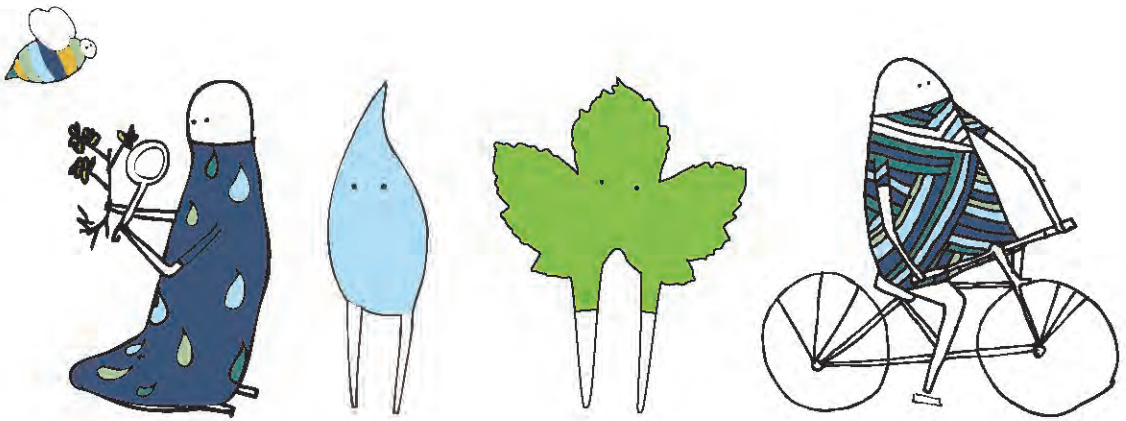
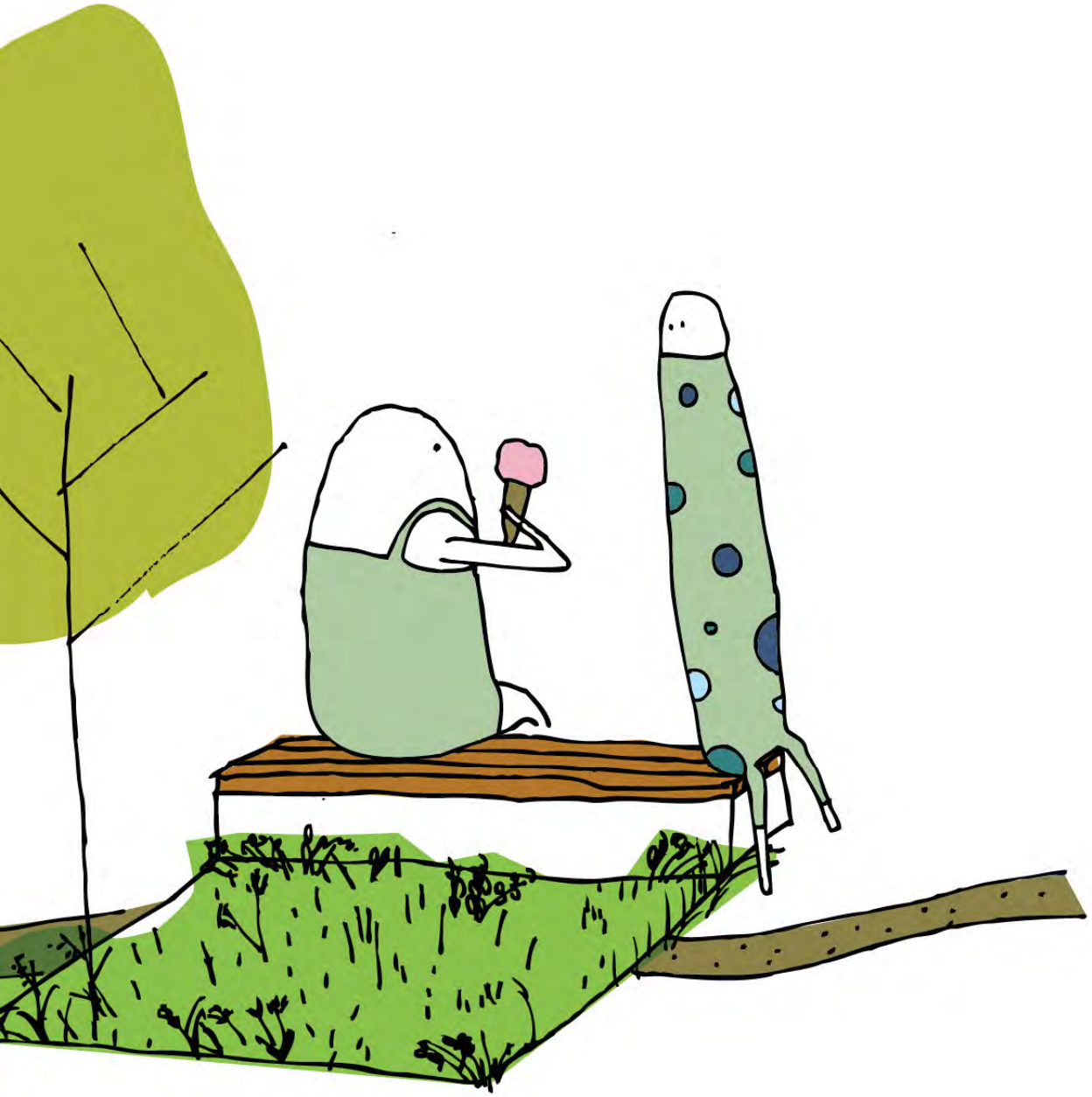
SYSTEM & SCALE

A GUIDE TO GREEN INFRASTRUCTURE





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FOREWORD

Green infrastructure is a concept and term that is applied to a range of environmental systems that overlap and combine to support human and environmental health and well-being. From urban forests to regional greenways, community gardens to local farms, streetside parklets to civic gathering places, and residential rain gardens to complex systems that harvest, treat and re-use stormwater, green infrastructure operates at a wide range of scales which, when distributed through and around cities, can coalesce to simultaneously address urban food, water, transport, habitat, recreational and social needs.

This document, developed by Robin Croen and Katie Poppel in the UW Green Futures Lab (GFL), explores the five green infrastructure systems that the GFL has identified as its research, planning and design foci. The pair has elegantly organized their study to present and illustrate examples of the five systems at the nested scales at which these systems operate, from micro to regional. Inspired by their residency in Copenhagen while completing their internship-abroad phase with the firm of Schulze + Grassov, Robin and Katie telescope Copenhagen examples to illustrate the scalar range of green infrastructure, and augment those cases with inspiring examples from around the globe.

We are grateful to the ScanlDesign Foundation for generously supporting this internship and project, and for the principals at Schulze + Grassov for mentorship and critique on this guidebook as it was developed and refined. We hope that this publication will advance the understanding, adoption and application of these urban design practices to help strengthen and regenerate healthy social, hydrological, biological, mobility, and metabolic systems of our cities and regions.

Nancy D. Rottle, RLA, FASLA
Director, UW Green Futures Lab
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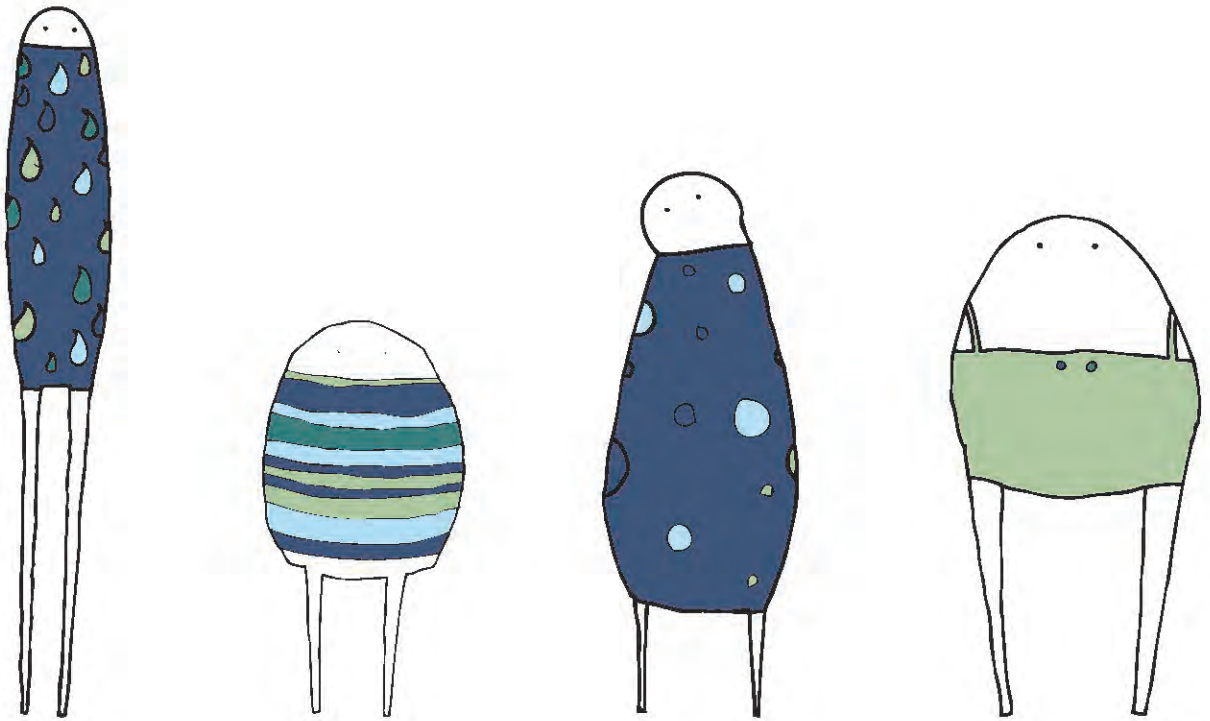


INTRODUCTION

It is nearly impossible to imagine a city without public infrastructure. Whether we are consciously aware of them or not, we rely on infrastructure systems every day to deliver drinking water and energy, to remove waste, and to allow for functional and safe mobility. Since its inception, **the fundamental goal of public infrastructure has been to directly improve human well-being.** In the past, public infrastructure was overlaid on the landscape with a blunt instrument, and the landscape was made to conform to the needs of these systems. More recently, however, an approach has emerged that blends together the practical needs of infrastructural systems with the harmonious workings of natural ecologies. This approach is called **green infrastructure**.

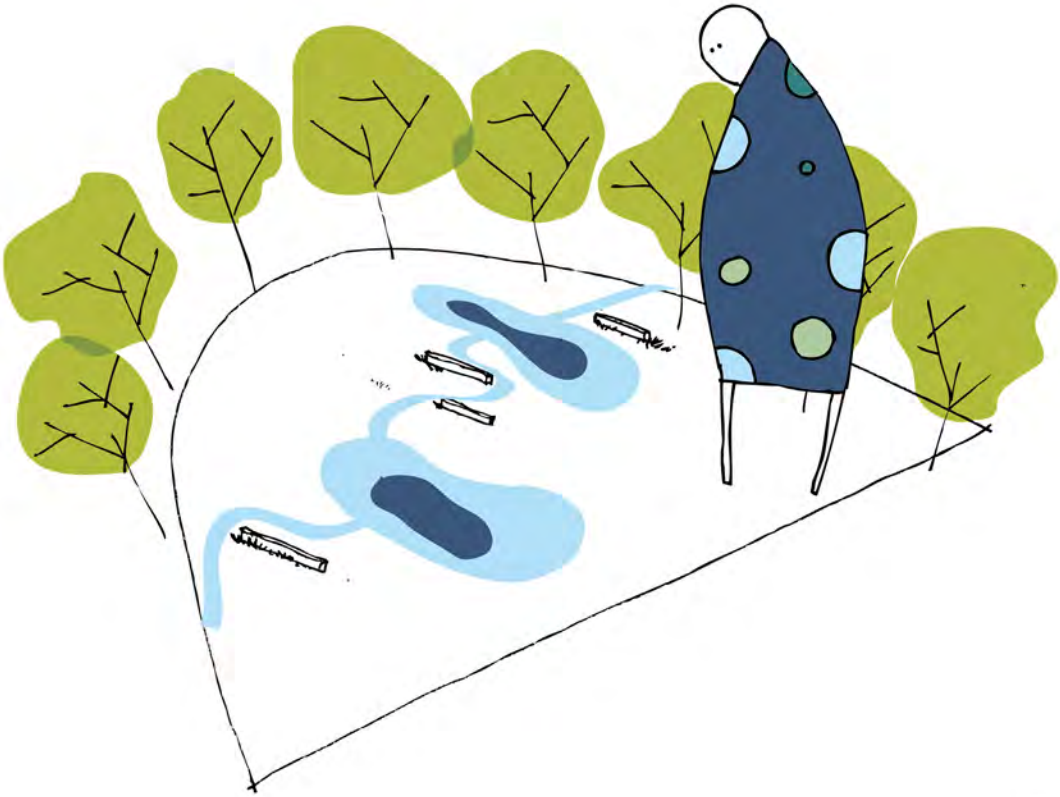
Green infrastructure is a way to rethink the **form and function of urban systems** by taking inspiration from **cyclical natural systems.** For example, whereas in the past a linear waste removal system might be successful if it simply moved waste out of the city to a landfill, today the question of "then what?" is asked. "Is that waste disposed of properly? Is it leaking toxic effluent into the environment? Will that toxicity damage the environment? Will damaging the environment effect human health? Can we recycle waste instead?" Based on a deeper understanding of systems-based complexities, linear models are being replaced by models that aim to have more holistic considerations, and a more complex understanding of the **interconnectedness of human action, environmental well-being, and ecological systems.**

This guide categorizes green infrastructure into five **systems**: *hydrological, biological, social, mobility,* and *metabolic;*

and investigates each system at five **scales**: *micro, site, neighborhood, city,* and *region*.

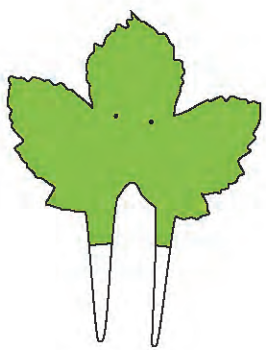
HYDROLOGICAL

Understanding water as a **closed-loop system**, and taking measures to incorporate urban waters - both consumed and produced - into a ecologically-sensitive system



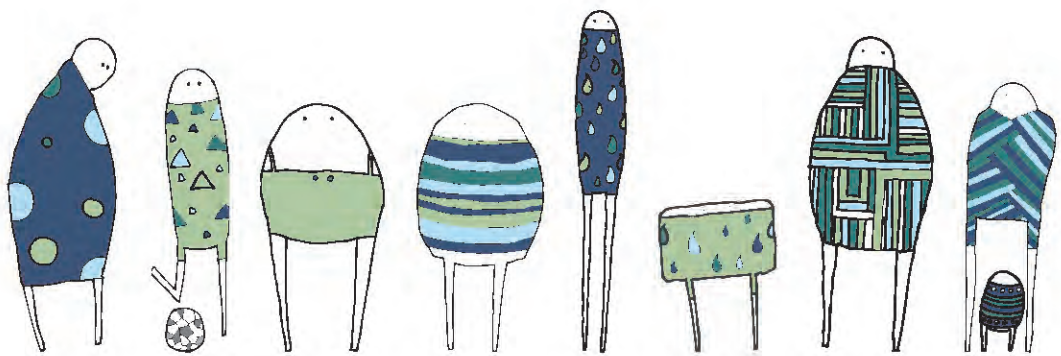
BIOLOGICAL

Spaces and qualities that support **multiple species, enhancing biodiversity** and providing a balance to the hard, urban environment.



SOCIAL

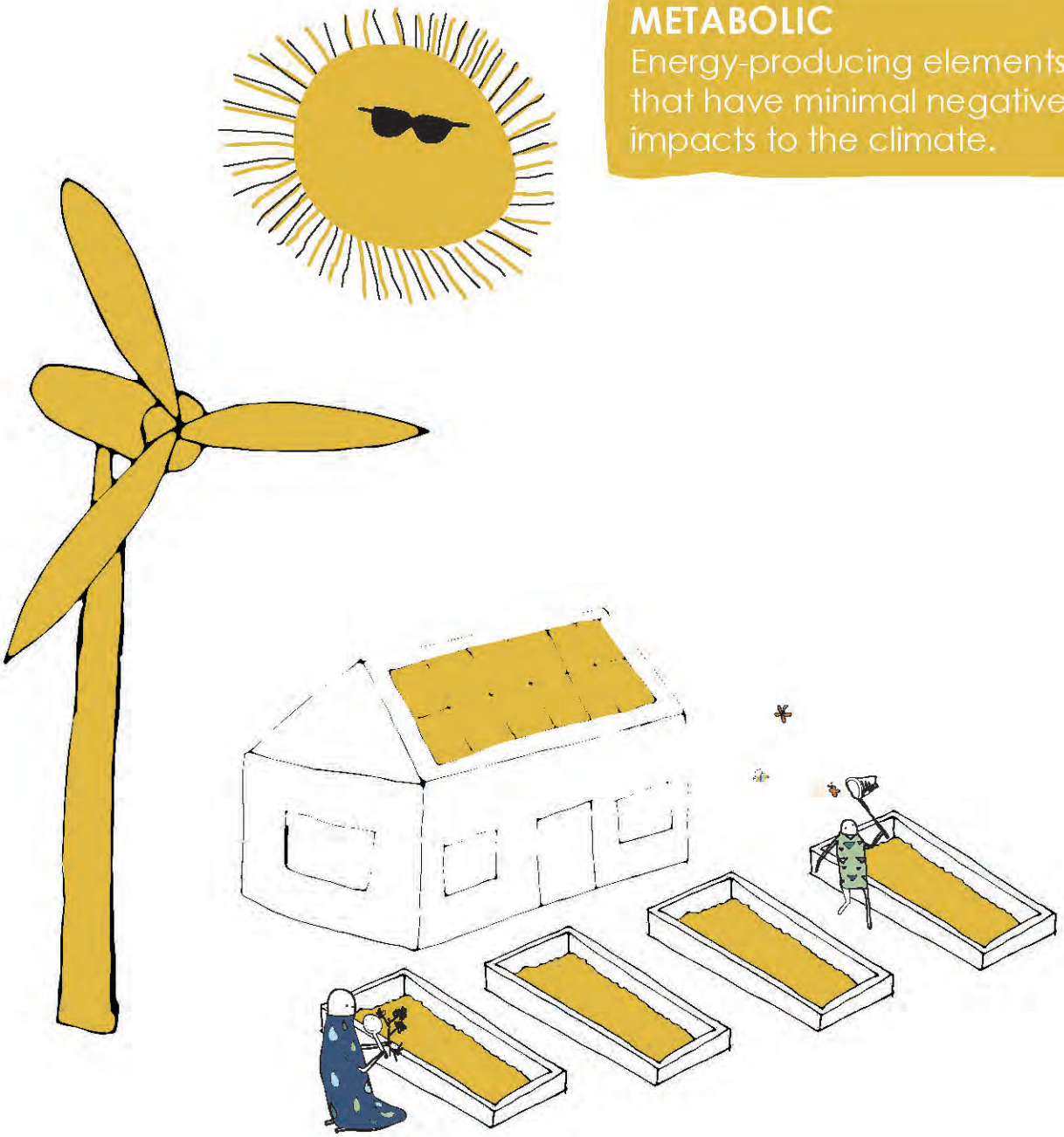
Community spaces designed and designated for the human population that provide interaction and gathering spaces within the **public realm**



MOBILITY

Networks and facilities that promote the use of active transportation.

METABOLIC
Energy-producing elements that have minimal negative impacts to the climate.



SCALES

micro

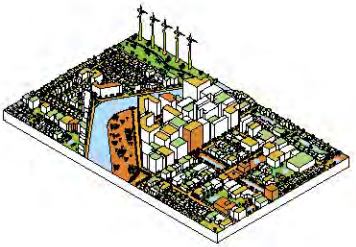
The smallest scale, this is the scale at which people experience the space around them.

site

This scale is what is often seen as the building block for cities. Site scale refers to places such as parks, courtyards, or a city parcel.

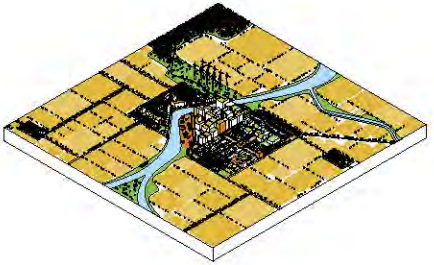
neighborhood

A neighborhood refers to a district with distinct characteristics in a given city. They are made up of multiple sites and many micro sites.



city

The city is a network of neighborhoods, and likewise a network of systems such as parks, plazas, water infrastructure, and transit. This is the only scale with a formal management boundary.



region

The largest scale in this guide, regions bring cities and their surrounding landscapes together. Regions can have natural borders, such as the coast or a mountain range, or be delineated by human borders such as management areas or roads.

CASE STUDIES

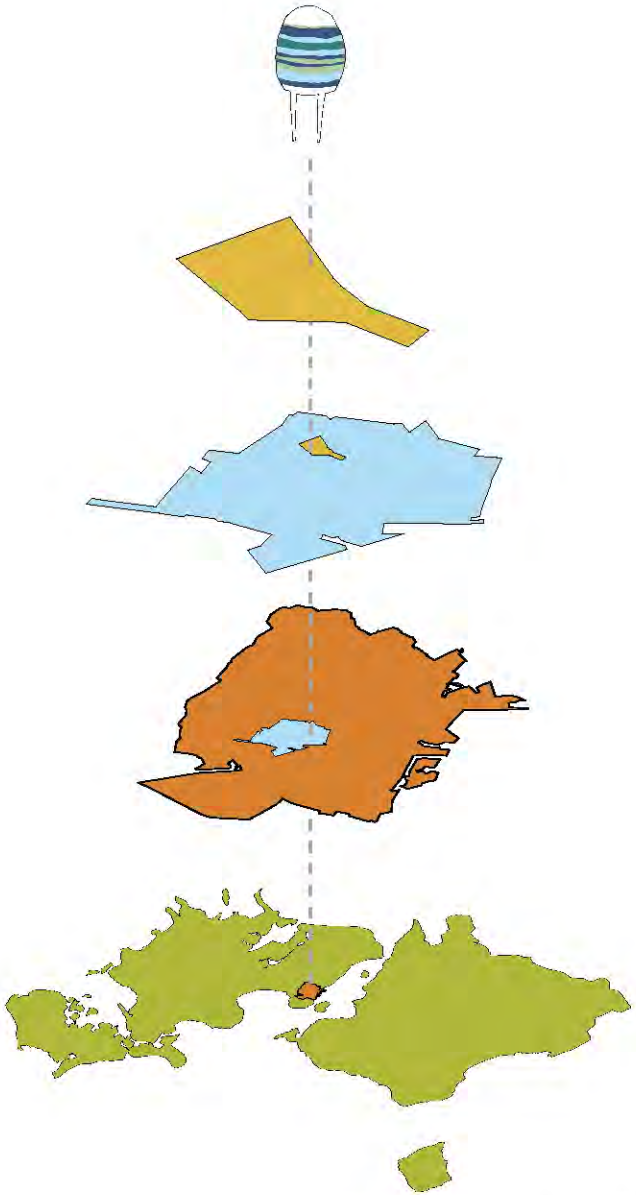
individual
The city as experienced through individual elements or small places. This is the fundamental unit of scale, based on the human experience of places.

Enghave Parken
Enghave Parken and the neighboring Enghave Plads make up the site case study. At this scale, individual components begin to coalesce into discernible systems.

Vesterbro
Vesterbro is the neighborhood case study. At this scale each system starts to form connected networks.

Copenhagen
Copenhagen is the city case study, made up of a collection of neighborhoods. At this scale the networks expand and overlap between systems.

Øresund
The Øresund Region is the largest scale case study presented. At the regional scale, emphasis is placed on policy and management as well as the connected parts of a given system.



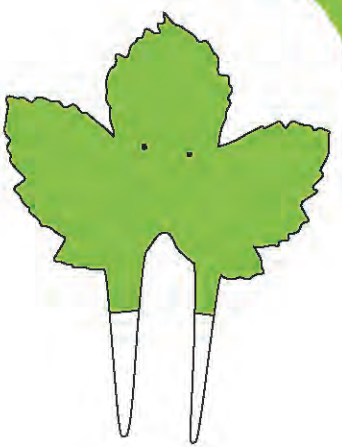
HOW TO USE THIS GUIDE

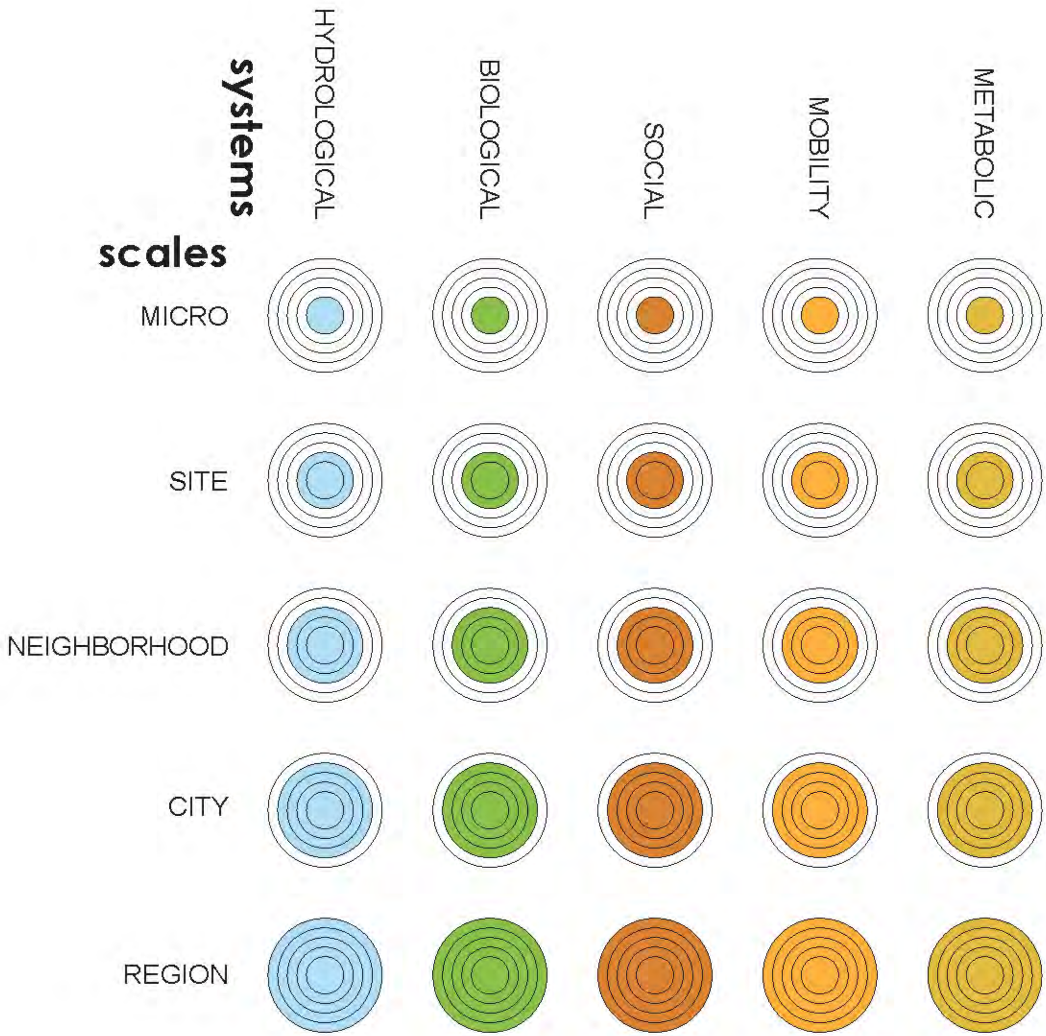
This book is a guide that you can use to explore your interest in green infrastructure. You can approach the guide in two different ways: by system or by scale.

Interested in water? Trace the hydrological system from the micro to regional scale and see how urban waters are connected. Interested in how green infrastructure works within a neighborhood? Check out how each of the five systems overlap at this scale.

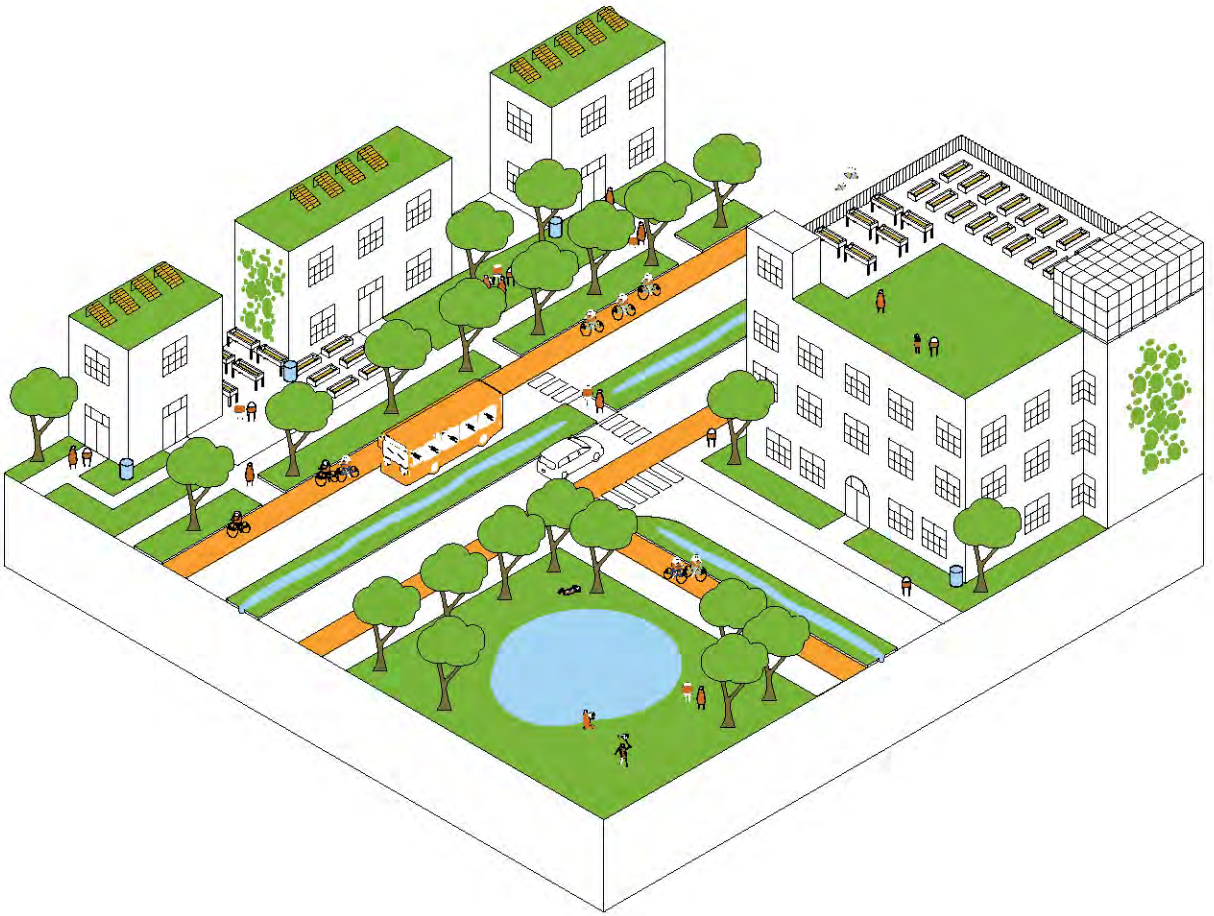
The matrix on the facing page can help you navigate the complexities of green infrastructure. Remember that **multifunctionality** is the hallmark of green infrastructure, so don't be surprised to see many of the systems mentioned in this guide overlapping with one another within each scale, and even from one scale to the next! Simply because a precedent is highlighted for one system or scale doesn't mean it is not applicable elsewhere.

By pulling apart and piecing back together the scales of green infrastructure, we can start to imagine where certain interventions could solve problems and create solutions.

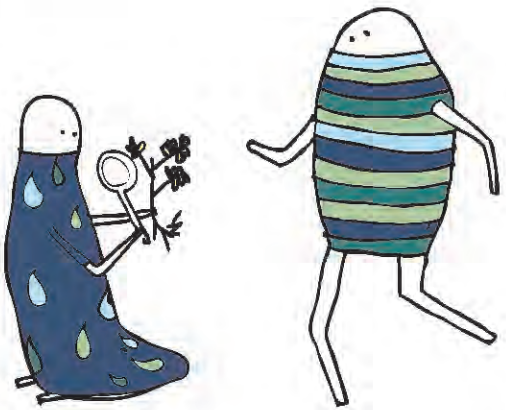



systems
HYDROLOGICAL
BIOLOGICAL
SOCIAL
MOBILITY
METABOLIC
scales
MICRO
SITE
NEIGHBORHOOD
CITY
REGION

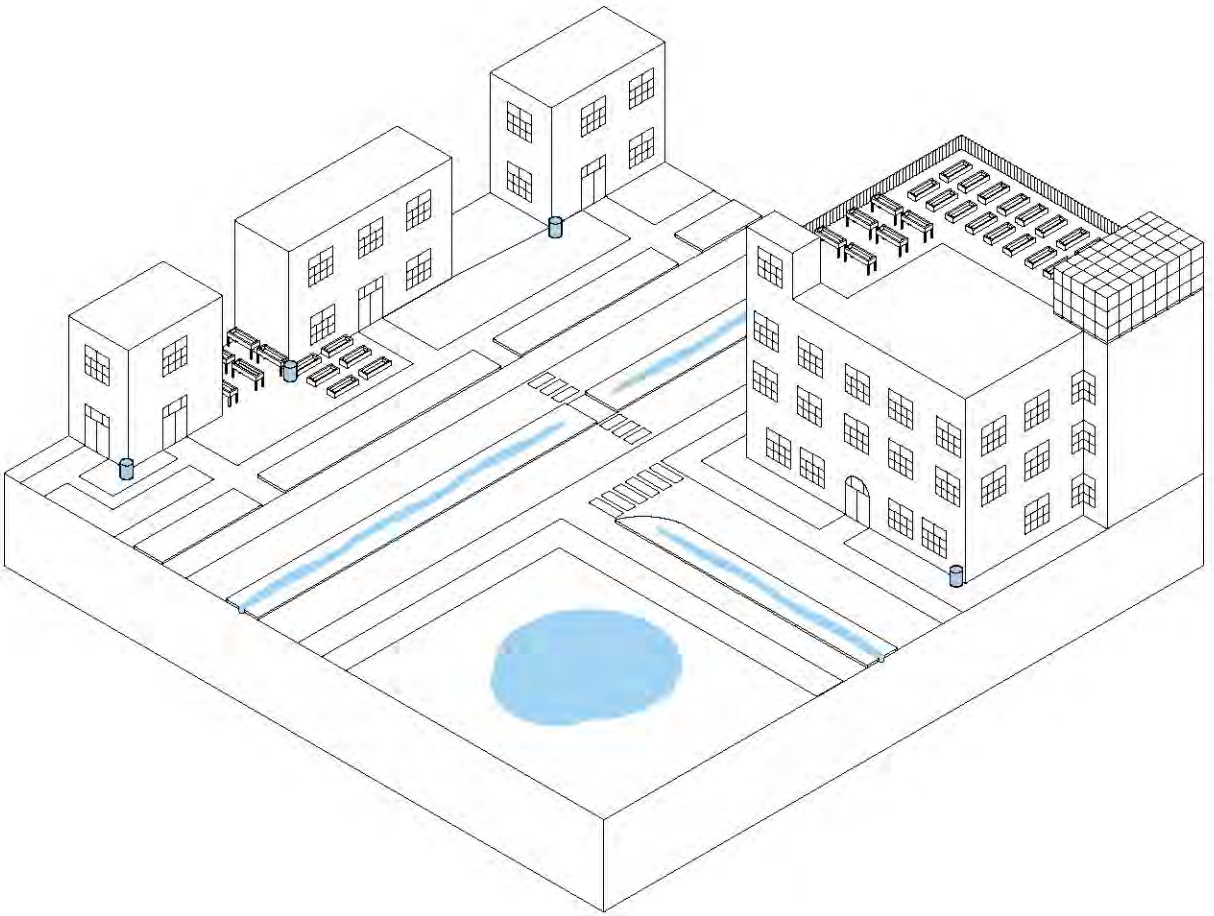
CHAPTER 1
MICRO SCALE



The micro scale is the smallest unit of measure in this guide. While later chapters will refer to *systems* of green infrastructure, the micro scale deals with **individual elements that comprise these systems**. Elements are things that can be understood and experienced at a human scale. For example, the mobility system is a complex web of bike paths, bus routes, and rail lines that can span an entire region, but a person will only experience one part of this system at a time. In this example, a bike rack, a bus stop, and a train station are all individual elements of the much bigger mobility system. The elements in this chapter can be thought of as **building blocks that come together to form systems at larger scales**.



MICRO | HYDROLOGICAL



water as a

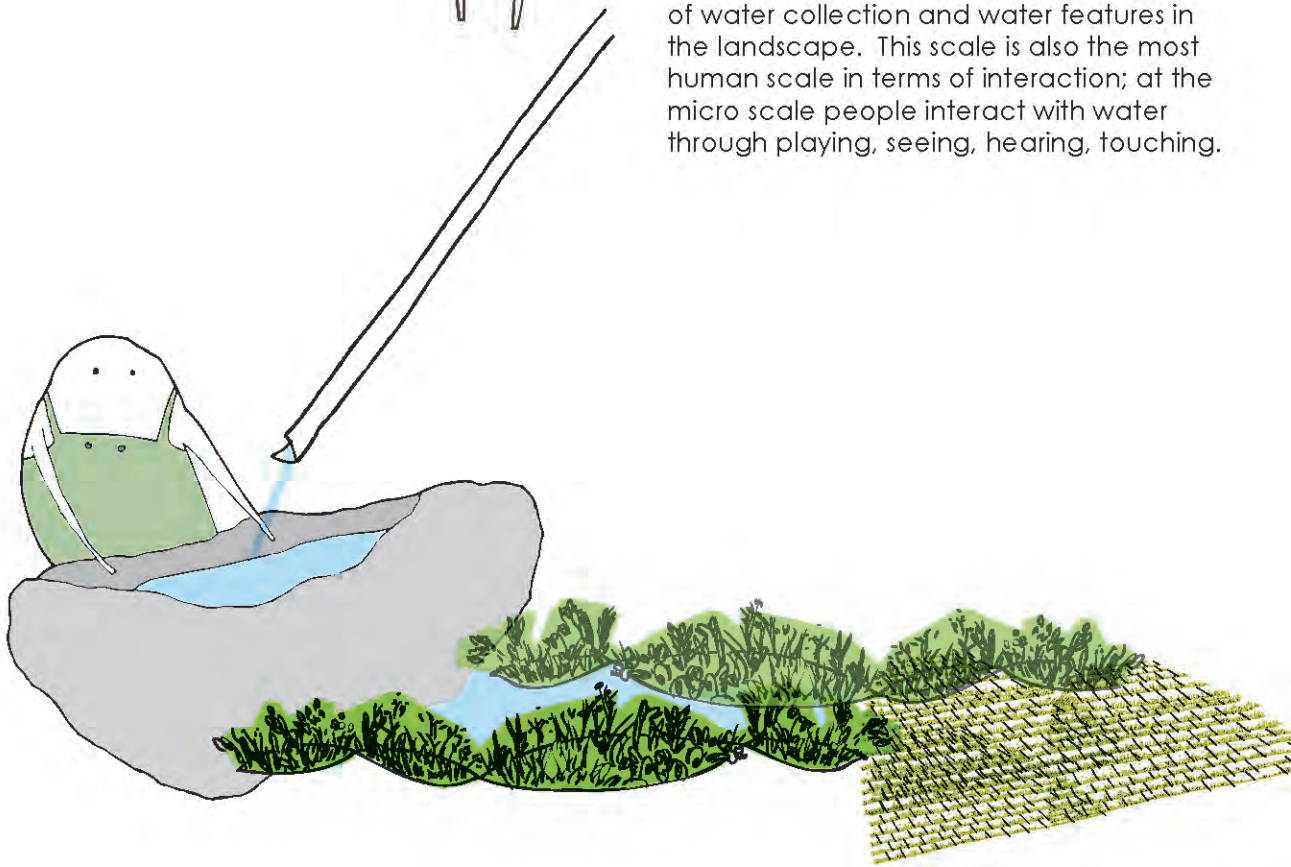
RESOURCE

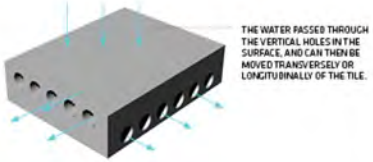
clean water source
stormwater
rainwater
greywater
black water

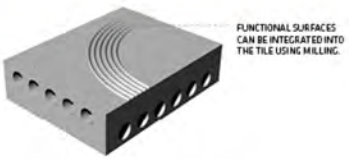
HYDROLOGICAL

Understanding water as a **closed-loop system**, and taking measures to incorporate urban waters - both consumed and produced - into a ecologically-sensitive system.

At the micro scale, the hydrological system is comprised of the smallest scale of water collection and water features in the landscape. This scale is also the most human scale in terms of interaction; at the micro scale people interact with water through playing, seeing, hearing, touching.







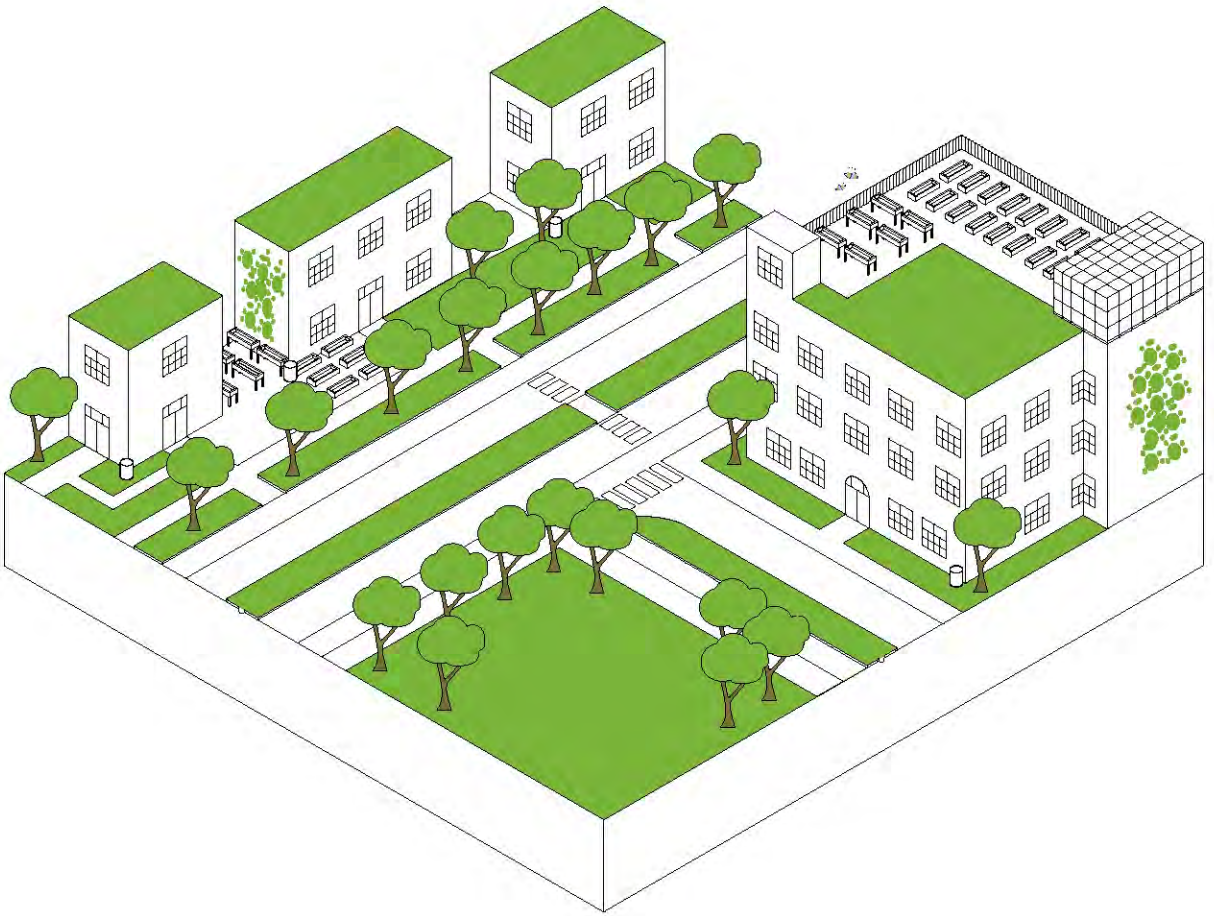
CLIMATE TILE

tredje natur

The Climate Tile capitalizes on making non-permeable pavement permeable. Climate Tile attempts to rework the urban water cycle; by allowing for permeability, water can be held to reduce downstream fooling, and filtered through the tile and back into the urban water system. While still in development, the tile has been tested in Copenhagen and has received substantial funding for continued development.

WALTON LOFTS ON VINE
Seattle, Washington
Swales, bioretention cells, rainwater catchment gardens, and similar interventions are increasingly being used in urban environments. More cities are moving towards both requiring developers to maintain responsibility for stormwater and increase permeable spaces; vegetated swales are used as an intervention to not only provide more greenery, but also capture and cleanse stormwater. The Walton Lofts on Vine also uses the cascading bioretention cells as a buffer between pedestrians and the street.

MICRO | BIOLOGICAL

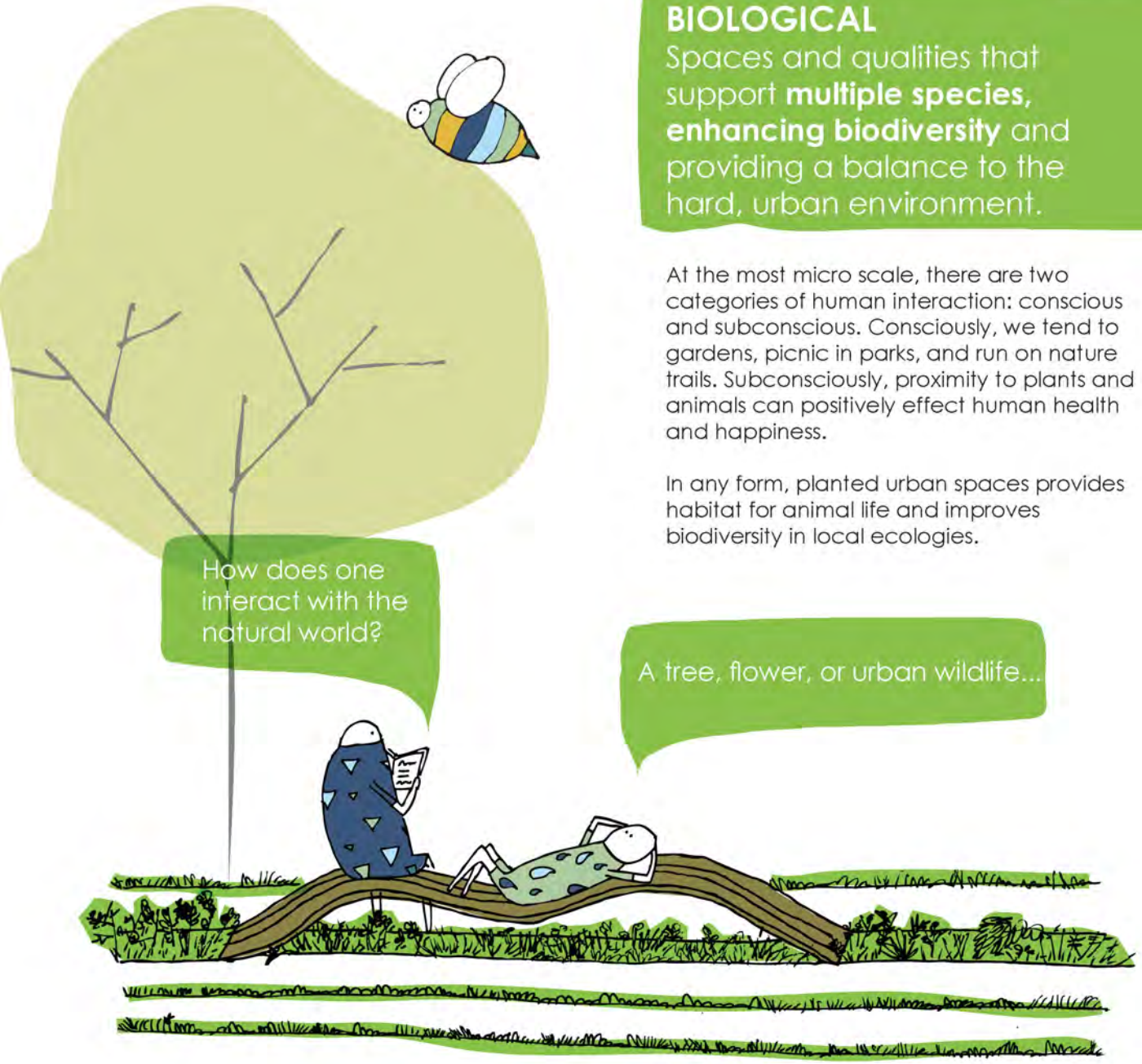


BIOLOGICAL

Spaces and qualities that support **multiple species, enhancing biodiversity** and providing a balance to the hard, urban environment.

At the most micro scale, there are two categories of human interaction: conscious and subconscious. Consciously, we tend to gardens, picnic in parks, and run on nature trails. Subconsciously, proximity to plants and animals can positively effect human health and happiness.

In any form, planted urban spaces provides habitat for animal life and improves biodiversity in local ecologies.



MICRO | BIOLOGICAL

PRECEDENTS

URBAN VEGETATION

The "Urban Heat Island (UHI)" effect, caused by heat-absorbing surfaces, tends to increase with urban development and the reduction of permeable surfaces. Planter boxes, street trees, and green roofs reintroduce permeable surfaces to developed areas and represent just a few ways that vegetation can positively impact the built environment.


Source: ADDI

URBAN BIRD & BAT BOX

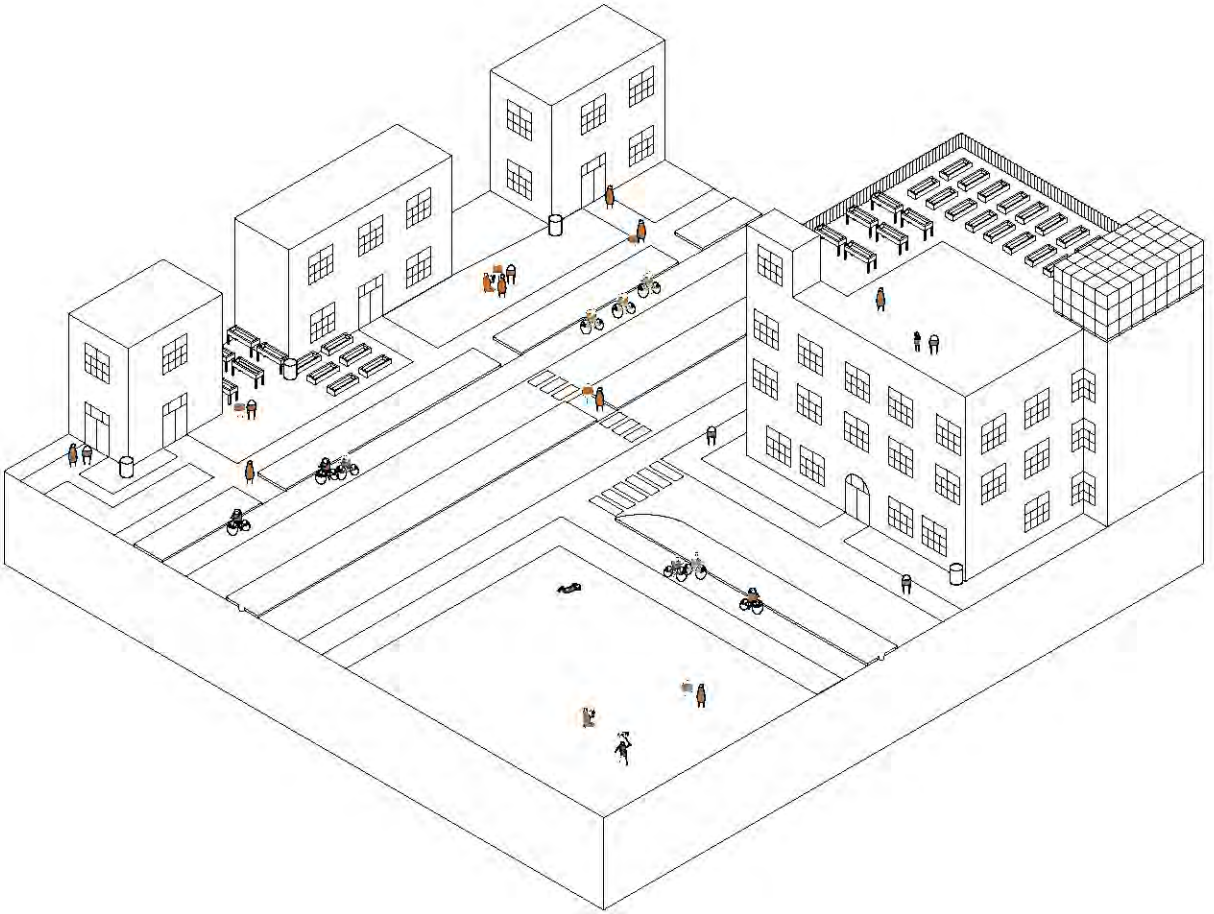
As global urbanization increasingly encroaches on undeveloped landscapes, it is important to not forgot who we share this planet with - all other organisms! Small animals like birds and bats can still thrive in urban conditions and are a vital part of the larger ecosystem.

Thomas Dambo

Source: Jaime Rojo


Source: Reuben Kyte

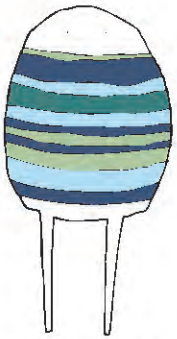
MICRO | SOCIAL



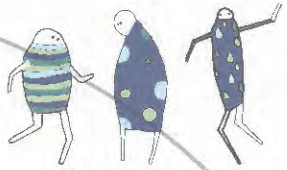
SOCIAL

Community spaces designed and designated for the human population that provide interaction and gathering spaces within the **public realm**

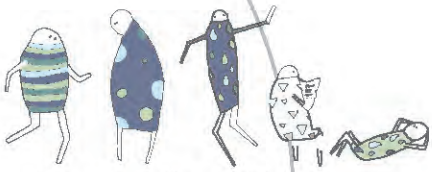
At the smallest scale, the individual brings human awareness to public space.



Individual



Groups and Individuals



Large, Mixed Group

Regional Group Identity

Groups x Groups

MICRO | SOCIAL

PRECEDENTS

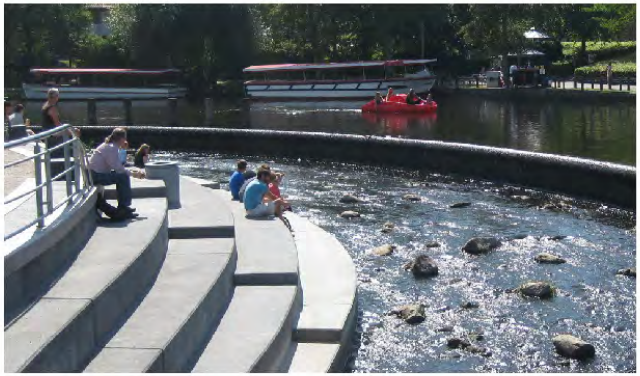
PUBLIC SPACES

From benches to steps, plazas to paths, and parks to gardens, publicly accessible spaces make up the fabric of the social system. Whether gray, green, or blue, spaces for people to sit, stay, meet, gather, and encounter the unexpected are what allow urban life to thrive and allow for social connections to be made. While most of the social system occurs outside, some public facilities such as community centers bring the public realm indoors.


Source: Source: Josh Saitelbach

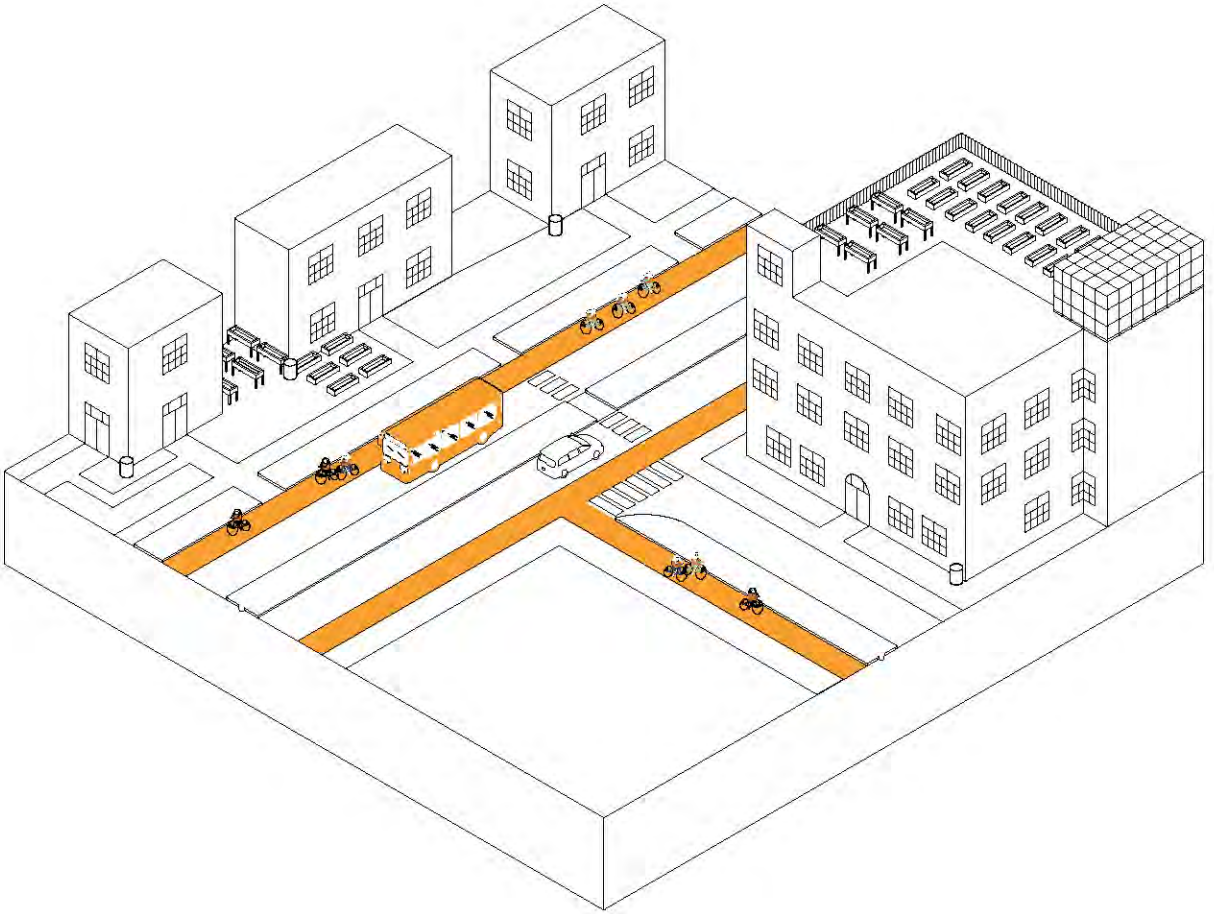

Source: Source: Josh Saitelbach


Source: Andrea Cochran Landscape Architecture



Source: Eileen Crawford

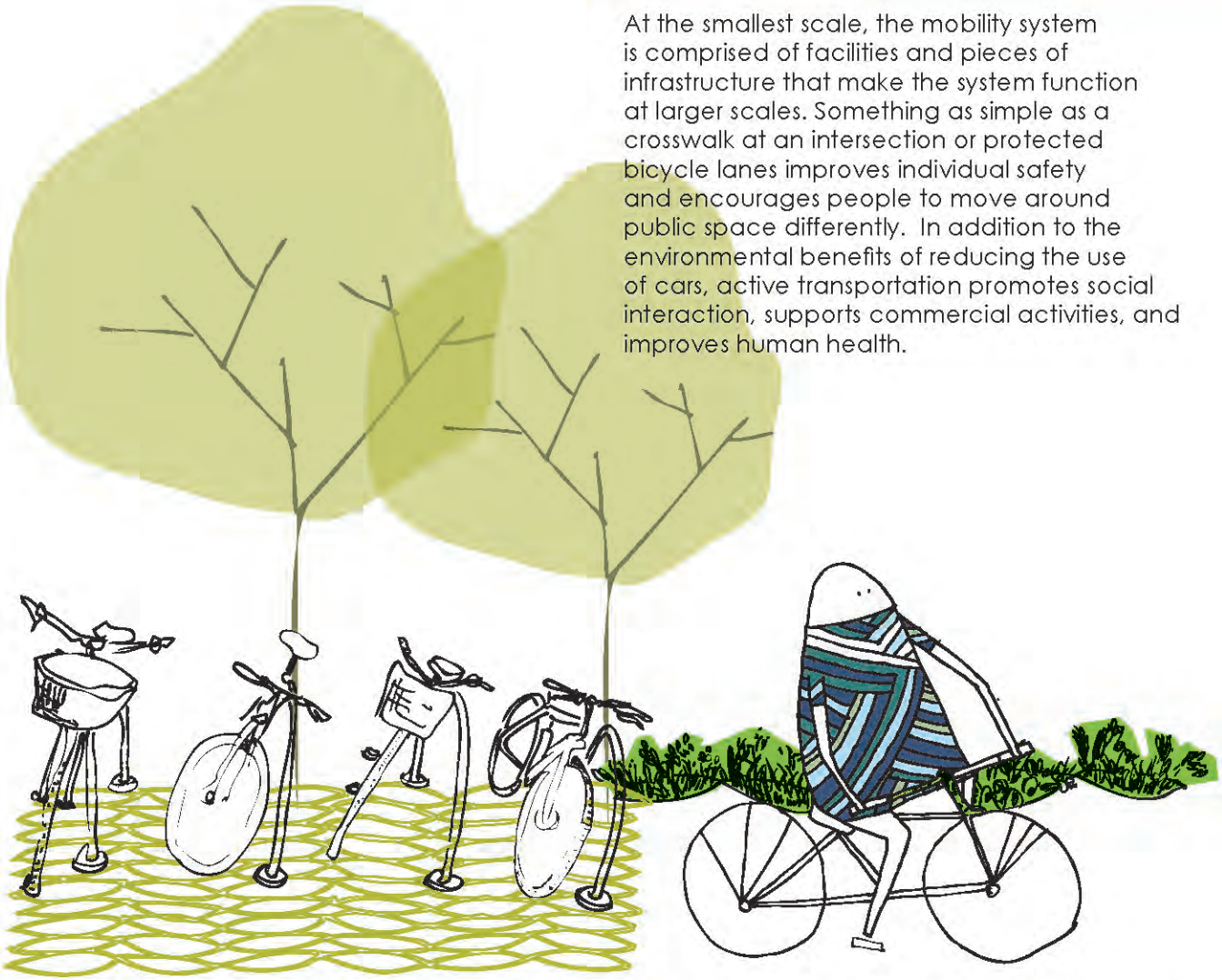
MICRO | MOBILITY



MOBILITY

Networks and facilities that promote the use of active transportation.

At the smallest scale, the mobility system is comprised of facilities and pieces of infrastructure that make the system function at larger scales. Something as simple as a crosswalk at an intersection or protected bicycle lanes improves individual safety and encourages people to move around public space differently. In addition to the environmental benefits of reducing the use of cars, active transportation promotes social interaction, supports commercial activities, and improves human health.



MICRO | MOBILITY
PRECEDENTS

BICYCLE INFRASTRUCTURE

Bikes are second only to walking in terms of green mobility. They leave no carbon footprint (besides the manufacturing process) and often have long lifespans in terms of usability. Comprehensive bicycle infrastructure promotes the use of cycling as a means of mobility, which also improves human health and reduces vehicular pollutants.

Source: 450 Architects

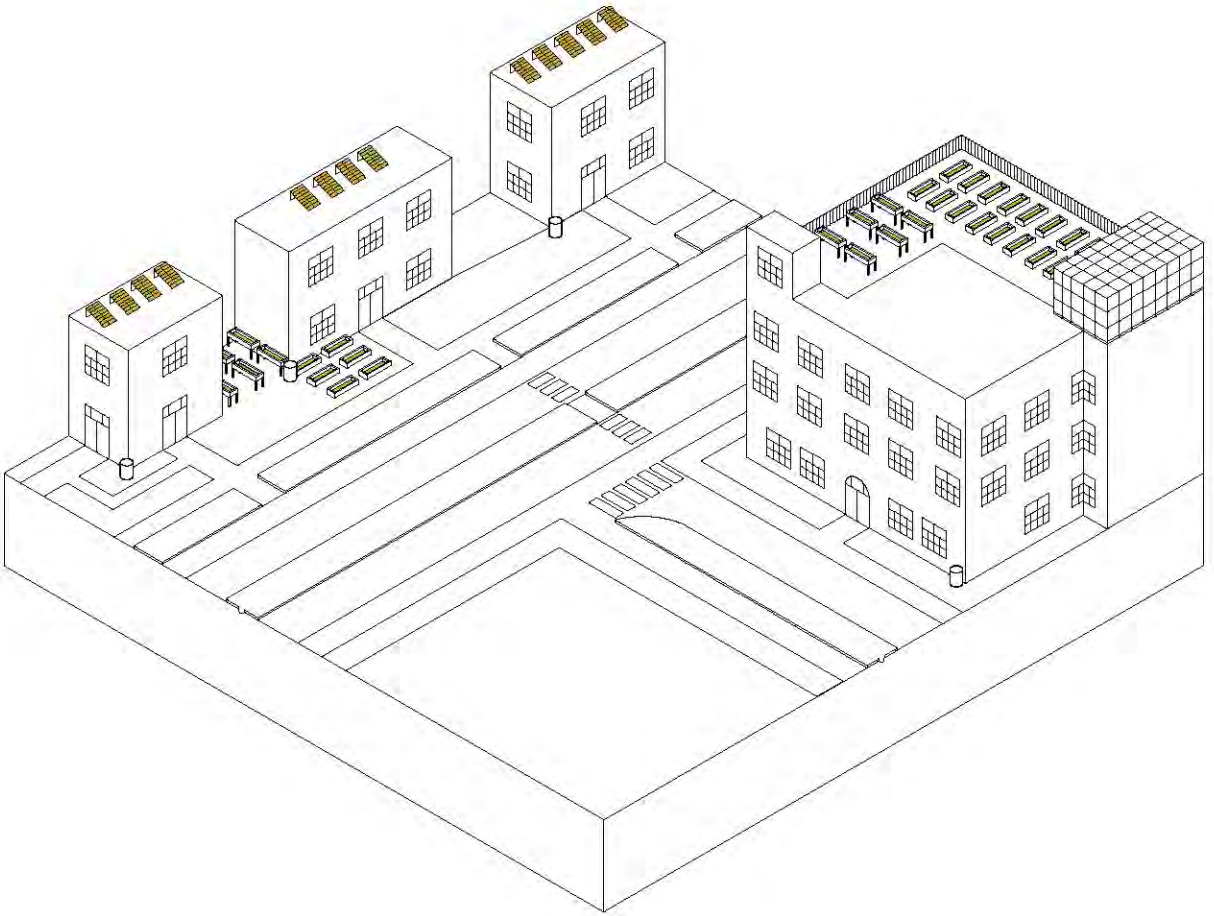
Source: crazy-kitch.tumblr

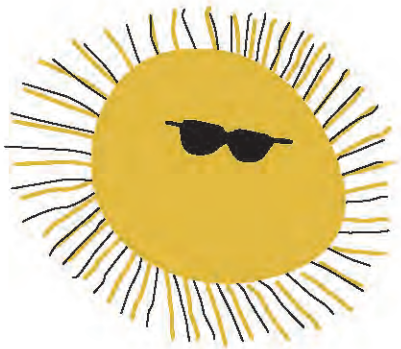
Source: Toshiyuki Yano

BUS STOP

Buses, trains, and other forms of mass transportation bring people together for the greater good: a reduction of individual automobile trips. Bus stops, whether elaborate like the examples above or simple shelters, are an important node of public transit infrastructure.

MICRO | METABOLIC

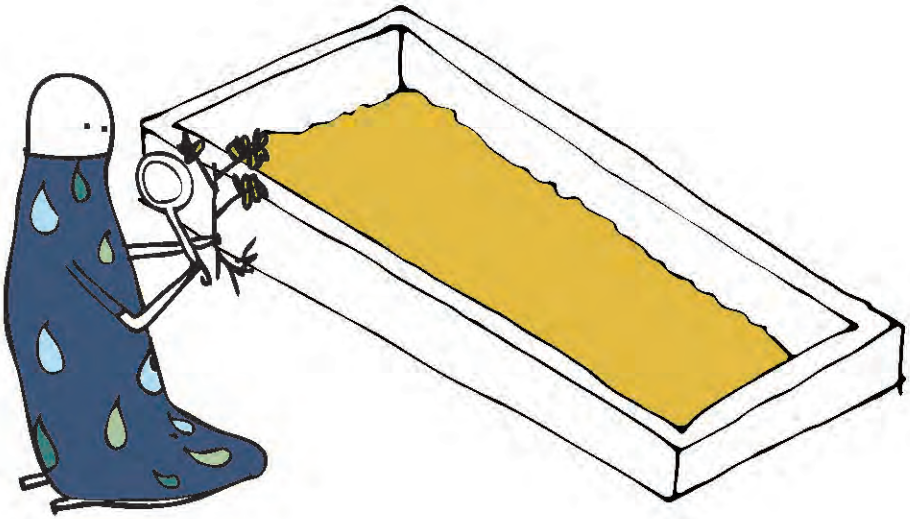




METABOLIC

Energy-producing elements that have minimal negative impacts to the climate.

At the smallest scale, the metabolic system is comprised of elements that produce sustainable energy. Wind turbines, solar panels, and micro hydro power facilities are all examples of metabolic system elements that produce energy in the form of electricity. Solar heating installations produce energy in the form of heat. Gardens and farms produce energy in the form of food.



MICRO | METABOLIC

PRECEDENTS

SOLAR HEATING

Solar heating arrays use renewable solar energy to heat water instead of burning fuel. In addition to providing hot water that you might use in your sink or shower, solar heating can also be used to heat buildings in place of conventional forced-air heaters. Small solar heating arrays like the one pictured below can be installed on building roofs for use within the structure below, while larger arrays can provide for an entire community.

SOLAR PANEL

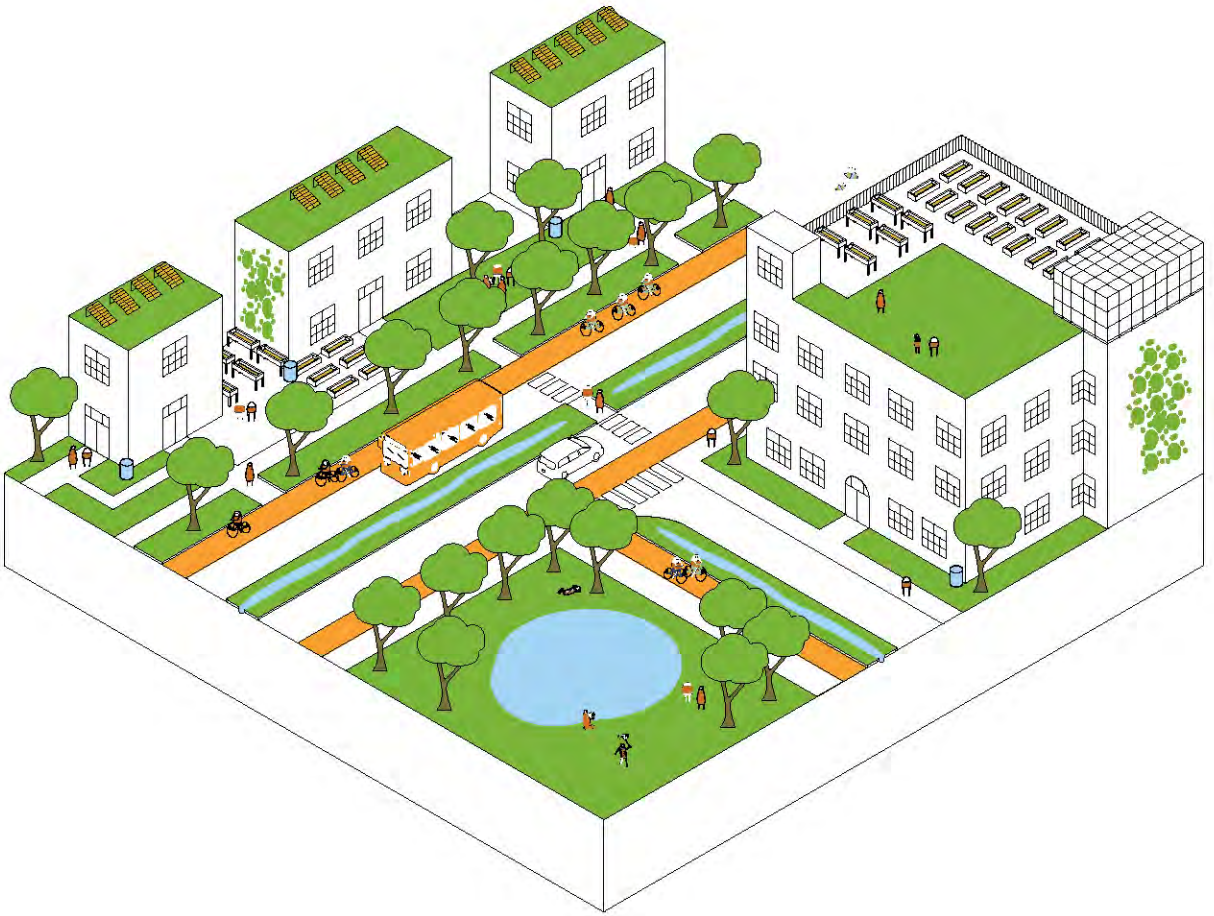
Green energy, or renewable energy, has grown in popularity and created an entire new sector of the economy (clean energy). Solar panels specifically are scalable: from the smallest example powering a streetlight to the largest powering an entire town.

Further research: Babcock Ranch, Florida, a town that will produce and sustain its own power.

GARDEN BED

The most basic scale of our food production system is the individual's growth of food. Consuming food grown nearby rather than shipped long distances reduces its carbon footprint. With the majority of the world's population living in cities, opportunities to grow food locally can be created, such as in planters and raised beds. Planters come in many shapes and sizes, including raised beds like those pictured above.

MICRO SUMMARY



INCREMENTAL BUILDING BLOCKS

The micro scale describes elements of green infrastructure that when put together form the systems that expand into a site, neighborhood, city, or region. Micro interventions can be pulled apart and put together again and again to form more complex interventions. A few solar panels put together power a house; even more solar panels put together can power an entire community and beyond.

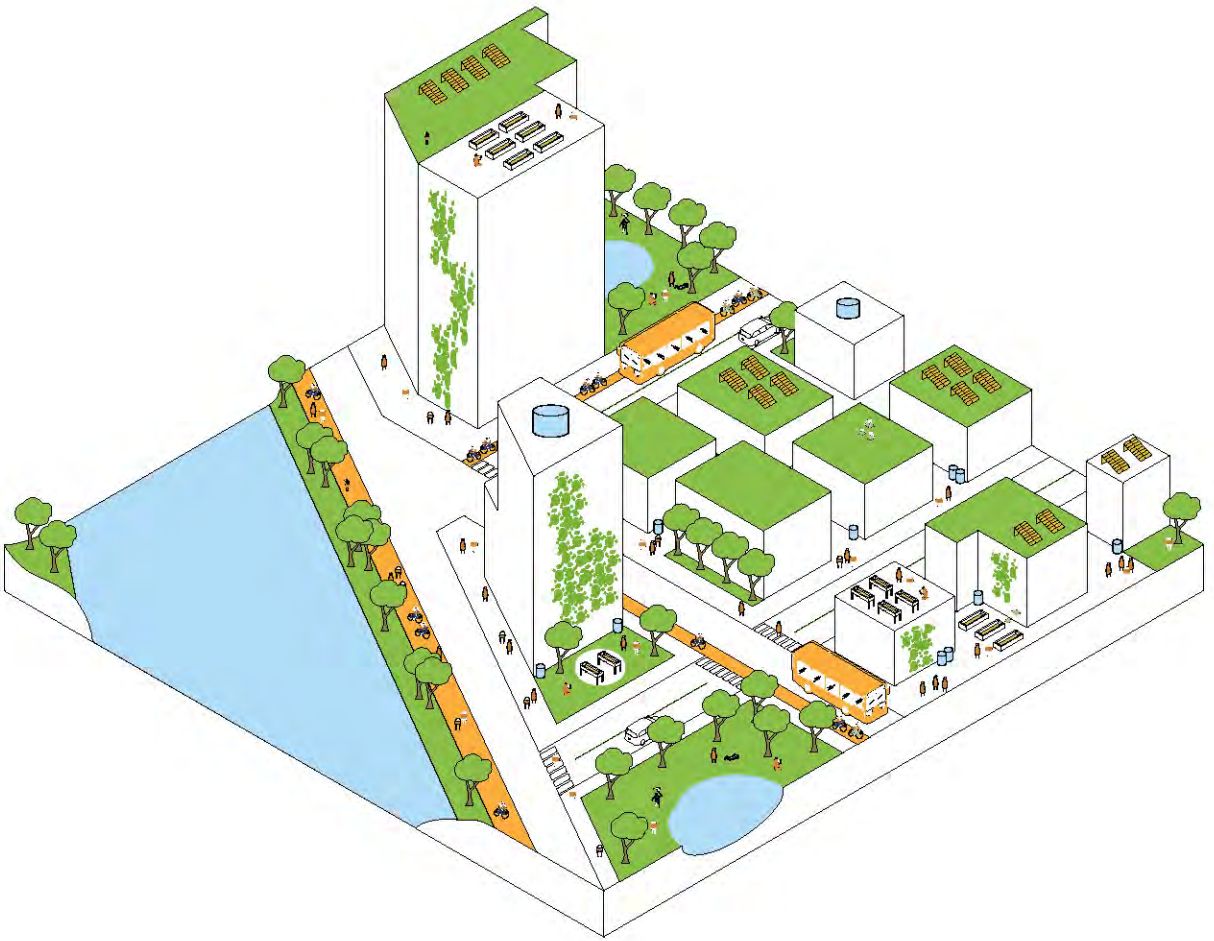
HUMAN SCALE

The micro scale is where green infrastructure systems are the most relatable and also the most tangible; it's the scale at which we use our senses to take in the world around us. Elements like a bioretention cell, vegetable garden, park bench, bus stop, or solar-powered street light are easy to understand as individual objects, but each is also one small part of a connected and complex system.

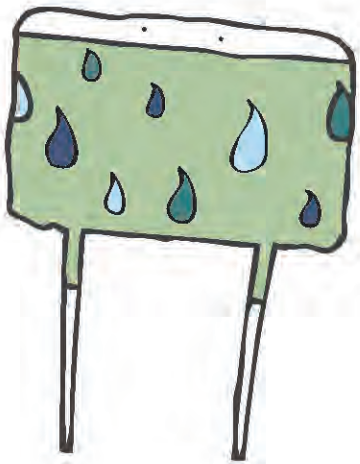
MULTI-FUNCTIONAL BY DESIGN

While we present green infrastructure in this guide as being comprised of five systems, it is crucial to understand that these systems overlap and blend together in ways that blur categorization. It is precisely this blending that gives green infrastructure its multi-functionality, efficiency and vitality; If an element seems to fit in more than one system, thats because it does!

CHAPTER 2
SITE SCALE



Site is the **combination of micro interventions** and the **coalescing of individual elements into a cohesive whole**. This scale is what is often seen as the **building block for cities**: individual parcels pieced together to form blocks, neighborhoods, and then cities. Site scale refers to places such as **parks, courtyards, and city parcels**.



CASE STUDY: **ENGHAVE PLADS**

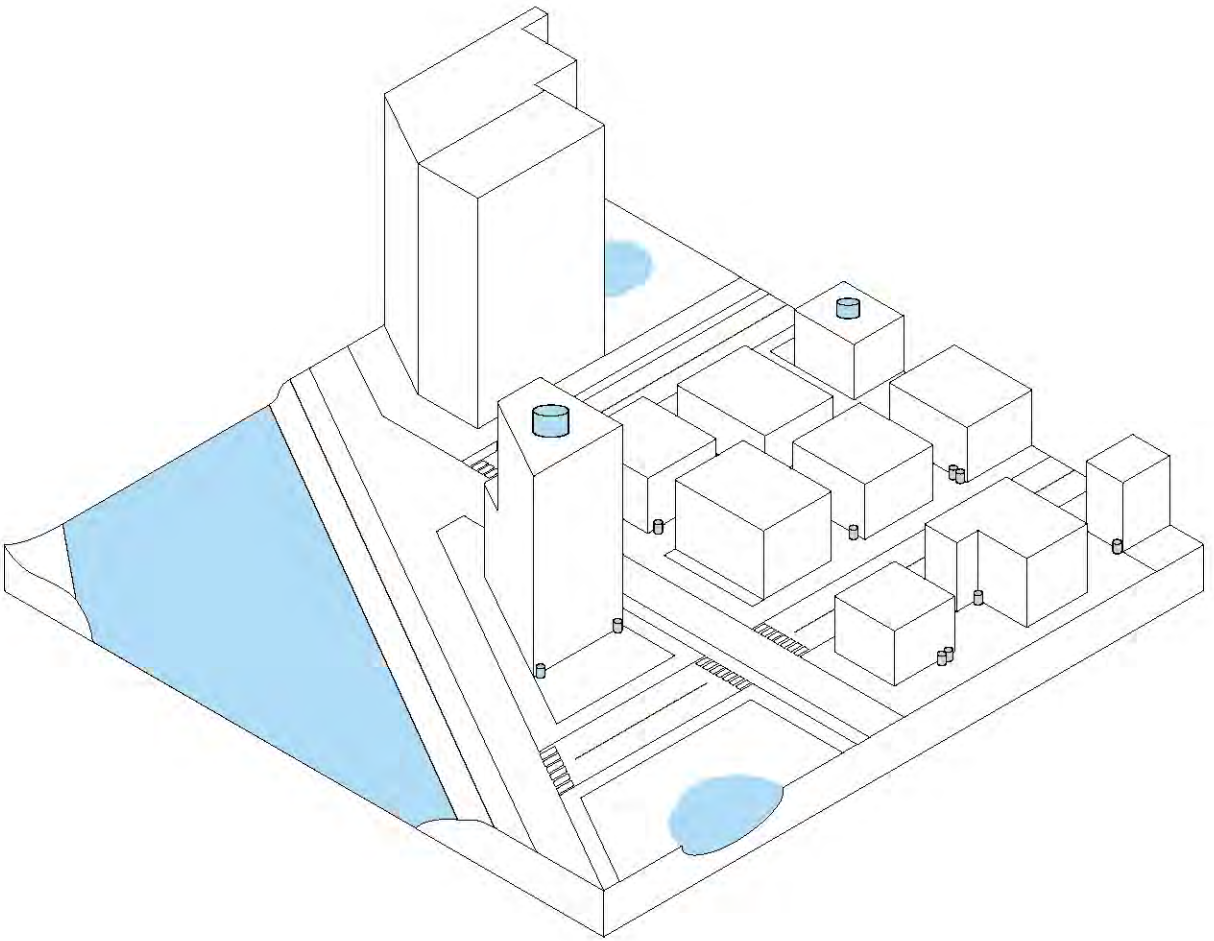
Enghave Plads is a complex site consisting of a large park, Enhave Parken, and the a new Metro station. Though the park and the plaza are divided by a busy street and have the feel of two distinct places, they are linked via the city's cloudburst management plan and their main use as public open space in the dense neighborhood of Vesterbro. Enghaveparken is being redesigned by the landscape architecture firm Treje Natur to manage some 26,000 cubic meters of floodwater during storm events. In the case of such an event, nearly the entire park will be submerged, with subterranean reservoirs storing a large portion of the water out of view from the surface.

Enghavparken is a historic site and as such the design of the park is performing its infrastructural duties while simultaneously preserving many of its traditional features, such as the duck pond, an outdoor stage, plaza gathering space, and numerous tree-lined promenades.

To the east, Enghave Plads is being completely redone to accommodate the arrival of a new Metro station, part of the new Metro line that will loop Copenhagen's inner-city neighborhoods. This important new piece of transportation infrastructure will reinvigorate the surrounding neighborhood by connecting it to transit, in addition to increasing the level of social activity within the site.

Overall, the site has a robust program that draws out the surrounding community. The combination of Enghavenparken, Enghave Plads, and the new Metro station will bring even more activity and use to the site.

SITE | HYDROLOGICAL

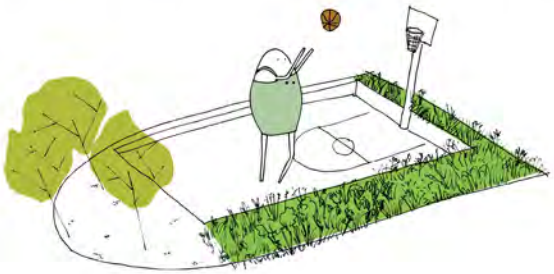


HYDROLOGICAL

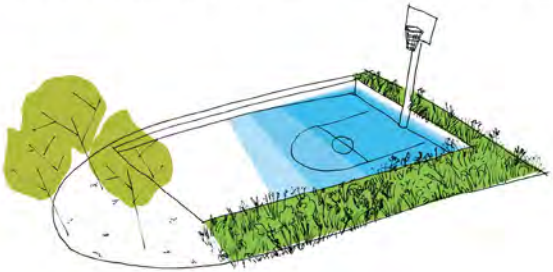
Understanding water as a **closed-loop system**, and taking measures to incorporate urban waters - both consumed and produced - into a ecologically-sensitive system

At the site scale, water is collected and sometimes treated (also a metabolic process). Micro hydrological features can be integrated into sites for direct human interaction such as with a fountain, and in raingardens and bioretention cells. On sites, these elements begin to connect into the greater hydrological system.

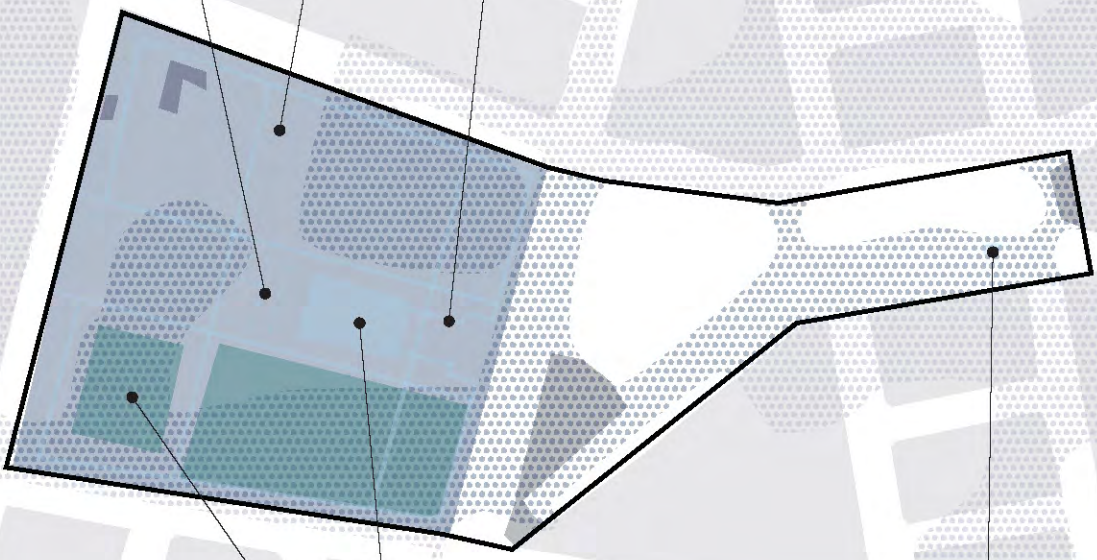
Traditional Stormwater Infrastructure



Green Stormwater Infrastructure (GSI)



ENGHAVE PLADS | HYDROLOGICAL



POND

The permanent pond is focal point of the site, attracting human and animal users alike. While it serves an aesthetic function, the pond is also an important stormwater detention feature that ties into the site's hydrological system.

MULTICOURT

The multicourt that serves as a recreatinal amenity can double as a massive detaining area for stormwater. The park has capacity to hold 26,000 cubic meters of water total. In cases of severe flooding, this detaining area will capture stormwater and prevent it from flooding nearby structures.

FLOODABLE PLAZA

The plaza, usually the social focal point of the park, can also double as a stormwater detention area in times of need. In fact, nearly all of Enghave Parken is designed to capture and detain stormwater to prevent flooding during cloudburst events.

SITE | HYDROLOGICAL
PRECEDENTS

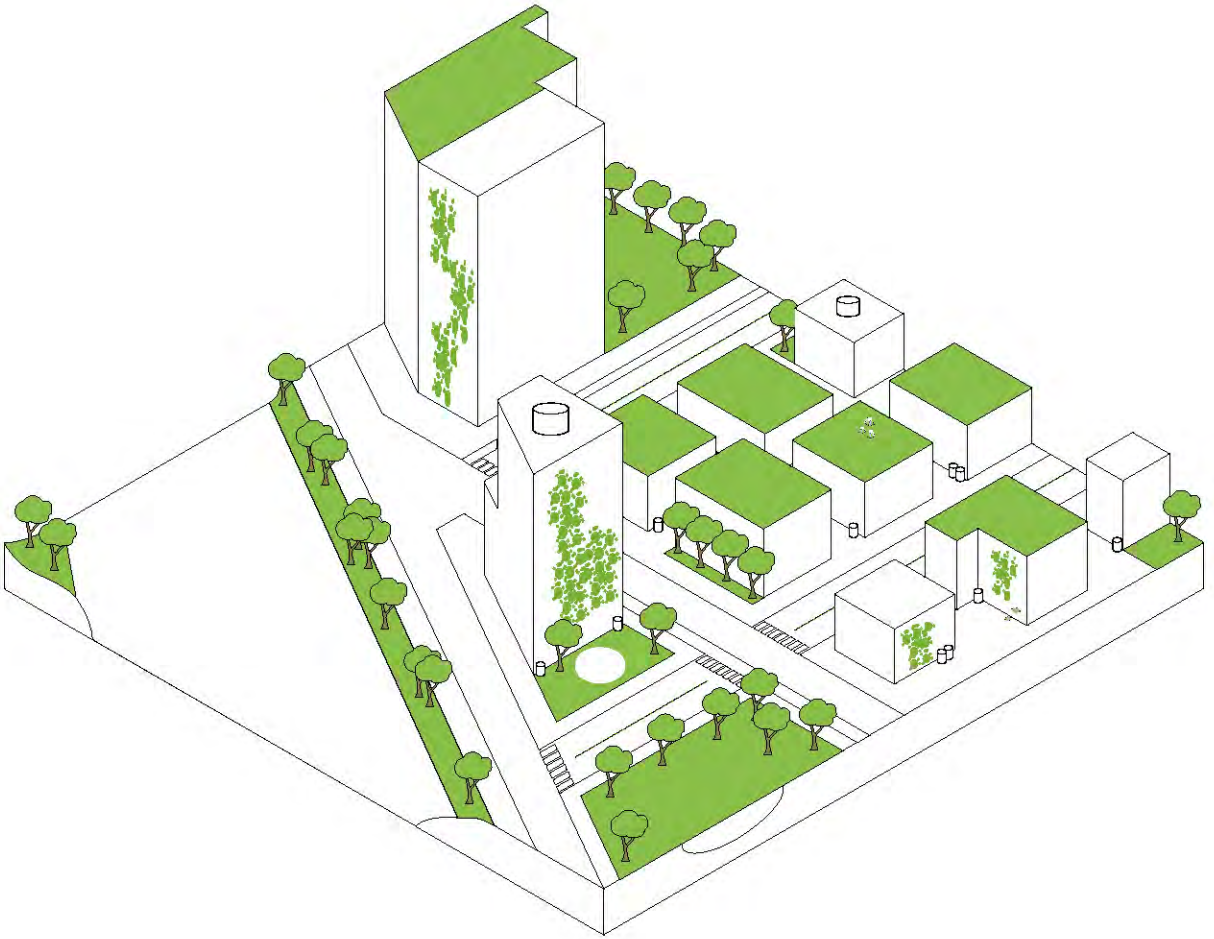
WATERWORKS GARDENS
Renton, Washington
Waterworks Gardens is adjacent to King County's south treatment plant and filters storm water from the plant's 50 acres. The garden provides treatment 'rooms' in an effort to cleanse the water before it reenters Springbrook Creek.

LINDEVANGSPARKEN
Frederiksberg, Denmark
Lindevangsparken was designed with climate adaptability in mind to manage larger storms predicted in the future. Hard and soft landscape features provide recreational amenities during normal conditions and capture flood waters during storm events.

Source: Nancy Rottle

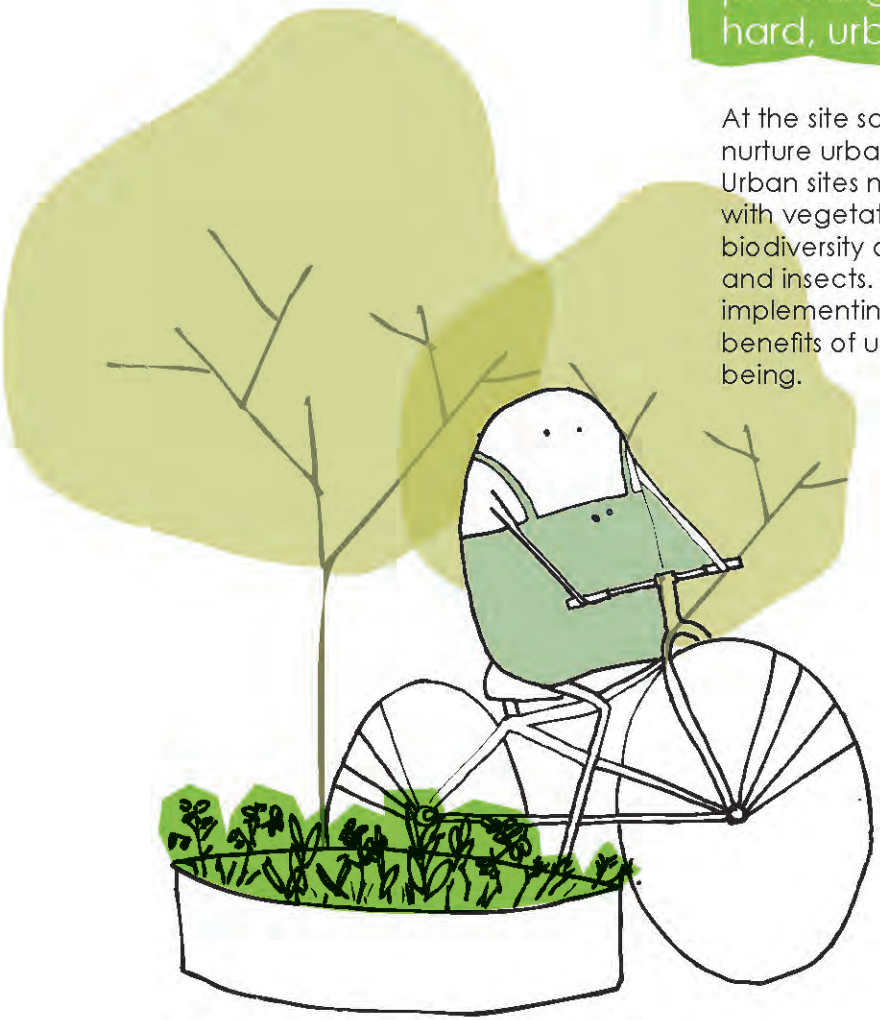
TÅSINGE PLADS
Copenhagen, Denmark
Designated "Copenhagen's first climate-adapted space," Tåsinge Plads is a pocket park that can manage 7,000m² of rainwater when needed. The park acts as a exposed courtyard for the adjacent residents. What was once solely asphalt is now an urban oasis - for both humans and the environment.

SITE | BIOLOGICAL



BIOLOGICAL

Spaces and qualities that support **multiple species, enhancing biodiversity** and providing a balance to the hard, urban environment.



At the site scale, the biological system must nurture urban nature in public spaces. Urban sites need to balance hard surfaces with vegetation that helps to increase the biodiversity of desirable plants, animals and insects. Cities around the world are implementing practices that recognize the benefits of urban nature to human well-being.

ENGHAVE PLADS | BIOLOGICAL


Source: Tredje Natur

FIELD
At first glance, the grassy field is easily recognizable as a space for people to gather, play, or relax. The lawn serves uses such as introducing vegetation into the urban environment, which can improve biodiversity while also reducing the heat island effect [metabolic] and allowing for water infiltration [hydrological].

URBAN CANOPY
The dense tree canopy surrounding Enghave Park creates a visual separation from the surrounding city, allowing park-goers to briefly escape the urban environment and immerse themselves in a more naturalistic setting. The vegetation also provides sanctuary for animals, creating a node of increased biodiversity.

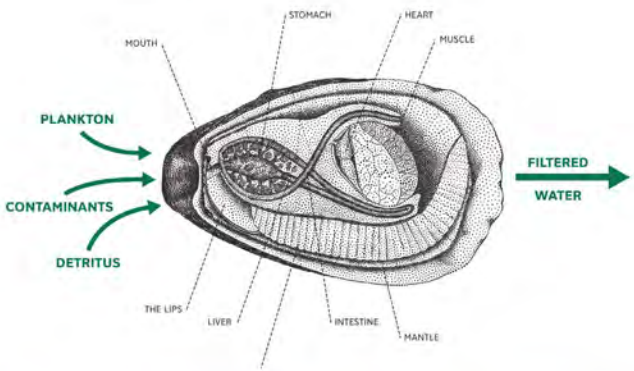
POND
The pond introduces aquatic plant and animal life to this urban park.

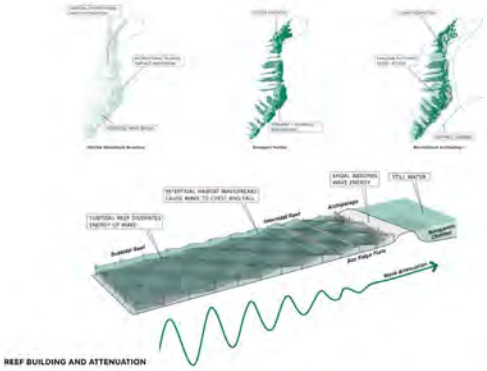
SITE | BIOLOGICAL
PRECEDENTS

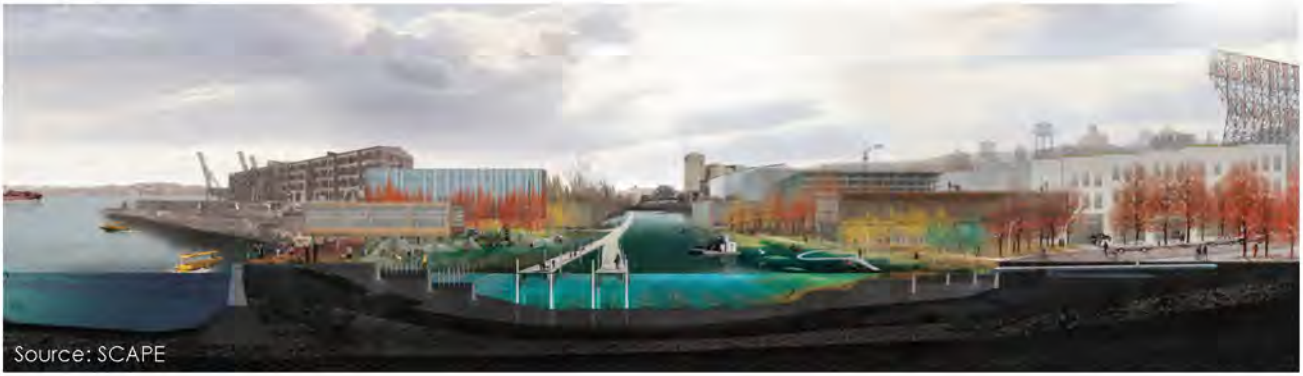

Source: Nancy Rottle

GARDENS BY THE BAY
Singapore
Singapore's Gardens by the Bay prioritizes biodiversity, creating numerous ecologies appropriate to the region's tropical weather, from the ground to the sky. Its "Supertrees" host aerial plants, produce energy, store water, and provide visitor views over the expansive botanical park.


Source: Nancy Rottle





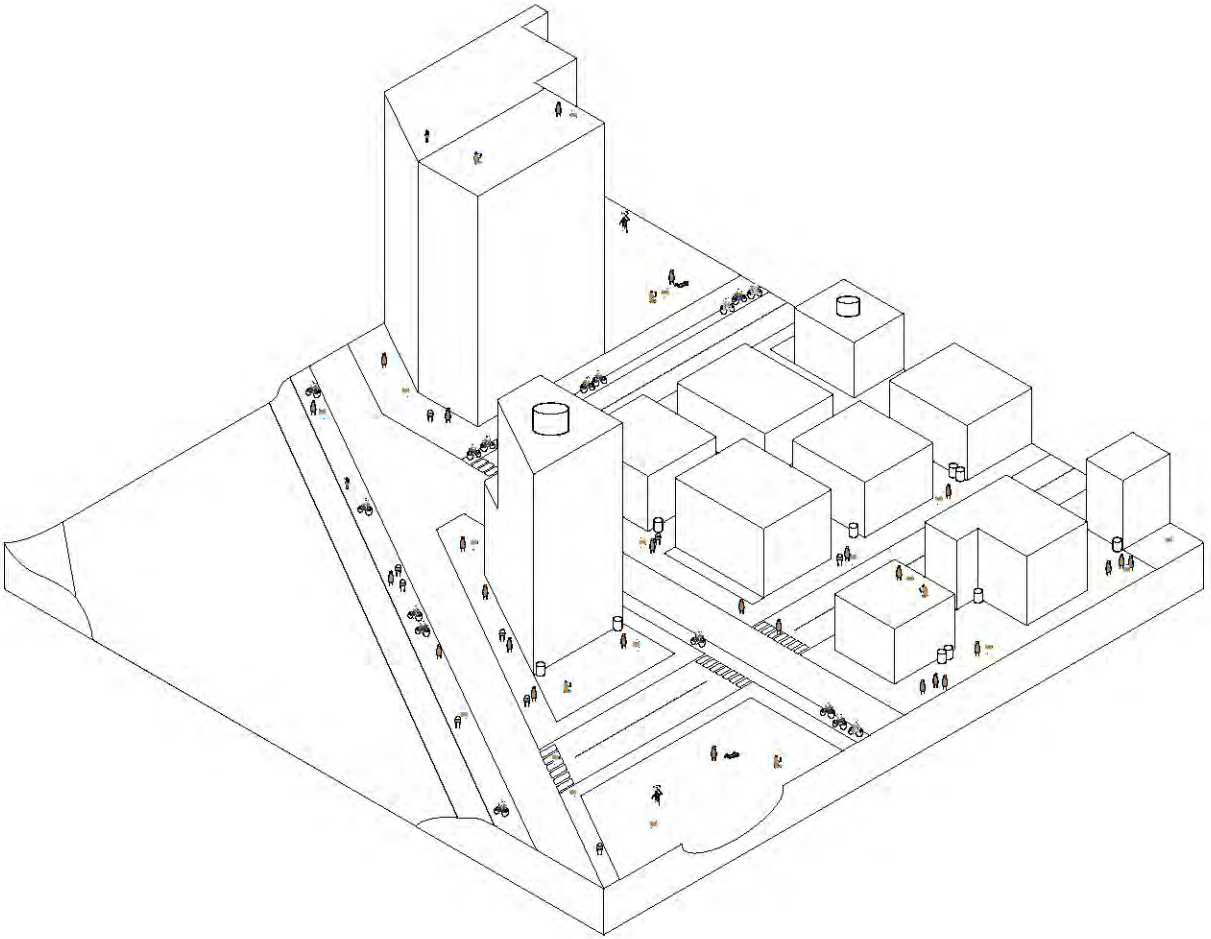

Source: SCAPE

OYSTER-TECTURE

New York City, New York

Oyster-tecture focuses on improving the ecosystem of the highly-polluted Gowanus Canal in Brooklyn. The project proposes re-introducing the keystone species of oysters, which while purifying the water in New York Harbor, would also bring more biodiversity to the bay with positive effects up the food web. In addition to environmental considerations the project aims to revitalize the local economy, currently dominated by industrial uses, by capitalizing on the potential of edible oysters and access to waterfront social spaces.

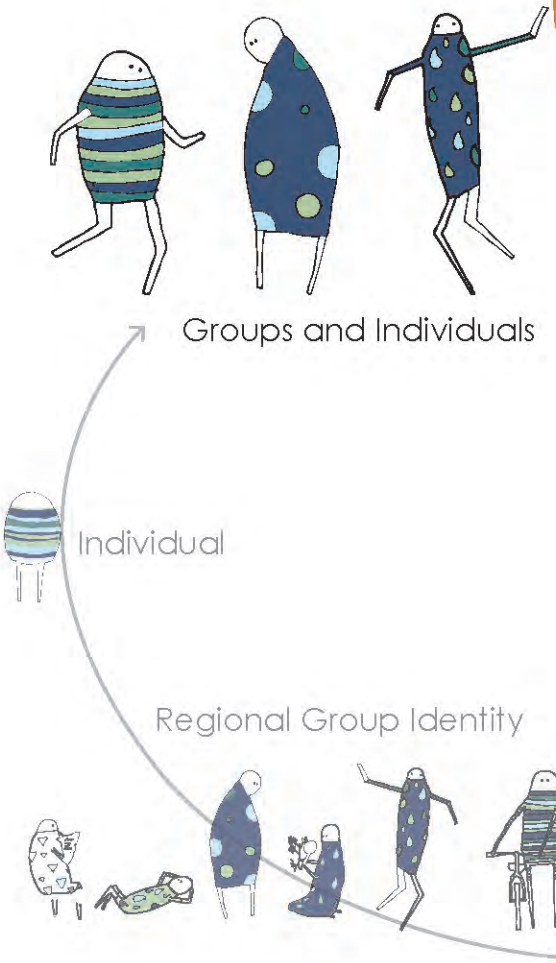
SITE | SOCIAL



Site scale brings together a multitude of users who might use the site in different ways.

SOCIAL

Community spaces designed and designated for the human population that provide interaction and gathering spaces within the **public realm**



ENGHAVE PLADS | SOCIAL

Source: Tredje Natur

MULTICOURT

This multi-use sports court introduces active recreation into the park. The space can be used both for casual play and for more organized events, with stands to accommodate a large number of spectators. The simple stadium seating can also be used by park-goers for meeting and socializing.

Source: Tredje Natur

PLAZA

A central meeting place eases the transition between the street and the park, and serves as a focal point for community gatherings. Spaces like these create a place for social life to thrive in the public realm.

Source: Københavns Metro

OUTDOOR SEATING

The newly designed Enghave Plads will feature outdoor seating ringing the metro station plaza, providing commuters with a place to rest or wait for their trains, as well as improving the social space of the site for locals and visitors.

SITE | SOCIAL
PRECEDENTS

ADVENTURE PLAYGROUND
Berkeley, California, USA
Adventure playground breaks down the stereotypical playground most Americans would imagine. The playground provides ample opportunity for children to design, build, and play with many types of low-risk equipment and tools. While Germany has capitalized on this concept long before Berkeley, the prominence and popularity of Adventure Playground is clear: children thrive under the freedom to be creative.

NIEUWMARKT
Amsterdam, The Netherlands
Nieuwmarkt is an important site within Amsterdam's west side and the city as a whole. The site has a diverse market on Saturdays attracting residents and tourists alike. While the market itself is maybe not world renowned, the concept is important to understand. Markets bring people together and perpetuate a lifestyle more suited to local goods and services.

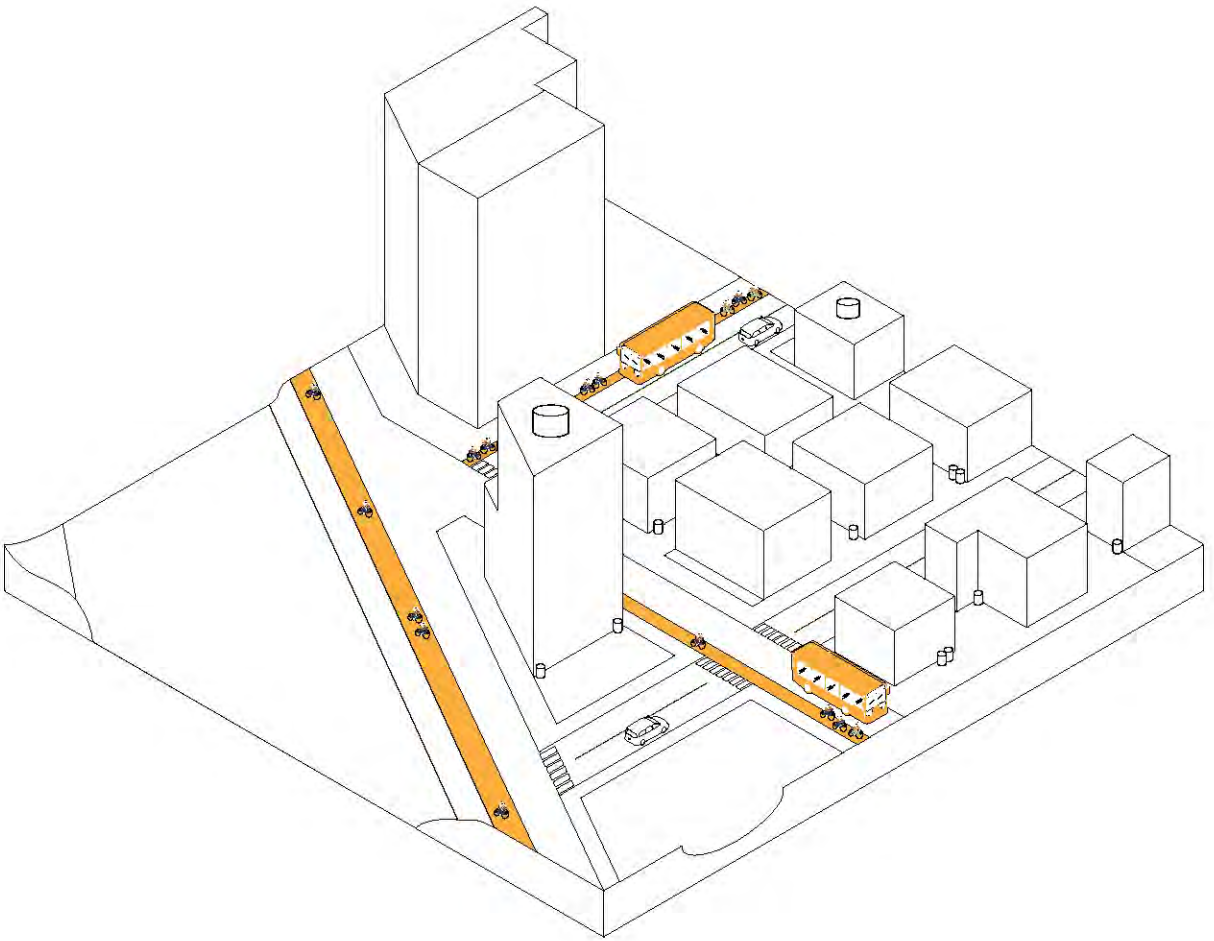
Source: Projects for Public Space


Map Source: Google Earth


Source: re:Streets

INSADONG-GIL
Seoul, South Korea
Insadong-gil went through a revitalization to become more pedestrian friendly in the early 2000s; benches, planters, and other public amenities were added to draw more pedestrians to the shopping street. The redesign, or design update, really focused on refining Insadong-gil as a place, instead of choosing generalized 'placemaking' interventions; the street character reflects some of the history of the street in its furnishings.

SITE | MOBILITY

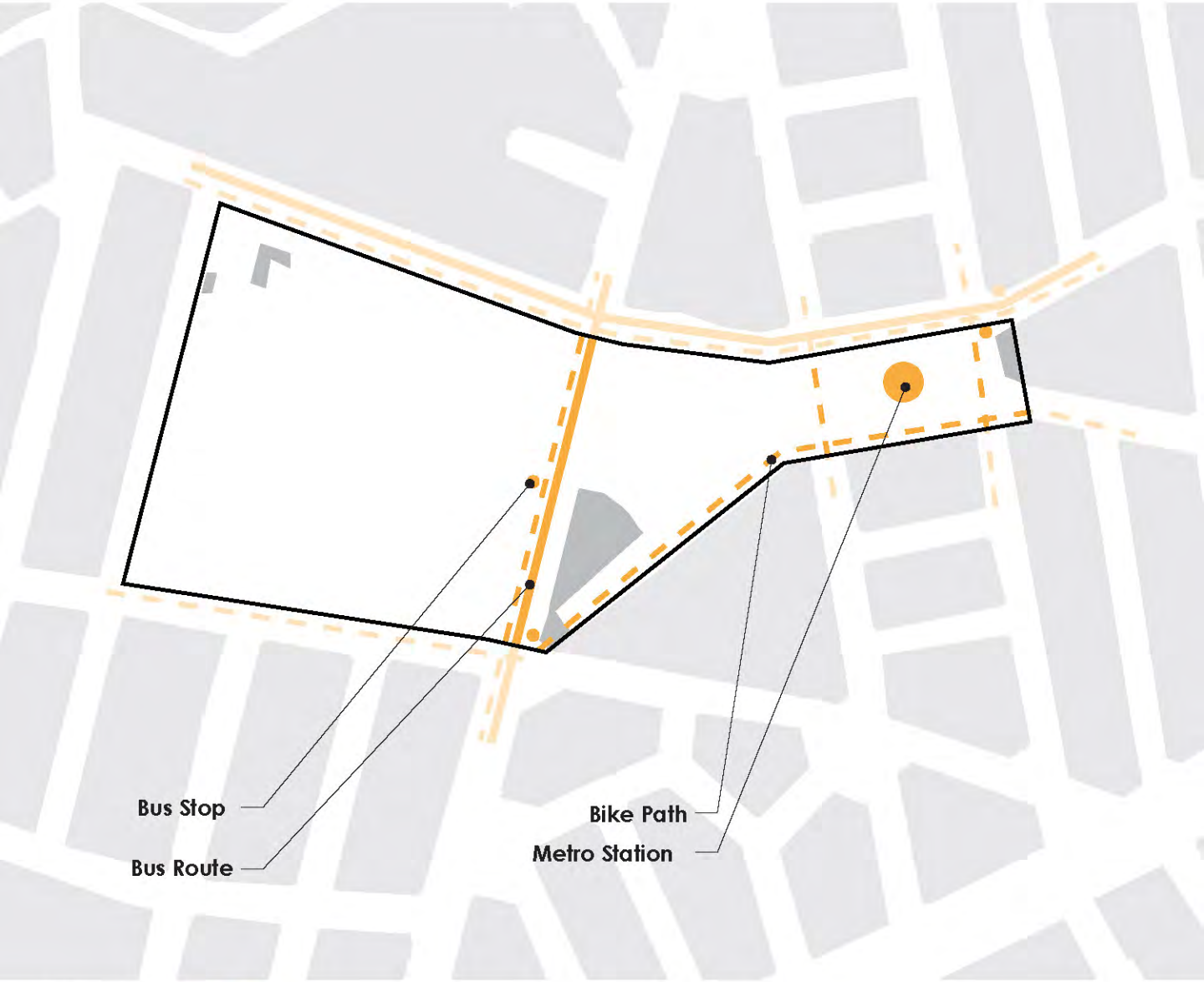


MOBILITY

Networks and facilities that promote the use of active transportation.

At the site scale mobility is not only about moving through a site, but also about the connection between the act of movement and the infrastructure needed to positively aid that movement. This references the interventions supplied on a micro scale - bicycle infrastructure as an example - to work with the overarching site circulation.

ENGHAVE PLADS | MOBILITY



METRO STATION

The new Enghave Plads metro station will connect this part of the neighborhood to Copenhagen's expansive public transit network. The station is part of the new *Cityringen* line that offers service in a loop around the city, allowing for easier mobility from one end of Copenhagen to the other.

BICYCLE INFRASTRUCTURE

Cycle paths are integrated into the site, both in shared pedestrian-cycle spaces and adjacent to roads in protected lanes. Bike stands are also strategically placed to make transitioning to another mode of travel convenient and easy. Maintaining comprehensive bicycle infrastructure encourages people to use bikes over cars which is beneficial to both the environment and human health.

BUS STOPS

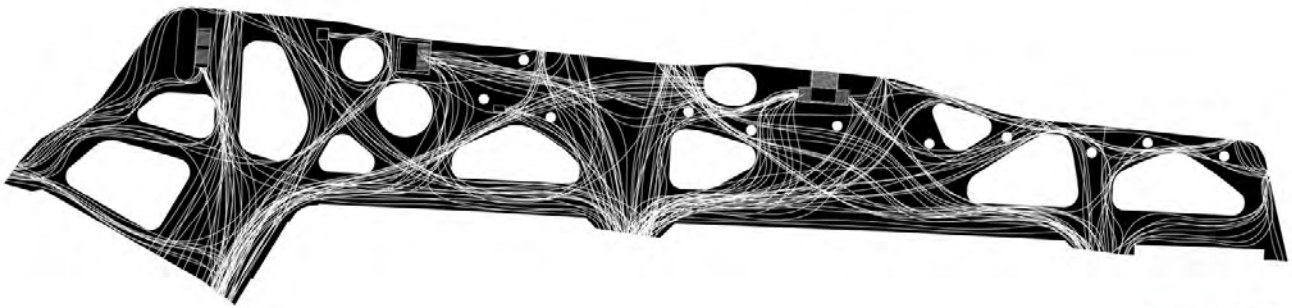
The 3A bus line runs down *Enghavevej*, bisecting Enghave Parken and Enghave Plads. This busy bus line connects the southwestern end of the city with the northeastern end. Buses come as frequently as every 10 minutes, making for easy connections. Clearly marked bus stops with schedule and route information make commuting an easy way to get around for both visitors and city residents alike.

SITE | MOBILITY

PRECEDENTS

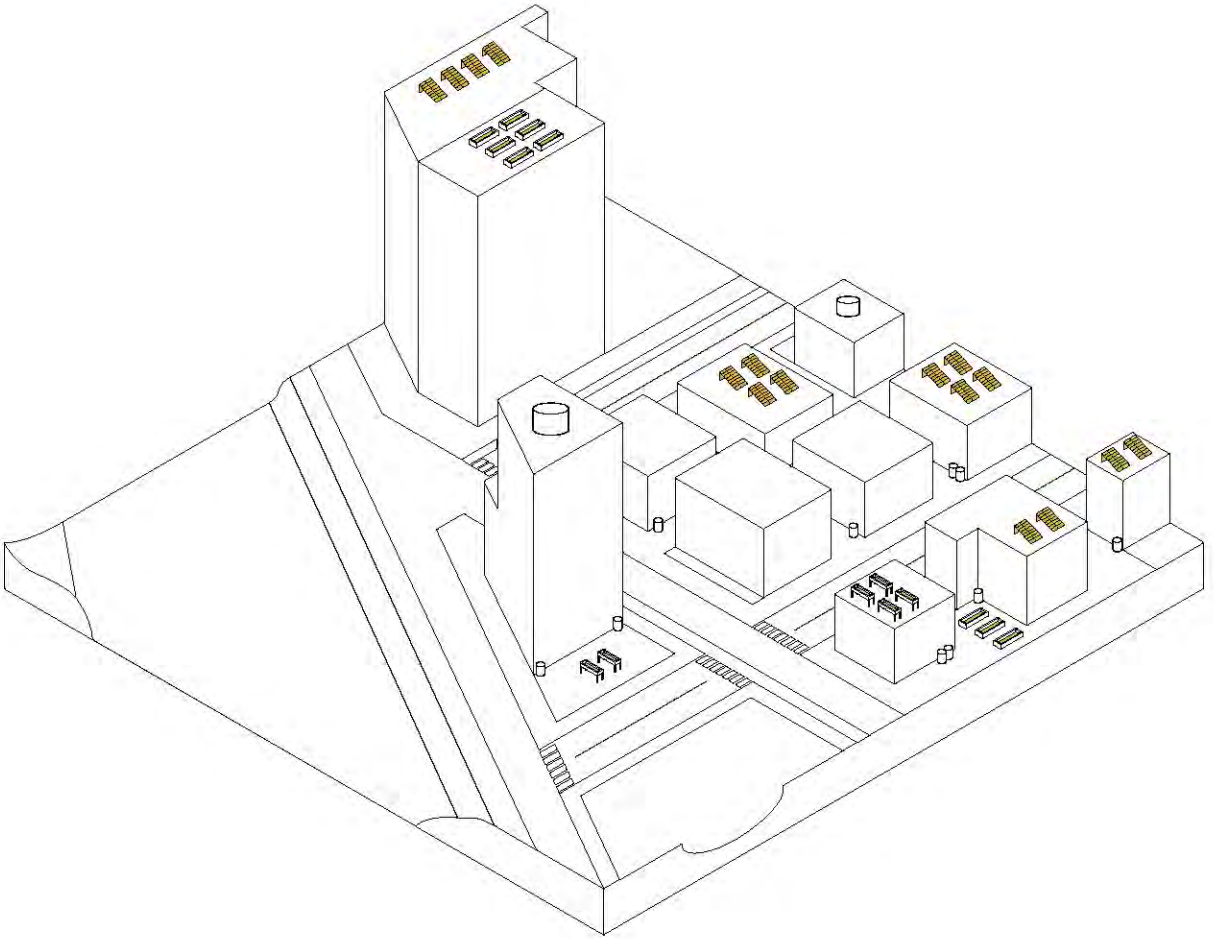
NORREPORT STATION

A major transit hub for light rail, metro, regional trains, bus, and bike, Norreport Station, recently redesigned by COBE Architects + of Copenhagen, is not only a social gathering space, but more so a major connection for mobility in Central Copenhagen. On the bottom of the next page is the circulation diagram completed by COBE; as part of the site analysis, the firm studied circulation patterns of pedestrians and bicyclists moving through and around the site. By reinforcing primary pedestrian and bicycle circulation, COBE identified the leftover spaces for bicycle parking. To delineate bicycle parking areas yet reduce the visual presence of bicycles, the cycle parking "rooms" were topographically depressed, which also provides a stormwater detention function. This busy hub now better accommodates people using and connecting all kinds of transportation, including walking, cycling, train and bus.



Source: COBE

SITE | METABOLIC



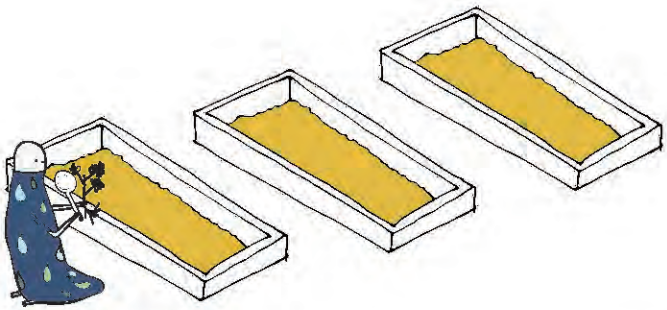
METABOLIC

Energy-producing elements that have minimal negative impacts to the climate.

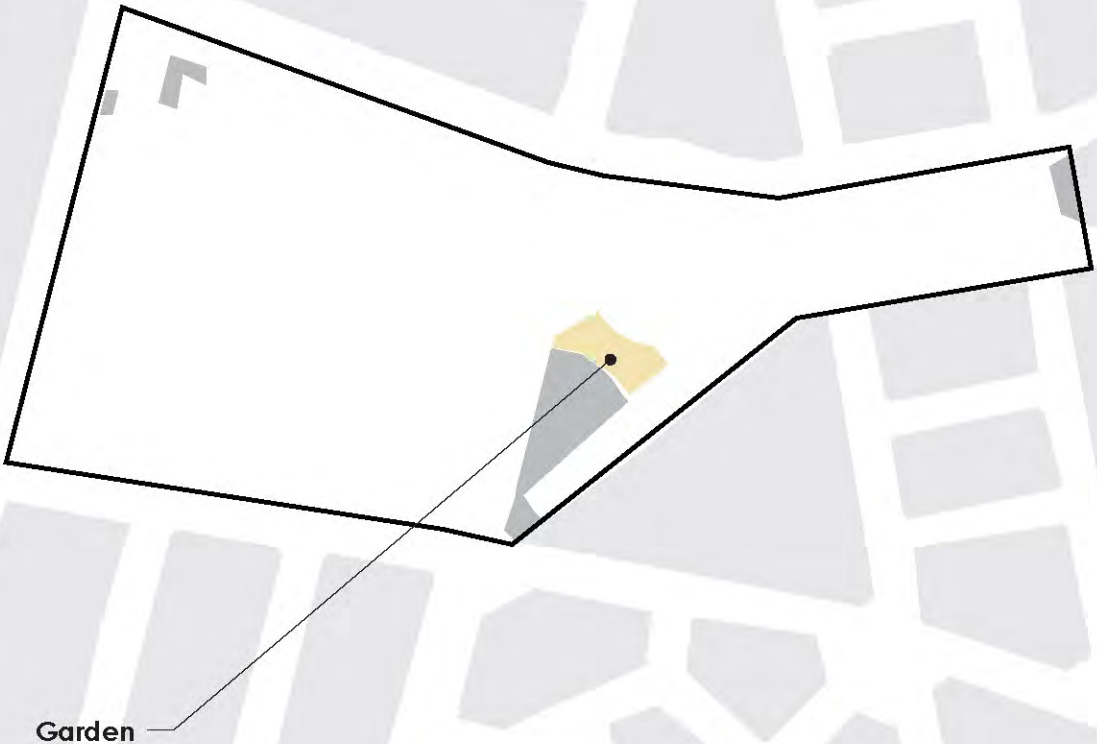
At the site scale, production of energy is the focus. This can take the form of solar arrays, food-producing gardens, and small-scale wind turbines.

The site is also where waste is gathered for removal to recycling or waste-to-energy facilities, or eventual disposal.

Contaminated water is another form of waste, but instead of being removed for treatment, it can be cleaned on-site through specialized plant systems such as retention ponds or bioswales.



ENGHAVE PLADS | METABOLIC



GARDEN

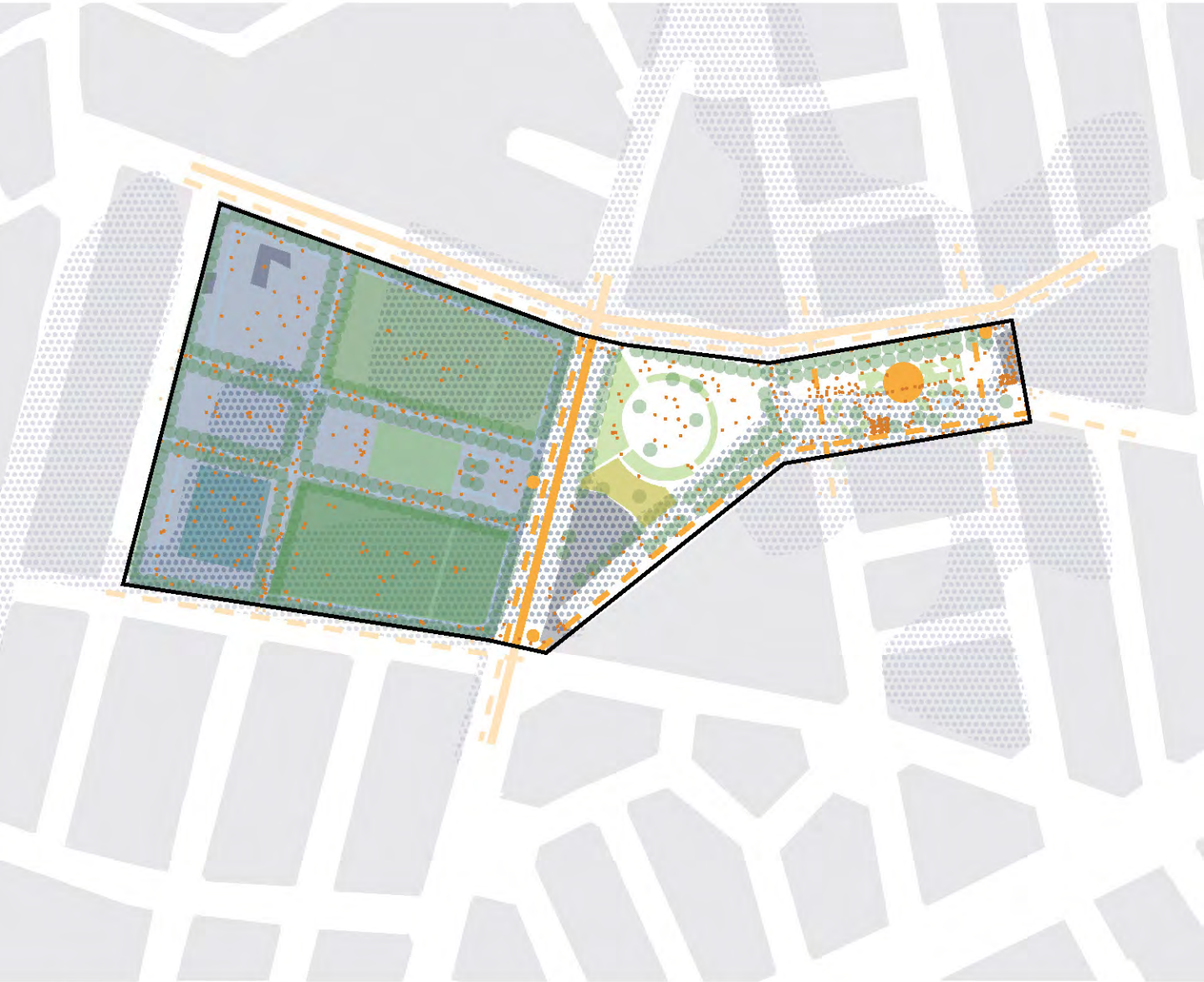
A small garden is the only energy-producing element on the site, generating food energy for children at the adjacent school. When many such food-producing gardens on sites across the city supply local nourishment, it can help to reduce a city's carbon footprint.

SITE | METABOLIC
PRECEDENTS

FR. COLLINS PARK
Dublin, Ireland
Collins Park is one of the few metabolic parks where people make the direct connection with wind energy. Many sites that collect wind energy are often not meant for human use. By allowing people to get up close to the wind turbines, there is a direct connection with education about harnessing wind energy, while also providing a refuge of nature in the city.

Ostergro
Copenhagen, Denmark
This rooftop urban garden is an example of productive agriculture stitched into the built environment. The garden provides food energy for the connected restaurant, which can be enjoyed by locals and visitors alike. Producing food on-site reduces environmental costs related to transportation and uses stormwater that might otherwise be funneled into drainage systems.

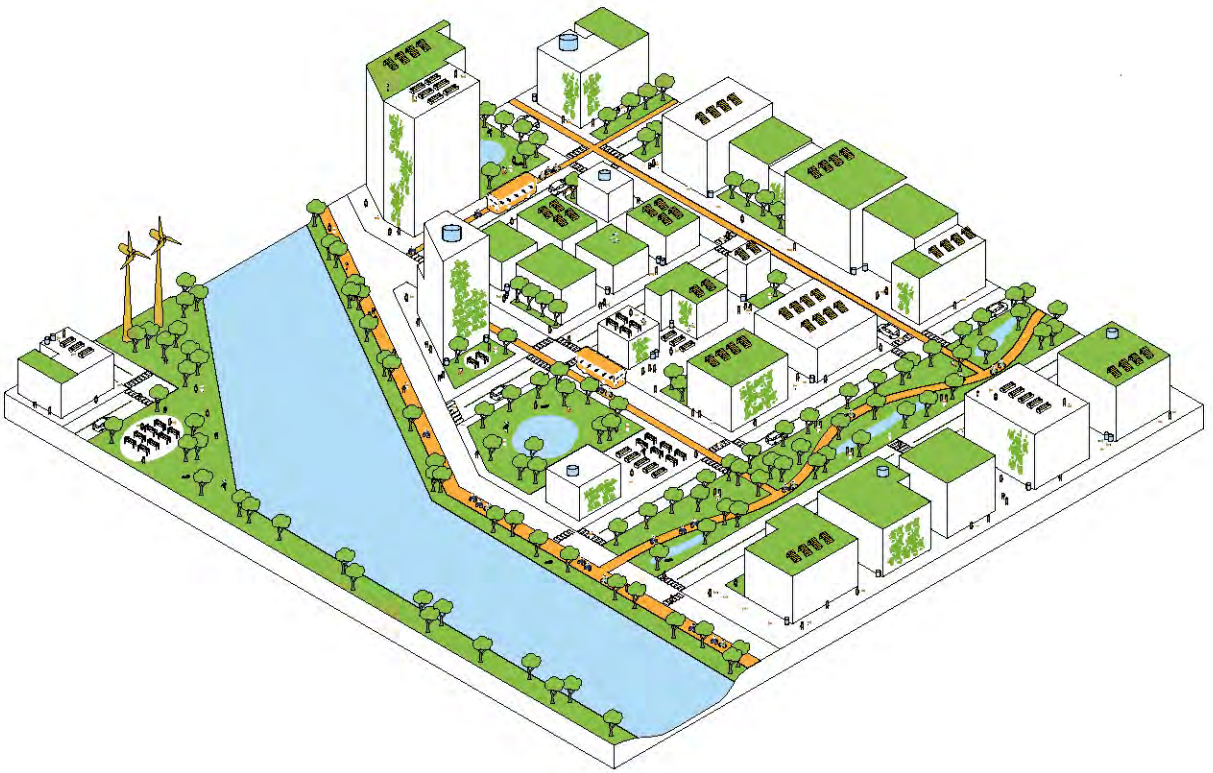
SITE SUMMARY



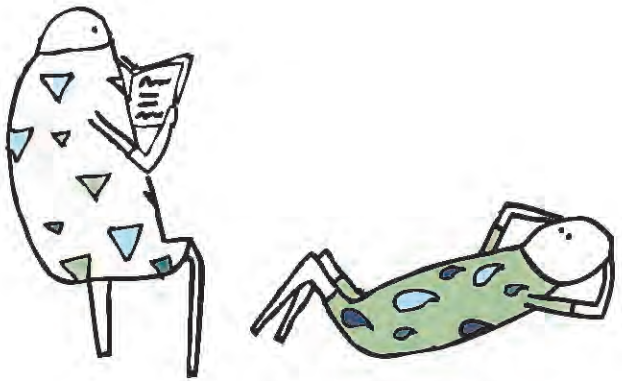
SITE AS A SET OF SYSTEMS

The site scale starts to piece interventions together. Enghaveparken's new water features provide a social focal point, while drainage for the plaza ties into the neighborhood's cloudburst management strategy. Street trees and planters bring vegetation and biodiversity to the site. Meanwhile, Enghave Plads plaza is a prominent meeting place in the area, and surrounding businesses utilize the space for seating. The nearby school garden is a food-energry producing space. The two halves of the site are split by Enghave street which has space for cars as well as public buses and raised cycle tracks. The new Metro station will tie the site into the city's transit network.

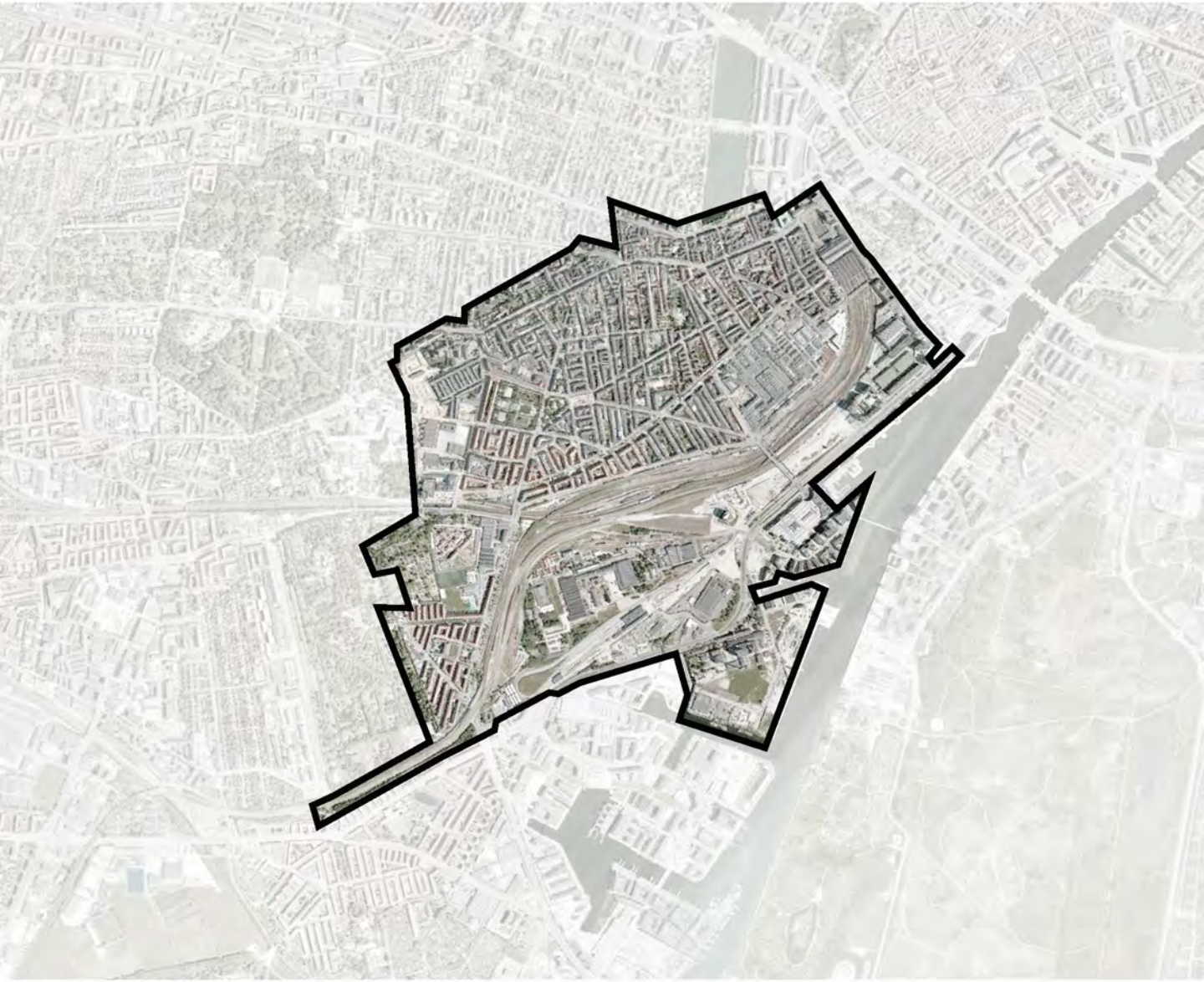
CHAPTER 3
NEIGHBORHOOD SCALE



A neighborhood refers to **a district with distinct characteristics in a given city.** It is made up of multiple sites and many micro units. The neighborhood can be **informal**, a designation given to it by residents as a means to create identity; **or formal**, a codified area with legislative borders. In either case, **a neighborhood interweaves site and community**.



CASE STUDY: **VESTERBRO**

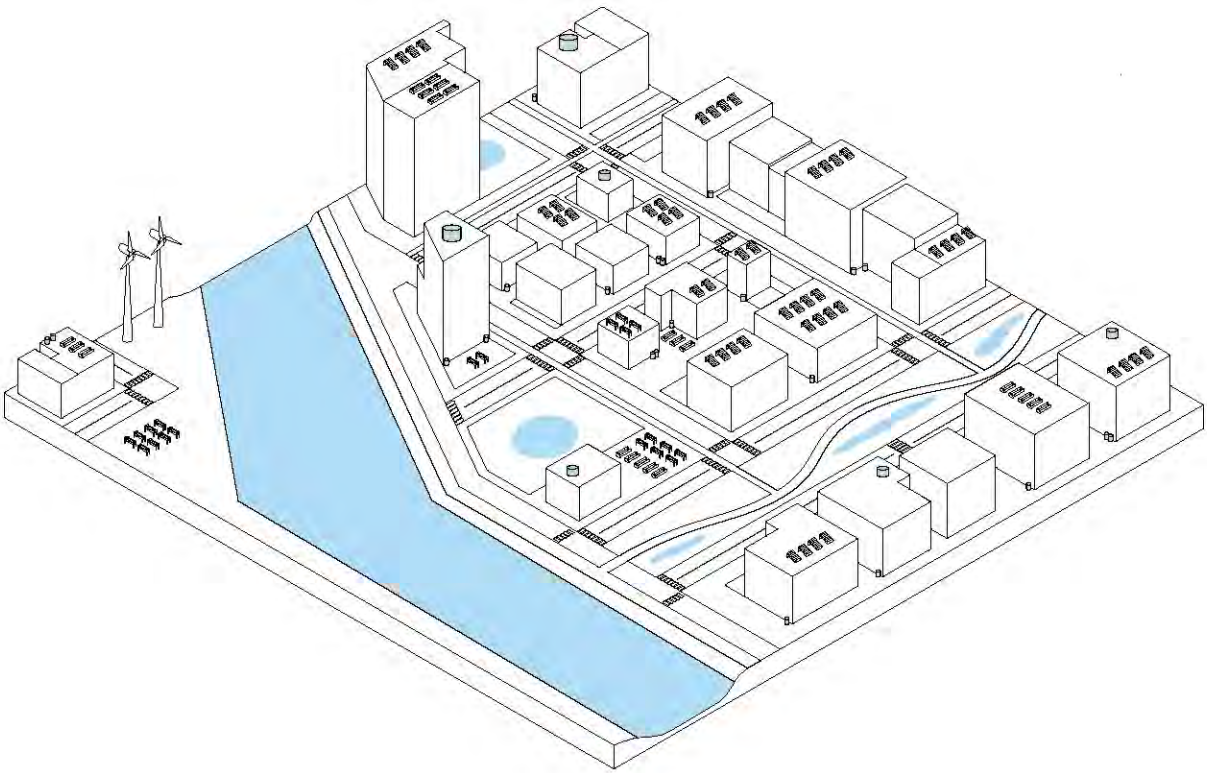


Vesterbro is historically known as a working class neighborhood. Historically, Vesterbro was part of the working class urban fabric that was established in an area as an 'after thought' or leftover space from the rest of the coveted city forming around Central Station. Vesterbro has gone through a few major phases of development (or revitalization): working class neighborhood, an unsafe, non desireable neighborhood, revitalization by minority groups, urban renewal by the municipality, and gentrification most recently. Historically, Vesterbro offered certain functions pertinant to the development of the neighborhood: main station, meat-packing district, schools, and churches.

Gentrification

Apart from physically upgrading Vesterbro's decaying buildings, the municipality's aim was to include the inhabitants in the urban renewal process and, seemingly, to prevent the dislocation of people from the neighbourhood. However, due to ambiguous policies, the workings of the property market and the lack of sufficient deflecting mechanisms, middle-class inhabitants are now replacing the high concentration of socioeconomically vulnerable people that characterised Vesterbro before the urban renewal. This process may appear `gentle', but it is nonetheless an example of how state and market interact to produce gentrification with `traumatic' consequences for individuals and the city as a socially just space.

NEIGHBORHOOD | HYDROLOGICAL



water as a

RESOURCE

clean water source
stormwater
rainwater
greywater
blackwater

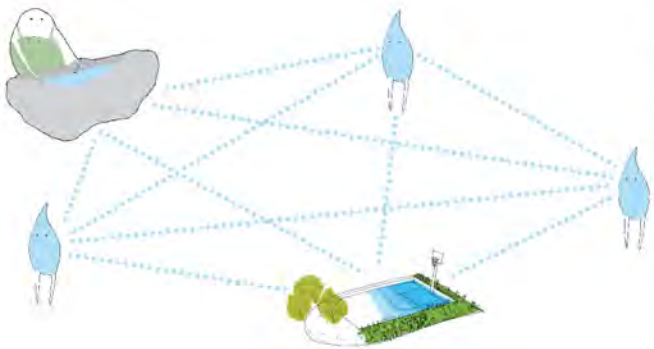
and as a

PROCESS

INTERACTION
COLLECTION
- RETENTION
- DETENTION
- INFILTRATION
- FILTRATION
- STORAGE

MOVEMENT
- DISCHARGE
- RUNOFF

REMEDIATION / TREATMENT
MANAGEMENT



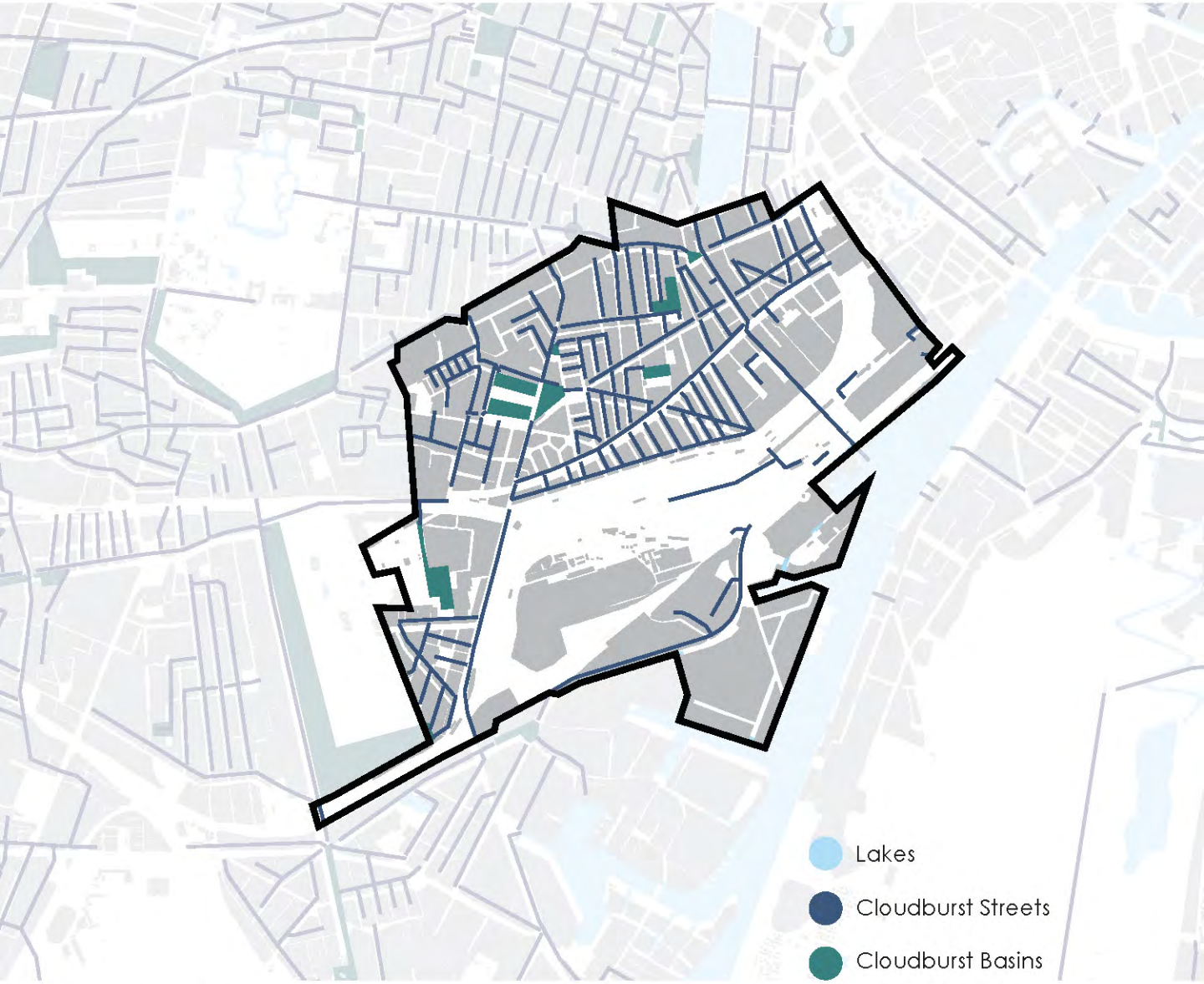
HYDROLOGICAL

Understanding water as a **closed-loop system**, and taking measures to incorporate urban waters - both consumed and produced - into a ecologically-sensitive system

At the NEIGHBORHOOD scale, there is less focus on human interaction with water and more emphasis on the network of water-related infrastructure, including facilities for collection, retention, and discharge of water. Depending on climate, the urban hydrological system can be used to defend against flooding as well as to capture and store water for future use.

Collection infrastructure like streets with inverted crowns, swales, and storm drains help move water from areas where it could be damaging to points where it can be managed and used as a resource. These management areas could be infiltration ponds that allow water to seep back into the soil and recharge the water table, or retention ponds where the water is retained for future use. Urban water should also be treated before being released back into the hydrological system, either by passive means or via active treatment facilities.

VESTERBRO | HYDROLOGICAL



CATCHMENT AREAS

The Copenhagen Cloudburst Management Plan specifies using catchment areas to define the borders of infrastructural works. The water volumes produced and accumulated within entire catchment area are considered in the stormwater management and flood prevention plan. Site-specific projects are designed with the larger area context in mind to ensure that all projects within the catchment are part of a functional networked system.

Source: City of Copenhagen / Ramboll

Below is an example of a multifunctional Cloudburst street; the street adapts to increased stormwater retention as needed. The boulevard offers a connection to larger retention areas, such as lakes and basins.

NEIGHBORHOOD | HYDROLOGICAL

PRECEDENTS

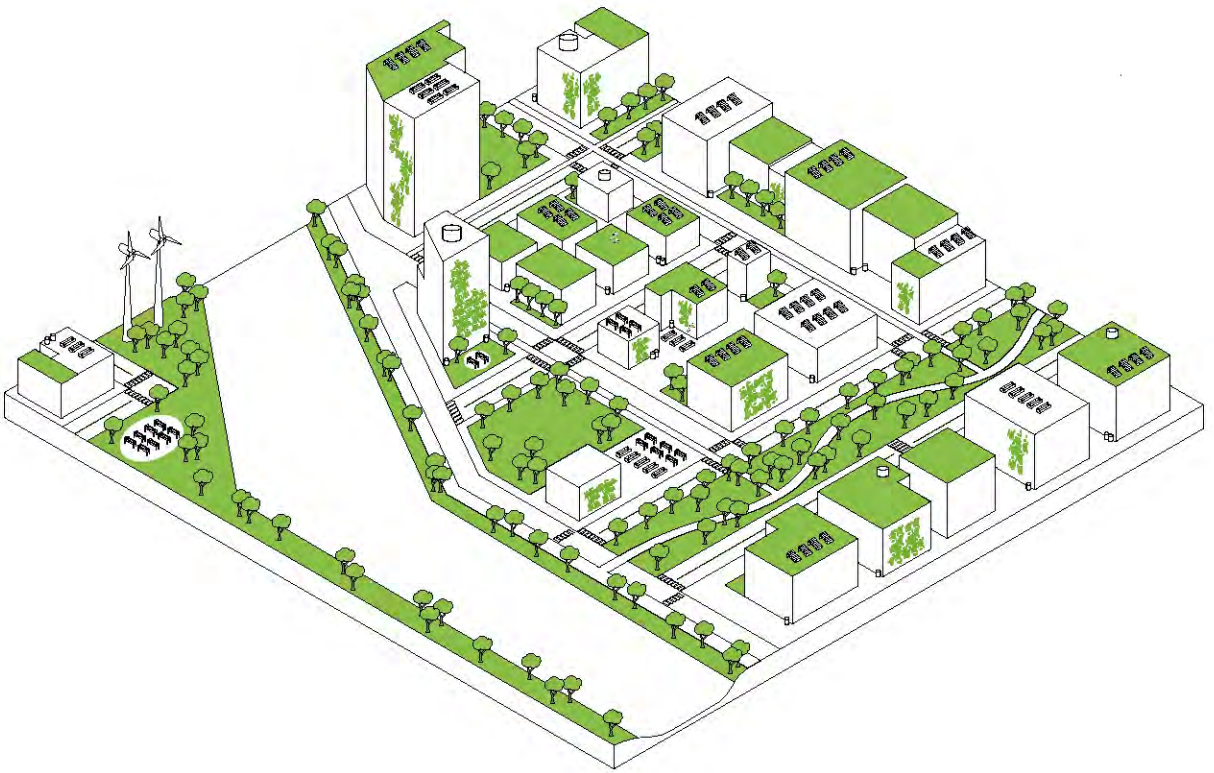
THE BIG U

New York City, New York, USA

The design firm BIG and its collaborators prepared a plan for the reconstruction and longevity of Manhattan's lower waterfront. This integrated green infrastructure project will supply the neighborhood with protection from major flooding with a network of sites, while simultaneously providing public space, habitat, and mobility.

IJBURG
Amsterdam, Netherlands
Ijburg is a recently constructed neighborhood in eastern Amsterdam which is being built on artificial land. Amsterdam, and the Netherlands, have started constructing land and development on said land in order to combat climate change and sea level rise; as most of the city and country's land is underwater, both entities have taken steps to protect their settlements and developments from flood and devastation. Ijburg is made up of six pieces of human constructed land in a very un-Amsterdam grid pattern. Since welcoming residents in 2002, the neighborhood is still under construction in some parts, but will eventually have over 15,000 homes and almost 50,000 residents. The floating houses are on concrete while the neighborhood is built atop an island of fill. What better way to manage sea level rise than to build giant pieces of floating concrete (in simple terms) with developments on top of them?

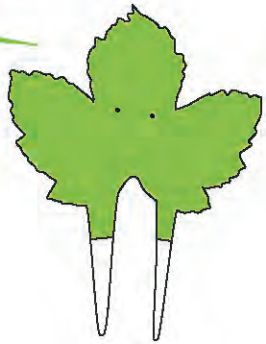
NEIGHBORHOOD | BIOLOGICAL



BIOLOGICAL

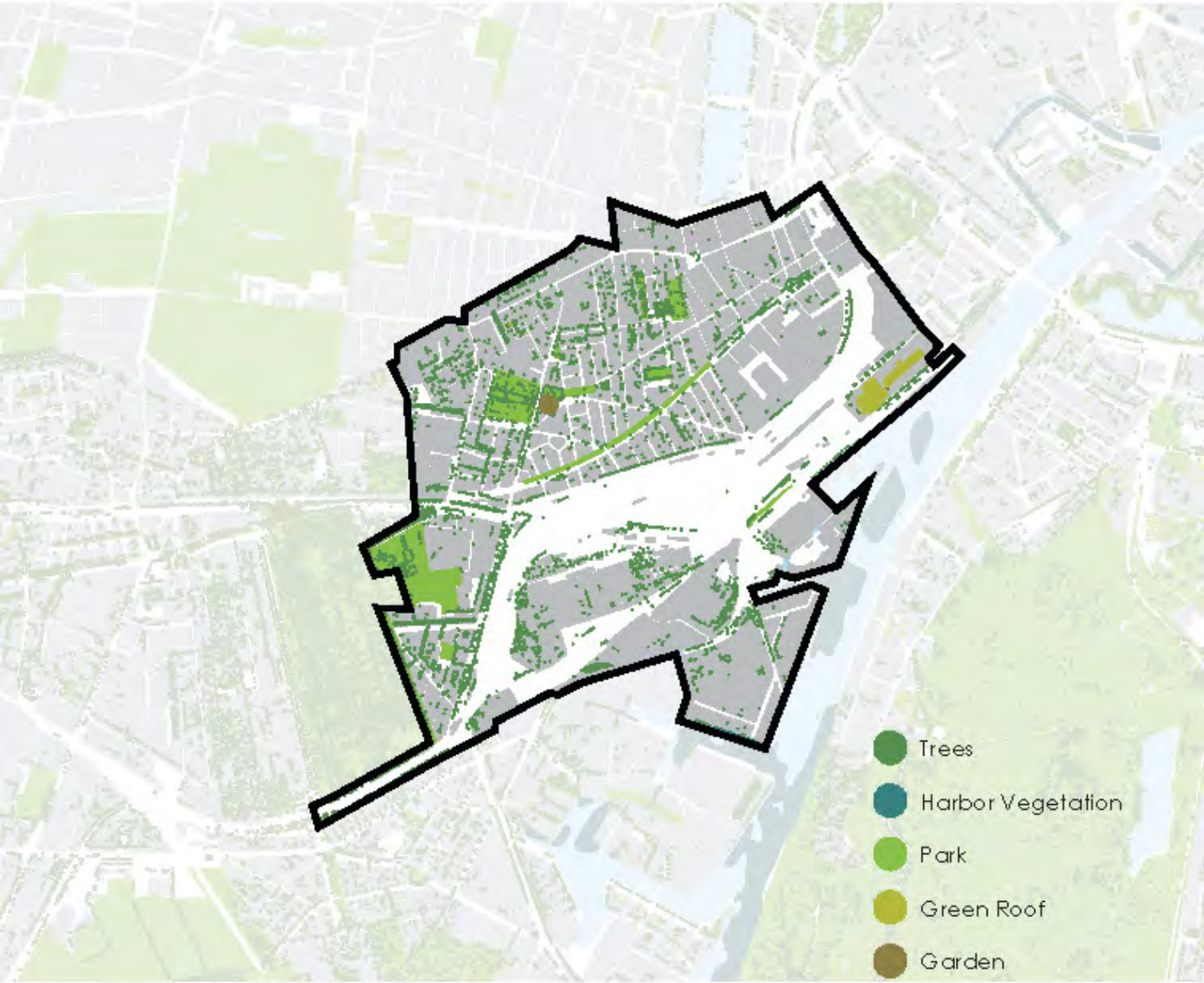
Spaces and qualities that support **multiple species, enhancing biodiversity** and providing a balance to the hard, urban environment.

More trees please!



Many species need large and diverse habitats to thrive. Vegetation at the neighborhood scale can provide these patches and corridors through networks of connected urban features, such as forests, streetside bioretention swales, residential rain gardens, pollination corridors, vegetated roofs, backyard gardens, natural shorelines, and parks of all sizes. With this natural infrastructure, people can experience communities of healthy nature on a daily basis, closest to their homes.

VESTERBRO | BIOLOGICAL




Source: Max Katz


Source: Lisa Risager

PARK NETWORK

Verterbro's network of parks and green spaces creates a web of vegetated nodes within the neighborhood. Whether used actively or passively, these softer spaces offer a reprieve from the hard urban landscapes they are set into. In addition to providing a vital amenity to people, these spaces are also a sanctuary for urban wildlife, making parks some of the most biodiverse spaces in the city. The park pictured below also acts as floodable stormwater collection area [hydrological].

NEIGHBORHOOD | BIOLOGICAL

PRECEDENTS

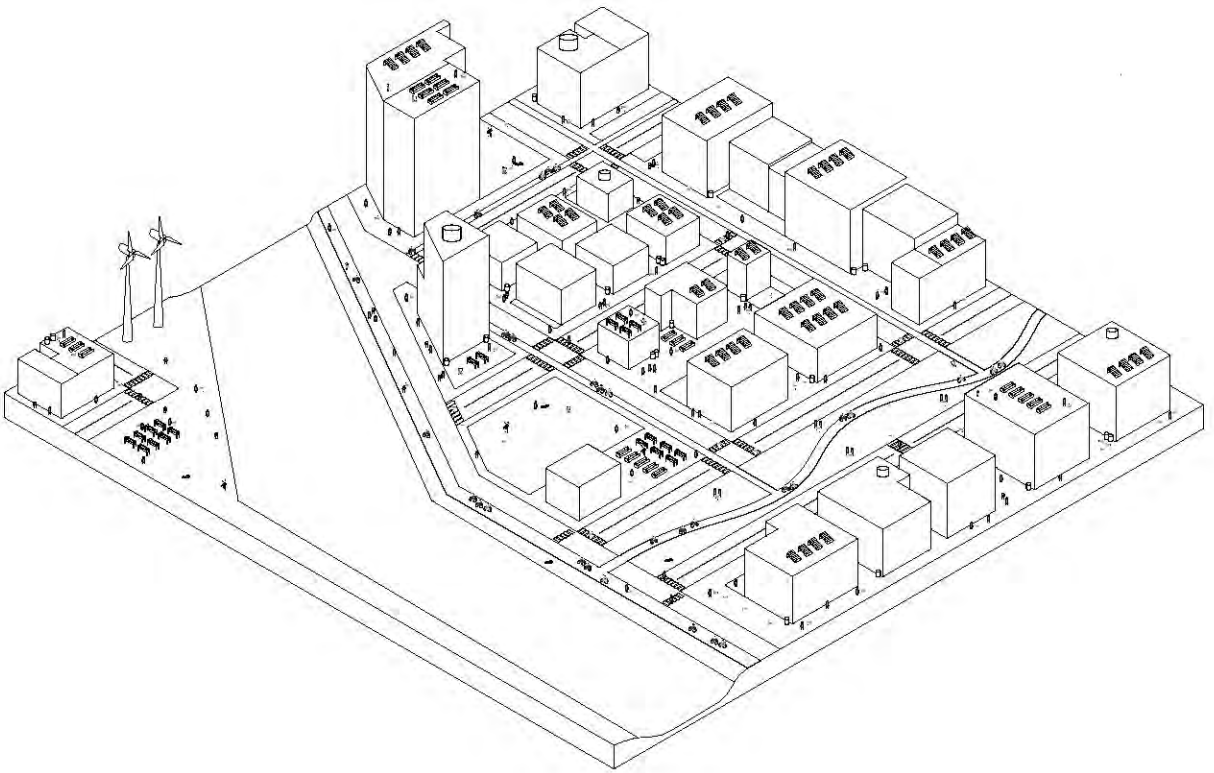
POLLINATOR PATHWAY ®
Seattle, Washington
The Pollinator Pathway is a global idea by designer Sarah Bergmann that encompasses connecting the national parks, seeking ways for cities to contribute to this goal by supporting connectivity and urban density, and creating an ecological counter-landscape to big scale farming (where lack of biodiversity has led to the use of non-native honeybees as pollinators). Highlighted here is Bergmann's initial proof of concept, a linear design project that connects two public parks: Seattle University's eastern edge and Nora's Woods in Seattle's Central District. By connecting these two landscapes, the project facilitated ecological interaction and engaged the residents between the parks in a collective participation. The project was monitored weekly for 6 years by an entomologist, moving from initially observing a half-dozen pollinators to supporting thousands. The below map shows the first Pollinator Pathway along Seattle's Columbia Street with installations highlighted in green.


Source: Sarah Bergmann


Source: Sarah Bergmann

Source: Sarah Bergmann

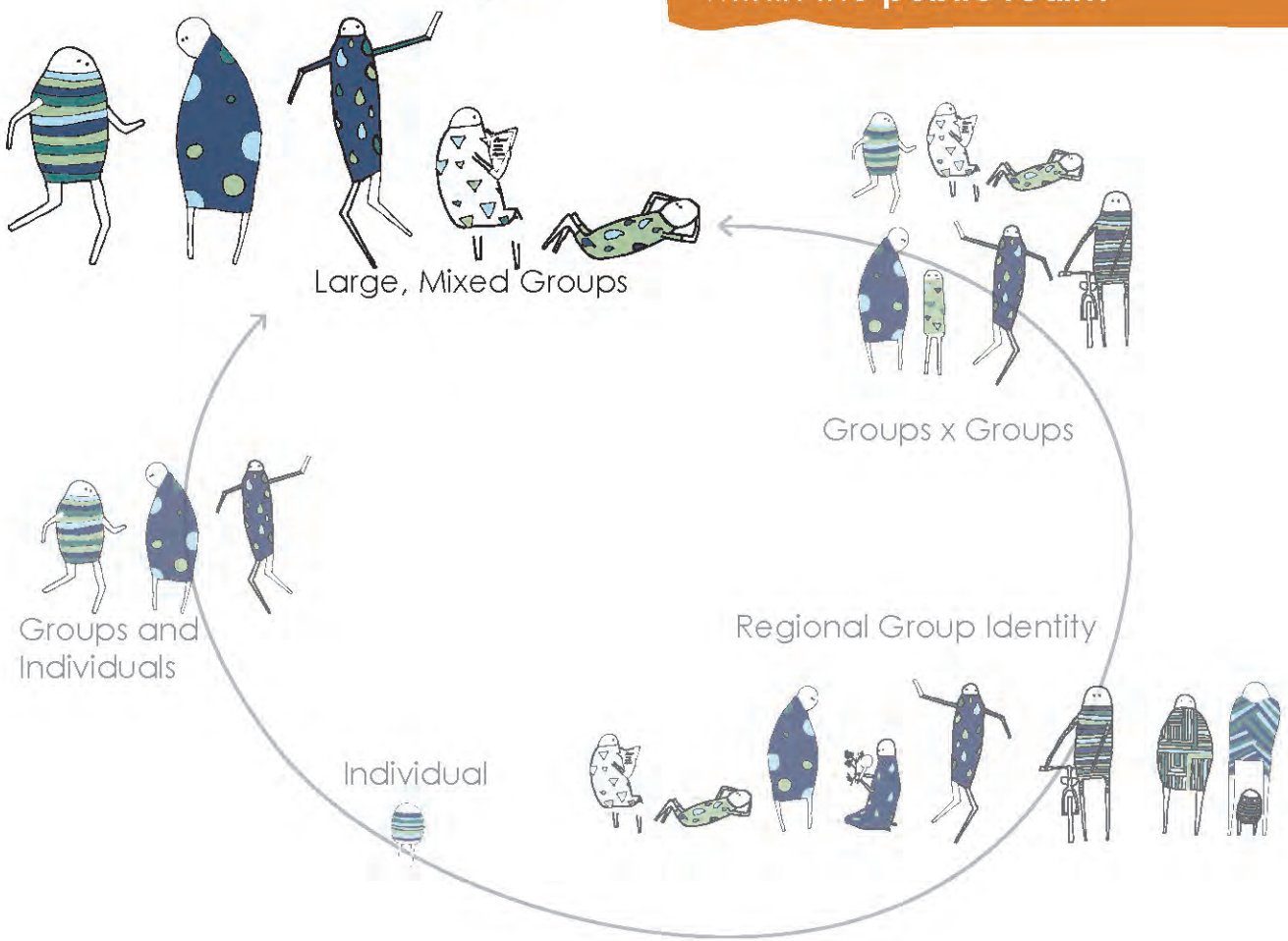
NEIGHBORHOOD | SOCIAL



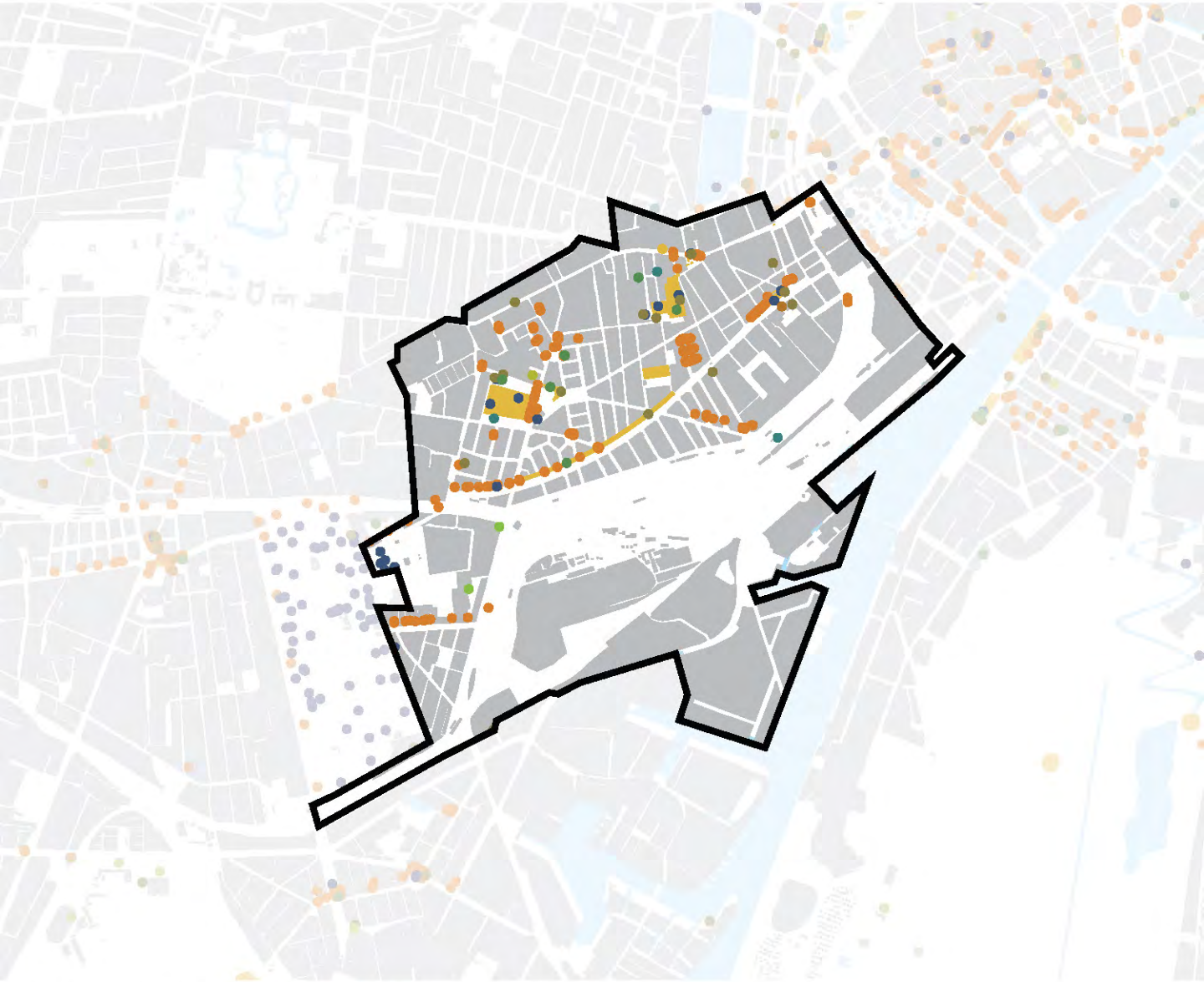
Within a neighborhood, the social system starts to have a larger, common identity connecting those in the neighborhood.

SOCIAL

Community spaces designed and designated for the human population that provide interaction and gathering spaces within the **public realm**



VESTERBRO | SOCIAL



- Library
- Culture House
- Public Restroom
- Fountain
- Benches
- Social Spaces
- Play Fields
- Sports Facilities
- Playgrounds
- Daycare
- Museums

SOCIAL SPACES IN THE PUBLIC REALM: SØNDER BOULEVARD

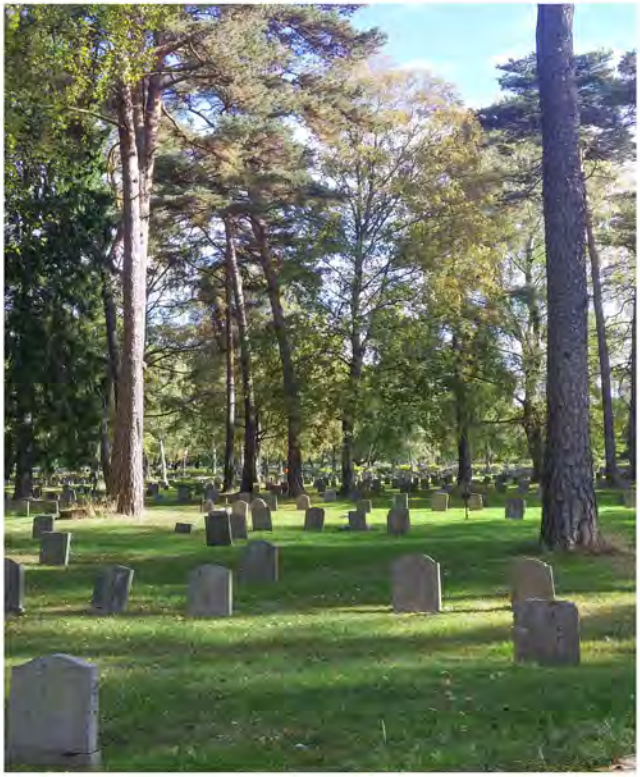
Sømder Boulevard is a wide street with a long linear park in its median. The park provides pedestrians a pleasant space to stroll the boulevard and is punctuated with places to gather, sit, relax, and play. In nice weather, it is not uncommon to see many local residents meeting along the boulevard. Streets like this do more than simply function as a right-of-way; they are important public amenities.

Source: Nancy Rottle

NEIGHBORHOOD | SOCIAL

PRECEDENTS

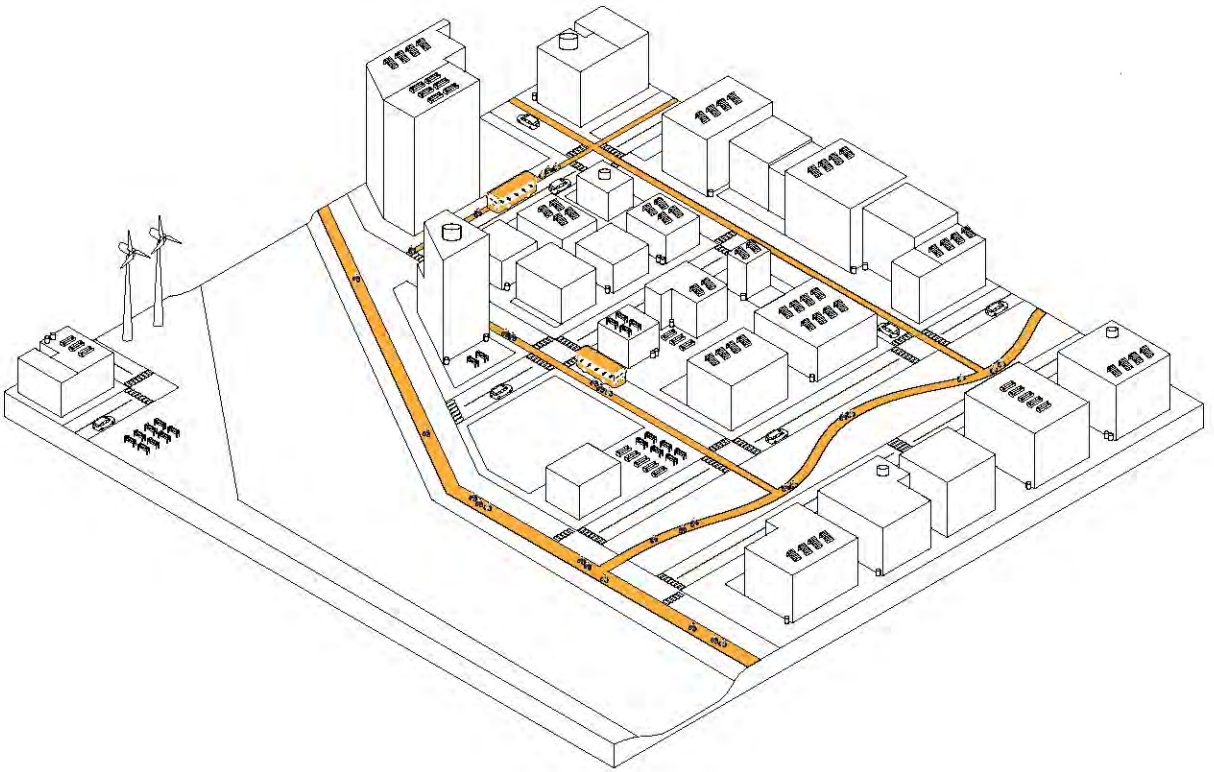
SUSTAINABLE SOUTH BRONX
South Bronx, New York
Sustainable South Bronx, founded in 2001, strives to put environmental justice at the forefront of development in the South Bronx through programming and advocacy, such as green job training and green jobs. Sustainable South Bronx, and many other non-profits and organizations started by Majora Carter, not only make a neighborhood 'greener' (more sustainable) but also strengthen the community socially.



SKOGSKYRKOGÅRDEN
Stockholm, Sweden
The concept of cemeteries as cultural space is not new, however, Skogskyrokogården was the first cemetery to be chosen as a UNESCO World Heritage site. In the planning and design, the cemetery reflects the original vegetation typologies of Greater Stockholm. Skogskyrokogården exemplifies the multifunctional approach to space we advocate for in cities: a place for the dead and alive alike.

KVARTERHUSET AMAGERBRO
Copenhagen, Denmark
Within the eastern neighborhood Amager of Copenhagen, the Kvarterhuset (community house) is a community center, library, cafe, meeting space for the hyper local community. Outside, the kvarterhuset has plenty of space for a range of activities and events, along with stellar architecture, bringing together the residents of Amager.

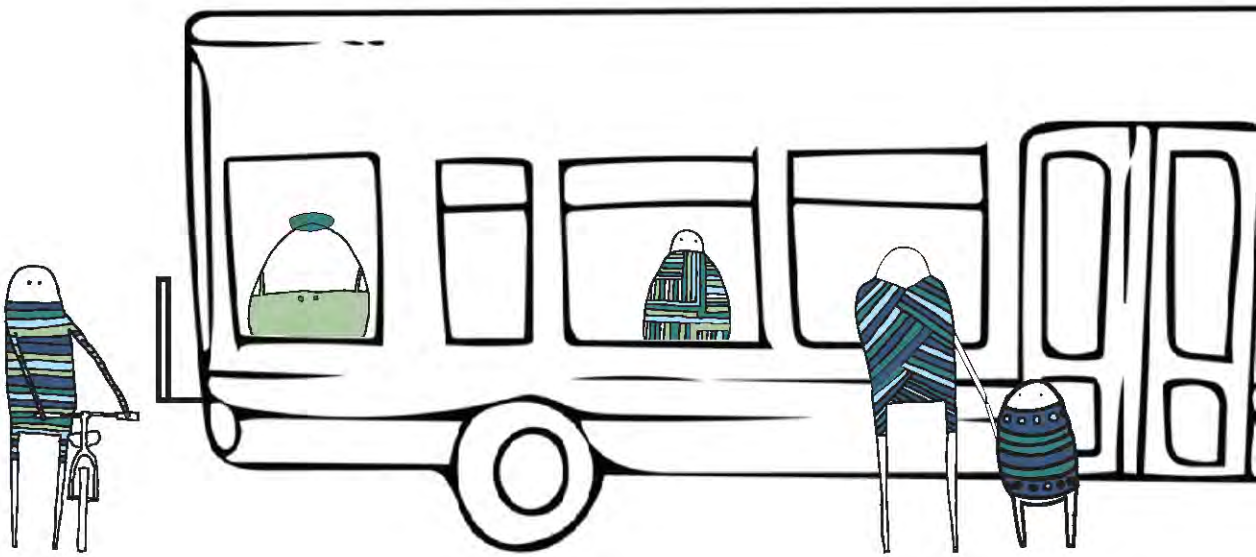
NEIGHBORHOOD | MOBILITY



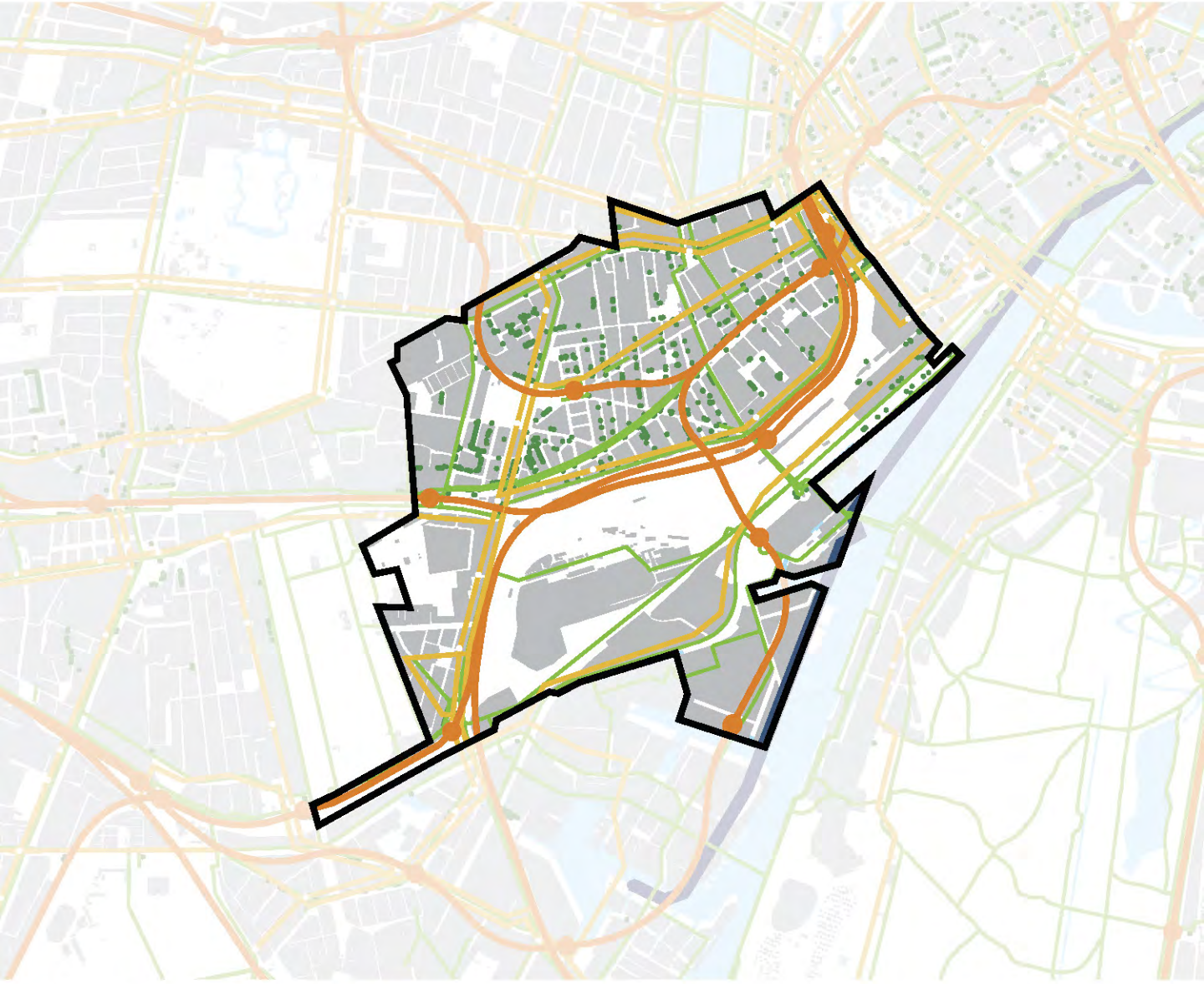
MOBILITY

Networks and facilities that promote the use of active transportation.

At the neighborhood scale, the mobility system links different modes of transportation into a connected, functional network. Train and bus stations will often occupy the same space so that travelers can transfer from one to the other. These station nodes are also furnished with bicycle parking so that travelers can change from public transit to human-powered vehicles. The cycle path network also expands at this scale, linking sites within neighborhoods and extending beyond into other neighborhoods as well.



VESTERBRO | MOBILITY




Source: Tony Webster

Source: Rafael Rybczynski


Source: Københavns Kommune

BICYCLE INFRASTRUCTURE

- **Bicycle Paths**
- **Bicycle Parking**

A network of on and off-street bicycle paths makes for safe and easy transit throughout the neighborhood, while ample bike parking facilities allow cyclists to become pedestrians without difficulty.

PUBLIC TRANSIT INFRASTRUCTURE

- **Rail**
- **Bus**

Vesterbro is emblematic of Copenhagen in its diversity of public transit: buses run at street level while rail lines run off-street or underground. A new metro line will connect Vesterbro to the other neighborhoods more quickly and easily.

PEDESTRIAN SPACES

Sønder Boulevard is a street with a wide median where pedestrian spaces were installed. The linear park provides a comfortable way to move about the neighborhood and provides a level of visual and physical separation from the street.

NEIGHBORHOOD | MOBILITY

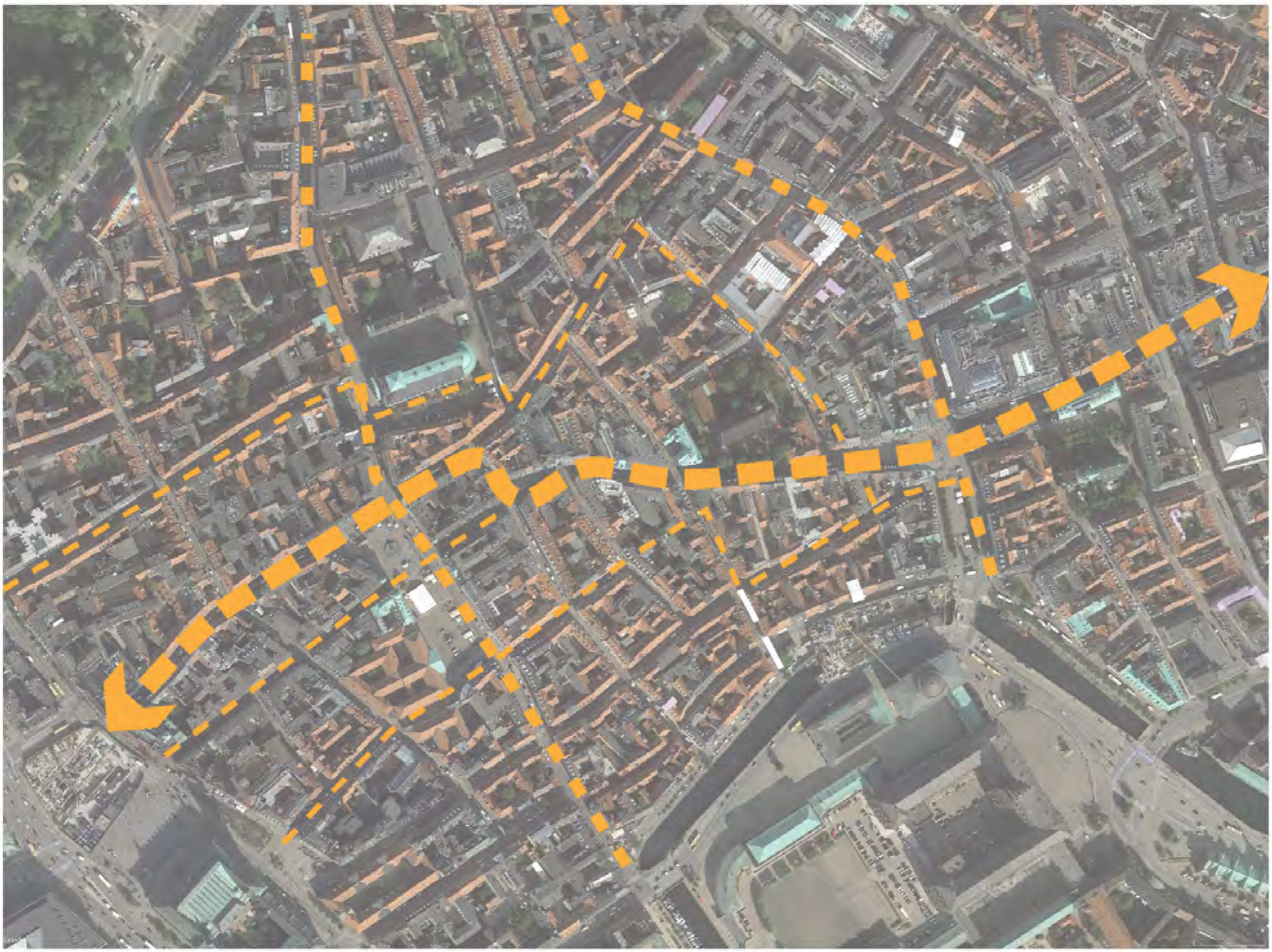
PRECEDENTS

BURKE GILMAN TRAIL

Seattle's multi-use, waterfront trail is a popular pedestrian and cyclist pathway that was converted from an unused railway corridor. The Burke Gilman goes through the neighborhoods of Ballard, Fremont, Wallingford, and the University District as a buffered transportation corridor along the water's edge. The separation from the primary automobile corridor linking the neighborhoods creates an ideal active transportation corridor.

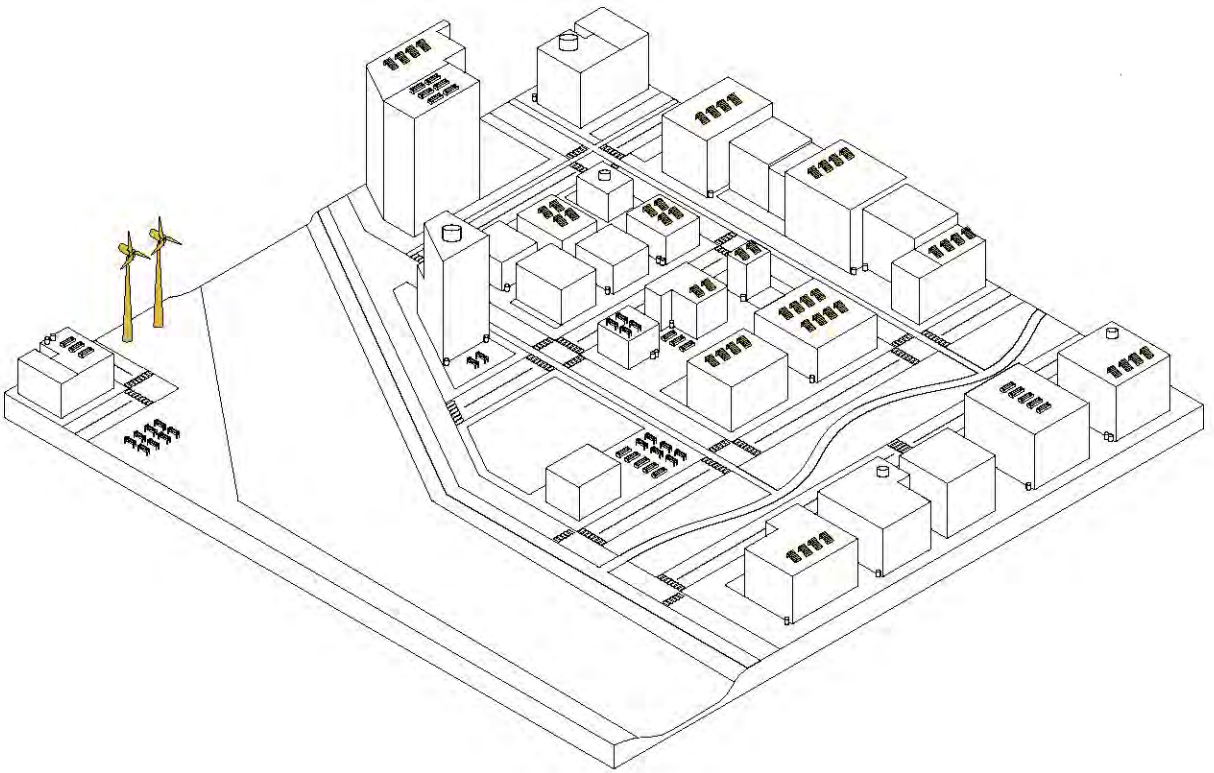
STRØGET

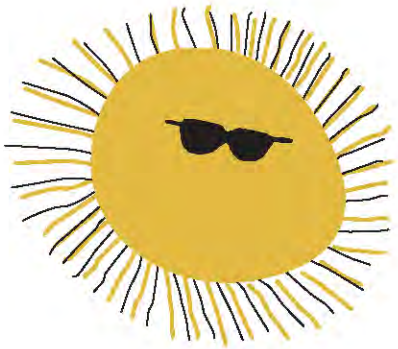
Copenhagen's famous pedestrian street, Støget is a highly-trafficked pedestrian corridor within the city center shopping district that forms the central spine of an extensive center-city network devoted to pedestrian use. At intersections with vehicular crossings, paving details, benches, and other pedestrian infrastructure let drivers know pedestrians have the right of way and emboldens pedestrians to occupy street space normally devoted to cars. Strøget is punctuated by plazas that are often the venue for seasonal events, such as Julemarked, Kulturnatten, and the World Cup showings. These temporary events bring even more vitality to the public realm, transforming the use of this traditional right-of-way space into truly social spaces.



STRØGET CIRCULATION
The main path of circulation (thickest line) is designated for pedestrian use only. Cars and not allowed and cyclists are required to walk their bikes, or to use cycle paths (thinnest lines) along parallel streets. Vehicles have signaled crossings only at specific intersections (medium line), and must yield to pedestrians and cyclists while negotiating this shared space.

NEIGHBORHOOD | METABOLIC



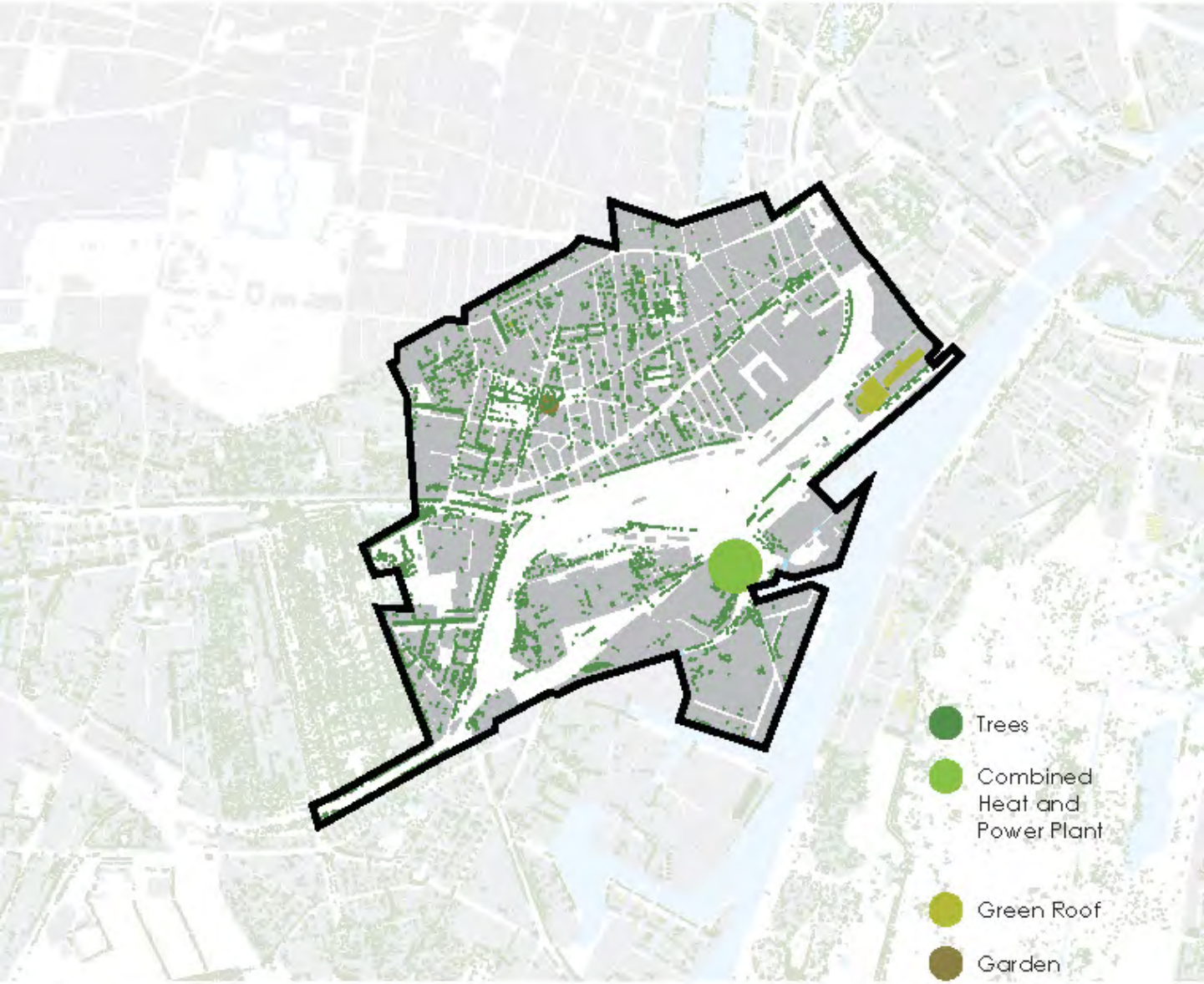


METABOLIC

Energy-producing elements that have minimal negative impacts to the climate.

At a neighborhood level, production space for gardens and energy-producing elements becomes feasible to serve a community. Space and programs can be initiated for shared food growing in neighborhood gardens, sustainable energy can be produced through community solar and wind programs. Waste materials can be burned to provide local heat and energy, and food and yard waste can be recycled into compost that helps gardens to grow, thereby reducing methane that would otherwise be emitted from landfills.

VESTERBRO | METABOLIC



WASTE COLLECTION
Waste is separated at the source into many categories for more efficient reuse and recycling of materials. Waste that cannot be recycled is sent to facilities where it can be incinerated, producing energy or hot water used in district heating.

URBAN AGRICULTURE
In neighborhood-scale urban agriculture operations, people work together to grow food. These food-energy producing spaces can take the form of rooftop gardens, community gardens, and networks of private gardens. Locally grown food reduces energy costs associated with the transportation of goods that might otherwise need to be shipped from far away.

RENEWABLE ENERGY
Renewable energy such as solar panels can provide power for the structures they are installed on, while larger solar arrays may generate a surplus of energy that can be fed back into the power grid. Some community solar programs are funded by local subscribers to receive sustainably produced energy. Solar power is just one example of renewable energy; other examples include wind-powered turbines and hydropower.

NEIGHBORHOOD | METABOLIC

PRECEDENTS

VILLAGE HOMES
Davis, California
Village Homes is a planned unit development in California with special attention to planning and design in order to create a strong community and a beautiful place. From a metabolic standpoint, the community made it a goal to plant mostly flowering, fruiting, and edible plants in the landscape.


Source: villagehomesdavis.org


Source: Axel Hindemith

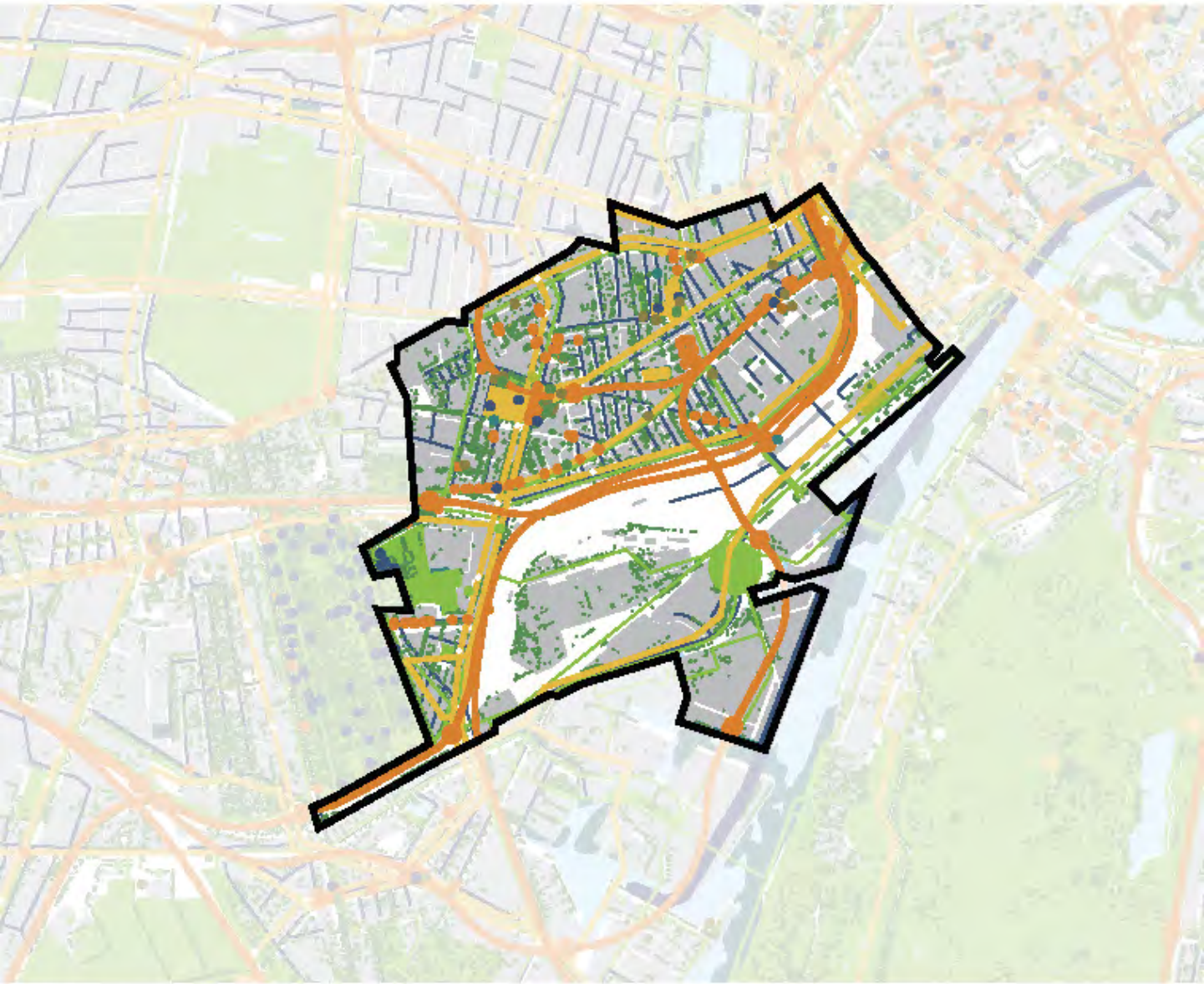

Source: Landeshauptstadt Hannover

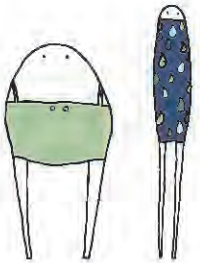
HANNOVER-KRONSBERG COMMONS

Hannover, Germany

Kronsberg takes sustainable development to another level - focusing on not one, but all of facets of sustainable development. Located just outside Hanover, Kronsberg Commons is a transit-oriented development which capitalizes on all aspects of sustainability: social, environmental, and economic. From the metabolic system specifically, Kronsberg integrates the entire food energy production and consumption process into its geographic bounds; from agricultural production to the consumption via local residents, Kronsberg is deliberate. Kronsberg promotes composting, as well as a network of community garden spaces for residents.

NEIGHBORHOOD SUMMARY



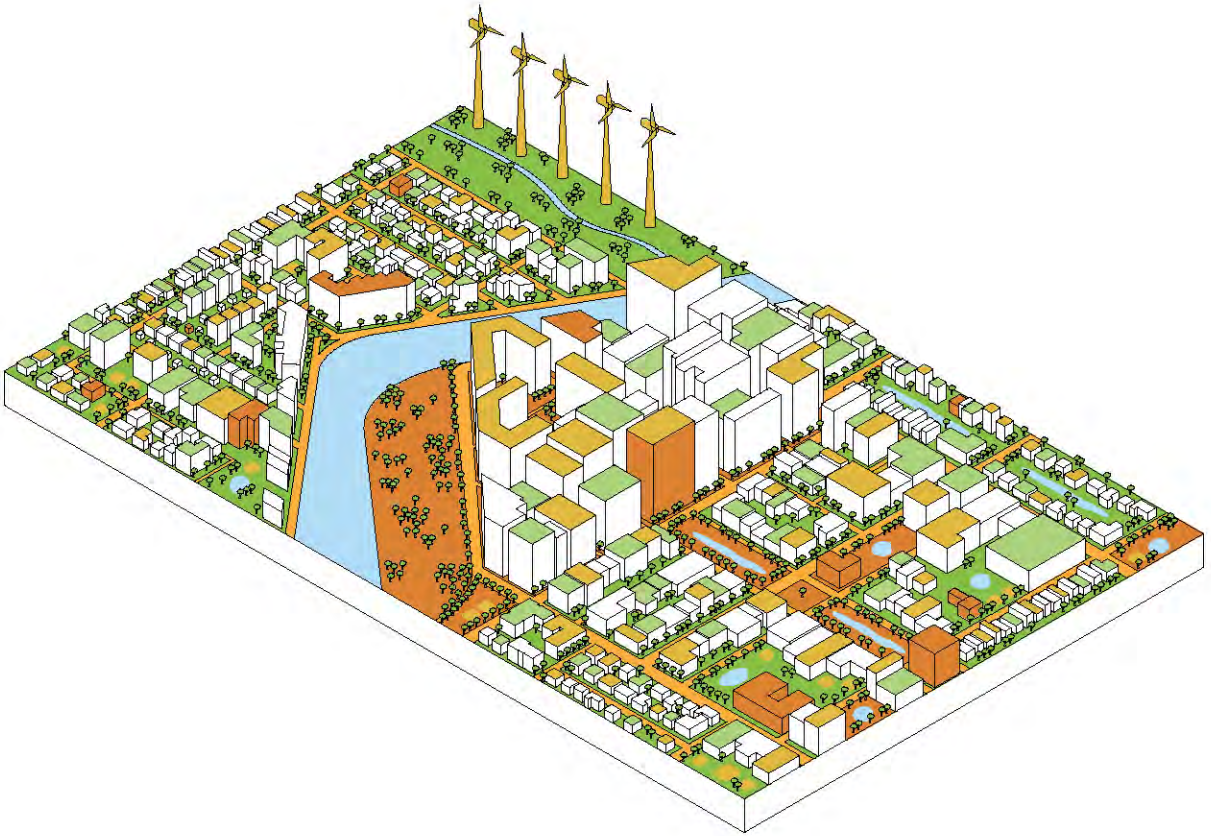


MOBILITY IS KEY
At the neighborhood scale, mobility becomes one of the most important systems of green infrastructure. The need of both humans and animals to move throughout a larger space (compared to a site) is imperative for proper function.

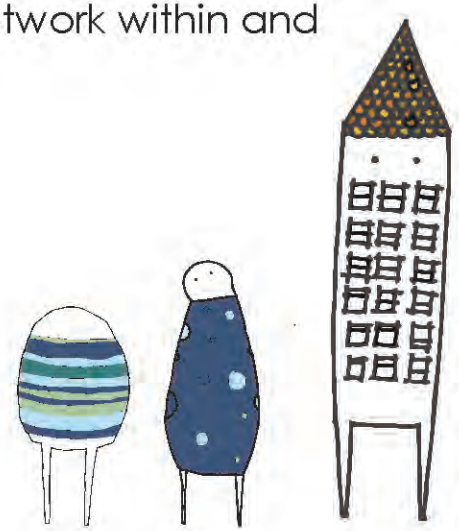
BEGINNING OF MANAGEMENT OF SYSTEMS
The neighborhood scales begins to piece together the smaller building blocks of sites (which are made up of micro sites) into larger functioning systems with interrelated parts.

PRODUCTIVE COMMUNITIES
While a site usually references an individual or a small group of individuals, the neighborhood scale creates communities of similar characteristics within all systems: a community of food production, a community of flood managment, a community of social gatherings, to name a few. These communities have overlap, but all must contribute to the larger function of the neighborhood.

CHAPTER 4
CITY SCALE



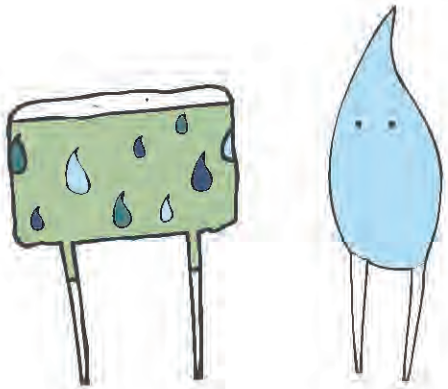
The city is a network of neighborhoods, and likewise a network of systems. While we sometimes see formal management of space at the neighborhood scale, **the city scale will codify best practices and methods of infrastructural management within specific boundaries**. At this scale, the systems become much less about specific micro or site level elements, and more about the network within and among systems.



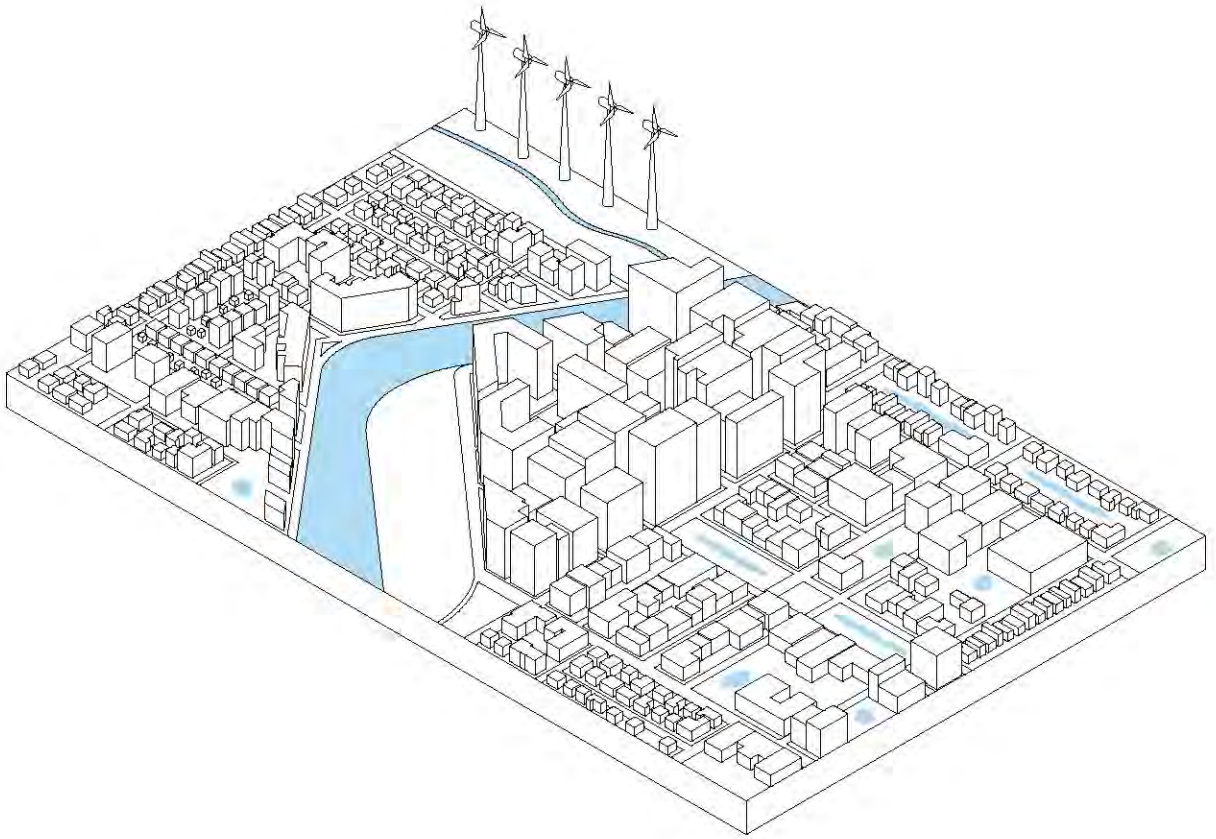
CASE STUDY: **COPENHAGEN**

Copenhagen has been known as a 'green city' or a sustainable city in Europe and around the world for decades. The forward thinking approach of the city is mostly unparalleled, with many cities in the United States and abroad copying methodologies from Copenhagen, Denmark, and their Scandinavian neighbors. The city has not only been upfront with policies addressing climate change and more positive transportation methods, but has also implemented interventions such as parks and public space to address green infrastructure at multiple scales.

While there are many other cities that could be valid case studies and precedents for the systems of green infrastructure, Copenhagen consistently stands out in its progressive and intentional approach to addressing the problems cities face today.



CITY | HYDROLOGICAL

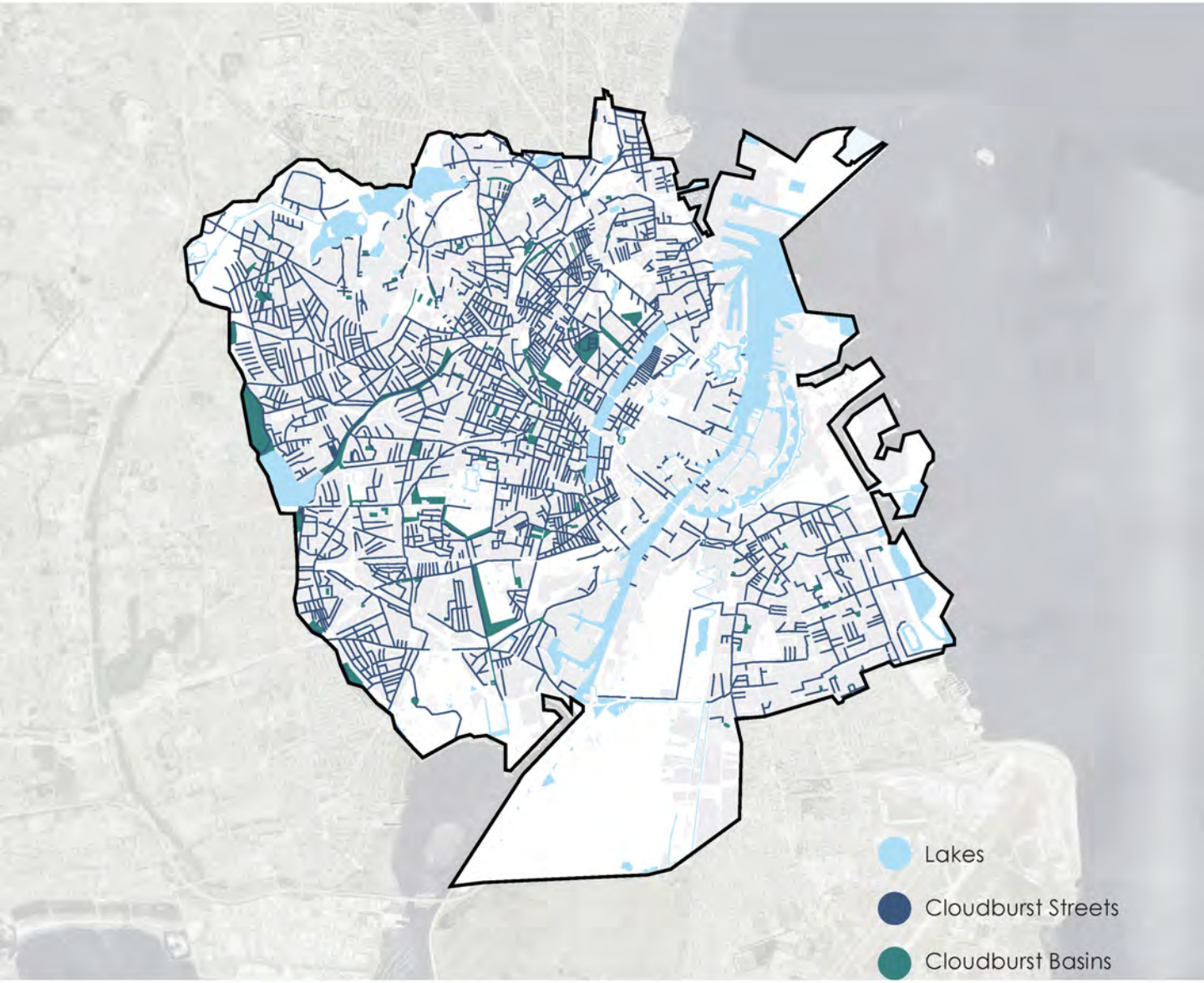


HYDROLOGICAL

Understanding water as a **closed-loop system**, and taking measures to incorporate urban waters - both consumed and produced - into a ecologically-sensitive system.

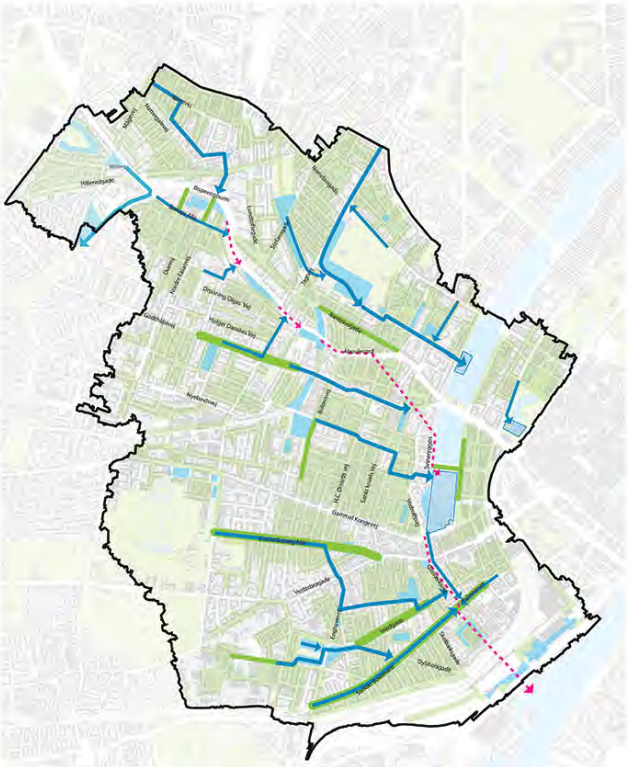
Hydrological at the city scale incorporates many of the aspects and operations of urban water. While the city scale encompasses the smaller scales, the city scale considers the management of water, including storage and overflow. The city scale is responsible for the large scale filtration and treatment of water through "gray" systems, which can sometimes be reduced through the application of smaller-scale green infrastructure facilities.

COPENHAGEN | HYDROLOGICAL



CLOUDBURST MANAGEMENT PLAN
Copenhagen, Denmark
The Cloudburst Management Plan, put together by the City of Copenhagen, COWI, Ramboll, and other consultants, identifies where and how climate change will impact the most residents through flooding caused by extreme rain events. The plan presents strategies to adapt to these threats of climate change. Using large urban public spaces such as streets, plazas, and parks as points of water retention and detention, the Cloudburst Management Plan seeks to direct water to specific locations where it will pose the smallest threat to people and property, while also providing public amenities.

In preparation for extreme weather predicted in the future, the plan breaks Copenhagen into management areas based on urban watersheds. This approach follows both piped and natural flows of water over the urban landscape. Each management area, such as the one pictured here, functions as part of a cohesive and comprehensive system.



Source: City of Copenhagen / Ramboll

STREET EDGE ALTERNATIVES
Seattle, Washington
The Street Edge Alternative (SEA) pilot project aims to provide drainage that more closely resembles the patterns of natural systems before human development, in an effort to reduce the negative impacts of stormwater falling on urban landscapes. In traditional drainage systems urban stormwater is piped away to treatment facilities that are costly to operate and can fail, resulting in the release of polluted water into natural waterways. In contrast, green stormwater projects (GSI) such as the SEA pilot aims to keep urban stormwater on-site by allowing for infiltration though vegetated bioretention cells and uptake via vegetation. This pilot project, completed in 2001, resulted in a 99% reduction of runoff from the street by reducing impervious surfaces and increasing vegetation.

While this particular pilot is just on one small stretch of one residential street, the findings of the project influenced City policy and street design standards city-wide. Other municipalities around the country and around the world are experimenting with similar projects in an effort to better integrate the built environment into local natural hydrological systems. The cumulative impact of all these projects could be huge!


Source: Seattle Public Utilities


Source: Tracy Tackett / Seattle Public Utilities


Source: Erik Stuhaug / Seattle Municipal Archives


Source: Erik Stuhaug / Seattle Municipal Archives


Source: Erik Stuhaug / Seattle Municipal Archives

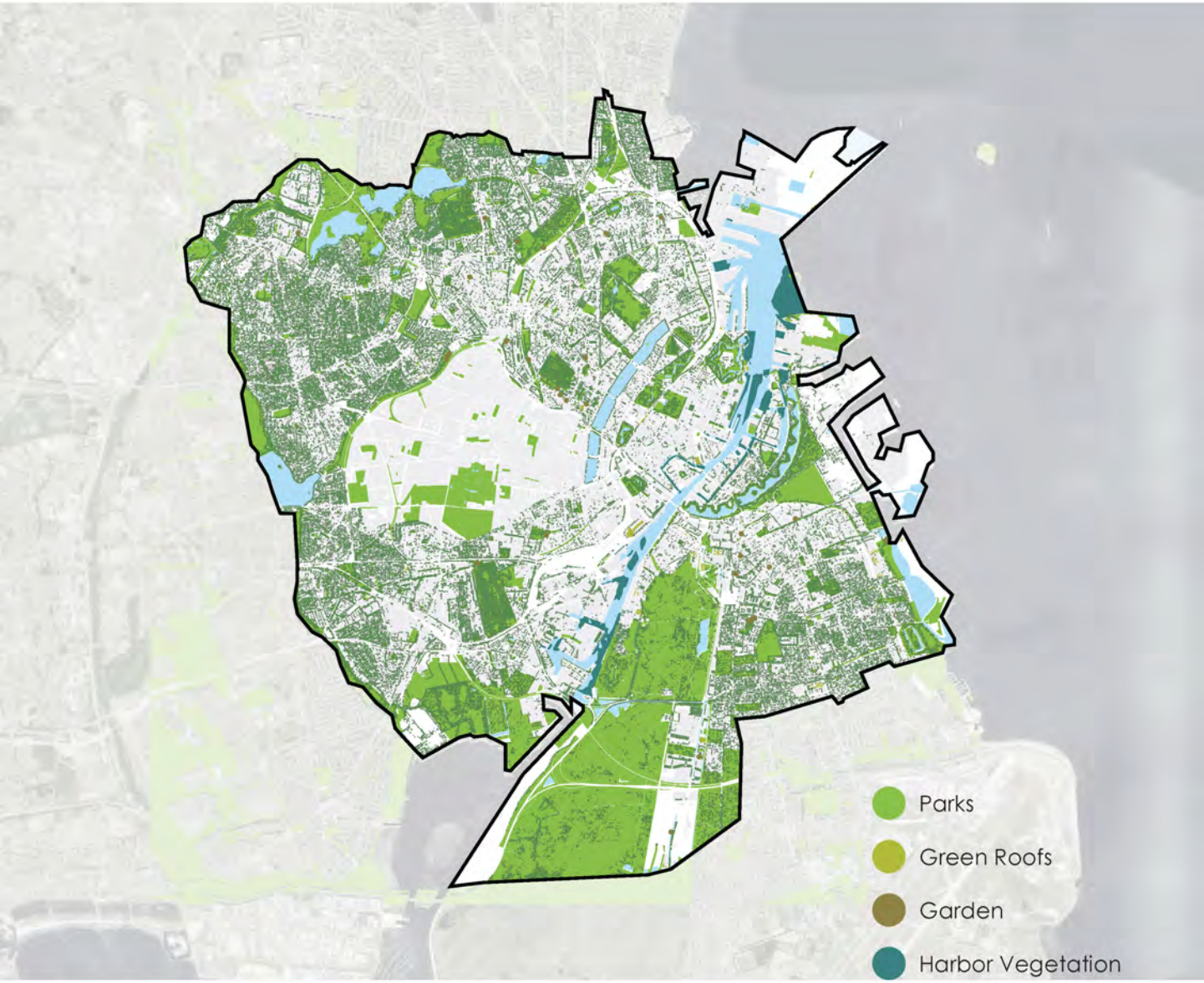
CITY | BIOLOGICAL

BIOLOGICAL

Spaces and qualities that support **multiple species, enhancing biodiversity** and providing a balance to the hard, urban environment.

At the city scale, components of the biological system found at smaller scales connect into a much larger network. All features of the urban environment that support life and enhance biodiversity are a part of this system. Planning and regulatory efforts often come into play at the city scale, and proper management helps to ensure that the biological system functions at this municipal scale.

COPENHAGEN | BIOLOGICAL



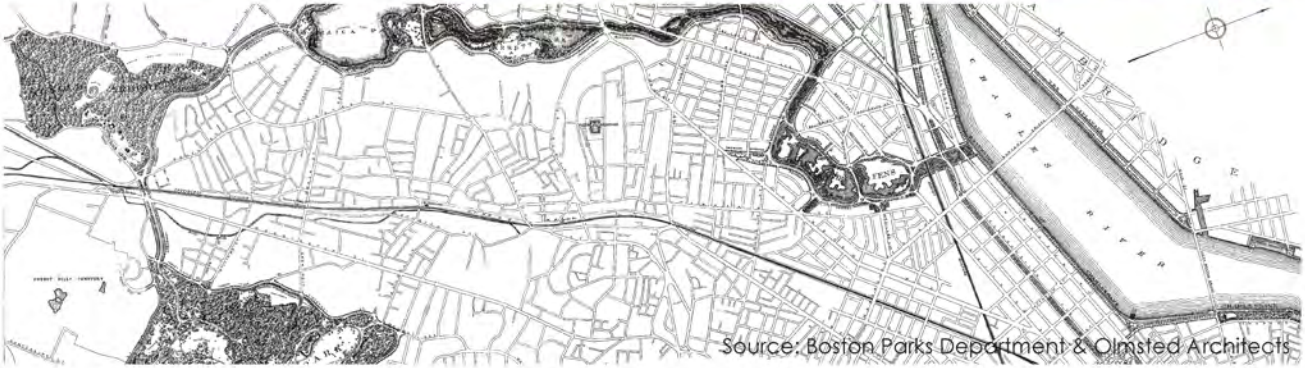
NATURE AREAS

Large nature areas border Copenhagen's southern side. The *Naturpark Amager* pictured here offers a naturalistic escape from the hustle and bustle of urban life just minutes from the dense urban core. Large nature parks can also serve as wildlife refuges and buffer the city from climatic events.

CITY | BIOLOGICAL
PRECEDENTS

A CITY-SIZED PARK...
Central Park, New York
Central Park, designed by renowned landscape architect Frederick Law Olmsted, is known in the US as a first of its kind - a tandem of city planning project and park design for all. The park is centralized, but is known for serving residents near and far in addition to millions of tourists each year from all over the world. Central Park and similarly-sized parks do not cater to any one smaller neighborhood, but are instead a public resource used by the city as a whole. While Central Park is a non-natural, man-made green space, it still serves as a important hub of urban biodiversity in New York City; many times smaller parks cannot handle or perpetuate the level of biodiversity a larger green space can. In tandem with the incredible density of New York City, Central Park acts as a refuge for all urban life - plants, animals, and humans.

Source: Boston Public Gardens Panorama / Rick Harris



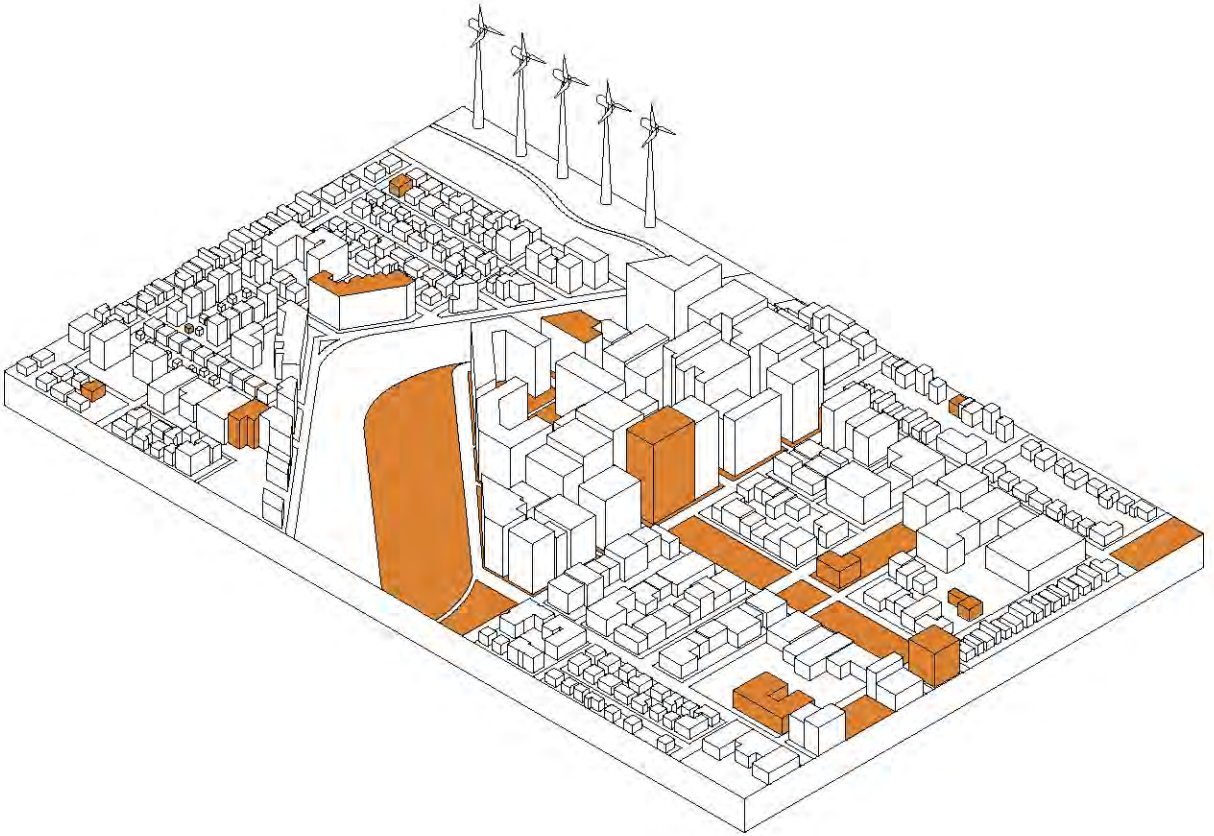
Source: Boston Parks Department & Olmsted Architects

...OR A CITY FILLED WITH PARKS

Emerald Necklace, Boston

Another of Frederick Law Olmsted's most well-known projects, the green space network in Boston, dubbed the Emerald Necklace, is a multi-scaled conglomerate of public green space. The string of parks, coastal reserves, and wildlife spaces creates a haven for biodiversity not often seen in urban settings, due in part to the interconnectivity of each park to the network as a whole. Multiple scales and typologies of public space give way to many ecological benefits: water management, increased biodiversity, public gathering spaces, and connection with nature.

CITY | SOCIAL



At the city scale, we can see the delineation of different groups forming a more complex, heterogeneous culture.

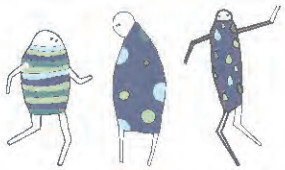
SOCIAL

Community spaces designed and designated for the human population that provide interaction and gathering spaces within the **public realm**

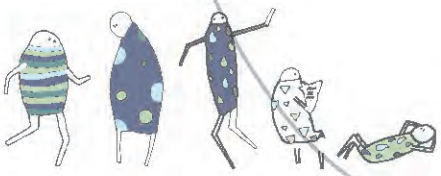
Groups x Groups

Regional Group Identity

Individual

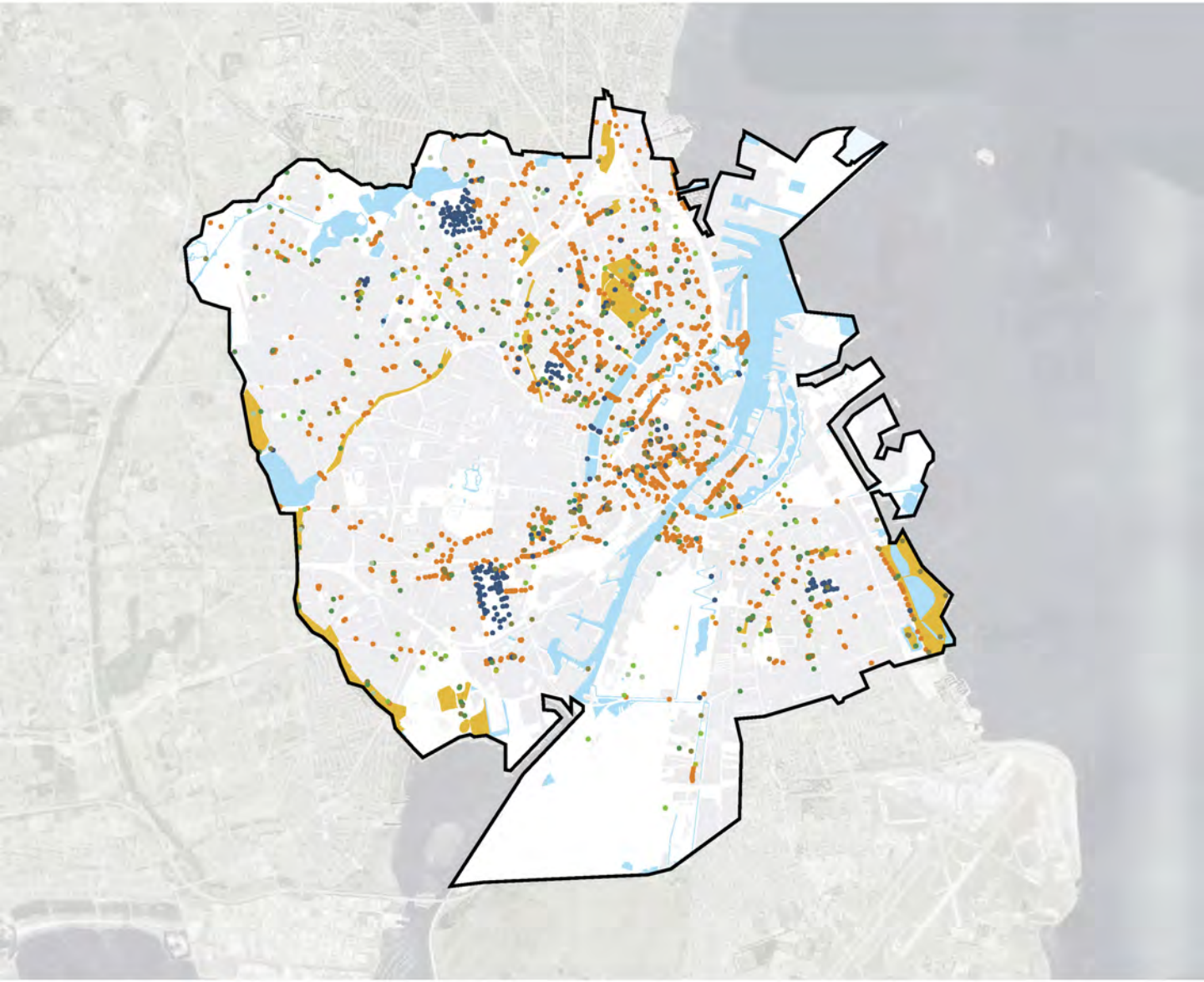


Groups and Individuals



Large, Mixed Groups

COPENHAGEN | SOCIAL



- Library
- Fountain
- Play Fields
- Daycare
- Culture House
- Benches
- Sports Facilities
- Museums
- Public Restroom
- Social Spaces
- Playgrounds

CITY CENTER: PUBLIC SPACE, PUBLIC LIFE

Plazas and parks provide the venue for every-day interaction as well as temporary events, such as one of Copenhagen's holiday markets in Nytorv (top left). Kultorvet (bottom left) is a popular public square located in the city's pedestrian-oriented city center. In outdoor space, such as Ørsteds Park (top right), people throughout the entire city engage with one another in many manners.


Source: Source: Josh Saitelbach

PARKING DAY

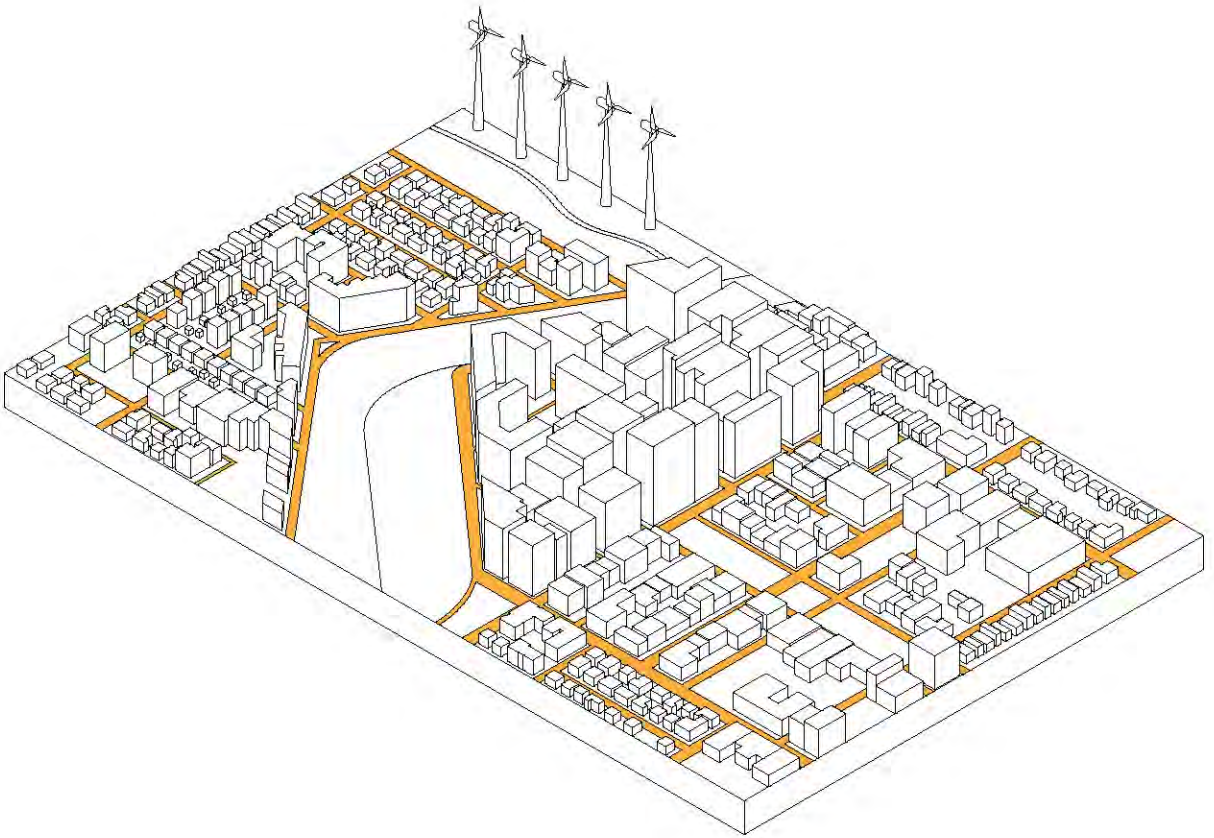
Parking Day started in San Francisco in 2005 to take advantage of underutilized space from which pedestrians could benefit. Once a year, now internationally, people are invited to 'take over' a parking space and create a space for people and community. Although not official, the concept of parklets (parking spaces converted into parks, temporary and permanent) is not far behind. Parking Day not only gives space back to the people of the city, but it also brings people together, facilitating more social interactions around positive public space.

See also: Parklets

Source: Josh Saitelbach

CIVIC SPACES
Seattle, WA
The Seattle Center is a campus in the city center containing sports fields, event spaces, museums, and other attractions such as the Space Needle. The Center's central location and diversity of spaces make it a popular venue for a multitude of city-wide events. The picture above shows marchers at the International Fountain after participating in Seattle's pride parade.

CITY | MOBILITY

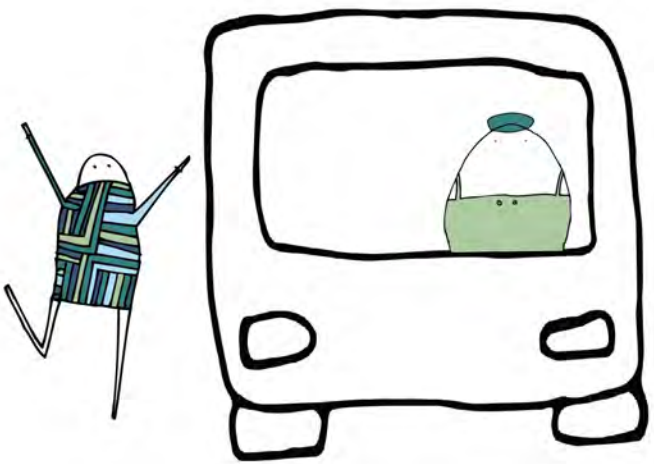


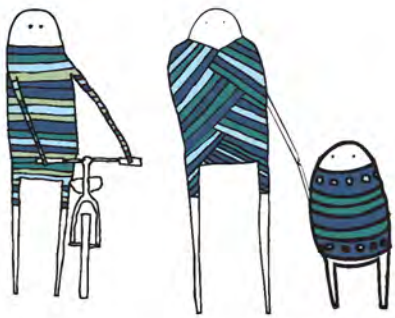
MOBILITY

Networks and facilities that **promote the use of active transportation.**

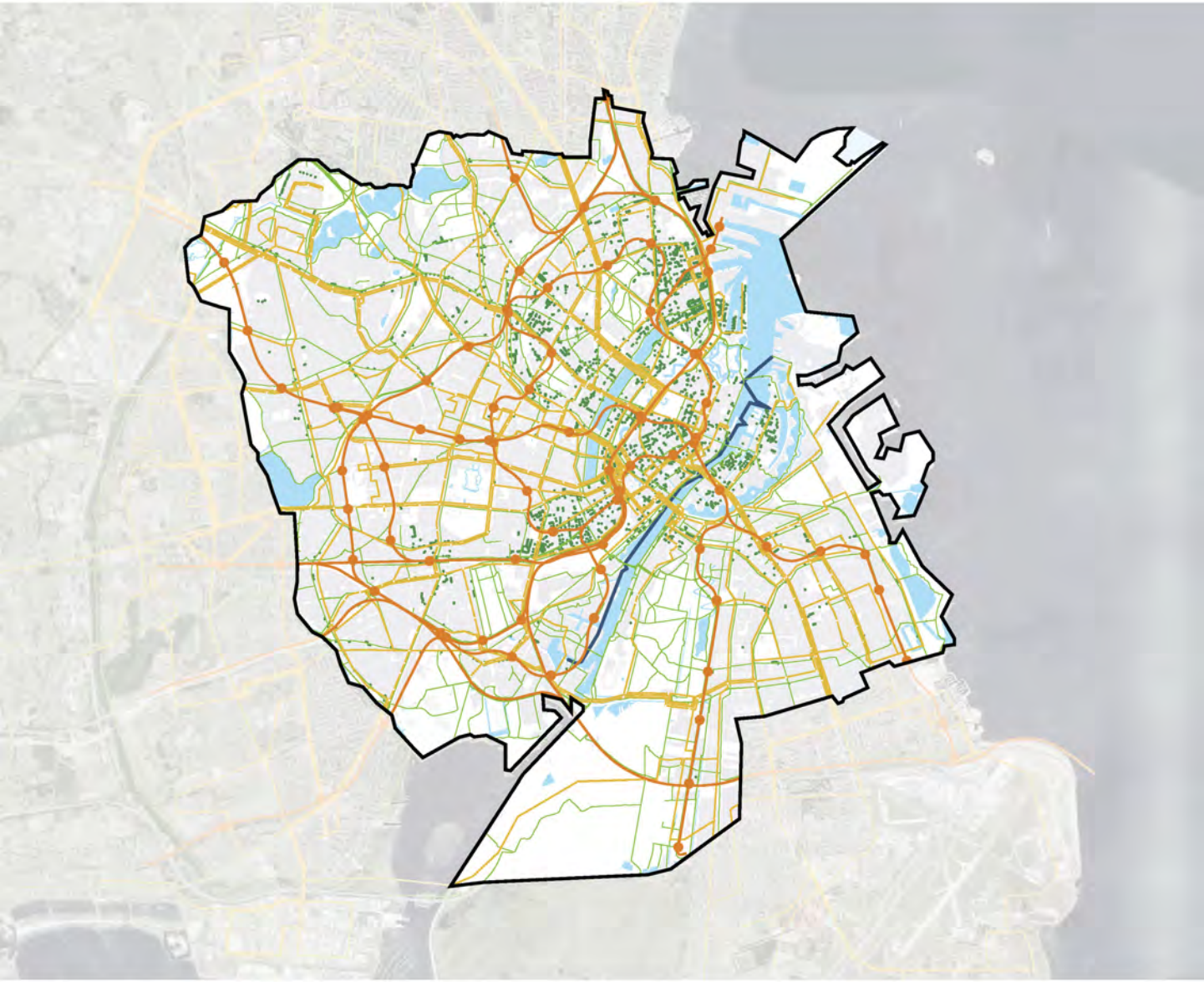
Local mobility networks join, expand, and overlap to form the mobility system at the city scale. Neighborhood public transit routes will often coalesce at one city-scale central station. Bicycle infrastructure will similarly expand with city-wide routes and connect with other transit modes. The resulting mobility system is a multi-modal way to travel around the city without the use of cars.

It should be easy to move around the city... right?



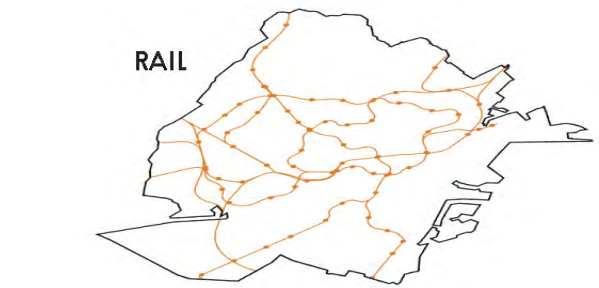


COPENHAGEN | MOBILITY

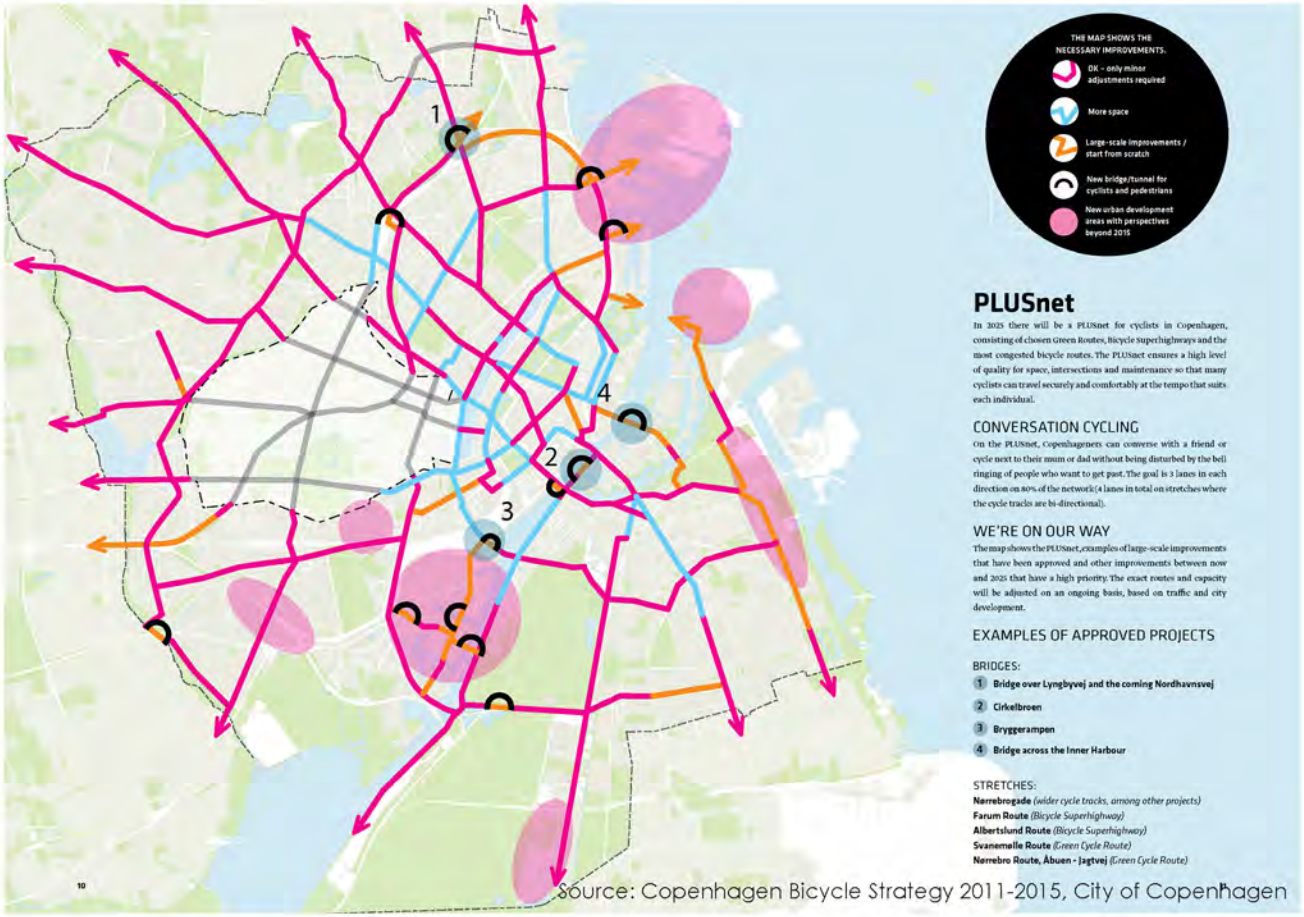



BIKE


BUS


RAIL


COPENHAGEN



Source: Copenhagen Bicycle Strategy 2011-2015, City of Copenhagen

BICYCLE MASTER PLAN

Copenhagen takes bicycling seriously. The bicycle has become the preferred mode of transportation for the majority of residents in Copenhagen; due to the Municipality's investment in bicycle infrastructure, transportation via bicycle is the easiest, and usually quickest, method of moving around the city. The graphic above depicts analysis used to guide bicycle infrastructure improvements and overall route connections aimed at better connecting the city by bike.

In the 1970s Copenhagen was overwhelmed by automobiles and the congestion that they

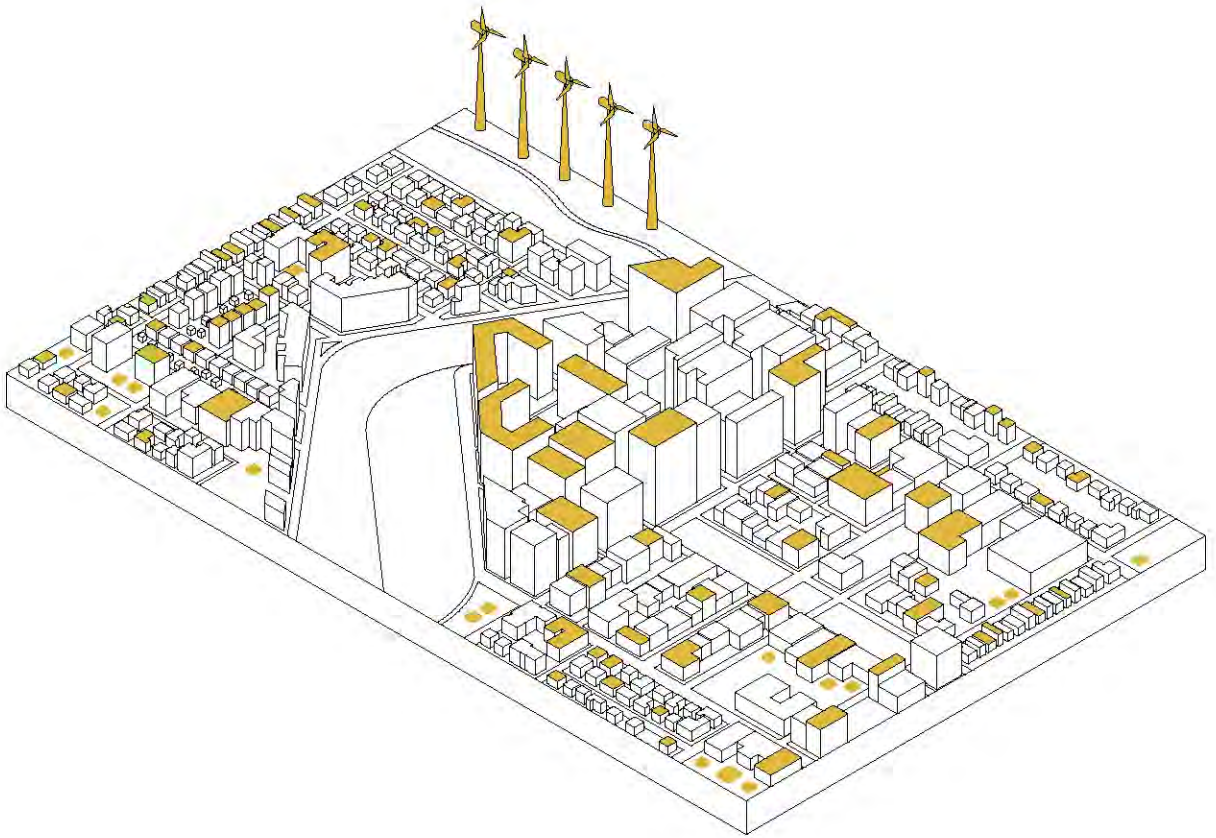
Source: Ursula Bach, visitcopenhagen.com


Source: RAFAA/Rafeal Schmidt

brought. Recognizing the need for change, the Municipality began implementing bicycle master plans in the 1970s in an effort to create a more sustainable method of transportation. These bicycle master plans have continued to evolve alongside the city, using the city's growth and development potential to help identify the need for new infrastructure projects both large and small.

One such project, the *Cycleslangan* (Cycle Snake) pictured above, traverses the Copenhagen Harbor, providing a critical link in the city's bicycle system.

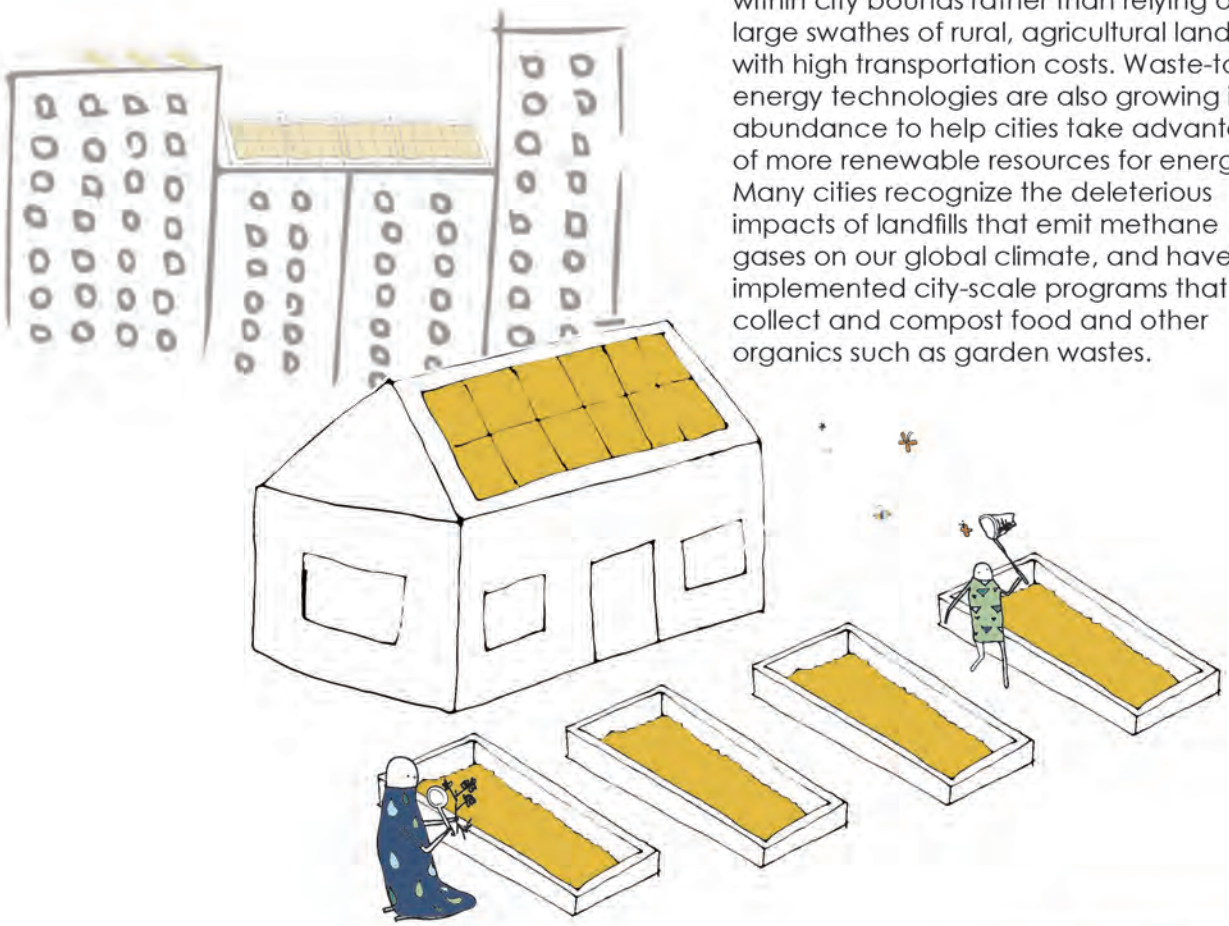
CITY | METABOLIC



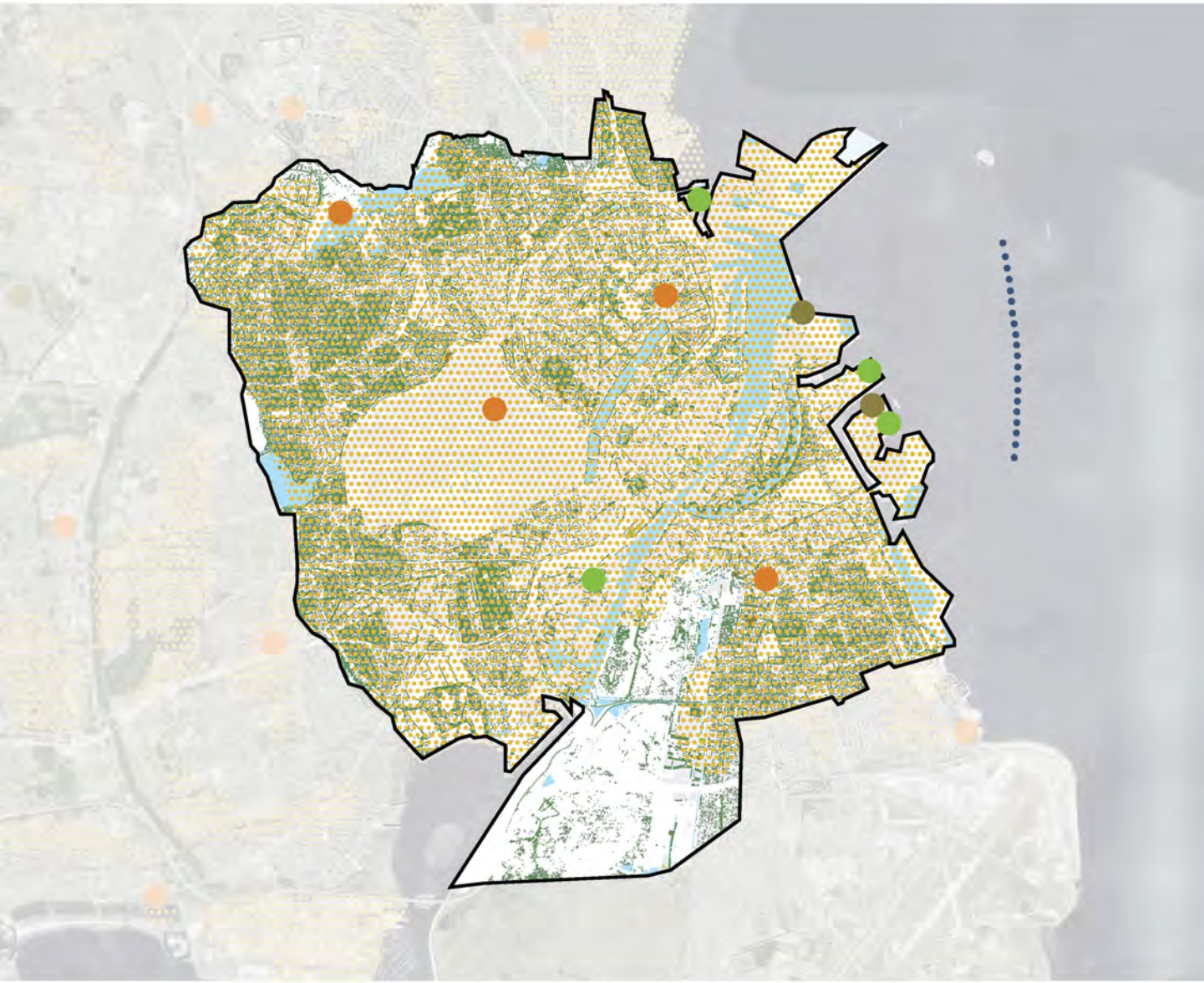
METABOLIC

Energy-producing elements that have minimal negative impacts to the climate.

As cities grow more dense and create more pressure on urban areas to produce their own food, new technology is continually developed to grow more food in cities within city bounds rather than relying on large swathes of rural, agricultural land with high transportation costs. Waste-to-energy technologies are also growing in abundance to help cities take advantage of more renewable resources for energy. Many cities recognize the deleterious impacts of landfills that emit methane gases on our global climate, and have implemented city-scale programs that collect and compost food and other organics such as garden wastes.



COPENHAGEN | METABOLIC



Wind Turbine

Combined Heat and Power Plant

Incineration Plant

Peak Load Plant

District Heating Area

DIVERSE POWER GRID

Copenhagen is on track to realize its goal of becoming the "carbon neutral capital" by 2025. In addition to building retrofits and mobility infrastructure, a major part of this effort comes from innovative waste management and transitioning to clean energy sources. Offshore wind turbines supply renewable energy to the city via underwater cables, and incineration plants safely burn non-recyclable waste to also produce power and heat. In addition to electricity, waste-to-energy plants use the hot water byproduct of their operations to supply 98% of the city's heat via district heating (c40cities.org). Additional peak load power plants kick in to support the power grid in periods of high demand.

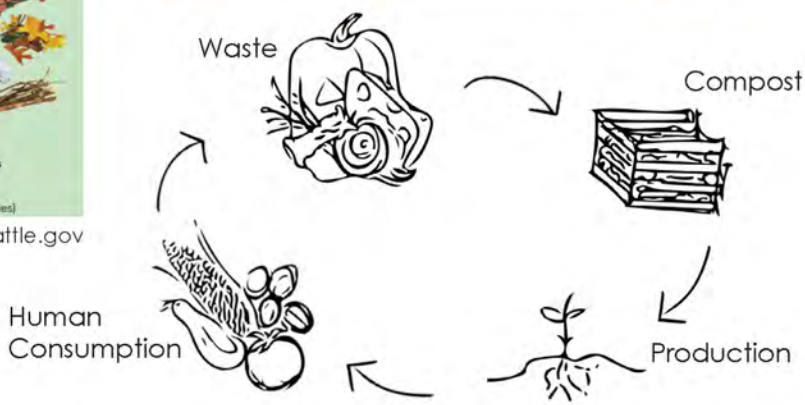
Vegetation from the urban canopy, green roofs, parks, and open space contribute to energy savings by reducing the urban heat island effect and the need for energy-consumptive air conditioning. In addition, the network of food-producing gardens provide food energy. Together, all of these networks make up a diverse, sustainable metabolic system for the city of Copenhagen

COMPOSTING

Seattle, Washington

Seattle, like Portland, San Francisco, and New York, now mandate composting of food scraps and organic waste material. Within the United States, not all cities require recycling, yet alone composting. Compost is organic matter that will decay into a nutrient-rich fertilizer; the act of composting allows vital nutrients to be kept out of landfills and returned to soil. In 2014, the city of Seattle passed the policy that residents and businesses must divert food scraps and organic waste from landfills/trash collection; the city also now provides curbside service for compost collection, like recycling and trash.

Source: seattle.gov



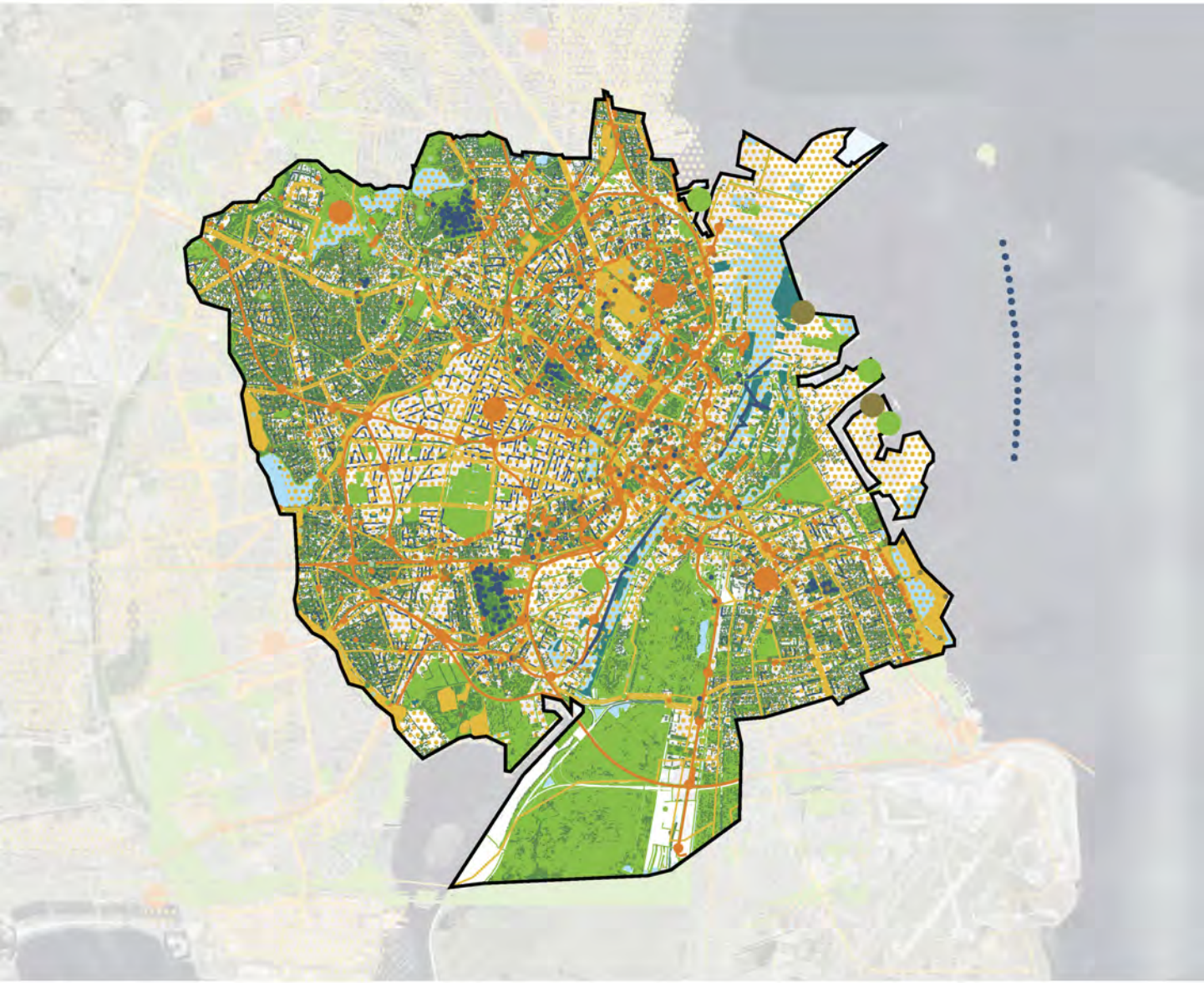
P-PATCH COMMUNITY GARDENING

Seattle, Washington

This network of the city's urban gardens produces food energy for neighborhoods in a sustainable, organic manner. "In 2017, P-Patch gardeners donated 63,511 pounds of fresh organic produce to 20 food banks, meal programs, housing programs, and homeless encampments throughout Seattle." -*Front Porch*, Seattle Department of Neighborhoods

Source: KNKX

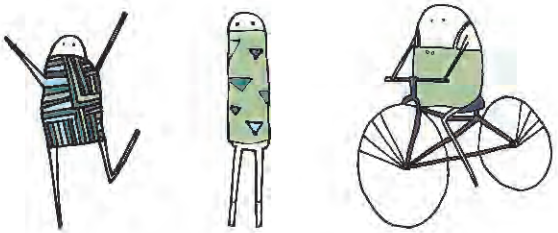
CITY SUMMARY



FORMAL MANAGEMENT
While the smaller scales are mostly without formal management, the city is defined by a formal physical and political boundary. This can sometimes make systems overlap in a multiplicity of ways, providing many benefits.

NETWORKS
As in almost all systems at the city scale, the networks created in neighborhoods are managed together in this larger context. A neighborhood must work within the umbrella of the city to contribute to and receive benefits from the system as a whole.

BALANCE AND SYNERGY
The city scale highlights the importance of balance within green infrastructure systems. For example, balancing green space with built space throughout the city makes the benefits of the ecological system available to many neighborhoods, individuals, and species. Similarly, the hydrological system - often integrated into parks and streets - should operate as a network of interventions that come together to serve the city as a whole. The synergistic relationship of the systems mentioned above is just one example of how the concept of multifunctionality is at the core of green infrastructure.



CHAPTER 5
REGIONAL SCALE

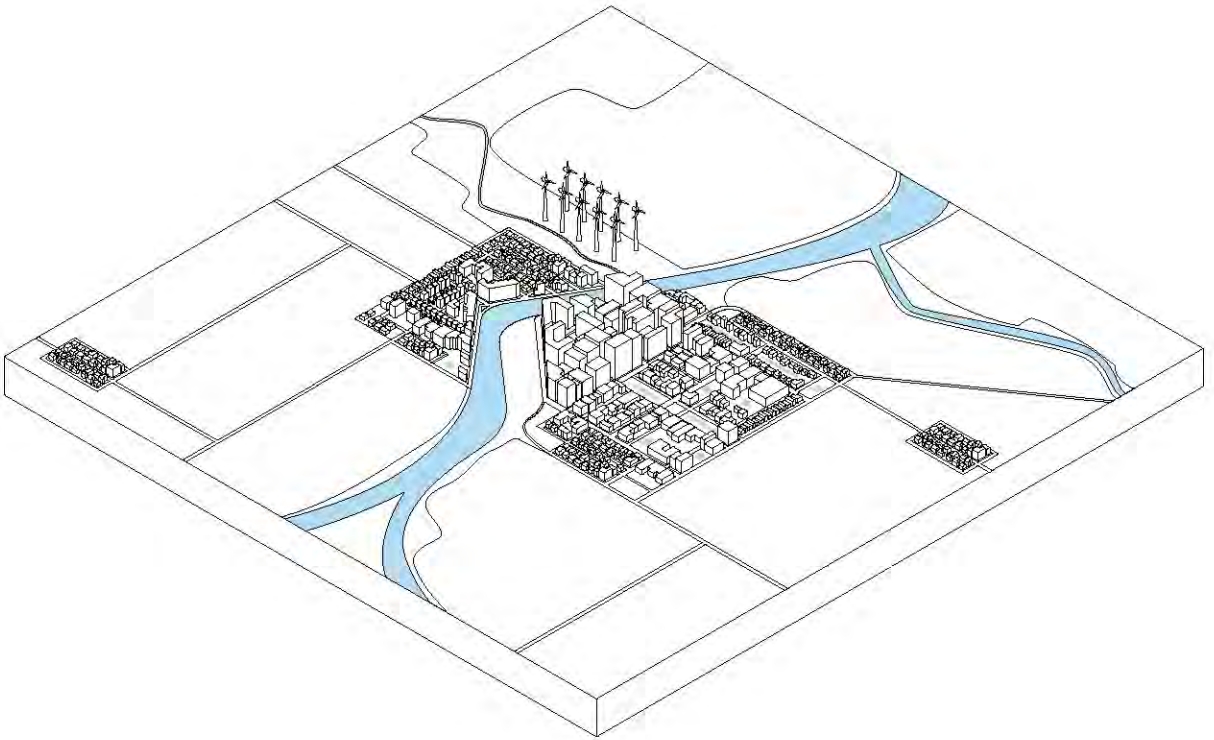
At the regional scale, the needs of the city are **integrated with the landscape and culture of the region**, and the **ecosystem services** that it provides. Zooming out this far enables us to see the cities as nodes of human development nestled into a larger geographic and ecological context. At this scale, green infrastructure systems are less about specific elements but focus on **aquisition, protection, and management of resources, landscape, and environment.**

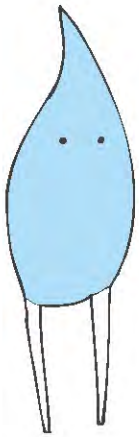
CASE STUDY: ØRESUND

The Øresund Sound is the body of water separating Denmark and Sweden and also refers to the surrounding lands which are considered the Øresund Region. The Øresund connects the Baltic Sea to the Atlantic Ocean and is a major throughfare for marine transportation.

An important part of the Øresund Region is the Øresund Bridge which links the two countries and almost four million diverse people together. For many years, there was no easy method of transportation between Sweden and Denmark.

REGION | HYDROLOGICAL

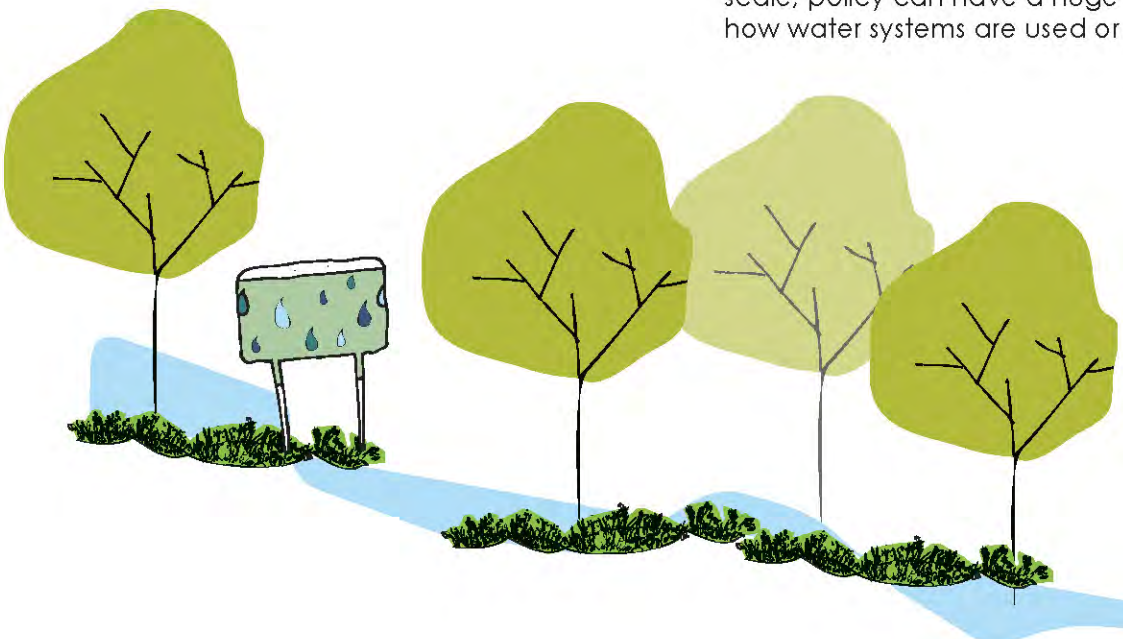




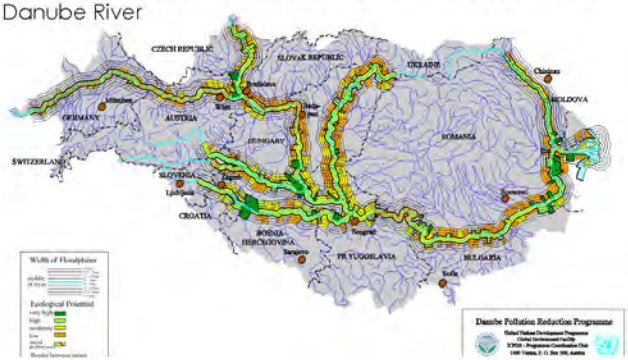
HYDROLOGICAL

Understanding water as a **closed-loop system**, and taking measures to incorporate urban waters - both consumed and produced - into a ecologically-sensitive system

At the regional scale, the hydrological system considers all of the inputs and outputs that could affect natural or human landscapes. Natural factors could include sea level rise, flooding, and drought. Human factors could include pollution from runoff, modifying waterbodies for irrigation, power generation, or development of land. At this scale, policy can have a huge impact on how water systems are used or misused.



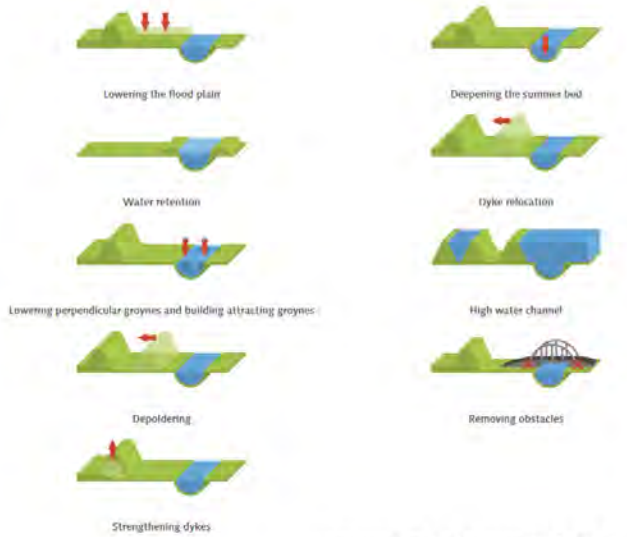
Source: International Commission for the Protection of the Danube River



LOWER DANUBE GREEN CORRIDOR

Bulgaria, Romania, Ukraine and Moldova

In 2000, the governments of Bulgaria, Romania, Ukraine and Moldova pledged to work together – with the signing of the Lower Danube Green Corridor Agreement - to establish a green corridor along the entire length of the Lower Danube River (~1,000 km). All partners recognized a need and shared responsibility to protect and manage the Lower Danube in a sustainable way. The Lower Danube Green Corridor Agreement aims to protect and restore wetlands along the river and reconnect the river to its natural flooding areas, reducing the risks of major flooding in areas with human settlements and offering benefits both for local economies – e.g. through fisheries, tourism – and for the ecosystems along the river. To achieve this, sections of dikes have been removed and isolated river meanders have been reconnected to the river.



Source: ruimtevoorderivier.nl

ROOM FOR THE RIVER PROGRAM

The Netherlands

The Dutch Room for the River Programme is to give the river more room to be able to manage higher water levels. At more than 30 locations, measures are taken to give the river space to flood safely. Moreover, the measures are designed in such a way that they improve the quality of the immediate surroundings. The Room for the River Programme was completed in 2016. Making "room for the river" allows landscapes along rivers to be restored in order to act as "natural water sponges" in the event of a flood. The program includes nine measures: deepening the summer bed (main river channel), water storage, dike relocation, strengthening of dikes, high water channel, lowering floodplains, lowering groynes, depoldering, and removing obstacles.

REGION | BIOLOGICAL

BIOLOGICAL

Spaces and qualities that support **multiple species, enhancing biodiversity** and providing a balance to the hard, urban environment.

The preservation (with careful use) and conservation (without use) of land is imperative at the regional scale of the biological system. In order to develop as a society, we need to take care of the natural world and the large swathes of land that promote a true, non-human wealth of biodiversity.

REGION | BIOLOGICAL

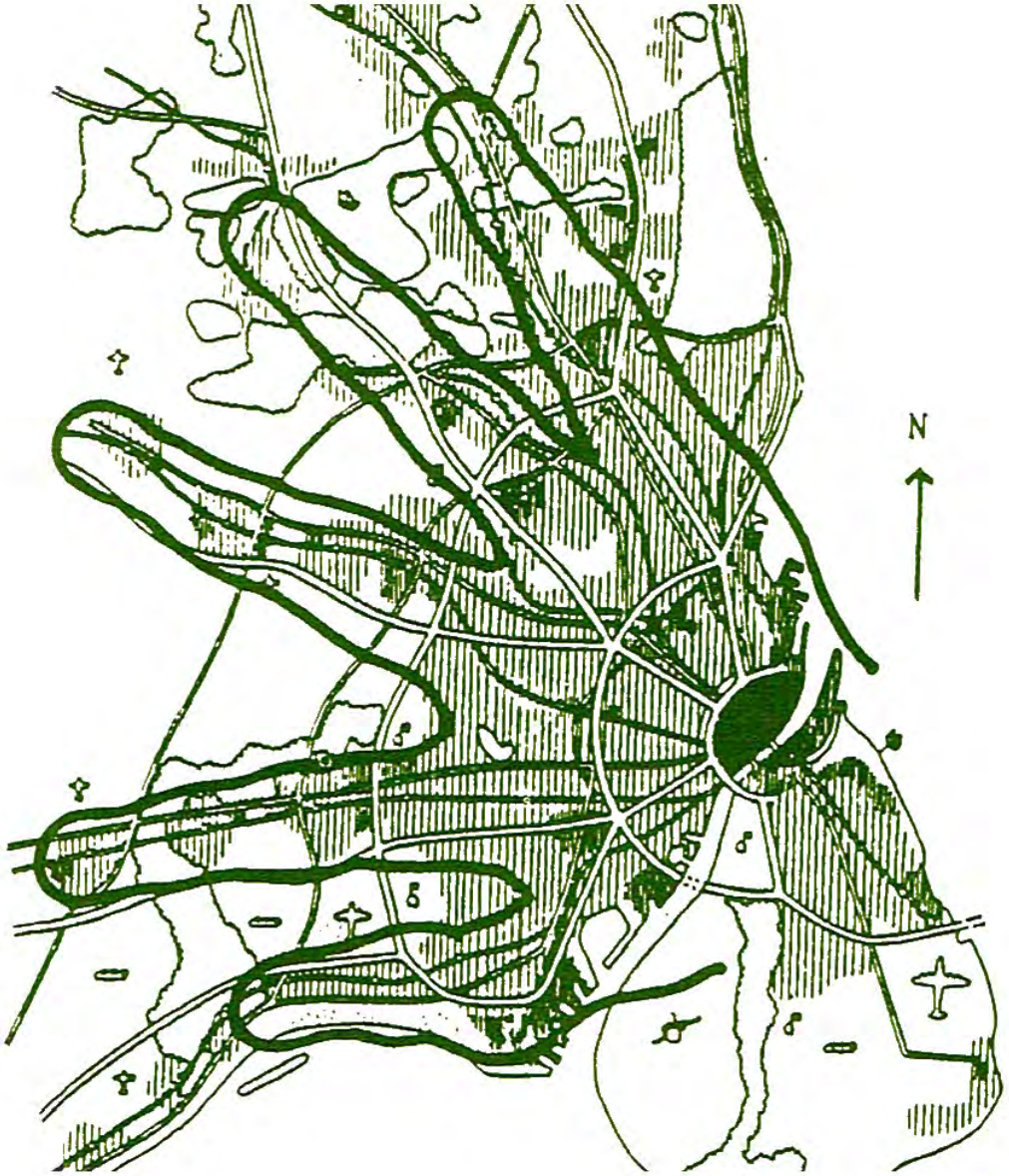
PRECEDENTS

Source: Regional Planning Office, 1947

COPENHAGEN FINGER PLAN

Copenhagen, Denmark

As a growing city, Copenhagen is expanding beyond the borders of the city proper and spilling into the surrounding countryside. The Finger Plan was developed in 1947 to help guide that growth, and to ensure that areas of farmland and parkland are set aside and preserved. This plan focuses urban growth and transportation corridors along the "fingers" that extend beyond the "palm" of the central city, with wedges of green space between the fingers to provide nearby access to nature for people in communities located along the rail lines. The preservation of greenfields and the regulation of development is vital to ecosytem health and the services it provides to a region.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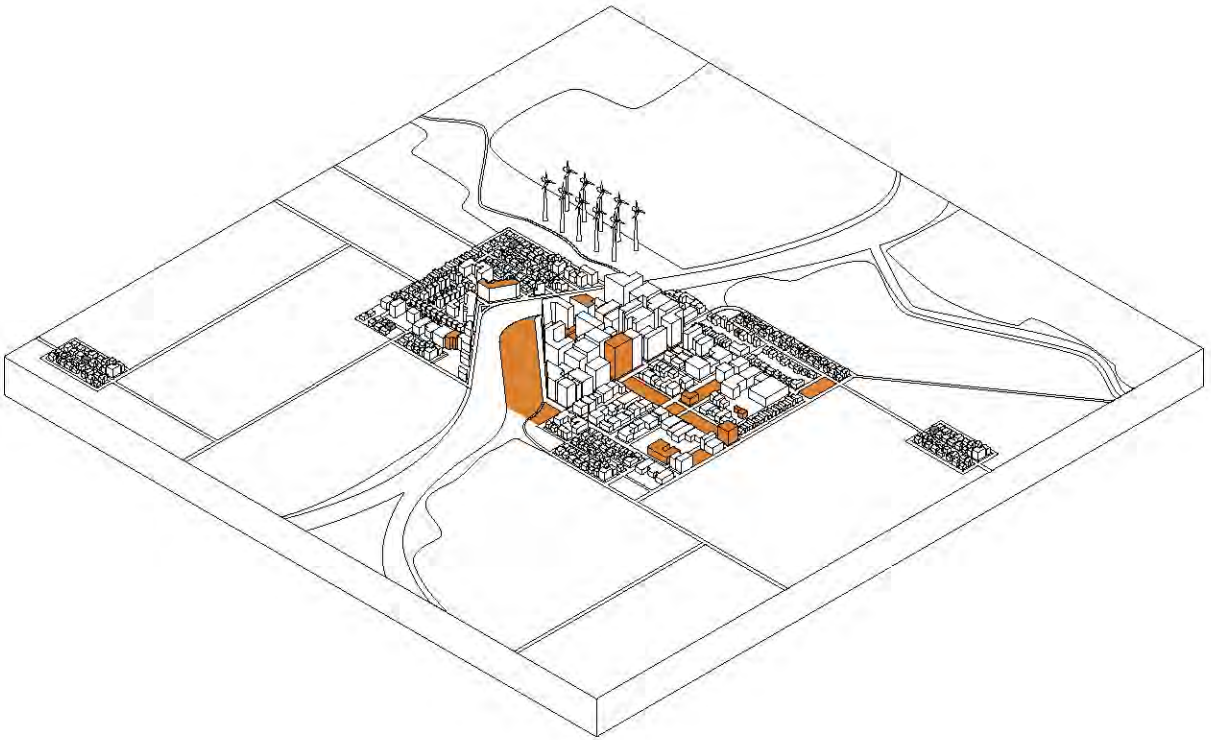
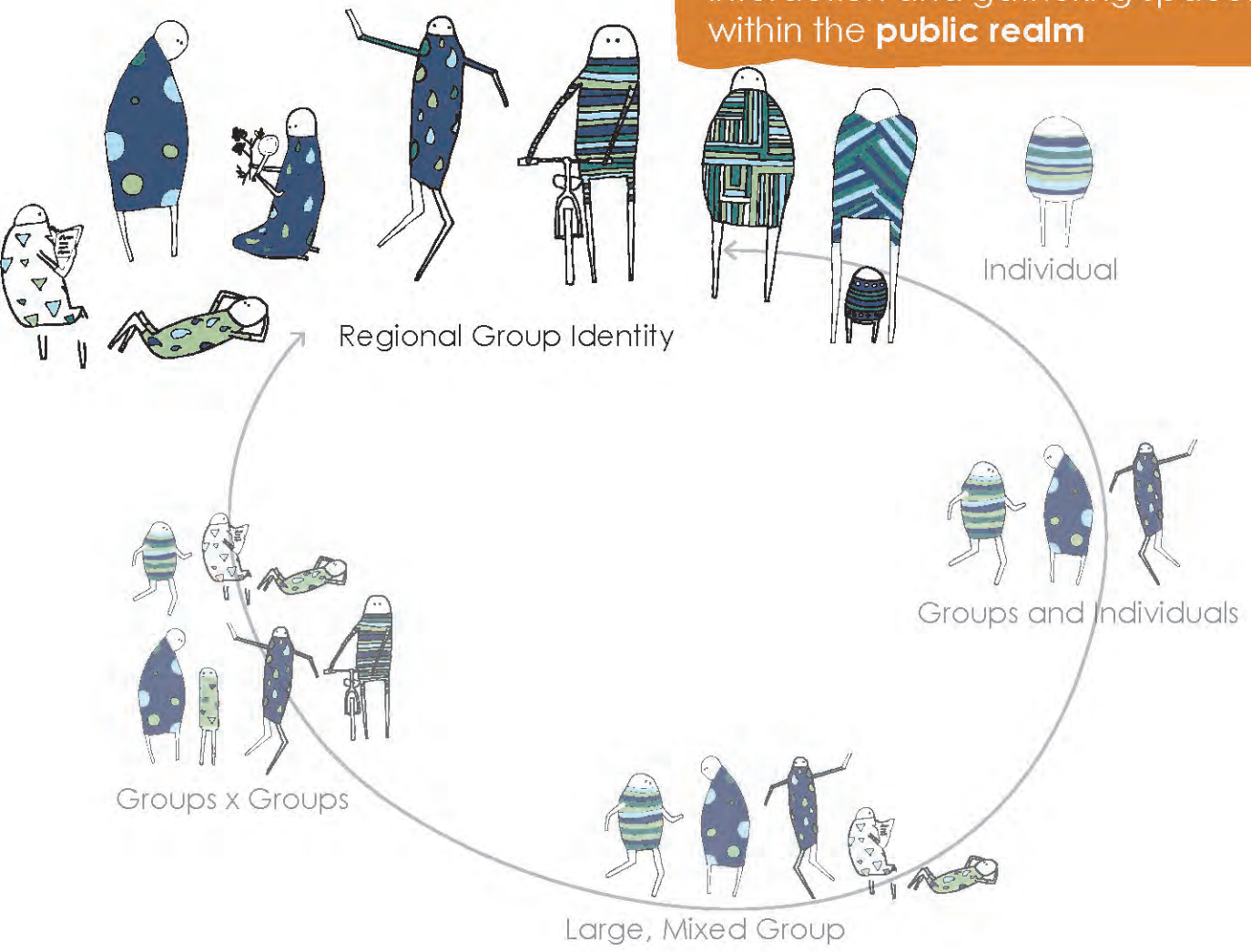
REGION | SOCIAL



Region insinuates that there are a few commonalities that bring groups of people together within a given physical distance.

SOCIAL

Community spaces designed and designated for the human population that provide interaction and gathering spaces within the **public realm**



REGION | SOCIAL

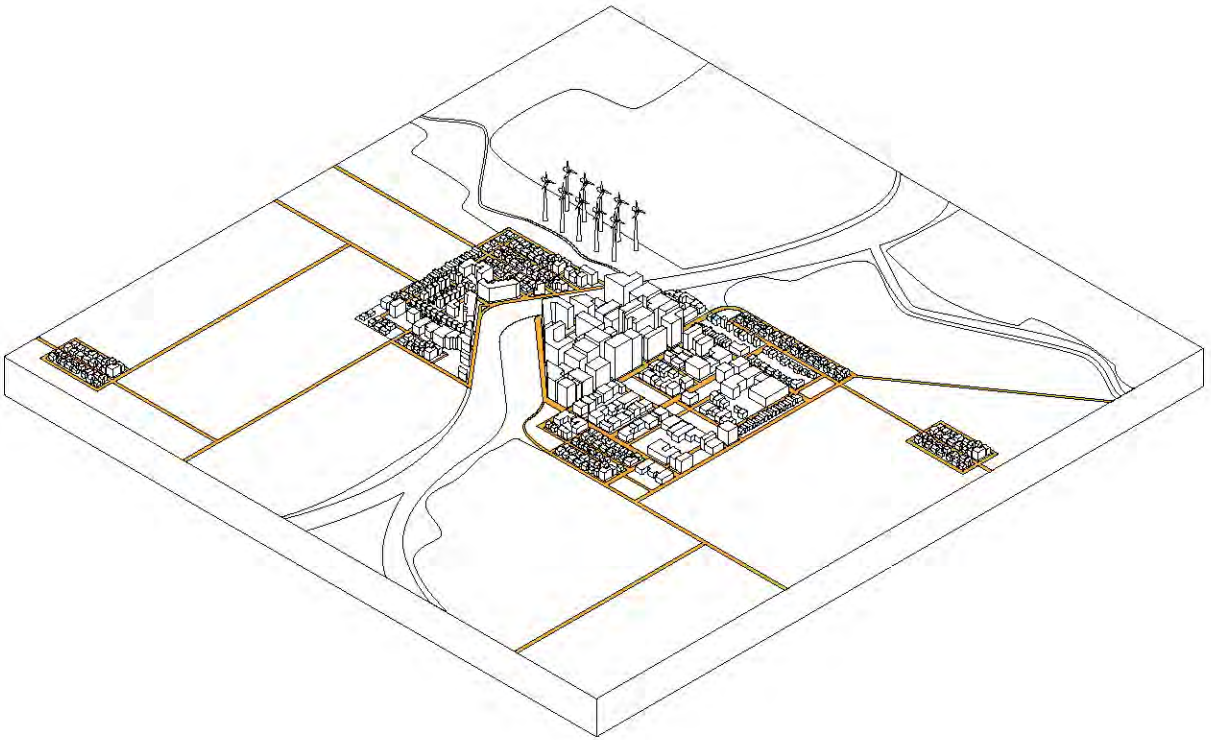
PRECEDENTS

HUMAN SETTLEMENTS

From small rural communities to mega-cities with populations in the millions, human settlements are the nodes of the social system network. The larger and more diverse the city, the more likely there is to be mixing of cultures and the evolution of new ideas, as well as the opportunity for social connections. Cities are not without their problems; dense urban development often comes at the cost of environmental and human health due to energy consumption, resource use, and waste production. However, by integrating the principles of green infrastructure into urban design, it is possible to better integrate these social nodes into the natural systems around them.

Below: Tokyo, Japan. Facing page, clockwise from top left: Davis, CA; New York City, NY; Barcelona, Spain; São Paulo, Brazil. Source: Apple Maps

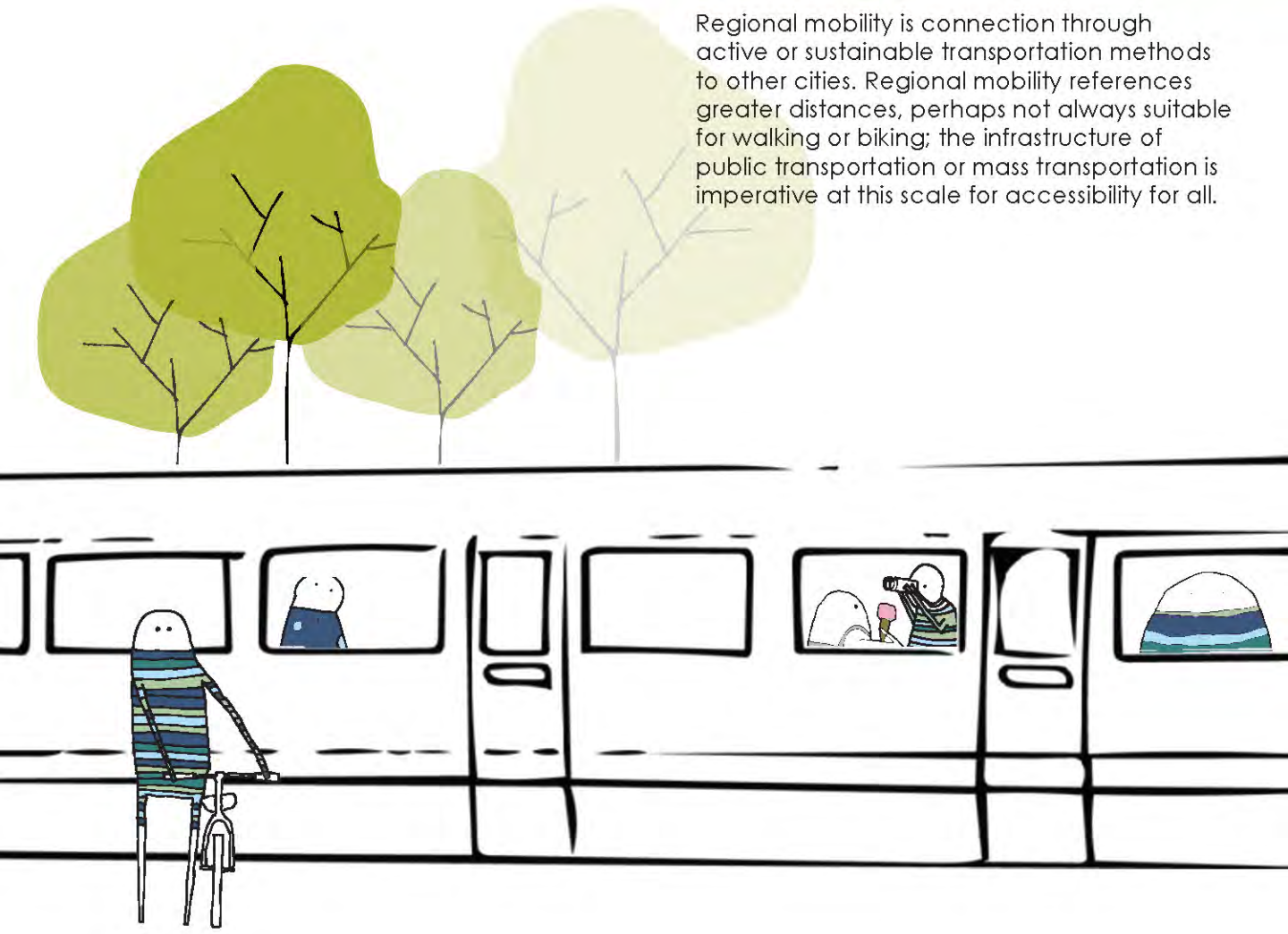
REGION | MOBILITY



MOBILITY

Networks and facilities that promote the use of active transportation.

Regional mobility is connection through active or sustainable transportation methods to other cities. Regional mobility references greater distances, perhaps not always suitable for walking or biking; the infrastructure of public transportation or mass transportation is imperative at this scale for accessibility for all.



REGION | MOBILITY

PRECEDENTS

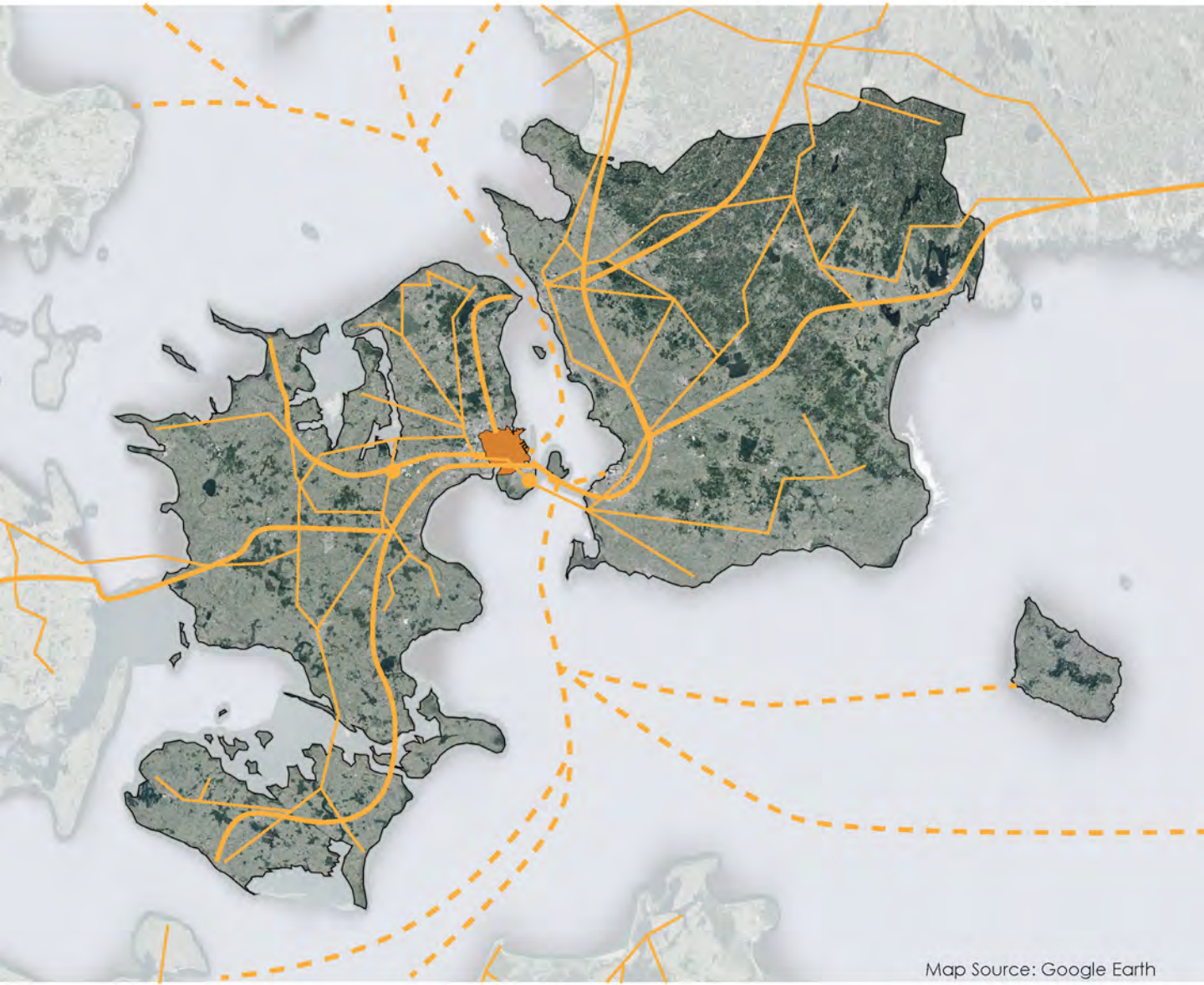

Source: Cycling Embassy of Denmark


Source: Cycling Embassy of Denmark

ØRESUND

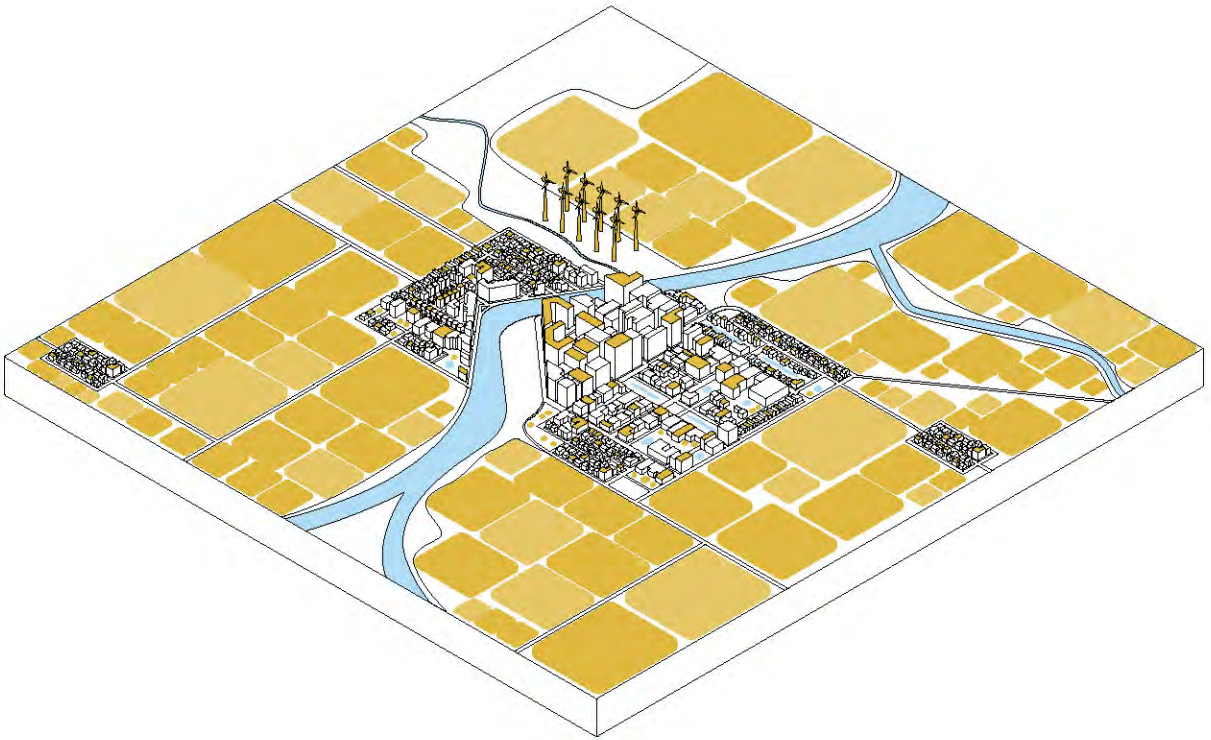
Eastern Denmark + Skåne Sweden

Øresund refers to the strait of water separating Denmark and southern Sweden, connected now by the Øresund Bridge. The map to the right shows a few important transportation networks: automobile, rail, air, and ferry. Bicycle infrastructure is harder to represent on a map at such a large scale; Denmark, and Copenhagen especially, is known for its 'bikeability,' which through regional connnections in infrastructure has expanded accessibility via bicycle around the country. Even with investment in other modes of transportation, bicycle infrastructure has been included and prioritized in most development efforts, as illustrated by the 21 suburban communities who banded together to approve a plan for almost 500 kilometers of bicycle infrastructure. Bicycle super highways connect the suburbs to Copenhagen for both commuting and recreational purposes. These super highways include good lighting, smooth lanes, safe separation from vehicular traffic, and bicycle-oriented amenities such as shelter and air pumps. The Øresund Bridge was constructed to connect the two countries and major cities (Copenhagen + Malmö) via automobile and rail, and the bridge also includes bicycle infrastructure, making it possible to do a full loop around the Øresund by land, ferry, and bridge.



Map Source: Google Earth

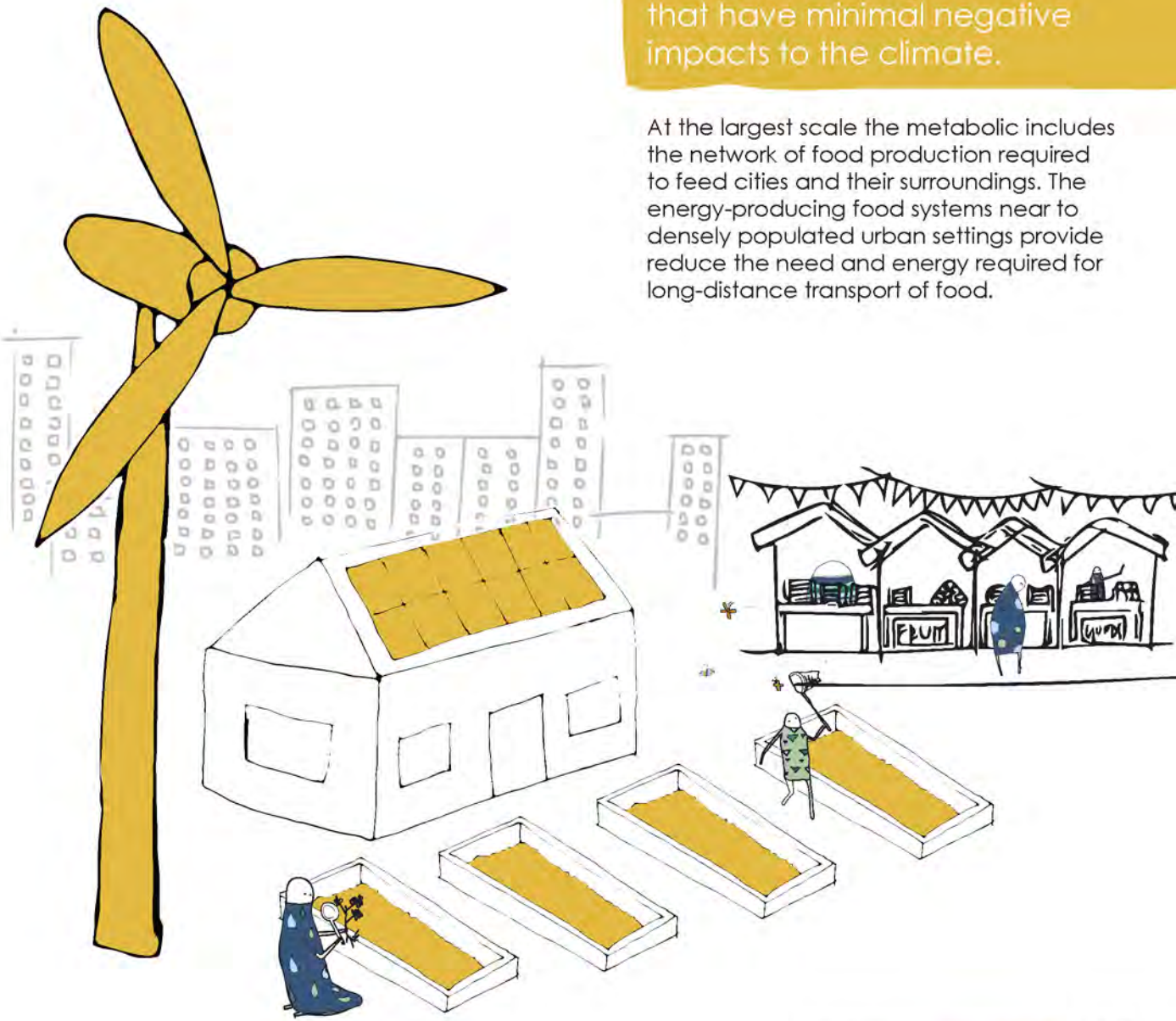
REGION | METABOLIC



METABOLIC

Energy-producing elements that have minimal negative impacts to the climate.

At the largest scale the metabolic includes the network of food production required to feed cities and their surroundings. The energy-producing food systems near to densely populated urban settings provide reduce the need and energy required for long-distance transport of food.



MIDDELGRUNDEN
Øresund, Denmark
Middelgrunden, established in 2000, has a capacity of 40 MW at full functioning power. Located just outside Copenhagen, the wind farm is located in a location with ample, yet weaker wind. The wind turbine was started as a cooperative between a group of those interested in wind turbines following the success of other wind turbine farms. Middelgrunden is located on water in the Øresund, offering ample opportunity to collect wind power for Copenhagen in a renewable manner.

COMMUNITY SUPPORTED AGRICULTURE

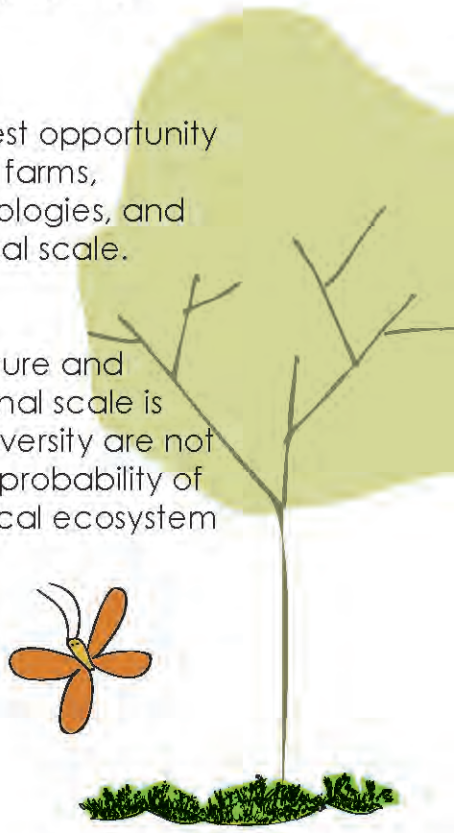
Community supported agriculture (CSA) connects the producer and the consumer, which is increasingly more difficult in a globalizing world. Garden plots are managed on a a volunteer basis by community members for the production of food and goods to be sold (flowers, plants, etc). The concept of CSAs builds upon a community-driven approach to social infrastructure. It is also important to note that CSAs sometimes differ from one another, and communities have adapted to better suit there needs. Not only do CSAs produce food locally or regionally, reducing the emissions from transportation of food, but they also bring people together on all scales.

REGION SUMMARY

LARGEST SCALE
Regional scale is important as it encompasses all scales we have covered. It looks at the connection between the smaller networks and connects the flow of services, people, and resources between urban areas and rural areas.

MOST ENERGY PRODUCTION
With the most space, the regional scale is the best opportunity for producing and collecting energy. From wind farms, traditional and non-traditional agriculture technologies, and more, the metabolic system thrives at the regional scale.

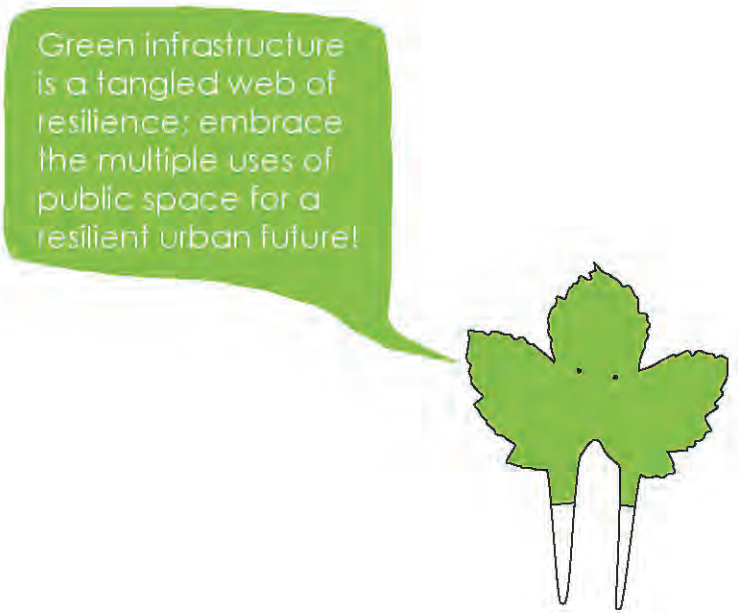
PROTECTION OF THE BIOLOGICAL SYSTEM
While it is important to protect and conserve nature and biodiversity at smaller, urban scales, at the regional scale is imperative. If ecosystems and their original biodiversity are not protected from human development, there is a probability of complete degradation, with extreme loss of critical ecosystem services to both cities and rural areas.

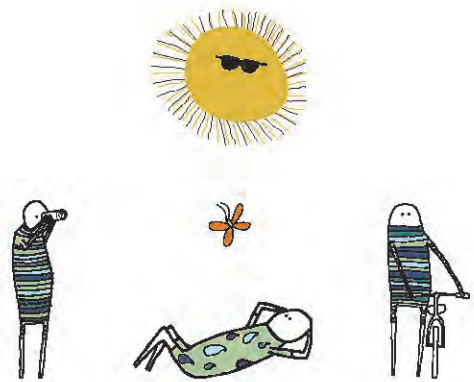


CONCLUSION

Green infrastructure isn't always the color green.
While the biological system is an important part of green infrastructure, other systems are equally important even if they are harder to see; the social and mobility systems connect people in cities, the hydrological system is imperative to climate adaptation and ecosystem health, and the metabolic system ensures that human energy consumption is sustainable.

Systems overlap - and that's a good thing!
Each of the five systems outlined in this guide overlaps and combines with all of the others. A park may appear to be comfortably sorted into the biological system, but digging deeper might reveal stormwater infrastructure, social amenities, mobility pathways, and energy-producing food gardens embedded within. This multi-functionality of elements and spaces is the foundation of green infrastructure!





SYSTEM + SCALE

A GUIDE TO GREEN INFRASTRUCTURE

UW GREEN FUTURES LAB