(E)CO-EXISTENCE

Rethinking the city of Piteå as a space for co-existence between humans and nature with a focus towards climate adaptation.

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"Study nature, love nature, stay close to nature. It will never fail you."

- Frank Lloyd Wright -

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(E)co-existence trova origine dalla partecipazione alla diciassettesima edizione di Europan, dove il progetto realizzato per la città svedese di Piteå è stato premiato con una menzione speciale vista la terza posizione ottenuta, generando un'occasione per l'approfondimento di temi urgenti quali il cambiamento climatico e la necessaria trasformazione delle città in relazione ad esso.
Lo scopo di questa tesi è quello di esplorare il tema dell'adattamento climatico degli insediamenti urbani attraverso l'utilizzo di natura e biodiversità, intese come strumenti di adattamento e mitigazione. Questo lavoro si conclude infatti con l'elaborazione di un insieme di strategie e azioni utili alla transizione delle città europee, in luoghi in cui gli esseri umani possano continuare a vivere e operare in prosperità, coesistendo in armonia con la natura e le altre forme di vita.

Il lavoro di ricerca può essere organizzato in due fasi principali: una prima fase di ricerca, costituita dall'analisi di diversi casi studio e dalla costruzione di una bibliografia, e una seconda di lavoro sul campo, effettuando interviste, sopralluoghi e disegni progettuali.
Il primo capitolo approfondisce i diversi impatti che il cambiamento climatico ha sui paesi europei, sottolineando l'importanza che un approccio transcalare riveste all'interno delle politiche e delle azioni da mettere in atto ai fini della transizione climatica In Europa, e illustrando differenti casi studio dalla scala urbana a quella di quartiere, con uno speciale focus sui paesi del Nord Europa.
Il secondo capitolo andrà invece ad introdurre i concetti di NbS (Nature-based Solutions) e biodiversità urbana, esplorando sia la stretta interconnessione che le lega, sia il ruolo che essi rivestono nell'ottica dell'adattamento e della mitigazione.
Il terzo capitolo esplora l'occasione progettuale del concorso, le interviste effettuate, le visite in sito e gli affondi progettuali che ne derivano. Questo capitolo si conclude con l'elaborazione di un toolkit volto a illustrare in maniera semplice ed immediata diverse strategie e soluzioni per l'adattamento climatico delle città, illustrando le applicazioni di intervento progettuale a scala urbana e microurbana sulla città di Piteå.
L'idea che questo lavoro mira a sostenere è quella secondo cui sia oggi più che mai necessario un radicale mutamento nel modo in cui intendiamo e progettiamo quartieri e città: non più luoghi in antitesi con la natura, bensì spazi che la riportino al centro, mostrando una nuova sensibilità del progetto, che dialoga e si rapporta con il costruito, oltre che uno strumento per il raggiungimento della sostenibilità climatica e del benessere umano.

ABSTRACT
(EN)

(E)co-existence originates from participation in the seventeenth edition of Europan, where the project created for the Swedish city of Piteå received a special mention, achieving third place. This success provided an opportunity to delve into urgent issues such as climate change and the necessary transformation of cities in response to it.
The aim of this thesis is to explore the theme of climate adaptation of urban settlements through the use of nature and biodiversity, understood as tools for adaptation and mitigation. The work concludes with the development of a set of strategies and actions useful for the transition of European cities into places where humans can continue to live and operate in prosperity, coexisting harmoniously with nature and other forms of life.

The research is organized into two main phases: a research phase, consisting of the analysis of various case studies and the construction of a bibliography, and a fieldwork phase, including interviews, site visits, and project drawings.
The first chapter delves into the different impacts of climate change on European countries, emphasizing the importance of a trans-scalar approach within the policies and actions to be implemented for climate transition in Europe, and illustrating different case studies from the urban to the neighborhood scale, with a special focus on Northern European countries.
The second chapter introduces the concepts of Nature-based Solutions (NbS) and urban biodiversity, exploring both the close interconnection between them and their role in adaptation and mitigation.
The third chapter explores the design opportunity presented by the competition, the interviews conducted, the site visits, and the resulting design explorations. This chapter concludes with the development of a toolkit aimed at illustrating various strategies and solutions for urban climate adaptation in a simple and immediate manner, showing the applications of project interventions at the urban and micro-urban scales in the city of Piteå.
The idea that this work aims to support is that a radical change is now more necessary than ever in the way we conceive and design neighborhoods and cities: no longer places in opposition to nature, but spaces that bring it back to the center, demonstrating a new project sensitivity that interacts with the built environment, and serving as a tool for achieving climate sustainability and human well-being.

Adaptation:

"The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects."

Mitigation (of climate change):

"A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). This report also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter (PM) emissions that can directly alter the radiation balance (e.g., black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides (NOx), Volatile Organic Compounds (VOCs) and other pollutants that can alter the concentration of tropospheric ozone (O3) which has an indirect effect on the climate."

- Report IPCC 2014 -


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Introduction

Floods, fires, earthquakes, ecosystem degradation, loss of biodiversity: these are just some of the tangible and now indisputable effects of climate change that in recent years have become increasingly evident, frequent, and destructive, to the point where the action of governments is now urgently needed, but above all, the definition of concrete and replicable measures to counter the devastating consequences of a series of water management and land use policies that have proven fundamentally inadequate to the changing conditions imposed by global warming. Architects, urban planners and designers must re-think their role on this matter, prioritizing sustainability and placing it at the core of their work in order address both current and future challenges.

In our country phenomena like the floods registered in 2023 in Emilia-Romagna and Tuscany, alongside episodes of intense rainfall, cases of damage from tornadoes and wind gusts, storm surge damage, landslides and prolonged drought (1) highlight both the profound inadequacy of government administrations and the vulnerability of today's urban settlements to climate change, as well as the importance of conscious territorial planning that takes into account the characteristics of the territory it operates on and is capable of adapting to the future scenarios related to ongoing climatic transformations.

At the same time, as both primary culprits and victims of climate change, cities, in global world only in 2019, were responsible for 75% of global natural resource consumption (2), while today they are still accountable for 80% of global CO2 emissions and 78% of the total global energy consumption (3;4). Considering that today more than 50% of the world's population lives in urban areas (5), a percentage that according to estimates could rise to 80% by 2050 (6;7), along with the increasingly recognized fact that the progressive increase in global temperatures disproportionately affects cities, exacerbating existing challenges, where factors such as urban density, scarcity of green areas, and low reflectance coefficient of materials commonly used in their construction further increase temperatures (8), inevitably aggravating heat discomfort (9) and ultimately leading to significant health issues in human beings (10), the need to rethink how we design urban settlements becomes evident: if until now urban planning mainly aimed at regulating anthropogenic transformations on the environment, now it also assumes the task of designing cities capable of reducing their impact on the ecosystem while adapting to the transformations our planet is undergoing. Added to this is the rapid and often uncontrolled expansion of cities, resulting from unstoppable demographic growth (11), which not only significantly reduces soil permeability, partly due to a perception of public space still strongly anchored to modernity ideas and past paradigms but also exposes an increasing number of people to a series of natural and anthropogenic risks. The effects of **climate change** have indeed shown how today's cities are still terribly inadequate to face such phenomena (12). As stated in the 2016 Amsterdam Pact, the rapid urbanization of post-industrial society will be one of the major challenges within the European urban agenda (11), as well as the development of an international adaptation strategy based on in-depth studies of **climate resilience** specific to each local reality (13) and capable of providing an effective response to the various types of risks concentrated in urban areas (14).

Moreover as underlined in various studies, the risks associated with urban life, mainly occur in urban fabrics mostly inhabited by low- to middle-income families, characterized by a strong lack of green spaces (15;16), thus highlighting how often climate change is also a social issue.

The Treccani Encyclopedia defines the concept of "**climate justice**" as "an ethical principle that establishes a condition of equality and equity of rights, duties, and resources in the face of local and global climate changes, especially negative ones, in which human action (17) has a strong impact". This term originated in 2000, when the first summit on climate justice was held simultaneously with COP6 (18), an event aimed primarily at building alliances among states in favor of sustainable development and during which climate change was recognized as a matter of rights. Two years later, in 2002, at the World Summit on Sustainable Development held in Johannesburg, the Bali Principles on climate justice were also adopted (19).

These disparities were further highlighted with the advent of the pandemic, during which those who did not have access to green areas or even to a mere balcony suffered more from the psychophysical consequences of lockdown than those who did (20). In 2020, the National Research Council (CNR) conducted a study, published in Urban Forestry & Urban Greening and conducted through an online questionnaire distributed via social networks and email, aimed at analyzing citizens' perception of urban greenery during social isolation and demonstrating how the quality of life in cities may be inherently linked to the presence and accessibility of urban green spaces (21), thus reaffirming the importance of **nature** on the human psyche, following the concept of "biophilia", a concept coined in 1960 by Erich Fromm, a German psychologist and academic, to describe "the passionate love of life

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and of all that is alive" (22) and later reiterated in 1984 by Edward Osborne Wilson, a biology professor at Harvard University, who argued for human attraction to nature and the well-being derived from the contact with it (23).
With the pandemic, innate human biophilia also led a significant number of citizens to move and approach those areas considered more fragile and marginal (24), as they are characterized by a more direct relationship with nature, giving rise to the phenomenon known as "City-Quitting" (25), a phenomenon where people were leaving cities, partly made possible by the increase in new forms of work such as remote work, often reserved for jobs that allow it, and thus still a phenomenon linked to economic and social factors.
It is precisely for this reason that it is so important to increase the accessibility and presence of green areas within cities: both as a tool for combating climate change and mitigating its effects, and as a means to guarantee every human being the right to contact with the natural environment and the well-being associated with it. In addition to an energy transition, it is indeed necessary to implement a transition in the way architecture is done as well as in the way cities are planned.
In this sense, urban greenery assumes the dual role of an element for the protection and increase of human well-being (10) and at the same time a tool for mitigating the effects of climate change on the urban environment and achieving resilience and adaptation in cities (26). In Europe, for years now, urban planners have argued that proximity to and accessibility of natural spaces should be an integral part of urban planning that is as sustainable as it is sensitive to socioeconomic inequalities (27), but to do this, it becomes essential to consider living space not only limited to individual residential units but extended to the entire urban scale (28).
Although most states are currently engaged in planning resilient cities (29), it is still uncertain how efficient the strategies adopted are in integrating mitigation and compensation actions together with the enhancement and development of natural capital (11). Introduced into the context of urban and territorial planning towards the end of the last century (30), the concept of resilience promotes urban policies aimed at making cities more sustainable and inclusive. Within the ecological approach, resilience is not simply the opposite of vulnerability but rather an "extended concept" that defines a resilient urban system as one that must not only be able to prevent and manage negative and unexpected events but also and above all to improve environmental and social quality, based on the concept of Evolutionary Resilience (31), a form of resilience that, unlike the engineering approach to the latter, generates flexible systems that, in response to a catastrophic event, have the ability to renew themselves (32).
From an urban planning point of view, there are several disciplines and approaches born to cope with climate change and the changes it entails. Among these, we find Nature-Based Solutions (NBS), Wildlife-inclusive Cities (WSD), Biodiversity-sensitive Urban Design (BSUD), Water Sensitive Urban Design (WSUD), and Eco-Districts.

As previously stated, the thesis's main objective is to analyze the different strategies adopted by member countries of the European Union, both at the urban and micro-urban scale and, based on these, to build a toolkit, an abacus of various solutions to be adopted according to the biogeographic region and the relative climatic conditions of the country in which the operation is carried out, which can subsequently offer a series of guidelines for the redevelopment of a waterfront located within the city of Piteå, in Sweden, the subject of the seventeenth edition of the international urban design competition Europan and the case study of this thesis, the writing of which was supported in part by consulting paper sources and in part by the use of sources available online, involving various aspects of comparative research and conceptual research as well as understanding the reading of essays, academic research, university thesis, reports, encyclopedias, regulations, articles and magazines.

Considering this research structure, the first chapter of this paper will examine the **different impacts of climate change** on the planet as well as on the countries of the European Community, together with the different strategies adopted by each of them based on the different biogeographic regions identifiable within the Union, as well as the ones adopted by northern european countries, on which this thesis is particularly interested.
The second chapter will instead analyze the various **mitigation and adaptation strategies** currently feasible on the urban and neighborhood scale, addressing the impacts that climate change has on urban centers, as well as the role that cities play in the fight against the climate crisis. This will be followed by the presentation of several case studies at the urban and micro-urban scale, thereby introducing the concept of eco-district as an element of inspiration fo the elaboration of a new, more sustainable way of living.
At last, the third chapter will be dedicated to the exposition of the occasion in which the thesis' project was elaborated, the **Europan Competition**, as well as the complex and unique situation to which the city of Piteå, in northern Sweden, is subjected today. This section will indeed start with a short explanation on what Europan is, illustrating the themes behind its 17th edition and the reasons behind our choice for the site. It will then explain the requirements for the project in Piteå, city where our intervention is located, later delving into the characteristics and peculiarities of this city located in the north of Sweden. Finally, it will illustrate the project realized for the competition, which won a special mention, giving us the opportunity to participate to a workshop organized by Europan in Stockholm and meet people from Piteå's municipality and the Swedish Transport Administration. This, in turn, gave us the opportunity to organize an on-site visit, as well as an interview with the city's municipality's architect. Lastly, the re-design of the project following the research process of this thesis will be illustrated, along with a series of solutions for mitigation and climate adaptation based on nature and biodiversity which have been implemented in the thesis' project, in order to offer an easily applicable compendium of solutions that could be replicated in cases similar to the one found in Piteå.

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CLIMATE CHANGE IN EUROPE:
A MULTISCALAR APPROACH

1

THE NATIONAL SCALE

1.1

1.1.1
The impacts of climate change and the European response:

Despite our planet having experienced various climate changes in the past, even in relation to changes in solar activity (1), it has long been scientifically demonstrated that the recent changes cannot be solely attributed to the cyclic alternation between glacial (cold) and interglacial (warm) periods (2), but rather to an increase in greenhouse gas concentrations unequivocally linked to human activity. Since the industrial revolution, between 1970 and 2004, there has been a 70% increase in global greenhouse gas emissions (3), along with a global temperature increase of 1.1°C compared to 1975, at a rate ranging from 0.15 to 0.20°C per decade (4), making the influence of human activities on the planet's climate balance quite evident. The primary driver of climate change is the greenhouse effect (5), a phenomenon caused by the ability of certain gasses to trap the sun's heat in the atmosphere, which can be natural or anthropogenic. While the former is essential for life on our planet, the anthropogenic greenhouse effect is causing the warming, along with numerous resulting effects.

Among the various **effects of climate change in Europe**, it is possible to find:

- Rise in global average temperatures:
In general, the climate crisis has caused an increase in global average temperatures, leading to more frequent extreme weather events, which, depending on the region, translate into increased precipitation or heatwaves, with severe consequences including infrastructure damage, decreased productivity, and, most importantly, increased mortality, especially among vulnerable groups such as children and the elderly. Furthermore, due to rising temperatures, a shift in the geographic distribution of climate zones is expected, with repercussions on ecosystems and local animal and plant species already under pressure due to habitat loss and pollution. Additionally, it is predicted that rising temperatures will affect species' phenology, their life cycles, and behavior, leading to an increase in invasive species, parasites, and diseases for humans. Meanwhile, agricultural and livestock yields, as well as the ability of ecosystems to provide essential services such as clean water and air, may decrease due to higher temperatures and increased water evaporation, associated with decreased precipitation, thus leading to an increased risk of drought (6).

- Droughts and wildfires:
Due to climate change, many European regions are already facing more frequent and prolonged periods of drought. Different from water scarcity, which is the structural lack of freshwater throughout the year due to excessive water consumption, drought is an unusual and temporary deficit in freshwater availability caused by a combination of decreased precipitation and increased evaporation, both linked to rising temperatures. Drought usually leads to a chain of effects, such as infrastructure damage, agricultural production losses, and biodiversity loss, while also reducing water levels in rivers and aquifers and increasing parasite attacks and the frequency of wildfires. Available studies predict an increase in the frequency, duration, and severity of drought periods for most European countries, with exceptions in some parts of northern Europe where a decrease might occur. However, the most noticeable increase is expected in southern Europe, where a greater competition for water use among agriculture, industry, tourism, and households will occur due to the same reason. With a 3°C increase in global average temperature, it is projected that droughts would occur twice as often, and absolute annual losses from drought in Europe would increase by up to 40 billion, with the most severe impacts in Mediterranean and Atlantic regions. More frequent and severe droughts would also increase the duration and severity of wildfires, especially in the Mediterranean region.

- Floods:
According to predictions, climate change will lead to increased precipitation in much of Europe, resulting in alternating periods of drought and heavy rainfall, which will inevitably cause river and pluvial floods. In some regions, certain risks, such as spring floods, may decrease in the short term due to fewer winter snowfalls, but the increased risk of sudden floods in mountainous areas that overload the river system could offset these effects in the medium term.

- Freshwater shortage:
With rising temperatures and consequent changes in precipitation, glaciers melt, evaporation increases, and so does sea level. All these factors influence the availability of freshwater, along with more frequent drought periods and increased water temperature, which promote the growth of algae and toxic bacteria, reducing the quality of the limited freshwater available, along with increased heavy rainfall, as rainwater can sometimes cause the discharge of untreated sewage into surface waters. European rivers generally originate in mountainous areas, and 40% of Europe's freshwater comes from the Alps. However, changes in precipitation patterns, snow, and glaciers could lead to temporary water shortages throughout Europe. Variations in river flows due to drought can also affect hydroelectric power production as

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well as inland navigation. Climate change is also expected to bring about major changes in water availability across Europe, due to less predictable precipitation patterns and more intense storms. This will result in increased water scarcity, especially in southern and southeastern Europe, as well as an increased risk of flooding across much of the continent.

- Rising sea levels:
During the 20th century, partly due to ocean thermal expansion and partly due to ice melt, sea levels have significantly risen, a trend that has been accelerating in recent decades. According to predictions, by the end of the century, Europe will experience an average sea level rise of between 60 and 80 cm, mainly depending on the speed at which the Antarctic ice sheet melts. Considering that about a third of the European population lives within 50 km of the coast and that these areas generate over 30% of the EU's total GDP, as well as the economic value of assets within 500 meters of European seas ranging from 500 to 1,000 billion dollars, the risk associated with rising oceans is clear, which will in turn increase the risk of flooding and erosion along the coasts, with significant consequences for people, infrastructure, businesses, and ecosystems in these areas. Furthermore, it is expected that sea level rise will reduce the availability of freshwater, as seawater will penetrate further into underground aquifers due to it, leading to increased intrusion of saltwater into freshwater bodies, affecting agriculture and drinking water supply. Finally, many natural areas will be lost, threatening animal and plant species and diminishing the natural protection these areas provide against storm surges.

- Soil erosion and desertification:
Climate change can worsen soil erosion, the decline of organic matter, salinization, loss of soil biodiversity, landslides, desertification, and floods. Moreover, changes in carbon storage levels in the soil may be correlated with changes in atmospheric CO2 concentrations, along with rising temperatures and precipitation pattern changes: extreme rainfall, rapid snow and ice melting, high river flows, and increased periods of drought are all climate-related events that influence soil degradation. Deforestation and other human activities (agriculture, skiing tourism, etc.) also play a significant role in soil degradation. Additionally, it is expected that saline soils will increase in coastal areas due to the intrusion of saltwater from the sea, linked to rising sea levels and low river flow.

- Ocean acidification:
Increased sea surface temperatures, ocean acidification, and changes in currents and wind patterns will significantly alter the physical and biological composition of the oceans. Furthermore, changes in temperatures and ocean circulation can potentially alter the geographical distribution of marine creatures. Increased sea surface temperatures could also enable invasive species to expand and cause harm to local species. Ocean acidification, for example, will impact various organisms that secrete calcium carbonate. These changes will have inevitable impacts on coastal and marine ecosystems, with significant socio-economic consequences for many regions.

- Loss of biodiversity:
Climate change is occurring so rapidly that many plant and animal species struggle to cope with it: clear evidence shows that biodiversity is already responding to climate change and will continue to do so. Direct impacts include changes in phenology (the behavior and life cycles of animal and plant species), in the number and distribution of species, in community composition, habitat structure, and ecosystem processes. Climate change is also leading to indirect impacts on biodiversity through changes in land use and other resources: these could be more damaging than direct impacts due to their scale and speed. They include: habitat fragmentation and loss, overexploitation of resources, air, water, and soil pollution, and the spread of invasive species (7).

Numerous studies and scientific research have documented the current effects of climate change, which, according to predictions, will affect almost all European regions, albeit unevenly among different countries and climate-related sectors, thus exerting additional pressures on existing socio-ecological structures (8). The impacts of climate change indeed vary depending on the biogeographical region being referred to, where by "biogeographical region" we mean the set of territorial areas characterized by homogeneous ecological features. Specifically, the European Union, composed of 27 Member States, is divided into 9 biogeographical regions, on which both the Natura 2000 network for habitat and species conservation and the designation of Sites of Community Importance (SCI) and Special Protection Areas (SPA) under the Birds Directive of 2009 are based, regardless of political-administrative boundaries. These biogeographical regions are: Atlantic, Continental, Alpine, Mediterranean, Boreal, Macaronesian, Pannonian, Steppe, and the Black Sea region (9).

- Atlantic Region:
This region will experience increased precipitation frequency. This will inevitably be associated with a higher risk of floods and winter storms. However, despite this, higher temperatures will also result in a lesser amount of energy required for heating.

- Continental Region:
The continental region will be characterized by more extreme climates, with lower summer precipitation and increased river flooding risk. Forests will be less economically viable due to summer droughts, leading to a higher risk of forest fires. Additionally, countries in this biogeographical region will experience increased energy demand for cooling.

- Alpine Region:
The Alpine Region, including much of Norway, will see higher temperature increases compared to the European average, leading to glacier reduction. Flora and fauna migration to higher altitudes, along with increased risks of species extinction and forest pest spread, are expected. This may negatively impact hydropower, increase landslide risk, and reduce winter tourism (10).

- Mediterranean Region:
The Mediterranean region has been subject to severe impacts in recent decades due to decreased precipitation and rising temperatures, and it is predicted that these will worsen as the climate continues to change. The main impacts include reduced water availability and crop yields, increased risk of drought and biodiversity loss, wildfires, and heatwaves. Improving irrigation efficiency in agriculture can somewhat reduce water withdrawals, but it will not be sufficient to offset the increased water stress induced by the

(7) Kirk, H., et al. (2021) 'Building biodiversity into the urban fabric: A case study in applying Biodiversity Sensitive Urban Design (BSUD)', *Urban Forestry & Urban Greening*, 62.

(8) European Commission. *Consequences of climate change*. Available at: https://climate.ec.europa.eu/climate-change/consequences-climate-change_en (Accessed: 20 March 2024).

(9) Biesbroek, R. G., et al. (2010) *Europe adapts to climate change: Comparing National Adaptation Strategies*. Available at: https://doi.org/10.1016/j.gloenvcha.2010.03.005 (Accessed: 20 March 2024).

(10) Ministero dell'Ambiente e della Sicurezza Energetica (2023) *Le Regioni biogeografiche*. Roma: Ministero dell'Ambiente e della Sicurezza Energetica.

climate. Additionally, the hydropower sector will be increasingly affected by lower water availability and growing energy demand, while the tourism industry will face less favorable conditions in summer. Environmental flows, crucial for maintaining healthy aquatic ecosystems, are threatened by the impacts of climate change and socioeconomic developments (7).

- Boreal Region:
Regarding the boreal region, forecasts suggest reduced snow and ice coverage on lakes and rivers, as well as increases and decreases in river flow in winter and spring depending on the area, not to mention the increasingly frequent damage caused by winter storms. More frequent and intense extreme weather events in the medium and long term could also have a negative impact on the region, making crop yields, for example, more variable. In general, the main climate challenges faced by this biogeographic region include increased precipitation, flooding, rising temperatures leading to biodiversity loss and parasite spread, more violent and damaging winter storms, and variations in frost and thaw periods, consequently affecting vegetative periods (11).

- Macaronesian Region:
Even the islands of Macaronesia have not been spared from the effects of climate change, as they are particularly sensitive due to their intrinsic insular characteristics and geographical position, which also causes a significant dependence on external factors. Pressures from tourism and high population density are also significant. These conditions, combined with a rich and biodiverse ecosystem highly sensitive to external stresses, as well as the expected risks associated with increasingly frequent periods of drought and evapotranspiration of plants and soils, compounded by excessive exploitation of water resources (12).

- Pannonian Region:
In recent decades, an increase in the frequency and severity of extreme weather events, such as heatwaves, droughts, and heavy precipitation, has been observed, which have already had negative impacts on many countries in the Pannonian region (13;14;15;16;17). According to current projections, this region is expected to be among the most severely affected in Europe in terms of various sectors and ecosystem services. This represents a significant challenge for managing various factors, such as biodiversity, healthcare, forests, agriculture, water, production, energy consumption, flooded areas, urban areas, and rural settlements (23). Along with the reduction in summer precipitation, the increase in temperatures can increase the risk of drought, and it is expected to increase energy demand in summer. It is also predicted that the intensity and frequency of river floods in winter and spring (in various regions) will increase due to higher winter precipitation. Furthermore, climate change is expected to lead to greater crop variability and increased frequency of forest fires (7).

- Steppic Region:
Climate-related challenges faced by the steppe region include rising temperatures, more frequent and intense heatwaves, reduced summer precipitation, increased drought risk, more frequent winter and spring river floods, greater crop yield variability, and increased forest fires (18).

- Black Sea Region:
Effects of climate change in the Black Sea region include significantly decreased annual average precipitation, especially in summer, increased temperatures, considerable water stress (defined as decreased water availability combined with increased demand from agriculture and domestic sectors), and higher coastal flood risk due to sea level rise, accompanied by storm surges. Other impacts include lower agricultural yields, biodiversity loss, and increased forest fires due to higher temperatures and heatwaves, accompanied by increased drought and risk of desertification (19).

In general, numerous laws have been established by the European Union regarding adaptation and mitigation. For example, on June 22, 2022, the European Commission decided to establish a **law on nature restoration**, the so-called "EU Nature Restoration Regulation", with the aim of actively contributing to the long-term recovery of all degraded natural systems, both terrestrial and marine, in all member countries, as well as respecting international commitments and achieving goals set by the Union on climate and biodiversity (with particular reference to the global Kunming-Montreal framework on biodiversity). This law, approved with 329 votes in favor, 275 against, and 24 abstentions, aims to restore at least 20% of EU land and marine areas by 2030, as well as all ecosystems by 2050 (8).

(11) EEA (2017) *Key observed and projected climate change and impacts for the main regions in Europe*. Available at: https://eea.europa.eu/data-and-maps/figures/key-past-and-projected-impacts-and-effects-on-sectors-for-the-main-biogeographic-regions-of-europe-5 (Accessed: 21 March 2024).

(12) Martel, G., et al. (2017) *ADAPTaRES: Adaptación al cambio climático en la Macaronesia a través del uso eficiente del agua y su reutilización*. Available at: https://adaptecca.es/en/casos-practicos/adaptares-project-adaptation-climate-change-macaronesia-through-efficient-use-water (Accessed: 21 March 2024).

(13) Marx, A., et al. (2017) *Terrestrial ecosystems, soil and forests. In: Climate Change, Impacts and Vulnerability in Europe 2016. An indicator-based report*. Available at: https://www.researchgate.net/publication/313692948_Terrestrial_ecosystems_soil_and_forests_In_Climate_change_impacts_and_vulnerability_in_Europe_2016_-_An_indicator-based_report (Accessed: 21 March 2024).

(14) Croitoru, A. E., et al. (2016) 'Changes in heat wave indices in Romania over the period 1961–2015', *Global and Planetary Change,* 146, pp.109-121.

(15) Stadtherr, L., et al. (2016) 'Record Balkan floods of 2014 linked to planetary wave resonance', *Science Advances*, 2(4).

(16) Spinoni, J., et al. (2015) 'Heat and cold waves trends in the Carpathian Region from 1961 to 2010', *International Journal of Climatology*, 35(14), pp. 4197-4209.

(17) Vučetić, V., Feist, O. (2015) *Heat stress and agriculture in Croatia: past, present and future*. Available at: https://meetingorganizer.copernicus.org/EMS2013/EMS2013-131.pdf (Accessed: 23 March 2024).

(18) Ceglar, A. (2018) 'PannEx: The Pannonian Basin Experiment', *Climate Services,* 11, pp- 78-85.

(19) Venturini, S., et al. (2013) *Overview of Key Climate Change Impacts, Vulnerabilities and Adaptation Action in Europe*. Climate Services Division.

1.1.2
National strategies for adaptation and mitigation:

The first signs of concern about climate change emerged within the scientific community in the 1960s and 1970s, after American physicist and meteorologist Charles David Keeling began recording concentrations of carbon dioxide in the atmosphere in 1961, noting a continuous increase over time and leading to the discovery of the so-called "Greenhouse Effect". However, it was only in the 1980s that climate change began to receive more international attention, due to a renewed awareness of the correlation between environmental degradation and human activities. In fact, it was in 1988 that the World Meteorological Organization and the United Nations Environment Programme established the Intergovernmental Panel on Climate Change (IPCC), tasked with assessing scientific knowledge on climate change. With the goal of limiting emissions of substances that damage the ozone layer, the Montreal Protocol was adopted in 1989, while the Rio Conference in 1992 led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC), the first international treaty aimed at addressing climate change (1). In 1997, with the Kyoto Protocol, the international debate focused on establishing a series of targets for reducing greenhouse gas emissions for industrialized countries. This protocol came into effect only in 2015, following the necessary number of ratifications, during the United Nations Climate Change Conference (COP21) held in Paris, resulting in the Paris Agreement, through which all countries, including major emitters such as China and the United States (2), committed to reducing emissions and limiting the increase in global temperatures to below 2°C compared to pre-industrial levels, as well as striving to keep them below 1.5°C (3).

Global efforts to combat climate change have progressively translated into a series of measures and legislations at both national and community levels. While not many years ago the main response to climate change was mitigation, sought through the reduction of greenhouse gas emissions, with the European Union mainly focused on achieving the Kyoto Protocol goals and mechanisms rather than adaptation, starting from the 1980s, the increasing evidence of the impacts of human activity on the climate ensured that adaptation entered the political debate not as a "fatalistic strategy", as it had been considered before (4;5), but as an explicit response to managing the inevitable impacts of climate change (6). With the publication of the Green Paper "Adapting to Climate Change in Europe – options for EU action" in 2007 (7) and the subsequent White Paper "Adapting to Climate Change: towards a European framework for action" (8), the European Commission finally recognized the need to develop a series of global adaptation strategies in all member states, emphasizing the importance of a unified assessment of impacts as well as a global adaptation strategy by 2013 (9).

Before mitigation and adaptation, various European countries had begun to incorporate the concept of resilience into their planning practices, including national and regional adaptation strategies, as well as practical steps at the community or individual level (10;11). Since 2005, Union Member States have also started developing what are known as comprehensive **National Adaptation Strategies** (NAS) to encourage, facilitate, and further coordinate adaptation efforts (9). In 2013, the Union adopted the Climate Change Adaptation Strategy, which outlined principles, guidelines, and objectives for community policy, primarily aimed at promoting coordinated national visions consistent with national plans for managing natural and anthropogenic risks (12). In 2021, the Commission adopted a new strategy for climate change adaptation, the EU **Strategy on Adaptation to Climate Change**, based on the 2013 Climate Change Adaptation Strategy and a fundamental part of the 2019 European Green Deal (13). This strategy is characterized by four main objectives: Smarter adaptation, Faster adaptation, More systemic adaptation, and Stepping up international action for climate resilience. Overall, the intent of the new European proposals is to shift focus from understanding the problem and planning to developing strategies and defining a path toward achieving resilience by 2050 (14).

But what are adaptation and mitigation, exactly? To ensure a common understanding of these two concepts, the IPCC (International Panel on Climate Change) provides a series of clear definitions. Within the glossary provided by the IPCC Report of 2014 (15), we find the following definitions:

- Adaptation: "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects".

- Mitigation (of climate change): "A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). This report also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter (PM) emissions that can directly alter the radiation balance (e.g., black carbon) or measures that

(1) Respini, D. (2013) *Il Cambiamento Climatico e la Pianificazione: Italia e Regno Unito a confronto*. Available at: https://www.politesi.polimi.it/handle/10589/90601 (Accessed: 23 March 2024).

(2) Caputo, M. (2023) *Promuovere la transizione verde a tutti i livelli di governance territoriale. Strumenti e politiche di adattamento nel contesto dell'Unione Europea*. Torino: Politecnico di Torino.

(3) European Commission. *Causes of climate change*. Available at: https://climate.ec.europa.eu/climate-change/causes-climate-change_en#causes-for-rising-emissions (Accessed: 23 March 2024).

(4) Schipper, E. L. F. (2006) *Conceptual History of Adaptation in the UNFCCC Process*, Review of European Community & International Environmental Law, 15(1), pp. 82- 92.

(5) Swart, R. J., et al. (2009) *Europe Adapts to Climate Change: Comparing National Adaptation Strategies*. Available at: https://climate-adapt.eea.europa.eu/en/metadata/publications/europe-adapts-to-climate-change-comparing-national-adaptation-strategies (Accessed: 23 March 2024).

(6) Jol, A., et al. (2008) *Impacts of Europe's changing climate – 2008 indicator-based assessment*. Available at: https://iopscience.iop.org/article/10.1088/1755-1307/6/29/292042 (Accessed: 25 March 2024).

(7) CEC (2007) *Adapting to climate change in Europe-options for EU action*. Bruxelles: Commission of the European Communities.

(8) CEC (2009) *WHITE PAPER: Adapting to climate change: Towards a European framework for action*. Bruxelles: Commission of the European Communities.

(9) Biesbroek, R. G., et al. (2010) '*Europe adapts to climate change: Comparing National Adaptation Strategies*', Global Environmental Change, 20(3), pp.440-450.

(10) Smit, B., et al. (2000) 'An anatomy of adaptation to climate change and variability', *Climatic Change*, 45, pp. 223-251.

(11) Smit, B., Wandel, J. (2006) 'Adaptation, adaptive capacity and vulnerability', *Global Environmental Change*, 16(3), pp. 282-292.

(12) Italiano, M. (2017/2018) *Linee guida per la pianificazione urbana resiliente. Misure di adattamento e mitigazione ai cambiamenti climatici*. Milano: Politecnico di Milano.

(13) European Commission. *The European Green Deal: Striving to be the first climate-neutral continent*. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_it (Accessed: 27 March 2024).

(14) European Commission (2023) *Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change*, Climate-ADAPT.

(15) Allwood, J. M., et al. (2014) *AR5 Climate Change 2014: Mitigation of Climate Change*. New York: Cambridge University Press.

control emissions of carbon monoxide, nitrogen oxides (NOx), Volatile Organic Compounds (VOCs) and other pollutants that can alter the concentration of tropospheric ozone (O3) which has an indirect effect on the climate".
According to these definitions, **mitigation involves avoiding the unmanageable**, **while adaptation involves managing the inevitable**, given the awareness that not all impacts of climate change can be avoided (1). There are also multiple definitions regarding adaptation strategies (16;17), which are usually defined as "a general action plan to address the impacts of climate change, including climate variability and extreme events". Depending on the circumstances, the strategy can be implemented at a national or regional scale (18).

The National Adaptation Strategies (NAS) of each country vary widely both in their structure and sectoral focus, yet they provide a fairly comprehensive overview of the particular vulnerabilities of different countries and the various impacts that climate change has on them (9). As for the different focuses they may have, NAS can address a wide range of topics and sectors, many of which are common across countries, in addition to addressing existing interconnections between them. For example, the Spanish strategy identifies key sectors within its National Strategy as water resources, biodiversity, and coastal areas, as they have significant impacts on other sectors such as agriculture, forestry, and tourism (20). Similarly, the French NAS distinguishes between cross-cutting issues like water, health, biodiversity, and risk prevention, and sectoral approaches like agriculture, energy, industry, transportation, construction, and tourism (21). Overall, each country presents specific and diverse topics reflecting local geographical conditions, natural resources, and specific livelihoods. While the emphasis is generally placed on risk response rather than exploring opportunities, a small number of countries, especially in Western and Northern Europe, explicitly consider potential benefits associated with climate change in their strategies. These benefits include exporting expertise in water and coastal engineering (Netherlands), new opportunities for tourism (Netherlands, UK, Sweden, Finland), extended growing seasons and increased agricultural yields (Sweden, Denmark, Finland, Germany, Latvia), or increased hydroelectric and wind energy production (Sweden, Finland, Latvia, Denmark). In terms of planned national adaptation, the European Commission considers Adaptation Strategies as the most effective tool for preparing Member States to assess impacts, vulnerabilities, adaptation options, and to address anticipated impacts of climate change across all sectors. **Unlike for mitigation, however, there is no single adaptation policy applicable to all countries**. Each Member State experiences different climate change-related issues based on its environmental, social, and economic characteristics, and the design and implementation of adaptation depend on each Member State's particular governance system. Adaptation is characterized by multi-sectoral and inter-sectoral spectrums due to its impact on various interconnected economic sectors. Additionally, adaptation is multi-level, involving competencies spanning various governance scales: from the European level to national and local levels. Horizontal and vertical integration of adaptation must therefore be coordinated or enabled by the executive or legislative power of a country. Generally, the various governments comprising the Union are at different stages of designing, developing, and implementing their NAS, if present. Since 2005, eighteen of the European Environment Agency Member States have formally adopted their Adaptation Strategy. These include Finland (2005), Spain (2006), France (2007), Hungary (2008), Denmark (2008), Netherlands (2008), UK (2008), Germany (2008), Sweden (2009), Belgium (2010), Portugal (2010), Switzerland (2012), Malta (2012), Ireland (2012), Austria (2012), Lithuania (2012), Norway (2013), and Poland (2013). Additionally, at least 10 other Member States, including Italy, among others, are considered to be at an advanced stage towards adopting a strategy, based on a national assessment of impacts, vulnerabilities, and adaptation measures. Up-to-date information on national strategies is available on the Climate-ADAPT platform, which provides access to data on impacts, vulnerabilities, and adaptation actions by country. Following the adoption of a national strategy, the main challenge in many countries, especially regarding the integration of adaptation into existing economic policies and instruments, is the development of an implementation plan and the creation of reporting and monitoring mechanisms. In general, the European Commission has recognized some gaps in national adaptation action, which it intends to address through the European Adaptation Strategy, highlighting the importance of an international-scale strategy in addition to national strategies. Nearly half of the Member States have not yet adopted their own adaptation strategy, and almost none of the existing NAS address transboundary issues or social problems. In some Member States, regions have significant administrative autonomy. However, regional adaptation strategies are still not very common, and relevant information is not adequately disseminated. The same issue exists for European cities: excluding successful cases where urban centers outperform national governments in adaptation preparation (e.g., Rotterdam and Copenhagen), most local administrations require specific assistance in planning adaptation. Although there is no absolute rule for adaptation, guidelines on national adaptation policies accompanying the European Adaptation Strategy, the "Guidelines on developing adaptation strategies", and guiding principles for adaptation to climate change in Europe allow governments to develop, implement, and review national adaptation strategies based on shared elements (22).

The function of the EU is to ensure coherence and collaboration between different national and regional plans at various levels of governance, taking into account both the diverse challenges faced by the various Union countries and the existing gap between them, further exacerbated by climate change. Essential for adaptation is indeed solidarity among Member States, as well as the administrative role of the EU, because without its action, the effectiveness of actions would be significantly reduced, along with cohesion among Member States (23). To this end, the European Commission has deemed it necessary to adopt policies aimed at supporting national governments in defining strategies (the aforementioned NAS) and plans. In addition to the already mentioned NAS, several states have actually developed comprehensive adaptation plans, both at the national scale (NAP) and at the sectoral scale (SAP).

While National Adaptation Strategies (NAS) are

(16) Carter, T. R., et al. (1994) *IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations*. London: University College London.

(17) Burton, A. M., et al. (2005) 'Robust representations for face recognition: The power of averages', ***Cognitive Psychology***, 51(3), pp. 256-284.

(18) Bosch, B., Niang-Diop, I. (2005) *Formulating an Adaptation Strategy*. Available at: https://www4.unfccc.int/sites/NAPC/Documents%20NAP/General/apf%20technical%20paper08.pdf (Accessed: 27 March 2024).

(20) PNACC (2012) Plan Nacional de Adaptacio´n al Cambio Climatico. Primer Programa de Trabajo. Available at: https://www.minambiente.gov.co/cambio-climatico-y-gestion-del-riesgo/plan-nacional-de-adaptacion-al-cambio-climatico/ (Accessed: 27 March 2024).

(21) ONERC (2007) *Stratégie nationale d'adaptation au changement climatique*. Paris: La Documentation française.

(22) Ministero dell'Ambiente e della Tutela del Territorio e del Mare (2023) *Strategia Nazionale di Adattamento ai Cambiamenti Climatici*. Available at: www.mase.gov.it/sites/default/files/archivio/allegati/clima/strategia_adattamentoCC.pdf (Accessed: 28 March 2024).

(23) Caputo, M. (2023) *Promuovere la transizione verde a tutti i livelli di governance territoriale. Strumenti e politiche di adattamento nel contesto dell'Unione Europea*. Available at: http://webthesis.biblio.polito.it/id/eprint/27287 (Accessed: 28 March 2024).

policy documents containing guidelines that a state must follow to adapt to climate change and reduce resulting risks, **National Adaptation Plans** (NAP) are more detailed strategic tools that provide specific indications for adaptation priorities and intervention models that each state intends to implement both at the regional and local levels. Established under the Cancun Adaptation Framework (CAF) and reiterated in the Paris Agreement, NAPs follow an iterative process, and their general objectives are to reduce vulnerability to the impacts of climate change and facilitate the integration of climate change adaptation consistently within new and existing policies, programs, and activities, particularly in development planning processes and strategies across relevant sectors and at different levels, depending on the cases (24). SAPs, or **Sectoral Adaptation Plans**, instead focus on adaptation and limited mitigation within a single sector, such as industry, health, or construction (25).

Together, NAS, NAP, and SAP can provide a fundamental strategic framework for adaptation and incorporate local action within cities and regions, setting national legislation. In order to address challenges related to global climate change, various forms of vertical collaboration are also crucial, achievable through different levels of governance, as well as through both a top-down and/or bottom-up approach (23). Indeed, compared to mitigation, climate adaptation represents a significant challenge at all administrative levels, as while mitigation lends itself to top-down approaches, such as the Kyoto Protocol or other emission reduction targets, adaptation is more suitable for bottom-up approaches due to the multitude of variables, context dependencies, and cultural contexts (9). However, for them to be feasible, the design, implementation, and enhancement of adaptation strategies require action and resources provided by the government, while many of the existing barriers to adaptation lie within the institutional and political contexts governing communities, especially in developing countries. Top-down planning involves government-level decision-making based on regional and long-term forecasting models, as well as a series of cost-benefit analyses. In contrast, the bottom-up approach to adaptation aims to empower communities by encouraging self-assessment of climate impacts through participatory methods. Both approaches have strengths and weaknesses, as while top-down planning is based on various national sectors and therefore cannot incorporate the priorities of various municipalities within the country, a solely local focus fails to have a global view capable of addressing higher-scale issues. Consequently, bottom-up strategies are influenced by limited community members' experience regarding local drivers and their immediate needs and are constrained by their limited power (28), and it is for this reason that both approaches must necessarily be integrated within the definition of a comprehensive and effective community strategy.

Essential for the adaptation of countries and cities, as well as for comparing different national plans and thus estimating their effectiveness, are also the so-called assessment systems. Since the late 1990s, the high potential for reducing environmental impacts related to the construction sector has led to the emergence of various assessment systems, also known as protocols, aimed at assessing the environmental sustainability of buildings. Among these, now widely used and widespread worldwide, we can find systems such as BREEAM, LEED, CASBEE, and the Italian Protocol Itaca. However, recent literature has emphasized the importance of going beyond the scale of the individual building and considering neighborhood or even urban scale (27;28). This is where the concept of MRE (Monitoring, Reporting, and Evaluation) comes into play, which constitutes the final phase of the adaptation policy cycle and aims to help understand progress and performance, as well as inform future policies and practices, and thus evolve and improve adaptation over time. Despite the significant progress made in recent years, the experience in MRE still appears to be highly limited: only a few countries have already begun to implement their MRE systems, focusing mainly on monitoring but often overlooking the evaluation aspect (29). When effectively implemented, MRE systems play a key role in this cyclical learning process. Similarly to the latter, the adaptation process has also been conceptualized as a cyclical and iterative process, a concept supported by a series of tools and frameworks, now applied in numerous European countries. In particular, this approach is still the basis of the European Adaptation Support Tool, as well as the European Commission's Guidelines for national adaptation strategies. Although these cyclical adaptation frameworks clearly recognize the role of MRE, until relatively recent times, few have considered the challenges associated with MRE related to adaptation, and even fewer have provided guidance on this subject. This is partly due to the positioning of MRE as the final phase within both the adaptation and political cycles (30). As of today, in Europe, there is no effort to methodologically connect national MRE systems to adaptation at other scales. This is partly because these systems were developed at different times, and in response to different issues. In addition to the national scale, typical of the top-down approach to adaptation (31), it is therefore important to also analyze scales more closely linked to the local context, and therefore to the bottom-up approach, such as the urban and neighborhood scale, which will be analyzed in the next chapters.
But before that, we will analyze the case of Northern European countries, where the project of this thesis is located.

(24) UNEP. *National Adaptation Plans*. Available at: https://www.unep.org/topics/climate-action/adaptation/national-adaptation-plans (Accessed: 28 March 2024).

(25) Nordic Council of Ministers (2023) *Comparison and analysis of national climate change adaptation policies in the Nordic region*. Available at: https://www.norden.org/en/publication/comparison-and-analysis-national-climate-change-adaptation-policies-nordic-region
(Accessed: 28 March 2024).

(27) Del Bianco, S. (2020) *La valutazione di sostenibilità su scala urbana*. Available at: www.rinnovabili.it/greenbuilding/smart-city/valutazione-di-sostenibilita-su-scala-urbana/
(Accessed: 29 March 2024).

(28) USGBC. *LEED for Cities and Communities: Track progress toward sustainability, net-zero and equity objectives*. Available at: https://www.usgbc.org/leed/rating-systems/leed-for-cities-communities (Accessed: 29 March 2024).

(29) CLIMATE Adapt. *Monitoring, Reporting and Evaluation (MRE)*. Available at: https://climate-adapt.eea.europa.eu/it/knowledge/mre/mre (Accessed: 12 February 2024).

(30) EEA (2015) *National monitoring, reporting and evaluation of climate change adaptation in Europe*. Luxembourg: European Environment Agency.

(31) Butler, J. R. A., et al. (2015) 'Integrating Top-Down and Bottom-Up Adaptation Planning to Build Adaptive Capacity: A Structured Learning Approach', *Coastal Management*, pp. 346-364.

1.1.3.
Northern Europe's strategy

When talking about adaptation strategies for climate adaptation and mitigation, Northern European countries have proven to be a virtuous example. This thesis will focus primarily on these countries, and on the Swedish case in particular, as the project that will constitute the practical outcome of this research is located in Sweden, Northern Europe.

In recent years, in the Nordic countries, as in other parts of Europe, numerous cases of heatwaves and extreme precipitation have occurred, phenomena that in many cases have far exceeded the capacity of existing physical and political infrastructure to respond. The Nordic countries, including Sweden, Denmark, Iceland, Finland, and Norway, have always been considered leaders in climate policy (1;2), and since they share many of the same challenges regarding the climate crisis, the Scandinavian countries can benefit from similar approaches and solutions (3) and collaborate with each other in this regard. However, according to a survey conducted in 2020 in 33 countries by the European Environment Agency, this is not always the case when it comes to adaptation: numerous studies and assessments conducted in recent years have indeed concluded that adaptation to climate change is still happening too slowly in some of these countries, and the adaptation measures currently being implemented often relate more to the current climate rather than to what is projected in the future, lacking the necessary knowledge to estimate future climate evolution.

Overall, all Nordic countries have official documents to guide adaptation work, as well as established scientific communities aimed at providing scientific bases on risks, vulnerabilities, and adaptation needs. At the same time, however, most of these countries do not have structured systems for assessing the costs and socioeconomic benefits of government action or inaction on these issues, and none of them have sufficient economic measures to incentivize measures that meet actual national and local adaptation needs, resulting in a growing gap between the country's real needs and the finances actually available. Additionally, most Nordic countries struggle to translate knowledge of risks and vulnerabilities into local adaptation measures, despite having well-structured platforms and websites aimed at ensuring comprehensive access to adaptation information and serving as a rich resource for both planning and implementation of adaptation strategies.

Another strength of these countries is that they adopt a **mainstream approach to adaptation**, meaning that all public authorities are committed to some extent to this shared goal, although, at the same time, there is a risk that this type of approach may lead to a situation where no one is truly responsible.

In addition, none of the Scandinavian countries currently possess the knowledge necessary to adopt an integrative approach to adaptation, aligning it, for example, with the European Union's mitigation goals or SDGs, despite being aware of the benefits of adopting such an approach. In some of them, adaptation at the municipal and county levels is addressed in relation to mitigation through the development of integrated plans.

Another critical issue concerning these countries is that none of them have suitable indicators and measures to account for the compounded, cascading, and transboundary risks of climate change, or adequate indicators to measure the long-term social impact of adaptation measures, which go beyond reducing immediate risks. Moreover, most of these countries lack a clearly articulated political cycle in which planning documents, knowledge, and MRE (Monitoring, Reporting, and Evaluation) procedures are related to each other to support adaptation at both national and sub-national levels.

It is also important to note that most of these countries currently lack adequate indicators to measure progress and outcomes achieved (especially regarding qualitative parameters such as well-being), as well as **MRE** systems, where MRE stands for Monitoring, Reporting, and Evaluation, indicating the final phase of the adaptation cycle, and constituting one of the key aspects of an iterative adaptation process, essential for understanding progress made and guiding future practices. Despite significant progress on this front in recent years, experience in MRE is still limited, as repeatedly emphasized by the IPCC (Intergovernmental Panel on Climate Change) in its report published in 2022 (4).

In addition to the points discussed above, "economic measures" are a topic of increasing importance in the Nordic countries, although their development is still in an initial phase. They can be divided into 3 main categories: positive economic measures (e.g., subsidies), negative economic measures (such as taxes), and neutral economic measures (e.g., insurance schemes that can apply to natural risks).

In general, for Scandinavian countries as for most other high-income Western countries, no "negative" economic policy measures have been established regarding adaptation: where current adaptation policies in Nordic countries include economic measures, they usually translate into the category of those incentives defined as "positive," unfortunately extremely inadequate on their own to ensure adaptation, if not of the "neutral" type, implemented through the creation of insurance schemes related to natural risks, where the Nordic

(1) Christensen, P. (1996) *Governing the Environment: Politics, Policy, and Organization in the Nordic Countries*. Nordic Council of Ministers.

(2) Witoszek, N., Midttun, A. (2018) *Sustainable Modernity. The Nordic Model and Beyond*. Available at: https://doi.org/10.4324/9781315195964 (Accessed: 11 February 2024).

(3) Berninger, K., et al. (2022) *Nordic Perspectives on Transboundary Climate Risk: Current knowledge and pathways for action*. Copenhagen:Nordic Council of Ministers.

(4) CLIMATE Adapt. *Monitoring, Reporting and Evaluation (MRE)*. Available at: https://climate-adapt.eea.europa.eu/it/knowledge/mre/mre (Accessed: 12 February 2024).

countries, with Norway at the forefront, emerge as a leading region internationally, despite such insurance programs being limited to the current climate only, which is a clear weakness. In this regard, in recent years, in Norway as in Sweden, there has been discussion about differentiating insurance premiums based on risk profiles, so that, for example, owners of buildings located in high-risk flood or landslide areas would have to pay higher premiums, a differentiation that could plausibly strengthen incentives for preventive measures but could also have undesirable negative social consequences, which is why such proposals have been rejected so far.

Also crucial in these countries is the debate on the relationship between mitigation and adaptation: funding for climate change research in the Nordic countries is still predominantly directed towards mitigation, while research on adaptation receives only a fraction of the funding. Similarly, research in natural sciences tends to take precedence over research in social sciences. This results in a persistent "black box" on how authorities and individuals can respond to climate change effectively, sustainably, and fairly, a stalemate where the close dialogue and collaboration necessary to ensure a coordinated effort towards adaptation are strongly hindered by a "silo" structure between ministries and sectors in all Nordic countries. A particularly clear example of this is the applied division between adaptation and mitigation, both areas characterized by high impact and mutual dependence, but which are nevertheless situated within different ministries with completely different political mandates. The lack of coordination and strategic collaboration between the fields of adaptation and mitigation thus translates into missed opportunities for creating synergies, while simultaneously increasing the risk of conflicts among various objectives.

In all Nordic countries, there is also a growing awareness of the connection between biodiversity loss and ongoing climate change, as well as the need to consider both issues in the context of the **Sustainable Development Goals** (SDGs). All five Scandinavian countries are finally beginning to consider **Nature-Based Solutions** as a useful tool to improve synergies between various areas and achieve adaptation, although this work is still in its early stages.

In most Nordic countries, municipalities are the furthest along in integrating adaptation into municipal planning, although a general lack of resources hinders this work. The commitment to NbS throughout the Nordic region is exemplified by the "Finalization of the global biodiversity agreement - The Nordic approach" declaration, approved by the environment and climate ministers of the Nordic Council, and the subsequent Nordic ministerial declaration on NbS.

Ultimately, with most Nordic countries having completed the first cycle of adaptation planning, and some of them about to complete the second cycle, it is now time to investigate organizational arrangements, lessons learned, challenges, and future possibilities. The Nordic countries are indeed in a unique position to take a leading role in the development of integrated, coordinated, and sustainable adaptation approaches, in achieving a society that is both fair and climate-resilient (3).

Although the Scandinavian countries are similar to each other in terms of culture and challenges related to climate change, each of them is now addressing the issue entirely independently of the others, making a detailed analysis of the Swedish case necessary, which is the main subject of study and analysis.

1.1.4. Sweden's strategy

In Sweden, in recent years, climate change has caused several extreme phenomena, which are not only harmful from a social, environmental, and economic standpoint. Among these are floods, erosion of riverbanks and coasts, inundations, heatwaves, and intense precipitation, among others.
Below is a comprehensive list of the various challenges that Sweden is currently facing due to ongoing climate change. These include:
- Drought
- Coastal erosion
- Floods
- Forest Fires
- Scarce groundwater
- Heatwaves
- Increasingly rare freezing of lakes and seas
- Longer growing season
- Mudslides
- Soil pollution
- Increase in precipitations
- Heavy snowfalls
- River flows
- Landslides
- Rising temperatures
- Rising sea levels
- Wind gusts (1).

From the perspective of addressing these issues, until 2018, Sweden was the only Nordic country without a **National Adaptation Strategy** (NAS), despite having numerous **Sectoral Adaptation Plans** (SAPs). Like many other northern countries, Sweden does not have complete monitoring, reporting, and evaluation (MRE) systems, even though, along with Norway and Finland, it has some elements of such a system, like formal procedures for reporting adaptation progress to the government annually (2).
The first major step towards climate adaptation in the country was in 2004 when the Swedish Environmental Protection Agency organized a seminar on adaptation and climate risks. This seminar brought together representatives from both national and subnational authorities, generating strong calls for a national adaptation strategy.
However, it was only after Sweden was severely impacted by Cyclone Gudrun a year later, causing significant environmental and economic damage, that the country's vulnerability to extreme weather events and climate change began receiving proper attention in political and public discourse. That same year, the Swedish government appointed a **National Climate and Climate Vulnerability Commission** to produce the first report on the regional and local impacts of climate change on Swedish society and their economic implications (3). Published in 2007, the report highlighted the need for greater commitment from subnational authorities towards adaptation and also called on municipalities to play a central role in adapting Swedish society and economy to climate change.
Two years later, in 2009, the Swedish Parliament published what was defined as the country's first coherent climate and energy policy, aiming to lay the groundwork for future actions and provide a series of guidelines (4). However, it was not until 2018 that the Swedish government published the country's first National Adaptation Strategy (NAS), making Sweden one of the last countries in the European Union to implement a policy framework guiding climate adaptation. This strategy complemented Sweden's Climate Law, which was the country's first legislative framework for climate policy published a year earlier in 2017, focused on mitigation, and with which the country aimed to achieve net-zero greenhouse gas emissions by 2045. This made Sweden the first country with a legally binding carbon neutrality goal (5;6).
The strategy also defined the roles and responsibilities of the various parties involved, highlighted priority areas for action and investment in adaptation, and listed a series of guiding principles, including sustainable development, mutuality, scientific bases, precautionary principles, and transparency. At the same time, a five-year political plan was established, along with a Climate Adaptation Expert Council to assess national adaptation work and provide useful advice for achieving this goal.
The strategy assigned the National Board of Housing, Building and Planning a primary role in coordinating climate adaptation for both new and old buildings, in conjunction with legislative amendments to the National Planning and Building Act (7), while strengthening the role of municipalities (8). Through a series of changes to the above law, it established the first legislative framework supporting climate risk assessments, clarified municipalities' responsibilities in land-use planning, risk assessment, and prevention of damage from natural climate-related events, and set more stringent requirements to address the ongoing climate crisis.
Shortly after publishing **the first NAS** in 2018 (9), the Swedish government approved a regulation on the work of Swedish authorities on climate adaptation, which came into force at the beginning of 2019. This regulation assigned responsibility to 32 national government agencies and all 21 County Administrative Boards (CABs) in Sweden to initiate, support, and evaluate climate adaptation work within their mandates.
Together with the National Planning and Building Act (2010:900), this regulation formed the legislative backbone for climate adaptation in Sweden. According to the latest communication

(1) Swedish Portal for Climate Change Adaptation. *Climate change in Sweden*. Available at: https://www.klimatanpassning.se/en/climate-change-in-sweden (Accessed: 12 February 2024).

(2) Nordic Council of Ministers (2023) *Comparison and analysis of national climate change adaptation policies in the Nordic region*. Available at: https://www.norden.org/en/publication/comparison-and-analysis-national-climate-change-adaptation-policies-nordic-region (Accessed: 28 March 2024).

(3) Swedish Ministry of Environment (2007) Sweden facing climate change - threats and opportunities. Available at: https://climate-adapt.eea.europa.eu/en/metadata/publications/sweden-facing-climate-change-threats-and-opportunities#:~:text=La%20Commissione%20sul%20clima%20e%20la%20vulnerabilit%C3%A0%20%C3%A8,La%20presente%20relazione%20riassume%20i%20risultati%20della%20Commissione. (Accessed: 13 February 2024).

(4) Government Offices of Sweden (2010) *Swedish Government Offices Yearbook 2009*. Katarina Strand, Information Rosenbad.

(5) Klimat - och näringslivsdepartementet (2017) *Det klimatpolitiska ramverket*. Available at: https://www.regeringen.se/artiklar/2017/06/det-klimatpolitiska-ramverket/ (Accessed: 13 February 2024).

(6) Murray, J. (2020) *Which countries have legally-binding net-zero emissions targets?* Available at: https://www.nsenergybusiness.com/news/countries-net-zero-emissions/ (Accessed: 14 February 2024).

(7) Boverket (2018) *Boverkets föreskrifter och allmänna råd (2018:8) om stöd för innovativt och hållbart byggande av bostäder*. Available at: https://www.boverket.se/sv/lag--ratt/forfattningssamling/gallande/inb---bfs-20188/ (Accessed: 14 February 2024).

(8) O'Brien, K., Gram-Hanssen, I., et al. (2023) *Fractal approaches to scaling transformations to sustainability*. Available at: https://www.researchgate.net/publication/370900894_Fractal_approaches_to_scaling_transformations_to_sustainability (Accessed: 16 February 2024).

(9) Englund, M., Barquet, K. (2023) 'Threatification, riskification, or normal politics? A review of Swedish climate adaptation policy 2005–2022', *Climate Risk Management*, 40.

on Swedish climate adaptation submitted to the UNFCCC in November 2022 (10), there are currently 45 different Sectoral Adaptation Plans (SAPs) at both national and regional levels, covering various sectors and business areas and collectively contributing to the implementation of the National Adaptation Plan (NAP). Other legislation, strategies, and plans have also had significant direct and indirect impacts on the implementation of climate adaptation in Sweden.
Among them, the Environmental Code is a legislative package that covers several sectors related to climate adaptation, including the protection of human and environmental health and the preservation of biodiversity (11). The National Forestry Strategy considers the need for adaptation in light of the growing risks from climate change (12). In 2021, the Swedish Public Health Agency published an action plan for adapting the national healthcare system to climate change (13).
It is expected that climate adaptation will also be included in the country's upcoming food strategy.
In addition, Swedish legal consultancy Delphi recently produced, commissioned by the National Knowledge Centre on Climate Change Adaptation (NKCCCA) at the Swedish Meteorological and Hydrological Institute (SMHI), a document providing a comprehensive overview of national laws and legislation that could be utilized or made operational to support climate adaptation work at both national and subnational levels (14).
In general, Sweden's governance model is divided between national, regional, and local levels. The Swedish Parliament (Riksdagen) has primary legislative authority at the national level, while the government is responsible for executing decisions and laws passed by parliament.
Regional governance is divided among Sweden's 21 counties, where healthcare is a primary responsibility, and regional councils are elected regularly. Each county also has a regional central government authority, known as a County Administrative Board (CAB).
At the local level, Sweden consists of 290 municipalities responsible for most public services (such as education and elderly care) and local planning through municipal councils, which govern according to local laws and are regularly elected (2).
In climate change policies, the Swedish Parliament is responsible for legislative aspects related to adaptation in collaboration with national agencies, while the government is responsible for developing and implementing these policies at the national level.
Specifically, the Ministry of Climate and Business is currently at the helm, overseeing and coordinating climate adaptation work in progress. However, each ministry is responsible for managing adaptation within its own political portfolio and mandates. Within this role, the Climate Unit of the Ministry of Climate and Business oversees a recently established intergovernmental working group that brings together 10-12 civil servants representing various ministries to develop a new national adaptation strategy.
The ministries initially associated with the working group included the Ministry of Environment, Ministry of Business and Innovation, Ministry of Health and Social Affairs, Ministry of Justice, Ministry of Infrastructure, and Ministry of Finance. However, since a new governing coalition took office, significant changes in governance structures have occurred within the government.
Through the government's 2018 climate adaptation ordinance, the Swedish government tasked national agencies (such as the Swedish Food Agency, the National Board of Housing, the Swedish Geological Survey, among others) and CABs with initiating, supporting, and evaluating work on climate change adaptation within their areas of responsibility and tasks, sectors, or regions (15).
As part of this assignment, these authorities were also tasked with developing an action plan for the work of their respective organizations/counties on climate change adaptation. National agencies and County Administrative Boards (CABs) are required to annually report their climate adaptation work to the SMHI (Swedish Meteorological and Hydrological Institute), which is responsible for analyzing these reports and presenting a summary of assessments to the government. Additionally, the SMHI is tasked with supporting these authorities in their work.
Since climate adaptation in Sweden has been strongly supported by land-use planning legislation, the Swedish National Board of Housing, Building, and Planning plays a key role in raising awareness about climate adaptation in the context of land-use planning and the built environment. It is also responsible for ensuring compliance with legal requirements established by the Planning and Building Act to consider climate risks in spatial planning and decisions on new buildings and other constructions.
The CABs, which are the 21 government authorities operating between national and municipal authorities, have the responsibility to ensure that government and parliamentary decisions are implemented in various counties. They also oversee government activities at regional and municipal levels. County councils have various regional responsibilities, such as informing the government of needs and supporting regional development while supervising inter-municipal interests. Before the ordinance, CABs were temporarily responsible for climate adaptation on an annual basis, but with the ordinance, several new tasks were assigned to them, including:
- Initiating, supporting, and monitoring climate adaptation work in municipalities.
- Analyzing how the country and neighboring countries are affected by climate change, if necessary.
- Supporting and following up on climate adaptation work of regional sectoral agencies.
- Contributing to and producing documentation to improve knowledge and planning.
- Supporting the work of river coordination groups CABs are also responsible for monitoring and coordinating climate adaptation work in county municipalities, ensuring that adaptation measures align with neighboring counties, and avoiding potential issues like transferring climate risks to neighboring countries (9). CABs often support municipalities in their climate adaptation efforts by organizing seminars and workshops, providing recommendations on land-use planning, or gathering regional risk data from climate and non-climate disasters, such as floods and heatwaves.

Under the ordinance, regional councils, elected every four years alongside national elections and governed by regional assemblies, do not have a statutory role in climate adaptation despite their responsibilities for services and functions impacted by climate change, such as healthcare, public transport, and regional development.
Regarding municipalities, legislative amendments made by the Swedish government to the Planning and Building Act and the 2018 Land Act (8) gave municipalities greater local responsibilities.

(10) Klimat - och näringslivsdepartementet (2022) *Sweden's Adaptation Communication - A report to the United Nations Framework Convention on Climate Change*. Stockholm: Ministry of the Environment.

(11) Ministry of the Environment (2022) *The Swedish Environmental Code: A résumé of the text of the Code and related Ordinances*. Available at: https://www.svk.se/siteassets/english/dam-safety/environmental-code-and-ordinances---a-summary.pdf#:~:text=The%20Environmental%20Code%20is%20the%20%EF%AC%81rst%20integrated%20body,water%20operations%2C%20genetic%20engineering%2C%20chemical%20products%20and%20waste.
(Accessed: 17 February 2024).

(12) Ministry of Climate and Enterprise (2020) *Revised National forestry accounting plan for Sweden*. Available at: https://www.government.se/reports/2020/01/revised-national-forestry-accounting-plan-for-sweden/
(Accessed: 18 February 2024).

(13) Climate ADAPT. *Information from Governance Regulation reporting on adaptation (2023, 2021)*. Available at: https://climate-adapt.eea.europa.eu/en/observatory/policy-context/country-profiles/sweden (Accessed: 18 February 2024).

(14) Lundh, C., et al. (2022) *Klimatanpassning – Urval av tillämplig lagstiftning till stöd för myndigheter och kommuner*. Available at: https://www.delphi.se/uploads/2023/01/klimatanpassning-urval-av-tillamplig-lagstiftning-till-stod-for-myndigheter-och-kommuner-version-3-230124.pdf
(Accessed: 18 February 2024).

(15) Ministry of the Environment and Energy (2018) *Ordinance (2018:1428) on climate adaptation work on the part of government agencies*. Available at: https://www.smhi.se/polopoly_fs/1.168055!/ordinance.pdf
(Accessed: 19 February 2024).

However, the climate adaptation ordinance failed to impose any direct legal obligations on municipalities for adaptation, resulting in some municipalities lacking designated personnel or teams working on the issue. Although CABs are tasked with ini tiating, supporting, and monitoring municipal adaptation work, municipalities are not required to report their adaptation efforts to CABs, making adaptation legislation incomplete or ineffective.
The government's climate adaptation ordinance provided a long-term framework to guide CABs' adaptation work, but their efforts were hindered because they did not receive substantial support from national agencies, which were not legally required to develop adaptation strategies or implement measures within their sectors.
In the private sector, there is currently no clear delegation of responsibility for private actors in climate adaptation. Nonetheless, businesses and private owners are legally obligated to take actions to manage and protect their assets according to Swedish laws (2).
Currently, Sweden has about 45 adaptation action plans covering various sectors and business areas at national and regional levels, contributing to the implementation of the national strategy. Over 90% of Swedish municipalities have recognized the need to act on adaptation, though progress varies significantly. A much smaller percentage have evaluated the effectiveness of measures adopted so far (16). Nevertheless, around half of the municipalities have developed their own action plan, resulting in around 150 local adaptation plans across Sweden (17).

The current **Swedish national adaptation strategy** identifies **seven priority areas** based on anticipated climate change impacts in the near future:
- Landslides and erosion
- Floods
- High temperatures
- Water supply for private, agricultural, and industrial sectors
- Biological and ecological effects that negatively impact sustainable development
- National and international food production and trade
- Pests, diseases, and non-native invasive species

In 2022, the Climate Adaptation Expert Council recommended that the government group these priority areas into **three broader risk categories** for a more accurate reflection of Sweden's specific climate risks:
1. Physical safety and land use
2. Water security
3. Food security (18)

Discussions with public officials and policy advisors revealed that most of Sweden's efforts have focused on protecting built environments and infrastructure from internal and coastal floods, landslides, and coastal erosion. Broader efforts to **safeguard ecosystems** have lagged nationally, as has the use of nature-based solutions (NbS). However, in 2021, the Swedish Environmental Protection Agency published **national guidelines** for using **NbS as adaptation tools** (19), and the Stockholm County Administrative Board is currently considering strengthening its NbS work, such as by restoring wetlands.
It's crucial to note that climate risks vary significantly across Sweden's regions. While sea level rise-related flooding is a particular concern in southern counties like Gothenburg and Stockholm, it poses no risk in the northern regions, which face expanding land due to coastal recession and other impacts on the Sami people and their livelihoods, including reindeer herding.
Sweden's first national climate assessment, launched in 2005 and presented in 2007, set the methodological approach for future assessments. A 2015 assessment by SMHI (20) collected data on current and future climate change risks and consequences for Swedish society, collaborated with various stakeholders, and mapped key climate adaptation work since the first report. It identified knowledge gaps, highlighting the need for clearer governance structures to provide knowledge, decision support, and access to risk information.
In 2022, the Climate Adaptation Expert Council published its first assessment of Sweden's adaptation status (18), analyzing current and future climate impacts and evaluating the effectiveness of existing strategies. It provided guidance and priorities for future action and will be updated every five years as tasked by the government (2).

For **mitigation**, Sweden has implemented tools and measures since the 1980s (21), including taxes, subsidies, sanctions, laws, voluntary agreements, and a strong dialogue between government and businesses. The country now has three energy taxes on fossil fuels: energy, sulfur, and CO2. Energy taxation has been a political tool since the 1970s oil crisis to support renewable and nuclear energy.
The "Renewable Energy Certificate System" (RECS) was introduced in 2003 to reduce greenhouse gas emissions and promote renewable energy (22). Since 1991, Sweden has launched programs to encourage renewable energy use and develop new technologies while collaborating internationally with the EU and carbon trading systems like PCF and AIJ. The country aims for oil independence and has a commission for its phased elimination (23).
In 2006, the government proposed targets for 2020, such as reducing road transport oil consumption by 40-50% and eliminating oil heating in buildings. By 2012, Sweden had met its EU renewable energy target for 2020 (24), while the 2019 plan included carbon taxes and green tax reforms to reduce emissions in transport, aiming for at least a 70% reduction by 2030.

For **adaptation**, the MSB (Swedish Civil Contingencies Agency) created guidelines and strategies to help society adapt, along with flood maps used for risk analysis and emergency planning. Adaptation tools include pumping equipment, dikes, and valves for shutting water supply and sewer systems in vulnerable seasons. The MSB's national information system for firefighting provides data to prevent and make decisions on vegetation fire risks. The agency also lends generators to storm-hit areas and maps landslide-prone zones. The government allocates SEK 40 million annually for prevention in storm-prone areas, providing subsidies to municipalities with preventive measures and offering compensation for natural disaster damage (25).
After having established national context in which the project of this thesis is located, the next chapter will delve into the urban scale, as climate adaptation and mitigation strategies should not stop to the national and international scale only, but involve the urban scale as well, following a multi-scalar approach.

(16) SMHI (2022) *Myndigheters arbete med klimatanpassning 2021*. Available at: https://www.smhi.se/publikationer/publikationer/myndigheters-arbete-med-klimatanpassning-2021-1.182528 (Accessed: 19 February 2024).

(17) SMHI (2020) *Kommunernas arbete med klimatanpassning 2019 – Analys av statusrapportering till SMHI*. Available ta: https://www.smhi.se/publikationer/kommunernas-arbete-med-klimatanpassning-2019-analys-av-statusrapportering-till-smhi-1.161291 (Accessed: 19 February 2024).

(18) Nationella expertrådet för klimatanpassning (2022) *Första rapporten från Nationella expertrådet för klimatanpassning*. Available at: https://klimatanpassningsradet.se/publikationer/forsta-rapporten-fran-nationella-expertradet-for-klimatanpassning-1.180035 (Accessed: 20 February 2024).

(19) Naturvårdsverket (2021) *Naturbaserade lösningar: Ett verktyg för klimatanpassning och andra samhällsutmaningar.* Available at: https://www.naturvardsverket.se/publikationer/7000/naturbaserade-losningar/ (Accessed: 20 February 2024).

(20) Andersson, L., et al. (2015) *Underlag till kontrollstation 2015 för anpassning till ett förändrat klimat*. Available at: https://www.smhi.se/publikationer/publikationer/underlag-till-kontrollstation-2015-for-anpassning-till-ett-forandrat-klimat-1.86345 (Accessed: 20 February 2024).

(21) Leduc, S., et al. (2006) *Sweden in the forefront for a green society: a review on policy activities for greenhouse gas emission reduction*. Available at: https://www.semanticscholar.org/paper/Sweden-in-the-forefront-for-a-green-society-%3A-a-on-Leduc-Wang/b2c0f490388b836fab2acc8182f38a7728913295 (Accessed: 22 February 2024).

(22) Ministry of the Environment and Energy (2019) *Sweden's draft integrated national energy and climate plan*. Available at: https://www.government.se/reports/2019/01/swedens-draft-integrated-national-energy--and-climate-plan/ (Accessed: 22 February 2024).

(23) Dagens Nyheter (2005) *DN Debatt. "Oljan ska vara borta från Sverige år 2020"*. Available at: https://www.dn.se/debatt/oljan-ska-vara-borta-fran-sverige-ar-2020/ (Accessed: 21 February 2024).

(24) REN21 (2014) *Renewables 2014: Global Status Report*. Available at: http://www.ren21.net/Portals/0/documents/Resources/GSR/2014/GSR2014_full%20report_low%20res.pdf (Accessed: 23 February 2024).

(25) Nordic Council of Ministers (2023) Comparison and analysis of national climate change adaptation policies in the Nordic region. Available at: https://pub.norden.org/temanord2023-525/1-introduction.html (Accessed: 23 February 2024).

THE URBAN SCALE

1.2

1.2.1
European initiatives for cities sustainable development

In this chapter, the issues related to climate change for cities in general will be addressed, along with the various urban-scale initiatives undertaken at the European level, often resulting from collaboration among various local administrations even before national ones.
Responsible for over 75% of global carbon emissions (1), cities are currently facing various climate change-related issues. **Heatwaves, heavy rainfall, floods, and droughts remain the most pronounced effects of climate change on European cities**. Generally, climate risks depend heavily on the context, as they are linked to the specific characteristics of the local area. Therefore, local assessments of climate risk and vulnerability, supported by high-quality data, are fundamental to understanding current and projected threats and supporting adaptation planning, requiring closer collaboration between cities and the research community (2). These issues are further exacerbated by factors such as reduced soil permeability, lack of vegetation, and reduced albedo of surfaces typically found in urban areas, such as asphalt and concrete.
In general, climate change is rapidly compromising the livability of cities. Today, over 70% of the world's major urban centers are considered at high to extreme risk of pollution, compromised water supplies, extreme temperatures, and other extreme natural phenomena. In July 2018, nearly 58% of cities worldwide were highly vulnerable to at least one of the 6 major natural risks, namely: cyclones, floods, droughts, earthquakes, landslides, and volcanic eruptions (1).
Traditionally built in coastal areas or on riverbanks (3), cities are also highly vulnerable to rising sea levels and river overflow, posing significant risks to infrastructure, residents' lives, and the entire urban system.

- Urban Heat Island effect:
The Urban Heat Island (UHI) effect significantly raises urban temperatures, especially during summer, causing health issues and infrastructure damage. According to the European Environment Agency, heatwaves have resulted in more fatalities than any other climate-related disaster in Europe. Events like the 2003 heatwave, which caused over 70.000 deaths, are predicted to become more frequent, particularly in Southern Europe. Without adequate adaptation measures, annual deaths due to extreme temperatures could rise from the current 2.700 to between 30.000 and 50.000 by 2050, exacerbated by urbanization. Additionally, rising temperatures increase the demand for cooling energy, particularly electricity, across Europe, notably in Italy, Spain, and France.

- Floods:
Urban areas face a significant challenge with heavy rains and floods, especially as they're often situated near water bodies like rivers and lakes. This proximity, combined with increased precipitation and impermeable surfaces, heightens the risk of urban flash floods, particularly in densely populated regions of Northwestern Europe. These floods inflict substantial economic losses, affecting various land uses including residential, commercial, and industrial areas, as well as vital social infrastructure like schools and hospitals. According to the European Environment Agency, floods are the most common natural risk in over 1,600 cities, causing $46 billion in losses and 4,500 deaths globally in 2019. Predictions indicate a doubling of damages by 2030 and a quadrupling of freshwater flood events in cities by 2050. Effective flood management requires maintaining and upgrading drainage systems, separating rainwater and wastewater networks, and employing natural solutions like wetlands to treat rainwater and prevent environmental harm (2).

- Scarcity of green spaces:
Another significant urban issue, closely tied to human health, is the limited availability of accessible green spaces. Currently, only 44% of city dwellers in European cities reside within a 300-meter walking distance of a public park, exacerbating economic and social disparities and posing health risks. Numerous studies highlight the positive correlation between green space access and psychophysical well-being. Access varies widely across countries and cities, with Denmark, Sweden, and Finland leading in accessibility. The scarcity of green spaces, compounded by frequent heatwaves, exposes urban populations to health hazards. Urban biodiversity, often overlooked, is essential for human well-being, offering benefits like improved health, reduced stress, and enhanced property values, with estimated annual health cost savings of $11.7 billion in the United States (4).

- Biodiversity loss:
Historically, cities have always been developed near, if not directly within, rich ecosystems, as they constitute an abundant source of various essential resources for urban settlements, such as water and fertile soils essential for agricultural production. The strong dependency relationship that has always linked the urban system to the natural one makes biodiversity a vital component of it, debunking the conception that has characterized and guided urban planning for many years, according to which natural and anthropic worlds are completely

(1) World Economic Forum (2022) *BiodiverCities by 2030: Transforming Cities' Relationship with Nature*. Milano: Humboldt.

(2) EEA (2020) *Urban adaptation in Europe: how cities and towns respond to climate change*. Luxembourg: European Environment Agency.

(3) European Environment Agency (2016) *Urban adaptation to climate change in Europe 2016: Transforming cities in a changing climate. Luxembourg:* European Environment Agency.

(4) Kirk, H., et al. (2021) 'Building biodiversity into the urban fabric: A case study in applying Biodiversity Sensitive Urban Design (BSUD)', *Urban Forestry & Urban Greening*, 62.

separate and self-contained. This belief has led over time to a slow but inexorable destruction of natural habitats surrounding cities, as a result of the direct and indirect impacts of urbanization, reflecting a lack of protection and integration of biodiversity within urban management. One of the most evident direct impacts of urban growth on biodiversity is primarily the loss of natural habitats: the rapid expansion of built environments worldwide, evidenced by a global increase in urbanized areas of 66% in the first 12 years of the 21st century, has had a significant impact on natural ecosystems, affecting much of the territory inside and around cities, as well as threatening native habitats, genetic and functional diversity of flora and fauna, as well as air and water quality. Although, from a purely spatial point of view, urban settlements have a relatively small footprint, as only 1% of ice-free land area is built upon, the indirect impact of urban growth on land use remains vast. For example, today, over 80% of European habitats are in poor condition, as stated on the European Parliament website (5), while, in order to feed all the cities in the world, an area 36 times larger than the entire global urban footprint would be needed. This inevitably translates into destruction of natural habitats surrounding cities, as well as loss of both urban and non-urban biodiversity. In addition, the conversion of open natural spaces by humans (known as "intronization") often leads to fragmentation of local habitats, resulting in qualitative and quantitative losses of habitat and ecological functions. One of the main threats to biodiversity is indeed the so-called "biotic homogenization", a process through which genetic, taxonomic, or functional similarities of regional biota increase over time. This phenomenon results in a loss of differences between species present in different ecosystems (6). The direct and indirect impacts that urbanized environments have on biodiversity create a cascading effect that leads to a rise in floods, as well as in raifalls and other climate-related phenomena.

- Drough:
Immediately after flooding, drought is considered the second most hazardous urban risk. According to the United Nations, due to drought, by 2050 almost half of all countries in the world will face water stress or scarcity, also in relation to population growth and rapid urbanization, affecting three-quarters of the world's population.
This issue is further exacerbated by inadequate wastewater management as well as inefficient waste disposal. In general, the costs resulting from urban water pollution can be significant, both for human health and the environment (1). An analysis resulting from collaboration between C40 and the Grundfos Foundation has highlighted how increasingly frequent and severe drought phenomena will increase water losses for C40 cities by 26%, also costing nearly $111 billion in damages per year over the next 3 decades (7).

- Air pollution:
Another challenge that European cities are facing today due to ongoing climate change is air pollution: a side effect of the growing use of heating and cooling systems, linked to increasingly frequent extreme temperature events, is the increase in emissions. Just in 2016, for example, emissions from air conditioning systems amounted to 1.25 gigatons, equivalent to almost 3% of annual global anthropogenic emissions, while, currently, the use of air conditioning accounts for 10% of global electricity consumption, a percentage that is expected to triple by 2050. Air pollution and the lack of green spaces, along with the poor air quality that follows, are risk factors for human health as well as for their productivity: in 2013, exposure to air pollution cost the global economy about $5.1 trillion in welfare losses, with a greater impact in low- and middle-income countries.

In order to address these issues, in recent years, European cities have gradually been taking action to reduce, or at least manage, the effects of climate change. Available data today show how many cities are already implementing policies aimed at strengthening their resilience (1).
Cities are increasingly at the forefront of efforts towards mitigation: many of them, over the years, have indeed joined programs for the reduction of greenhouse gas emissions, including, for example, **Cities Race to Zero**, by C40, the global network **ICLEI** (Local Governments for Sustainability), the **Carbon Neutral Cities Alliance** (CNCA), **+CityxChange**, **BiodiverCities**, **Eurocities**, **NetZeroCities**, or the **New European Bauhaus**, along with others (8).
Recognized as one of the most important initiatives for the implementation of policies aimed at promoting climate change mitigation and defining adaptation strategies, the Cities Climate Leadership Group (C40) is a network composed of a total of 83 metropolises and large cities sharing experiences in the fight against climate change.
From reports released by C40, it is learned that climate adaptation measures have significantly increased from 2011 to 2015 among member cities, and that 52% of them have created municipal offices focused on adaptation. In addition, the report highlights how some metropolises have also drafted or even implemented their own Climate Adaptation Plan (9).
GLOBAL NETWORK of over 1500 cities in 86 countries aimed at achieving a sustainable low-carbon future, ICLEI (Local Governments for Sustainability) collaborates with more than 2,500 local and regional governments committed to sustainable urban development and, active in over 125 countries, it aims to lead local action for sustainable development, based on emissions reduction, nature restoration, resilience, circular economy, and social equity (10). At the core of this network, founded in 1990 as the International Council for Local Environmental Initiatives, is the belief that local action drives global change and that the leadership of local and regional governments can make a significant difference in addressing the complex environmental, economic, and social challenges that governments face. It is also based on the idea that, through joint action, peer learning, and the establishment of partnerships, business leaders and all levels of government can accelerate local sustainable development and bring real change (11).
Another example of city-to-city initiative addressing climate change, the CNCA (Carbon Neutral Cities Alliance), is a global network focused on the concept of CO2 compensation, which works towards achieving carbon neutrality within the next 10-20 years. The main mission of CNCA is to mobilize transformative action in all member cities, prioritizing climate action that promotes the well-being of minorities and historically marginalized communities. This is perpetuated through various actions, such as funding transformative climate actions to mobilize development, adopting and implementing climate policies in cities, exercising collective influence, supporting policies aimed at reducing all emissions not directly controlled

(5) Parlamento europeo (2024) *PE: via libera alla legge sul ripristino della natura*. Available at: https://www.europarl.europa.eu/news/it/press-room/20240223IPR18078/pe-via-libera-alla-legge-sul-ripristino-della-natura (Accessed: 3 April 2024).

(6) Quaglia, A., et al. (2023) *BiodiverCities Atlas: A participatory guide to building urban biodiverse futures*. Luxembourg: Publications Office of the European Union.

(7) C40 Cities (2022) *Le inondazioni e la siccità legate al clima dovrebbero avere un impatto su milioni di persone e costare alle principali città del mondo 194 miliardi di dollari all'anno*. Available at: https://www.c40.org/it/news/climate-related-flooding-drought-cities-billions/ (Accessed: 30 March 2024).

(8) Mi, Z., et al. (2019) 'Cities: the core of climate change mitigation', *Journal of Cleaner Production*, 207, pp.582-589.

(9) Gerundo, C. (2016) *Città e Clima: forma urbana e adattamento ai cambiamenti climatici*. Napoli:fedOAPress.

(10) ICLEI. *About the organization*. Available at: https://iclei.org/ (Accessed: 2 April 2024).

(11) ICLEI. *Who we are*. Available at: https://iclei-europe.org/who-we-are/ (Accessed: 2 April 2024).

by cities, defining methodologies, standards, and advanced governance tools for planning, implementation, measurement, and continuous improvement towards carbon neutrality, promoting peer learning among climate-leading cities, so that they can learn from each other, establishing transformative leadership to enable city sustainability directors to excel in their role as change agents, actions to help cities communicate more effectively, and integrating the concept of climate justice into ambitious climate action (12).

+CityxChange (Positive City ExChange) is instead a smart city project that has received funding from the European Union's Horizon 2020 research and innovation program under the "Smart Cities and Communities" call. The Norwegian University of Science and Technology (NTNU) hosts and leads the +CityxChange consortium together with the city council and county of Trondheim and Limerick (13).

An EU pilot project initiated in late January 2020 and concluded in April 2023, BiodiverCities is an example of a European project aimed at restoring nature and biodiversity within cities. Conducted through the collaboration of the Joint Research Centre and Directorate-General for Environment of the European Commission, it has defined a series of guidelines on how to involve citizens in urban planning and policy-making for biodiversity, as well as for monitoring and defining solutions to improve biodiversity within cities both within the planning and decision-making processes. The project has also contributed to the mapping of ecosystem services and the evaluation of urban green infrastructure as tools to improve regional biodiversity and provide benefits to local residents and nature simultaneously. This project is part of the EU Biodiversity Strategy for 2030, as well as the 2022 Conference on the Future of Europe. Born from the collaboration of experts from each city and the involvement of citizens, planners, local communities, researchers, and organizations, based on the concept of co-design as the centerpiece of urban planning, the project has given rise to 10 participatory and innovative experiments characterized by different focuses, from mapping swifts to defining new biodiversity policies (14).

Comprising over 200 large member cities inside and outside the European Union, Eurocities is an initiative whose work spans 9 thematic areas, including governance, climate and environment, digital transformation, culture, food, mobility, migration, social affairs, and economic development. Currently, it is involved in 29 projects, mostly funded by the Union, through which it strengthens the link between the EU and cities, addressing global issues at the local level through various activities, events, training, and campaigns, and ensuring that municipal administrations have a seat at the Union's decision-making table (15).

Like CityxChange, NetZeroCities is part of the European Union's Horizon 2020 research and innovation program in support of the Union's Green Deal. Designed to help cities overcome existing structural, institutional, and cultural barriers to achieve climate neutrality by 2030, NetZeroCities supports the EU's mission "100 Climate-Neutral and Smart Cities by 2030", recently launched under the aforementioned European Horizon program. The project is conceived as a unique platform accessible to all cities through an online portal, supported by global-level professionals to help European cities by providing them with the support and solutions they need to achieve the Net Zero goal in a socially inclusive manner. Additionally, NetZeroCities supports a series of pilot projects aimed at fostering rapid learning of strategies and solutions useful for achieving climate neutrality at the urban scale, as well as managing a twinning program aimed at promoting peer-to-peer exchange (16).

A more recent example of a European initiative aimed at addressing climate change is the New European Bauhaus, launched in September 2021 by President von der Leyen and aimed at adding a cultural dimension to the Green Deal. It aims to accelerate the green transition with tangible changes on the ground, according to the principles of sustainability, aesthetics, and inclusion (17), and is a creative and transdisciplinary movement in the making that seeks to bridge the worlds of science and technology, art and culture, combining sustainability, circularity, low emissions, biodiversity aesthetics, quality and functionality, diversity enhancement, accessibility, and affordability, in order to address complex social issues through co-creation (18).

CitiesWithNature, on the other hand, is an organization that now includes 316 cities in 75 countries, supported by various international partners, including ICLEI, TNC, and IUCN, which recognizes and promotes the role of nature within and around cities. Recently, the CityWithNature platform has also launched an online Hub, the Tools and resources Hub (19), which, accessible even if not enrolled, offers a wide range of cutting-edge resources and tools on various topics, including biodiversity, Nature-based solutions, and ecosystem restoration, among others (20).

Another initiative that offers a toolbox of tools, guidelines, case studies, and standard methodologies useful for adaptation and environmental assessment in cities is the IUC Urban Alliance. Among the tools offered by the alliance, there are several open-source resources easily accessible online, including, for example: IUCN Urban Toolbox, IUCN Urban Nature Indexes: Methodological framework and key indicators, IUCN Global Standard for Nature-based Solutions, Making Nature's City Toolkit, Species Threat Abatement and Recovery Metric, and A guide for pollinator-friendly cities, along with many others (21).

These are just some examples of how cities, under the guidance of a supranational entity such as the European Union, can constitute an important laboratory for innovation and change, through coordinated, multidisciplinary action across various governance levels aimed at promoting new ways of managing resources and thinking about urban space.

For this reason, in the next chapter, we will analyze some of the actions and plans developed by different European cities, with a particular focus on the Continental and Baltic bioclimatic regions.

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(13) +CityxChange. *The +CityxChange vision is to enable the co-creation of the future we want to live in*. Available at: https://cityxchange.eu/ (Accessed: 3 April 2024).

(14) European Commission. *Knowledge for Policy: Supporting policy with scientific evidence*. Available at: https://knowledge4policy.ec.europa.eu/ (Accessed: 3 April 2024).

(15) Eurocities. *About us*. Available at: https://eurocities.eu/ (Accessed: 3 April 2024).

(16) NetZeroCities. *Towards climate neutral European Cities by 2030*. Available at: https://netzerocities.eu/ (Accessed: 4 April 2024).

(17) European Parliament (2022) *REPORT on the New European Bauhaus*. Available at: https://www.europarl.europa.eu/doceo/document/A-9-2022-0213_EN.html (Accessed: 4 April 2024).

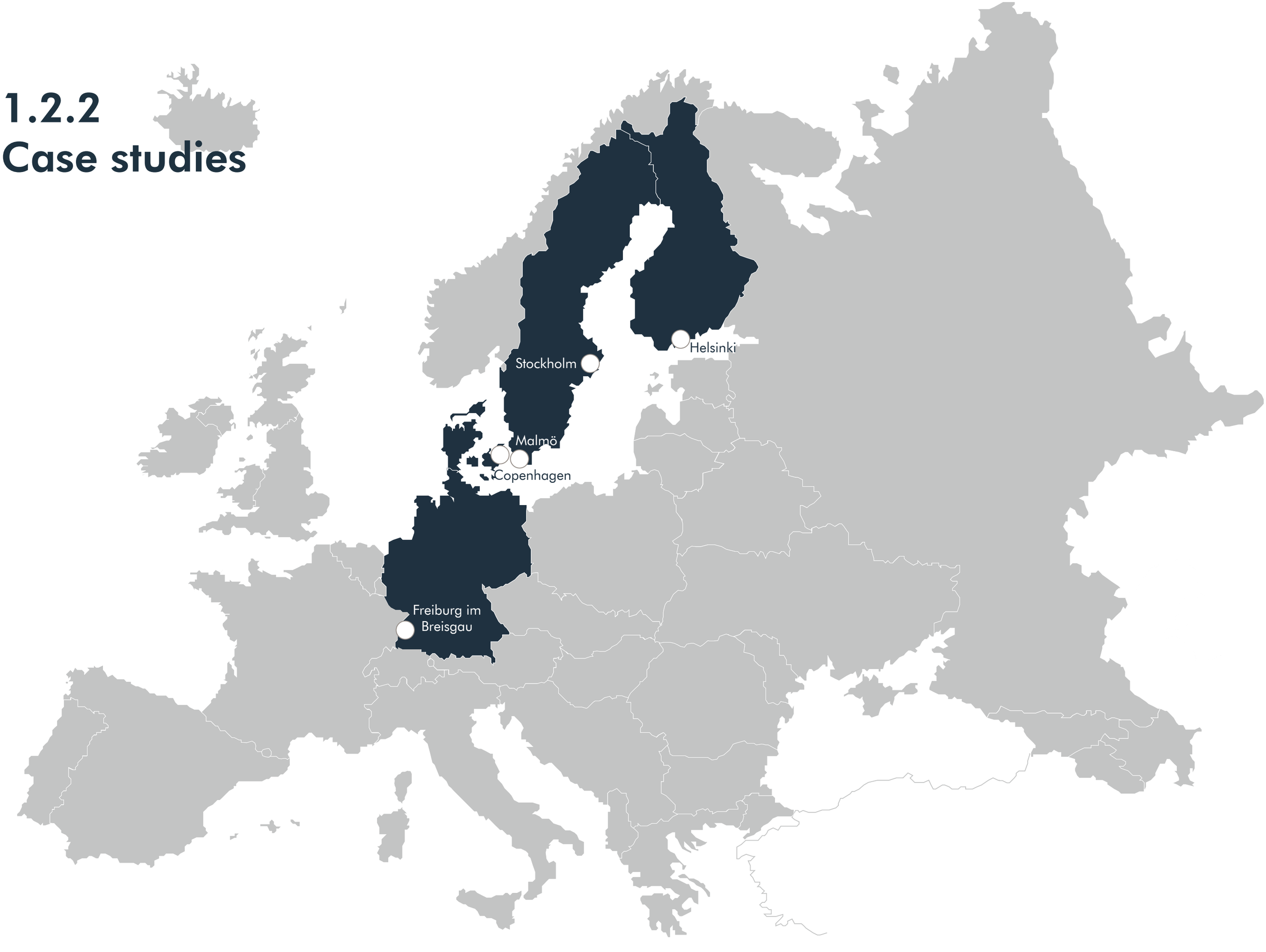
(18) European Union. *New European Bauhaus*. Available at: https://new-european-bauhaus.europa.eu/ (Accessed: 5 April 2024).

(19) CitiesWithNature. *The new Tools and Resources Hub on CitiesWithNature*. Available at: https://citieswithnature.org/the-new-tools-and-resources-hub-on-citieswithnature/ (Accessed: 3 April 2024).

(20) CitiesWithNature. *WELCOME TO CitiesWithNature*. Available at: https://citieswithnature.org/ (Accessed: 5 April 2024).

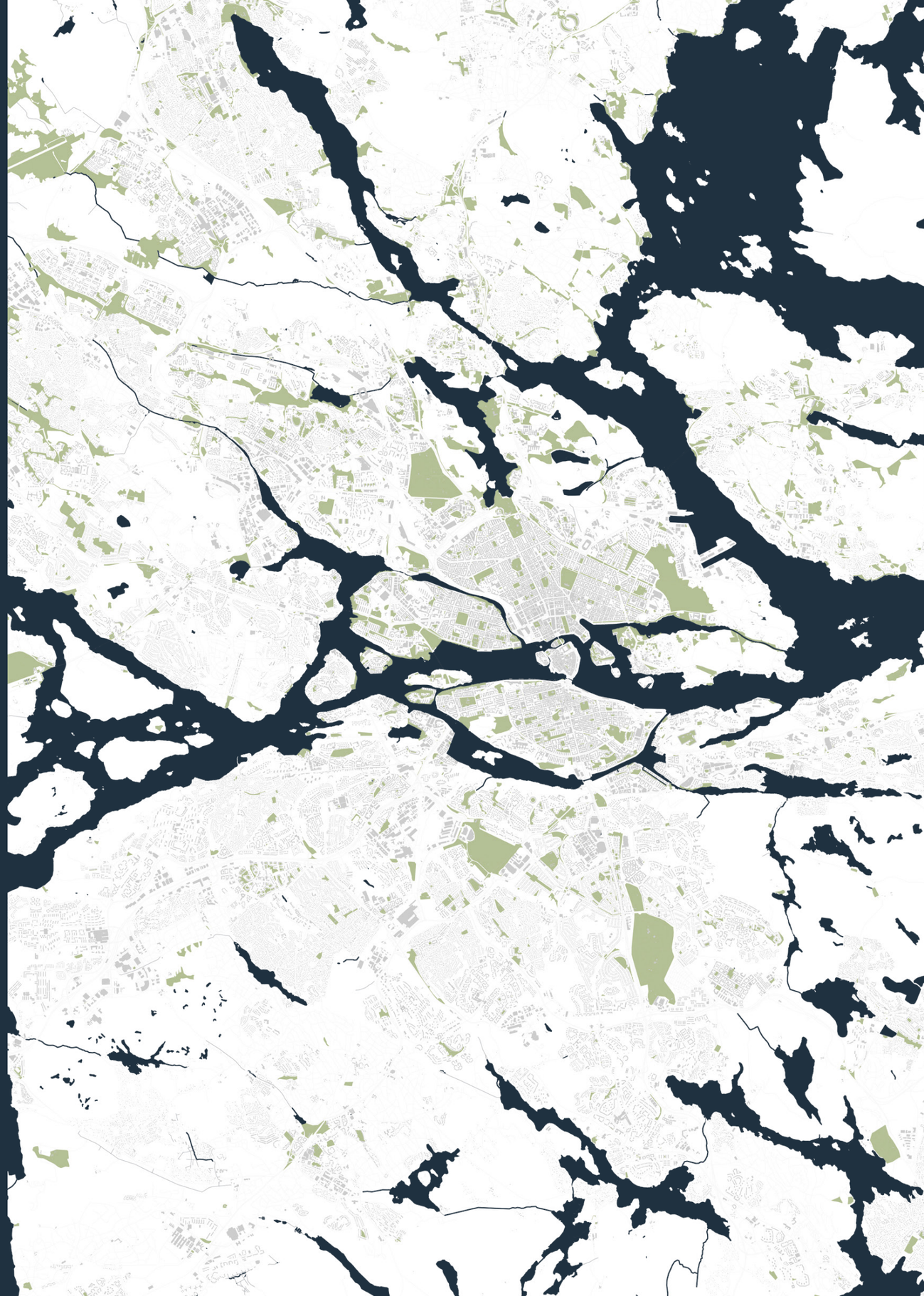
(21) IUCN Urban Alliance. *Tools & resources*. Available at: https://iucnurbanalliance.org/tools_and_resources/ (Accessed: 4 April 2024).

1.2.2
Case studies



STOCKHOLM

Sweden



①

0km 5km 10km 15km 20km 25km

Legend: Blue infrastructure, Green infrastructure, Buildings, Main roads, Bike paths, Ecosystem services, Adaptation measures, Nature conservation measures, Water quality measures

City	Stockholm
Location	Sweden
Biogeographical region	Boreal
Context	Lake
Population size	984.748
Population density	5.261,53 pop./sq.km
Critical climate issues	Increase in temperatures, increase in precipitation, flooding, reduced seawater salinity, rising sea levels.

Action Plans

- Stockholm City Bicycle Plan (October 2012)
- Stockholm City Accessibility Strategy (developed in 2012, updated June 2022)
- Microplastics Action Plan 2020-2024 (January 2020)
- Chemical Plan 2020-2023 (April 2020)
- Environmental Program 2020-2023 (May 2020)
- Climate Action Plan 2020-2023 (May 2020)
- Biodiversity Action Plan (November 2020)
- Circular Construction Action Plan 2021-2024 (October 2021)
- Stockholm Climate Adaptation Action Plan 2022-2025 (December 2021)
- Action Plan the Sustainable Use of Plastic 2022-2026 (February 2022)

Goals

- Stockholm City Bicycle Plan:
  15% of peak-hour travel by bicycle by 2030.
- Stockholm City Accessibility Strategy:
  Prioritize walking and cycling, as well as public transportation. Applies to both existing and new roads, as well as squares and docks with traffic areas, such as parking lots.
- Microplastics Action Plan 2020-2024:
  Reduce the spread of plastic and microplastics in the environment through 50 concrete measures divided into 2 different areas of action, which are sources and pathways of diffusion.
- Chemical Plan 2020-2023:
  Prevention and management of chemicals produced, disseminated, or already present in the environment.
- Environmental Program 2020-2023:
  7 objectives including phasing out fossil fuels by 2040, a fossil fuel-free city organization by 2030, city climate adaptation, resource protection, biodiversity restoration and conservation, prevention of air and noise pollution, and a city free of toxic substances.
- Climate Action Plan 2020-2023:
  City's transition away from fossil fuels by 2040, setting a maximum allowable emissions quantity of 19 million tonnes of carbon dioxide equivalent during the period 2020-2040.
- Biodiversity Action Plan:
  Strengthen urban nature and biodiversity through 5 strategies for urban biodiversity conservation, including highlighting priority species and natural qualities, paying attention to biological diversity within urban processes, implementing ecological reinforcement measures, developing knowledge and communication, and developing tools to facilitate collaboration and implementation.
- Circular Construction Action Plan 2021-2024:
  Transform Stockholm into a city where resources are used efficiently and in accordance with the EU waste hierarchy by 2030.
- Stockholm Climate Adaptation Action Plan 2022-2025:
  Unlike the 2020 Environmental Program, the Stockholm Climate Adaptation Action Plan, approved in 2021, focuses more on problems posed by heavy rainfall and heatwaves.
- Action Plan the Sustainable Use of Plastic 2022-2026:
  The plan applies to the period 2022-2026 and contributes to achieving 4 of the main objectives of the 2020-2023 Environmental Program, including: phasing out fossil fuels by 2040, a fossil fuel-free city organization by 2030, resource protection, and a city free of toxic substances (1).

Surrounded by water, Stockholm is a city in the southeast of Sweden, located on the Baltic Sea, from which the eponymous biogeographic region takes its name. Signatory to the C40 Reinventing Cities initiative since 2005 (2), as well as several "Accelerators" of this initiative, the city is a member of various international projects and alliances, such as NetZeroCities, EuroCities, and CNCA (Carbon Neutral Cities Alliance).

Regarding the impacts of climate change on the city, these mainly consist of increased temperatures, as well as precipitation and sea levels, which in turn lead to an increased risk of flooding (3). On December 13, 2021, the Stockholm City Council developed a new climate adaptation action plan for the years 2022-2025, divided into 3 chapters, two of which are predominantly focused on heavy rainfall and heatwaves (4). In general, the action plan embodies the third objective of the city's 2020-2023 Environmental Program, which defines a total of 7 main objectives (5).

In general, the Municipal Administration has developed various plans to address the ongoing climate change, such as the adaptation and mitigation strategies adopted. Among the various mitigation strategies, we can find plans aimed at encouraging the use of bicycles and public transport over cars, as seen in the Stockholm City Bicycle Plan of 2012, which sets a target for 15% of peak-hour trips to be made by bicycle by 2030.

From the adaptation perspective, there are several strategies such as green roofs, like those found in the Husarvikstorget area [Fig. 5], ecological corridors, like those installed in the Loudden district or on Spångavägen in the northwest of Stockholm [Fig. 3]. Following the development of a plan to restore and connect areas hosting common toad populations, birds, and native oak insects in that area (6), or even nests made from waste materials, as seen in the Stockholm Royal Seaport area [Fig. 4].

Another key element of the city's climate change strategy is research: the development of measurable and updated data is essential for reasoned urban planning in view of future climate and extreme weather events, which is why the municipal council of Stockholm has produced various county-level maps related to both precipitation and heatwaves, as well as maps aimed at inspiring and providing ideas for measures to strengthen the city's biological diversity (7).

Among the city's goals, as defined by the Environmental Program 2020-2023, include, among others, the abandonment of fossil fuels by 2040, a plan that also establishes a maximum amount of emissions allowed up to 19 million tons of carbon dioxide equivalent during the period from 2020 to 2040.

Fig. 1 (in the previously page) - Map of the city of Stockholm with data reworked from Stockholm's geoportal.
Source: [www.dataportalen.stockholm.se].

Fig. 2 - Aerial view of Stockholm's Gamla Stan.
Source: [www.repubblica.it].

Fig. 3 - Tunnels for amphibians and aquatic salamanders at Loudden.
Source: [www.norradjurgardsstaden2030.se].

Fig. 4 - Nests made from waste in the Stockholm Royal Seaport area.
Source: [www.norradjurgardsstaden2030.se].

Fig. 5 - Husarvikstorget's green roofs.
Source: [www.vargarkitekter.se].

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(3) Stockholms Stad (2007) *Adapting to Climate Change in Stockholm: Stockholm's Action Programme on Climate Change*. Available at: http://portal.mc-4.org/uploads/1/2/1/4/12146463/adapting_to_climate_change_in_stockholm.pdf (Accessed: 4 November 2023).

(4) Stockholms Stad (2023) *Handlingsplan för klimatanpassning*. Available at: https://miljobarometern.stockholm.se/miljomal/handlingsplan-for-klimatanpassning/ (Accessed: 3 November 2023).

(5) Stockholms Stad (2023) *Miljöprogram 2020-2023*. Available at: www.miljobarometern.stockholm.se/miljomal/miljoprogram-2020-2023/ (Accessed: 3 November 2023).

(6) Stockholms Stad (2019) *STÄRKT GRÖN INFRASTRUKTUR I MELLERSTA SÖDERORT: Förstärkningsåtgärder och strategier.* Available at: www.insynsverige.se/documentHandler.ashx?did=1966870 (Accessed: 4 November 2023).

(7) Stockholms Stad (2023) *Handlingsplan för biologisk mångfald*. Available at: https://miljobarometern.stockholm.se/miljomal/hpbm/ (Accessed: 4 November 2023).

MALMÖ
Sweden

6

Legend: Blue infrastructure · Green infrastructure · Buildings · -- Bus routes · Main roads · Urban development areas · — Cycle paths

Location	Sweden
Biogeographical region	Continental
Context	Coastal
Population size	357,377
Population density	5.000 pop./sq.km
Critical climate issues	Increase in temperatures, increase in precipitation, flooding, reduced seawater salinity, rising sea levels.

Action Plan

- General Plan 2000 (2000)
- Sustainable Development and Food Policy (2010)
- Action Programme for Better Air (2010, revised in 2011)
- Pedestrian and Bicycle Programmes (2012)
- Traffic Environment Programme (2005)
- Energy Strategy (2009)
- Malmö Environmental Programme (2009)
- General Plan 2012 (2012)
- Pedestrian Programme (2012)
- General Plan 2014 (2014)
- Sustainable Urban Mobility Plan SUMP (2016)
- Malmö Agenda 2030, adopted in 2018 (16)
- Environment Programme 2020 (2020)
- Plan 2021 (2020)

Goals

- General Plan 2000: the city's first steps towards a more sustainable society (8).
- Sustainable Development and Food Policy: reduce greenhouse gas emissions related to food procurement by 40% by 2020 compared to the 2002 level, and ensure that by 2020 all food served in Malmö is completely organic (9).
- Action Programme for Better Air: achieving better air quality and reducing air pollution through a new mobility approach consisting of cycle paths and improved connections with public transportation.(10).
- Pedestrian and Bicycle Programmes: promoting the status of cyclists and pedestrians and making walking and cycling more attractive.
- Traffic Environment Programme: regarding the period 2005-2010, the program aims to create a healthier, cleaner, quieter, and more efficient transportation system, gradually replacing car travel with cycling and public transportation to reduce carbon dioxide and nitrogen oxide emissions.
- Energy Strategy: a 20% reduction in energy consumption. 50% of all energy used should be renewable. Energy consumption in Malmö city departments should decrease by 30%, with 100% of energy coming from renewable sources.
- Malmö's Environmental Programme: a more efficient energy consumption (energy consumption in Malmö must decrease by at least 20% per capita by 2020 and by an additional 20% by 2030), an increase in the use of renewable energy (by 2020, the percentage of renewable energy in the city of Malmö must reach 100%), a reduction in emissions (which must decrease by 40% compared to 1990), a transition within the transportation sector (through the implementation of a well-integrated system of bicycle lanes and public transportation, powered by electricity), and the adaptation of the city to climate change (11;12).
- General Plan 2012: a dense and green, sustainable, and inclusive city (10).
- General Plan 2014: the general plan has defined three main objectives for sustainable development, which are the dense, green, and mixed-use city, green growth through regional action, and the city as a place of culture and democracy (8).
- Sustainable Urban Mobility Plan SUMP: elaborated in 2016, the year in which bike sharing was first introduced in the city of Malmö, the plan aims to achieve the following percentages regarding the modes of transportation of its inhabitants: 15% by walking, 26% by bike, 23% by public transport, and 36% by car. As for commuting, the percentages are: 4% by bicycle, 39% by public transport, and 57% by car. The 2016 SUMP also combines the objectives and strategies of various plans, including the Traffic Environment Programme (2012), the Traffic Safety Strategy, the Pedestrian Programme of 2012, the Bicycle Programme, the Koll2020 (or Public Transport Strategy), the Freight Traffic Programme, the Action Programme for Better Air, the Action Programme against Noise, the Environment Programme, the Energy Strategy, and the Plan for Malmö's Green and Blue Environments.
- Energy Strategy 2020: a reduction in energy consumption by 20%, ensuring that 50% of total energy used comes from renewable sources, and a 30% reduction in energy consumption by the municipal administration.
- Environment Programme 2020: climate neutrality of public administration, a 40% reduction in emissions compared to 1990, as well as a healthy and welcoming urban environment (10).
- 2021 Plan (2020): reduce carbon emissions by 70% by 2030 (13).

Fig. 6 (in the previously page) - Map of the city of Malmö with data re-elaborated from the Malmö Municipality website.
Source: [www.malmo.se/].

Fig. 7 - Aerial view of the eco-district Bo01 in Malmö.
Source: [www.cosvig.it].

Fig. 8 - Ohboy, sustainable hotel near the eco-district Bo01.
Source: [www.siegel.nu].

Third largest city in Sweden after Stockholm and Gothenburg, Malmö is a city in southeastern Sweden characterized by a rather mild climate compared to the rest of Sweden, as it is part of the continental region of Europe (9). Strong rains and floods are just some of the major challenges related to climate change , issues that it has addressed through the development of various plans for managing rainwater and protecting coasts (12), as well as the implementation of green roofs and a drainage system consisting of 6 km of water channels and 10 retention ponds (13). The first city in Sweden to adopt European SDGs (14) and part of the Urban-Regional Innovation Partnership (15), Malmö has been a Resilience Hub within the Making Cities Resilient 2030 campaign since 2022.

Following an intense downpour that occurred in 2014, the city implemented several projects aimed at adapting to more frequent and intense weather events. It has adopted a plan for downpours and is currently developing a strategy to cope with rising sea levels, as well as storms. Regarding biodiversity, in order to address parasites and infections related to low biological diversity as well as drought, Malmö is working to diversify its urban forests (11). Additionally, Malmö is trying to involve its citizens in taking care of the city's biodiversity by providing them with a series of tips to follow, like leaving dead wood and leaves in the garden, choosing plants that bloom at different times to provide continuous food for pollinators, installing bee hotels, birdhouses and bat houses, and creating a compost pile to serve as a winter nest for hedgehogs (16).

Overall, the city is pursuing various policies in response to climate change, along with adaptation strategies, educational strategies in collaboration with local universities, as well as projects for recycling, waste management, biogas production from food waste used to fuel city buses (17), garbage trucks, and taxis (12).

To cope with heat waves, the city is working to increase the amount of greenery within the urban landscape, aiming to provide shade during increasingly hot summers and prevent the urban heat island effect, while at the architectural scale buildings will gradually be equipped with a greater number window filters, green roofs and walls, and ventilation systems (13).

In general, the city aims to achieve zero emissions by 2030 (18), defining 6 objectives to reduce climate impact, 3 for a good living environment, and 3 for a rich and healthy nature (19), as well as 7 priority conversion areas, including circular economy, electricity, food, zero-impact construction, sustainable mobility, emissions, and heat from waste incineration and biogas (20).

Regarding mobility, the city is traversed by 515 km of bike paths (9), while concerning the city's green and blue structures, green roofs, management of meteoric waters, organic gardening, and the green space factor (experimented in the western port and now incorporated into the municipal environmental building code) are the main strategies employed (21).

(8) Malmö Stad. *Population*. Available at: https://malmo.se/Facts-and-statistics/Population.html
Accessed: 3 November 2023).

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(Accessed: 3 November 2023).

(10) Malmö Stad (2024) *Klimatanpassning*. Available at: https://malmo.se/Stadsutveckling/Sa-utvecklar-vi-staden/Klimatanpassning.html (Accessed: 4 November 2023).

(11) Malmö Stad. *Malmö Resilience Hub*. Available at: https://malmo.se/Malmo-Resilience-Hub.html
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(14) Climate Adaptation Platform (2020) *Ecosystem-based Approach to Climate Adaptation in Malmö, Sweden*. Available at: https://climateadaptationplatform.com/ecosystem-based-approach-to-climate-adaptation-in-malmo-sweden/
(Accessed: 5 November 2023).

(15) Malmö Stad. *Malmö and nature based solutions*. Available at: https://www.growgreenproject.eu/wp-content/uploads/2020/05/H-NILSSON-Malmo-GrowGreen.pdf
(Accessed: 6 November 2023).

(16) Malmö Stad (2024) *Nu gör vi fler ängar i Malmö*. Available at: https://malmo.se/Stadsutveckling/Sa-utvecklar-vi-staden/Natur-och-biologisk-mangfald/Nu-gor-vi-fler-angar-i-Malmo.html (Accessed: 6 November 2023).

(17) Malmö Stad (2023) Circular economy. Available at: https://malmo.se/Welcome-to-Malmo/Sustainable-Malmo/Sustainable-Lifestyle/Circular-economy.html
(Accessed: 7 November 2023).

(18) Malmö Stad (2023) *COP28: Dystra klimatrapporter – Malmö går före*. Available. at: www.malmo.se/Aktuellt/Artiklar-Malmo-stad/2023-12-12-COP28-Dystra-klimatrapporter---Malmo-gar-fore.html (Accessed: 7 November 2023).

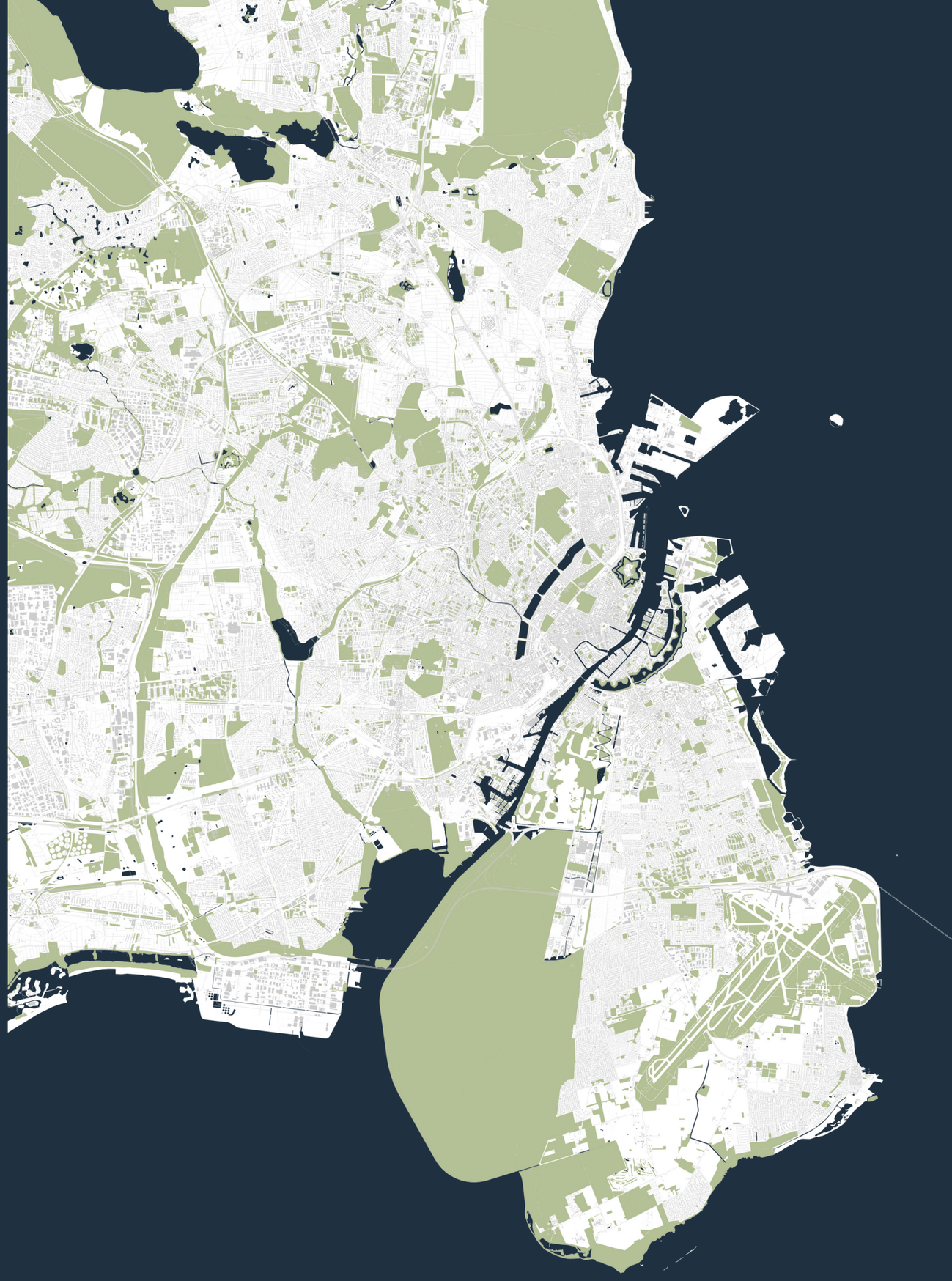
(19) Malmö Stad. *Så jobbar vi med våra miljö- och klimatmål*. Available at: www.malmo.se/Miljo-och-klimat/Sa-jobbar-vi-med-vara-miljo--och-klimatmal.html
(Accessed: 7 November 2023).

(20) Malmö Stad. *Prioriterade omställningsområden*. Available at: www.malmo.se/Miljo-och-klimat/Klimatomstallning-Malmo/Sa-arbetar-vi-for-att-stalla-om-Malmo/Prioriterade-omstallningsomraden.html (Accessed: 5 November 2023).

(21) Malmö Stad (2023) *Green and Blue*. Available at: https://malmo.se/Welcome-to-Malmo/Sustainable-Malmo/Sustainable-Lifestyle/Green-and-Blue.html
(Accessed: 6 November 2023).

COPENHAGEN

Denmark



Legend: Blue infrastructure · Green infrastructure · Buildings · Main roads · Cycle paths · Flow routes · Community gardens · Projects related to Energy production · Projects related to Climate Adaptation · Projects related to Energy efficiency · Projects related to Mobility

Location	Denmark
Biogeographical region	Continental
Context	Coastal
Population size	656.787
Population density	7.614,92 pop./sq.km
Critical climate issues	Increase in temperatures, increase in precipitation, flooding, reduced seawater salinity, rising sea levels.

Action Plans

- Climate Adaptation Plan Copenhagen (2011)
- Cloudburst Management Plan (2012)
- 2025 Climate Plan (2012)
- Climate Change Adaptation and Investment Statement (2015)

Goals

- Climate Adaptation Plan Copenhagen: the plan, aimed at preventing floods, includes two measures: the modification of city sewers to withstand extreme weather events and to separate stormwater from wastewater, and the so-called "Plan B", based on implementing adaptation measures and creating new "Flow Routes" to channel excess water towards the harbor and ultimately the sea. This measure, which proved more effective in combating floods, was adopted with the Cloudburst Management Plan in 2012. The plan also emphasizes issues related to increasingly heavy rainfall, future sea level rise, and rising temperatures. Its main objectives include preserving and caring for existing green areas, creating more green and blue structures, and establishing coherent ecological networks (22).
- Cloudburst Management Plan: the plan divides the city into 26 watersheds to prioritize stormwater management efforts where the risk is higher and where there is an opportunity to create new synergies with urban development in general. Additionally, the plan maps the various "Flow Routes" established, which traverse the urban fabric and flood-prone areas, directing water that would otherwise overwhelm the city's conduits towards the sea (23;24).
- 2025 Climate Plan: it unfolds in three implementation phases, spanning from 2013 to 2016, from 2017 to 2020, and from 2021 to 2025, with an interim evaluation between phases. It focuses on four themes: energy consumption, energy production, mobility, and administration. The plan's main objectives include reducing CO2 emissions by 20% by 2015 compared to 2005 levels and achieving climate neutrality by 2025 (24;25).
- Climate Change Adaptation and Investment Statement: the implementation plan is based on the 2012 Cloudburst Management Plan and describes the inputs, effectiveness, and challenges of the adaptation plan, identifying the potential for improving urban spaces within various neighborhoods of the city (26).

Capital of Denmark located at the border with Sweden, and connected to the city of Malmö through the Öresund Bridge, Copenhagen is a city actively engaged in the fight against climate change. Following the climate summit (COP15), held in Copenhagen in December 2009, the city initiated a series of measures aimed at climate adaptation, collected in the Copenhagen Climate Adaptation Plan, adopted on August 25, 2011, by the City Council (27), especially after the extreme downpours that occurred in 2010 and 2011 (10), which had hit the metropolitan area, causing damages of over 6 billion Danish kroner (23).
Since then, the city has taken a leading role in the fight against climate change, defining for itself three main objectives, which are:
- Minimize potential damages resulting from climate change
- Establish warning systems to signal and act in case of abnormal conditions
- Implement preventive infrastructure to address damages and potential traffic disruptions following extreme weather events (28).
Additionally, the city of Copenhagen has developed a series of plans, including:
- The Climate Adaptation Plan of 2011
- The Cloudburst Management Plan of 2012
- The 2025 Climate Plan of 2012 (25)
- The Climate Change Adaptation and Investment Statement of 2015.
In addition to this, the city of Copenhagen is part of a wide variety of national and international networks and initiatives aimed at developing and

Fig. 9 (in the previously page) - Map of Copenhagen illustrating data that have been re-elaborated from various sources.
Source: [Copenhagen Climate Projects 2016 ; https://www.google.it/maps ; Linaki, E., et al. (2016) The bicycle as a means of ecological, social and economic sustainable mobility].

Fig. 10 - Aerial view of the city of Copenhagen.
Source: [www.getbybus.com].

(22) EGHN (2018) *Copenhagen Climate Adaptation Plan*. Available at: https://www.eghn.org/en/copenhagen-climate-adaptation-plan/ (Accessed: 6 November 2023).

(23) City of Copenhagen. *Climate Adaptation: The changing climate and weather faces Copenhagen with a number of challenges*. Available at: https://international.kk.dk/about-copenhagen/liveable-green-city/climate-adaptation
(Accessed: 6 November 2023).

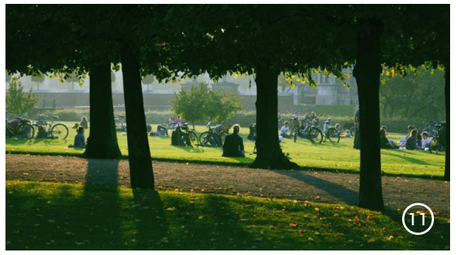
(24) City of Copenhagen. *The CPH 2025 Climate Plan*. Available at: https://urbandevelopmentcph.kk.dk/climate
(Accessed: 7 November 2023).

(25) C40 (2017) *Copenhagen 2025 Climate Plan: Roadmap 2017 - 2020*. Available at: https://www.c40knowledgehub.org/s/article/Copenhagen-2025-Climate-Plan-Roadmap-2017-2020?language=en_US
(Accessed: 6 November 2023).

(26) Xu, H. (2021) *Building Climate Resilient City through Multiple Scale Cooperative Planning: Experiences from Copenhagen*. Available at: https://iopscience.iop.org/article/10.1088/1757-899X/1203/3/032063
(Accessed: 6 November 2023).

(27) The City of Copenhagen. *Cloudburst Management Plan*. Available at: https://international.kk.dk/about-copenhagen/liveable-green-city/climate-adaptation
(Accessed: 6 November 2023).

(28) The Index Project (2013) *The Climate Adaptation Plan: The Danish capital's ambitious adaption plan to climate change*. Available at: https://theindexproject.org/post/the-climate-adaptation-plan (Accessed: 7 November 2023).



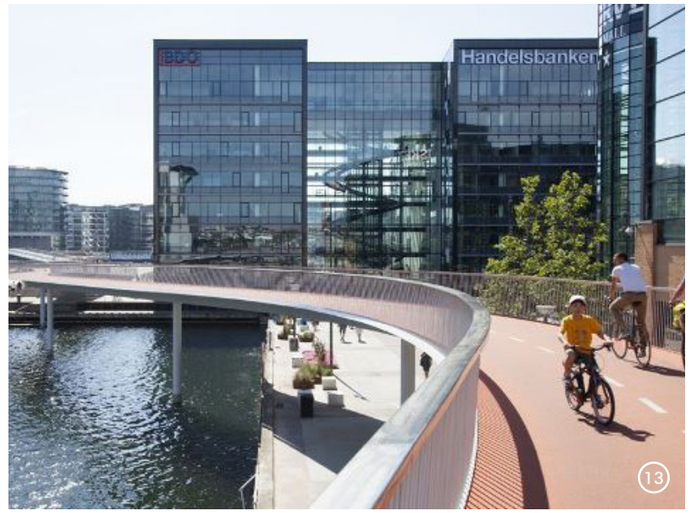


Fig. 11 - View of a park in Copenhagen. The city has approximately 3,260 ha of green areas, reachable by at least 96% of citizens on foot within 15 minutes.
Source: [www.ohga.it].

Fig. 12 - View from above of CopenHill.
Source: [www.world-architects.com/].

Fig. 13 - Cykelslangen (The Bicycle Snake): a 'suspended' bicycle lane that runs through the area adjacent to the harbor.
Source: [www.living.corriere.it/].

(29) Arbizzani, E., et al. (2023) ***Technological Imagination in the Green and Digital Transition***. Roma: Eugenio Arbizzani, Eliana Cangelli, Carola Clemente, Fabrizio Cumo, Francesca Giofrè, Anna Maria Giovenale, Spartaco ParisMassimo Palme.

(30) City of Copenhagen. ***The CPH 2025 Climate Plan. Available*** at: https://urbandevelopmentcph.kk.dk/climate
(Accessed: 7 November 2023).

implementing climate solutions, including the C40, the Carbon Neutral City Alliance (CNCA), and the Energi på Tværs (Danish municipal collaboration). In collaboration with the Amager Resource Center (ARC), the city of Copenhagen has also contributed to the creation of a carbon capture plant at CopenHill [Fig.12], one of the first carbon capture plants installed on an incinerator, characterized by a potential CO2 capture capacity of up to 500,000 tonnes. With the support of the Carbon Neutral Cities Alliance (CNCA), NIRAS, Bellona (a Norwegian NGO), as well as cities like Amsterdam, Helsinki, Oslo, and Stockholm, it has recently completed a carbon capture investigation project and the role it can play in making cities carbon neutral. Additionally, several pilot projects have been initiated for the development of zero-emission construction sites and machinery, a goal for which the city plans to initiate a series of partnerships with both public and private organizations, as well as with cities involved in the C40 project (29).
In 2019, the city managed to reduce CO2 emissions by 54% compared to 2005, the base year defined by the 2025 Climate Plan (30). Regarding mobility, the city has set the goal for 75% of city trips to be made by walking, cycling [Fig.13], or public transportation, a goal achieved through reduced car usage, improved metro systems, and better traffic management.

HELSINKI
Finland

Legend: Blue infrastructure · Green infrastructure · Building · Main roads · Cycle paths · Green corridors · Stormwater sewerage · Combined swerage (wastewater+stormwater) · Community gardens · Implementation of NbS around the city

Location	Finland
Biogeographic region	Boreal
Context	Coastal
Populaion size	664.028
Population density	3.105,84 pop./sq.km
Critical climate issues	Rising temperatures, precipitation, flooding and rising sea levels

Action Plans

- The Flood Strategy (2008)
- The Climate Change Adaptation Strategy of the Helsinki Metropolitan Area (2012-2020)
- Carbon Neutral Helsinki 2035 Action Plan (2018)
- Helsinki's climate change adaptation policies 2019-2025 (2019)
- Sustainable urban living programme (may 2021)
- Helsinky City Strategy 2021-2025 (2021)
- Biodiversity Action Plan (2021)

Goals

- The Flood Strategy: Helsinki is the first municipality in Finland to have developed a strategy for coastal floods, which establishes the responsibilities of various city authorities for flood risk management. Additionally, in 2010, this led to the establishment of a flood working group, comprised of various departments including the Finnish Environment Institute, tasked with monitoring the actions outlined within the strategy (31).
- The Climate Change Adaptation Strategy of the Helsinki Metropolitan Area: the goal is to assess the consequences of climate change on the region, prepare for the impacts of climate change and extreme weather events, and reduce the region's vulnerability to climate variations and changes, in order to safeguard the well-being of the region's inhabitants and the functioning of cities even under changing conditions (32).
- Carbon Neutral Helsinki 2035 Action Plan: the city's objective is to reduce direct emissions (those emissions generated within the geographical boundaries of the city, while indirect emissions are, for example, those related to the construction sector) by at least 80% compared to 1990 levels by 2030, with the possibility of offsetting the remaining emissions. Since the most significant sources of emissions are heating, transportation, and electricity, carbon neutrality can be achieved primarily through energy efficiency measures in buildings, low-emission transportation solutions, and increasing the share of renewable energy in heat and electricity production. The actions currently underway are divided into 3 categories:
  - Actions aimed at reducing emissions
  - Actions aimed at facilitating emissions reduction
  - Investigations aimed at defining new emissions reduction actions
- Helsinki's climate change adaptation policies 2019-2025: with this plan, the city has defined a series of priority actions for climate adaptation, including:
  - Extending climate risk mapping to the entire city
  - Establishing a management process for flood risk related to rainwater in already built-up areas
  - Developing a flood strategy
  - Using models to evaluate the current water management system
  - Incorporating the concept of climate resilience into the planning, construction, and maintenance of buildings, energy networks, transportation systems, and other infrastructures
  - Preventing possible water body contaminations due to floods

  Among others (33).
- Sustainable urban living programme: designed to support the climate objectives of the cities in the Helsinki metropolitan area, both in terms of mitigation and adaptation, as well as to accelerate the transition to circular economy principles, the program has been developed with consideration for cities' carbon neutrality, circular economy, and adaptation plans. It comprises 68 measures across 6 priority areas: consumption, food, waste and water, urban planning, construction, and well-being (34).
- Helsinky city strategy 2021-2025: the program advances the goal introduced with the city's strategy for the period 2017-2021 to become carbon neutral by 2035, aiming to make Helsinki carbon neutral by 2030, as well as achieving zero emissions by 2040 and ultimately becoming carbon negative (35).
- Biodiversity Action Plan: linked to Finland's national action plan, "Saving Nature for People", the plan aims to:
  - Increase and better utilize nature's diversity in city's operations
  - Reinforce the functionality of blue and green networks
  - Identify and promote the preservation of nature types comprehensively
  - Identify the effects of forest management and systematically increase biodiversity
  - Enrich biodiversity in the built environment in anticipation of the future
  - Identify and secure the underwater nature values of islands, shores, and the marine area
  - Identify and improve the nature values of rivers, small water bodies, swamps, and wetlands
  - Improve living conditions for species
  - Intensify prevention of invasive alien species
  - Strengthen Helsinki residents' relationship with nature and increase awareness of biodiversity
  - Promote sustainable recreational use of nature and support residents' activities for biodiversity.

Fig. 14 (in the previously page) - Map of Helsinki with data reworked from various sources.
Source: [www.networknature.eu/].

Fig. 15 - Top view of the Helsinki Cathedral (the Helsingin tuomiokirkko).
Source: [www.thewildernessociety.it].

City of Finland located in the southeast of the country, Helsinki is a coastal city facing the Baltic Sea, and as such, it is part of the Baltic region of Europe. In terms of the effects of climate change, Helsinki is affected by several phenomena, such as rising temperatures and precipitation, as well as rising sea levels, heatwaves, and floods. The adaptation strategy to climate change in the Helsinki metropolitan area was developed in 2012 and included policies for the period 2012-2020. The purpose of this strategy, particularly focused on improving urban environment adaptation to climate change, was primarily to reduce the vulnerability of the city of Helsinki to extreme weather events, aiming for a "climate-proof city." Cities within the Helsinki metropolitan area are also involved in the Covenant of Mayors for Climate and Energy, which requires the preparation of a sustainable energy action plan, including an assessment of climate vulnerability and the definition of adaptation measures: the Sustainable Urban Life program, approved in May 2021, therefore proposes new measures for adapting to climate change that emphasize the development of green infrastructure, as well as collaboration and communication of adaptation information to residents of the metropolitan area. For this reason, a series of adaptation indicators based on the EEA classification have also been developed (34). Another objective of Helsinki is to achieve carbon neutrality by 2030, zero emissions by 2040, and eventually become carbon negative from 2040 onwards (36).

(31) Mees, H. L. P., et al. (2013) 'Legitimate Adaptive Flood Risk Governance Beyond the Dikes: the cases of Hamburg, Helsinki and Rotterdam', *Reg Environ Change*, 14, pp. 671-682.

(32) Helsingin seudun ympäristöpalvelut-kuntayhtymä (2012) *Helsinki Metropolitan Area Climate Change Adaptation Strategy*. Available at: https://ilmastotyokalut.fi/files/2014/10/11_2012_Helsinki_Metropolitan_Area_Climate_Change_Adaptation_Strategy.pdf
(Accessed: 8 November 2023).

(33) City of Helsinki (2019) *Helsinki's climate change adaptation policies 2019–2025*. Available at: https://www.hel.fi/static/kanslia/Julkaisut/2019/Helsinki-climate-change-adaptation-policies-2019-2025.pdf
(Accessed: 8 November 2023).

(34) HSY (2021) *Sustainable urban living programme*. Available at: https://julkaisu.hsy.fi/en/index/sustainable-urban-living-programme.html (Accessed: 8 November 2023).

(35) City of Helsinki. *Helsinki is a model city of sustainable development*. Available at: https://www.myhelsinki.fi/en/work-and-study/helsinki-is-a-model-city-of-sustainable-development (Accessed: 7 November 2023).

Fig. 16 - Tram converted into a 'grenn tunnel'.
Source: [www.stock.adobe.com].

(36) HSY. *Adaptation*. Available at: https://www.hsy.fi/en/air-quality-and-climate/climate-change/adaptation/
(Accessed: 7 November 2023).

(37) City of Helsinki. *Nature conservation and biodiversity*. Available at: https://www.hel.fi/en/urban-environment-and-traffic/protection-of-the-environment-and-nature/nature-conservation-and-biodiversity
(Accessed: 8 November 2023).

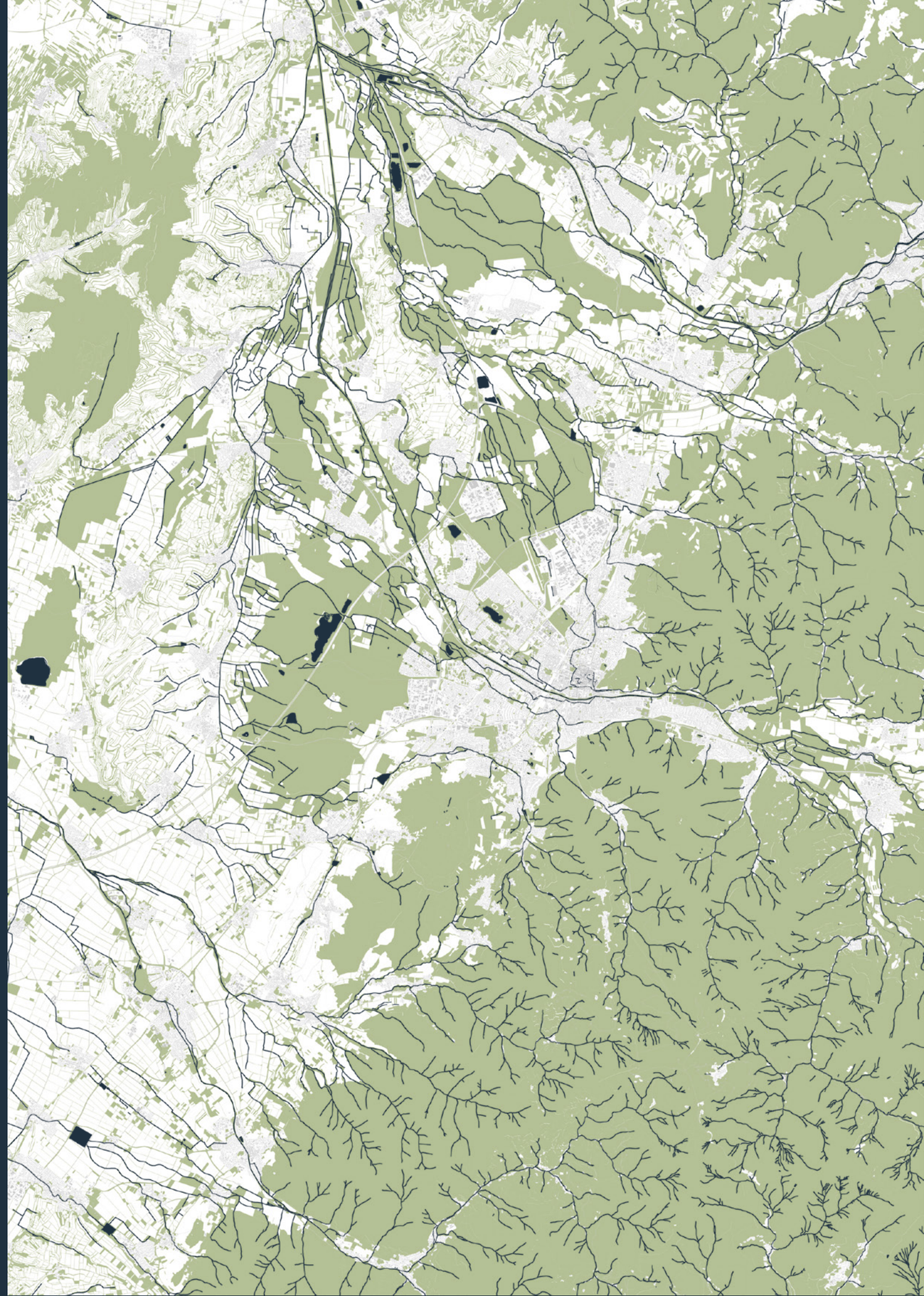
(38) Helsingin ilmastoteot. *Monitoring of the Carbon Neutral Helsinki Action Plan*. Available at: https://helsinginilmastoteot.fi/en/city-act/helsinki-climate-objectives-monitoring/
(Accessed: 8 November 2023).

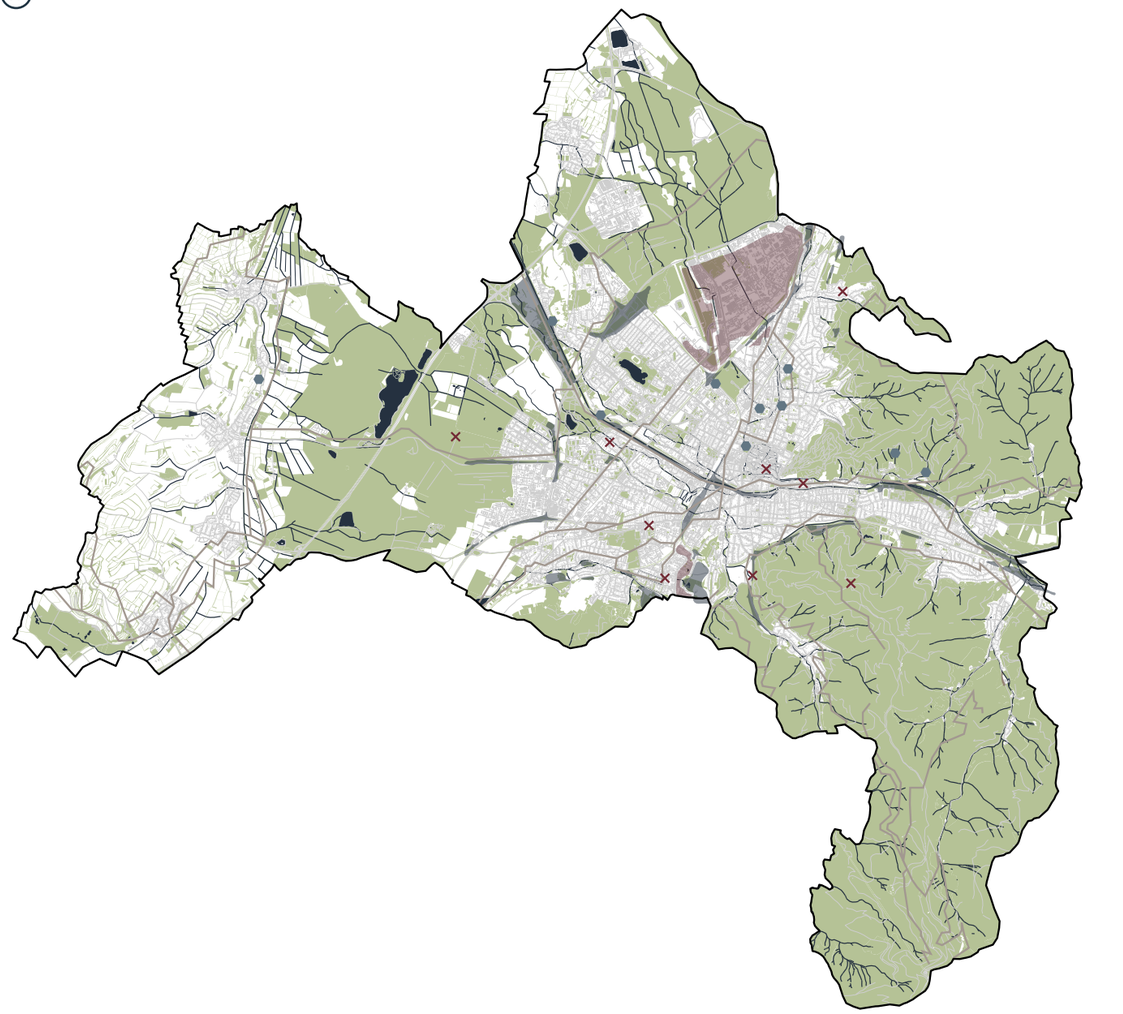
(39) Vierikko, K., et al. (2022) 'Shifting concepts of urban landscape in Helsinki: From primary forests to high tech nature-based solutions', *Creating Resilient Landscapes in an Era of Climate Change : Global Case Studies and Real-World Solutions*, pp. 179-193.

Helsinki has managed to control the expansion of the urban structure, maintaining a relatively high percentage of green areas [Fig. 16], natural landscapes, and biologically rich semi-natural areas. According to the Helsinki City Strategy 2021-2025, the City of Helsinki aims to create 5 new nature reserves annually within the city. Among 2021's Biodiversity Action Plan goals are also the implementation of NbS, the promotion of sustainable recreational use of nature, the monitoring of species and habitats around the city, and the preservation and restoration of the natural state of some areas, like the arcipelago, the forest and shores, when possible, maintaining the surroundings of recreation routes and service areas (37).
The city has adapted quite well to the increased precipitation observed during spring, summer, and autumn by using blue and green infrastructure, with the declared goal of purifying rainwater before it reaches the sea or larger rivers. To cope with heavy rains expected during the summer months, Helsinki is working on various pilot projects, while regarding winter precipitation, Helsinki unfortunately has not yet adopted specific measures, mainly aiming for integrated rainwater management within planning as well as better accessibility to the city's blue-green structures (38). In general, according to the City Strategy (2021-2025), Helsinki is positioned as an ambitious city in terms of climate responsibility, citizen well-being, economic growth, and nature conservation (39).

FREIBURG IM BREISGAU

Germany





Location	Germany
Biogeographic region	Continental
Context	Forest
Population size	236.140
Population density	1.543 pop./sq.km
Critical climate issues	Rising temperatures, loss of biodiversity, urban heat islands, invasive species, drought

Action Plans

- Klimaschutzkonzept (1996)
- Energy Conscious Refurbishment (2002)
- Klimaschutzkonzept 2007 (2007)
- Klimaanpassungskonzept (2018)
- Klimaschutzkonzept 2019 (2019)
- Biodiversitäts- 2019 (2019)
- General Heating Plan of Freiburg 2030 (2021)

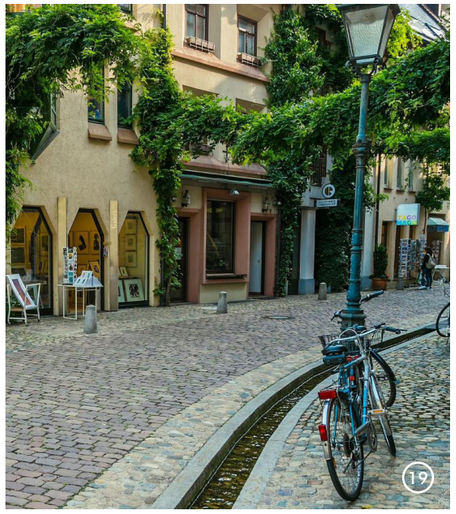
Goals

- Klimaschutzkonzept: Climate Action Policy aimed for a 25% reduction in greenhouse gas emissions compared to 1992 levels by 2010 (40).
- Energy Conscious Refurbishment Programme: in mid-2002, the municipal grant program "Conscious Energy Renovation" was launched, through which Freiburg supported the energy renovation of approximately 12% of the city's buildings. The program's approach is comprehensive: depending on the size of the renovated surfaces, thermal insulation of walls, roofs, or basements, and window replacement are sponsored. For each applicant, subsidies of up to 5,000 are provided for single or two-family houses, and up to 14,000 for multi-family houses. Particularly interesting are major renovations that transform a house into a KfW Efficiency Home. For these, Freiburg offers bonuses ranging from 1,000 to 7,000, depending on the efficiency class (41).
- Klimaschutzkonzept 2007: its objectives include reducing the city's CO2 emissions by 50% by 2030, as well as addressing various issues such as slow mobility, car sharing, and public transportation. It also involves creating an annual energy report, accompanied by defining indicators such as electricity consumption per capita and heating consumption per living area according to building age class (42;43).
- Klimaanpassungskonzept: it features 5 main action areas, which are:

- Green system and open spaces
- City and building structure
- Building-related measures
- Mobility
- Water

The plan also defines various measures for the city's climate adaptation, including the planting of large-canopy trees within green areas, which have a cooling effect through shading and evaporative cooling, greening of roofs, facades, and inner courtyards, as well as shading of buildings, parking lots, and bus stops, protection of cold air channels from the Black Forest, and de-sealing of open spaces (44).

- Klimaschutzkonzept 2019: the plan addresses various issues, including sustainable construction, emission-free mobility, the implementation of renewable energies, and climate-neutral heat supply. Additionally, as part of the city's anniversary celebration, the plan included the designation and implementation of the first climate protection district, followed by the selection of a new district every two years. Furthermore, the plan updated the goal of the 2007 Klimaschutzkonzept: the new interim target for 2030 is to achieve a CO2 reduction of -60%, in addition to climate neutrality by 2035 (45;46).
- Biodiversitäts-Aktionsplan 2019: approved in April 2019, the Biodiversity Action Plan, with its 45 priority measures, is aimed at reversing the trend against species and population loss (47).
- General Heating Plan of Freiburg 2030: approved by the city council in 2021, this plan aims to achieve climate neutrality in the city's heating (48).



Located in southern Germany, the city of Freiburg is seen as a model of urban sustainability, especially concerning green building practices. It boasts rigorous sustainability policies, high energy requirements, and a high density of research institutions focused on alternative energy, as well as pioneering projects on both large and medium scales.

The city's initial sustainability policies date back to the 1970s. After the proposal to build a nuclear power plant near the city center sparked dissent among Freiburg's residents, the city was tasked with finding an alternative energy source, leading to investments in renewable energies. Freiburg was also the first German city to establish an energy plan in 1986, while the eco-districts of Rieselfeld and Vauban began attracting international attention from their development in the 1990s (49).

The network of green infrastructure, crucial to much of the planning process, has been incorporated into territorial planning from the outset. Today, it spans across the entire city, creating valuable connections with the surrounding natural landscape.

In 2019, a referendum was held in which the municipality asked its citizens to support the development of a new neighborhood, Dietenbach, with construction set to begin in 2022.

Despite achieving the highest score among all 104 German cities in terms of mitigation, Freiburg only published an adaptation strategy in 2019 (50).

Freiburg exemplifies how a combination of social, nature-based, and technological solutions to urban climate challenges can prove effective in combating climate change in cities, while also offering long-term sustainable development.

One example is the city's efforts to improve public transport accessibility. As a technological solution for rainwater drainage, tram corridors have been built with grassy and permeable surfaces, reflecting a water-sensitive urban design approach. Social solutions include subsidizing public transport costs to discourage car usage and conducting mixed-use zoning operations to ensure community needs such as schools, shops, services, and green spaces are met locally, thus reducing the need for private car ownership (51).

In 2022, Freiburg received the Blue Community certificate, designating it as a community that considers water a public good and supports the implementation of human rights related to access to clean water and sanitation services (52). In 2023, the first European solar-panel-equipped bike path was inaugurated [Fig.20] (53).

To promote biological diversity, the city has initiated the funding program 'Species Protection in the City', based on the planting of native trees, the installation of bird and bat boxes and insect hotels, the creating of water bodies and biotopes, cairns and dry stone walls with sand lenses. Additionally, the city has implemented actions such as long-term monitoring of insect and vegetation populations in open areas throughout the city and reducing the use of pesticides (54).

Fig. 17 (in the previously page) - Map of the city of Freiburg im Breisgau reworked of data from various sources.
Source: [www.geoportal.freiburg.de/freigis/ ; www.opencyclemap.org/ ; www.costoffood.wordpress.com/wp-content/uploads/2013/06/compass-inside-english.jpg ; www.nature.uni-freiburg.de/teaching/Insektenhaeuser-en].

Fig. 18 - Aerial view of the historic centre of Freiburg im Breisgau
Source: [www.vvisit.freiburg.de].

Fig. 19 - Bächle (canaletti) of Freiburg; the first documentation mentioning them dates back to 1220, and they were designed to supply the city with water and combat fires.
Source: [www.booking.com].

Fig. 20 - The first European bicycle lane equipped with solar panels.
Source: [www.pv-magazine.it].

(40) Stadt Freiburg. *Climate change and a sustainable lifestyle: Energy and climate protection*. Available at: https://greencity.freiburg.de/pb/elements/energy_climate_protection.html (Accessed: 10 November 2023).

(41) City of Freiburg im Breisgau. *Environmental and Climate Protection in Freiburg*. Freiburg: City of Freiburg im Breisgau.

(42) Reckien (2014) 'Climate change response in Europe: What's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries', *Climatic Change*, 122, pp. 331-340.

(43) Gutachten Öko-Institut (2007) *Klimaschutzkonzept Freiburg 2007*. Freiburg: Öko-Institut e.V.

(44) City of Freiburg im Breisgau. *Klimaanpassungskonzept Handlungsfeld Hitze: Ein Fachkonzept mit zwei Auszeichnungen*. Freiburg: Stadt Freiburg.

(45) City of Freiburg im Breisgau (2019) *Freiburger Klimaschutzkonzept 2019: auf dem Weg zur klimaneutralen Kommune*. Freiburg: Stadt Freiburg.

(46) City of Freiburg im Breisgau. *Klimaschutzpolitik*. Available at: www.freiburg.de/pb/,Lde/232053.html (Accessed: 12 November 2023).

(47) City of Freiburg im Breisgau. *Biodiversitäts-Aktionsplan*. Available at: https://www.freiburg.de/pb/1448173.html (Accessed: 14 November 2023).

(48) City of Freiburg im Breisgau. *Freiburg: The Emblematic Green City*. Cham: Springer, pp- 69-98.

(49) tcpa (2019) *Lessons from Freiburg, Germany: A report on the learning from the PERFECT project study tour to Freiburg, Germany*. Available at: https://projects2014-2020.interreg-europe.eu/fileadmin/user_upload/tx_tevprojects/library/file_1576579826.pdf (Accessed: 13 November 2023).

(50) Otto, A., et al. (2021) *Ranking local climate policy: assessing the mitigation and adaptation activities of 104 German cities*. Available at: https://link.springer.com/article/10.1007/s10584-021-03142-9 (Accessed: 13 November 2023).

(51) Stockholm Resilience Centre. *Three things needed for successful climate adaptation in cities*. Available at: https://www.stockholmresilience.org/research/research-news/2021-09-21-three-things-needed-for-successful-climate-adaptation-in-cities.html (Accessed: 14 November 2023).

(52) City of Freiburg im Breisgau. *Menschenrecht auf Wasser: Freiburg ist Blue Community*. Available at: https://www.freiburg.de/pb/1900111.html (Accessed: 13 November 2023).

(53) Tutt, K. (2023) *Germany's first solar cycle path roofing*. Available at: https://www.solarwatt.com/company/press/news/germanys-first-solar-cycle-path-roofing (Accessed: 15 November 2023).

(54) City of Freiburg im Breisgau. *Biodiversitäts-Aktionsplan*. Available at: https://www.freiburg.de/pb/1448173.html (Accessed: 14 November 2023).

THE MICROURBAN SCALE

1.3

1.3.1
Introduction to eco-districts

Sustainability is now at the center of extensive media coverage and spans a wide range of sectors, from cities to agriculture, from economy to tourism, from industry to architecture. Despite the growing interest in this crucial issue expressed by many disciplines, there is often a tendency to resort to easy slogans that capture the public's attention, creating the illusion of innovative solutions to global problems without truly questioning the established relationship between humanity and environmental resources (1). An effective example of this trend of linguistic abuse is highlighted by Robert Engelman in the introductory chapter of the State of the World 2013 report, where he states: "The era we live in is the era of 'sustainablabla', a cacophonous profusion of uses of the term 'sustainable' to define something better from an environmental point of view or simply fashionable" (2).

One year after the publication of the Brundtland Report in 1987, within UNESCO's Man and the Biosphere (MAB) research program, **the concept of "sustainable city" emerged, which today represents a transformation process characterized by a diversity of proposals aimed at redefining the relationship between urban development and the natural environment**. These proposals also seek to provide solutions to the growing population in urban areas (3;4;5).

Reflection on eco-districts primarily focuses on the new and innovative strategies developed to address the urgency of environmental issues, particularly exploring the specificity of design choices aimed at informed and conscious management of natural resources.

Over the past 30 years, in Europe, there has been a diversified series of residential settlement projects that have sought to reconcile the conservation of the environmental heritage with urban expansion. The prefix 'eco' symbolizes a complex of elements embracing various facets, including energetically efficient building design, the adoption of renewable energy sources, sustainable management of water resources and waste, aspects that connect very different experiences in terms of settlement choices and architectural results.

The term "**eco-district**", now widely used and frequently employed by the media (6), does not refer to a specific formulation but rather identifies those projects positioned in a border area between the private sphere of housing and the public space of the city (7). These projects express a common desire to overcome the dichotomy between the natural and the urban (8).

However, despite the existence of urban public transport services, the expansion of land consumption, and the predominance of private road transport, give such projects a stamp of unsustainability (9).

In addition to the primary goal of contributing to the global reduction of polluting emissions caused by road vehicles, with a priority given to public transportation systems and cycling mobility for daily commutes, European eco-districts seek to reaffirm the importance of open public spaces by creating a network of areas designed for pedestrian accessibility (10).

Already by the late 1990s, it was demonstrated that the per capita ecological footprint, associated with building type and transportation modes, could decrease by 40% by transitioning from single-family houses to multi-story buildings (11). This data undoubtedly supports the idea of a compact and multifunctional urban fabric built around key public transportation nodes within the context of the debate on "sustainable urban forms". Indeed, studying various proposals concerning the "sustainable city" reveals that one of the main requirements is the combination of diverse uses and functions within the urban fabric. This principle is highlighted by Richard Rogers in the 'Urban Task Force', envisioning urban environments characterized by multi-story buildings housing a considerable number of inhabitants, encouraging pedestrian movement through a **mix of building functions and uses**, a vision aligned with the guidelines of the Urban Ecology Agency of Barcelona, which aims to promote urban complexity (12); a notion of sustainable neighborhoods also proposed in Switzerland, emphasizing three key elements: density, variety of functions, and sustainable mobility (13).

Despite being primarily residential-oriented projects, European eco-districts demonstrate a clear understanding of the environmental benefits of diversification, including a variable range of services and commercial activities with the aim of stimulating neighborhood vitality and, at the same time, reducing the need for travel for daily activities, thus contributing to reducing residents' **ecological footprint**.

For the most part, these projects represent a manifestation of strong public commitment translated into attention to social and economic aspects. This commitment is reflected in the creation of infrastructure and services for residents, including childcare, primary and secondary education, leisure spaces, and community activities. Furthermore, conditions are promoted for broad housing accessibility and income diversification, thanks to a multitude of publicly-funded initiatives. (14)

(1) Tabb, P. J., Deviren, A. S. (2014) 'The Greening of Architecture: A Critical History and Survey of Contemporary Sustainable Architecture and Urban Design', *The Greening of Architecture: A Critical History and Survey of Contemporary Sustainable Architecture and Urban Design*, pp. 1-193.

(2) Engelman, R. (2013) *Oltre la sosteniblablablà*. Milano: Ambiente Edizioni.

(3) Mega, V. P. (2005) *Sustainable Development, Energy and the City*. Springer.

(4) R.Camagni, R. (1996) *Economia e pianificazione della città sostenibile*. Bologna: il Mulino.

(5) Levy, A., Emelianoff, C. (2011) *Espaces et Sociétés*. Available at: https://www.researchgate.net/publication/343054225_Espaces_et_Societes
(Accessed: 12 December 2023).

(6) Lefèvre, P., Sabard, M. (2009) *Les Écoquartiers*. Rennes: Editions Apogée.

(7) Borlini, B., Memo, F. (2008) *Il quartiere nella città contemporanea*. Milano: Mondadori.

(8) Souami, T. (2011) *Écoquartiers, secrets de fabrication. Analyse critique d'exemples européens*. Available at: https://archive.org/details/ecoquartierssecr0000soua
(Accessed: 15 December 2023).

(9)Botti, M., et al. (2014) 'Sustainable Urban Regeneration and European Eco-districts', in Cappochin, G., Botti, M., Furlan, G., Lironi, S. (eds.) *Eco Districts: Strategies and Techniques for Urban Regeneration in Europe*. Venezia: Marsilio, pp. 28-45.

(10) Consonni, G. (1989) L'internità dell'esterno. Scritti su l'abitare e il costruire. Milano: Città Studi Edizioni.

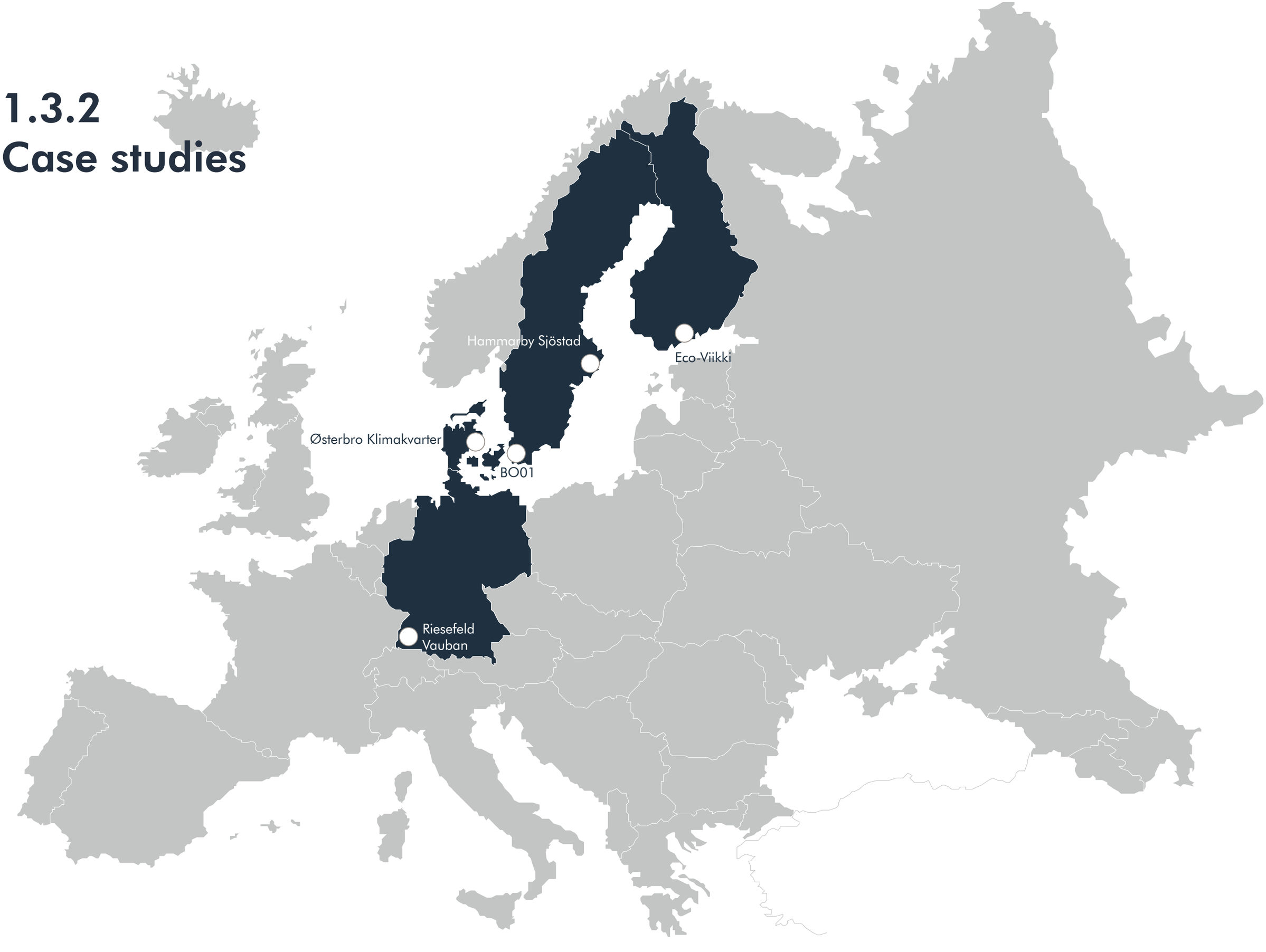
(11) Tolley, R. (2003) *Sustainable transport: planning for walking and cycling in urban environments*. Available at: https://www.semanticscholar.org/paper/Sustainable-transport-%3A-planning-for-walking-and-in-Tolley/cf85273d173042360d86cd0b49713df0fabbb4c9
(Accessed: 15 December 2023).

(12) Rueda, S., et al. (2012) *El Urbanismo Ecológico: su aplicación en el diseño de un Ecobarrio en Figures*. Available at: https://www.academia.edu/42905647/EL_URBANISMO_ECOL%C3%93GICO_Salvador_Rueda_Agencia_de_Ecolog%C3%ADa_Urbana_de_Barcelona
(Accessed: 15 December 2023).

(13) Rey, E. (2011) *Quartieri sostenibili. Sfide e opportunità per lo sviluppo urbano*. Available at: https://www.are.admin.ch/are/it/home/media-e-pubblicazioni/pubblicazioni/sviluppo-sostenibile/nachhaltige-quartiere---herausforderungen-und-chancen-fuer-die-u.html
(Accessed: 15 December 2023).

(14) Codispoti, O. (2018) *Forma urbana e sostenibilità. L'esperienza degli ecoquartieri europei*. Listlab.

1.3.2
Case studies



HAMMARBY SJÖSTAD

Stockholm, Sweden

Legend: Blue infrastructure Green infrastructure Building

Location	Stockholm, Sweden
Biogeographic region	Boreal
Critical climate issues	Increased temperatures, flooding, precipitation, sea levels and decreased salinity
Year of construction	2012
Type of intervention	Redevelopment of former industrial area
Project goals	Creation of an urban environment where living, working, studying and leisure activities are possible
Context	River
Initiative	Public
Design practice	Public
Governance level	Local
Intervention area	200 ha (160 ha + 40 ha of water)
Population size	25.000, 35.000 considering also the workers
Population density	15.625 pop./sq.km
Functional destination	Mixitè: residential, tertiary and commercial (1)

Fig. 1 - Map of Hammarby Sjöstad with data reworked from google maps.
Source: [www.google.it/maps/].

Fig. 2 - Aerial view of Hammarby Sjöstad.
Source: [www.urbandesignpoliba.wordpress.com/].

(1) Ramiti, S. (2008) *HAMMARBY SJÖSTAD.* Available at: http://www.urbanistica.unipr.it/?option=com_content&task=view&id=133 (Accessed: 8 December 2023).

(2) Gazzola, M. (2012) *Un modello per le città sostenibili de futuro: Hammarby Sjöstad*. Available at: https://www.architetturaecosostenibile.it/architettura/progetti/modello-citta-sostenibili-futuro-hammarby-sjostad-737 (Accessed: 8 December 2023).

Located 4 km south of Stockholm's city center lies the neighborhood of Hammarby Sjöstad. Translated literally, the term "Sjöstad" means "city of water" (2), a name derived from the neighborhood's position on the shores of the lake that embraces the city. This appellation reflects not only its location but also the fact that water constitutes its main source of energy.
This settlement was intended to be the hub for the 2004 Olympics, as Stockholm was a candidate to host them, but once that plan was rejected, the decision was made to finish it nonetheless and turn it into a model for inspiration.
In the 1990s, Stockholm embarked on a transformation strategy to address the growing demand for housing, redesigning some parts of the boundary between the city and the aquatic landscape of the archipelago. Among the areas affected, Hammarby Sjöstad stands out as the most significant case in terms of size and innovative character, emerging where various industrial sites once operated. This neighborhood, designed as a new low-impact residential settlement, represents a significant example of initiatives undertaken to address housing challenges.
Introducing compactness in planning and increasing density and volumes compared to prevailing standards are two aspects implemented in the project to promote greater integration of functions. This approach aims to promote proximity between residences and services, workplaces, and commercial activities, thus reducing private vehicle travel and consequently consumption.

Fig. 3 - View of Hammarby Sjöstad canal.
Source: [www.urbandesignpoliba.wordpress.com/].

Crossed entirely by a wide central road artery, Hammarby Allè serves as the main vehicular access to the settlement. It accommodates public transportation lines, and at the base of the multi-story buildings lining its path, there are commercial and tertiary activities. This layout grants the street a continuous vital center character. However, the true defining element of the neighborhood is defined by the energy circuit.

The provision of photovoltaic panels covers part of the demand, already reduced by the high construction standards of the architectural components. Waste materials are reintegrated into a cycle allowing for their nearly complete reuse for the neighborhood's operation. This "Hammarby model" is based on a compact layout design, offering various opportunities related to efficiency in the use of network infrastructure. Among these, the district heating system, already tested in the Stockholm area, and the automated system for separate collection of urban solid waste, stand out.

This latter system consists of a network of underground pneumatic pipes that transport waste, previously separated at the source through a system of colored hatches, to recycling plants or alternatively to an energy recovery facility to generate thermal and electrical energy for the neighborhood. Organic waste is used as fertilizer for non-food crops, thus contributing to the production of a portion of the biofuel destined for the district heating plant. An additional portion of biofuel is generated through the treatment of

Fig. 4 - View of Hammarby Sjöstad green area.
Source: [www.ohga.it/].

domestic wastewater, which is also used to extract biogas for cooking in households and fueling public transportation vehicles.

Stormwater management becomes part of the landscape project: for example, the waters from the Sickla Kaj area - coming from pedestrian surfaces - are collected in a system of channels and reach Lake Hammarby through the "Vattentrappa" (water staircase).

Unlike other eco-neighborhoods in Central-Northern Europe, such as Vauban or Eco-Viikki, known for their abundance of greenery and wild areas, here emerges a different conception of landscape design. This stems from the decision to create a new portion of the city characterized by compactness and density. The natural element is thus regulated and hierarchized within a system of public parks and residential courtyards with gardens and sometimes vegetable plots. In this context, the boundaries and areas of relevance of such natural elements are clearly defined.

Special attention is also given to permeability, thanks to openings at ground levels that allow pedestrians to pass through many buildings, thus connecting the neighborhood's open space system and offering multiple pedestrian travel opportunities. (3;4)

(3) Codispoti, O. (2018) *Forma urbana e sostenibilità. L'esperienza degli ecoquartieri europei*. Listlab.

(4) Cortese, G. (2019) *Hammarby Sjöstad, il quartiere ecologico e sostenibile di Stoccolma*. Available at: www.ohga.it/hammarby-sjostad-il-quartiere-ecologico-e-sostenibile-di-stoccolma/ (Accessed: 8 December 2023).

BO01

Malmö, Sweden

5

0m | 100m | 200m | 300m | 400m | 500m | 600m | 700m

Legend: Blue infrastructure Green infrastructure Building

Location	Malmö, Sweden
Biogeographic region	Continental
Critical climate issues	Increased temperatures, flooding, precipitation, sea levels and decreased salinity
Year of construction	2001
Type of intervention	Redevelopment of former industrial area on artificial peninsula
Project goals	Creation of an urban environment where living, working, studying and leisure activities are possible
Context	Coastal
Initiative	Public
Design practice	Public
Governance level	Local
Intervention area	25 ha
Population size	10.000, 30.000 considering also the workers
Population density	40.000 pop./sq.km
Functional destination	Mixitè: residential, tertiary, commercial, healtcare and cultural (5)

6

Fig. 5 - Map of BO01 with data reworked from google maps.
Source: [www.google.it/maps/].

Fig. 6 - Aerial view of Bo01.
Source: [www.stock.adobe.com/].

(5) Massimini, G. I. (2009) *BO01 CITY OF TOMORROW - MALMO.* Available at: www.urbanistica.unipr.it/?option=com_content&task=view&id=367 (Accessed: 8 December 2023).

(6) Caperna, A. (2013) *Il Quartiere Bo01 di Malmo, Svezia.* Available at: https://biourbanistica.com/blog/2013/4/8/il-quartiere-bo01-di-malmo-svezia/ (Accessed: 8 December 2023).

The Bo01 neighborhood represents the first step in the redevelopment of the Västra Hamnen area, an artificial peninsula of over 100 hectares overlooking the Øresund Strait, between Sweden and Denmark. The overall urban development choice favors a compact built environment, with carefully designed maximum volumes from an environmental standpoint, contributing to defining a spatial system with a collected atmosphere. Before its transformation into a residential neighborhood, the area was initially designated for industrial purposes, previously hosting the Kockums shipyards and later the Saab automotive company.

The heart of the Bo01 eco-district is represented by the 500 housing units, in fact “Bo” in Swedish means “to inhabit” (6), which serve as a permanent exhibition and are presented as an exemplary settlement example for their ability to combine “environmental sustainability, social aspects, and urban quality”.

The urban organization of Bo01, which accommodates approximately 1400 residents on an area of about 25 hectares, is characterized by a block layout that interprets the particular condition of the location, allowing the Øresund Canal landscape to penetrate through a series of views created by the different positions of the buildings. The diversity of architectural solutions is remarkable and reflects the participation of over forty design studios, mostly national, directly selected by the companies involved in the project. The design process began in 1996 and is

Fig. 7 - Terraced residences on a canal.
Source: [www.loquis.com/].

characterized by close collaboration among all involved parties. In addition, a consultation group composed of around three hundred members of the local community is established. Klas Tham assumes the role of project leader for the masterplan developed by the city planning office and the 'quality program', which establishes precise requirements, including maximum energy consumption allowed, exclusive dependence on renewable sources for energy supply, and specific indications for the design of green spaces to promote biodiversity. These requirements must be strictly followed by property developers.

The buildings along the Øresund Canal, characterized by square volumes of five to six floors and flat roofs, feature large openings, projecting balconies, and top-floor terraces designed to maximize panoramic views of the aquatic landscape. The Erskine Tovatt studio stands out for the design of the corner building on Scaniaplatsen, open towards the sea, with an architectural language like that of the Greenwich Millennium Village in London, characterized by distinctive 'barrel vault' roofs.

While along the Øresund Canal the design choices show common characteristics, within the neighborhood a variety of landscapes emerges from terraced houses with gardens - interpreted in diverse ways by the designers, often using wood and colorful plaster - to three to four-story buildings defining a shared green courtyard. An example of terraced houses is the Core project by MIMA arkitekter, consisting of four wooden units

Fig. 8 - Internal courtyard of a residential lot.
Source: [/www.welchdesignstudio.com/].

with pitched roofs and a rear terrace. Meanwhile, among the three to four-story buildings, the Treehouse 2001 building, designed by Danes Kim Dalgaard and Tue Traerup Madsen along Ankarparken, stands out, featuring two wooden buildings with facades equipped with long balconies.

Some Bo01 buildings serve as a testing ground for European guidelines on building materials. For example, the 'European Village', with twelve residences in the northern part of the neighborhood, includes the Det Norske Hus - 'the Norwegian house' - end building designed by Bjørn Larsen, featuring a wooden structure and a southern facade with a double-height solar greenhouse. Solar energy is used to produce domestic hot water and underfloor heating. The apartments in the Tango building, designed by Moore Ruble Yudell Architects and Planners & SSWECO FFNS Arkitekter, boast cantilevered glazed pavilions overlooking the collective garden and a 'smart wall' for daily energy consumption measurement. The Tegelborgen building by Månson Dahlbäck Arkitektontor, overlooking the Øresund Canal, features a geometric facade combining brick cladding and large windows to make the most of natural light.

The energy supply in Bo01 is based solely on renewable sources, including geothermal, solar energy - with a surface area of 1400 m2 of solar panels distributed over nine buildings - and wind energy. Most of the electricity is produced by a 2 MW wind turbine located in the Norra Hamnen

Fig. 9 - View of Erskine Tovatt's project, characterized by distinctive 'barrel covers'.
Source: [www.cityseeker.com/].

area, about 3 km from Bo01, supplemented by photovoltaic panels.
Food waste from kitchen sink disposals in approximately two hundred apartments is recovered and converted into biogas. An underground pneumatic piping system, like that of the Hammarby Sjöstad eco-district in Stockholm, allows for the recycling of various fractions of solid waste.
The rainwater management system is articulated on different scales, using small ducts along the perimeter of the buildings, real channels like the one next to Ankarparken, which winds through sinuous banks and marks the eastern boundary of Bo01, and artistic installations like the wall with one hundred and two faucets of Waterfall, created by Kari Caven. These artistic works aim to raise awareness among residents and visitors about the value of water resources.
A 120 m2 'glass bubble' designed by Monika Gora in 2006 offers a sheltered space protected from winter winds. Positioned halfway along the promenade on the Øresund Canal, accompanied by long wooden steps, this space serves as an attractive destination for the entire city, offering the opportunity to contemplate the water landscape and the green expanse of Daniaparken. (6;7)

(7) Codispoti, O. (2018) *Forma urbana e sostenibilità. L'esperienza degli ecoquartieri europei*. Listlab.

ØSTERBRO KLIMAKVARTER

Copenhagen, Denmark

Legend: Blue infrastructure · Green infrastructure · Building

Location	Copenhagen, Denmark
Biogeographic region	Boreal
Critical climae issues	Increased temperatures, flooding, precipitation, sea levels and decreased salinity
Year of construction	2016
Type of intervention	Climate adaptation of a pre-existing area
Project goals	Creation of an experimental ecodistrict in order to define a series of measures and solutions that can eventually be repeated in other areas of the city
Context	Coastal
Initiative	Public
Design practice	Public
Governance level	Public
Intervention area	105 ha
Population size	81.278
Population density	8.248 pop./sq.km
Functional destination	Mixitè: residential, tertiary, industrial and commercial

Fig. 10 - Map of Østerbro Klimakvarter with data reworked from google maps.
Source: [www.google.it/maps/].

Fig. 11 - Tåsinge Plads.
Source: [www.klimakvarter.dk/wp-content/uploads/2015/06/TP-mod-Vennemindevaej.jpg].

(8) Larsen, R. S. (2018) *Copenhagen: World's First Climate-Resilient Neighborhood.* Available at: www.goexplorer.org/copenhagen-worlds-first-climate-resilient-neighborhood/ (Accessed: 9 December 2023).

(9) Tolderlund, L. (2023) *Østerbro Klimakvarter - The First Climate Adaptation Neighborhood in Denmark.* Available at: www.livingarchitecturemonitor.com/articles/sterbro-klimakvarter-the-first-climate-adaptation-neighborhood-in-denmark-fa23 (Accessed: 9 December 2023).

As the municipality of Copenhagen has learned that large-scale renovations of grey infrastructure are not always the best response to climate change, faced with increasing flood rates, the Danish capital has created the world's first climate-resilient neighborhood, known as Østerbro Klimakvarter.
The pre-existing district served as a pioneering project for the city, aimed at testing affordable solutions that could be reproposed around the city whether deemed effective for the adaptation of the urban fabric to extreme weather conditions using green infrastructures that could also enhance the quality of life of its inhabitants.
This concept is more cost-effective to implement and maintain compared to expanding sewers, reducing the financial impact of extreme weather events (8).
Completed in 2018 and commissioned by the Municipality of Copenhagen, and carried out in collaboration with Malmos, GHB Landskabsarkitekter, Orbicon, VIA Traffic Counseling and Feld Studio for Digital Craft, Nature-Based Design Studio SLA, Tredje Natur Architects, NIRAS, and HOFOR (9) in 2013, the project was selected by Sustainia100 as a visionary and innovative solution for the future climate-resilient city, while in 2016, it won the International Guangzhou Award for Urban Innovation.
The project is composed by various intervention areas, that are: Tåsinge Plads, Skt. Kjelds Plads and Bryggervangen (9).
Designed by GHB Landskabsarkitekter, Tåsinge Plads [Fig. 8;9;11] is a green oasis that both

Fig. 12 - Aerial view of Tåsinge Plads.
Source: [www.cgconcept.be/overstromingsparken-voor-kopenhagen/].

Fig. 13 - Biowswale with curb cut and overflow drain.
Source: [www.livingarchitecturemonitor.com/].

manages large amounts of rainwater and creates a new meeting place for the neighborhood's residents. The square's 1000 square meters of urban wilderness can altogether delay and infiltrate rainwater from a surrounding area of approximately 8000 square meters. By diverting and infiltrating rainwater from roofs and squares locally, the water is kept away from the sewer, which can therefore better handle future cloudbursts. The project was particularly important for the Municipality of Copenhagen because it confirmed that cloudburst protection can consist of more than just sewers and underground facilities. The square is furnished with light installations: Water droplets and rain umbrellas. The drop-shaped containers mirror the sky and invite people to touch and climb on them. With manual pumps, one container can be made to release its water content, which is then directed into the vegetation (10).
Designed by Tredje Natur, Skt. Kjelds Plads is an area where 7 streets converge into a delimited urban space of 8,000 m2. The square serves as the physical central point and is intended to become the natural meeting and gathering place for the neighborhood in the future. Considering its central location and size, it has the potential to serve as a showcase and exhibition space for the climate district, both nationally and internationally. Its design is inspired by the landscape in Denmark known as "Dødis" (literally "dead ice"), which naturally occurs in various places throughout Denmark. The transformation of Sankt Kjelds, originally a large roundabout designed for

(10) Dansk Arckitektur Center (2015) ***Tåsinge Plads: Et pionerprojekt i Danmarks første klimakvarter. Byrum.*** Available at: www.dac.dk/viden/arkitektur/taasinge-plads-et-pionerprojekt-i-danmarks-foerste-klimakvarter/ (Accessed: 9 December 202).

Fig. 14 - Urban forniture in Tåsinge Plads.
Source:[www.klimakvarter.dk/en/projekt/tasinge-plads/].

(11) Mezzi, P. (2020) ***Climate change/4. Danimarca docet.*** Available at: www.ilgiornaledellarchitettura.com/2020/06/20/climate-change-4-danimarca-docet/ (Accessed: 9 December 2023).

(12) Thomsen, F. R., Schrøder, O. (2016) ***THE FIRST CLIMATE DISTRICT.*** Available at: www.tredjenatur.dk/en/portfolio/the-first-climate-district/ (Accessed: 9 December 2023).

(13) Jørgensen, L. (2024) Copenhagen Climate-Resilient Neighbourhood strategy. Available at: https://use.metropolis.org/case-studies/copenhagen-climate-resilient-neighbourhood-strategy (Accessed: 9 December 2023).

vehicular traffic, has given the square a strong identity, turning it into a recognized urban space. The result is a new area that provides the idea of nature at hand, thanks to the planting of 586 new trees of native species (11).
Bryggervangen serves as a pivotal street in the district's climate resilience efforts. Tredje Natur refers to it as "The Green Spring," taking into account Kildervældsparken and the water flowing into the street. The St. Kjelds district forms a watershed peaking south of St. Kjelds Square, offering an ideal solution for water drainage. By optimizing the placement of parking lots and adjusting the street width, space is created for water drainage, greenery, and new bicycle paths (12).
The Copenhagen Climate-Resilient Neighborhood strategy presents an innovative approach to climate adaptation: through this initiative, ground-level "green" and "blue" solutions are being implemented to effectively manage rainwater flow in urban areas, enhancing the neighborhood's resilience against cloudburst damage. Developed through collaboration between the Central City Planning Office, the Integrated Urban Renewal office in St. Kjelds, and HOFOR, Copenhagen's largest utility company, the strategy incorporates features like bicycle paths doubling as stormwater channels, water towers, and canals diverting water to the harbor. These municipal climate adaptation measures, complemented by smaller private initiatives such as green roofs and rain gardens, from the basis of its strategy (13).

ECO-VIIKKI

Helsinki, Finland

15

0m | 100m | 200m | 300m | 400m | 500m | 600m

Legend: Blue infrastructure Green infrastructure Building

Location	Helsinki, Finland
Biogeographic region	Boreal
Critical climate issues	Increased temperatures, flooding, precipitation, sea levels and decreased salinity
Year of construction	2010
Type of intervention	Ex novo
Project goals	Creation of pilot ecological settlements to promote sustainable and innovative solutions
Context	Peripheral
Initiative	Public
Design practice	Participatory
Governance level	Local
Intervention area	23 ha
Population size	1700
Population density	7.390 ab/km^2
Functional destination	Residential (14)

16

Fig. 15 - Map of Eco-Viikki with data reworked from google maps.
Source: [www.google.it/maps/].

Fig. 16 - Aerial view of Eco-Viikki.
Source: [Eco Viikki: Aims, Implementation and results].

(14) Castriotta, S. (2009) *ECO QUARTIERE VIIKKI.* Available at: www.urbanistica.unipr.it/?option=com_content&task=view&id=423 (Accessed: 11 December 2023).

In 1994, the Ministry of the Environment and the Finnish Association of Architects (SAFA) issued an invitation to local administrations to participate in a program aimed at creating pilot ecological settlements. This initiative aimed to identify potential project areas to promote sustainable and innovative solutions.
In the same year, Petri Laaksonen won an international competition for the design of a new "ecological neighborhood." The project is located in the southern part of the vast Eco-Viikki area, covering approximately 23 hectares, intended to accommodate 1700 inhabitants. The layout is structured with sequences of buildings aligned along an east-west axis to allow for optimal exposure to the buildings.
The idea also involved the alternation of "green corridors" between the buildings, allowing nature to infiltrate within the settlement, especially in the southern direction. This innovative and sustainable design promoted a harmonious integration between the built environment and the natural environment, thus creating an ecological neighborhood that prioritized energy efficiency and positive interaction with the surrounding nature.
The privileged location allowed residents to enjoy direct contact with a natural area while also offering relative proximity to the city center. Additionally, thanks to the expansion of the nearby university campus, job opportunities were created in the immediate vicinity of the residences. This strategic choice aimed to promote a sustainable

Fig. 17 - Urban vegetable garden designed among the residences.
Source: [Eco Viikki: Aims, Implementation and results].

Fig. 18 - Houses with solare greenhouse.
Source: [Eco Viikki: Aims, Implementation and results; pag. 52].

lifestyle by fostering a connection with nature while ensuring easy access to urban resources.
In 1995, the Department of Urban Planning developed a detailed program for the implementation of the new ecological neighborhood. The program included comprehensive guidelines regarding housing layouts, natural light management, building heights, the use of renewable energies, materials used, and parking arrangements. To implement these directives, specific competitions were organized for each of the neighborhood's lots, which were subsequently developed by both public and private operators, as well as future resident cooperatives.
Each lot was required to present detailed plans for the management of rainwater, waste, and parking. The projects had to conform to the requirements of the Pimwag environmental assessment system, specially created in 1997 at the request of the Helsinki Planning Department and the Ministry of the Environment. This system included five assessment areas, each associated with a score: pollution, availability of natural resources, environmental health, biodiversity, and food resource production.
Within the context of Eco-Viikki, the buildings are organized into blocks of row apartments, with a height of four to five floors. These blocks feature linear volumes with a distinct articulation and transparency of facades facing the internal green spaces. The intention is to create an architectural edge that contrasts with the smaller-scale terraced houses in the area, which are united by a widespread use of wood.
The buildings in Eco-Viikki stand out for the implementation of advanced strategies in terms of energy sustainability. The perimeter walls have significant insulation thickness, with particular attention to thermal bridge treatment. Additionally, they are equipped with highly efficient windows and adopt both heat recovery from indoor air and active and passive use of solar energy.
Solar panels dedicated to domestic hot water production are installed in eight lots, comprising a total of 368 units. These panels meet approximately one-third of the total annual demand. In the northern area of the neighborhood, a project included in the European SUNH (Solar Urban New Housing) program was completed in 2001. This project, which includes 44 units, features characteristics such as solar greenhouses, an advanced mechanical ventilation system with heat recovery, and solar collectors covering 60% of the hot water demand.
The 'Salvia solar-energy house', completed in 2003, is a multi-story building with photovoltaic panels integrated directly into balcony parapets. This solution contributes to covering approximately 15% of the total energy demand of the 39 units.
Exploring Eco-Viikki, the attention to the design of appropriate slopes in the open space system, aimed at facilitating the conveyance and disposal of rainwater, is clearly evident. The presence of a network of small open-air channels is also apparent. A collection and drainage network has

been specifically developed, converging towards the three “green corridors”, allowing water runoff into the Viikinoja canal. The lush vegetation of gardens and orchards, dotted with fruit trees, emerges as a predominant element in the structure of the open space system. This system takes on a branching configuration starting from the “green corridors”, manifesting a progressively more collected and private character. This design offers Eco-Viikki residents the opportunity to maintain a close proximity connection with the natural element, creating a vibrant and sustainable scenario.

A continuous public space has been designed, articulated into three wide parallel paths traversing the neighborhood. These paths provide access to the system of semi-private spaces between the rows of residences, as well as specific common parking areas. In order to meet the demand generated by multi-story residential buildings, a parking lot with over 100 spaces has been created. Positioned along the entire northern edge, this parking lot also serves as a dividing element between Eco-Viikki and nearby residential areas. (15)

Fig. 19 - Viikinoja canal.
Source: [Eco Viikki: Aims, Implementation and results; pag.29].

Fig. 20 - Cultivable area that can be transformed into a parking area if necessary.
Source: [Eco Viikki: Aims, Implementation and results; pag.33].

(15) Codispoti, O. (2018) *Forma urbana e sostenibilità. L’esperienza degli ecoquartieri europei*. Listlab.

VAUBAN

Freiburg im Breisgau, Germany

21

0m 100m 200m 300m 400m 500m 600m

Legend: Blue infrastructure Green infrastructure Building

Location	Freiburg im Breisgau, Germany
Biogeographic region	Continental
Critical climate issues	Rising temperatures, loss of biodiversity, urban heat islands, invasive species, drought
Year of construction	2006
Type of intervention	Redevelopment of former military area
Project goals	Traffic restriction in the neighborhood and priority to private or cooperative housing projects.
Context	Peripheral
Initiative	Public
Design practice	Participatory
Governance level	Local
Intervention area	40 ha
Population size	5000
Population density	12.500 pop./sq.km
Functional destination	Mixitè: residential and commercial (16;17)

22

Fig. 21 - Map of Vauban with data reworked from google maps.
Source: [www.google.it/maps/].

Fig. 22 - Aerial view of Vauban.
Source: [www.researchgate.net].

(16) Silvia (2008) *VAUBAN*. Available at: www.urbanistica.unipr.it/?option=com_content&task=view&id=171 (Accessed: 11 December 2023).

(17) Multilab, Vauban. Da area dismessa a modello di green city equa e sostenibile. Available at: www.darsenaravenna.it/home-tematica-collabora/magazzini/cerchi-ispirazione-ti-raccontiamo-dei-progetti/progetto-vauban (Accessed: 11 December 2023).

A few kilometers south of the city center lies the Vauban neighborhood, an advanced model of sustainable urban development. Vauban's distinctive feature is its design aimed at minimizing environmental impact, with particular attention to limiting car traffic, which is virtually absent in this area.

In 1994, the municipality held a competition for urban planning design, which was won by the Kohlhoff&Kohlhoff studio. The masterplan developed was subsequently refined in collaboration with citizens through working groups and workshops. Key elements of the project include the overall layout, building energy efficiency standards, the mobility system, certain aspects related to stormwater management, and the presence of green roofs, remaining fixed throughout the development process.

Even during the implementation phase, which began in 1998, the Vauban Forum played a crucial role in promoting the formation of a consulting company and the Genova housing cooperative (GENOssenschaft VAuban). These entities provide technical and financial assistance to future residents, facilitating their aggregation into Baugruppen. These groups consist of future residents, architects, and financiers who organize within cooperatives. They proceed to purchase the plot from the municipality at a fixed price, subsequently initiating construction in accordance with the masterplan's guidelines.

The configuration of the linear building structures results from the overlapping of various residential

Fig. 23 - Solar village designed by Rolf Disch.
Source: [www.visit.freiburg.de].

structures, whose varied facades succeed one another to form the overall building complexes. These are unified through the uniformity of the eave heights and the presence of continuous bands of greenery, characterized by shrubs and trees. These bands also serve to protect the private spaces of the dwellings facing them.
The creation of low-energy buildings and the adoption of neighborhood-level centralized heating systems have been two central objectives of the project since its early stages. The buildings are connected to a district heating network powered by a pellet thermal plant with combined electricity and heat production. This result is achieved through the use of significant insulation thicknesses, triple-glazed windows, solar panels for domestic hot water production, and the integration of green roofs.
Within the neighborhood, there are also passive houses, totaling 170 units, among which the multi-story residence 'Wohnen & Arbeiten' (living and working) stands out, built on the initiative of sixteen families. This residence features external distribution stairs and walkways designed as social spaces.
Across Merzhauser Straße, the Solarsiedlung designed by Rolf Disch consists of "energy surplus houses." These homes, powered exclusively by renewable energy, significantly reduce energy consumption, even generating more energy than consumed.
The renovation of the four barracks acquired from S.U.S.I., carried out in collaboration with future

Fig. 24 - Reuse of a former military barracks into a socio-cultural center Haus 037.
Source: [www.alemannische-seiten.de].

residents, each dedicating over 100 hours of work, aims to transform the buildings into housing for low-income brackets. This intervention is based on ecological criteria, including the use of recycled or salvaged materials, electricity production through a cogeneration plant fueled by rapeseed oil, and rainwater recovery for garden irrigation.
The extensive presence of green areas and the creation of an articulated system of slopes, depressions, and channels allow for the almost complete retention of stormwater within the neighborhood or its redirection to collection basins, later slowly channeled into the Dorfbach stream flowing along Vauban's southern edge.
Within the plan, Vaubanallee, with a speed limit of 30 km/h, represents a central element in the project's organization. Along this artery are also the main public spaces, such as Alfred Döblin Platz, a venue for outdoor events and the weekly market. The Haus 037 center, located in one of the barracks buildings, hosts spaces for neighborhood activities, events, and religious functions. Despite residential volumes with porticoed frontages on the ground floor, often intended for commercial activities, and distribution roads along with transverse parks extending north and south of it, there is limited effectiveness in enhancing the reservoir and character of this open space. These risks turning it into a mere transport infrastructure serving the neighborhood, particularly near the barrier represented by the railway.
Although not a project entirely devoid of vehicles, Vauban emphasizes pedestrian and cycling

mobility. The internal network of the settlement is specifically dedicated to pedestrians and cyclists, free from car traffic and parking. The latter are only allowed for loading and unloading operations. (18;19)

Fig. 25 - Residential street dedicated to pedestrians.
Source: [Eco Viikki: Aims, Implementation and results].

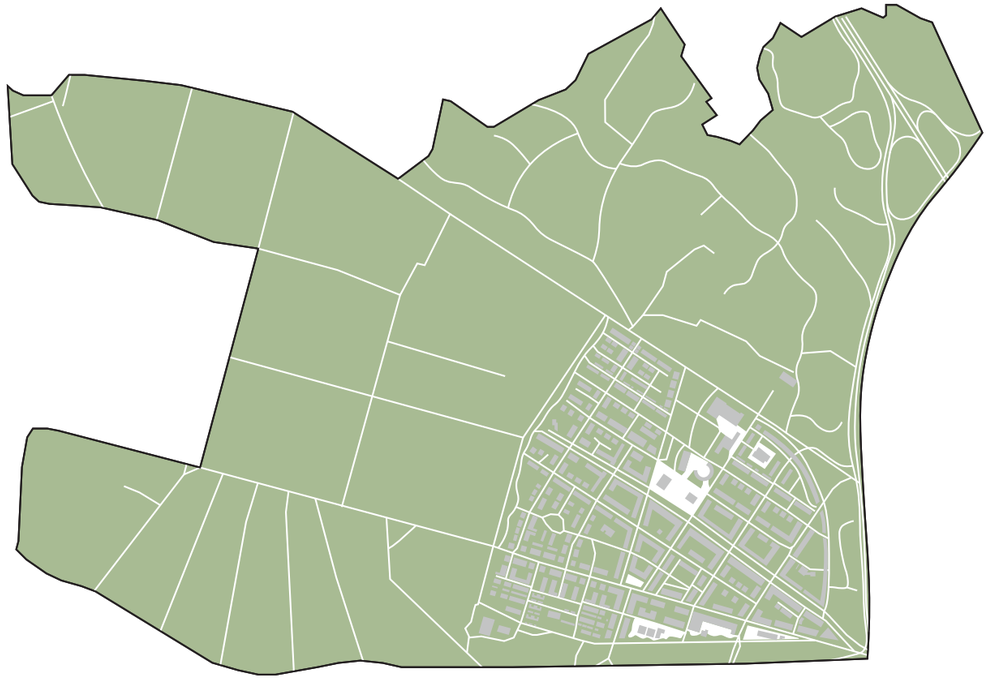
(18) Codispoti, O. (2018) Forma urbana e sostenibilità. L'esperienza degli ecoquartieri europei. Listlab.

(19) il Post (2023) Il quartiere di Friburgo che vuole fare a meno delle auto. Available at: https://www.ilpost.it/2023/09/10/friburgo-vauban-germania/ (Accessed: 11 December 2023).

RIESELFELD

Freiburg im Breisgau, Germany

26



0m 5m 10m 15m 20m 25m 30m

Legend: Blue infrastructure Green infrastructure Building

Location	Freiburg im Breisgau, Germany
Biogeographic region	Continental
Critical climate issues	Rising temperatures, loss of biodiversity, urban heat islands, invasive species, drought
Year of construction	2010
Type of intervention	Redevelopment of an area designated for wastewater treatment
Project goals	The creation of public infrastructures from the outset and the initiation of participatory design processes.
Context	Peripheral
Initiative	Public
Design practice	Participatory
Governance level	Local
Intervention area	320 ha of which only 70 are buildable
Population size	Approximately 11.000
Population density	15.715 pop./sq.km in the buildable area
Functional destination	Mixitè: residential, commercial and services (20)

27

Fig. 26 - Map of Rieselfeld with data reworked from google maps.
Source: [www.google.it/maps/].

Fig. 27 - Aerial view of Rieselfeld.
Source: [www.freiburg.de].

(20) Giovanni, (2008) *QUATIERE RIESELFELD*. Available at: www.urbanistica.unipr.it/?option=com_content&task=view&id=82 (Accessed: 11 December 2023).

(21) Freiburg Wirtschaft Touristik und Messe GmbH + Co. KG. *Quartiere Rieselfeld*. Available at: www.visit.freiburg.de/it/attrazioni/quartiere-rieselfeld (Accessed: 11 December 2023).

Since 1995, to the west of Freiburg, a new and attractive neighborhood has developed over an area of 70 hectares: Rieselfeld, an example of urban and architectural design. Today, this model neighborhood is known for its pleasant open building structures, abundant greenery, and open spaces. With facilities for childcare, schools, shops, restaurants, medical practices, and modern service companies, Rieselfeld, a traffic-limited neighborhood, offers the convenience of having many daily needs within short distances (21).
Among the main objectives of the municipality of Freiburg for the Rieselfeld eco-district is the establishment of public infrastructure from the outset and the activation of participatory design processes. Half of the housing has been developed with “public subsidies aimed at moderating sale prices and rents,” while the other half follows market dynamics, promoting at the same time the construction of a sense of community and belonging.
Planning directives have emphasized an eco-sustainable building policy from the outset. Over an area of 320 hectares, of which only 70 are designated for construction, a decision by local authorities aimed to allocate the rest of the area to protected parks. Initially used as a zone for wastewater treatment plants, this area was later moved 15 km from the city: since the 1990s, it has been made available for construction through a soil reclamation process.
Buildings are positioned and spaced to ensure optimal exposure and prevent shading phenomena.

Fig. 28 - Rainwater collection basin.
Source: [www.architetturaecosostenibile.it].

From an energy perspective, the municipal administration foresees the supply of energy from renewable sources, particularly photovoltaic and heat pumps, as a binding practice aiming to reduce heating energy consumption. Buildings are connected to a district heating network powered by a cogeneration plant, located in the nearby Weingarten district, which produces thermal and electrical energy in a combined manner.

A dense network of green spaces characterizes the entire municipal territory on various scales: the gardens of the different blocks are interconnected and linked to large public parks through a green structure composed of tree-lined avenues. The block structure of the neighborhood has a clear interruption near the Freiburger Rieselfeld nature reserve, which, extending over 250 hectares, is one of the largest in Germany, creating a marked division between built-up areas and green areas. This boundary is emphasized by a thin pedestrian path marking the settlement's limit. There are two exceptions to this interruption: the first is represented by a series of small parks located within some contiguous blocks, integrating stormwater management basins into the overall landscape; the second is the Neunaugenbach canal, characterized by grassy and tree-lined banks, which crosses residential plots and connects to the small lake Dietenbachsee beyond Besançonallee. This canal also intersects a park that penetrates the neighborhood from the north, passing by school buildings and sports facilities, including a gym that forms the head on Rudloff Platz in the form of an

Fig. 29 - Green tram infrastructure.
Source: [www.architetturaecosostenibile.it].

artificial hill, creating continuity with the system of agricultural and natural areas surrounding Rieselfeld.

Stormwater is collected and reused for irrigation of the neighborhood's green spaces, and after a phytodepuration process, it is channeled into the nearby nature reserve, contributing to the maintenance of the original wetland habitat. To discourage the use of private cars and reduce emissions, strict traffic management measures have been implemented, promoting the use of bicycles and public transportation. Priority respect for pedestrians, cyclists, and the tram connecting the neighborhood to the center of Freiburg is required on the entire road network. The speed limit is set at 30 km/h, some streets, reserved for play, are completely closed to traffic, and all areas of the neighborhood are easily accessible by public transport. (22;23)

(22) Codispoti, O. (2018) *Forma urbana e sostenibilità. L'esperienza degli ecoquartieri europei*. Listlab.

(23) Tarquini, V. (2015) *La trasformazione di Rieselfeld, quartiere ecosostenibile di Friburgo*. Available at: www.architetturaecosostenibile.it/architettura/progetti/trasformazione-rieselfeld-friburgo-525 (Accessed: 11 December 2023).

ADAPTATION AND MITIGATION

2

NATURE AS A TOOL

2.1

2.1.1.
Nature-Based Solutions

The following chapters will illustrate the concepts of Nature-Based Solutions (NbS) and urban biodiversity, intended as useful tools for adaptation and mitigation. This will be aimed at defining a toolkit, a compendium of solutions applicable across various scales, ranging from the urban to the neighborhood level.
So what are Nature-based Solutions? And how do they help in tackling climate change and its effects on cities and human well-being?
The term Nature-Based Solutions appeared for the first time in the early 2000s, and, more specifically, within the agricultural field. In the same period, the concept began to appear within discussions on land use planning and water resources management, while from the mid-2000s it extended to industrial planning. Moreover, from 2009, the term became more widely used in literature regarding ways to increase climate resilience. Today, the term generally refers to those kinds of solutions aimed at conserving biodiversity, adapting to climate change and using natural resources in a sustainable way (1), but it can also incorporate concepts like 'nature-based interventions,' 'ecosystem-based solutions,' and notably 'ecosystem-based adaptation'. As a matter of fact, as stated by a report by the Horizon 2020 Expert Group on NBS, this concept "extends and complements other closely linked concepts, such as the ecosystem approach, ecosystem services, ecosystem-based adaptation/mitigation, and green and blue infrastructure" (2). Also, the Jeju Declaration, bursting from the 2012 IUCN World Conservation Congress "Nature+", emphasized nature's role in bolstering social resilience, introducing the concept of "nature-based solutions" to tackle challenges related to climate change, sustainable energy, food security, and economic and social development. Similarly to IUCN, which since 2013 made NbS one of its priority program areas, also the EU BiodivERsA programme considers NbS a way to "conserve and use biodiversity in a sustainable manner" (1).
In 2015, the European Commission published the final report of an expert working group titled "Towards an EU Research and Innovation policy agenda for Nature-Based Solutions and Re-Naturing Cities." This document systematically examines the various research and innovation opportunities related to new design, implementation, and management practices that utilize natural components to support urban regeneration processes, focusing on resilience and the development of the green economy. Specifically, Nature-Based Solutions are identified as useful tools for achieving objectives such as increasing urban sustainability, restoring degraded ecosystems, implementing adaptive and mitigation measures for climate change, and improving risk management and resilience. Utilizing NbS provides practical and applicable value to the various strategies and policies that identify "natural capital" and ecosystem services as foundational elements of new urban models. Furthermore, the recent document "Toward the implementation of the Manifesto of Green Economy for architecture and urban planning" prepared by the Policy Working Group for Green Economy Architecture in Cities, as part of the 2017 General States of the Green Economy, assigns a central role to NbS in developing new action models that balance environmental, social, and economic needs. Through the use of NbS, whether individually or systematically, it is possible to contribute to intersectoral and multi-scalar strategies that leverage environmental and landscape resources and components as drivers of socio-economic development, and enhance natural capital governance tools as a means of effectively reconciling economic activities and the environment, even within innovative production chains.
Individually, **NbS are technical solutions alternative to traditional methods that use, are inspired by, or imitate natural elements to meet specific functional needs**. These solutions are also characterized by their ability to be aggregated into multifunctional systems capable of generating significant added value beyond the simple sum of their parts. NbS rely on substituting or integrating functions provided by ecological systems that would otherwise be delivered using non-renewable resources. The NbS approach is connected to concepts such as Natural Systems Agriculture, Natural Solutions, Ecosystem-Based Approaches, Green Infrastructures (GI), and Ecological Engineering. Specifically, GI represents an advanced application of NbS, which goes beyond mitigation to propose a theoretical and practical reflection on how to proactively obtain ecosystem services by enhancing the shared benefits of positive socio-ecological interactions. For this reason, GI has been recognized as an effective tool for increasing territorial and urban resilience (3).
As of today, the European Commission defines Nature-based Solutions as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience; such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions", also highlighting how "nature-based solutions must benefit biodiversity and support the delivery of a range of ecosystem services" (4).

(1) Potschin, M., et al. (2015) *Nature-Based Solutions*. OpenNESS.

(2) EC (2015) *Nature-Based Solutions & Re-Naturing Cities Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities*. Available at: ec.europa.eu/research/environment/pdf/renaturing/nbs.pdf (Accessed: 17 May 2024).

(3) Mussinelli, E., et al. (2018) *Il ruolo delle Nature-Based Solutions nel progetto architettonico e urbano*. Available at: https://oaj.fupress.net/index.php/techne/article/download/5003/5003/4968&hl=it&sa=X&ei=¡YZLZpT0OIrSy9YP5JWFwA4&scisig=AFWwaebT-CcCI_I-SwMQtYjWJNy1&oi=scholarr (Accessed: 17 May 2024).

(4) CORDIS (2023) *Nature-based solutions: Benefits and opportunities*. Available at: https://cordis.europa.eu/article/id/421771-nbs-benefits-and-opportunities-wild-et-al-2020 (Accessed: 19 May 2024).

Although the term "Nature-based Solutions" is relatively new in modern science, Indigenous Peoples and Local Communities (IPLCs) have been employing these strategies for centuries to safeguard their local environments. Despite making up less than 5% of the global population, IPLCs protect over 80% of the biodiversity in areas that store at least 24% of the total carbon in the world's tropical forests (5). An infographic produced by Tebtebba (Indigenous Peoples' International Centre for Policy Research and Education) summarizes the findings of a 2021 scoping study on the views and perspectives of Indigenous peoples regarding their role in Nature-based Solutions and their opinions on NbS principles. The infographic underscores that Indigenous peoples perceive nature as a complex web of interdependent life forms, considering it as home, and referring to it as the "foundation of life," "cradle of life," "focal point of life," or, alternatively, "spaces for life". This connection to nature forms the basis of their identity and ensures their survival, and, while Nature-based Solutions can spark debates between traditional and modern climate change approaches, for Indigenous peoples, NbS are rooted in practices and systems that have been handed down through generations, long before the term "Nature-based Solutions" was coined (6). This is just to say that, despite NbS being a relatively new concept in the urban and architectural fields, they are deeply rooted in practices that have been proven successfully by many cultures and populations during history, even if it is only now, with rising temperatures and other phenomena linked to climate change, that we are recognizing their role in making cities, and communities, resilient.

While the first scientific report on Nature-Based Solutions was published in 2009 and two EU presidency conferences on NbS were held in 2014, it was from 2015 that publications on NbS saw a massive increase, reflecting the growing interest and ongoing discussions on this topic (7).

In September 2019, the UN Climate Action Summit convened by the UN Secretary-General, brought great political attention to the power of Nature-Based Solutions for climate and sustainable development, and the NbS Coalition, co-led by China and New Zealand, launched the "NBS for Climate Manifesto", a plan to unlock the full potential of nature for climate action, with the support of more than 70 governments, private sector, civil society and international organizations, accompanied by nearly 200 initiatives and best practices from around the world (8).

Moreover, in February 2020, a coalition of 20 UK-based organizations developed a set of guidelines for the President of COP26, urging other Parties to the UN Framework Convention on Climate Change (UNFCCC) to adopt them. By May 2020, these guidelines were adopted by the "Together With Nature campaign", which urges corporate leaders to commit to 4 principles for investing in Nature-based Solutions, which are specifically designed to deliver various benefits to local communities, such as supporting livelihoods, improving health, and reducing vulnerability to climate change, and aim to address the needs of different societal sectors, particularly marginalized groups like women, with benefits being monitored and enhanced through adaptive management (9).

Alongside new guidelines aimed at defining how NbS could and should be used over time, a series of catalogues were elaborated, in order to make the use of these solutions more immediate and accessible. An example of this is the catalogue developed by the World Bank's Global Program on Nature-based Solutions (GPNBS) and the City Resilience Program (CRP) (10), or compendium funded by the European Union's Horizon 2020 research and innovation programme created in the framework of the European project GROWGREEN - Green Cities for Climate and Water Resilience, Sustainable Economic Growth, Healthy Citizens and Environments (11), among others.

Numerous are also the European knowledge platforms addressing Nature-Based Solutions for Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR). Some of them are: BISE, Climatescan, Climate-ADAPT, Natural Hazards-Nature-based Solutions Platform, Nature-based Solutions Initiative, Naturvation Urban Nature Atlas, NWRM, OPPLA, Panorama, ThinkNature, and weADAPT (12).

In general, NbS include a wide range of measures, such as green roofs, green walls, screens, and sustainable drainage systems (13). Being so, over time, many have tried to categorize them in subgroups, in order for them to be more comprehensible and easily applicable. Just as an example, Earth.Org, a leading environmental news website dedicated to providing comprehensive coverage of crucial issues affecting our planet, defines 3 major types of Nature-Based Solutions, which are:

- Type 1: The expansion and protection of existing natural ecosystems (for examples by rewetting peatlands or stopping deforestation);
- Type 2: The implementation of sustainable practices for managing or restoring ecosystems (for example through agroforestry, reforestation, and blue carbon projects);
- Type 3: The establishment of new ecosystems that can sequester greenhouse gasses (for example by constructing green buildings with green roofs and walls) (5).

Similarly, the H2020-funded UNaLab project, in its "Nature Based Solutions -Technical Handbook", published in 2019, defines 3 main typologies of NbS, which are as follows:

- Type 1: solutions that involve making better use of existing natural or protected ecosystems;
- Type 2: solutions based on developing sustainable management protocols and procedures for managed or restored ecosystems;
- Type 3: solutions that involve creating new ecosystems or managing them in a highly intrusive manner.

In the same handbook, NbS actions are categorized in:

- Type 1: Protection and Conservation Actions;
- Type 2: Restoration and Management Actions;
- Type 3: Retrofitting and Creation Actions (14).

Talking about the role of NbS in tackling climate change and its effects, in general, they have been deemed pivotal in urban revitalization and enhancing well-being in urban settings, particularly in public spaces. As an example, recent modeling research conducted by scholars at the University of Surrey suggests that implementing green roofs could potentially lead to a significant decrease in air pollution, ranging from 30 to 57% (13).

A key element of the Nature-based Solutions approach is also enhanced carbon sequestration, that is to say the capture and storage of greenhouse gasses, as GHG emissions must be reduced in order to stop climate change from occurring, or anyway to weaken its effects.

As a matter of fact, **NbS are not only useful strategies for climate adaptation, but also mitigation**. The potential of Nature-Based Solutions in addressing climate mitigation has indeed recently garnered growing attention in

(5) Beardmore, A. (2023) *Explainer: What Are Nature-Based Solutions And How Can They Help Tackle the Climate Crisis?* Available at: https://earth.org/nature-based-solutions-can-help-tackle-the-climate-crisis/ (Accessed: 20 May 2024).

(6) Nature-based Solutions Initiative (2022) *The Contributions, Perspectives and Recommendations of Indigenous Peoples on Nature-Based Solutions*. Available at: https://www.naturebasedsolutionsinitiative.org/news/the-contributions-perspectives-and-recommendations-of-indigenous-peoples-on-nature-based-solutions/ (Accessed: 18 May 2024).

(7) The University of Sheffield (2020) *Nature-based solutions: state of the art in EU-funded projects*. Available at: https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/nature-based-solutions-state-art-eu-funded-projects_en (Accessed: 18 May 2024).

(8) UN Environment Programme. *Nature-Based Solutions for Climate*. Available at: https://www.unep.org/nature-based-solutions-climate (Accessed: 19 May 2024).

(9) Nature-based Solutions Initiative (2024) *Nature-based Solutions to Climate Change*. Avaliable at: https://www.nbsguidelines.info/ (Accessed: 18 May 2024).

(10) World Bank (2021) *A Catalogue of Nature-Based Solutions for Urban Resilience*. Washington:World Bank Group.

(11) Petsinaris, F., et al. (2020) *Compendium of Nature-based and 'grey' solutions to address climate- and water-related problems in European cities*. Avaliable at: https://climate-adapt.eea.europa.eu/en/metadata/publications/compendium-of-nature-based-and-2018grey2019-solutions (Accessed: 20 May 2024).

(12) EEA (2021) *Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction*. Luxembourg: European Environment Agency.

(13) Lehmann, S. (2021) *Growing Biodiverse Urban Futures: Renaturalization and Rewilding as Strategies to Strengthen Urban Resilience*. Available at: https://www.mdpi.com/2071-1050/13/5/2932 (Accessed: 20 May 2024).

research, policy, and public discourse. As an example, a 2019 Science paper suggested that large-scale and sustained tree planting could be a highly effective strategy to mitigate climate change, and, despite debates regarding its feasibility and scientific validity, it's becoming clear that interventions addressing land use are crucial in society's response to climate challenges. The IPCC indeed emphasizes the importance of land-use change mitigation methods in limiting global warming to 1.5°C, with terrestrial ecosystem stewardship and agricultural improvements cited as key contributors.

In general, NbS for climate mitigation primarily involve conserving, restoring, or enhancing forests, wetlands, grasslands, and agricultural lands to reduce CO2 emissions or enhance carbon sequestration, but they can also reduce energy demand by providing thermal comfort and promoting active transport, potentially reducing emissions associated with heating, cooling, and transportation. Moreover, NbS may contribute to reducing embodied emissions in urban development and infrastructure provision by using alternative materials, supporting climate mitigation efforts (7).

Additionally, NbS have been recognized to be an effective if not essential tool for climate adaptation. In fact, evidence indicates that strategically deployed Nature-based Solutions can mitigate the impacts of floods and droughts (14), reduce urban temperatures through evapotranspiration and shading and so on (15).

It is also important to clarify that NbS are not a solution-to-all, but a tool that, when applied in combination with more traditional solutions, like gray infrastructures (16). While green infrastructure refers to natural systems like wetlands and forests and soils that offer additional benefits for human well-being, such as flood protection and climate regulation, gray infrastructure encompasses all those types of man-made structures such as roads and pipes (17). The utilization of gray infrastructure, like enhancing drainage networks with larger pipes, storage facilities, or pump stations, stands as usually the primary approach in urban management for alleviating inundation. However, acknowledgment of the necessity for incorporating green infrastructure alongside traditional gray drainage systems is widespread. Green infrastructure, encompassing innovations like green roofs, permeable pavement, and rain gardens, has indeed emerged as a synergistic blend of green-gray technologies, effectively enhancing urban drainage systems (18).

While gray solutions are based on the principle of human control over nature within the bounds of "normal operation", while, in contrast, nature-based solutions embrace a degree of unpredictability in ecological processes, which are considered more resilient to non-standard conditions. Also, gray solutions often rely on the expertise of civil engineers, granting them significant decision-making power, while NbS involve more ecologists and allow users to have a say in management and maintenance. Additionally, since access to nature can reflect environmental inequality, NbS in urban areas can provide more natural spaces for residents who cannot travel far to enjoy them (19), and complement hard engineering approaches, such as carbon capture and storage, in the quest to achieve net-zero emissions. That said, NbS are not a quick fix for achieving net-zero emissions, as they are most effective over long timescales and require a substantial amount of land, water resources, and time to reach their carbon saturation and mitigation potential. For instance, while older trees store more carbon, the ability of forests to sequester carbon decreases with age. But, in general, the implementation and maintenance costs of NbS are often offset by the benefits (20), and NbS can be 2 to 5 times more cost-effective than grey solutions when it comes to the economic point of view (21). For this reason, the concept of "green-gray infrastructure" has been developed (18).

Nowadays, Nature-based Solutions are implemented all over Europe also in relation to the Sustainable Development Goals defined by the European Union (22), and can offer a way to address climate change while strengthening both ecosystems and communities' resilience, playing a crucial role in promoting biodiversity conservation and mitigating the risks associated with climate change impacts (23).

In conclusion, Nature-Based Solutions are crucial to the global effort to achieve the Paris Agreement's climate goals, as they are effective, long-lasting, cost-efficient, and scalable worldwide. They complement decarbonization efforts by mitigating climate change risks and fostering climate-resilient societies, and emphasize harmony between people and nature, also promoting ecological development and offering a holistic, people-centered response to climate change (24).

(14) The Nature Conservancy (2024) *Accelerating Adaptation: Exploring the promise and limitations of nature-based solutions in the race to adapt to increasing floods and droughts.* Available at: https://www.nature.org/en-us/what-we-do/our-insights/perspectives/accelerating-adaptation-nature-based-solutions/ (Accessed: 21 May 2024).

(15) Johnson, B. A., et al. (2022) 'Nature-based solutions for climate change adaptation: A systematic review of systematic reviews', ***Nature-Based Solutions***, 2.

(16) Anderson, C. C., et al. (2022) *Green, hybrid, or grey disaster risk reduction measures: What shapes public preferences for nature-based solutions?* Available at: https://www.sciencedirect.com/science/article/pii/S0301479722003000?via%3Dihub (Accessed: 20 May 2024).

(17) Conservation International. *GREEN-GRAY INFRASTRUCTURE: Working with nature to protect vulnerable communities.* Available at: https://www.conservation.org/projects/green-gray-infrastructure (Accessed: 20 May 2024).

(18) Chen, W., et al. (2021) 'The capacity of grey infrastructure in urban flood management: A comprehensive analysis of grey infrastructure and the green-grey approach', ***International Journal of Disaster Risk Reduction***, 54.

(19) Bouleau, G., et al. (2021) *Grey Solutions versus Nature-based Solutions: which infrastructures to prevent pollution in urban water bathing sites?* Available at: https://www.ippapublicpolicy.org/file/paper/60c2860134b78.pdf (Accessed: 20 May 2024).

(20) Eisenberg, B., Polcher V. (2019) *Nature Based Solutions -Technical Handbook.*

(21) Tye, S. (2022) *How to Scale Up Nature-based Solutions for Adaptation.* Available at: https://www.wri.org/insights/how-scale-nature-based-solutions-adaptation (Accessed: 17 May 2024).

(22) Faivre, N., et al. (2017) 'Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges', ***Environmental Research***, 159, pp. 509-518.

(23) Lera, M., et al. (2021) *Nature Based Solutions for climate change mitigation.* Available at: https://www.unep.org/resources/report/nature-based-solutions-climate-change-mitigation (Accessed: 18 May 2024).

(24) European Commission (2019) *The Nature-Based Solutions for Climate Manifesto.* Available at: https://cordis.europa.eu/article/id/421771-nbs-benefits-and-opportunities-wild-et-al-2020 (Accessed: 20 May 2024).

2.1.2.
Urban biodiversity and human-nature coexistence

Over the centuries, humanity has evolved into a powerful force capable of transforming the planet, with such profound changes that they could potentially disrupt Earth's entire system. In 2020, scientists discovered that, for the first time, the total weight of all human-made objects surpassed the combined weight of all living things (biomass) on Earth. In other words, the total mass of buildings, roads, plastic, bricks, concrete, and other human-made materials now outweighs all animals and plants (1). Driven by the rise of science, technological advancements, and the subsequent Industrial Revolution, our current disconnect from nature has developed over the past 300 years, with a transition, within a relatively short period of time, from a life largely spent outdoors to one predominantly spent indoors and within urban environments. This shift has fundamentally altered our relationship with nature. In the contemporary world, an overwhelming proportion, that is to say almost 90%, of our time is spent indoors (2), with an escalating amount of time dedicated to solitary online "screen time". Recently, the livability of many urban areas has seen a decline, marked by challenges such as air pollution, worsening traffic congestion primarily caused by private vehicles, and housing costs spiraling beyond reach. To ensure cities remain desirable places to live amidst burgeoning populations, our urban planning strategies must adapt (3).

The recent COVID-19 pandemic has underlined the importance of having direct access to small green spaces or rooftop gardens, leading to a reevaluation of housing priorities that places renewed emphasis on factors like sunlight exposure and physical and visual access to green spaces, which architects have previously overlooked.

The concept of **biophilia**, introduced in the 1960s by German psychologist and academic Erich Fromm to describe "the passionate love of life and of all that is alive" and later expanded in 1984 by Edward Osborne Wilson, a biology professor at Harvard University, suggests humans possess an innate inclination to connect with nature and other living beings. As predicted by Rachel Carson in "Silent Spring" in 1962, we are now reevaluating our bond with nature and acknowledging its vital role in our well-being. This realization doesn't mean abandoning technology but rather harnessing advanced technologies and nature-inspired solutions to create innovative urban solutions.

Biophilic urbanism leverages nature's calming and cooling effects in urban planning, exploring ways to blend density with greenery to fortify urban resilience. Successful initiatives in cities such as Singapore, Milan, and Barcelona have demonstrated that dense urban landscapes can coexist harmoniously with abundant green spaces: the key is to increase urban density while concurrently expanding accessible green areas and integrating vegetation into the urban fabric, including novel methods like urban agriculture and rooftop farming on large structures. Therefore, advancing urban density should coincide with a simultaneous expansion of green spaces and seamless integration of vegetation into urban environments (4).

But why is nature so important for our well-being? In recent years, there has been renewed interest in the role of green spaces in promoting healthy living in urban areas, as it has been growingly recognized that green and blue spaces offer significant benefits for human health and well-being.

At the 5th Ministerial Conference on Environment and Health, held in 2010 in Parma, WHO European Region Member States committed to providing every child with access to healthy environments and green spaces for physical activity by 2020. Improving access to urban green spaces is also part of the United Nations Sustainable Development Goal 11.7, which aims for universal access to safe, inclusive, and accessible green and public spaces by 2030, particularly for women, children, the elderly, and people with disabilities. Additionally, the WHO Action Plan for the European Strategy for the Prevention and Control of Noncommunicable Diseases of 2012–2016 calls for the creation of health-supporting urban environments (5). Moreover, the European Union has implemented various policies and initiatives to boost urban biodiversity, acknowledging the critical role that urban green spaces and Nature-based Solutions (NbS) play in enhancing the resilience and sustainability of cities. The EU Biodiversity Strategy for 2030, introduced in May 2020, sets a specific goal to increase urban biodiversity by creating and restoring green and blue infrastructure and improving the connectivity between urban and peri-urban areas. This strategy also aims to integrate biodiversity into urban planning and design and promote the use of NbS in urban settings to aid climate change adaptation and mitigation. Additionally, with the new EU Nature Restoration Law, the Commission has established an ambitious target to restore 20% of the EU's land and sea areas by 2030 and all ecosystems in need of restoration by 2050 (6).

Talking about the benefits, a 2010 WHO report noted that green spaces positively affect physical activity, social and psychological well-being, air quality, and noise exposure, while another WHO report evaluated how green spaces can reduce public health inequalities by promoting active recreation for all age groups, especially among disadvantaged groups where physical activity

(1) Briggs, H. (2020) *Human-Made Objects to Outweigh Living Things*. Available at: https://www.bbc.com/news/science-environment-55239668 (Accessed: 20 May 2024).

(2) ASHRAE (2011) *Interactions Affecting the Achievement of Acceptable Indoor Environments*. Available at: https://webstore.ansi.org/preview-pages/ASHRAE/preview_ASHRAE+Guideline+10-2011.pdf (Accessed: 20 May 2024).

(3) Chakrabarti, V. A. (2013) *A country of cities: a manifesto for an urban America*. New York: Metropolis Books.

(4) Lehmann, S. (2021) *Growing Biodiverse Urban Futures: Renaturalization and Rewilding as Strategies to Strengthen Urban Resilience*. Available at: https://www.mdpi.com/2071-1050/13/5/2932 (Accessed: 20 May 2024).

(5) PEDRR, FEBA (2020) Promoting NbS in the Post-2020 Global Biodiversity Framework. Available at: https://www.iucn.org/sites/default/files/2022-07/promoting_nbs_in_the_post-2020_global_biodiversity_framework.pdf (Accessed: 20 May 2024).

(6) Gionfra, S., et al. (2023) *Embracing biodiversity: Paving the way for nature-inclusive cities*. Available at: https://www.iucn.org/story/202305/embracing-biodiversity-paving-way-nature-inclusive-cities (Accessed: 21 May 2024).

levels are low. Recent studies have also shown that green spaces contribute to human health through mechanisms such as improved air quality, increased physical activity, stress reduction, and social cohesion, proving the restorative psychological effects of nature and supporting theories like the psycho-physiological stress reduction theory and the Attention Restoration Theory, which explain how nature helps reduce stress and restore cognitive function. Studies have also demonstrated physiological benefits of green spaces, such as reduced blood pressure, heart rate, and cortisol levels, while social benefits include increased social cohesion, reduced feelings of loneliness and a reduction of crime in disadvantaged areas.

Green spaces also promote physical activity, which is crucial for preventing noncommunicable diseases, such as mental illness, obesity, cardiovascular diseases, type 2 diabetes, and cancer remain significant public health challenges. As a matter of fact, studies have linked green spaces to reduced obesity and improved mental health, suggesting that physical activity in natural environments is particularly beneficial.

Green spaces have also been proven to mitigate noise pollution and improve air quality, providing indirect health benefits. Vegetation can indeed buffer noise from traffic and other urban sources, while natural sounds like bird songs can enhance the perceived pleasantness of urban soundscapes. Trees and plants also reduce air pollution and sequester carbon, further contributing to public health.

Overall, the evidence underscores the importance of urban green spaces in promoting health and well-being through multiple pathways and mechanisms. This understanding supports the development of policies and practices that enhance access to green spaces, ultimately addressing public health challenges more effectively (7).

The goal of ensuring "universal access to safe, inclusive, and accessible green and public spaces" is explicitly acknowledged in Sustainable Development Goal 11 (8). Consequently, it is crucial to understand the role urban green and blue spaces play in supporting human wellbeing in the Global South. This knowledge is vital for guiding sustainable land-use planning interventions to address ecological and public health challenges amid global environmental changes. It is important to determine how often and how long people need to visit urban green and blue spaces to achieve measurable wellbeing benefits, as this can shape policy recommendations. Human wellbeing encompasses several dimensions: positive and negative experiences (pleasure and pain), evaluative (overall life assessment), and eudaimonic (purpose and meaning in life). In the UK, more frequent visits to natural environments are linked to higher eudaimonic and positive experiential wellbeing, and spending at least 120 cumulative minutes per week in nature is associated with improved evaluative wellbeing. In addition to that, a study conducted in Hong Kong found out that recreational visits to blue spaces were associated with a statistically lower risk of depression (9).

As well as blue and green spaces, and natural areas in general, **urban biodiversity** plays a key role in human well-being.

Cities are central to both the causes and effects of major environmental challenges, such as the climate crisis, pollution, and biodiversity loss. Urban ecosystems typically have lower biodiversity levels compared to natural environments due to intensive land use, fragmentation of green spaces, and the introduction of non-native species. Over recent decades, urbanization has been a major driver of habitat loss, with "residential and commercial development" being the third most frequently cited threat to species on the IUCN Red List. These threats displace native flora and fauna, reducing species abundance and diversity. Additionally, urbanization creates physical and chemical barriers that impede species movement and dispersal, limiting their access to food, shelter, and breeding partners.

However, cities are also at the forefront of addressing these crises, offering opportunities for biodiversity conservation and enhancement. Well-managed urban areas can support high biodiversity levels, and many cities are already located within globally recognized biodiversity hotspots. Urban green spaces, such as parks, gardens, and green roofs, can support a diverse range of native species and provide crucial habitats for pollinators, birds, and other animals.

Conserving urban biodiversity benefits both wildlife and humans, as biodiversity can reduce flood risk by improving soil drainage, control pest populations, pollinate local flora, and enhance mental health and psychological well-being.

It is estimated that each hectare of urban green space provides annual benefits worth between €2.500 and €16.500 in terms of carbon storage, stormwater reduction, and pollution removal. Additionally, tree shade and evapotranspiration can lower temperatures by 1-5 °C, mitigating the urban heat island effect.

Birdwatching and listening to birdsong have also positive effects on mental health, and many urban residents value wildlife presence, supporting conservation efforts. Beyond health benefits, conserving urban biodiversity and improving local parks can foster community building and social cohesion.

The presence of wildlife also indicates environmental health, as areas that attract animals are likely free from chemical, air, and noise pollution and are safe for human recreation.

Some benefits of urban biodiversity include:

- Improved Air Quality: Green spaces improve air quality by capturing and filtering harmful pollutants.
- Enhanced Mental Well-being: Access to nature in cities is linked to better mental health and well-being, with research showing lower mental distress and better overall well-being in neighborhoods with more green space.
- Climate Regulation: Urban green areas help regulate local climates by providing shade and reducing the urban heat island effect. Increased urban vegetation cover can reduce daytime temperatures by up to 6°C.
- Biodiversity Education and Awareness: Urban biodiversity offers educational opportunities and fosters environmental awareness through green spaces and wildlife habitats, engaging communities in nature-based activities.
- Ecological Resilience: Diverse urban ecosystems are more resilient to environmental changes and better able to provide ecosystem services and adapt to disturbances.
- Supporting Pollinators: Urban areas can serve as crucial refuges for pollinators, essential for food production and ecosystem functioning.
- Recreational Opportunities: Urban biodiversity offers recreational spaces for residents, promoting relaxation, physical activities, and connection with nature. Proximity to green spaces significantly improves mental health.

(7) World Health Organization (2016) *Urban green spaces and health: A review of evidence*. Available at: https://iris.who.int/handle/10665/345751 (Accessed: 21 May 2024).

(8) United Nations (2016) *United Nations Conference on Housing and Sustainable Urban Development (Habitat III)*. Available at: https://www.un.org/en/conferences/habitat/quito2016 (Accessed: 21 May 2024).

(9) Fisher, J. C., et al. (2021) 'Exploring how urban nature is associated with human wellbeing in a neotropical city', *Pesaggio e Pianificazione Urbana*, 212.

- Economic Benefits: Over half of global GDP—around €40 trillion-depends on nature. Nature-based solutions (NbS) for infrastructure can be 50% cheaper than gray infrastructure alternatives and deliver 28% more in added value, such as carbon sequestration, cleaner air and water, better health, and job creation (6).

On the base of this considerations, new disciplines as well as new approaches to urban design had sparked.

Some examples are Biodiversity Sensitive Urban Design (10), Biophilic Urbanism (11), post-human urbanism (12) and More-than-human design (13).

Biodiversity Sensitive Urban Design (BSUD), in particular, is a concept proposed for the first time in 2017 in the publication "Biodiversity Sensitive Urban Design", by Garrard, Williams, Mata and others (14), as a protocol designed to create urban environments that positively impact native species and ecological communities by supplying vital habitats and food sources, and which follows mainly 5 principles, that is to say:

- Preserve and establish habitats
- Support the movement of species
- Reduce threats and man-made disruptions
- Facilitate natural processes
- Foster opportunities for beneficial human-nature interactions (15).

Another example of a new approach to urban design that takes into account biodiversity is **More-than-human design**, also appeared at the 2018 Media Architecture Biennale, when Froth and Cadwell emphasized the need to understand the effects of media displays on non-human species and advocated for expanding Media Architecture discourse to include more-than-human interactions (13).

Taking into account all of the above, it becomes therefore crucial to incorporate biodiversity into mainstream urban planning and development processes. Currently, the integration of biodiversity in urban design and strategic planning is insufficient, and this shortcoming is further aggravated by challenges such as institutional constraints, socioeconomic factors, the lack of clear policies and assessment targets for urban biodiversity, as well as by conflicts among stakeholders and the public (10). With our thesis, we aim at re-designing a city with urban biodiversity in mind, making it a place for both human and non-human.

In the next chapter, we will examine the close relationship between urban biodiversity and Nature-based Solutions, highlighting their role in addressing Climate Change and the impacts it has on cities as well as on human health and well-being.

(10 Kirk, H., et al. (2021) 'Building biodiversity into the urban fabric: A case study in applying Biodiversity Sensitive Urban Design (BSUD)', *Urban Forestry & Urban Greening*, 62.

(11) Totaforti, S. (2020) *Emerging Biophilic Urbanism: The Value of the Human–Nature Relationship in the Urban Space*. Available at: https://doi.org/10.3390/su12135487 (Accessed: 21 May 2024).

(12) Dalziel, M. (2022) *'Towards a Posthuman Practice for Architecture and Urbanism?', Nordic Journal of Urban Studies,* 2, pp.90-96.

(13) Pollatri, S., et al. (2021) *More-Than-Human Future Cities: From the design of nature to designing for and through nature*. Available at: https://www.researchgate.net/publication/352903527_More-Than-Human_Future_Cities_From_the_design_of_nature_to_designing_for_and_through_nature (Accessed: 22 May 2024).

(14) Garrard, G. E. (2017) *Biodiversity Sensitive Urban Design*. Available at: from https://doi.org/10.1111/conl.12411o (Accessed: 22 May 2024).

(15) Hernandez, C. (2023) *Enabling Biodiversity Inclusive Design*. Available at: https://icon-science.org/biodiversity-sensitive-urban-design/ (Accessed: 22 May 2024).

2.1.3.
The link between NbS and urban biodiversity

So, why are the concepts of biodiversity and Nature-based Solutions so deeply connected? And what is their role in tackling Climate Change? As previously mentioned, the European Union has recently introduced several policies and initiatives to enhance urban biodiversity, recognizing the essential role that urban green spaces and Nature-based Solutions play in improving the resilience and sustainability of cities (1). At the same time, it has been widely recognized how **Nature-Based Solutions provide a means to combat climate change while also enhancing the resilience of ecosystems and communities, playing a vital role in promoting biodiversity conservation** (2).

In general, urban areas are increasingly recognized for their potential to contribute to species and habitat protection, climate change adaptation, and disaster risk reduction through the implementation of biodiverse Nature-based Solutions. These solutions, such as urban allotments, gardens, green parks, pollinator sites, green corridors, wetland restoration, sustainable urban drainage systems, and green walls and roofs, aim, as stated in the European Environment Agency (EEA) Report, to introduce more diverse nature into cities. As a matter of fact, the issues of biodiversity and climate change are deeply interconnected crises that must be addressed together.

In recent years, various policies are beginning to reflect the understanding that while ecosystems and their services are vulnerable to climate change, they also offer protection against its impacts.

As stated by the President of the European Commission, Ursula von der Leyen, in her comments on the EU's biodiversity strategy for 2030: "Making nature healthy again is key to our physical and mental wellbeing and is an ally in the fight against climate change and disease outbreaks. It is at the heart of our growth strategy, the European Green Deal, and is part of a European recovery that gives more back to the planet than it takes away".

Originally advocated by the International Union for Conservation of Nature (IUCN) and subsequently endorsed by the European Commission, the term Nature-based Solutions was created to unify various nature-centered approaches, including concepts such as "ecosystem-based approaches", "ecosystem-based disaster risk reduction", green infrastructure/blue-green infrastructure, "ecosystem-based management", and "ecosystem-based adaptation", a term which had emerged in the 1990s in discussions surrounding biodiversity's role in reducing climate-related risks (3). Nature-based Solutions are indeed grounded in the ecosystem approach, which recognizes that ecosystems provide a wide array of services essential to human well-being. These services include carbon storage, flood control, shoreline and slope stabilization, and the provision of clean air, water, food, fuel, medicines, and genetic resources. Consequently, people can benefit from nature while also taking active steps to protect, manage, or restore natural ecosystems, making a significant and purposeful contribution to addressing major societal challenges.

"By introducing a broader category like NbS you are saying: ecosystem-based approaches are not useful just in specific sectors such as adaptation, disaster risk reduction (DRR), and water management but they are key to tackling bigger societal challenges and contributing to our wider wellbeing. An umbrella concept like NbS usefully emphasizes the importance of multi-functionality (i.e. providing multiple environmental, economic and social benefits at the same time) within sectoral interventions and policies," says Elisa Calliari, CMCC researcher in the Risk Assessment and Adaptation Strategies division.

Today, the IUCN Global Standard provides a clear definition and a common framework for NbS, which is crucial for scaling up their impact, preventing unforeseen negative consequences or misuse, and aiding funding agencies, policymakers, and other stakeholders in assessing the effectiveness of interventions (4).

According to the International Union for Conservation of Nature (IUCN) (5), NbS are "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". Along with green roofs and other Nature-based Solutions, other solutions that can be put in the same category are rewilding activities are ecological restoration and conservation efforts aimed at restoring and protecting natural processes and wilderness areas by restoring an area of land to its natural uncultivated and self-regulated state. The term is used especially with reference to the reintroduction of species of wild animals, insects, birds, and flora and fauna that have been driven out or exterminated. **Rewilding** has significant potential to increase biodiversity, create self-sustainable environments, and mitigate climate change, while passive rewilding aims to reduce human intervention in ecosystems, giving human-cultivated land back to nature and restoring nature (6).

As outlined by the Nature-based Solutions Initiative, Nature-based Solutions are approaches to societal issues that entail collaborating with nature to generate benefits for both people and biodiversity. These approaches encompass safeguarding, revitalizing, or overseeing natural

(1) Gionfra, S., et al. (2023) *Embracing biodiversity: Paving the way for nature-inclusive cities*. Available at: https://www.iucn.org/story/202305/embracing-biodiversity-paving-way-nature-inclusive-cities (Accessed: 21 May 2024).

(2) Lera, M., et al. (2021) *Nature Based Solutions for climate change mitigation*. Available at: https://www.unep.org/resources/report/nature-based-solutions-climate-change-mitigation (Accessed: 21 May 2024).

(3) Potschin, M., Kretsch, C., et al. (2015). *Nature-Based Solutions*. Available at: http://www.openness-project.eu/library/reference-book/sp-NBS (Accessed: 21 May 2024).

(4) Bassetti, F. (2021) *Nature-based solutions*. Available at: https://www.climateforesight.eu/seeds/nature-based-solutions/ (Accessed: 21 May 2024).

(5) IUCN (2020) *IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of NbS*. Gland: IUCN.

(6) Lehmann, S. (2021) *Growing Biodiverse Urban Futures: Renaturalization and Rewilding as Strategies to Strengthen Urban Resilience*. Available at: https://www.mdpi.com/2071-1050/13/5/2932 (Accessed: 20 May 2024).

and semi-natural ecosystems, responsibly managing productive land and seascapes or creating innovative ecosystems like urban green infrastructure. Thoughtfully crafted NbS can aid in addressing challenges such as climate change and biodiversity decline while also advancing various sustainable development objectives. Moreover, all types of ecosystems present opportunities for NbS to enhance the delivery of ecosystem services to people. However, NbS should be evaluated based on their multifaceted benefits for people, rather than relying on overly simplistic metrics such as the number of trees planted, as poorly devised initiatives may result in negative repercussions.

Biodiversity forms the foundation for the societal advantages derived from NbS by bolstering the delivery of numerous ecosystem services in the short term, mitigating trade-offs between services (such as between carbon storage and water supply), and bolstering the health and resilience of ecosystems, thereby enhancing their capacity to provide benefits in the long term. To uphold ecosystem health, other location-specific ecological factors must also be taken into account, including ecosystem connectivity. Therefore, successful, sustainable NbS are explicitly designed to yield measurable benefits for biodiversity and ecosystem health, with these benefits being assured through monitoring and adaptive management. Nature-based Solutions entail collaborating with nature, as an integral component of nature itself, to confront societal challenges, thereby supporting local human well-being and biodiversity (7).

Although better indicators, evaluation tools, and integrated assessment methods are necessary to accurately evaluate the net effect of NbS, the growing recognition of their potential and the acceptance of NbS as an umbrella term can help align strategies for biodiversity and ecosystem restoration with those aimed at combating climate change (4).

As a matter of fact, the **Nature-Based Solutions for Climate Manifesto**, crafted for the UN Climate Action Summit in 2019, positions NBS as a vital component in the fight against climate change and biodiversity loss and, ultimately, NBS are increasingly recognized as a dual solution for combating biodiversity decline and climate change while promoting sustainable development (8).

Since the publication of the first version of **UNaLab's NbS Technical Handbook** in 2018, the European Commission (EC) has adopted a more comprehensive definition of Nature-based Solutions (NbS) with a stronger focus on biodiversity. The EC currently defines NbS as follows: "Nature-based solutions to societal challenges are solutions inspired and supported by nature. They are cost-effective, provide environmental, social, and economic benefits, and help build resilience. These solutions introduce more diverse natural features and processes into cities, landscapes, and seascapes through locally adapted, resource-efficient, and systematic interventions. Therefore, nature-based solutions must benefit biodiversity and support the delivery of a range of ecosystem services" (9).

Overall, **NbS are powerful tools in the restoration and conservation of urban biodiversity**.

Urban ecosystems typically exhibit limited biodiversity compared to adjacent conserved areas. This reduction is primarily due to the installation of infrastructure and facilities deemed essential for logistics, transport, and welfare by humans. Such "hardscape" installations significantly alter the local environment, resulting in suppressed vegetation due to ground development impermeability, among other modifications. Decreases in biodiversity compromise ecosystems' capacity to capture vital resources, produce biomass, and sustain ecological processes like nutrient cycling. These ecological losses have repercussions for human welfare, diminishing the benefits derived from nature. "**Softscape**" development, including urban parks, public gardens, and street afforestation, presents alternatives to urban environment hardening, enriching urban biodiversity. Such areas foster connectivity within the urban matrix through linkages like railway networks or ravines acting as stepping stones or corridors. However, the high maintenance costs and relatively low biodiversity patterns in these softscape spaces pose challenges for managers and decision-makers. Urban parks and public gardens typically feature grassy areas (often with non-native species) and limited herbaceous species diversity. Commonly used tree and shrub species may support weak biodiversity, especially if non-native, with reduced capacity to provide expected ecosystem services. Species used in urban landscaping often exhibit low survivorship after planting, leading to significant seedling loss. In general, increasing biodiversity in urban parks proves challenging, as incorporating new plant species is costly and logistically complex, while seeds represent a critical and limited resource for restoring biodiversity and ecological functions. Hence, exploring new alternatives for urban biodiversity restoration is essential and, if successful, should be implemented (10).

NbS encompass a wide range of measures. Some examples of NbS aimed at promoting biodiversity, enhance ecosystem services, and improve the overall quality of life for their residents are:

- Urban Green Spaces: parks, public gardens, and community gardens that provide habitats for various species and promote biodiversity.

- Green Roofs and Walls: vegetated rooftops and vertical gardens that create habitats for plants, birds, and insects while improving air quality and reducing heat islands.

- Street Trees and Urban Forestry: planting and maintaining trees along streets and in public spaces to enhance canopy cover and support urban wildlife.

- Pollinator Gardens: creating spaces specifically designed to attract and support pollinators like bees, butterflies, and other insects by planting native flowering plants.

- Wetland Restoration: restoring or creating wetlands in urban areas to support aquatic and semi-aquatic species, improve water quality, and manage stormwater.

- Green Corridors and Wildlife Bridges: establishing green pathways and wildlife bridges that connect fragmented habitats, allowing species to move safely across urban landscapes.

- Permeable Surfaces: using permeable materials for pavements and other surfaces to allow water infiltration, support plant growth, and reduce runoff.

- Rain Gardens and Bioswales: installing rain gardens and bioswales to manage stormwater, improve water quality, and provide habitat for

(7) Nature-based Solutions Initiative. *Nature-based Solutions to Climate Change*. Available at: https://www.nbsguidelines.info/ (Accessed: 20 May 2024).

(8) IUCN. *Nature-based solutions for biodiversity and climate*. Available at: https://www.iucn.org/our-work/topic/nature-based-solutions-climate (Accessed: 21 May 2024).

(9) UNaLab. *TYPES OF NATURE-BASED SOLUTIONS*. Available at: https://unalab.eu/en/types-nature-based-solutions (Accessed: 22 May 2024).

(10) Castelli, K. R., et al. (2021) 'Improving the biodiversity in urban green spaces: A nature based approach', *Ecological Engineering*, 173.

wetland plants and animals.

- Community Allotments and Urban Agriculture: encouraging urban farming and community allotments to increase green space and local food production while enhancing biodiversity.
- Native Plant Landscaping: using native plants in landscaping projects to support local wildlife, reduce maintenance, and improve ecosystem resilience.

- Artificial Ponds and Water Features: creating water bodies in urban areas to support aquatic life and provide recreational and aesthetic benefits for residents.

- Ecological Restoration Projects: initiating projects aimed at restoring degraded urban ecosystems to their natural state, thereby enhancing biodiversity.

- Nucleation Techniques: implementing nucleation methods, such as artificial perches and seed banks, to encourage natural seed dispersal and habitat formation.

- Shoreline Renaturalization: removing artificial structures and reintroducing native vegetation to reduce erosion, support wildlife, and improve water quality (6).

But how can nature help us in tackling Climate Change and its effects?
In recent years, the term **Ecosystem-based Adaptation** (EbA) was coined in order to define a subset of Nature-based Solutions that "aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change" (11). Currently, there is a global debate on the advantages of employing ecosystem-based adaptation as a framework for Climate Change adaptation. This approach is being highlighted for its cost-effectiveness, societal benefits, contribution to biodiversity conservation, and its role in reducing the vulnerability of populations and ecosystems to Climate Change (12).
Restoring and protecting nature is a powerful strategy for addressing Climate Change, not only from the perspective of mitigation, as it removes carbon from the atmosphere: for example, forests, wetlands, and other ecosystems can act as buffers against extreme weather, safeguarding homes, crops, water supplies, and vital infrastructure (13).
In conclusion, incorporating Nature-based Solutions into urban design and planning can enhance ecological connectivity and bolster the resilience of local ecosystems. Additionally, urban biodiversity offers significant benefits for human well-being, including improved air quality, reduced urban heat island effects, and increased recreational and educational opportunities (1).
In the next chapters, we will try to put in practice everything we have learned through research, analyzing the reality of a small town in Sweden, subject of our thesis project, from the international, to the national and urban scale, using nature as a tool in order to make the city more inclusive, climate adapted and resilient.

(11) Parmesan, C., et al. (2022) *Climate Change 2022: Impacts, Adaptation and Vulnerability Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Available at: https://www.researchgate.net/publication/362431678_Climate_Change_2022_Impacts_Adaptation_and_Vulnerability_Working_Group_II_Contribution_to_the_Sixth_Assessment_Report_of_the_Intergovernmental_Panel_on_Climate_Change (Accessed: 22 May 2024).

(12) IUCN. *Building Resilience to Climate Change: Ecosystem-based adaptation and lessons from the field*. IUCN.

(13) UNEP (2020) *Six ways nature can protect us from climate change*. Available at: https://www.unep.org/news-and-stories/story/six-ways-nature-can-protect-us-climate-change (Accessed: 22 May 2024).

FROM THEORY TO PRACTICE:
designing Piteå

3

3.1.
Europan competition

Practical outcome of the theoretical research, the project designed for the purpose of this thesis was developed as a result of the participation in an international and interdisciplinary biennial competition known as '*Europan*'.
Established in 1989 as an extension of the French organization Pan (Programme Architecture Nouvelle: New Program for Architecture) (1), founded in 1972 (2), Europan emerged from the start as a pioneering competition of architecture, urbanism and landscape design coordinated in collaboration with 12 European countries, and specifically aimed at designers under the age of 40 also in order to ease their entry into the professional arena (3).
Europan's objective, similarly to Pan's, is to enable practitioners under 40 to collaborate with European city authorities on innovative urban environment projects.
Throughout its history, Europan has addressed numerous themes, consistently emphasizing the design of innovative forms of housing and urban plans for sites across Europe in order to highlight the individual and the swift evolution of lifestyles.
Recognized as the world's largest competition in its field, Europan encourages participants to tackle social, cultural, and economic transformations in towns and cities, providing a platform for cross-cultural learning and networking among architects and site promoters as well as a call to action. What makes it different from other architectural competitions is indeed that, from its beginning, Europan's aim was to blend the concept of a competition for ideas with their implementation, bridging designed processes with physical projects. As noted by the mayor of Besançon, France, during the Europan 14 Forum in Brussels in 2018, this process enables participating teams, cities, and other urban stakeholders to gradually develop common concerns and visions for an inclusive European city, as local issues are translated to a European level of discussion, and vice versa (2), while fostering connections between young designers, municipalities, and other industry professionals, enhancing collaboration and practical application. This, in turn, allows for experimentation, the reformulation of poorly posed questions, and the creation of new questions about the future of sites.

Held in 2023, the 17th edition of this biennial competition had as its core theme "LIVING CITIES: REIMAGINING ARCHITECTURES BY CARING FOR INHABITED MILIEUS".
Its goal was to investigate how living environments can regenerate within emerging ecologies that seek to bridge the gap between nature and culture, as well as human-centered perspectives, especially in the face of natural disasters and the climate crisis.
This edition sought proposals for 51 different sites across Europe, challenging its participants to "re-imagine architectures by taking care of inhabited milieus" (2) with strategies able to address local and translocal dimensions, including managing natural resources sustainably and promoting inclusivity in development processes, as seen in E16 (4).

Fig. 1 - Europan 17's results cover.
Source: [https://www.europan-europe.eu/fr/]

Among the sites proposed by Europan in its 2023's edition, the one presented by the municipality of **Piteå**, a city located in northern Sweden, was particularly interesting for us, as it tackled the themes of redesigning a city in the face of a changing climate while preserving urban biodiversity.
As the city is currently facing the effects of climate change, such as floods, rising rainfalls, snowfall and temperatures, as well as a changing landscape, among others, the municipality has joined the competition in order to find ideas to make the city more resilient and inclusive, while also allowing the creation of a new railway aimed at connecting the coastal city to the land and creating new vibrant areas in order to accommodate the city's expected urban and demographical growth.
In general, the competition provided the perfect purpose for putting into practice the principles previously established through theoretical research, and was also an occasion to design a project while keeping its attractiveness, effectiveness and feasibility in mind.

(1) Stratis, S. (2020) *Translocality as Urban Design Tool for the Inclusive City: The Case of Europan*. Rosenberg & Sellier Ardeth. 7, pp. 25-45. Available at: https://journals.openedition.org/ardeth/1768
(Accessed: 17 May 2024).

(2) Younes, C., Maugard, A., et al. (2019) Villes et architectures en débat - Europan. Paris: Parenthèses editions. Available at: https://www.editionsparentheses.com/Villes-et-architectures-en-debat
(Accessed: 17 May 2024).

(3) Archdaily (2023) Europan 17's Living Cities Competition. Available at: https://www.archdaily.com/1001158/europan-17-s-living-cities-competition)
(Accessed: 17 May 2024).

(4) Europan (2023) *EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF*. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se
(Accessed: 17 May 2024).

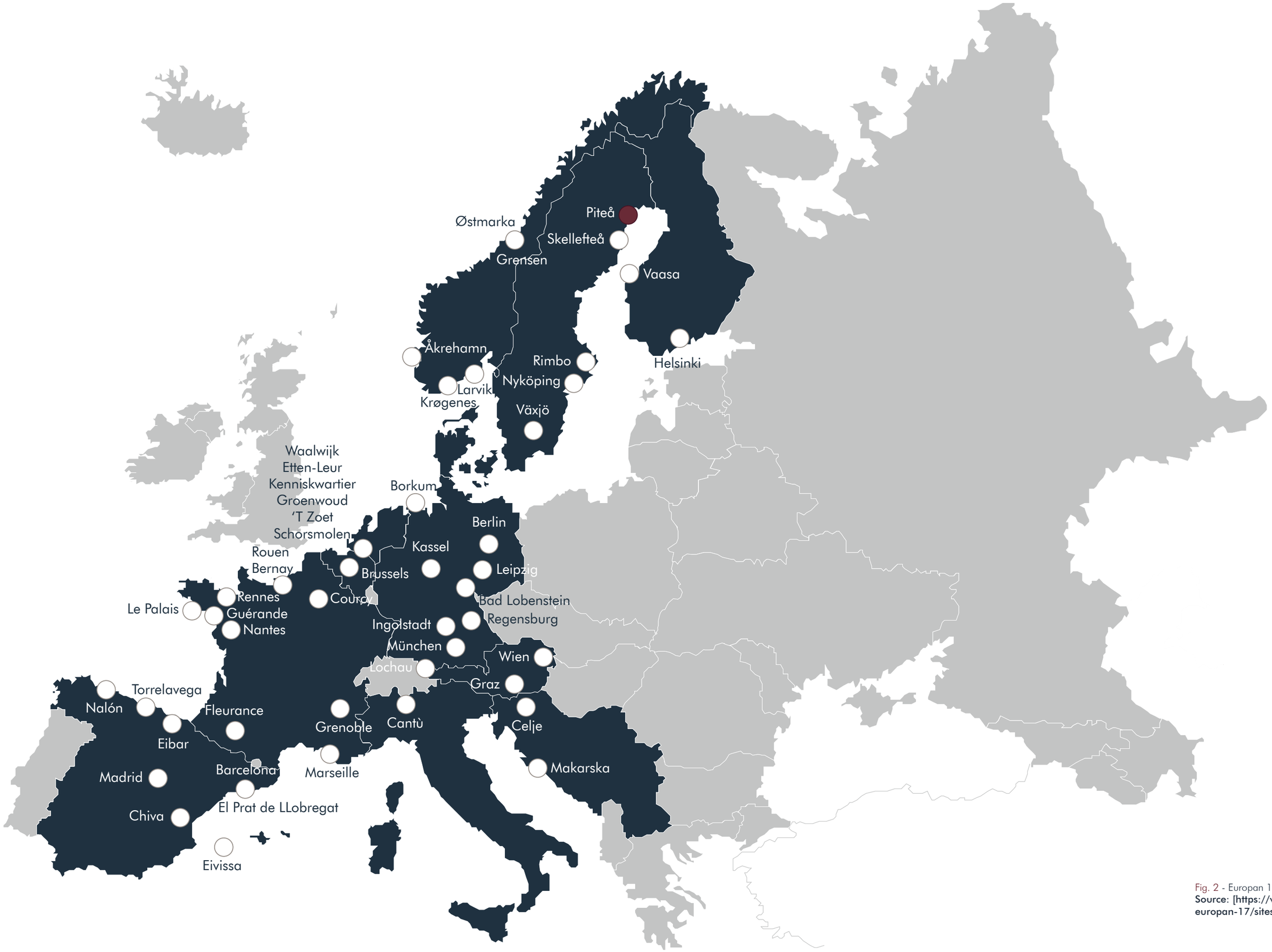


Fig. 2 - Europan 17's project sites.
Source: [https://www.europan-europe.eu/en/session/europan-17/sites]

3.2.
Europan 17: Piteå

As stated in Europan's website, under the "*THINK TABULA NON-RASA! Designing new habitats as a holistic environment*" sub-group of project sites, where our project site is located, "some nature reserves around the world are deserts - hot or cold -, but they host all kinds of animals and microorganisms hiding in the cracks and crevices, under the rocks. Some of our sites look empty, vacant, but they are not. They are full of life: in the soil, in the air, in the breeze. They are part of a larger balance of natural forces and processes. On these sites, substantial new volumes of programme are required. Think of these sites as the opportunity to multiply the number of life forms, think of the request to build new habitats as an opportunity to design a holistic environment. Think tabula non-rasa!" (2).

Among the requirements defined by the competition for the city of Piteå, were:

- The **expansion of Piteå's city center** towards the west, integrating the existing railway, used by the industries in the city, to create a new appealing space, blending residential, commercial, and business functions together. Additionally, proposals had to facilitate the city center's proximity to the Sörfjärden shore (South Bay), while development plans for the Västra Kajen area (West Quay), adjacent to the paper mill, should have been focused on cultural, sports, and office uses rather than housing, removing barriers between the center and Sörfjärden.
- The **development of a green recreational space** at Sörfjärden, defining how Södra Hamn

Fig. 1 - Redrafting of a map depicting the ipothesis for the North Bothnia Line's path in Piteå.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

(1) Europan. *Europan Europe*. Available at: https://www.europan-europe.eu/en/ (Accessed: 17 May 2024).

(that is to say the South Port) could be preserved and enhanced as a green oasis and social hub, emphasizing contact with the water.

- The **creation of a sustainable transportation hub**, placed within the new North Botnia Line corridor, that were to be positioned along the main road, Timmerleden, further causing a disgregation between the city center and the seaside, in a way that could prevent this disgregation.

Along with this, the participants were required to take into account the unique conditions of northern latitudes regarding daylight and snow management, as well as to propose solutions that could be attractive all year round (3).

The new areas were also to be connected through a well-designed green structure, characterized by a pedestrian and bicycle paths protected from the traffic, while the expansion of the city center had to be based on the existing historical grid. Another important aspect to take into account was also the creation of a series of passages that could ensure the passage of animals in a safe manner, including other species' needs into the new urban asset.

A particular emphasis had also to be placed on considering the perspective of children, ensuring their safety as well as their interaction with nature, highly regarded as an important part for their cognitive development, and much of the effort was around preserving and enhancing existing green areas while improving **accessibility** to them. As access to waterfront and recreational areas were seen as essential for the well-being of the population, it was also required to incorporate green spaces not only within the existing city, but also within the new developments.

In general, the project had to enhance the quality of urban spaces and create gathering spots suitable for all age groups, encouraging sustainable lifestyles and establishing connections between currently separated areas and functions, while enhancing the integration of surrounding nature into the urban landscape.

The following chapter will provide a quick introduction to Piteå, delving into its major characteristics, peculiarities and challenges.

Fig. 2 - An analysis of the city's green infrastructure, its mobility system and its buildings' functions.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

(2) Europan (2023) *THINK TABULA NON-RASA! designing new habitats as a holistic environment*. Available at: https://www.europan-europe.eu/en/session/europan-17/sites#connected-themes-33 (Accessed: 17 May 2024).

(3) Europan (2023) *PITEÅ (SE)*. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se (Accessed: 17 May 2024).

(4) Europan (2023) *EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF*. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se (Accessed: 17 May 2024).

3.3.
Introducing Piteå

City located in northern Sweden, **Piteå is the second largest urban area in Norrbotten County** immediately after the capital of the region, Luleå. Facing the coast of the Gulf of Bothnia about 900 km north of Stockholm and 100 km south of the Arctic Circle, the city is particularly distinguished for its wood industry, which takes place in areas located a few kilometers from the center, thus constituting, along with the old railway lines associated with them, a strong barrier as well as a limit to the urban development of the city itself (1).
From a mobility point of view, like most cities along the coast of Norrbotten County, the city is connected by a single regional railway line, mostly located inland. For example, to reach Piteå from Stockholm, it would indeed be necessary to undertake a journey of about 12-14 hours with several changes between train and bus from Umeå or Älvsbyn (2). For this reason, it has been deemed necessary to realize a new line in order to connect the major cities along the coast, the **North Bothnia Line** [Fig. 2], a new 270 km railway line between Umeå and Luleå that will allow a 30% reduction in freight transport costs, as well as halving travel times for passengers, significantly improving commuting conditions along the Swedish coast and reducing the environmental impact that the Swedish transport system has on the climate (3).
According to studies defining the areas occupied by the different sections of the new railway line, the North Bothnia Line will also pass through the center of Piteå, thus constituting an opportunity for

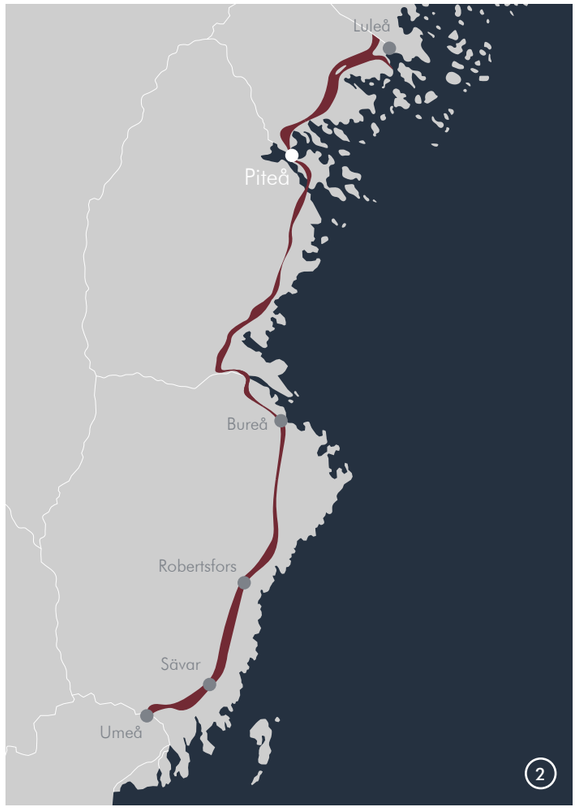


Fig. 1 - Redrafting of a map depicting the current Swedish national railway network.
Source: [https://www.sj.se e https://www.openrailwaymap.org/]

Fig. 2 - Redrawing of a map depicting the future North Bothnia Line.
Source: [https://bransch.trafikverket.se/en/startpage/projects/Railway-construction-projects/north-bothnia-line/]

(1) Europan (2023) *EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF.* Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se (Accessed: 17 May 2024).

(2) Vy. *Vanliga frågor.* Available at: https://www.vy.se/ (Accessed: 22 May 2024).

(3) Trafikverket (2022) *North Bothnia Line*. Available at: https://bransch.trafikverket.se/en/startpage/projects/Railway-construction-projects/north-bothnia-line/ (Accessed: 17 May 2024).

(4) Piteå Kommun. *Piteå Havsbad område*. Available at: https://www.pitea.se/Upplev/nordens-riviera/produkt/?lang=sv&TLp=341263 (Accessed: 17 May 2024).

(5) Piteå Kommun (2022) *Winter in Piteå*. Available at: https://www.pitea.se/en/Visitors/special/winter-in-pitea/ (Accessed: 17 May 2024).

the development and economic growth of the city. The main roads passing through the city center are primarily Sundsgatan, Storgatan, and the aforementioned Timmerleden, which encircle the heart of Piteå along with the canal bordered by the two parks Badhusparken and Stadsparken.
The Norrbotten region also boasts 5 airports, with Luleå Airport being the busiest in northern Sweden.

From an economic and cultural point of view, the city represents a significant attraction, as it is rich in activities both in summer and winter. Its location along the Baltic coast makes it relatively less exposed to harsh weather conditions compared to other areas of Sweden (1). It is also for this reason that the city, and particularly the Pite Havsbad area, attracts a considerable number of tourists, especially from northern Norway or from cities located north of the country, such as Kiruna, much more exposed to harsh weather and Arctic cold, earning the title of "*Northern Riviera*" (4). In winter, on the other hand, the sea freezes almost completely, allowing activities such as icebreaker ship excursions along the archipelago, cold baths, and ice fishing in holes carved in the ice (5).
In general, the city indeed attracts about half of the summer tourism in Norrbotten County, both for its rich nature and the numerous events and activities it offers. The city of Piteå hosts several annual events, which attract visitors from all over Europe, as well as various local events. The Pite Havsbad hotel, located on the southeast outskirts of the municipality, equipped with various amenities such as a golf club, water parks, go-kart tracks, beach volleyball courts, camping areas, and an event center, hosts various conferences and shows. In addition to this, to the northwest of the city, the Studio Acusticum, one of the most modern concert halls in Europe, hosts several world-class artists. Overlooking Rådhustorget square, along with the city museum and the Piteå Konsthall modern art gallery, the Kaleido creative meeting space also contributes to a lively cultural life for the city (6). Piteå is also home to the KYH University of Applied Sciences and the music faculty of the Luleå University of Technology (LTU), while 3 hours by public transport and 2 by car away is the University of Umeå (7).

Within the city, we also find an athletics sports hall, the Lindbäck Bygg ski stadium, and the Vallsberget

Residential area

Police station

"Trädgårdens förskola"
kindergarten

"Timmerleden"
street

"Sundsgatan"
street

"Storgatan" main
commercial street

Old railway area

Piteå Church

Residential historic
city center area

"Rådhustorget"
the main square

"Smurfit kappa"
paper mill

Sea front

Port

Piteå hospital

"Stenvalls Trä AB"
sawmill

Master plan

100m 500m 1000m 1500m 2000m 2500m 3000m

Alpine Facility, equipped with various slopes including several for cross-country skiing, 3 with two ski lifts, one for children, and one for biathlon (8). Additionally, there are the Lindbäcksstadion stadium, the LF Arena ice hockey, soccer, and athletics hall, the Norrmalmia Sports Hall, and the Hellströms Arena. Apart from these, the city hosts several museums, including the Piteå Historical and Cultural Museum, the Gammelgården Summer Museum, the Piteå Boat Museum on the waterfront, and the open-air museum of the medieval Öjeby church (9).

To testify to the city's past, some wooden buildings still remain around Rådhustorget and the adjacent Storgatan. However, during the 20th century, especially after 1950, the construction of larger buildings began, initiating a slow transformation process that made bricks and concrete the dominant building materials (1). Finally, the construction of several solitary skyscrapers dates back to 2010, such as the KUST Hotel & Spa, located near the city center. Historical maps [Fig. 3] show how the city's shape has changed significantly over time, also in relation to the particular phenomenon that characterizes this area of Sweden, where ground levels change along with sea level fluctuations. The ground in northern Sweden is rising by about 10 millimeters every year. This geological process, ongoing since the last ice age, causes the coastline to undergo perpetual change, which has indeed influenced, as previously seen, the history, location, and morphology of the city.
As previously stated, the city of Piteå is located within Norrbotten County. Situated on the border with Norway and Finland, the latter is the northernmost county in Sweden, as well as the largest by size. Despite its significant size, it is sparsely populated, mainly due to the harsh climate, with only about 250,000 inhabitants, less than 2 inhabitants per square kilometer. Initially, the region was mainly inhabited by the **Sami** people as well as various Finnish-speaking ethnic groups, while in the Middle Ages, it was colonized by Swedish farmers, thus becoming Swedish territory. As can be seen from the map provided, the Sami population is mainly distributed among northern Sweden, northern Norway, northern Finland, and northwestern Russia, while the Sami language, now internationally recognized, is divided into several dialects: the area where the city of Piteå is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located is characterized by the Pite Sami dialect. Today, the Sami are a national minority and have gained the status of indigenous people (10), with their own parliament (11), as well as special rights over land, concessions, and migration routes for the reindeer they breed (12). For this reason, the Swedish Transport Administration must take particular care in planning the routes for the North Bothnia Line, which also requires in-depth studies regarding the animal and plant species along the railway corridor.

Regarding the city, Piteå's population is approximately 42,000 (14), a number that has been slowly but steadily growing and is expected to continue growing in the coming years, with the municipality aiming for a population of 43,000 by 2020 (14).

From a climatic perspective, Piteå has a **subarctic climate**, with long, cold, snowy winters contrasting with warm, bright summers and relatively short autumns and springs. The landscape is characterized by forests and numerous rivers flowing from the mountains along the Norwegian border to the Gulf of Bothnia. Mining, forestry, the wood industry, and hydroelectric power production are among the dominant industries in the county today, as well as reindeer husbandry, still part of Swedish diet and tradition (1).
Piteå boasts a rich variety of animal and plant species, primarily dictated by the region's climatic and landscape characteristics, ranging from


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beaches to coniferous forests to wetlands, among others. However, forestry, agriculture, and industry have inevitably influenced the local nature. Nonetheless, remnants of the original nature can still be found in roadless areas, high-altitude areas, mountain peaks, pristine marshes, and near some watercourses, as well as in certain areas of Markbygden and near Rosfors. These natural forested areas, often inaccessible, are particularly appreciated by predators and animals that require peace and quiet.
Additionally, the Piteå archipelago is divided into inner and outer archipelagos, with islands closer to the mainland being more protected, while those farther offshore are heavily influenced by the sea and winds. The **rising land**, about 1 cm per year, along with river sediments, constantly modifies the archipelago landscape. The size of the islands in the Norrbothnia archipelago, also called the "low coast" due to the low altitude of the islands, varies considerably, as do the species inhabiting them: larger islands like Vargön, Mellerstön, Jävreholmen, Jävre-Sandön, and Baggen are covered by coniferous forests, while smaller islands, especially in the outer archipelago, like Stor-Räbben, have drier vegetation, while others, like Kluntarna, are characterized by extensive rock outcrops or pure rock islands, which is quite unusual in Norrbotten. Many of these islands are home to ancient and picturesque fishing villages, although it is only possible to stay there during the summer months due to inclement weather (15).
The archipelago is also home to various

Fig. 3 - Redrawing of a map of Piteå as of today.

Fig. 4 - The city plan of Piteå from 1667. Archive of the National Land Survey Board, National Archives.
Source: [Berg., A. E., Nordic Journal of Settlement History and Built Heritage. Available at: www.bebyggelsehistoria.org].

Fig. 5 - A photo of the city of Piteå.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

(6) Piteå Kommun (2022) *Living in Piteå*. Available at: www.pitea.se/en/move-to-pitea/link/living-in-pitea/ (Accessed: 18 May 2024).

(7) Piteå Kommun (2023) *Universitet och högskola*. Available at: https://www.pitea.se/invanare/skola-forskola/vuxenutbildningen/Universitet-och-hogskola/ (Accessed: 18 May 2024).

(8) Piteå Kommun (2024) *Lindbäcksstadion*. Available at: https://www.pitea.se/Lindbacksstadion (Accessed: 18 May 2024).

(9) Piteå Kommun (2024) *Museum*. Available at: https://www.pitea.se/Upplev/se/museum/ (Accessed: 18 May 2024).

(10) Piteå Museum. *Tre platser, tre skeden av Piteås historia*. Available at: https://piteamuseum.nu/utstallningar/tre-platser-tre-skeden-av-piteas-historia/ (Accessed: 19 May 2024).

(11) Sametinget (2024) *Bakgrund*. Available at: https://www.sametinget.se/bakgrund (Accessed: 19 May 2024).

(12) Kater, I., et al. *Reindeer: ancient migration routes disrupted by roads, dams - and now wind farms*. Available at: https://www.arcticfocus.org/stories/reindeer-ancient-migration-routes-disrupted-by-roads-dams-and-now-wind-farms/#! (Accessed: 19 May 2024).

endangered species, including the Calypso bulbosa, an orchid mainly found in Norrbotten and Västerbotten counties, and the Rubus Articus, a flower found only in Norrbotten County. The most common trees in Piteå are the Scots pine (Pinus sylvestris), Norway spruce (Picea abies), birch (Betula), trembling aspen (Populus tremula), gray alder (Alnus incana), bird cherry (Prunus padus), rowan (Sorbus aucuparia), and goat willow (Salix caprea), while the wildlife of Piteå includes common animals such as moose, reindeer, foxes, mountain hares (Lepus timidus), and squirrels. Less common are pine martens, lynxes, wolverines, otters, and bears, although the latter two have seen a significant increase in recent years. The most common marine mammals on the coast are gray seals (Halichoerus grypus) and ringed seals (Pusa hispida), while the harbor porpoise (Phocoenidae), although now rare in the Baltic Sea, can sometimes be seen in the waters of Norrbotten. Piteå's fauna also includes a rich avian population: Stor-Räbben and Mellerstön are part of an international list of wetlands, with only 51 areas listed in Sweden, one of which is in Piteå. The unique environment of the Bothnia Bay, characterized by land uplift and brackish water with low salinity due to freshwater from rivers and low evaporation, offers special conditions that allow the Gulf of Bothnia to host both marine animals such as ringed seals, gray seals, and herring, as well as freshwater animals such as pikes, whitefish, and perches. Additionally, Piteå's archipelago and marine environments are of great importance for the presence of rare and endangered birds such as the white-tailed eagle (Haliaeetus albicilla), the razorbill (Alca torda), the black guillemot (Cepphus grylle), and the osprey (Pandion haliaetus) (16).
In addition to local species, the city also has to deal with several invasive alien species, both animal and plant. Among the alien plant species are: giant hogweed (Heracleum mantegazzianum), Persian hogweed (Heracleum persicum), Nuttall's waterweed (Elodea nuttallii), common milkweed (Asclepias syriaca), Carolina fanwort (Cabomba caroliniana), and western skunk cabbage (Lysichiton americanus). While among the alien animal species, we find the raccoon dog (Nyctereutes procyonoides), muskrat (Ondatra zibethicus), signal crayfish (Pacifastacus leniusculus), Chinese mitten crab (Eriocheir sinensis), red-eared slider (Trachemys scripta) (17). The municipality of Piteå

Fig. 6 - A photo of the old railway area of Piteå.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 7 - A photo of the Piteå's sea.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

(13) Piteå Kommun (2018) *About Piteå.* Available at: https://www.pitea.se/en/invanare/The-municipality-and-politics/about-pitea/ (Accessed: 21 May 2024).

(14) Hjördis Rut Sigurjonsdottir, H. R. (2019) *PITEÅ IN SWEDEN: Striving to attract former residents back home.* Available at: https://www.nordregioprojects.org/wp-content/uploads/2020/03/Pitea.pdf (Accessed: 20 May 2024).

(15) Piteå Kommun (2024) *Naturtyper och livsmiljöer.* Available at: https://www.pitea.se/invanare/Boende-miljo/Naturvard/Naturtyper-och-livsmiljoer/ (Accessed: 20 May 2024).

(16) Piteå Kommun (2024) *Naturtyper och livsmiljöer.* Available at: https://pitea.naturskyddsforeningen.se/om-piteakretsen/piteas-natur/ (Accessed: 23 May 2024).

(17) Piteå Kommun (2024) *Invasiva främmande arter.* Available at: https://www.pitea.se/invanare/Boende-miljo/Naturvard/invasiva-frammande-arter/ (Accessed: 23 May 2024).


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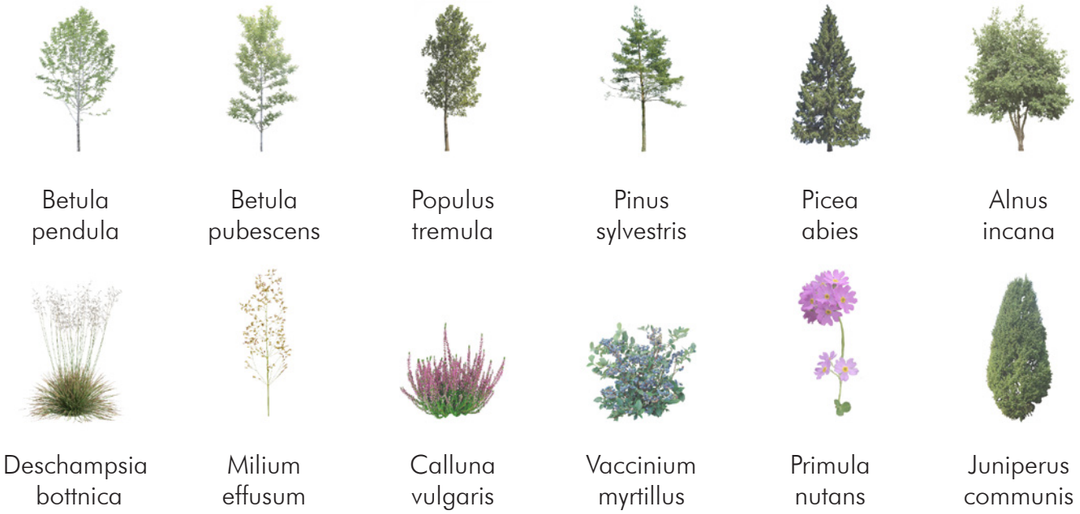
also has numerous nature reserves (18).
In terms of adaptation, mitigation, and resilience, in recent years, northern Sweden (also called Norrland), including Norrbotten County, has taken a leading role in Europe regarding the transition to green, fossil-free technologies, with positive effects in terms of economic and demographic growth. This has also led to an expansion of infrastructure: for example, in the municipality of Piteå, Europe's largest wind farm, Markbygden, is currently under construction (1).

Regarding the **effects of climate change in Piteå**, they primarily include, as stated on the municipality's website:

- an increase in average annual temperatures
- heatwaves
- wildfires
- droughts
- pests and bacteria
- deterioration of air quality
- spread of infections
- increased operating and maintenance costs
- less ground frost, when the temperature near the ground, measured at a height of 5 cm from the ground, drops to or below zero (19)
- more zero-crossings, when the highest temperature of the day at 2 m above the ground has been above 0°C and the lowest temperature of the same day has been below 0°C (20)
- ice storms

In addition to these, there has been a significant increase in snowfall in recent years, obliging the city to manage large quantities of snow in short periods of time, as well as average annual precipitation, prompting the municipality to create a series of maps aimed at geolocating those areas at higher risk of flooding.
These effects are all inherently linked to a slow shift towards a warmer and wetter climate, as well as an increase in extreme weather phenomena both in winter and summer. For several years, the municipality has been actively working on climate adaptation for the city, partly based on climate scenarios developed by the Norrbotten County Board and SMHI, and partly by conducting risk and vulnerability analyses in collaboration with administrations and companies. In addition to this, various local companies have developed their own action plans for adaptation, while at the municipal level, a series of guidelines have been adopted for managing stormwater, as well as various analyses of cloudbursts, and the planning of a new climate adaptation reserve to manage heavy rainfall (21).



TREES AND PLANTS IN PITEÅ

Fig. 8 - Piteå's camping area.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 9 - Abacus of Piteå's trees and plants species.
Source: [https://pitea.naturskyddsforeningen.se/om-piteakretsen/piteas-natur/].

(18) Piteå Kommun (2024) *Naturreservat i Piteå*. Available at: https://www.pitea.se/invanare/Boende-miljo/Naturvard/skyddad-natur/Naturreservat-i-pitea/ (Accessed: 23 May 2024).

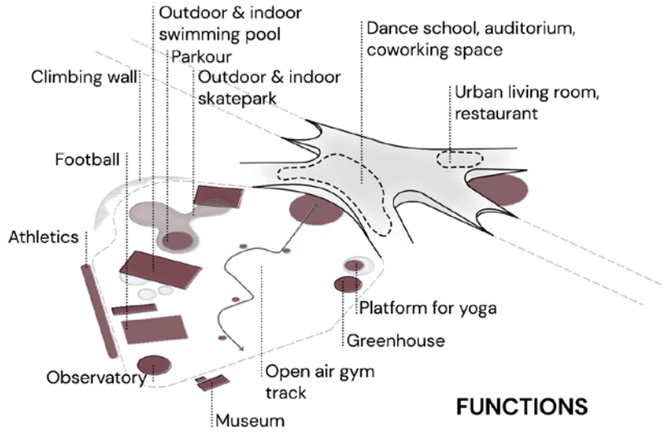
(19) Schweizerische Eidgenossenschaft (2020) *Danger levels frost*. Available at: https://www.natural-hazards.ch/home/dealing-with-natural-hazards/frost/danger-levels.html (Accessed: 22 May 2024).

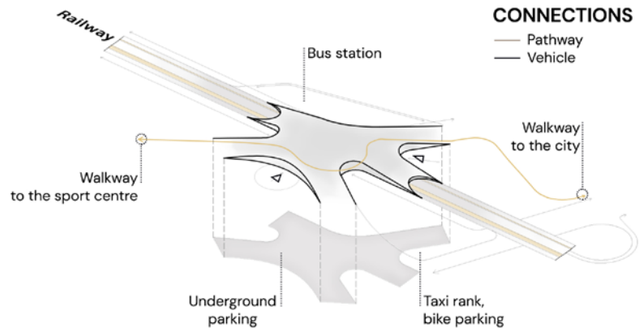
(20) Swedish Portal for Climate Change Adaptation (2020) *Zero crossings*. Available at: https://www.klimatanpassning.se/en/climate-change-in-sweden/climate-effects/zero-crossings-1.96652 (Accessed: 22 May 2024).

(21) Piteå Kommun (2023) *Klimatanpassning*. Available at: https://www.pitea.se/invanare/Boende-miljo/Planer-och-fysisk-planering/klimatanpassning/ (Accessed: 22 May 2024).

3.4.
Lagom

In this chapter, the project developed with *Collettivo Selvaticus* (1) for the competition will be addressed, in order to explain the foundational framework from which the thesis's project has originated.
Submitted with the title *Lagom* (2), a swedish word that could be translated with words such as "balance" or "harmony", aims at **reconnecting the inhabitants of the city with its natural surrounding**, creating a city designed for both human and non-human.
Moreover, we aim to recreate Smultronstället (a sanctuary, a place of the heart) where people can reconnect with nature and immerse themselves in it, inspired by the concept of gökotta (waking up at dawn to listen to the birds sing).
As previously stated, one of the main aims of the project of the competition was to connect Piteå's recreational area by the seaside with its city center and future transportation hub, ensuring a safe pathway. Another key requirement was to ensure a visual and physical link between Uddmansgatan, one of the main commercial streets inside the city center, and the sea (3). This was obtained through the creation of an **elevated cyclable and walkable path**, that connects the area along Timmerleden, today characterized by the presence of different parking lots and commercial buildings, with the new path along the waterfront, also elevated in order to create a biological corridor that could ensure a safe path for the animals. While Uddmansgatan is currently partially pedonalized, it is still crossed by cars, making it impossible for it to be a true social core and meeting point for the citizens. For this reason, the project aims to transform it into a sort of "linear square", enlightening it as a high-quality social space enjoyed by citizens and tourists, particularly during summer, and making it a direct visual connection to the sea and to the **new residential area designed along Timmerleden**. The new residential area maintains the parking areas while ensuring commercial and residential functions, but also making it a new skyline for the city, as it was also visually inspired by local architectural elements and designed in order to revitalize the urban landscape. This new area will indeed feature mixed-use buildings features commercial spaces on the ground floor facing the street and covered parking spaces behind them. By doing so, all the residential areas are elevated on this sort of "platform," making the squares with green areas enclosed between the residential buildings semi-private. These elevated spaces are not only intended for residents as community spaces, but also to provide them with a view of the seascape and to shield them from street noise. The project's construction of multi-story residential units, offices, and services not only meets housing demands but also contributes to the overall enhancement of the city and coastal areas.
This new area located in the south of the city center will be also one of the crossing points for the new walkable path along the coastline, which will connect all of the elements of the project such as the new transportation hub and the nearby





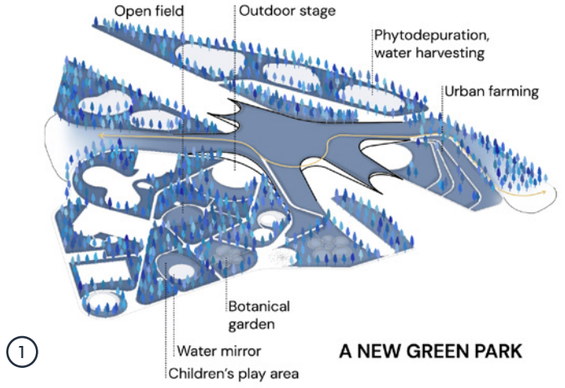


Fig. 1 - A diagram showing the design process for the new railway station, realized for the project "Lagom", in collaboration with *Collettivo Selvaticus*.

(1) The *Collettivo Selvaticus* members for this competition are: Filippo Fiandese, Silvia Lanteri, Maicol Negrello, Giulia Barucci, Chiara Fabbri, Sara Marzio, Alessandro Monaldi.
All the works developed on the following pages by the team *Collettivo Selvaticus* were created by the mentioned members.

(2) Kamann, M. (2016) *"Lagom" in Sweden - What It Means and Where It Comes from*. Available at: https://hejsweden.com/en/lagom-how-to-be-swedish/
(Accessed: 17 May 2024).

(3) Europan (2023) *PITEÅ (SE)*. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se
(Accessed: 17 May 2024).

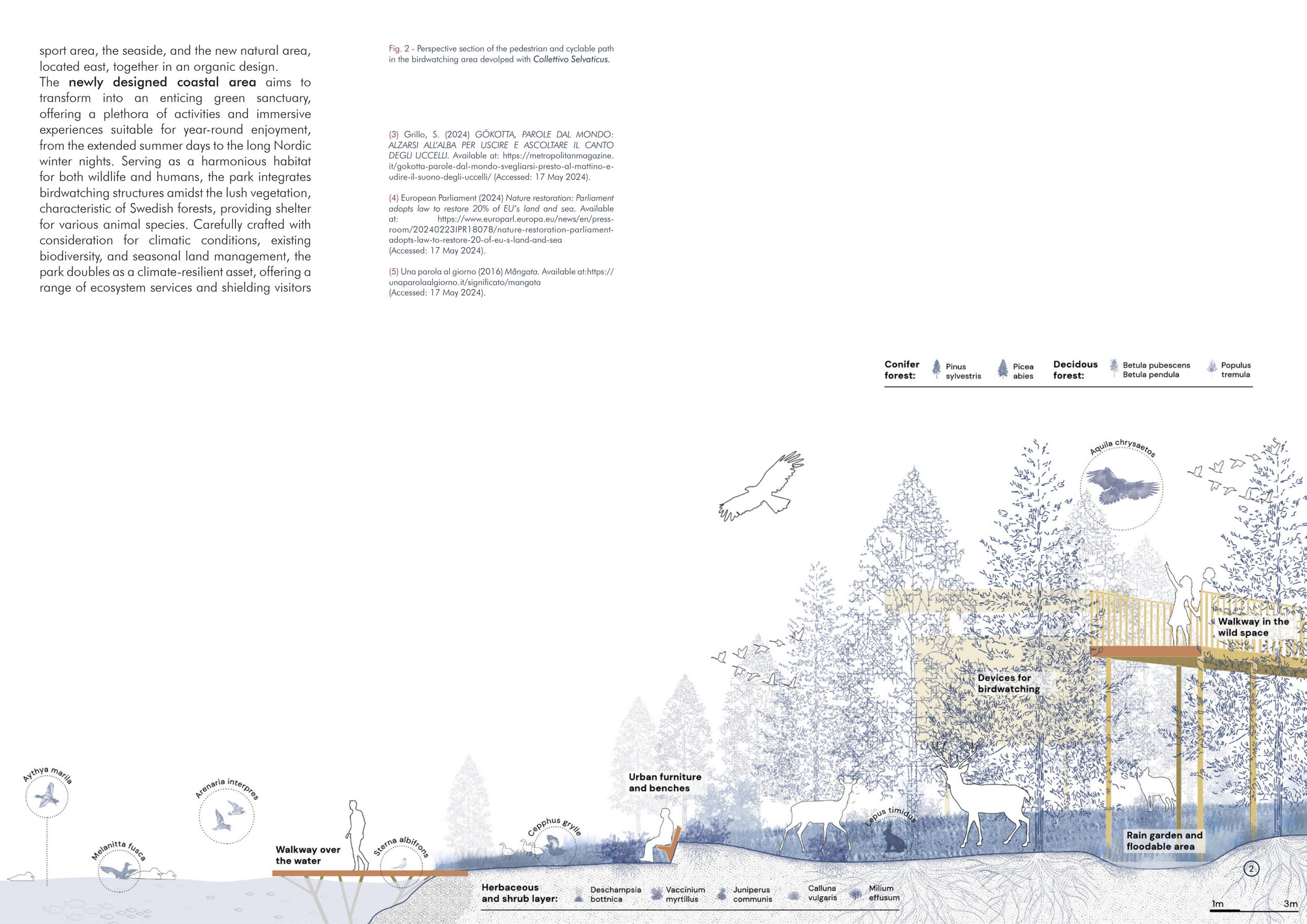
sport area, the seaside, and the new natural area, located east, together in an organic design.
The **newly designed coastal area** aims to transform into an enticing green sanctuary, offering a plethora of activities and immersive experiences suitable for year-round enjoyment, from the extended summer days to the long Nordic winter nights. Serving as a harmonious habitat for both wildlife and humans, the park integrates birdwatching structures amidst the lush vegetation, characteristic of Swedish forests, providing shelter for various animal species. Carefully crafted with consideration for climatic conditions, existing biodiversity, and seasonal land management, the park doubles as a climate-resilient asset, offering a range of ecosystem services and shielding visitors

Fig. 2 - Perspective section of the pedestrian and cyclable path in the birdwatching area devolped with *Collettivo Selvaticus*.

(3) Grillo, S. (2024) *GÖKOTTA, PAROLE DAL MONDO: ALZARSI ALL'ALBA PER USCIRE E ASCOLTARE IL CANTO DEGLI UCCELLI*. Available at: https://metropolitanmagazine.it/gokotta-parole-dal-mondo-svegliarsi-presto-al-mattino-e-udire-il-suono-degli-uccelli/ (Accessed: 17 May 2024).

(4) European Parliament (2024) *Nature restoration: Parliament adopts law to restore 20% of EU's land and sea*. Available at: https://www.europarl.europa.eu/news/en/press-room/20240223IPR18078/nature-restoration-parliament-adopts-law-to-restore-20-of-eu-s-land-and-sea (Accessed: 17 May 2024).

(5) Una parola al giorno (2016) *Mångata*. Available at:https://unaparolaalgiorno.it/significato/mangata (Accessed: 17 May 2024).



from cold currents and northern winds.
Furthermore, the coastline has been reimagined to offer accessible and enjoyable swimming opportunities, fostering continuous interaction between individuals and nature through a biophilic approach. Pathways connecting different areas are constructed with **eco-friendly materials** like wood or limestone, and illuminated with renewable energy sources to ensure year-round usability. Elevated human paths along the coast, supported by wooden walkways or "gökotta" towers (4) for birdwatching, safeguard biodiversity and provide varied perspectives.
In alignment with the principles of the new European Nature Restoration Law (5), the coastline undergoes renaturalization, featuring beaches and rocks to promote the reproduction of local bird species. The "Mångata Bridge" (6) offers a unique viewpoint of the city from the coast and a spot for summer sea dives.
The transformation of the Västra Kajen area into a vibrant meeting point within the park involves revitalizing the existing Piteå Södra harbor and camping area. A new marina with a semicircular wooden deck offers picturesque views of the city and bay, ideal for watching the sunset and for protecting boats moored in the port from sea currents. The camping area is upgraded with new greenery, lighting, and accessible facilities, fostering community engagement.
The park boasts diverse attractions including the old Piteå Boat Museum, experiential paths teeming with biodiversity, top-notch sports facilities such as swimming pools, skate parks, sports fields and versatile performance spaces for cultural events. Central to it all is the **new transportation hub**, the "Piteå Hill."
The new hub, envisioned as an elevated ecological corridor, emerges organically from the landscape, as a hill, covered with vegetation, and extends its slopes to connect various points of the adjacent park with the city, while serving as a distinctive yet understated landmark. The interchange hub integrates seamlessly with its surroundings, linking cycle paths, pedestrian routes, and a new roadway, while providing access to newly installed parking facilities equipped with electric charging stations for bikes and cars. This ensures convenient access to the railway tracks, sheltered from inclement weather, within an active and dynamic hub environment. Featuring amenities such as conference rooms, a small auditorium, cafes, restaurants, coworking spaces and multifunctional spaces, the hub caters to the needs of travelers on the new North Bothnia Line railway. In the summer months, the hub extends its reach outdoors, offering spaces for performances and events amidst the captivating greenery of the adjacent park. This architectural structure serves as a cohesive connection, spanning the divide caused by the new railway line. It goes beyond merely linking green areas, enabling effortless transit for both wildlife and people across different zones. Additionally, it provides a sweeping viewpoint of the city, transforming into a sledding and skiing terrain come winter.

Overall, the proposal elaborated for the competition, which draws inspiration from leading northern european designers such as Effekt Architects, SLA, White Arkitekter, and Lola Landscape, seeks to enrich Piteå's ecological system by developing a biophilic infrastructure aimed at reconnecting the city's inhabitants with nature and biodiversity.
After the competition's results, **the project won a special mention for its innovative approach to climate adaptation through the use of nature and biodiversity**. This, led to the participation to a **workshop in Stockholm**, for which a follow-up of the project was presented, and which allowed us to meet people both from the Swedish Transport Administration and Piteå's municipality.

Fig. 3 - Landscape section for the new residential area on the old raylways' site, realized for the project "Lagom", in occasion of the competition's follow-up.

TABULA NON-RASA

CONNECTIVITY

New transportation hub and railway
Implemented infrastructures
15 minutes city
Access from inside to outside the city
Accent on green and slow mobility

Essential services for every neighbourhood
Uninterrupted walkways
A green loop knitting the city
A new hub for multiple activities
Reconnecting the city to the waterfront
Elimination of existing barriers
Access to nature and water for all
Easy access to all type of services
Sport facilities for everybody
Accent on children's perspective

HUMAN - CITY

NEW HUB

INCLUSIVITY

Nature-based solutions
Design for climate adaptation
Protection of the ecosystems
Coexistence of all living beings
Nature restoration principles
Widespread renaturalisation
Implementation of biodiversity
Biophilic design

NATURE - WATER

NEW RAILWAY LINE

ATTRACTIVITY

The harbour as a social meeting place
Eco-neighbourhoods for new citizens
Improving line sights to the bay area
Redesign of the waterfront
Widespread green areas

BIODIVERSITY

500m 2.000m

Legenda
- Ecological corridors
- Spaces of biodiversity concentration and renaturalisation
- Unused land for densification of the natural landscape
- Integration of sports venues into the landscape
- Places for social gathering in residential clusters
- Urban expansion areas
- Industrial areas to be use for future expansion
- Green mobility
- The new railway

Legenda
- Ecological corridors
- Conifer forests
- Unused land for densification of the natural landscape
- Existing and new trees
- Sports area
- Urban green areas
- New residential areas
- Paved paths
- Urban expansion areas
- Green mobility and walkways
- The new railway

100m 500m

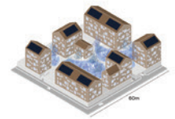
THE BUILT ENVIRONMENT

RECONNECTING THE WATERFRONT TO THE CITY

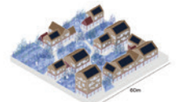
THE COEXISTENCE OF HUMAN AND NATURE

100m 300m

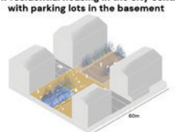
ABACUS OF STRATEGIES, ACTIONS AND SOLUTIONS



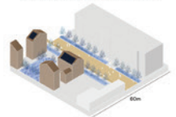
New residential housing in the city centre, with parking lots in the basement



New residential housing in the park, with services on ground floor

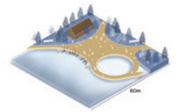


Pedestrianisation of the main street to ease a sustainable connection with the waterfront

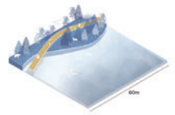


Beyond the railway: from ground plan to elevated walkway as a connective bridge

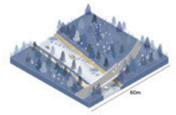
The meeting of old and new: Södra Hamn as a place of dynamism and sociality



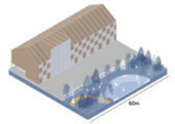
New activities close to the water: water sports and a pier for boats



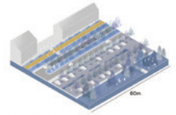
The walkway as a system for stitching up the city, above sea and land level



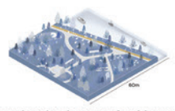
The walkway as a system for stitching up the city, enjoying water in a direct way



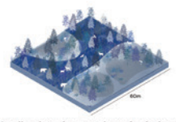
The continuity of green paths inside and outside the city: new spaces for social gathering



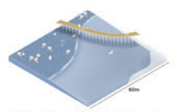
Nature permeates the urban fabric: depaving measures in parking areas and green cycle paths



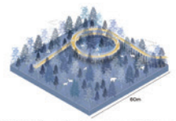
The equipped park: a space for citizens and children, with playgrounds and bike stations



Application of nature-based solutions: phytodepuration and water harvesting



Actions for nature improvement: renaturalization of sandy areas



Activities for nature improvement: areas of biodiversity densification and nesting of species

ILLUSTRATIVE SECTION

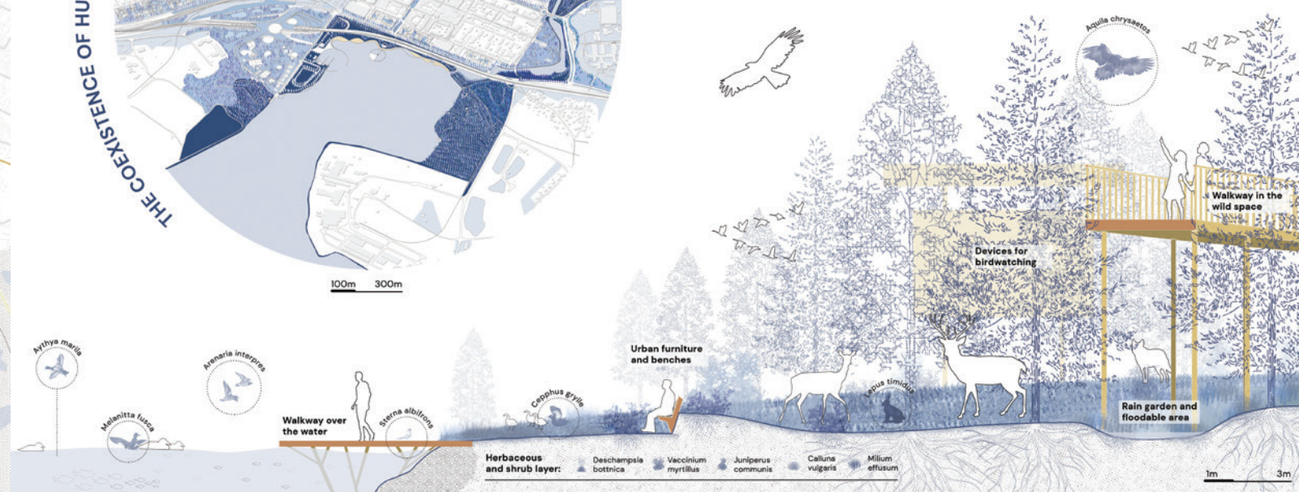


Fig. 4 (in the previously page) - First board realized for the project "Lagom", developed with *Collettivo Selvaticus*.

Fig. 5 (in the previously page) - Second board realized for the project "Lagom", developed with *Collettivo Selvaticus*.

Fig. 6 - Third board realized for the project "Lagom", developed with *Collettivo Selvaticus*.

3.5.
Piteå:
on-site visit and interview

A crucial step in the design of a project is the **on-site visit**, as it allows for direct observation, clarifying project requirements, identifying potential challenges, fostering client relationships, and ensuring effective communication with stakeholders.

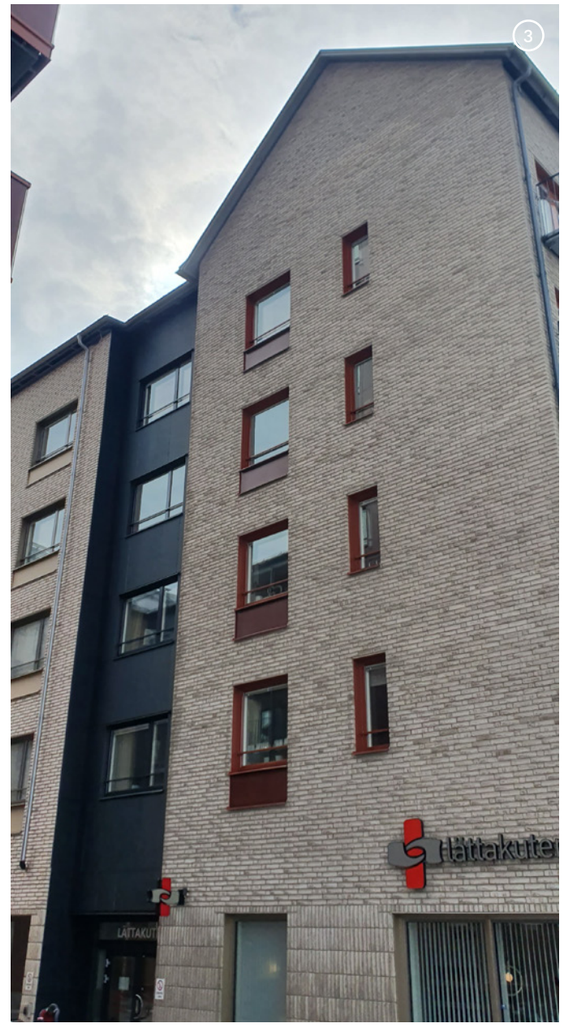
Fig. 1 - Map of the path followed during the on-site visit. **[All of the photos have been taken on the 26th of May 2024]**.

The visit, which took place on the 26th of May 2024, started at the bus station [Fig. 2] and then proceeded at the Stadsporten, located in Västergatan, where we met with **Florian Steiner**, architect for Piteå's municipality.

Along the road towards the waterfront, we noticed a series of buildings along Västergatan, built quite recently, as our guide told us, from the local company Lindbäcks, which realized also a series of buildings in Stockholm made through the use of **prefabricated wood elements, with a brick finish** [Fig. 3].

Fig. 2 - Piteå's bus station.

Fig. 3 - The mixed use buildings realized by the local construction company Lindbäcks. v



After reaching the intersection of Västergatan and the busy Timmerleden, waiting for quite a bit for the streetlight to turn green, we arrived in the **waterfront area**. Here we had the chance to take some pictures of the sea, still frozen even during the springtime, and the small red houses in the camping area.

On the **frozen sea**, far away from us, we could also see the industries located south east, as well as some people who were fishing through holes in the ice [Fig. 4]. At the end of the walkable path along the seafront [Fig. 5], we reached the rail crossing along the **railways connecting the two industrial areas of the city** [Fig. 6].

Fig. 4 - The industries located south east, with people ice fishing.

Fig. 5 - The path along the waterfront.

Fig. 6 - The rail crossing.

From there, we could see the suburbian residential area beyond the canal [Fig. 7], characterized by single housing units made using mainly wood and bright colors. After crossing Timmerleden again, we reached a park facing the canal. Beyond that, a wetland covered in ice, completely untouched [Fig. 8].
Next to the park, Badhusparken, where a folkethus constitutes a small place for community making, there was a residential area characterized by social housing of poor material and design quality [Fig. 9]. From there, we walked along Storgatan, towards the main square [Fig. 10].

Fig. 7 - The canal east of the city center.

Fig. 8 - The canal as seen from the bridge near Timmerleden, towards the city center.

Fig. 9 - The social housing near Badhusparken.

Fig. 10 - Storgatan, towards Rådhustorget.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So we reached the **main square**, Rådhustorget, where a series of historical buildings is still located, along with the city's museum [Fig. 11].

In this area, one of the buildings surrounding Rådhustorget square was undergoing a requalification intervention, showing the wood behind the paint, aimed at faking stone [Fig. 12].

We then proceeded along Storgatan and turned right in order to take some pictures of the Stadsberget, parking garage designed by *White Arkitekter* and *Henning Larsen Architects* [Fig.13;14].

Fig. 11 - Piteå's museum.

Fig. 12 - One of the buildings surrounding the main square, under requalification.

Fig. 13 - The parking garage Stadsberget, by White Arkitekter and Henning Larsen Architects.

Fig. 14 - The parking garage Stadsberget by White Arkitekter and Henning Larsen Architects, seen from Piteå's church.

After that, we walked through Uddmansgatan, a partially pedonalized road where **the artist Sture Berglund realized a piece of art illustrating how the distance of seaside from the city center changed along the years** [Fig. 15].

Later, we reached the KUST Hotel & Spa [Fig. 16], one of the highest buildings in the city center, with its 13 storeys, used both as an hotel for tourists and as a spa by the city's inhabitants. Finally, we visited **the area along the old railway** [Fig. 17], where the new development for the expansion of the city will find its location. Today, it is mainly characterized by a series of abandoned buildings, used mainly as deposits, even if one of them was once used as a restaurant [Fig. 18], as well as a series of wagoons. There is also a semicircular building east of the site [Fig. 19], that our project aims to maintain, as well as the buildings mentioned above. The area is also characterized by a snow deposit, which the city needs in order to store all of the snow covering the roads during the winter.

Fig. 15 - The artist Sture Berglund's piece of art in Uddmansgatan.

Fig. 16 - The KUST Hotel & Spa.

Fig. 17 - The paper industry is visible from the old railway site.

Fig. 18 - The preexisting buildings along the old railway are now used as deposits.

Fig. 19 - The old railway and the semicircular building the project aims to repurpose.

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As previously stated, this thesis was conducted through the conjunction of both theoretical and on-site research, as both are an essential parts of the design process. Following the competition, the project was subjected to the evaluation of the jury, and was awarded with a special mention for its unique and innovative approach to urban design for climate adaptation and mitigation and its particular focus on the inclusion of non-human species as one of the key elements of the project.
At the premiation ceremony, which took place in Stockholm, we had the opportunity to meet members of the Swedish Transport Administration, as well as the city architect for the municipality of Piteå, Florian Steiner (1), who was so kind to meet our needs and organize an on-site visit and interview with us.
The on-site visit, which took place on the 26th of May, was an occasion for us to ask a few questions to Florian, who guided us around the city, following the path illustrated on the map, and answered a few questions:

1. Are you from Piteå? If yes, what is your perception of the city? What do you think Piteå major strenghts are? What do you think Piteå lacks in terms of services? Do you think something could be improved in some way?
"No, I am originally from Germany. I came here with my wife - she's from Germany as well - and we now live here with our kids. My perception of the city is that it's a quite small city but that it has a lot of things to offer. I would say that its strenghts are that it is close to nature, as the center is embedded by water, and also th-e majority of residential areas have good access to nature at a walkable distance. Even if it is an originally industrial city, which also affects the mentality, Piteå made a strong effort to strenghten the cultural life, and that is why we have the university and musical education and I think that it makes impact. We need even more culture, service diversification, and places for young people, needed in order to make the city more attractive. We would also need more creative clusters, and maybe some spaces for start-ups. We have something like that in the university area, like the Piteå Science Park, where we have some clusters of small companies, and we may need more of that, maybe to develop a more research based wood industry in order to move from the traditional one we have now."

2. Do you think the city is well prepared in terms of climate adaptation? Is the municipality doing something in order to face the current climate change and the incoming future?
"We don't really know what rising sea levels mean for Piteå, because we have land rise and we don't know which prediction will be the right one. That's why our planning always takes rising sea level into consideration. It is not always possible to build close close to the water, since here in Sweden we have the Shore Protection Law, but sometimes in the city center you can do that. If we have a map showing that a certain area is subject to floods, wecannot build there, unless you show technical solutions, like pillars, for example, that can be applied in order to make it possible, but you need a special pass in order to do that anyways. We also made a heatmap of the city, measuring the temperatures during the summmer, and implemented more trees like poplars and birch trees, that grow fast and are both very effective for the prevention of floods, as they absorb a lot of water and strive in wet conditions. The city also takes advantages of the heat produced by the industries, like the Smurfit Kappa, and use it in order to heat, for example, the main shopping street of the city, as well as almost 60% of the houses around Piteå. Close to the university area, there is also an experimental implemented a series of solar panel."

3. Is the city doing something in order to preserve/improve urban biodiversity?
"Not enough. For example, I recently spoke to the person that is responsible for the city parks and green areas and he told me that all the trees along the road were cut down quite early. We also have a lot of green areas, but it is mainly grass, also because peolpe think that more natural areas could attract rats. If you look around the residential areas it is a competition among neighbors for the best-manicured lawns. We don't have pollinator gardens owned by the municipality, but the few pollinator gardens and insect hotels that are present in the city are property of privates or the Swedish church, which installed some of them near the graveyard"

4. What is the relationship between Piteå and nature? Do you think the city would benefit from the implementation of more nature?
"People here think we have so much nature, so we don't need more, because everything is actually cultivated or productive land. This makes it important to teach people what nature actually is. Overall the city would benefit from the implementation of more nature."

5. Are the industries in the city a menace to Piteå's biodiversity in some ways? Is nature seen just as a source of production? Are there things they could do in order to prevent its degradation?
"If we talk about the wood industries, they don't have true policies regarding this topic. There is surely some ambition to be more ecological, but it is mostly greenwashing, because the truth is that they need a lot of wood in a very short time span, and of course wood harvesting would be possible but it would also lead to higher prices. This, in turns, leads to the destruction of the bushwood, and of the plants the animals need as a source of nutrition, forcing moose to enter the city searching for food, and causing a series of problems. It is indeed not unusual to see a moose wandering around the city, and this in turns makes both animals and humans I unsafe. The majority of the forests around here are used for wood production, but we also have an untouched forest owned by the municipality, a few natural reservoir, and some biotopes, which national authorities would cut down only if needed."

6. Do you think the Sami culture influences the view Piteå's citizens have on nature?
"Piteå museum's historian and pedagogue Morgan Stenberg is half or a quarter sami. Here in the north of Sweden it is not unusual to have Sami ancestors in some branch of the family. Sami people influence many aspects of the northern Sweden culture and connection to nature. Just as an example, many schools in Sweden are forest schools, a kind of school that values nature as an important element for children's cognitive development."

7. We named our project "lagom" because we read that swedish people like to wake up and listen to the birds singing. As we are designing some devices in order increase the local fauna, such as bees, insects, bats, and birds, that are particularly close to residential buildings, it could be a problem for the citizens?
"There are some bee houses inside the garden of a few houses around the city, as well as bird houses, but the answer is very personal, as sometimes this kind of devices create conflicts between neighbors. Also, education and information is crucial to make people understand the importance of urban biodiversity in the city."

8. Are there some invasive species in Piteå? If so, what are the measures the city can take in order to restore the local species and eradicate the invasive ones?
"There are some invasive plants. They can be found also on the municipality's website. Some of them are Impatiens glandulifera and Lupin, which citizens need to put in a closed plastic bag and throw it in the normal waste bin whether found in their gardens.

9. What do you think the new area near the old railway we are designing may need the most?
"As the city needs more housing areas because of the population growth, it will new schools as well. Now there is a discussion on whether it would be better to build bigger schools, in order to minimize the number of staff members, or smaller schools well distributed around the city in order to be accessible by walk. We think the latter would be more beneficial, since it would make it possible to avoid using cars in order to get there, but of course it is a still ongoing discussion. Another thing that would be needed would be some cultural spaces, since we don't have a culture house like the one in Luleå, but it is something that is more spread out in smaller spaces, like Kaleido, the city library, exposition halls, theater stages, but we do not have all in one building."

Overall, the interview was extremely helpful in order to gain a better understanding of the site and the city itself, as it confirmed some of our

hypotheses and added new ideas and insights into our project.
Fow example, as we were wondering if to implement urban farming in the new residential area we are designing, he told us that it was becoming a quite popular activity, and that Piteå's citizens would definitely benefit from those, as also a new residential area not far away from the city center was quite popular because of that, even if it didn't succeed as the prices were too high compared to the actual sizes of the buildings.
He told us about the different problems the city has, such as the lack of places for community, making art, as well as places for younger generations to meet, guiding our decision to design one of the two buildings located in the service area for coworking and offices and the other one for a culture house.
He also explained to us how the industries affect the city and its surrounding, as the forests nearby the city are mainly used as a means of production and the bushes the animals need as a source of nutrition are destroyed, forcing the animals to enter the city searching for food, and causing a series of problems.
When we asked if the city was well prepared in terms of climate adaptation, Florian told us the city is trying to implement renewables (for example the main shopping street of the city is heated by the surplus energy produced by the industries, as well as almost 60% of the houses around the city), as well as to implement more trees (typical trees in the city are poplars and birch trees) in order to help against the heat island effect, as well as floods.
When we asked if the city was doing something in order to preserve or improve urban biodiversity, he told us that it could do probably more, as the city started cutting all the trees along the roads, and the various green areas around the city are mostly grass, and that in general that the city would benefit from the implementation of more nature.
Talking about urban biodiversity, he also told us the few pollinator gardens and insect hotels that are present in the city are not of the municipality but are property of privates or the Swedish church.
Additionally, as there are a series of invasive species in Piteå, the municipality created a guide on the website in order to inform the citizens about the actions they can take in order to help.

Florian Steiner, former architect of a small firm in Neumarkt, Germany, works for the municipality of Piteå, where, in 2008, he secured a job as a physical planner, and, 8 years, later became the city architect (1).

(1) Piteå Kommun (2023) From Bayern to Piteå. Available at: https://www.pitea.se/en/move-to-pitea/personal-portrait/from-bayern-to-pitea/)

3.6.
(E)co-existence:
a new design for the city


Preserved old railway tracks
Facility buildings
Semi-private residential area: three-bedroom and four-bedroom apartments in the park with shared spaces
New police station
Private residential area: single-family villas among urban gardens
Snow deposit
Biodiversity corridor
Eco-parking lots
Re-naturalized shore
"Mångata" sea viewpoint
New hub
New port design
Public residential area: one-bedroom and two-bedroom apartments with elevated courtyards
Sport area
Reforested area
Pedestrian path
Bird watching area
2
100m
500m
1000m
1500m
2000m
2500m
3000m

Master plan

Fig. 1 (in previous pages) - Perspective section of the waterfront area.

Fig. 2 (in previous pages) - The project's new masterplan.

Fig. 3 - Scheme showing: new buildings, slow mobility paths, streets and pre-existing buildings.

Fig. 4 - Scheme showing: Urban forests, green roofs, designed green areas, pre-existing green, urban farming and pre-existing buildings.

Fig. 5 - Scheme showing different types of relationship between nature and designed buildings.

3

4

5

Public residential area
with elevated courtyard.

Semi-private residential area
in the park.

Private residential area:
villas among urban gardens.

Facility buildings with indoor
green courtyard.

For the purpose of this thesis, some parts of the project, such as Mångata, the walkable ring located along the waterfront, at the end of Uddmansgatan, were changed in order to better respond to the city's needs. Moreover, the idea of **eco-district** was further researched, leading to a redesign of the residential and commercial area close to the city center, facing Timmerleden, designed for the competition, as well as to the design of a new vibrant area along the old railways near the bus station, surrounded by Timmerleden, Västergatan, Storgatan and Bergsviksvägen.

Aim of the thesis project was also to go more in depth with the themes of biodiversity and nature as tools for climate adaptation and mitigation, mostly by integrating a series of Nature-based Solutions and solutions for the implementation of urban biodiversity into the urban fabric. This will be illustrated further in the next chapter.

As the project designed for the competition was lacking in a residential area along the old railways, as it was stated by the jury after the competition (1), one of the areas we decided to focus and redesign was indeed the area nearby the existing bus station, where the old railway is today still standing.

In order to accommodate the city's population growth, a new residential and commercial area is indeed proposed west of the city center. This fits harmoniously with existing vegetation and promotes biodiversity, merging different ways of living in an area that transforms itself the farest you go from the historical grid. Crossing the path defined by the traces left by the **old railway**, like a backbone for this new residential area that crosses it longitudinally for its entirety, you pass by purely service oriented buildings, which constitute the connection between this new area and the historic center, then passing through a mixed-use area that merges commercial use, situated on the ground level, with residences on the upper floors, to an exclusively residential area. Services oriented buildings prioritize community engagement and expression on the ground level, with spaces for making art and exhibitions, and places for creating community even during the harsh winters, while also providing office and coworking spaces above. Instead the last residential area along the main path takes the shape of small "villages" connected by a straight way, creating community spaces in

Fig. 6 - View from one of the courtyards of the private residential area at the end of the old railway's area.

(1) Kamann, M. (2016) *"Lagom" in Sweden - What It Means and Where It Comes from*. Available at: https://hejsweden.com/en/lagom-how-to-be-swedish/ (Accessed: 17 May 2024).

Fig. 7 - View from one of the courtyards of the public residential area close to the city center.

the centers with spaces set aside for community greenhouses, and urban farming areas all around as well as small private gardens.
From a more pragmatic point of view, the project outlines several transformational steps for its realization. The initial phase of construction will indeed focus on the planting of new evergreen trees around the area, as well as on the moving of the existing ones, mainly poplars and birch trees. **Trees**, especially the evergreens, are used as a sound barrier against the traffic sounds coming from the surrounding roads, for this reason positioned mainly on the perimeter of the area, while the ones positioned into the core of the site are used for the prevention of floods, both acting as a tool for the implementation of urban biodiversity in the area as well as regulating the sunlight exposure in different seasons, thus reducing the urban heat island effect during the summer and granting natural illumination during the winter. A second step will involve the creation of a series of rain gardens and a water collection pond to manage rainfall and snow, as well as designated areas for snow storage, addressing a crucial need highlighted by municipal authorities. Subsequent construction phases will align with Piteå's economic growth trajectory, utilizing metal and prefabricated wood from local companies, such as Lindbäcks (2), facilitating the deconstruction of the buildings at their end-of-life phase, following the principles of **Design for Deconstruction** (DfD), for the construction of the new residential, commercial and office buildings.
In fact, each building starts from the design of a regular grid with 3 meter by 3 meter modules, so as to allow the prefabrication of its constituent elements and reuse at the end of its life, but also to facilitate its reading, construction and demolition.
The project particularly emphasizes on the coexistence between man and nature implementing urban biodiversity as a tool for human well-being and climate adaptation, using solutions such as green roofs, rain gardens, and structures aimed at giving home to non-human species, such as birds, bees and bats.

As an example, in the new residential area close to the city center, a series of urban birds nests have been implemented into the building's facades inside the common courtyards, linked by a walkable and cyclable elevated path in order to

(2) Lindbäcks. *Bygg klimatsmart. Bygg i trä med oss!* Available at: https://lindbacks.se/ (Accessed: 17 May 2024).

make the connection between the various lots as organic and direct as possible while also avoiding cars, sign of a particular attention to children's safety and overall accessibility. Particular attention was indeed paid to the themes of accessibility and inclusivity, as every part of the project was carefully designed in order to be accessible both by walking and cycling, as well as to families with strollers and to wheelchair users.
As well as birds, the courtyards near the city center give home to bats, a species usually overlooked but whose presence has been proven extremely beneficial, while also being integrated with pollinator gardens and constituting a pocket park in itself.
The same has been done also for the courtyards in the new residential area located on the old railways's site, along a series of rain gardens aimed at collecting excess water in order to avoid floods, since it is indicated as an area at risk by the flood risk map created by the city's municipality.
In addition to that, both the new residential areas near the city center and the new residential area at the center of the old railways' site feature green walls, but, differently from the firs, the latter is also characterized by the use of green roofs on the top. These has also been implemented on the top of the service buildings, also characterized by green circular courtyards which constitute a "green heart" aimed at implementing nature and making good use of its psychological benefits inside the buildings.
Inside the courtyards of the village at the end of the railways axis, a series of insect hotels were also integrated, as well as pollinator gardens, in order to give home to animal species that are particularly necessary for the context hereby presented, characterized by urban farming areas and greenhouses.
At the end of the new area along the old railways, an eco-parking lot was also integrated, in order to accommodate the incoming inhabitants' need for parking areas while also integrating vegetation in order to give home and nutrition to small animals such as birds and insects and avoiding the act of paving, oftentimes among of the indirect causes of floodings.
For the purpose of this thesis, a toolkit was also produced in order to illustrate all of the Nbs and all of the solutions for biodiversity implemented in the final project, result of the project realized for the competition and the studies conducted for this thesis.
Example of these are the renaturation of the waterfront area, the implementation of underpass and overpass biological corridors, such as the one constituted by the new railway station, among others.
These will be further illustrated in the following chapter.

Fig. 8 - View from one of the courtyards of the semi-private residential area on the center of the old railways's area.

Fig. 9 (in the next page) - A section of one of the courtyards in the semi-private residential area on the center of the old railway's area.


Green roof to manage rainwater runoff and improve thermal insulation
Urban nests are implemented on buildings facades
Pocket parks reduce the heat island effect
Green walls help reducing the urban heat island effect
Bat boxes give home to bats
Small hills serve as protection from the wind
Rain gardens reduce the risk of floodings
Pollinator gardens attract wild pollinators

3.7.
A toolkit for adaptation and mitigation

In an era of rapid urbanization, integrating nature into cityscapes is not just a luxury but a necessity. This chapter introduces a comprehensive toolkit of Nature-based Solutions (NbS) and strategies for enhancing urban biodiversity, aimed at guiding urban planners, architects, and policymakers in creating greener, more resilient cities.

A toolkit in this context is a structured collection of practical methods, techniques, and solutions that demonstrate how natural elements can be seamlessly integrated into urban environments. This resource is indispensable for the design process, offering adaptable solutions that cater to diverse urban settings and specific ecological challenges.

The versatility and evidence-based approach of this toolkit are its key strengths. It provides actionable insights on incorporating green roofs, urban forests, wetland restoration, and biodiversity corridors, among other strategies. By leveraging these solutions, cities can enhance their ecological footprint, improve residents' quality of life, and build resilience against climate change.

This chapter not only showcases the transformative potential of NbS in urban spaces but also underscores the importance of biodiversity as a cornerstone of sustainable urban development. By integrating these tools into planning and design processes, cities can foster vibrant ecosystems that coexist harmoniously with human habitats.

The toolkit is a compilation of skills, knowledge, procedures, and information tailored for specific topics or activities, making these solutions accessible and replicable. It delves into its contents, providing illustrations from the project and highlighting commonly encountered NbS technologies at landscape, urban, and micro-urban scales, and implementing these solutions in conjunction with biodiversity-related strategies.

Ultimately, this toolkit aims to provide a compendium of solutions applicable to different design scales, with the goal of making cities with similar characteristics to the one analyzed in this thesis more resilient, livable, and inclusive.

(1) Crisostomo, A. (2020) *Biodiversity [+] Urban Design Toolkit*. New York: Columbia University.

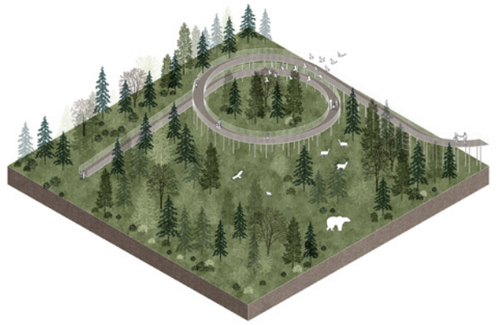
(2) World Bank (2021) *A Catalogue of Nature-Based Solutions for Urban Resilience*. Washington:World Bank Group.

Underpass biological corridors

Underpass biological corridors, also known as "wildlife underpasses" or "ecopassages", are structures built beneath highways or other infrastructure to facilitate the safe movement of wildlife underneath roads. These corridors serve to mitigate the negative impacts of roads and habitat fragmentation on wildlife habitats by providing a continuous pathway for animals to travel between fragmented areas. Similar to overpass biological corridors, they typically consist of tunnels or culverts designed to mimic natural habitats and encourage animals to use them as safe crossings (1).

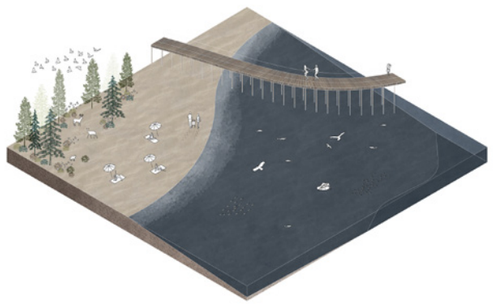
Overpass biological corridors

Overpass biological corridors, also known as "wildlife overpasses" or "ecoducts", are structures built over highways or other infrastructure to facilitate the safe passage of wildlife over roads. These corridors help mitigate the negative impacts of roads and fragmentation on wildlife habitats by providing a continuous pathway for animals to move between fragmented habitats. They typically consist of vegetated bridges or tunnels designed to mimic natural habitats and encourage animals to use them as safe crossings. Overpass biological corridors are essential for maintaining biodiversity, reducing the risk of wildlife-vehicle collisions, and preserving ecological connectivity (1).



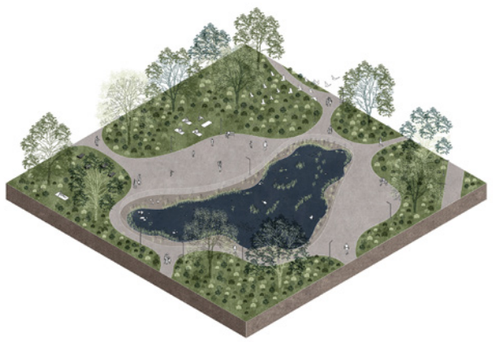
Urban forest

Urban forests are resilient ecosystems located within cities or at the rural-urban interface. They mitigate the urban heat island effect, reduce air pollution, and retain stormwater. They protect rivers by intercepting rainfall, increasing infiltration, and reducing flooding. Urban forests also clean soils, sequester carbon, and regulate water cycles through retention, infiltration, and evapotranspiration. They enhance air and water quality, provide critical habitats, and lower ambient temperatures. Additionally, urban forests contribute to the physical, mental, social, and economic wellbeing of urban communities, making their preservation vital for climate resilience (2).



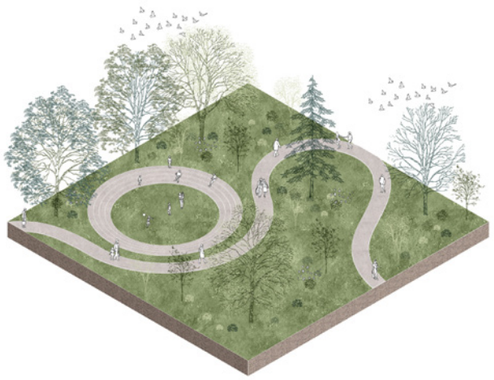
Shore renaturation

Shore renaturation involves restoring and enhancing natural shoreline ecosystems to improve resilience and biodiversity. This approach includes planting native vegetation, creating habitat structures, and implementing erosion control measures to stabilize shorelines. By mimicking natural processes, shore renaturalization helps mitigate coastal erosion, enhance habitat for wildlife, and promote sustainable shoreline management, contributing to the overall health and resilience of coastal ecosystems (1).



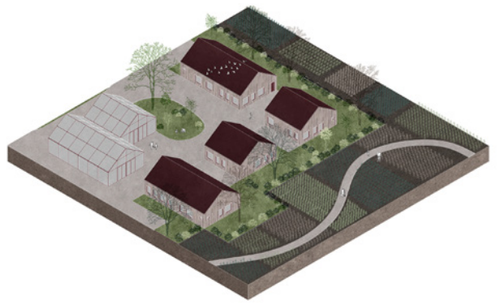
Retention ponds

Retention ponds are bioretention areas featuring a permanent body of water and vegetated edges. Unlike detention ponds, they are always filled with water. These ponds collect stormwater from the surrounding areas, adding storage capacity and alleviating pressure on surface water treatment and sewerage systems. Additionally, retention ponds store water for reuse during drought conditions, provide habitats, and enhance the diversity of public green spaces (2).



Detention ponds

Detention ponds, deeper and less biologically diverse than bioswales and rain gardens, act as bioretention systems that capture and temporarily store stormwater during heavy rainfall. These ponds can completely fill with water during storms, allowing much of it to infiltrate the ground and discharging the excess into the sewer system. For the majority of the time, they remain dry. Additionally, detention ponds can enhance the scenic value of public areas, playgrounds, and sports fields (2).



Urban farming

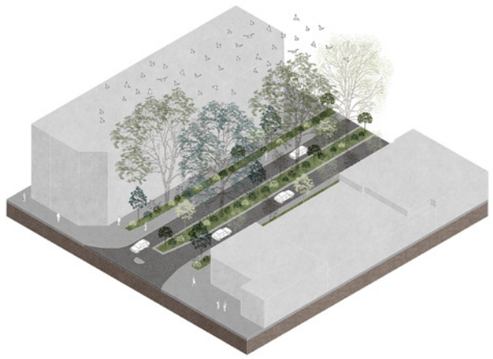
Urban farming offer opportunities for individuals without private outdoor areas to cultivate and care for their own plots. This not only fosters social connections, thereby building community, but also cultivates a deeper connection to the land and provides associated health benefits. For instance, research has shown that engaging in just 30 minutes of gardening daily can lower cortisol levels, decrease the risk of heart disease, and enhance immune function and memory (2).

Permeable pavments

Permeable pavements, including pervious asphalt, concrete, interlocking pavers, and plastic grid pavers, offer an alternative to traditional pavements. They reduce surface runoff during mild storms by infiltrating, treating, and storing rainwater, allowing it to penetrate through layers of pavement, stone aggregate, and a filter layer. Suitable for commercial, institutional, and residential areas like walkways, driveways, bike lanes, parking lots, and low-traffic roads, they are not recommended for high-traffic roads or spill sites to avoid clogging. (2).

Eco-parking lots

Eco-parking lots, also known as eco-friendly parking lots or green parking lots, are parking facilities designed with environmental sustainability in mind. These parking lots incorporate various features and technologies to minimize their ecological footprint and promote environmental conservation, such as the creation of permeable pavement surfaces, the use of recycled or environmentally-friendly materials, the installation of green infrastructure elements such as rain gardens, bioswales, or vegetated strips, the use of native plants to provide habitat for wildlife, improve air quality, and enhance the aesthetic appeal of the parking lot, and the integration of renewable energy sources such as solar panels and of electric vehicle charging stations (1).

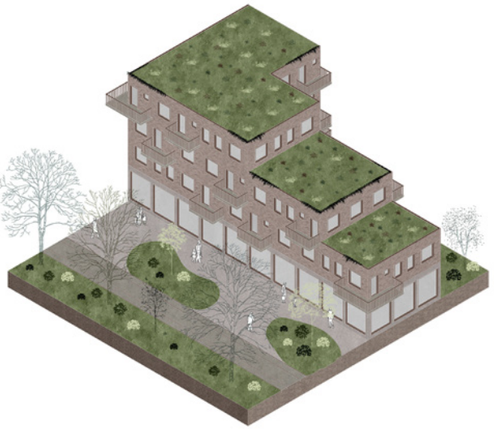


Street tree canopies

City streets adorned with expansive tree canopies not only elevate the city's aesthetic appeal but also bolster its competitive edge while offering a host of economic and environmental advantages. Street tree canopies serve as natural conduits for rainwater, foster localized microclimates, purify the air by absorbing pollutants, and provide cooling shade, thereby mitigating heat. This reduction in temperature not only leads to decreased cooling costs for buildings but also encourages pedestrian activity and social connections, ultimately driving up revenue in retail and hospitality sectors (2).

Residential gardens

Residential gardens, when seamlessly woven into broader green infrastructure systems, wield significant influence in curbing stormwater runoff. These gardens efficiently handle precipitation from buildings, rooftops, and courtyards, adeptly capturing and reusing stormwater. Moreover, the lush vegetation aids in tempering urban heat, with trees, shrubs, and other flora doubling as habitats for local wildlife. Beyond environmental benefits, residents can enjoy these gardens for cultivating vegetables and engaging in leisure activities (4).



Rain gardens

Rain gardens are innovative landscapes designed to manage rainwater runoff in urban areas. These gardens utilize a combination of specialized soil and native plant species to capture, absorb, and filter rainwater, thereby reducing the risk of flooding and improving water quality. With their bowl-shaped design, rain gardens promote water retention and infiltration into the ground, replenishing groundwater supplies and mitigating the impacts of heavy rainfall events. Additionally, the diverse vegetation within rain gardens provides habitat for various wildlife species, contributing to urban biodiversity. Overall, rain gardens serve as eco-friendly solutions for sustainable stormwater management and environmental conservation (2).

Pollinator gardens

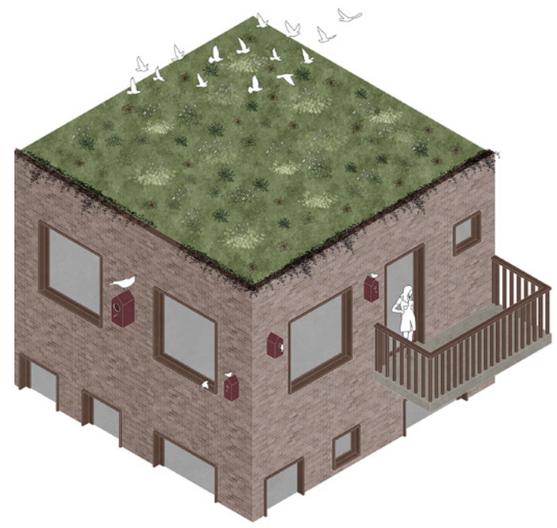
Pollinator gardens reduce fragmentation in the landscape and can be employed to create ecological corridors in order to improve urban biodiversity. They are designed to attract and support pollinating insects such as bees, butterflies, and hummingbirds. They typically contain a variety of flowering plants that provide nectar and pollen as food sources for pollinators, and play a crucial role in supporting biodiversity and maintaining healthy ecosystems by facilitating pollination, which is essential for the reproduction of many flowering plants (1).

Insect hotels

An effective method for boosting the population of local insect pollinators and promoting urban biodiversity is by installing **insect hotels**. These structures offer solitary bees and other pollinating insects a safe refuge to inhabit. To properly install an insect hotel, it should be positioned against a flat or sturdy surface and securely fastened to prevent it from swaying in the wind. Ideal locations for placing a bee hotel include the side of a shed, garage, fence, post, or even a substantial, mature tree. It's crucial to ensure that no vegetation obstructs the entrance to the bee hotel (1).

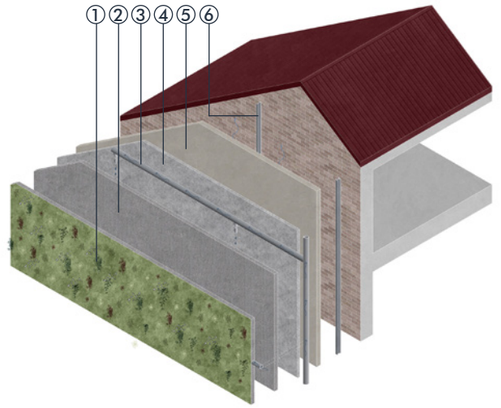
Bat boxes

Bat boxes are crafted to attract bats to areas lacking natural roosting sites. These boxes come in different designs, ranging from DIY wooden constructions to pre-assembled external units, and even integrated options for incorporation into walls. To effectively entice bats, bat boxes should be positioned at least 4 meters above ground level, facing eastward. They can be mounted on dead trees, poles, or buildings, provided there's a clearance of at least 6 meters from tree branches, wires, and other obstructions (1).



Urban birds nests

Strategically situating **urban bird nests** can create ecological corridors within fragmented urban landscapes, simultaneously enhancing the urban environment and enriching people's interactions with nature in the city. In order to accommodate multiple species, these nests must vary in size and feature entrances of different dimensions (1).



Green walls

Also known as "living walls" or "vertical gardens", **green walls** are vertical built structure covered by vegetation. They include a vertically applied growth medium such as soil, substitute substrate, or hydroculture felt, as well as an integrated hydration and fertigation delivery system.
They improve biodiversity by accomodating a variety of plant species and creating habitat, also providing insulation and reducing the urban heat island effect (2).

1. Vegetation
2. Reinforced polyamide felt
3. Polypropylene irrigation tube
4. Polypropylene geotextile
5. Rigid plastic panel
6. Steel frame

Green and brown roofs

Also referred to as "living roofs," **green roofs** come in 2 main categories: intensive and extensive. They offer a wide range of benefits, including providing habitat for wildlife, sound and thermal insulation, mitigating rooftop runoff, sequestering CO_2, and reducing the urban heat island effect.
While green roofs involve the introduction of seeds or plants into the substrate during construction, **brown roofs** allow vegetation to naturally establish itself through windblown seeds and bird droppings. They require minimal maintenance and their substrate may eventually incorporate waste materials or construction debris, contributing to a sense of recycling within the project (2).

1. Vegetation
2. Soil
3. Filtering and stabilization component
4. Water storage and drainage panel
5. Root-resistant waterproof membrane
6. Double wood-cement panel
7. Corrugated sheet metal

Open issues

In conclusion, which is the role of nature within cities? Can humans and non-humans coexist harmoniously in a climate-changing future? These are just some of the questions this thesis wanted to underline.
Starting from an analysis of the European context, the different policies implemented in various biogeographical regions have been examined using a trans-scalar approach, from the national scale, through the urban scale, and finally reaching the neighborhood and building ones. As a matter of fact, the thesis has highlighted how the European Union's climate policies, integrated with local initiatives, can provide an effective framework for cities, and how the adoption of climate policies and actions must be integrated and coordinated across multiple levels to ensure consistency and effectiveness, since, just as a building is part of a broader urban context, a city is embedded in a national and global system. However, it is equally important for cities to develop their own strategies and targeted actions adapted to local specificities. Cooperation between cities, through collaborative networks such as the Covenant of Mayors and sustainable city initiatives, demonstrates how local actions can be enhanced through support and the exchange of best practices at the supranational level. The analysis conducted on the theme of eco-districts has also revealed how they can serve as an inspiring model for a new way of living, as they combining energy efficiency, sustainable resource management, sustainable mobility and green spaces, demonstrating how integrated urban design can significantly contribute to climate mitigation and adaptation. These neighborhoods not only reduce the environmental impact of housing, but also improve residents' quality of life by promoting a healthier and more sustainable lifestyle.

One of the key elements connecting all the case studies analyzed in this research is **nature**, used as a tool to improve energy performance, economic savings, sustainable design, and as a means to ensure human well-being.
Adaptating this conceptualization, this thesis delved into the idea of nature as a tool for climate adaptation and mitigation, introducing the concepts of **Nature-based Solutions** and urban biodiversity, highlighting their strict relationship as well as their role in addressing climatic issues.
In general, Nature-based Solutions emerge as fundamental tools for promoting urban climate resilience. These solutions, which include the creation and maintenance of green spaces, green roofs, green walls, and sustainable stormwater management, among others, significantly contribute in tackling some of the consequences of climate change, such as the Urban Heat Island effect, while also absorbing carbon, and improving air quality. Additionally, we have seen that NbS enhances urban biodiversity by creating habitats for native species, thus promoting harmonious coexistence between humans and nature. Urban biodiversity plays a vital role in building resilient cities, as having a rich diversity of plants and animals in urban areas not only improves residents' quality of life but also provides essential **ecosystem services** such as **pollination**, microclimate regulation, and water purification. Urban biodiversity is, therefore, an indispensable component in addressing climate challenges, reducing cities' vulnerability to extreme weather events, and enhancing their recovery capacity.
After proposing this frame, the thesis aimed to test these ideas by analyzing and redesigning the project site of this research. The area under analysis is part of one of the sites proposed in the seventeenth edition of Europan "Living Cities", a competition in which our project won a special mention, thanks to innovative approach to climate adaptation through the use of nature and its novel way of designing cities with biodiversity in its core. The result of our design process was a redesign of the city of Piteå, located in northern Sweden, culminating with the proposal of a toolkit of solutions for climate resilience and biodiversity conservation aimed at the coexistence of humans and nature.
Indeed, one of the central questions of this thesis concerned the possibility of coexistence between humans and non-humans in cities. The research demonstrates that not only is it possible, but it is also essential to address climate challenges, as cities and neighborhoods must be seen as part of something else. As we have seen throughout this dissertation, actions and policies for climate mitigation and adaptation must necessarily involve different scales and cannot be limited to the neighborhood or city dimension, nor can they remain confined to the building scale alone. Just as a building is part of a broader context, regulated by rules and conditions that inevitably impact its design. A city is in itself an ecosystem made of interconnected elements that, however small and insignificant they may seem, inevitably influence the urban, as well as the national and international systems, ultimately reaching the global scale. For too long, we have focused on our own small, separate worlds, ignoring how every of our actions, even the smallest, affects the whole system. Like any other living being, we are part of a complex network of interconnected vital processes and cycles. In this sense, the system and the individual element are deeply interdependent: just as the individual element cannot live without the system, the system's existence depends on the individual element and the connections it forms with other elements. Similarly, we can no longer afford to think of the city and humans as entities separate from nature and the other species that inhabit our planet. Nature should not be seen as a separate or accessory element, but as an integral component of the urban reality, while cities must be designed and managed to promote the symbiotic relationship between humans and nature by integrating green spaces and Nature-based Solutions into urban planning policies.

In conclusion, the climate transition of cities requires a paradigm shift that recognizes the central role of nature and urban biodiversity. Nature-based solutions and the promotion of urban biodiversity are fundamental tools for building resilient and sustainable cities, however, to be effective, these actions must be part of an integrated and coordinated approach across multiple levels, involving all scales from buildings to neighborhoods, cities, and beyond.
The future of our cities depends on our ability to integrate nature and urbanization harmoniously and sustainably. Only through collective commitment and long-term vision we can create cities that not only survive climate change, but thrive in it, adapting and evolving like every form of life does to new and challenging conditions, looking at cities like an integral part of the ecosystem, or a creature that, in order to survive, needs necessarily to evolve into something else. For too long we kept designing cities, neighborhoods and buildings as separate from its context, and completely ignoring the importance of designing the spaces in which we live by taking the surrounding, climatic conditions and local biodiversity into account. In this sense, climate transition is no more just a necessity, but it becomes an opportunity to rethink and redesign our cities to ensure a better future for all forms of life that inhabit them, both human and non-human.

At its core, everything stems from a simple idea behind it: we are nature.

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Iconography

All the images not present in the iconography were created by the authors of the thesis.

1.2.2. Case studies:

The plans of the cities are reworkings of data obtained from various sources, including GIS data and aerial photos, produced by the authors of the thesis.

Fig. 2 - Aerial view of Stockholm's Gamla Stan.
Source: [www.repubblica.it].

Fig. 3 - Husarvikstorget's green roofs.
Source: [www.vargarkitekter.se].

Fig. 4 - Tunnels for amphibians and aquatic salamanders at Loudden.
Source: [www.norradjurgardsstaden2030.se].

Fig. 5 - Nests made from waste in the Stockholm Royal Seaport area.
Source: [www.norradjurgardsstaden2030.se].

Fig. 7 - Aerial view of the eco-district Bo01 in Malmö.
Source: [www.cosvig.it].

Fig. 8 - Ohboy, sustainable hotel near the eco-district Bo01.
Source: [www.siegel.nu].

Fig. 10 - Aerial view of the city of Copenhagen.
Source: [www.getbybus.com].

Fig. 11 - View of a park in Copenhagen. The city has approximately 3,260 ha of green areas, reachable by at least 96% of citizens on foot within 15 minutes.
Source: [www.ohga.it].

Fig. 12 - View from above of CopenHill.
Source: [www.world-architects.com/].

Fig. 13 - Cykelslangen (The Bicycle Snake): a 'suspended' bicycle lane that runs through the area adjacent to the harbor.
Source: [www.living.corriere.it/].

Fig. 15 - Top view of the Helsinki Cathedral (the Helsingin tuomiokirkko).
Source: [www.thewildernessociety.it].

Fig. 16 - Tram converted into a 'grenn tunnel'.
Source: [www.stock.adobe.com].

Fig. 18 - Aerial view of the historic centre of Freiburg im Breisgau
Source: [www.vvisit.freiburg.de].

Fig 19 - Bächle (canaletti) of Freiburg; the first documentation mentioning them dates back to 1220, and they were designed to supply the city with water and combat fires.
Source: [www.booking.com].

Fig. 20 - The first European bicycle lane equipped with solar panels.
Source: [www.pv-magazine.it].

1.3.2. Case studies:

The plans of the eco-districts are reworkings of data obtained from various sources, including GIS data and aerial photos, produced by the authors of the thesis.

Fig. 2 - Aerial view of Hammarby Sjöstad.
Source: [www.urbandesignpoliba.wordpress.com/].

Fig. 3 - View of Hammarby Sjöstad canal.
Source: [www.urbandesignpoliba.wordpress.com/].

Fig. 4 - View of Hammarby Sjöstad green area.
Source: [www.ohga.it/].

Fig. 6 - Aerial view of Bo01.
Source: [www.stock.adobe.com/].

Fig. 7 - Terraced residences on a canal.
Source: [www.loquis.com/].

Fig. 8 - Internal courtyard of a residential lot.
Source: [/www.welchdesignstudio.com/].

Fig. 9 - View of Erskine Tovatt's project, characterized by distinctive 'barrel covers'.
Source: [www.cityseeker.com/].

Fig. 11 - Tåsinge Plads.
Source: [www.klimakvarter.dk/wp-content/uploads/2015/06/TP-mod-Vennemindevaej.jpg].

Fig. 12 - Aerial view of Tåsinge Plads.
Source: [www.cgconcept.be/overstromingsparken-voor-kopenhagen/].

Fig. 13 - Biowswale with curb cut and overflow drain.
Source: [www.livingarchitecturemonitor.com/].

Fig. 14 - Urban forniture in Tåsinge Plads.
Source:[www.klimakvarter.dk/en/projekt/tasinge-plads/].

Fig. 16 - Aerial view of Eco-Viikki.
Source: [Eco Viikki: Aims, Implementation and results].

Fig. 17 - Urban vegetable garden designed among
the residences.
Source: [Eco Viikki: Aims, Implementation and results].

Fig. 18 - Houses with solare greenhouse.
Source: [Eco Viikki: Aims, Implementation and results; pag. 52].

Fig. 19 - Viikinoja canal.
Source: [Eco Viikki: Aims, Implementation and results; pag.29].

Fig. 20 - Cultivable area that can be transformed into a parking area if necessary.
Source: [Eco Viikki: Aims, Implementation and results; pag.33].

Fig. 22 - Aerial view of Vauban.
Source: [www.researchgate.net].

Fig. 23 - Solar village designed by Rolf Disch.
Source: [www.visit.freiburg.de].

Fig. 24 - Reuse of a former military barracks into a socio-cultural center Haus 037.
Source: [www.alemannische-seiten.de].

Fig. 25 - Residential street dedicated to pedestrians.
Source: [Eco Viikki: Aims, Implementation and results].

Fig. 27 - Aerial view of Rieselfeld.
Source: [www.freiburg.de].

Fig. 28 - Rainwater collection basin.
Source: [www.architetturaecosostenibile.it].

Fig. 29 - Green tram infrastructure.
Source: [www.architetturaecosostenibile.it].

3.1.1. Introducing Europan:

Fig. 1 - Europan 17's results cover.
Source: [https://www.europan-europe.eu/fr/]

Fig. 2 - Europan 17's project sites.
Source: [https://www.europan-europe.eu/en/session/europan-17/sites]

3.1.2. Europan 17:

Fig. 1 - Redrafting of a map depicting the ipothesis for the North Bothnia Line's path in Piteå.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 2 - An analysis of the city's green infrastructure, its mobility system and its buildings' functions.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

3.2.1. Introduction to Piteå:

Fig. 1 - Redrafting of a map depicting the current Swedish national railway network.
Source: [https://www.sj.se e https://www.openrailwaymap.org/]

Fig. 2 - Redrawing of a map depicting the future North Bothnia Line.
Source: [https://bransch.trafikverket.se/en/startpage/projects/Railway-construction-projects/north-bothnia-line/]

Fig. 4 - The city plan of Piteå from 1667. Archive of the National Land Survey Board, National Archives.
Source: [Berg., A. E., Nordic Journal of Settlement History and Built Heritage. Available at: www.bebyggelsehistoria.org].

Fig. 5 - A photo of the city of Piteå.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 6 - A picture of Piteå's old railway area.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 7 - A picture of Piteå's waterfront, with the wood industry clearly visible.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 8 - Piteå's camping area.
Source: [EUROPAN 17 PITEÅ: LIVING CITIES - COMPETITION BRIEF. Available at: https://www.europan-europe.eu/en/session/europan-17/site/pitea-se].

Fig. 9 - Abacus of Piteå's trees and plants species.
Source: [https://pitea.naturskyddsforeningen.se/om-piteakretsen/piteas-natur/].