important. It enables diversity and robustness, compactness and synergies, intensity, and participation.
Mixed-use is therefore not an idealistic idea, but a prerequisite for creating liveable and sustainable urban spaces. There is a strong correlation between mixed-use, social housing, and social mixing.
The Paris Climate Agreement promotes for the careful use of resources in dense functional agglomerations in Europe. Since power and population growth are concentrated in metropolitan areas..
In terms of regionally different economic structure and population dynamics, the ideal of a spatially compact, mixed-use, socially and culturally integrated city is now seen as the best possible option for sustainable urban development.
Due to its central location in the city, which is attractive to many users, the wholesale market area offers a lot of perspective for a sustainable form of mixed-use (cf. Forlati/Peer 2017: p. 11f.).

Various programmatic scenarios thematically show the possibilities of mixed-use. For example, sustainable mobility, where post-fossil, resource-saving, and socially acceptable mobility is implemented. As well as zero-emission businesses, which are resource-saving and low in pollution. Creative Stations are innovative companies from the fields of art and culture as impulse generators for the diversity of use and creativity in the neighborhood. A qualitative mix of networked services in small-scale interlinking in the neighborhood is important to serve everyone‘s needs.
As the population is altering, care stations are needed which includes embedding of care and nursing work. To reduce individual resources various models of share stations are indispensable.
Due to the foreseeable social consequences of the ecological crises, it becomes important to encourage fair business which means to pursue measures for ecologically and socially fair trade.
And last but not least (re)integration of production in the urban fabric, as well as wholesale and trade.

In this case, the wholesale market is seen as an urban industry that should be integrated into the future mixed neighborhood. Extensive and producing commercial units with large space requirements find room in a strongly elevated and flexibly usable ground floor. The arrangement of the uses in the building complex is conceived as a horizontal stratification with a two- to three-story slab, which is designed as a special type with its own access.
Above the commercial/ industrial area, there are one to two raised, flexibly usable stories that can accommodate work forms with a small-scale structure such as offices. These form a buffer area for the residential use above (cf. Forlati/Peer 2017: p. 11ff.).

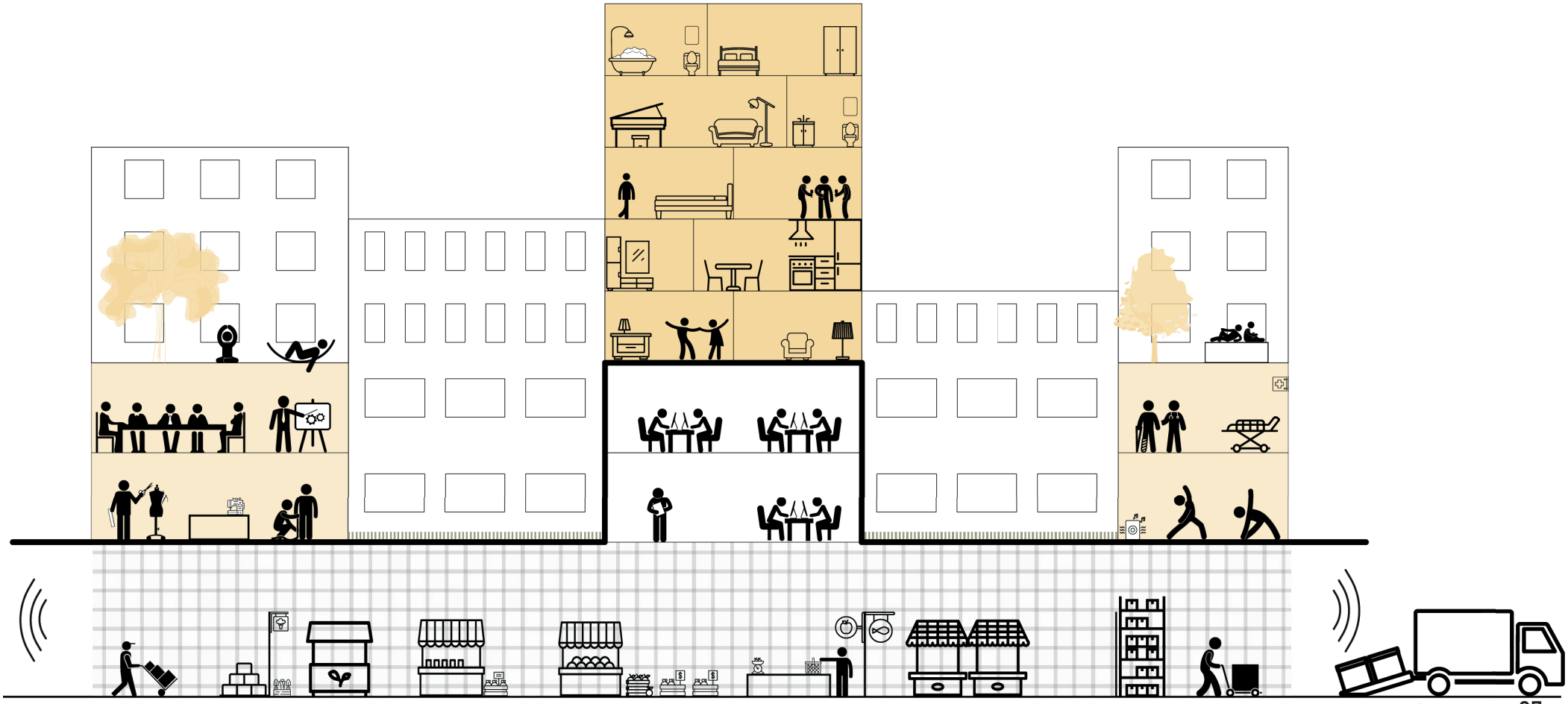


Figure 37: Mixed-Use

03

THE SITE

LOCATION

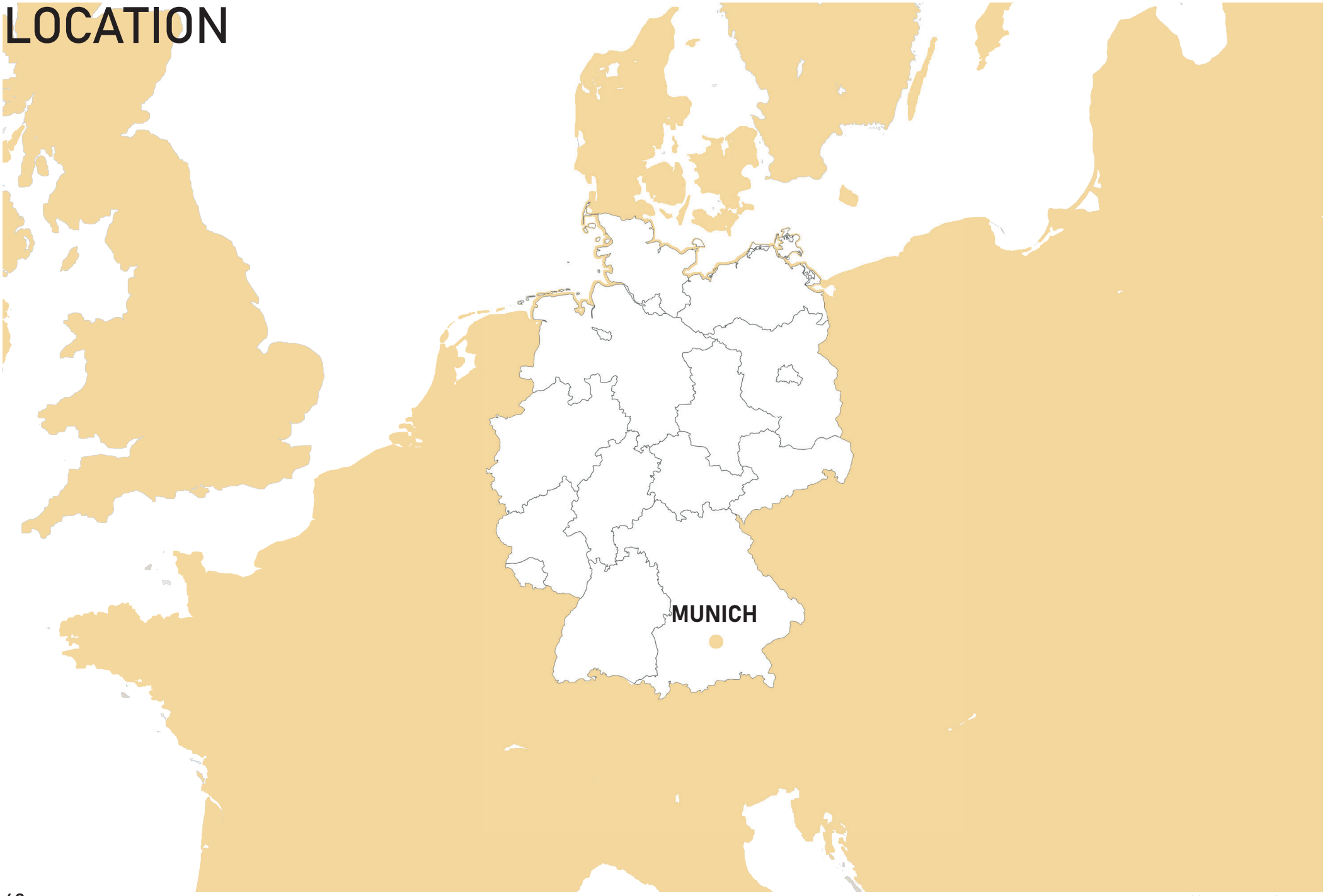


Figure 38: Location in Germany

MUNICH

Munich is the capital and largest city of the state of Bavaria in Germany. With 1.578.132 inhabitants (31 May 2022) and 4.686 inhabitants per square meter, it‘s the most populous city in Bavaria and the most densely populated municipality in Germany. It‘s also the third-largest city in Germany, after Berlin and Hamburg. The city‘s metropolitan area, which includes the surrounding suburbs, has a population of over 6 million, further contributing to its vibrant and diverse community.

It is located in the southeastern part of the country, about 50 kilometers (31 miles) north of the Bavarian Alps. The city is situated on the banks of the River Isar, which flows through the city center and enriches the picturesque landscape. Munich‘s favorable geographic location places it at the heart of Europe, making it an important hub for transportation and commerce.

This city is an important place for culture, politics, sciences, and media. It‘s a major economic powerhouse, known for its thriving industries in technology, automotive, and finance. It serves as the headquarters for several multinational companies and is a prominent location for trade fairs and conferences.
Munich is also home to important universities and colleges, major museums, and theatres.
In addition to its many historical buildings, international sporting events, trade fairs, congresses, and the world-famous Oktoberfest, the city is a tourist attraction from all over the world.

Munich offers a high quality of life and a wealth of leisure activities. The city‘s parks, such as the „Englischer Garten“, are popular spots for outdoor activities and relaxation. In addition, Munich‘s beer gardens are famous for their convivial atmosphere and traditional Bavarian culture.

Overall, Munich is a vibrant, modern city with a deep appreciation for its historical and cultural heritage. It attracts tourists, students, and professionals alike, providing a unique blend of tradition and innovation, making it a fascinating destination in Europe.

THE SITE

Figure 39: Location in Munich

Figure 40: The site before

THE WHOLESALE MARKET MUNICH

After Paris and Barcelona, it's the third-largest transshipment point for fruit and vegetables in Europe. Flowers, delicacies, and fish are also part of the range . As well as horticulturists who sell their vegetables, fruits, and herbs from the region in a separate hall.
In addition to Munich's four permanent food markets, there are also around 35 weekly markets and numerous independent fruit and vegetable merchants who purchase their fresh produce from the wholesale market.
The wholesale market also serves as a hub for daily grocery shopping, gastronomy and commercial kitchens. In addition, there are numerous companies, agencies, and authorities dealing with food for optimal business opportunities (cf. Stadt München 2023a).

Figure 41: View of the Wholesale Market

The wholesale market hall, designed by Richard Schachner, was built in 1912. This was followed in 1927 by the construction of the listed Kontorhaus 1. At that time, the area was still outside the city gates, taking into account the location requirements of the railway connection, the possibility of expansion, water law problems, etc. Since 1998, the city-owned company Markthallen München has been operating the wholesale market.

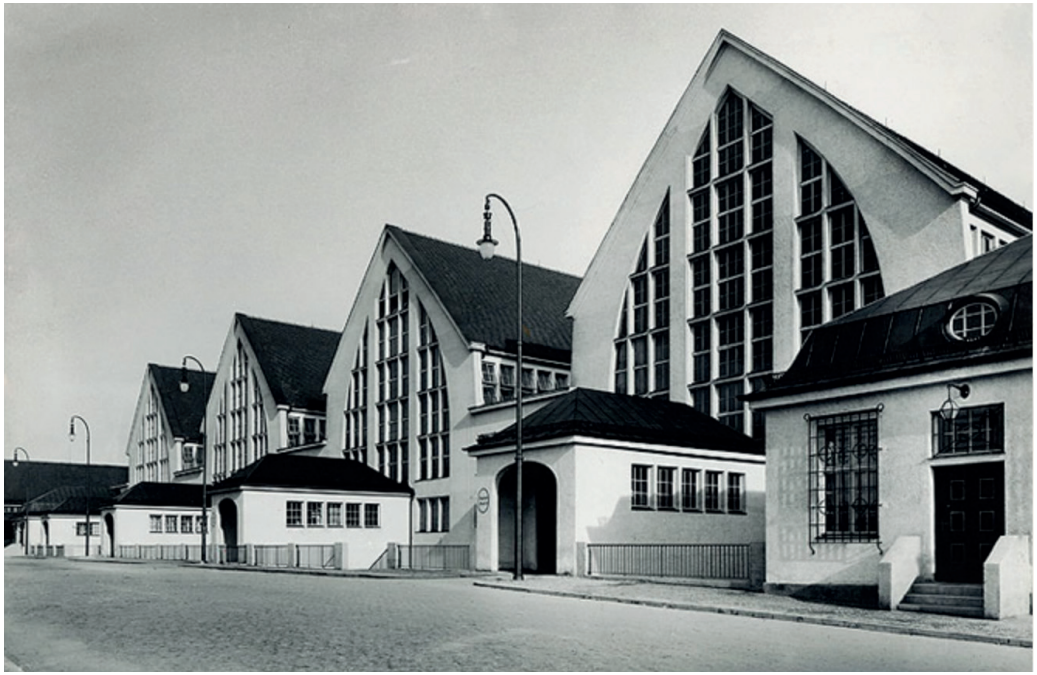


Figure 42: Wholesale Market Hall, 1912

Figure 43: Trading Hall II, 1915

0 Former main gate
1 Hall 1
2 Hall 2
3 Hall 3
4 Hall 4
5 Hall 5
6 Hall 6
7 Delicacies hall (former flower hall)
8 Hall 23
9 Hall 10
10 Gardeners‘ Hall
11 Row of shops (former potato hall)
12 Restaurant Großmarkthalle
13 Post office and workshop
14 Sorting facility
15 Fruit farm
16 Kontorhouse I
17 Kontorhouse II
18 Frozen food warehouse
19 Former transhipment hall (UGM II)
20 Former transhipment hall (UGM I)
21 Truck parking space
22 Company „Hausladen“ (banana ripening)
23 Transhipment hall (UGM III)
24 Flower wholesale market
25 Kontorhouse Brunthaler
26 Combined heat and power plant south (SWM)
27 Former station of the Isartal Railway
28 Alte Utting (old ship as a restaurant)

Historical monument

Figure 44: Programm of the wholesale market today

Figure 45: Wholesale Market Hall, today

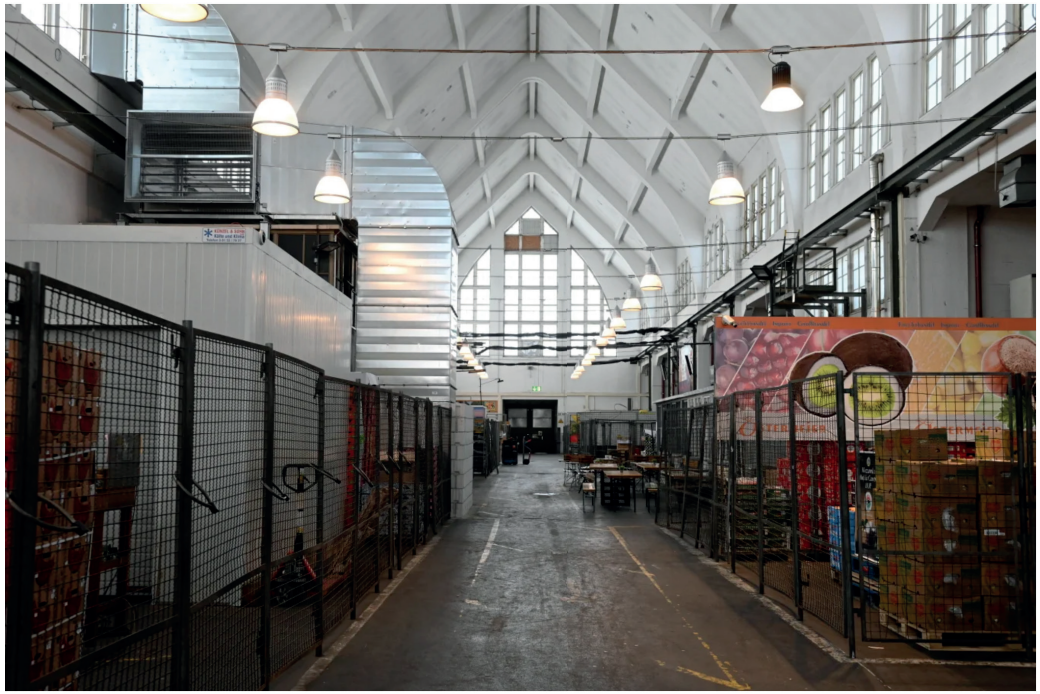


Figure 46: Trading Hall, today

Nevertheless, the historical building does not meet the requirements of a modern wholesale market hall in terms of structure, hygiene, and logistics. In response to the Munich City Council's decision to keep the market hall at its original location, the site will undergo a major reorganization, that includes the construction of a new and functional wholesale market hall as well as new residential and office space. The area with the existing wholesale market will be transformed into a sustainable, climate-resilient urban district with the strategies of water-sensitive urban development.

SITE ANALYSIS

The wholesale market in Munich is a mono-functional area in the middle of the Munich metropolis. It is located in a busy environment with mainly residential use and an active ground floor.
At the northern end of the area is the „Alte Utting“ (1). An old boat that has been converted into a popular bar and event location and is located on the old railway bridge. Access is currently not possible from the wholesale market area. Another cultural hotspot is located to the north, above the railway line called „The Bahnwährter Thiel“ an event location and magnet for artists that attracts many young people.
To the east of the area is the „Flaucher“ recreation area, which forms a large green corridor along the Isar. On the other hand, there is hardly any greenery or trees within the area.
The area is self-contained and can only be accessed via four gates. It is only accessible to the public during market opening hours. Within the area, there are hardly any, or no, cycle paths or footpaths, which makes it very difficult to move around among the lorry traffic. Apart from that, the area is easily reachable, both by public transport and by car. You can get to the city center within 10 minutes by bus or metro and the connections are very frequent.
Due to the mono-functionality of the area, it is very heavily sealed and offers hardly any infiltration possibilities. Along with that, the groundwater level is very high, and only a little water can be discharged directly into the groundwater.
Therefore, the wholesale market has problems with flooding and urban heat islands.

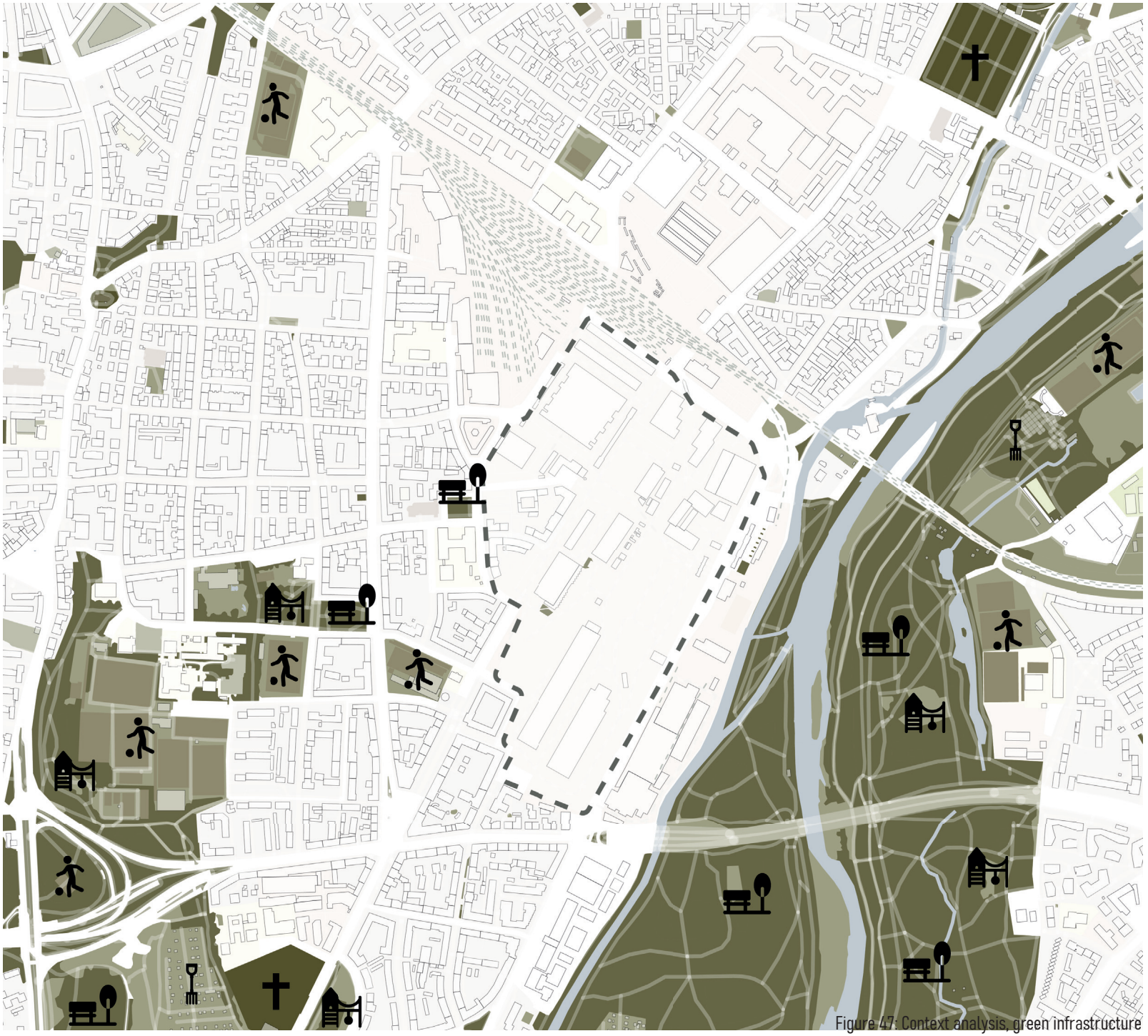


Figure 47: Context analysis, green infrastructure

+ Big park close by
+ Walking distance to the Isar
+ Sport facilities
- No green in the area

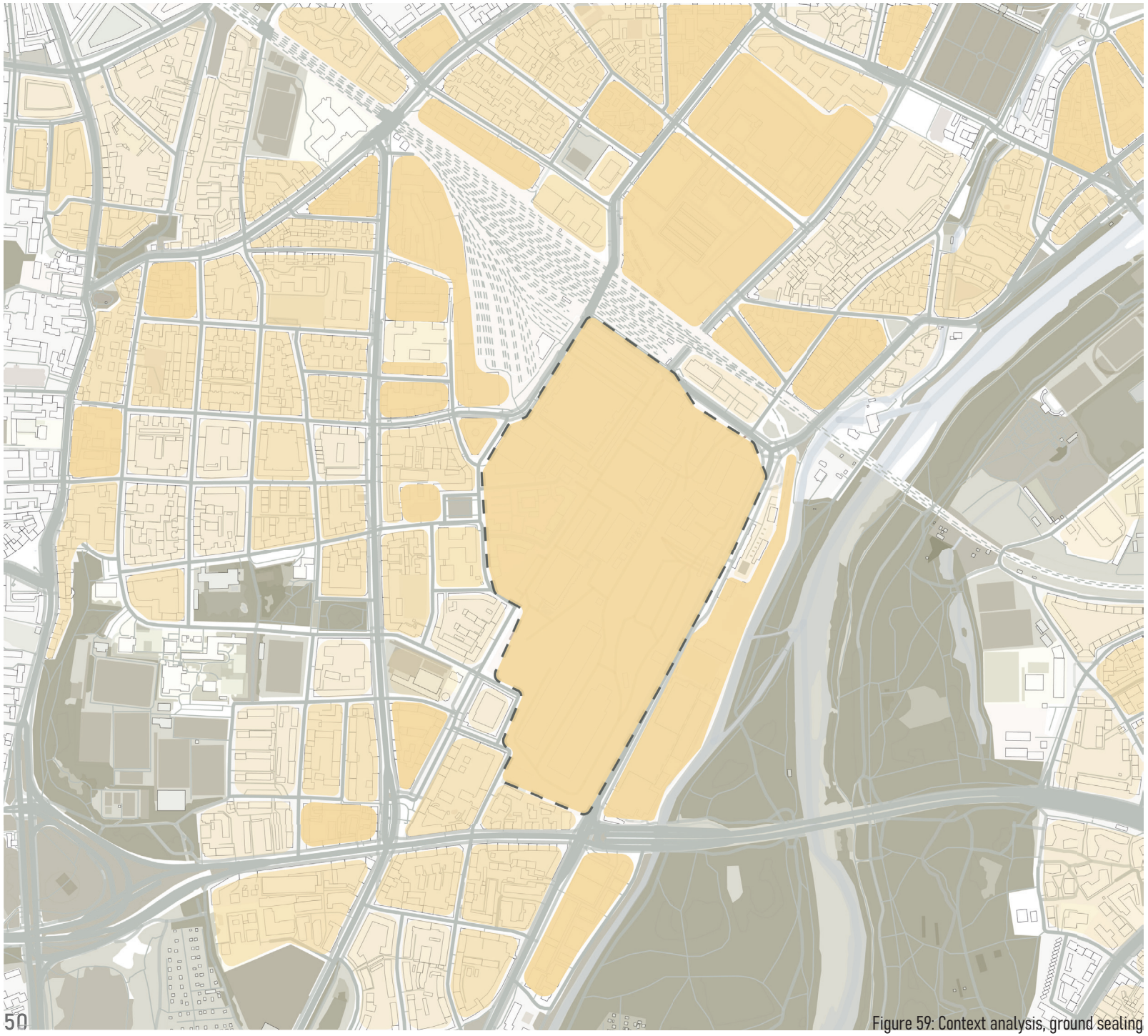
park

playground

sport

cemetery

allotment site



- Heavily sealed
- No permeable surfaces

ground sealing

90-100%

70-90%

50-70%

Figure 59: Context analysis, ground sealing

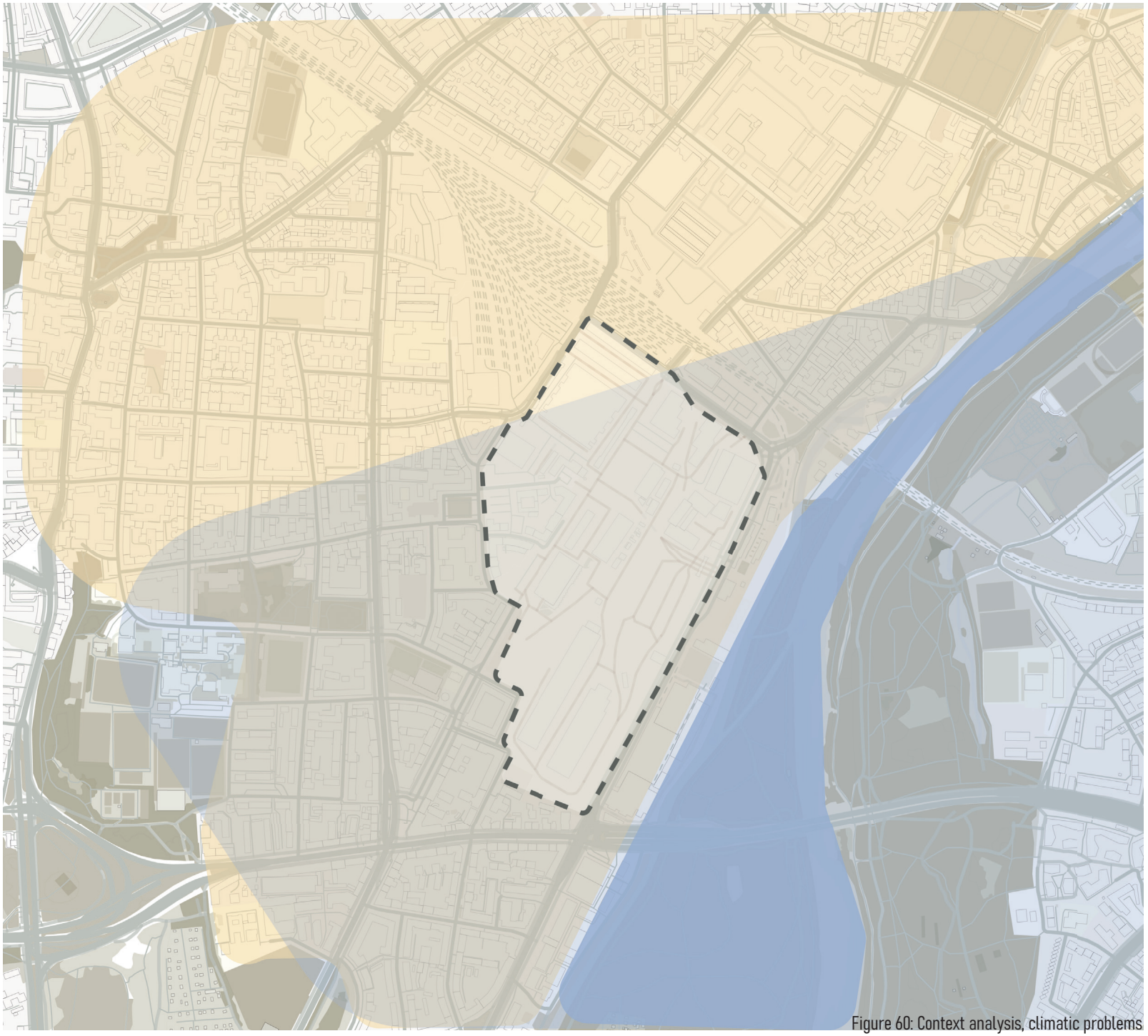
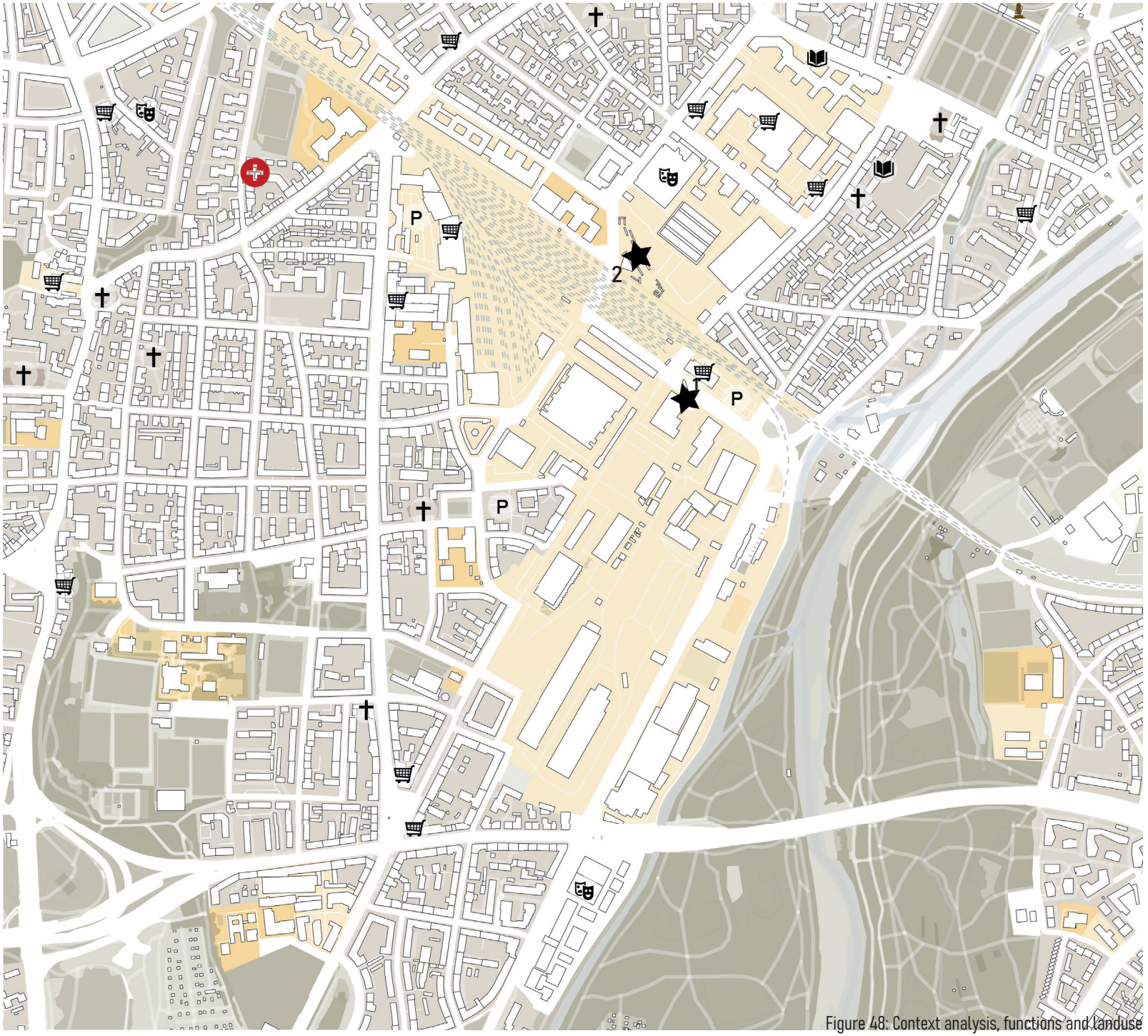


Figure 60: Context analysis, climatic problems

- Urban heat island
- Problems with infiltration due to high groundwater levels



+ Busy area
+ A lot of active ground floors
- Site is monofunctional

industry

education

residential/ mixed-use

special interest

grocery

bibliothek

hospital

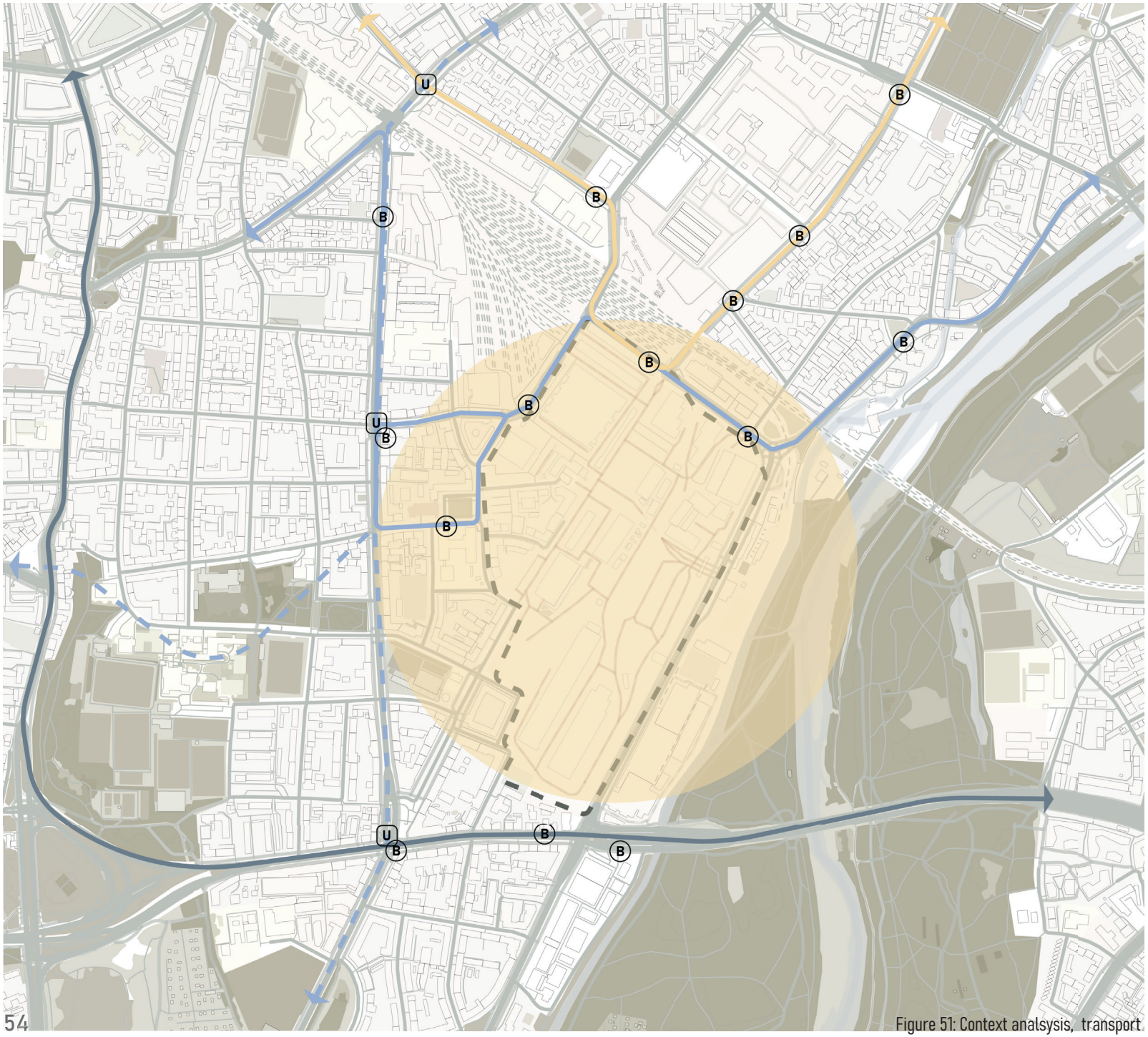
cultural

church

Figure 48: Context analysis, functions and landuse

Figure 49: 1 Alte Utting - Bar

Figure 50: 2 Bahnwärter Thiel - Event location and cultural hotspot



+ Good public transport connection
+ 10 min to city centre

U metro station

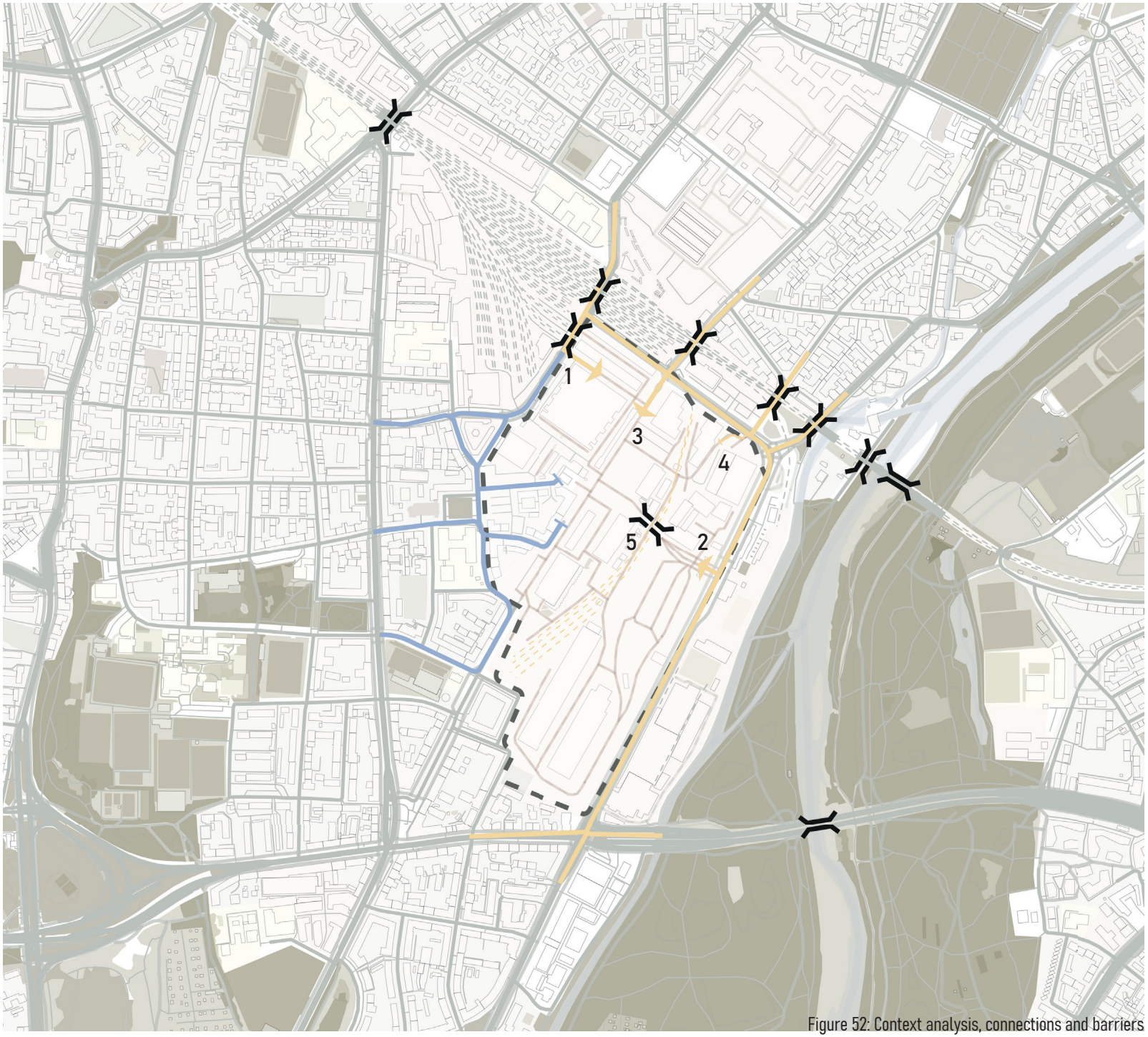
metro route

B bus station

bus route

5min walking distance (500m)

Figure 51: Context analsysis, transport



- Area is gated and not accessible for the public
- Barely no pedestrian side walks
- Not safe for biking or walking in the area
+ Good road connection in and to the area

under ground passage

bridge

main truck entrance

dead ends

old railway

Figure 52: Context analysis, connections and barriers

Figure 53: 1 Entrance at the Münchner Tafel e.V.

Figure 54: 2 Main entrance delivery

Figure 55: 3 Entrance Thalkirchenerstraße

Figure 56: 4 Entrance Lagerhausstraße

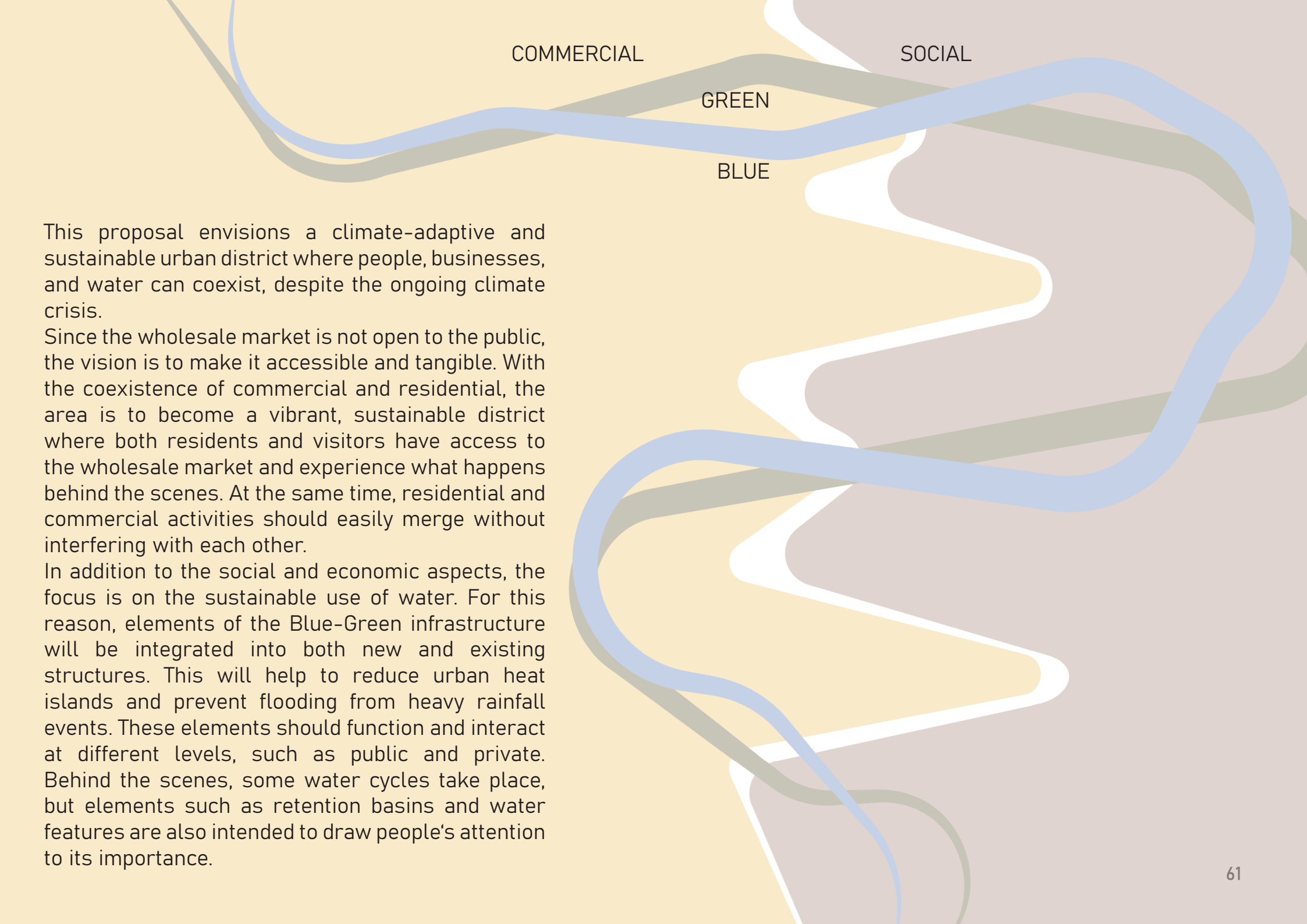
Figure 57: 5 Undersurpass in the area below the old railway line, west view

Figure 58: Undersurpass, east view

04

DESIGN

VISION

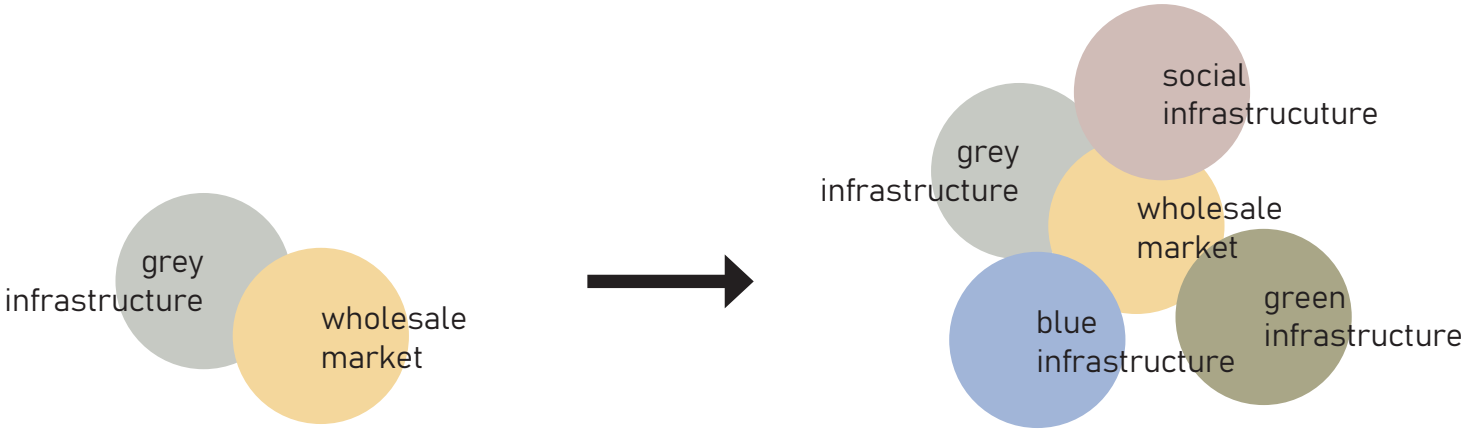


This proposal envisions a climate-adaptive and sustainable urban district where people, businesses, and water can coexist, despite the ongoing climate crisis.

Since the wholesale market is not open to the public, the vision is to make it accessible and tangible. With the coexistence of commercial and residential, the area is to become a vibrant, sustainable district where both residents and visitors have access to the wholesale market and experience what happens behind the scenes. At the same time, residential and commercial activities should easily merge without interfering with each other.

In addition to the social and economic aspects, the focus is on the sustainable use of water. For this reason, elements of the Blue-Green infrastructure will be integrated into both new and existing structures. This will help to reduce urban heat islands and prevent flooding from heavy rainfall events. These elements should function and interact at different levels, such as public and private. Behind the scenes, some water cycles take place, but elements such as retention basins and water features are also intended to draw people‘s attention to its importance.

STRATEGY



WHOLESALE MARKET
- Enhance and keep historical character
- Provide new and modernized market halls
- Support local markets
- Open up for the public

GREY INFRASTRUCTURE
- Keep the working truck network
- Make the streets safer

GREEN
- Decrease sealed surfaces
- Increase green space and permeable surfaces
- Provide more trees for shade and evaporation

BLUE
- Include retention space and green roofs
- Include elements for water recycling
- Making water tangible

SOCIAL
- Add new buildings for residential, commercial, and business use
- Enable safety on the streets by creating a walk and bike network
- Add public spaces and activities in the public realm to bring life outside

KEYWORDS

This are the guiding keywords and strageties for the blue-green infrastructure.

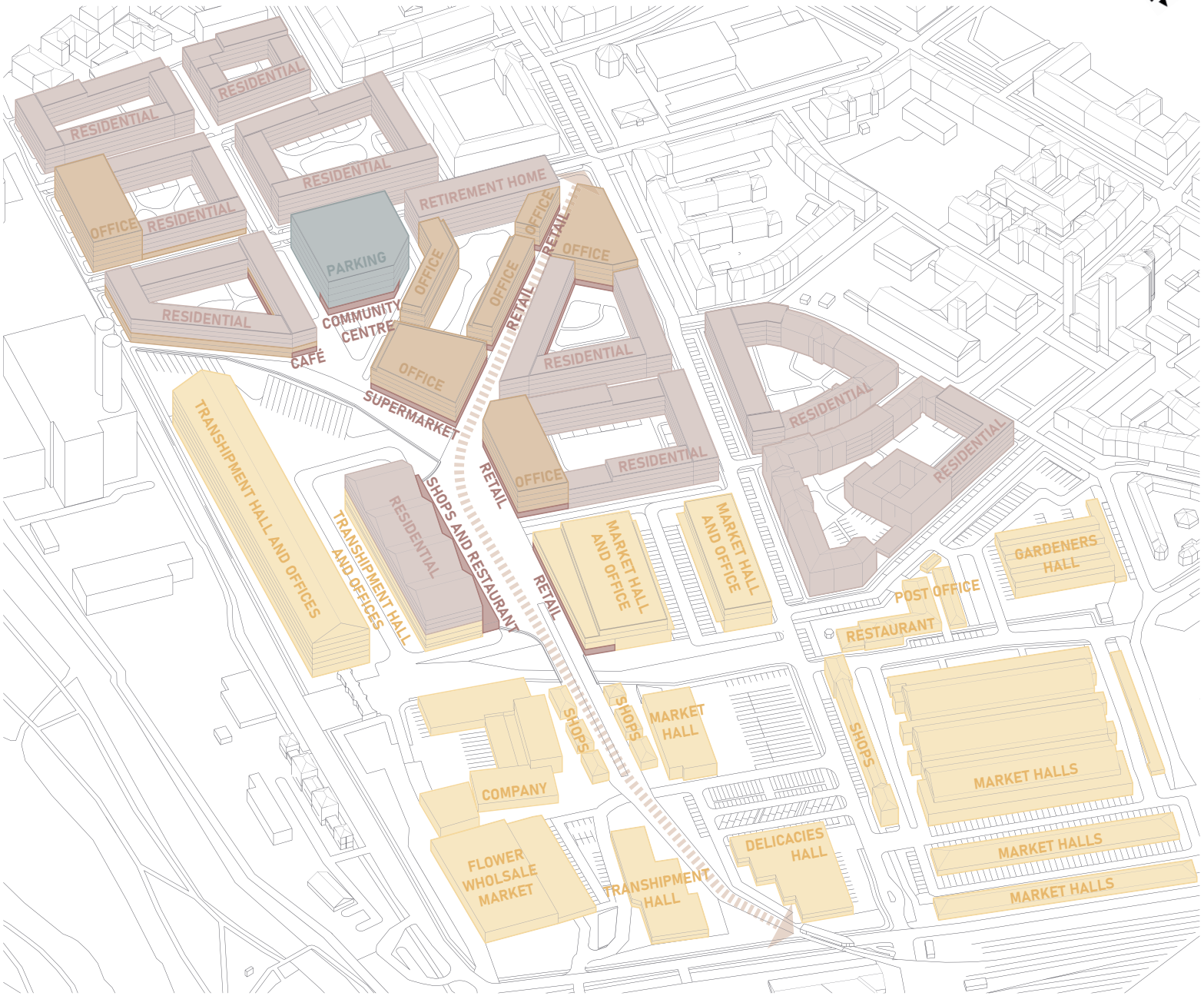
MASTERPLAN

A mixed-use quarter is being built on the newly developed wholesale market site in Munich, in which the old wholesale market will be largely retained. In place of the old buildings in need of renovation, new market halls, office buildings and new apartments for around 2700 people are being built. The concept is reinforced by a water-sensitive design, that will be integrated into both the new and the existing structures.

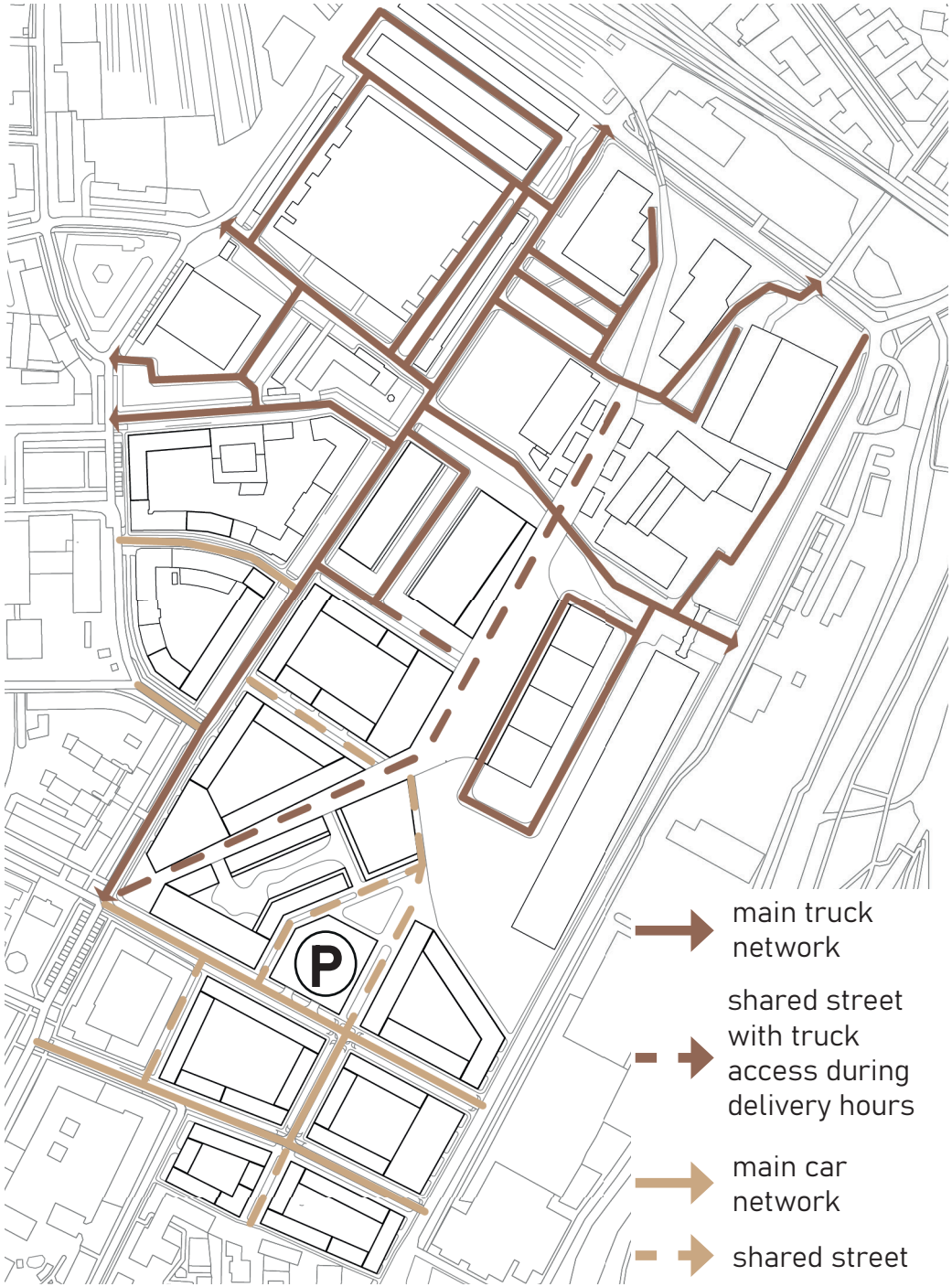
WHOLESALE MARKET

The wholesale market will be retained in its function and the buildings in need of renovation in the south will be replaced by new halls. The new large halls in the southeast are located at a lower level, so that truck traffic can continue to function independently of other activities. With their gable roofs, they are intended to be reminiscent of the old Kontor buildings to strengthen the historic character of the wholesale market.

The hall with the connection to the upper level is complemented with apartments on the upper floors. In conjunction with the main square, an annex with retail and gastronomy will enliven the square, and wholesale products can be marketed directly to local residents, creating a sustainable cycle.



Since it is complicated to combine private traffic and commercial traffic while ensuring the safety of people on the roads, the main delivery routes are separated from normal roads. In this way, delivery traffic can continue without restriction on the main access routes. The promenade, that runs through the area, is open to delivery traffic at certain times, otherwise, it is a traffic-free zone for pedestrians and cyclists.
In the area of residential use, there are both normal roads with additional sidewalks and cycle paths, and shared streets that can only be used by cars when necessary to reduce traffic.
In order to support sustainable mobility, there is a central Mobility Hub, which, in addition to parking spaces for the neighborhood, also provides various sustainable mobility alternatives, such as cargo bikes, car sharing, e-scooters, etc.

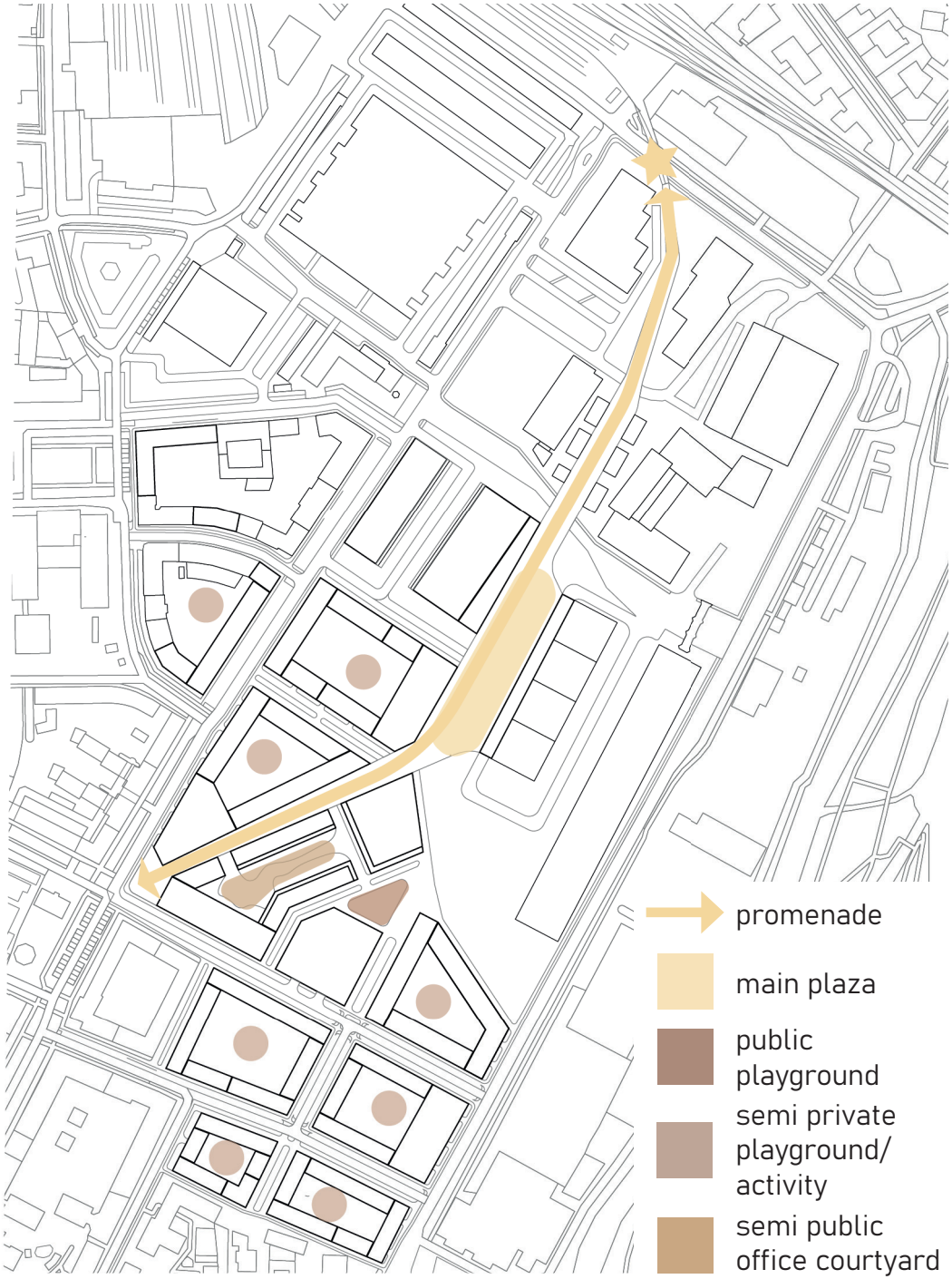


1 | WHOLESALE MARKET MEETS LIFE

SOCIAL INFRASTRUCTURE

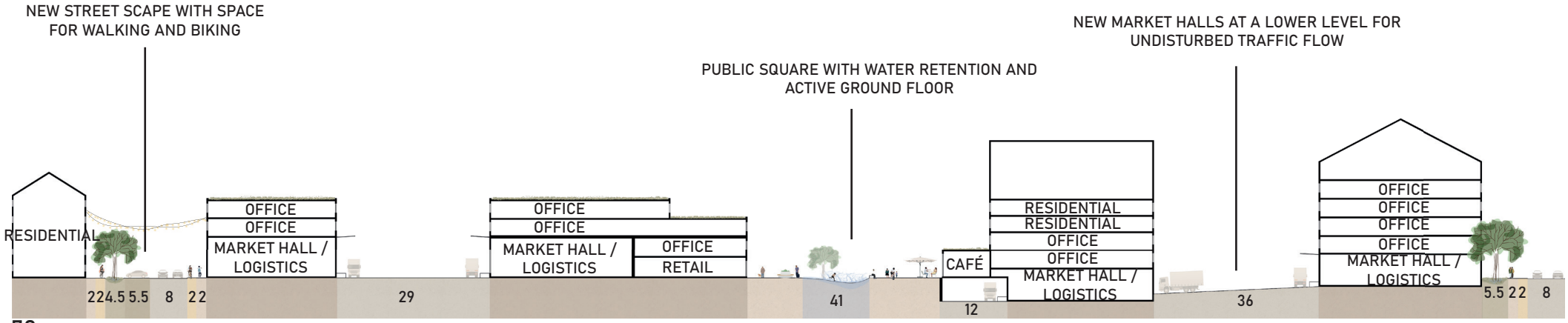
The basic module to enable mixed-use and strengthen social infrastructure is to achieve everything you need for daily life in the immediate vicinity. Therefore, a well-developed network of foot paths and cycle paths is indispensable. Since there were little or no footpath or cyclepaths before, a new network was formed, that covers the most important routes and allows people to move safely on the roads and in the traffic.
To strengthen this, there are mixed streets, as well as the promenade where pedestrians and cyclists have priority.

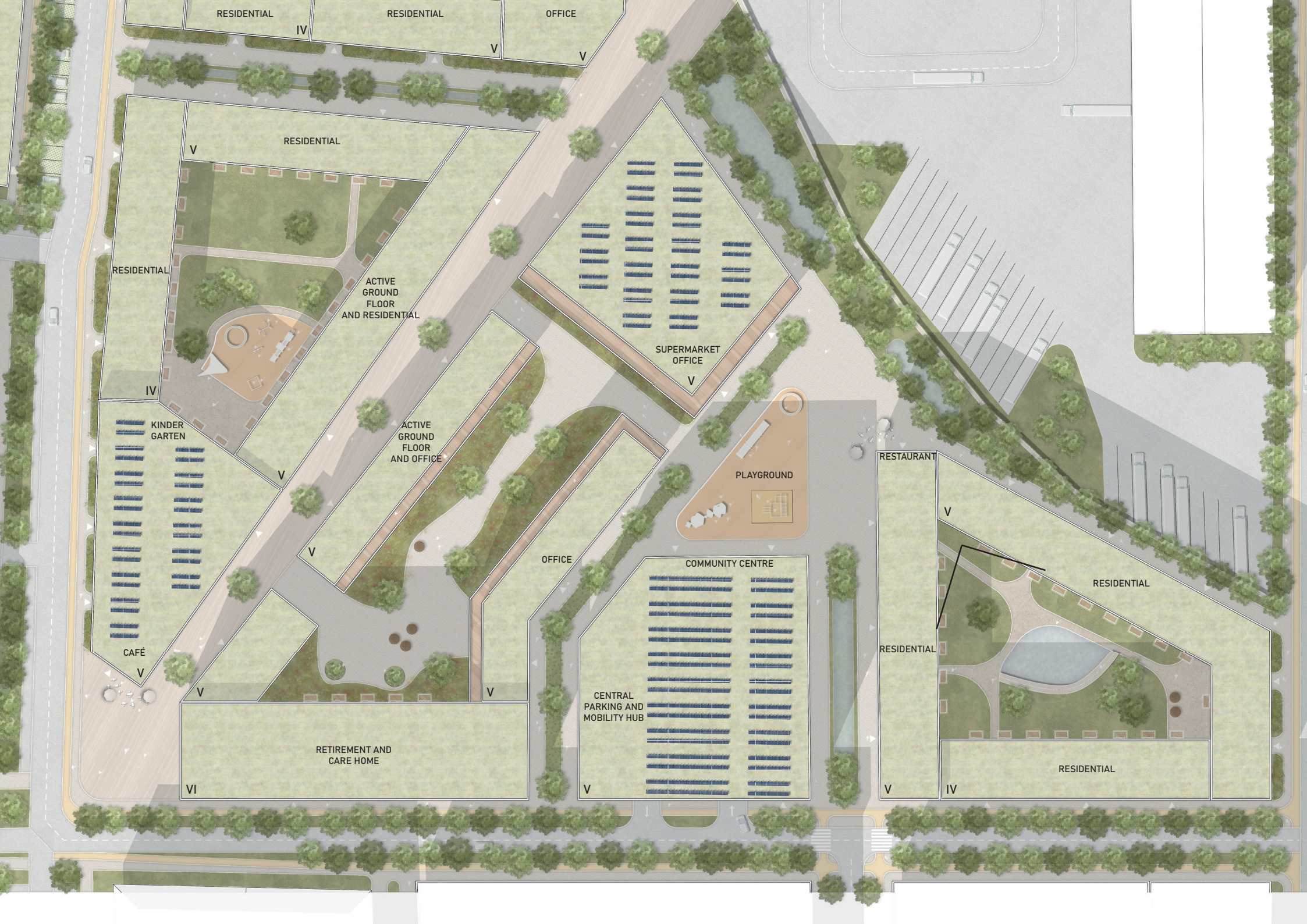
To establish the social aspect of mixed-use, various leisure facilities are needed, both indoors and outdoors.
The block structure in the south has created rather private courtyards, that can be used by residents for a variety of purposes. Each courtyard is designed differently but also offers space for free design and creativity of use.
The somewhat more open inner courtyard in the area of the office buildings, which include a mix of Co-working spaces and Office rooms for rent, and the retirement home, offers visitors to the retirement home as well as for the workers‘ lunch break a place to stay between grasses and flower meadows.
Adjacent to the Community Center and the Mobility Hub is a playground with calisthenics, a climbing block, and various seating options as a central meeting place.
The promenade, that runs through the area, connects the existing attraction: the boat „Alte Utting“, which is used as a bar, with the main square in the area and the residential area adjacent to the south.
The aim is to strengthen the social infrastructure and create a quick connection between the various places to stay.
The main square serves as a link between the wholesale market and the residential area, where you can watch the trade from above in the lower halls or even buy fruits and vegetables in the new small shops or the large supermarket. The square also offers space for exchange and lingering, whether at the water feature or in a café.



SECTION BEFORE

SECTION AFTER




RESIDENTIAL
IV
RESIDENTIAL
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OFFICE
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ACTIVE GROUND FLOOR AND RESIDENTIAL
IV
SUPERMARKET
OFFICE
V
KINDER GARTEN
V
ACTIVE GROUND FLOOR AND OFFICE
V
PLAYGROUND
RESTAURANT
V
OFFICE
COMMUNITY CENTRE
RESIDENTIAL
CAFÉ
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CENTRAL PARKING AND MOBILITY HUB
RESIDENTIAL
RETIREMENT AND CARE HOME
VI
V
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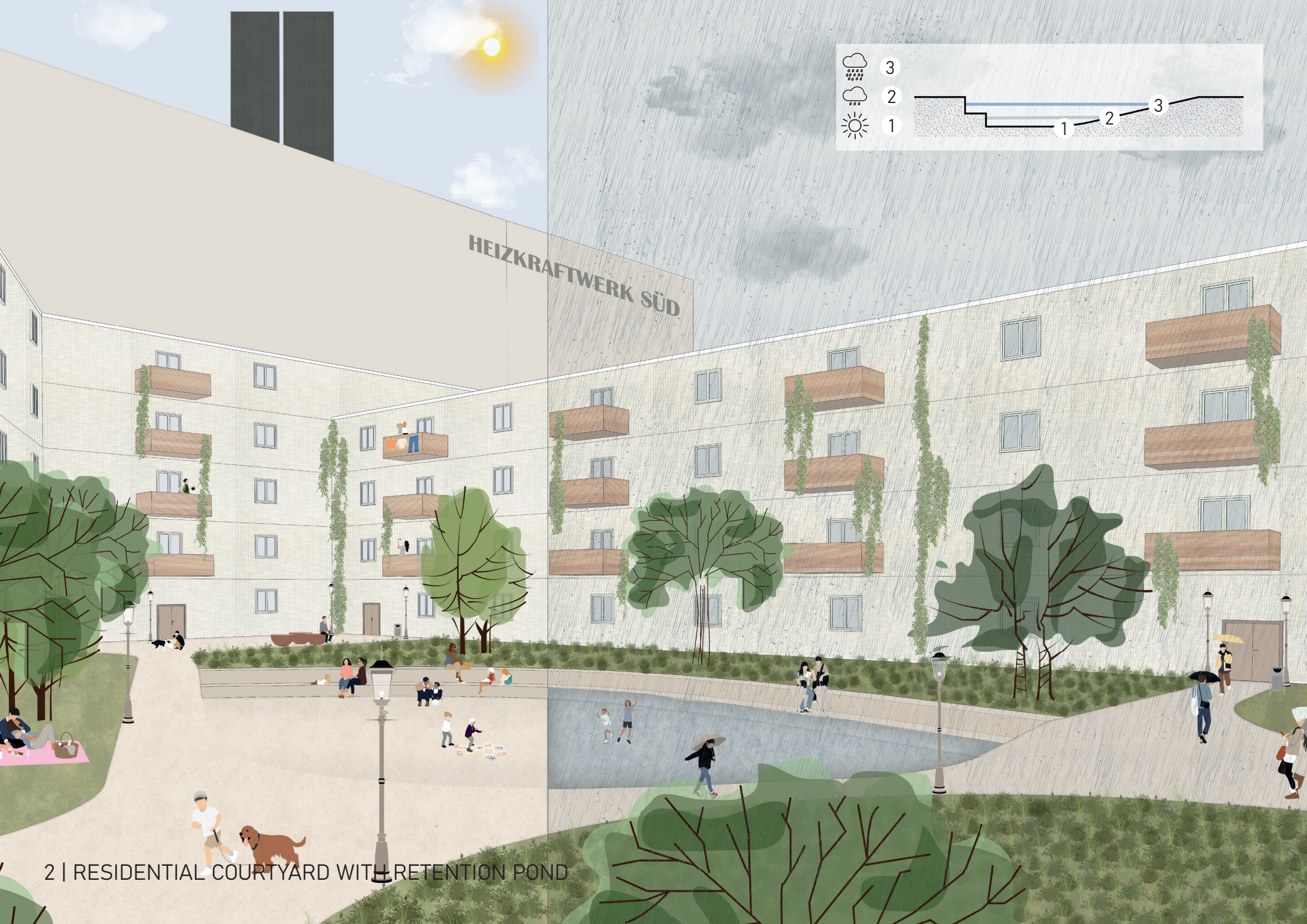
RESIDENTIAL
IV



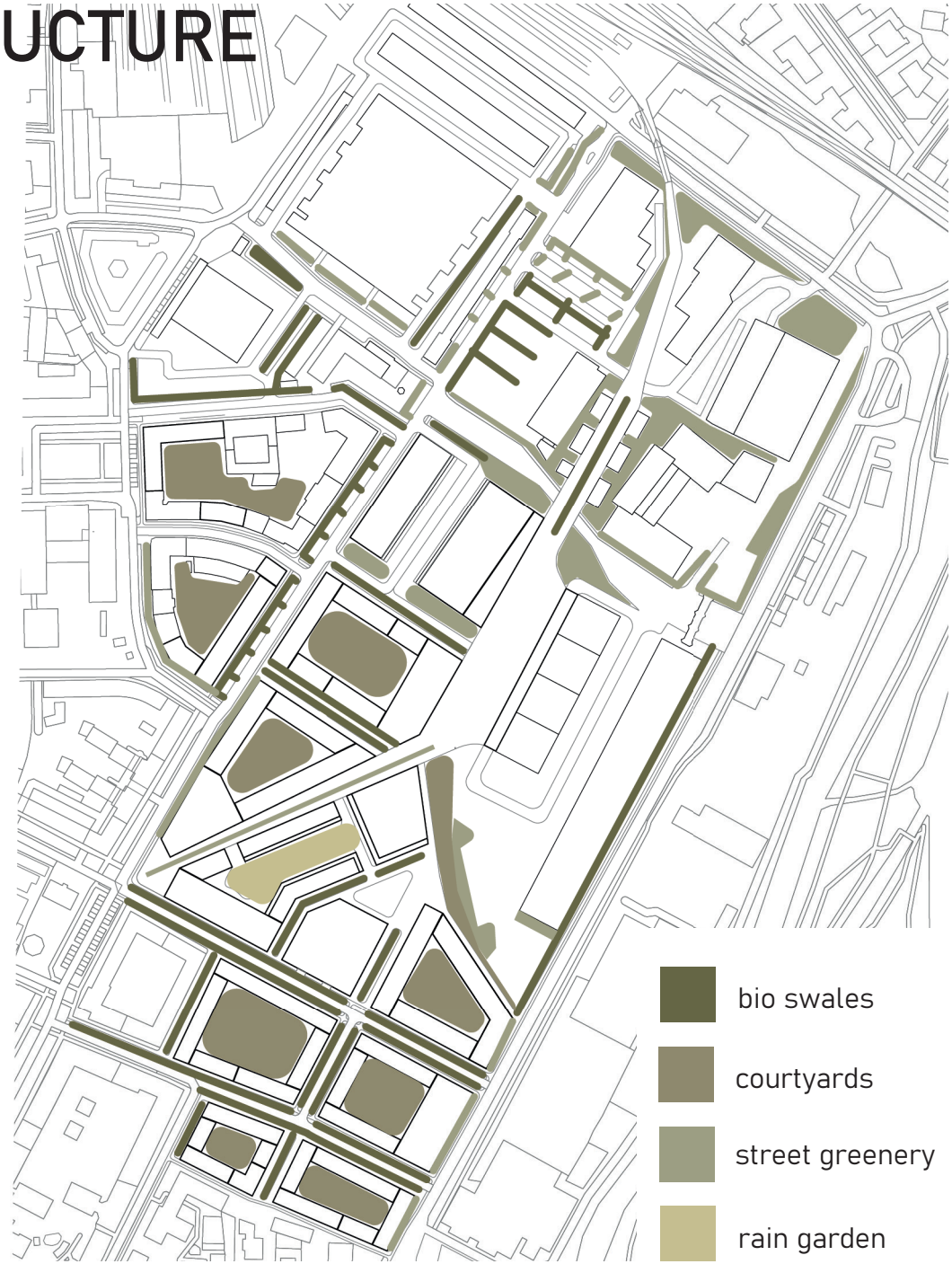
2 | RESIDENTIAL COURTYARD WITH RETENTION POND

BLUE AND GREEN INFRASTRUCTURE

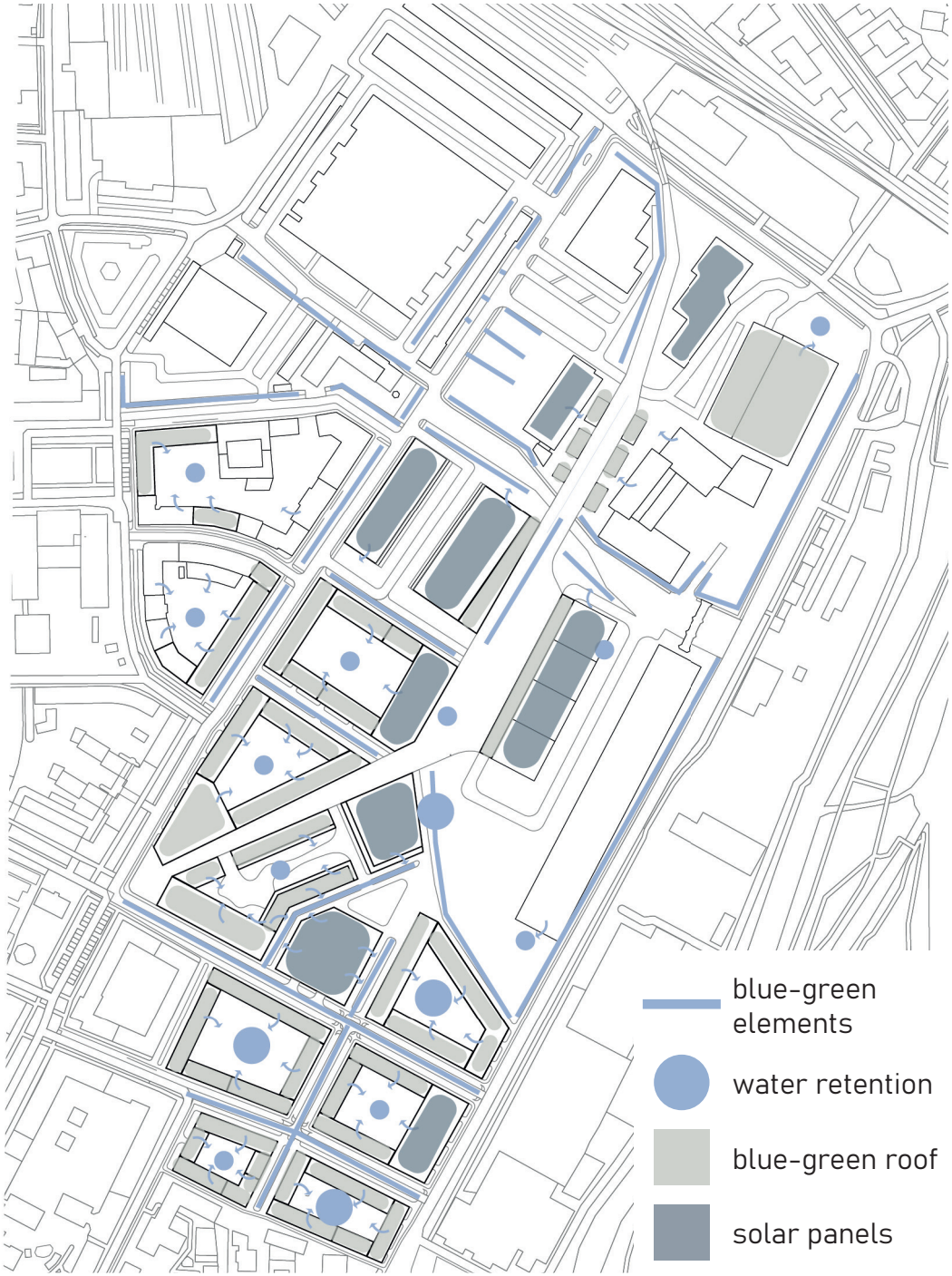
The proportion of greenery in the area is currently 5-10%, which has a negative impact on both biodiversity and microclimate. That is why, a new green network is being created. In the area of the wholesale market, the street space is complemented by bioswales and trees, which provide shade and cooling. Likewise, the existing greenery will be complemented by new trees.

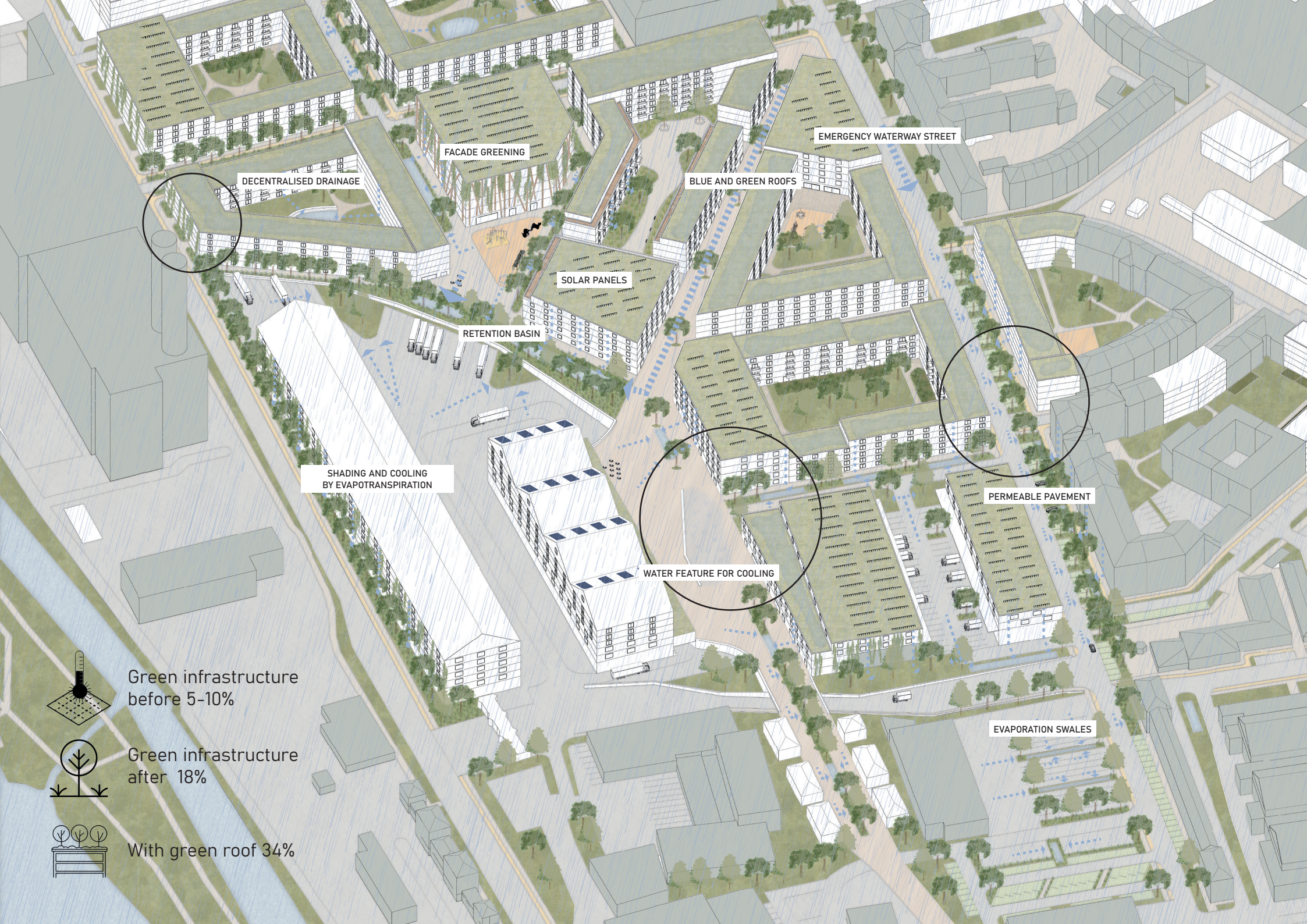
In the new development to the south, bioswales will also be integrated into the new streetscapes, and green inner courtyards will be designed.

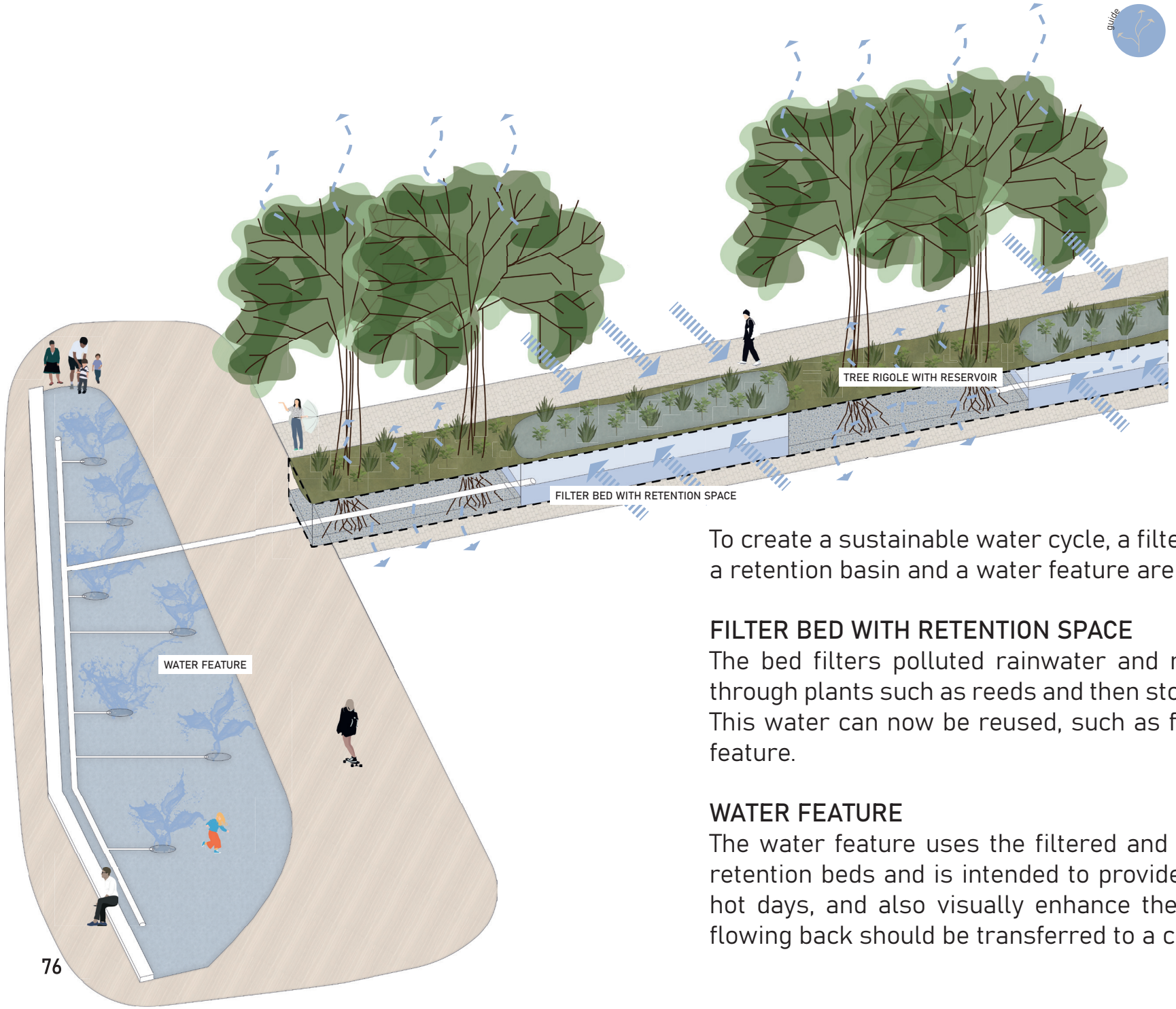
In order to maximize the proportion of greenery in the area, green roofs are also located on all flat roofs. This increases the new proportion of green space in the region to 34%.



The wholesale market was a heavily sealed area before the transformation and had problems with heat islands and flooding during heavy rainfall.
Since the groundwater level in this area is slightly higher, there is not much room for infiltration of precipitation water.
To counteract these problems, a decentralised drainage network is being created.
Various elements of the blue infrastructure will be installed in the area, which will help to store or evaporate as much water as possible during heavy rainfall to relieve the sewer system, and the groundwater.
This includes elements for retention and detention of stormwater for short-term storage or reuse, as well as elements for evaporation of water and cooling of the air for the microclimate.
The decentralised network includes retention functions in each courtyard, as well as various evaporation/infiltration swales along the streetscapes.
In order to utilize as much area as possible, blue-green roofs are laid on the roofs of the new buildings, which also have storage for short-term water retention.
Moreover, office and retail buildings are equipped with solar panels to minimize their energy consumption as part of strengthening the sustainable cycle.
In the following, the most important elements are described and illustrated in more detail.




FACADE GREENING
DECENTRALISED DRAINAGE
SOLAR PANELS
RETENTION BASIN
SHADING AND COOLING
BY EVAPOTRANSPIRATION
EMERGENCY WATERWAY STREET
BLUE AND GREEN ROOFS
PERMEABLE PAVEMENT
WATER FEATURE FOR COOLING
EVAPORATION SWALES
Green infrastructure
before 5-10%
Green infrastructure
after 18%
With green roof 34%



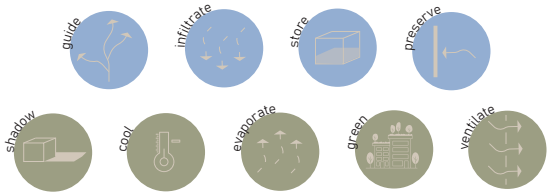
To create a sustainable water cycle, a filter bed in combination with a retention basin and a water feature are used in this street space.

FILTER BED WITH RETENTION SPACE

The bed filters polluted rainwater and runoff from the buildings through plants such as reeds and then stores it in a retention basin. This water can now be reused, such as for the trees or the water feature.

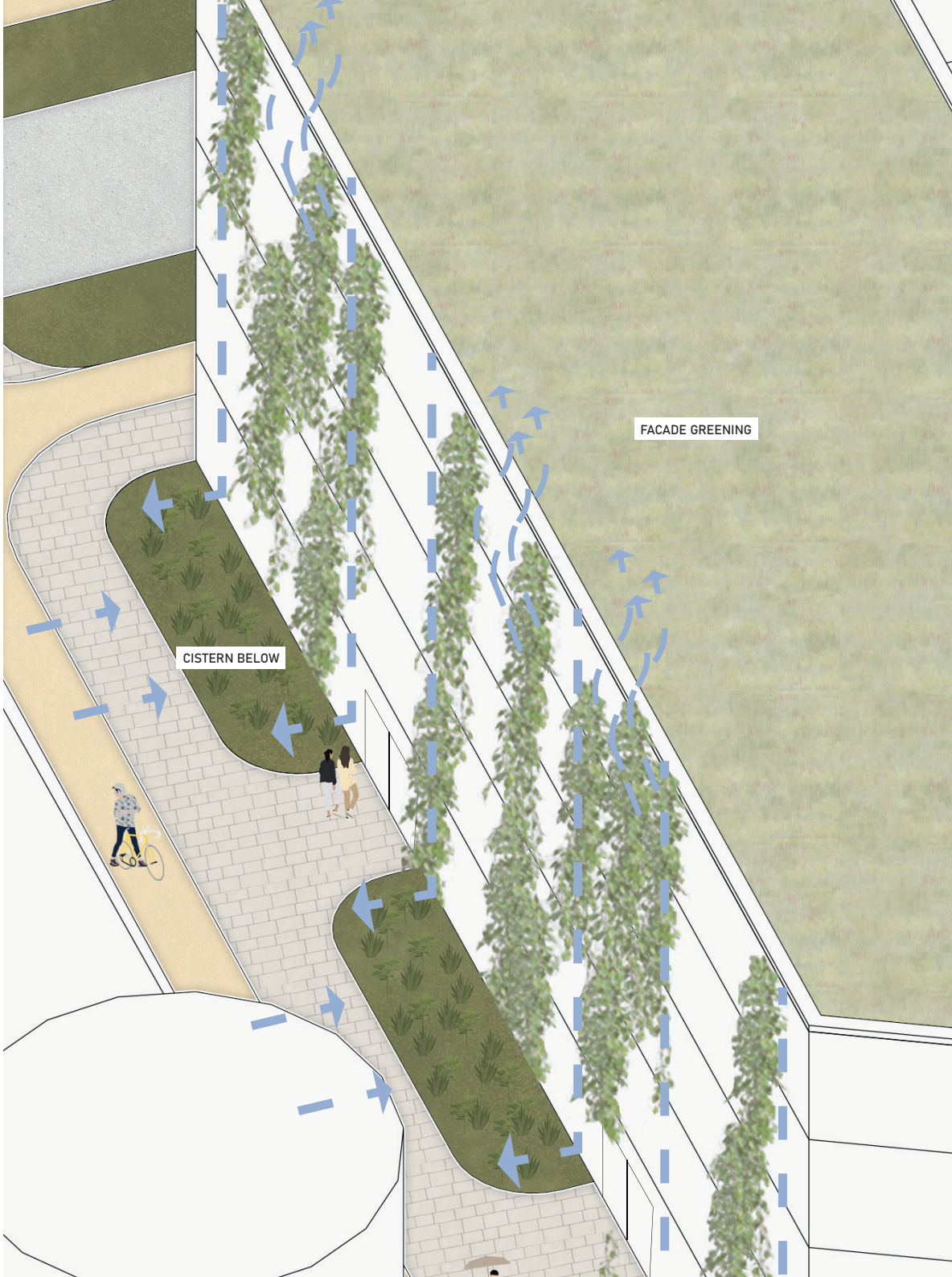
WATER FEATURE

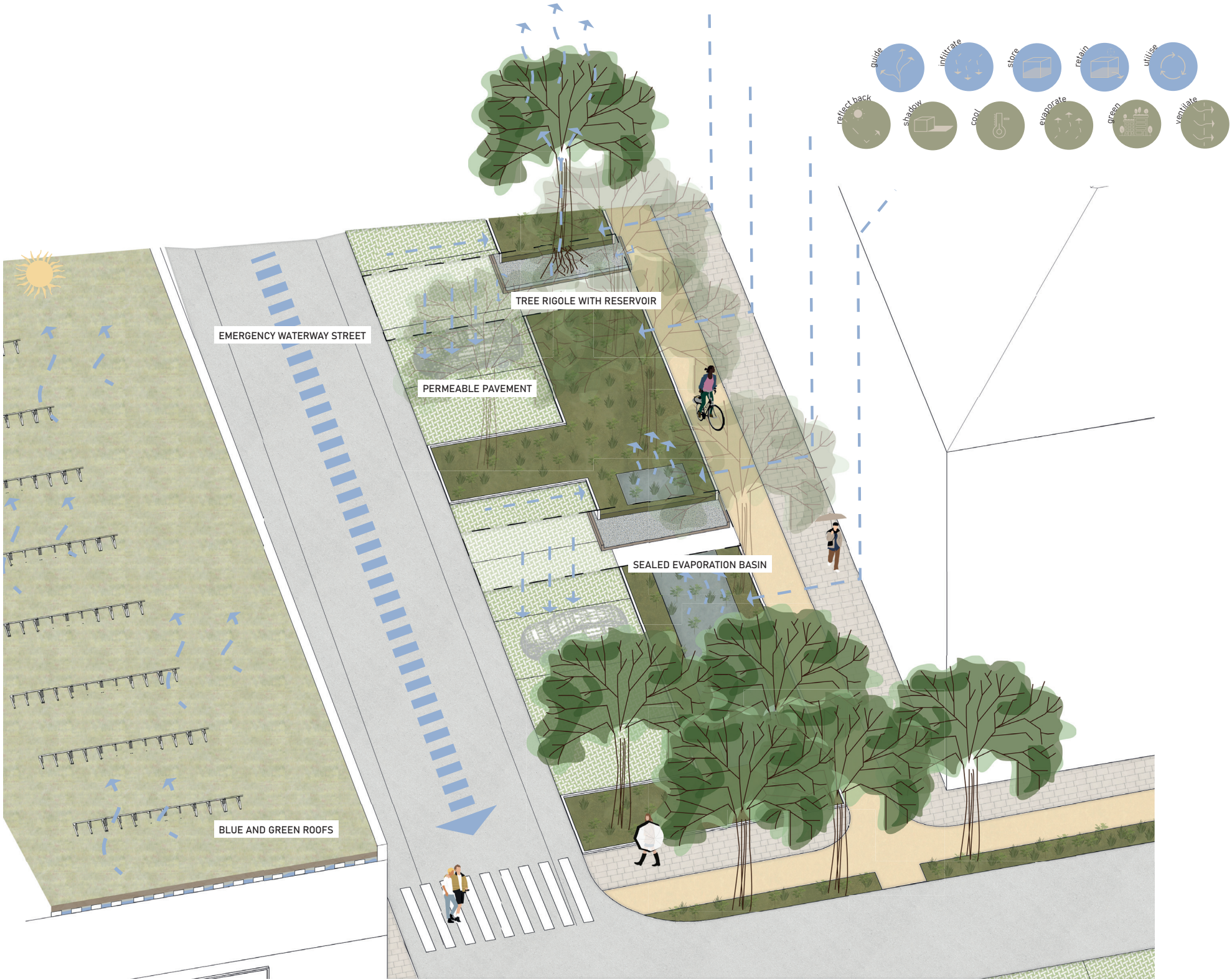
The water feature uses the filtered and collected water from the retention beds and is intended to provide cooling for residents on hot days, and also visually enhance the environment. The water flowing back should be transferred to a circuit to be reused.



FACADE GREENING

The facade greenery purifies the air and helps to regulate temperatures in the building.
The run-off water from the roof and the greenery can be stored in cisterns under the greenery and then used elsewhere.
Furthermore, facade greening also serves to protect against noise and is therefore well suited in the area with truck traffic.




guide
infiltrate
store
retain
utilise
reflect back
shadow
cool
evaporate
green
ventilate
TREE RIGOLE WITH RESERVOIR
EMERGENCY WATERWAY STREET
PERMEABLE PAVEMENT
SEALED EVAPORATION BASIN
BLUE AND GREEN ROOFS

These water-sensitive elements help to reduce local pressure on the canal system and also provide cooling and water for plants during dry periods.

BLUE AND GREEN ROOFS

These roofs help stabilize temperatures inside the building through evaporation and shading. In the event of heavy rainfall, the drainage layer absorbs water and the artificial storage space can retain water and drain it into the sewage system at a reduced rate.

EMERGENCY WATERWAY STREET

This system is used in areas with high densification. Since there are still many sealed surfaces in the area of the wholesale market, despite greening, the emergency waterway helps with targeted retention and emergency drainage in the street space.

PERMEABLE PAVEMENT

In the parking lot area, permeable paving helps to absorb rainwater and allow it to percolate over large areas. This avoids overloading the local sewer system.

TREE RIGOLE WITH RESERVOIR

The tree trench absorbs water from adjacent buildings or streets. Due to the silty subsoil, the infiltration trench can store water and is available to the trees during dry periods.

SEALED EVAPORATION BASIN

Here, pollutants can be filtered out of the water and then stored to be available for the plants during dry periods, as is the case with the tree rigole. In addition, the bioswales have a positive effect on flora and fauna and blend aesthetically into the cityscape.

05

CONCLUSION

Referring back to the research question “How can an efficient blue-green infrastructure as well as social infrastructure be maintained and integrated even in growing, denser cities?”, this work illustrates, using the example of the wholesale market in Munich, that a sustainable neighborhood can be created through a mix of uses and the implementation of various elements of blue-green infrastructure in existing and new structures.
Through a mix of uses, the existing industries and businesses can be preserved and supplemented with new uses, such as housing and offices. With further addition of social structures such as recreation areas, various activities, workplaces, and a good network of walking and cycling paths, a social mix can be achieved.
In order to also counteract the problems that arise from urban densification, various elements of Blue-Green infrastructure have been implemented in both existing and new construction. In existing structures, the elements can best be integrated into the streetscape by reducing the driving surface and creating space for green elements. In the newly constructed area, various elements are used to achieve decentralized drainage and to hold back as much water as possible to prevent flooding and overflow of the sewer systems during heavy rainfall. These help avoid urban heat islands and create a better microclimate in the city.
To sum up, this project should be an incentive for future restructuring of existing structures and how to redesign them in a more sustainable way.

06

BIBLIOGRAPHY

WRITTEN SOURCES

Bayerisches Landesamt für Statistik (2023): München ist die Pendlerhauptstadt Deutschlands. Available online at: https://www.statistik.bayern.de/presse/mitteilungen/2023/pm099/index.html (Access: 20 August 2023).

BlueGreenStreets (2022): BlueGreenStreets Toolbox - Teil B. Multifunktionale Straßenraumgestaltung urbaner Quartiere.

Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz BMUV (2016): Nachhaltige Stadtentwicklung. Available online at: https://www.umwelt-im-unterricht.de/hintergrund/nachhaltige-stadtentwicklung#:~:text=Nachhaltige%20Stadtentwicklung%20bedeutet%2C%20dass%20bei,Soziales%20sowie%20Kultur%20und%20Umwelt. (Access: 08 July 2023).

Deutscher Wetterdienst (2023a): Extremwetterereignis. Available online at: https://www.dwd.de/DE/service/lexikon/Functions/glossar.html?nn=103346&lv2=100652&lv3=100780 (Access: 24 July 2023).

Deutscher Wetterdienst (2023b): Städtische Wärmeinsel. Available online at: https://www.dwd.de/DE/service/lexikon/Functions/glossar.html?lv2=102248&lv3=744502 (Acess: 15 June 2023).

Deutscher Wetterdienst (2023c): Starkregen. Available online at: https://www.dwd.de/DE/service/lexikon/Functions/glossar.html?nn=103346&lv2=102248&lv3=102572 (Access: 27 July 2023).

Dr. Deschermeier, Philipp; Henger, Ralph (2020): Größer wohnen. Available online at: https://www.iwd.de/artikel/groesser-wohnen-489720/ (Access: 02 August 2023).

EEC Environmental (2023): What Is Stormwater Management and Why Is It Important?. Available online at: https://eecenvironmental.com/what-is-stormwater-management/ (Access: 03 August 2023).

Forlati, Silvia; Peer, Christian (2017): Mischung: Possible! Wege zur zukunftsfähigen Nutzungsmischung. 2. Auflage. Wien.

Freie und Hansestadt Hamburg, Behörde für Umwelt und Energie BUE (2023): Dachbegrünung Leitfaden zur Planung. Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.hamburg.de/contentblob/10603292/c6eb1f159c491cfd8c7188f77b0dd277/data/d-leitfaden-dachbegruenung.pdf (Access 10 August 2023).

Georgetown Climate Center (2023): Green Infrastructure Toolkit. Available online at: https://www.georgetownclimate.org/adaptation/toolkits/green-infrastructure-toolkit/introduction.html (Access: 11 July 2023).

IPCC (2021): IPCC Factsheet - What is the IPCC? Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ipcc.ch/site/assets/uploads/2021/07/AR6_FS_What_is_IPCC.pdf (Access: 08 July 2023).

Landeshauptstadt München Referat für Gesundheit und Umwelt (2016): Konzept zur Anpassung an die Folgen des Klimawandels in der Landeshauptstadt München. Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://stadt.muenchen.de/dam/jcr:8eb68d50-5c21-4948-92ae-62fa129ab566/bericht_klwa_10_2016.pdf (Access: 13 July 2023).

Landeshauptstadt München Referat für Stadtplanung und Bauordnung (2022): Wohnungsbauatlas für München und die Region. Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://stadt.muenchen.de/dam/jcr:7aa34193-f9d5-417a-9201-885a55ec20d8/LHM_Wohnungsbauatlas_2022_web.pdf (Access: 02 August 2023).

Landeshauptstadt München Referat für Stadtplanung und Bauordnung I/22 (2023): Demografiebericht München - Teil 1. Analyse 2022 und Bevölkerungsprognose 2023 bis 2040 für die Landeshauptstadt. Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://stadt.muenchen.de/dam/jcr:934018c0-0a9e-47a2-aea6-0dafcf829ea8/LHM_Demografiebericht-Teil1_2023.pdf (Access: 03 August 2023).

Kleerekoper, Laura; van Esch, Marjolein; Baldiri Salcedo, Tadeo (2012): How to make a city climate-proof, addressing the urban heat island effect. In: Resources, Conservation and Recycling. Nr. 64, p. 30-38.

Stadt München (2023a): Großmarkt. Available online at: https://stadt.muenchen.de/infos/grossmarkt.html (Access: 16 June 2023).

Stadt München (2023b): Hitze und Gesundheit. Available online at: https://stadt.muenchen.de/infos/hitze-gesundheit.html (Access: 27 June 2023).

Stadt München (2023c): Nachhaltige Stadtentwicklung in München. Available online at: https://stadt.muenchen.de/infos/nachhaltige-stadtentwicklung-muenchen.html (Access: 14 July 2023).

Statista (2023): Städte mit den höchsten Mietpreisen für Wohnungen in Deutschland im 2. Quartal 2023. Available online at: https://de.statista.com/statistik/daten/studie/1885/umfrage/mietpreise-in-den-groessten-staedten-deutschlands/ (Access: 20 August 2023).

Süddeutsche Zeitung (2023): Gefährliche Hitze. Available online at: https://www.sueddeutsche.de/muenchen/klimawandel-in-muenchen-gefaehrliche-hitze-1.3259851 (Access 01 August 2023).

United Nations (2023): What is Climate Change? Available online at: https://www.un.org/en/climatechange/what-is-climate-change (Access: 06 July 2023).

IMAGES

All artwork, images and visualizations are created by the author, unless stated otherwise.

Figure 1: Own illustration by author, adapted from World Meteorological Organization (2023): Urban heat island. Available online at: https://community.wmo.int/en/activity-areas/urban/urban-heat-island (Access: 17 July 2023).

Figure 2-8: Own illustration by author, adapted from Kleerekoper, Laura; van Esch, Marjolein; Baldiri Salcedo, Tadeo (2012): How to make a city climate-proof, addressing the urban heat island effect. In: Resources, Conservation and Recycling. Nr. 64, p. 30-38.

Figure 9: Süddeutsche Zeitung (2023): Stadtplanung Heiße Nächte. Available online at: https://www.sueddeutsche.de/projekte/artikel/wissen/stadtplanung-hitze-metropole-e121234/ (Access: 15 August 2023).

Figure 10: Süddeutsche Zeitung (2016): Gefährliche Hitze. Available online at: https://www.sueddeutsche.de/muenchen/klimawandel-in-muenchen-gefaehrliche-hitze-1.3259851 (Access 01 August 2023).

Figure 11: Süddeutsche Zeitung (2023): Klimawandel. Wenn es regnet, schüttet es. Available online at: https://www.sueddeutsche.de/projekte/artikel/wissen/wie-starkregen-klimawandel-hochwasser-zusammenhaengen-e327797/ (Access 15 August 2023).

Figure12: Süddeutsche Zeitung (2023): Deutschland im Jahr 2050. Eine Reise in die Klimazukunft. Available online at: https://www.sueddeutsche.de/projekte/artikel/wissen/klimawandel-in-deutschlands-zukunft-starkregen-hitze-duerre-e884175/ (Access: 15 August 2023).

Figure 13: Own illustration by author, adapted from Melbourne water (2023) Impacts of stormwater on waterways. Available online at: https://www.melbournewater.com.au/building-and-works/stormwater-management/introduction-wsud (Access: 13 July 2023).

Figure 14: Own illustration by author, adapted from U.S.-China CEO Council for Sustainable Urbanization (2017): Sustainable Urban Planning Principles. Available online at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://www.paulsoninstitute.org/wp-content/uploads/2017/12/Sustainable-Urban-Planning_EN_vF.pdf (Access: 24 July 2023).

Figure 15: Own illustration by author, adapted from bgmr Landschaftsarchitekten (2023): Prinzip Schwammstadt. Available online at: https://www.bgmr.de/de/projekte/StepKlimaKonkret (Access: 14 August 2023).

Figure 16-31; 34: Own illustration by author, adapted from BlueGreenStreets (2022): BlueGreenStreets Toolbox - Teil B. Multifunktionale Straßenraumgestaltung urbaner Quartiere.

Figure 32-33: Own illustration by author

Figure 35-36: Own illustration by author

Figure 37: Own illustration by author, adapted from Forlati, Silvia; Peer, Christian (2017): Mischung: Possible! Wege zur zukunftsfähigen Nutzungsmischung. 2. Auflage. Wien.

Figure 38-39: Own illustration by author

Figure 40: Google Earth

Figure 41: Süddeutsche Zeitung (2022c): Händler zweifeln an Plänen für neue Großmarkthalle. Available online at: https://www.sueddeutsche.de/muenchen/muenchen-grossmarkthalle-neubau-haendler-skepsis-1.5641509 (Access 23 August 2023).
Figure 42-43: MünchenArchitektur (2023): Großmarkthalle München 1912 & 1915. Available online at: https://www.muenchenarchitektur.com/beitrag/16884-taeglich-frisch-100-jahre-muenchner-grossmarkthalle (Access: 02 August 2023).

Figure 44: Own illustration by author, adapted from Großmarktareal mitgestalten (2023): Bauten und Anlagen der Großmarkthalle München. Available online at: https://www.grossmarkt-mitgestalten.de/der-grossmarkt-heute.html (Access 01 August 2023).

Figure 45: Süddeutsche Zeitung (2022a): 316 Kilogramm Marihuana, zehn Kilogramm Haschisch. Available online at: https://www.sueddeutsche.de/muenchen/muenchen-drogenschmuggel-grossmartkhalle-prozess-1.5658009 (Access: 27 July 2023).

Figure 46: Süddeutsche Zeitung (2022b): Ein schwer verdauliches Desaster. Available online at: https://www.sueddeutsche.de/muenchen/grossmarkthalle-muenchen-neubau-1.5573878 (Access: 28 July 2023).

Figure 47-48: Own illustration by author

Figure 49: Hallo München (2018): Endlich! Die Alte Utting wird eröffnet. Available online at: https://www.hallo-muenchen.de/muenchen/sued/sendling-ort43335/endlich-alte-utting-wird-eroeffnet-10063222.html (Access: 29 July 2023).

Figure 50: Nachrichten München (2022): Krims & Krams - Flohmarkt am 10.04.2022 im Bahnwärter Thiel. Available online at: https://www.nachrichten-muenchen.com/krims-krams-flohmarkt-am-10-04-2022-im-bahnwaerter-thiel/166945/ (Access: 30 July 2023).

Figure 51-60: Own illustration by author

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Annika Enzinger | 2023