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Nature-based solutions: the role of a waterfront park in mitigating the climate effects caused by urban emissions.

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Summary

Introduction

Nature-Based Solutions (NbS) have gained worldwide recognition for their potential to provide sustainable, cost-effective, and flexible strategies in addressing the critical and complex issues surrounding climate change. Utilizing the inherent capacities of natural ecosystems, NBS focuses on the protection, restoration, and management of these ecosystems to achieve benefits for both people and nature. In the face of the devastating effects of climate change, these solutions represent a comprehensive, interdisciplinary approach that encourages synergistic relationships between natural and human systems, facilitating climate mitigation, adaptation, and resilience.

One of the major advantages of NBS lies in their capacity to absorb carbon dioxide, thus reducing the volume of greenhouse gases in the atmosphere. Forests, wetlands, and other green spaces, for example, sequester carbon while simultaneously providing habitats for a diverse range of flora and fauna. They can also offer ecosystem services, such as freshwater supply, erosion control, and natural disaster risk reduction. Furthermore, NBS have the potential to create healthier, more livable urban environments by moderating temperature extremes, improving air quality, and enhancing urban biodiversity.

In the context of rapidly growing urban areas, NBS are critical in mitigating the impacts of urban heat islands and associated emissions. Urban heat islands are characterized by significantly higher temperatures compared to their rural surroundings, primarily resulting from human activities, extensive concrete and asphalt surfaces, and limited vegetation. This phenomenon contributes to higher energy consumption, increased emissions of greenhouse gases and air pollutants, and exacerbated heat-related illnesses.

This is where the concept of a waterfront park comes into play. As an NBS, waterfront parks provide green open spaces within urban areas, playing a pivotal role in mitigating the impacts of climate change. They serve as green lungs, cooling urban environments, absorbing CO2, and improving air quality, thus reducing the severity of urban heat islands and associated emissions.

Waterfront parks also possess unique features due to their proximity to water bodies. The water can create a cooling effect, helping to regulate the microclimate

and further mitigate urban heat island effects. They can also serve as habitats for aquatic and terrestrial biodiversity, promoting ecological connectivity and resilience in the face of climate change. Furthermore, they provide a recreational and social space for residents, enhancing the quality of urban life and fostering community engagement in environmental stewardship.

The research problem of constraining emissions produced by urban heat islands" is addressed by recognizing the capacity of waterfront parks in mitigating the heat island effect and the resulting emissions. By increasing green coverage and utilizing the cooling properties of water, waterfront parks can reduce ambient temperatures, decrease energy consumption for cooling, and consequently lessen greenhouse gas emissions.

The research question "How can a waterfront park effectively mitigate the climate change effects caused by urban emissions?" directs attention to the design and management aspects of these parks. Optimizing the types of vegetation used, their placement and density, ensuring the park's accessibility and usability, and maintaining the health of the aquatic ecosystem can maximize the park's cooling capacity and carbon sequestration potential. Studies focused on this can provide guidelines and recommendations for urban planning and management, contributing to sustainable and climate-resilient cities.

The urgent need for effective climate change mitigation strategies and the promising potential of NbS, particularly waterfront parks, make this research highly significant. By enhancing our understanding of the potential and challenges of waterfront parks in mitigating urban emissions, we can more effectively harness the power of nature for a more sustainable and resilient future.

CHAPTER 1: Climate change impacts and Nature-based solutions

1.1 Climate change and cities

Climate change and cities are closely linked. Cities contribute the most to climate change and probably offer the best opportunities to combat it. More than half of the world's population lives in cities, and that number is expected to rise to more than two-thirds by 2030. Cities consume a large share of the world's energy supply and are responsible for about 70 percent of global energy-related greenhouse gas emissions, which trap heat and lead to global warming. Cities are also one of the parts of human society most affected by the impacts of climate change, and probably one of the most important solutions to reduce the environmental impact of humans. Human impact on the environment (or anthropogenic impact) refers to changes in the biophysical environment and ecosystems, biodiversity, and natural resources caused directly or indirectly by humans. (Cities, 2019)

Adapting the environment to society's needs has serious consequences such as global warming, environmental degradation (e.g., ocean acidification), mass extinction and biodiversity, ecological crisis, and ecological collapse. Human activities that damage the environment worldwide (directly or indirectly) include population growth, overconsumption, overexploitation, pollution, and deforestation. Some of the problems, including global warming and biodiversity loss, have been described as catastrophic risks to the survival of the human species. Climate change impacts vary by geographic location and vulnerability. Nevertheless, all cities are likely to be affected, and climate change will impact many aspects of urban life, quality of life, and provision of basic services such as transportation, water, energy, health care, and so on. Furthermore, Due to high population density and effects such as the urban heat island effect, climate change-induced weather changes are likely to exacerbate existing problems, particularly water scarcity, air pollution, and heat illness in metropolitan areas.(Cities and Towns — English, n.d.)

Air pollution and climate change are inextricably linked in terms of (i) emission sources, (ii) climate characteristics and chemistry, and (iii) mitigation measures. Both have significant impacts on human health. For example, particulate matter (PM) is not only associated with adverse health effects, but also has an indirect impact on climate, as it can serve as a cloud-forming nucleus and thus influence both climate forcing and meteorological phenomena, e.g., by scattering or trapping incoming radiation. Similarly, global temperature rise, droughts, diminishing water resources, shrinking ice sheets, coastal flooding and erosion, ocean acidification, sea level rise, and increases in extreme weather events are irrefutable evidence of global warming (European Environment Agency, 2022).

Although these global problems are considered discrete issues in numerous research and policy areas, they are inevitably interconnected, and any policies to alleviate problems in one area could impact circumstances in another, requiring a holistic approach to solutions. Global warming is causing cities to warm, while urbanization is exacerbating this process by creating heat islands and radiative forcing from aerosols. The consequences of the interactions between climate change, heat island effect, and air pollution are expected to increase the risk of poor human health in cities worldwide by the mid-21st century. Examination of the associations between climate variables (e.g., temperature, relative humidity, air quality index) and health risks (e.g., oral, foot, and hand diseases) found that the health effects of climate change are more pronounced in areas with poorer air quality. In short, global warming and urban development, along with excessive energy consumption, are warming metropolitan areas and affecting urban air pollution chemistry (European Environment Agency, 2022).

1.2 Health and Environmental Risks to Cities under a changing climate

Global warming will have an enormous impact on human well-being, particularly regarding waterborne and vector-borne infectious diseases. The ways in which climate change and associated variability affect human health are linked to a variety of social, natural, biological, and economic factors. At the same time, the evolution, spread and persistence of pathogens play an important role in disease transmission. Global warming could threaten human health and well-being by triggering an

increase in weather extremes, climatic events (e.g., droughts, heat waves, floods), and air pollution. The geography of ecological and welfare impacts of climate change-related pollutants is uneven. In particular, urban dwellers in low- and middle-income countries are most at risk because of their high exposure to changing weather patterns and air pollutants and their limited ability to control and adapt to these risks.(Patz et al., 2014)

The impact of extreme weather events on human well-being has not been directly reported, nor is there strong evidence. However, numerous studies suggest that human interventions have consistently affected natural environmental factors over the past 50 years. For example, heat waves, floods, air pollution, airborne allergens, drought, and vector-borne infections can be considered the result of mankind's historical actions, which subsequently lead to increased morbidity and mortality. Therefore, actions to mitigate and adapt to climate change are a major challenge that will continue for a long time (Kumar, 2021).

In addition, global warming projections show an increase in the frequency and magnitude of natural disasters that will impact the global community and the environment. A natural hazard, because of its interaction with coping capacity, vulnerability, and exposure, can cause widespread losses and severely disrupt the normal functioning of societies in any given location, resulting in economic losses, loss of life, and damage to biodiversity. Hazard intensity is determined by the impact of a disaster on communities, and the magnitude of the impact depends on the choices a community makes for its life and environment. For example, rapid urbanization in the wake of climate change, without efforts to increase resilience, is exposing cities around the world to enormous risks, especially those located along waterways or near coastlines. Overall, most of the world's riskiest cities are located in East Asia, China, Taiwan, the Philippines, and Japan, based on their degree of exposure to natural hazards. Many of these metropolitan areas are vulnerable to floods, storms, earthquakes, and other natural disasters. It is clear that the impact of a natural hazard can be catastrophic in some densely populated cities. Therefore, disaster risk planning and management are more urgent than in the world's major metropolitan areas.(Kumar, 2021)

1.3 Urban heat islands

Climate change then threatens both large population centres and natural environments. In light of these alarming facts, there is a critical component common to all urban ecosystems in terms of emissions generation: urban heat islands.

Urban heat islands (UHIs) are considered one of the most serious 21st century problems facing humans as a result of the intense urbanization and industrialization of society (Rizwan et al., 2008).

An urban heat island (UHI) is an urban area that is significantly warmer than surrounding rural areas due to human activities. In fact, heat islands experience higher temperatures than suburban areas (Figure 1). Structures such as buildings, roads and other infrastructure absorb and release more solar heat than natural landscapes such as forests and water bodies. Urban areas where these structures are highly concentrated and where there is little greenery, become “islands” of higher temperatures than remote areas. As cities develop, more and more vegetation is lost and increasingly more land is paved over or covered by buildings. The change in land cover results in reduced shade and moisture that keep urban areas cool. Less water also evaporates in built-up areas, contributing to higher surface and air temperatures. The temperature difference occurs when unshaded urban streets and buildings absorb heat during the day and radiate it to the surrounding air. As a result, highly developed urban areas can be 6 to 9 °C warmer in the afternoon than surrounding vegetated areas.(National Integrated Heat Health Information System, n.d.)

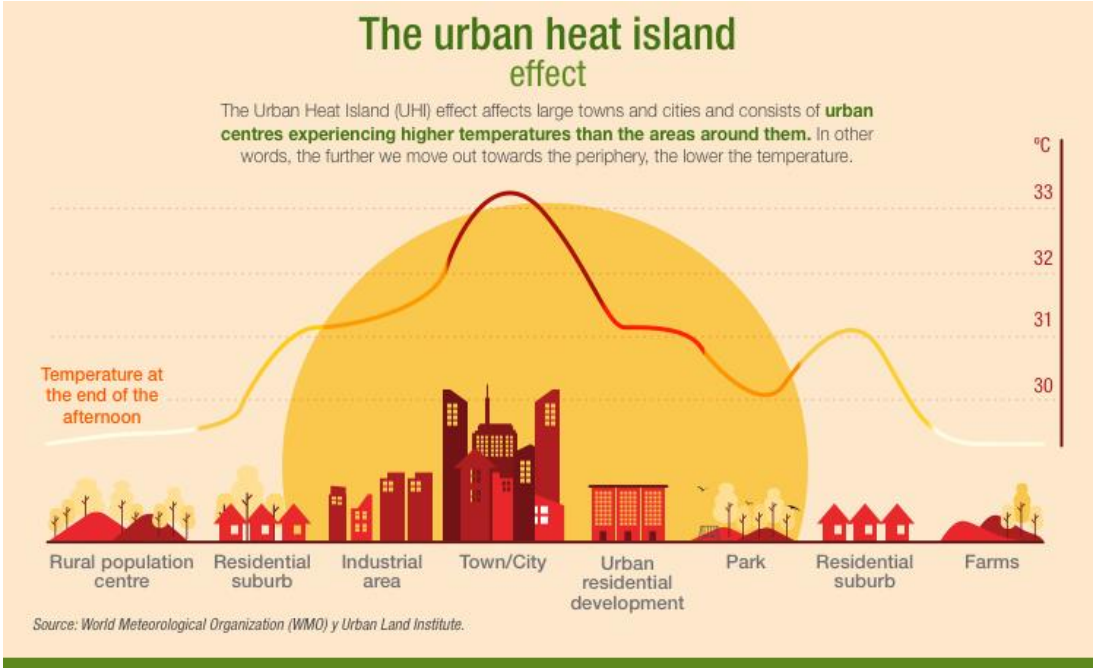

Figure 1 - Urban heat island effect - Iberdrola

1.3.1 UHI Causes

The warming of urban areas, known as urban heat islands, is caused by the development of urban infrastructure and the resulting changes in radiative and thermal properties. Buildings can have an impact on the local micro-climate, and tall buildings can slow the rate at which cities cool off at night. The intensity of heat islands varies depending on the geographic location of a city and local weather patterns and can change daily and seasonally. Heat islands are formed due to a combination of factors:

Reduced Natural Landscapes in Urban Areas. In rural areas, vegetation and open land dominate the landscape, which provides shade and helps lower surface temperatures. Trees and vegetation also reduce air temperatures by releasing water to the surrounding air through a process called evapotranspiration. However, in urban areas, there are more dry, impervious surfaces, such as conventional roofs, sidewalks, roads, and parking lots, which lead to less shade and moisture to keep urban areas cool. As cities develop, more vegetation is lost, and more surfaces are paved or covered with buildings, resulting in less evapotranspiration, and contributing to elevated surface and air temperatures.

Urban Material Properties. Urban materials have a significant impact on the development of the urban heat island phenomenon, as they influence how the sun’s energy is reflected, emitted, and absorbed. The three key properties that determine this are solar reflectance, thermal emissivity, and heat capacity. Solar reflectance,

also known as albedo, refers to the percentage of solar energy reflected by a surface and is closely linked to a material's color. Darker surfaces tend to have lower solar reflectance values than lighter surfaces, and urban areas typically have surfaces with lower albedo values than rural areas. This means that urban surfaces tend to absorb more of the sun's energy, leading to higher surface temperatures and the formation of urban heat islands. While solar reflectance is the most important fa'tor in determining a material's surface temperature, thermal emittance or emissivity also plays a role. Thermal emittance measures a surface's ability to release heat, and surfaces with high emissivity values tend to stay cooler as they release heat more readily. Most construction materials have high emissivity values, except for metal. Another important property that affects heat island development is a material's heat capacity, which refers to its ability to store heat. Building materials like steel and stone tend to have higher heat capacities than rural materials like dry soil and sand, meaning that cities are better at storing the sun's energy as heat within their infrastructure. As a result, downtown metropolitan areas can absorb and store twice as much heat as their rural surroundings during the daytime.

Urban Geometry. Urban geometry, referring to the size and placement of buildings in a city, is an important factor in the development of urban heat islands, particularly at night. It affects wind flow, energy absorption, and a surface's ability to emit long-wave radiation back to space. In urban areas, buildings and other structures often obstruct surfaces, making them large thermal masses that cannot easily release heat. This causes the air above urban areas to be warmer than rural areas, which can be a serious health concern for urban residents during heat waves. Urban canyons, which are created by narrow streets surrounded by tall buildings, are a key aspect of urban geometry. During the day, urban canyons can have competing effects. On one hand, urban canyons can create shade, reducing temperatures, but they can also absorb and reflect sunlight, lowering the city's overall reflectance and increasing temperatures. At night, urban canyons hinder cooling, as buildings obstruct heat that is being released from infrastructure. The effects of urban geometry are often measured through the "sky view factor," which refers to the visible area of sky from a given surface. For example, an open parking lot or field with few obstacles would have a high SVF value (closer to 1). Conversely, a street canyon in a city center surrounded by closely spaced tall buildings would have a low SVF value (closer to zero) because only a small area of sky is visible.

Heat Generated from Human Activities. Anthropogenic heat is heat caused by human actions that leads to atmospheric heat islands. It arises from different sources, and its estimation involves the sum of all energy used in activities such as running appliances, industrial processes, transportation, and heating or cooling. The amount of anthropogenic heat generated depends on the nature of urban infrastructure and activities, with buildings and transportation that consume more energy producing more heat. Anthropogenic heat is typically not a significant concern in rural areas or during summer but becomes an issue in winter and in densely populated urban areas, where it contributes significantly to the formation of heat islands.

Weather and Geography. Urban heat island formation is greatly impacted by weather conditions and location. Although communities cannot control these factors, residents can benefit from understanding their role. The development of urban heat islands is primarily affected by two weather characteristics, namely wind and cloud cover. Generally, urban heat islands are more likely to form during periods of calm winds and clear skies because these conditions maximize the amount of solar energy reaching urban surfaces and minimize heat that can be convected away. On the other hand, strong winds and cloud cover can suppress urban heat islands. Additionally, urban heat island formation is influenced by climate and topography, which are partly determined by a city's geographic location. For instance, large bodies of water can moderate temperatures and generate winds that carry heat away from cities. Nearby mountain ranges may obstruct the wind from reaching the city or create wind patterns across it. Local terrain has a greater impact on heat island formation when larger-scale effects, such as prevailing wind patterns, are relatively weak.(Akbari et al., 2008)

1.3.2 UHI Impacts

The environment and quality of life in a community can be affected in various ways by high temperatures resulting from heat islands. Although some heat islands effects' like extended plant-growing periods may appear beneficial, the majority of impacts are unfavorable, including:

Increased energy consumption. Cities experience higher energy demand for cooling during summer due to increased temperatures, especially on hot weekdays when people use cooling systems, lights, and appliances in their homes and offices.

This results in a peak demand for electricity that typically increases by 1.5 to 2 percent for every 0.6°C rise in temperature. The heat island effect, caused by steadily increasing downtown temperatures over the last few decades, accounts for 5 to 10 percent of community-wide electricity demand.During extreme heat events, exacerbated by urban heat islands, the resulting cooling demand can overload systems and force the electric utility to institute controlled and continuous blackouts to avoid power outages.

Air quality and Greenhouse Gases. As previously discussed, hotter temperatures can lead to an increase in energy demand, which can result in higher levels of air pollution and greenhouse gas emissions. The majority of electricity is generated through the combustion of fossil fuels, which produces pollutants such as sulfur dioxide (SO2), nitrogen oxides (Nox), particulate matter (PM), carbon monoxide (CO), and mercury (Hg). These pollutants can be harmful to human health and contribute to complex air quality problems, such as acid rain. Additionally, fossil fuel-powered plants release greenhouse gases, particularly carbon dioxide (CO2), which contribute to global climate change. Apart from an increase in air emissions, higher temperatures can also accelerate the formation of ground-level ozone, which is produced when Nox and volatile organic compounds (VOCs) react in sunlight. In sunnier and hotter weather, the rate of ground-level ozone formation will be higher, assuming all other factors remain constant, such as the level of precursor emissions or wind speed and direction.

Compromised human health and comfort. Urban heat islands can have negative effects on human health through various factors such as higher daytime temperatures, reduced cooling at night, and increased air pollution levels. These effects can cause respiratory difficulties, general discomfort, heat cramps and exhaustion, non-fatal heat stroke, and even heat-related mortality. In addition to this, urban heat islands can worsen the impact of heat waves, which are periods of abnormally hot and humid weather. Certain groups, including older adults, children, and people with pre-existing medical conditions, are particularly vulnerable to these events. Although it is rare for heat waves to be highly destructive, heat-related mortality is a frequent occurrence: for example, according to the Centers for Disease Control, exposure to excessive heat has been linked to more than 8,000 premature deaths in the United States between 1979 and 1999.

Impaired water quality. Water quality is negatively impacted by urban heat islands (on city surfaces), mainly due to thermal pollution. Surfaces, such as roofs and sidewalks, can reach temperatures 27-50°C higher than those of the surrounding air and transfer excess heat to stormwater. During summer days when sidewalk temperatures at midday averaged 11-19°C higher than the air temperature, runoff from urban areas was about 11-17°C warmer than runoff from nearby rural areas. However, when it rained before the pavement could warm up, the difference in runoff temperature between rural and urban areas was less than 2°C. Heated stormwater is usually discharged into storm drains and increases the temperature of water flowing into streams, rivers, ponds, and lakes. Water temperature is critical to the well-being of aquatic life, particularly metabolism and reproduction. Warm stormwater runoff can cause sudden temperature changes in aquatic ecosystems, which can be very stressful for many aquatic species.(Akbari et al., 2008)

1.4 Cities' climate action planning

Cities, as pointed out before, have been identified as significant contributors to climate change, but they also present an opportunity for humanity to address and reduce it. As hubs of innovation and wealth, cities are taking a leading role in framing strategies and programs, integrating climate action into urban development, and building partnerships to effectively respond to climate challenges (Mi et al., 2019).

As discussed in the High-level Meeting on the Implementation of the New Urban Agenda on the 28 April 2022, "The role of urban areas in contributing to climate mitigation and adaptation, global sustainable development goals (SDG) and the New Urban Agenda (NUA) is undisputed". This role of urban areas in climate mitigation and adaptation is well-established, as recognized by the UN Habitat, IPCC, and other global organizations. Many cities have committed to frameworks for reducing greenhouse gas emissions, with groups like the C40 Cities Climate Leadership Group representing more than 600 million people and 25% of the global economy and bringing together megacities from around the world to drive climate action and reduce emissions (UN HABITAT, 2016).

Over the past few decades, an increasing number of cities and local governments have joined forces to address climate change at a grassroots level. They have created and are executing numerous local climate action plans. This effort from cities

requires scientists to provide prompt and valuable information and expertise to meet their urgent needs. To tackle climate change effectively, cities require a comprehensive approach that takes into account factors such as urban development, energy consumption, environmental impacts, human health, and ecosystems.

This approach is outlined in "Guiding principles for City Climate Action Planning." The Guiding Principles for City Climate Action Planning offer a set of globally relevant principles to support local officials, planners, and stakeholders in creating effective plans for reducing greenhouse gas emissions and adapting to the effects of climate change (Figure 2). These principles were developed through a thorough and inclusive process that involved multiple stakeholders. The guidelines serve as an international standard for city-level climate action planning and can be used flexibly alongside detailed manuals to help cities better achieve their emissions reduction and climate resilience goals. Overall, the aim of these principles is to help cities adopt low emission development strategies and build local climate resilience. City climate action planning, as shown in the figure below, should be ambitious, inclusive, fair, comprehensive, and integrated, relevant, actionable, evidence-based and transparent and verifiable (UN HABITAT, 2016).

Figure 2 - Guiding principles for City Climate Action Planning – UN HABITAT

More and more, city governments and their partners are being required to create plans for acting on climate change. This is being recognized not only by international organizations, but also by regional, provincial, and national governments as crucial in addressing this global challenge. As cities have risen to meet this challenge, they have come to realize that climate action planning can bring about additional benefits beyond just addressing climate change. By implementing both mitigation and adaptation strategies, cities can meet their development priorities, tackle social challenges, address local environmental issues, and align with international agendas such as the 2030 Sustainable Development Goals' one. Indeed, there is no hope of reducing global emissions to safe levels and effectively combating climate change if new and expanding cities are based on a sprawling, resource-intensive urban development model (UN HABITAT, 2016).

1.5 What are the Nature based solutions

When dealing with climate change, there are several paths to pursue which can be based on laws, regulations, plans, strategies, programs, and projects. Spatial planning, disaster risk management, river basin management, and other water resources tools and policies are some of the priority tools and actions that can prevent hazards. However, because it's important to take immediate action, it's crucial to adopt holistic, collaborative, and innovative approaches that involve multiple stakeholders (Mercer, 2022).

One of the most promising approaches nowadays is the one that introduces the so-called 'nature-based solutions1. Nature-based solutions (NBS) are an integral component of the strategy to mitigate climate change and combat the interconnected issue of declining global biodiversity. The European Commission supports research and innovation initiatives aimed at developing NBS through funding programs such as Horizon 2020 and Horizon Europe. These solutions not only offer ways to address climate change and biodiversity loss but also have potential benefits for human health and employment opportunities. According to the Commission, nature-based solutions are defined as "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience". The implementation of these solutions leads to an increase in the presence of nature and its various elements and functions

within urban, rural, and coastal environments. This is achieved through interventions that are customized to the local context, environmentally sustainable, and work within a larger interconnected system (European Commission, n.d.)

Nature-based solutions (NBS) refer to a set of strategies that are employed to safeguard, manage, or revive natural or human-altered ecosystems. The aim of NBS is to promote a range of benefits across social, ecological, and economic domains. NBS acknowledges the wide array of interventions and possibilities that nature provides, and employs them to address critical global challenges, such as water and food security, climate change, health, and disaster risk reduction. NBS is an approach that operationalizes the ecosystem services framework within spatial planning policies and practices. It integrates the ecological dimension while simultaneously tackling current societal challenges in cities. Unlike traditional approaches that seek to "preserve and protect," NBS goes beyond this and involves enhancing, restoring, co-designing, and co-creating urban green networks with nature that possess multifunctionality and connectivity. NBS incorporates green and blue infrastructure, ecosystem services, and biomimicry concepts, and serves as a planning and design tool for ecologically sensitive urban development. Until not so long ago, most cities did not place much importance on nature, ecosystems, or biodiversity in their daily activities. However, now they are being recognized as crucial elements of urban living and are becoming increasingly popular as part of both national and international policies. The widespread adoption of NBS in Europe and around the world is a testament to their relevance and significance for creating livable and sustainable cities. Incorporating NBS into urban planning can benefit cities and their residents, regardless of whether they experience the full impacts of climate change. Therefore, they can play a vital role in the sustainable development of municipalities (Dushkova & Haase, 2020).

1.5.1 European NBS legal framework context: policies & strategies

In order to tackle the negative effects of climate change and urbanization, decision-makers at various levels have changed their approach from traditional hard engineering methods to more adaptive and flexible strategies that incorporate nature-based solutions such as eco-engineering and ecological restoration. This shift towards NBS has been gaining momentum since 2015 and is seen as a more

resilient, efficient, and equitable way to improve the lives of urban residents regardless of their socioeconomic status, gender, cultural background, or age.

According to SEP, nature-based solutions offer a viable approach to tackle various societal issues such as climate change, biodiversity loss, and disaster risk. Numerous scientific studies have proven that NBS can significantly enhance air quality, microclimate, and the health and well-being of people.(European Commission, 2021b) As a result, NBS have received significant attention in the European Green Deal, as well as in significant European policies such as the EU Biodiversity Strategy for 2030 and the new EU Strategy on Adaptation to Climate Change(European Commission, 2021a) (European Commission, 2020a). The EU Biodiversity Strategy for 2030 recognizes the value and significance of NBS in addressing critical challenges such as climate change and biodiversity loss, and pledges to provide funding for NBS investment. In addition, Nature-based solutions are expected to play a vital role in the new EU Forest Strategy (currently open for public consultation), as well as the upcoming EU Soil Strategy and European Zero Pollution Action Plan for air, water, and soil.

The role of NBS as a natural and operational infrastructure can promote sustainability, enrich the environment and enhance the well-being of citizens. At the same time, NBS offers opportunities for economic growth, which aligns with the EU's Adaptation Strategy to address climate change. This strategy was published in 2013 and focused on preparing and responding to climate change impacts, while also improving coordination(European Commission. Directorate General for Climate Action., 2013). The updated EU Strategy on Adaptation to Climate Change released in February 2021 emphasized the importance of NBS as a priority area for supporting the development and implementation of climate adaptation strategies at all levels of governance. The EC has also expressed support for the 'NbS for Climate Manifesto', which was proposed at the UN Climate Action Summit in August 2019.

The implementation of NBS can improve the execution of other major European policies and strategies. Focused interventions using NBS can support the more complete execution of the Floods Directive by supplementing national flood management strategies and plans for managing flood risks, for example, through the use of natural flood management schemes. NBS can also help reduce the burden

on groundwater resources, aligning with the objectives of the Groundwater Directive. Additionally, NBS can support compliance with the Urban Waste-Water Treatment Directive by infiltrating a portion of surface runoff. The overall Water Framework Directive mandates the implementation of local river basin management plans, to which NBS contribute both directly and indirectly. NBS directly contribute to the Water Framework Directive through integrated water management to achieve good ecological, physicochemical, and other statuses of surface waters and groundwater, and by engaging stakeholders in co-designing NBS measures for water security.

Nature-based solutions (NBS) are also used for disaster risk reduction (DRR) and have multiple benefits. They not only help achieve environmental targets and monitor coastal zones, as required by the Marine Strategy Framework Directive, but also support the new focus on the Blue economy. Additionally, they indirectly contribute to the EU Civil Protection Mechanism by facilitating joint planning and coordination of disaster response activities, which enhances prevention and preparedness for disasters. Furthermore, the use of NBS for DRR helps to fulfill the objectives of the Floods Directive by reducing the potential impact and severity of flooding in areas previously identified as being at risk during the preliminary flood risk assessment (Directorate-General for Research and Innovation (European Commission), 2021).

Regarding biodiversity, the NBS concept is closely related to the Natura2000 network and the Birds and Habitats Directives. It achieves this by restoring natural habitats and connecting them, in accordance with the EU's green infrastructure objectives, in order to reduce pressures on local biodiversity. The EU Green Infrastructure strategy explains the significance of NBS in enhancing biodiversity within an urban setting.

NBS, on the other hand, takes also measures to reduce urban air pollution and comply with the Air Quality Directive, thus contributing to the improvement of local levels of particulate matter (PM2.5, PM10), nitrogen dioxide NO2, and ground-level ozone (O3), with the aim of safeguarding human health. By explicitly addressing the issue of urban air pollution, NBS also supports the Clean Air for Europe Program.

Concerning climate ambitions, lastly, The EU Research and Innovation (R&I) Policy Agenda on NBS and Renatured Cities is focused on positioning the EU as a

leader in “Innovating with Nature” to create more sustainable and resilient societies. This policy agenda has several main objectives:

1. enhancing the policy framework for NBS at the EU level;
2. developing a research and innovation community for NBS;
3. establishing an evidence and knowledge base for NBS;
4. promoting the development, adoption, and deployment of innovative NBS;
5. integrating NBS into the international agenda.

The policy agenda seeks to contribute to the development of relevant areas such as biodiversity, water management, climate change mitigation and adaptation, sustainable development, and disaster risk reduction. By proposing NBS as more effective and efficient solutions than traditional approaches, this agenda views environmental, social, and economic challenges as opportunities for innovation. The key underlying concepts of this policy agenda include addressing social challenges with nature, maximizing multiple benefits, co-creating, and building communities, establishing an evidence base, and integrating NBS into European and international policies (Directorate-General for Research and Innovation (European Commission), 2021).

1.5.2 European taxonomy and Do Not Significant Harm (DNSH)

Nature-based solutions, being project interventions that use ecological and environmental services to address contemporary environmental, social, and economic challenges, must comply with the DNSH principles set forth in the European Taxonomy. The DNSH principle is based on what is specified in the “Taxonomy for Sustainable Finance,” which was adopted to promote private sector investment in green and sustainable projects and help achieve the goals of the Green Deal(Technical Expert Group, 2020). The EU Taxonomy functions as a tool for project promoters, issuers, companies, and investors to effectively manage the transition towards a resilient, resource-efficient, and low-carbon economy. The Taxonomy outlines specific performance standards, which are known as "technical screening criteria,” for economic activities which:

- Contribute significantly to one of the six environmental goals (Figure 1).
- do no significant harm (DNSH) to the other five, where relevant;
- meet minimum safeguards (e.g., OECD Guidelines on Multinational Enterprises and the UN Guiding Principles on Business and Human Rights).

The performance standards will aid organizations, project initiators, and issuers in obtaining green financing to enhance their environmental impact, while also identifying activities that are already environmentally sustainable. This will facilitate the expansion of low-carbon sectors and the reduction of carbon-intensive ones. The EU Taxonomy is a major advancement in sustainable finance and will have far-reaching consequences for investors and issuers operating not just within the EU but also globally (Technical Expert Group, 2020).

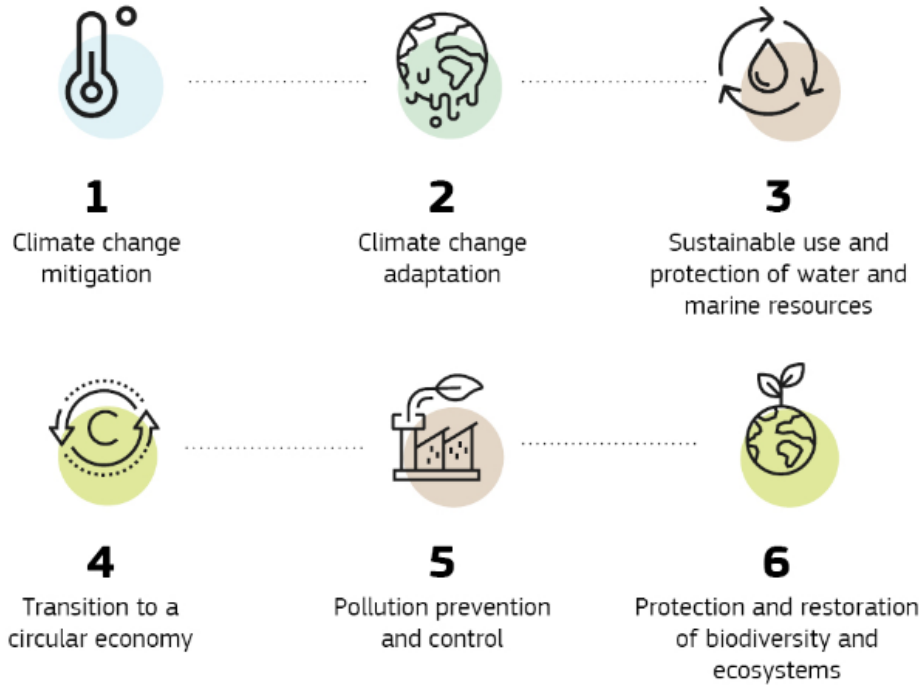

Figure 2 - EU Taxonomy criteria for ecosystem protection – Taxonomy technical report 2020

The taxonomy regulation then identifies six criteria for determining how each economic activity contributes substantially to ecosystem protection without harming any of the environmental objectives (Figure 3):

1. Climate change mitigation;
2. Climate change adaptation;
3. Sustainable use and protection of water and marine resources;
4. Transition to the circular economy, including waste prevention and recycling;
5. Prevention and reduction of air, water, and soil pollution;
6. Protection and restoration of biodiversity and health of ecosystems.

The Taxonomy includes a specific technical Annex that outlines the criteria for determining whether economic activities contribute significantly to reducing the impact of climate change or if they have a negative impact on other goals. This Annex uses the Statistical Classification of Economic Activities in the European

Community (NACE) to identify activities that help mitigate climate change, highlighting sectors that are crucial for effectively reducing pollution. By using the Taxonomy framework, investors can make sustainable investment decisions with confidence, as it has become a central factor in deciding how European resources are allocated (Italiadomani, n.d.).

The aforementioned Do No Significant Harm (DNSH) is therefore a key component of the various interventions that NEXT GENERATION EU aims to support, helping to implement the Paris Agreement and the UN Sustainable Development Goals, consistent with the European Green Deal. The NRRPs must incorporate measures, including nature-based solutions, that adhere to the DNSH principle, and it falls upon the Member States to prove that they are in compliance with this principle. DNSH requires that interventions under the national NRRPs do not cause any significant harm to the environment: this concept is crucial for accessing RRF funding (Italiadomani, n.d.).

1.5.3 Types of Nature Based solutions

During 2014-2015, BiodivERsA, a European network, gathered a group of scientists, research donors, and individuals with vested interests, and presented a classification system that describes nature-based solutions (NBS) using two scales:

1. “How much engineering of biodiversity and ecosystems is involved in NBS”, and
2. “How many ecosystem services and stakeholder groups are targeted by a given NBS”.

The categorization emphasizes that Nature-Based Solutions (NBS) can encompass a wide range of actions toward ecosystems, such as safeguarding, regulating, or establishing new ecosystems. It is presumed that as the number of services and stakeholder groups targeted increases, the ability to effectively provide each service and simultaneously meet the unique needs of all stakeholder groups decreases (Eggermont et al., 2015).

Thus, three types of NBS are identified:

1. Type 1 involves preserving ecosystems without interfering or making any significant changes to them, with the aim of maintaining or enhancing the provision of various ecosystem services both within and beyond the preserved areas

2. Type 2 pertains to the definition and execution of management techniques that create sustainable and multifunctional ecosystems and landscapes, which may be extensively or intensively managed. This approach enhances the provision of particular ecosystem services over to what could be achieved with traditional interventions.
3. Type 3 consists of managing ecosystems in a highly intrusive manner, or even establishing new ecosystems such as artificial ones composed of different organisms, which can be used for green roofs and walls to reduce city heat and improve air quality. This type is associated with concepts like green and blue infrastructures, as well as goals such as restoring heavily damaged or polluted areas (Benedict et al., 2012).In this category, new methods like animal-aided design are being studied to connect the fields of biodiversity conservation and landscape architecture(Weisser & Hauck, 2019).

The distinction between these three categories is clearly not sharp. Thus, there are hybrid solutions that can be found across this continuum across a range of space and time. For instance, to achieve both sustainability and multifunctionality objectives, a combination of protected and managed areas may be necessary at a landscape level. Similarly, while a constructed wetland may initially fall under type 3, once it's fully developed, it may be conserved and monitored as a type 1 wetland (Eggermont et al., 2015).

1.5.3 NBS Applications

Governments and scientific communities have acknowledged the effectiveness of NBS in building resilient landscapes and cities. However, they now face the challenge of putting these solutions into practice. The EC has suggested several actions to implement NBS in urban areas. These actions include: identifying obstacles and enabling factors for NBS delivery, creating citizen awareness, empowerment, and involvement, integrating research and policy with the economic sector to support NBS, expanding the use of NBS across Europe through a comprehensive evidence base, scaling-up new business, investment models, and legal frameworks for NBS, developing NBS that maximize cost-effectiveness and co-benefits (Lafortezza et al., 2018).

Furthermore, NBS can contribute to achieving four primary objectives:

1. Promote sustainable urbanization, stimulating economic growth and enhancing the environment, thereby making cities more attractive and improving human well-being.
2. contribute to the revival of damaged ecosystems, making them more resilient and able to provide essential services and address other societal challenges.
3. Support the development of climate change adaptation and mitigation strategies, providing more robust responses and increasing carbon storage.
4. Improve environmental risk management and resilience, providing greater benefits than traditional methods and synergies in reducing multiple risks.

These four objectives suggest seven primary practical actions that should be implemented (Hanssen et al., 2020). These applications involve using NBSs for urban regeneration, improving the welfare of urban areas through NBSs, creating NBSs for coastal resilience, implementing multifunctional NBSs for watershed management and ecosystem restoration, using NBSs to increase sustainable use of matter and energy, enhancing the insurance value of ecosystems through NBSs, and increasing carbon sequestration through NBSs (Griscom et al., 2017).

Furthermore, the EC has provided several reports and publications showcasing different instances of NBS. These examples include urban agriculture, green roofs, afforestation, or park creation on abandoned industrial land, rain gardens for managing stormwater, green spaces for improving human health, and the

implementation of permeable surfaces and vegetation in urban environments. Ecosystem-based methods, such as Nature-Based Solutions, have been encouraged in the UN Convention on Biological Diversity regarding the restoration of

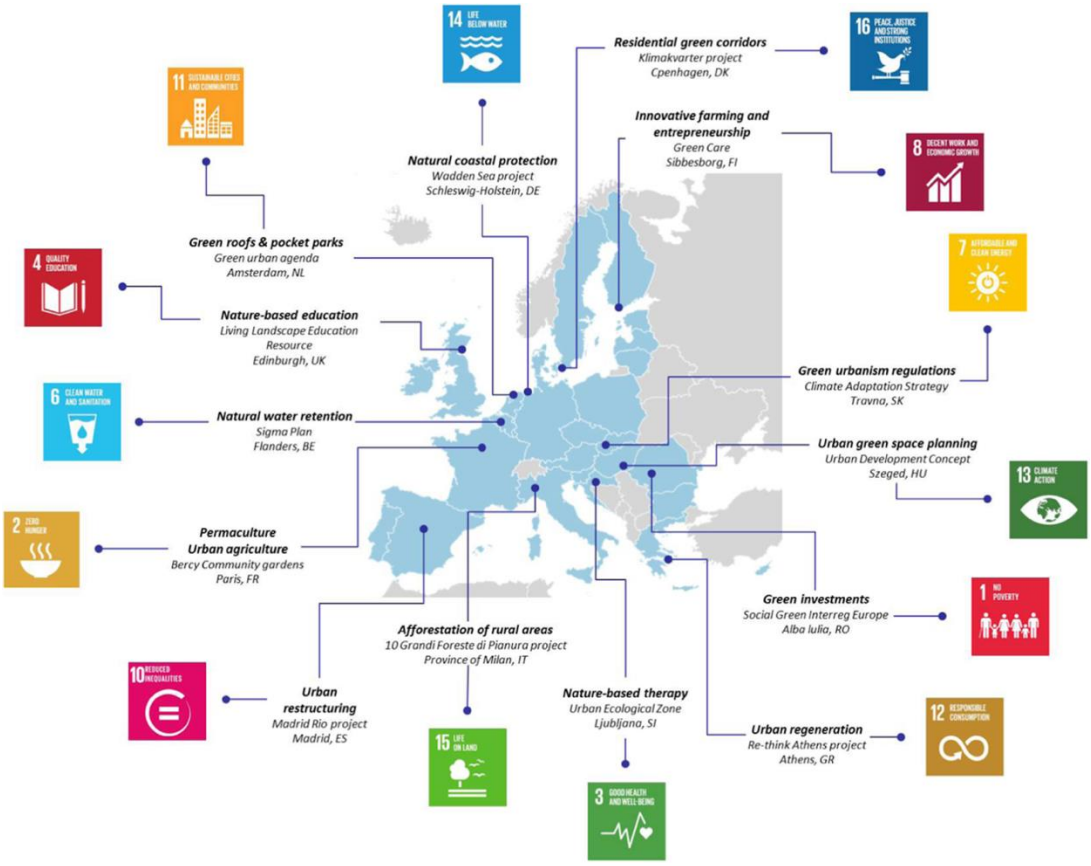

Figure 4 - UN 2030 Agenda for Sustainable Development Goals achievements in Europe - Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges

biodiversity, climate change, and mainstreaming biodiversity. EU policies on climate action, disaster risk reduction, the circular economy, biodiversity protection, and health security have helped to advance policies that incorporate nature and have been instrumental in implementing the UN 2030 Agenda for Sustainable Development Goals at an international level (Figure 4). The UN 2030 Agenda recognizes the necessity of addressing the negative global trends that affect society, the economy, and the environment. The Nature-Based Solutions research and innovation agenda can contribute to numerous Sustainable Development Goals (SDGs), not just those related to improving nature and natural processes (such as SDGs 14 and 15) (Faivre et al., 2017).

1.5.4 Green and Blue infrastructures

Blue Green Infrastructure (BGI) is a defined by the European Commission as a: "Strategically planned network of natural and semi-natural areas with other

environmental features designed and managed to deliver a wide range of ecosystem service". BGI networks offer benefits such as enhancing biodiversity, purifying water, improving air quality, providing space for recreation, and aiding climate mitigation and adaptation. These networks consist of a combination of water-based and landscape-based element (Southern Regional Assembly, n.d.).

For urban areas struggling with the effects of climate change, blue-green infrastructure offers a practical and worthwhile solution. The requirement for grey infrastructure is supplemented and, in certain situations, even replaced by it. In the design of urban landscapes, BGI links vegetation systems and urban hydrological functions (blue and green infrastructure). These BGI project components work as a whole to strengthen urban ecosystems by utilizing natural processes in artificial settings. They bring together the requirements of adaptive urban life and planning with the demand for sustainable water and stormwater management.

Grey infrastructures are conventionally human-engineered solutions that serve as water and wastewater treatment facilities, stormwater retention basins, or defensive constructions like dykes and seawalls (US EPA, 2022). Green infrastructures are mostly made up of healthy biophysical systems that may benefit from some management and restoration. They are primarily represented inland by woods, parks, street trees, and grasslands, as well as by healthy oyster reefs, coastal salt marshes, mangroves, coral reefs, seagrasses, sand beaches, and dunes in the coastal environment. All bodies of water, including ponds, wetlands, rivers, lakes, streams, estuaries, seas, and oceans, are considered blue infrastructures. For CCA and DRR, combining blue and green infrastructure is becoming more popular in study and practice. Green and blue infrastructures are firmly positioned within the ecological domain of the SETs framework since they rely primarily on robust, functioning ecosystems and permit little to no technology or physical intervention (Depietri & McPhearson, 2017).

At present, typical grey water infrastructure can temporarily reduce water needs but frequently creates new issues that must be addressed in the long run. Reduced surface water quality altered or decreased groundwater recharge, and increased flooding are some of these unexpected outcomes. Grey water infrastructure is not

resilient enough to withstand extreme weather, rising urbanization, and climate change on its own (Brears, 2021).

Therefore, when discussing GBI, the grey infrastructures and their possible integrations and hybridizations, should also be considered. Hybrid, green-grey methods make use of both green and grey infrastructure. A good example is when wetlands restoration is combined with engineering solutions for coastal flood protection, such as tiny levees. Additional examples of engineered ecosystem approaches to CCA and DRR include bioswales, rain gardens, green roofs, street trees planted in sidewalk tree pits, and others. Thus, hybrid techniques integrate engineering with appropriate ecosystem services and are located where the ecological and technological aspects of the SETs framework converge. It is crucial to note that the term "green infrastructure" often refers to hybrid systems, as they have been characterized here. It should be stressed, nonetheless, that there is a difference between a system that depends solely on ecosystem services (green or blue infrastructure) and one where a built or technological infrastructure supplements the service supplied by a green or blue infrastructure (= hybrid infrastructure) (Brears, 2021).

Furthermore, there is growing evidence that hybrid strategies offer reasonably priced hazard protection options. For instance, floods frequently affect Hamilton City, California, USA, as well as the rural areas around it. When compared to renovating existing levees, setback levees were thought to be a more cost-effective choice since they help the floodplain function naturally. In urban settings, where relying simply on green infrastructures rarely satisfies requirements for risk reduction but where urban planners have traditionally depended only on physical structures, biotechnologies, or hybrid approaches like these are especially appropriate. The aim of hybrid approaches is to decrease the urban system's dependence on traditional grey infrastructure and the associated downsides, while also enhancing the sustainability of cities and the well-being of their residents by creating mutually beneficial outcomes (Depietri & McPhearson, 2017).

In conclusion, blue and green infrastructure should seek to:

- Restore natural water systems, catchment areas and networks
- Use multi-functional landscapes to slow water flow and mimic natural water cycles while creating and providing habitats for nature and places for people to enjoy
- Connect, improve, and preserve individual landscape elements to create a coherent and high-quality GBI networks (Southern Regional Assembly, n.d.).

The essential aspect of establishing functional wildlife corridors is the tangible link between individual sections or areas of habitats and the surrounding landscape. Both blue and green networks can be implemented at various levels of intervention, including site, neighbourhood, city, region, and sub-region. In order to create successful BGI plans, there must be coordination and integration among these different scales to form a comprehensive GBI network (Southern Regional Assembly, n.d.).

The Blue-Green Infrastructure (BGI) concept marks a significant change in the approach to urban water management, recognizing the significance and usefulness of incorporating the role of urban hydrology. The term "blue" emphasizes the importance of water as a physical element, while "green" establishes a link between urban hydrological functions and vegetation systems in the design of urban landscapes. The resulting BGI offers socioeconomic benefits that exceed the sum of its individual components (Surrey County Council, 2022).

The increasing use of green and blue infrastructure can help reduce some of the consequences of climate change that are likely to occur over the course of the century, such as increased risk of flooding, heat waves, drought, and changes in ambient temperatures. In urban settings, green and blue infrastructure can provide numerous benefits, including:

- decreased risk of flooding through the use of water storage and retention areas (e.g., ponds, canals, roof gardens) and the use of earth-covered surfaces instead of hard surfaces to facilitate drainage, which reduce surface runoff and discharge and slow tides;
- temperature regulation through evapo-transpiration, vegetation shading and airflow through open spaces;

- maintenance of freshwater quality and supply when sediment and pollutants are retained by dense vegetation and soil (e.g., biofiltration channels);
- increased thermal performance of buildings using green roofs and walls;
- increased resilience of species through the provision of varied habitats and green corridors, which allow species to move easily to new climatic spaces (Surrey County Council, 2022).

Incorporating both green and blue infrastructure into current and upcoming constructions can enhance urban surroundings' resilience and lead to lowered expenses, better health, and greater well-being. The use of BGI can also minimize the demand for traditional grey infrastructure and counteract some of the harmful effects of urbanization on nearby water systems, making it particularly useful in mitigating climate change-related hazards (Brears, 2021).

1.5.5 NBS benefits and opportunities

There has never been a more crucial time than now to utilize Nature-based Solutions to tackle global and societal challenges, and the potential benefits and opportunities are significant. Throughout history, civilizations have tried to harness nature's power, but these attempts have resulted in both positive and negative outcomes. Nevertheless, with human-induced climate change, environmental degradation, and loss of biodiversity, caused by pollution, destruction of natural habitats, and urban expansion, it has become even more critical to consider how we modify ecosystems, access their benefits, utilize their services, and protect ourselves from natural disasters. Both urban and rural areas heavily depend on traditional infrastructures and systems to provide essential services such as water supply, heating, lighting, drainage, cooling, and other services such as social gathering places. However, it has become increasingly clear that these systems may no longer be suitable considering the global changes that are occurring more frequently and with greater severity. Addressing these urgent issues requires rapid and substantial changes to deeply ingrained cultural heritage, legal frameworks, and governance systems, as well as personal and professional norms that have developed over thousands of years (Coombes & Viles, 2021).

The networks and systems that have been established play a crucial role in how people handle disputes and make agreements between individuals, communities, cities, regions, and even continents. Due to the vast scope of these networks and systems, there is a high potential for errors, but also significant opportunities, particularly if societies work together to innovate and learn from one another. Natural-based solutions provide a substantial opportunity for innovation and have the potential to deliver long-lasting and tangible benefits across various social groups, in diverse environmental, economic, and cultural settings (European Commission, 2020b). This is in sharp contrast to the conventional, "traditional" or "grey" solutions that are designed, constructed, and managed over time. However, many NBS are still relatively new and present significant challenges and uncertainties regarding their design, operation, maintenance, and implementation (Directorate-General for Research and Innovation (European Commission) et al., 2022).

Urban biodiversity in the shape of nature-based solutions, is a solution to multiple urban challenges, as it offers numerous benefits and opportunities. These solutions provide a variety of benefits and opportunities, known as ecosystem services, which are derived from nature and can help improve the economic, health, environmental, and social aspects of urban life. The following are some of the potential advantages and benefits associated with the adoption of such solutions (Directorate-General for Research and Innovation (European Commission) et al., 2022):

1. Mitigating the effects of heat islands

Urban biodiversity serves multiple purposes that can reduce high temperatures, which is a crucial concern in developed cities. Trees not only provide shade for non-permeable surfaces but also play a vital role in evapotranspiration, which is the combined process of water evaporation from land and plants. This process is similar to human perspiration, where leaves release water vapor into the urban atmosphere. This transformation of water into vapor helps cool the air and contributes to the water cycle (Directorate-General for Research and Innovation (European Commission) et al., 2022).

2. Improving air quality

The underside of leaves has a small plant part called stoma, which is responsible for interacting with the surrounding air through tiny pores. Different tree species absorb air pollutants to varying degrees, making them crucial as air filters. Many studies have evaluated the air filtering ability of individual trees, but further academic research is necessary to assess the potential of tree species especially the Brazilian ones, given the country's exceptional biodiversity. Apart from pollutants, airborne dust is another important factor. Streets with trees may contain significantly lower levels of particulate pollution than those without, up to 75% less (Directorate-General for Research and Innovation (European Commission) et al., 2022).

3. Preventing floods, rising tides, flash floods, and river and coastal erosion

In urban areas, excessive soil sealing hinders the infiltration and retention of rainwater in appropriate vegetated areas. As a result, stormwater accumulates in the lowest parts of the city, causing flooding in places that were once wetlands, lakes, and rivers, particularly during storms. This mismanagement of rainwater occurs because natural systems are not fully understood. Natural systems are highly effective in capturing and retaining rainwater, and they can be utilized in urban areas through strategies such as using vegetation to absorb water and installing green coverings on buildings. By implementing these measures, a city can become a sponge that absorbs rainwater effectively (Directorate-General for Research and Innovation (European Commission) et al., 2022).

4. Improving the quality of urban water

During the initial moments of rainfall, the city is cleaned; however, as the water flows through the streets, it collects various forms of pollution and carries it to bodies of water. By implementing green infrastructure solutions that connect drainage systems to various elements of NBS this water can be absorbed and cleansed through phytoremediation, thereby enabling ecological rainwater management (Directorate-General for Research and Innovation (European Commission) et al., 2022).

5. Balancing the carbon cycle

The vegetation and soil in urban areas play a crucial role in trapping and storing carbon emissions that contribute to the greenhouse effect. Thus, managing biodiversity in cities is essential for mitigating the overall increase in greenhouse gas emissions (Directorate-General for Research and Innovation (European Commission) et al., 2022).

6. Providing people with physical and psychological benefits

Enhancing the environment to improve general well-being is a crucial goal for humanity, and several studies have verified the healing influence of nature in urban areas. The economic value of including green and blue spaces in cities is at least equal to the expenses saved on health care and other social costs. The absence of quality green and blue areas in our cities has led to harmful impacts on people's health. Most existing noncommunicable diseases, such as cancer, depression, obesity, respiratory and cardiovascular diseases, are the result of the environment in which people live and their lifestyle choices (including the food they consume) (Directorate-General for Research and Innovation (European Commission) et al., 2022).

7. *Reconnecting*

Cities have a shortage of natural elements because humans have become disconnected from the natural world and its functions. People in urban areas interact with nature only through gardens, parks and streets. To cultivate love and connection with nature among urban residents, it is essential that these urban green spaces possess the necessary environmental features and ecological functions. Biodiversity represents a culture, and that culture should be locally specific, establishing a sense of identity and togetherness between inhabitants and urban multiple-use areas (Directorate-General for Research and Innovation (European Commission) et al., 2022).

8. *Developing a green economy*

Managing urban land in an ecologically responsible manner has the potential to create employment opportunities. The practice of urban agriculture is one such example that is rapidly growing, enabling rooftops to be utilized for various

purposes while squares and unused areas are being converted into urban forests. Just like any other area, urban spaces possess ecological characteristics and networks that offer chances for biodiversity preservation and research (Directorate-General for Research and Innovation (European Commission) et al., 2022).

9. Supplying habitats and shelters for fauna and flora

Urban and peri-urban areas are home to a considerable number of animals and other species that share these spaces. In addition to native species, there are many so-called opportunist species that inhabit urban areas and create novel urban ecosystems. In peri-urban areas, which are usually less dense than urban areas and have more opportunities to accommodate biodiversity, places such as wetlands and forests are particularly noteworthy. So-called residual areas, which are usually attached to road systems, are also highly important for the conservation of nature in the city. In rural areas, agricultural expansion and the use of chemical pesticides are causing tremendous losses in biodiversity. As such practices do not exist in urban areas, they are becoming a shelter for multiple species, including bees, which have a greater survival rate in cities (Directorate-General for Research and Innovation (European Commission) et al., 2022).

10.Ensuring ecological continuity

Biodiversity can be conceptualized as a network of numerous connections at various scales, with one of its primary purposes being to connect urban vegetation ecosystems. Green and blue networks in cities allow species to circulate. Brown connections are also specifically crucial because they ensure that soils continue to support life systems. Because of land use and transportation networks, these brown networks are more deteriorated than others (Directorate-General for Research and Innovation (European Commission) et al., 2022).

11.Being a living laboratory

The combination of native, exotic, and opportunistic species creates novel ecosystems that require examination regarding their ecological roles and ability to provide ecosystem services. Several species have acclimated to urban and suburban environments, developing unique features, and could play a crucial role in

preserving and enhancing urban biodiversity (Directorate-General for Research and Innovation (European Commission) et al., 2022).

CHAPTER 2: Marconi Waterfront Park

2.1 RQ and Case study: “Marconi Waterfront Park”

Areas along the rivers’ banks, lakes and the sea are important places of interaction between the environmental network and densely inhabited parts of the territory. Catalysts of social life, these environmental axes are an important resource for urban regeneration: recognizing their value is the first step toward their redevelopment. Citizens in western metropolises today are attentive to the quality of the environment in which they live and the quality of life. In Rome for example, green and blue zones, particularly that of the Tiber and its surrounding areas, are potentially a great resource for the city's ecosystem. But the inhabitants are only partly aware of the value the Tiber has for the city and therefore do not always recognize the embankment spaces that important role they could play for their well-being. Far more serious is the limited awareness of the river's value to the city by public administrators, which is the main cause of the advanced state of degradation in which the roman river is in today (Cannavò, 2018).

With all their efforts, willing individual citizens have never succeeded in curbing the decline of the urban river area, particularly the Marconi area, caused mainly by the total inadequacy of the complex system that is supposed to administer it. It is therefore necessary today, in the state of degradation in which Rome finds itself, to build an alliance to save the river, a pact between citizens and social innovators, associations, businesses, articulations of organized civil society, schools and administrative, cognitive, cultural and scientific institutions, a collaboration between all parties willing to commit themselves, putting at the service of the community their time, ideas, skills, abilities and useful resources to save the Tiber River and its banks from decay. Only in this way, what is now in many of its stretches a degraded and dangerous space, exploited by illegality and in some cases completely inaccessible, the Marconi River area could once again become a vital space for the city (Cannavò, 2018).

Aiming at this goal in the summer of 2021, after clearing the floodplain area of the river near the Marconi neighborhood, the cleanup began to remove the fifteen shacks and the many accumulated garbage that had often been reported to have

possible consequences on the healthiness of the river. This reclamation work set the stage for the construction of the new Marconi Waterfront Park (Grilli, 2022).

Marconi Park is Aa new space positioned on the bank of the Tiber with a children's play area, dog area, green lawns, and new green installations (trees and green corridors) (*Figure 5*). The Lazio Region directly carried out the work to create the new park, which has an area of about 3.5 hectares and stretches from Lungotevere di Pietra Papa to Marconi Bridge. The reclamation work of what was effectively a large landfill involved the clearing of a squatter settlement and the cleaning between July and August 2021 of the surface. The operations, which cost about 335,000 euros, enabled the regeneration and redevelopment of the green area (Roma Capitale, 2022).

Figure 5 - Marconi waterfront park project, Dr. Tullio Interview, follow-up material

As a waterfront park, Marconi Park is a nature-based solution, which, embedded in one of Rome's most developed neighborhoods, can perform a function of mitigating the heat island generated by the surrounding area, as well as enhancing, restoring, co-creating, and co-designing with nature, urban green networks characterized by multifunctionality (environmental, economic, and social) and connectivity.

Therefore, the research question devised, which is the basis of this dissertation, is: How can a waterfront park effectively mitigate the climate change effects caused by urban emissions?

In order to answer this question, the scenario within which Waterfront Park Marconi is located will be analyzed over the next few paragraphs, e.g., the wetland area, the regeneration work of the Tiber bank, the characteristics of the park, the blue and green infrastructure included, and the involvement of stakeholders during the design phase.

2.2 Research methods: desk analysis and empirical analysis on qualitative interview

The qualitative research methods employed for the study of the Marconi waterfront park project involved a combination of desk analysis and empirical analysis, supplemented by qualitative interviews. The initial phase of the research involved an extensive desk analysis, which included a thorough review of existing literature, reports, and documents related to the project. This helped to establish a solid theoretical foundation and identify key themes and concepts to explore during the empirical analysis phase. The empirical analysis involved conducting a qualitative interview with one of the most relevant stakeholders: landscape architect and designer Masterplan Tevere Maria Cristina Tullio. This interview provided valuable insights into the perceptions, experiences, and expectations of the various public and private actors closely associated with the Marconi waterfront park project. In the interview, it was also possible to get an overview of the park, starting from the reclamation work on the area where the park was established, to its opening. It was essential then to learn about the procedures and types of green installations with their related purposes, which have been implemented within the park. Contributing to the environmental aspect of the park is "Progetto Ossigeno", the Lazio Region project to plant new native trees and shrubs in Lazio. Thanks to the availability of Dr. Tullio, it was also possible to retrieve satellite images that tell the history, evolution, plans, and project areas of interest as well as technical data sheets of each naturalistic and non-naturalistic installation.

The data obtained from the interview was then carefully analyzed to identify patterns, themes, and emergent insights. The combination of desk analysis and empirical analysis through qualitative interview ensured a comprehensive and holistic research approach and in-depth understanding of the Marconi waterfront park project from multiple perspectives, providing valuable insights for the project's planning and development. The following paragraphs have therefore been incorporated with the information gained from the interview and the materials studied. A transcript of the interview conducted with Dr. Tullio will be made available as an appendix to this paper.

2.3 Marconi Waterfront Park – Scenario Analysis

Marconi Waterfront Park is a remarkable urban development project that focuses on various aspects of wetlands for urban resilience, urban river regeneration, stakeholder engagement, disaster risk reduction, and overall impact. The park serves as a living example of innovative strategies to enhance the resilience of urban areas in the face of environmental challenges. Through scenario analysis, the park's planners and stakeholders have explored different possibilities and outcomes related to wetland conservation, river revitalization, and community involvement. By incorporating these elements, Marconi Waterfront Park aims to create a sustainable and vibrant space that not only mitigates disaster risks but also fosters ecological restoration and meaningful engagement with local communities. This integrated approach acknowledges the interconnectedness between urban development, environmental stewardship, and social well-being, making Marconi Waterfront Park a model for future urban projects.

The following three images are satellite stills used for topographic mapping of the Marconi district riverfront area (Figure 6). The first figure is a representation of the areas of interest of the final project: interventions for the redevelopment, cleaning, and reclamation of the floodplain areas of the urban stretch of the Tiber River. In the second figure, the areas of enhancement, open spaces of environmental value, fabrics, and buildings in the Marconi neighborhood are highlighted. The last figure is a PS5 excerpt of the Tiber floodplain area layout guidelines from Castel Giubileo to the mouth. Specifically, it is an arrangement diagram where the optimal areas for the allocation of floating installations, the existing bicycle path, the cornerstones of

riverine greenery (the waterfront parks), and the strips of naturalness within Marconi Park are visible.

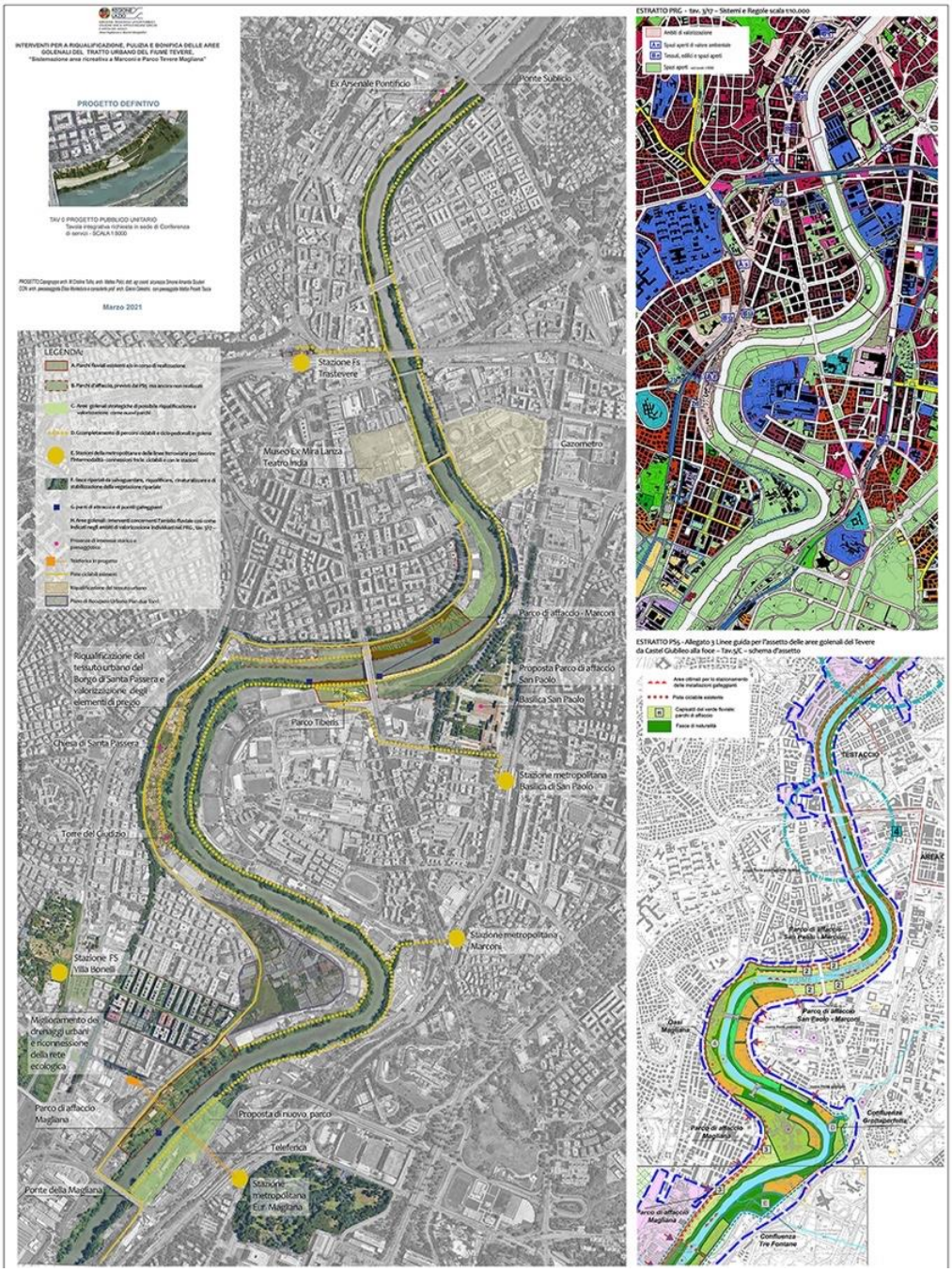

Figure 6 - Parco Marconi satellite stills – Dr.Tullio Interview, follow-up material

2.3.1 Wetlands for urban resilience

As cities face rising challenges from rapid urbanization, population increase, and the effects of land degradation and climate change, sufficient solutions for sustainable city development are required. Because most of this development is

taking place along rivers and along coastlines, the rapid loss of rich wetland habitats renders urban areas more exposed to the effects of extreme weather events and climate change. The continued degradation of wetlands, particularly urban wetlands, highlights the ineffectiveness of existing solutions and the need to increase efforts across several sectors and with a diverse range of stakeholders (Alikhani et al., 2021). Some of the key issues in urban wetland protection include:

- **Weak regulation**

The weak regulation concerning the protection of urban wetlands has emerged as a concerning issue in recent years. Despite the vital role played by these wetlands in supporting biodiversity, water filtration, and flood control, their preservation is often overlooked. Insufficient legal frameworks and inadequate enforcement mechanisms have allowed urban development to encroach upon these delicate ecosystems, resulting in their degradation and loss. The lack of clear guidelines and stringent regulations has led to uncontrolled land reclamation, pollution, and the destruction of wetland habitats. Urgent action is needed to address this regulatory gap and ensure the preservation and sustainable management of urban wetlands, safeguarding the invaluable services they provide to both human and natural communities (Dooley, 2021).

- **Sectoral approaches**

Wetlands are frequently governed using distinct sector-specific methods. This hinders the whole spectrum of ecosystem services, biodiversity values, and connections from being included in landscape scale management actions. Sectoral approaches cannot address the multiple factors of wetlands degradation (Dooley, 2021).

- **Limited capacities for integrated management**

Wetland conservation is frequently divided among various departments, such as environment and forestry, urban development, revenue, fisheries, and water resources. The administration of wetlands located inside the city limits is delegated to the concerned urban local authority in numerous smart cities programs. Wetlands, which are located at the intersection of land and water, necessitate unique management approaches that are not handled by government ministries' sectoral

objectives. Due to limited capacity within these departments, developing and implementing integrated strategies and management plans is a difficult challenge (Dooley, 2021).

- **Focus on hard-infrastructure solutions**

So far, the prevailing urban planning techniques in Italy have been infrastructure-oriented, with upstream supplies being tapped to fulfill water demands and waste and runoff being sent downstream as rapidly as feasible. Cities are arid, prone to floods and droughts, and more water insecure, highlighting the limits of these methods. Such methods frequently exclude management of wetlands located inside urban limits (Dooley, 2021).

- **Limited consideration of impact of urban development on wetlands**

The footprints of urban spaces are significantly larger than is often imagined and experienced. An urban area's water and food security needs are frequently satisfied by changing wetlands in far upstream and downstream regions. Many urban development projects fail to assess the entire impact on wetlands and offer necessary corrective measures (Dooley, 2021).

Overall, urban areas influence hydrological regimes in a variety of ways. The runoff increases as the built-up surface grows. The demand for water and the generation of wastewater increases exponentially as the population density increases. This eliminates the need for wetlands in urban environments to serve as a natural buffer for storing runoff, replenishing groundwater, processing wastewater, and controlling microclimate. Wetlands also reduce the heat island effect caused by land surface change in numerous metropolitan areas. As wetlands disappear, so do these critical processes, exposing urban areas to a variety of risks. This is the main reason why it was deemed necessary to regenerate the Marconi wetland by designing an urban river park within it. The severity and frequency of urban floods are increasing. Rainfall is growing more intense, concentrated over shorter periods, and causing excessive runoff because of climate change. Because flood water tends to concentrate in low-lying regions such as wetlands, infrastructure built on encroached wetland areas and feeder channels is vulnerable to floods. Because of

the reduced floodwater capacity, bigger areas are impacted ("Building Urban Resilience with Nature," 2019).

Wetland ecosystems then serve as essential buffers against extreme weather occurrences. Coral reefs, sandbanks, and barrier islands protect the shoreline from the forces of the sea. Mangroves, seagrass, and salt marshes form soils in the intertidal zone by storing silt and organic matter, minimizing the effects of sea-level rise. Their dense vegetation also lessens wave damage, erosion, and, in rare circumstances, storm surge effects ("Building Urban Resilience with Nature," 2019). Building with Nature, as in the case of the Marconi Waterfront Park, provides significant opportunity to reintegrate ecosystems as crucial climate buffers in urban planning and design:

- **Natural hazard mitigation**: Wetlands defend against a variety of extreme weather phenomena, including floods, storm surge, erosion, and heatwaves.
- **Water management**: Healthy rivers, floodplains, and marshes can store vast amounts of water and refill aquifers, decreasing destructive flooding and soil subsidence while also cushioning drought risk during dry seasons.
- **Climate Change Adaptation and Mitigation**: Wetlands are ecosystems that give a long-term answer to climate change adaptation while also storing large amounts of carbon emissions.
- **Citizens engagement**: Integrating wetlands into urban landscapes produces living surroundings for citizens to enjoy recreation and reconnect with nature.
- **Economic activities**: Wetlands are valuable for biodiversity and for supporting fisheries, making wetland conservation and rest an integral part of urban development, alongside other measures such as the construction of water infrastructure, roads, housing, and industry, creating livable and sustainable cities that are resilient in the face of climate change. To ensure that this approach becomes completely ingrained in urban development trajectories, public and private stakeholders must collaborate in innovative collaborations ("Building Urban Resilience with Nature," 2019).

2.3.2 Urban River regeneration: applying nature-based solutions for environmental and urban improvement

The conventional urbanization model often adapts waterways to the needs of the city without taking into account the natural dynamics of water and the space required for water processes to occur. Proposals for rivers frequently disregard not just their environmental importance, but also their cultural and social value. Furthermore, land use and water system changes may generate one of the most serious challenges currently confronting cities: urban flooding. The increased frequency of urban floods is directly proportional to city growth. Flood dangers have increased all over the world as more people, goods, services, and houses have been concentrated in metropolitan areas, making them vulnerable to floods (Wallemacq & House, 2018).

It is consequently critical to handle the water problem, but not in the conventional sense, and an everlasting solution cannot be envisaged. Traditional waterway design and flow control (and wastewater management) entails considering city-generated outflows as waste to be transferred outside the area of interest. This point of view is founded on a flawed logic. It is crucial to restore hydrological functions and reverse the negative consequences of urbanization. It is also necessary to organize growth in order to make room for water and bring the city closer to the natural system on which it was built, learning to design with nature rather than against it. The ecologically resilient approach prepares a city to face future hazards and problems. However, in big cities, waterways frequently become invisible, and there is little or no connection between the city and its natural ecosystems (Directorate-General for Research and Innovation (European Commission) et al., 2022). The prevalence of man-made recreational spaces (e.g., shopping malls, condominiums, playgrounds, and squares), where most social gatherings occur, is one of the factors contributing to a lack of understanding concerning the role of ecosystems and the water system in city environmental sustainability. It is usual to find rivers with altered courses and wetlands that have been filled over. Many cities have turned their backs on rivers by growing onto their banks. As a result, rivers have become hidden within the urban landscape, since they are regarded as basic drainage channels, receivers of residential and industrial waste, and are sometimes referred to informally as ‘big ditches' because they relate to the conveyance of

domestic sewage (Directorate-General for Research and Innovation (European Commission) et al., 2022).

In recent decades, an intriguing approach to the concept of river regeneration has gained a place in technical literature. Rivers might be thought of as a synthesis of the land that flows through them. As such, they must be acknowledged as essential environmental structures in the development of a landscape. River regeneration has been suggested as an alternative in the global struggle against the steady deterioration of river ecosystems. The findings have the potential to boost the amount and quality of water resources, as well as their potential usage by the riverfront population (Nardini & Centro Italiano per la Riqualificazione Fluviale, 2006).

River regeneration is considered a way of recovering the environmental quality of water ecosystems, with the goal of restoring natural values by managing this recovery process in a balanced and comprehensive manner with river communities and the economic activities carried out. This definition proposes that environmentally enhanced rivers will also serve other purposes better. As a result, restoration is seen as an environmental aim in a way that an improved overall state of water bodies is desirable because it may enable recreational or leisure activities that provide value for society while preserving nature and biodiversity (Directorate-General for Research and Innovation (European Commission) et al., 2022).

The purpose of restoration is to make rivers more natural so that they require fewer interventions. They will also be more economically feasible and give better long-term answers to critical concerns confronting water basins, such as how to control flooding and decrease water risks. The river restoration strategy is typically constrained in metropolitan settings, where the natural river basin has been severely transformed and deteriorated, and only partial benefits are achieved. The large changes witnessed across the basin, such as the construction of houses and roadways, make obtaining the required space to recover the natural processes of riverbeds and banks more difficult. There are more constraints in this scenario, and compromises must be reached between natural and man-made surroundings (Guimarães et al., 2021).

To generate a real urban river regeneration (URR) strategy, it is important to consider this approach in conjunction with the city's local setting, taking historical and socioeconomic factors into account. In this process, the river's assessment, and reintegration as part of the urban landscape are critical.
A series of environmental restoration interventions must be identified that fall under the limited actions possible for urban rivers, able to integrate, or at least interact, multiple city interests, such as the needs for hydraulic safety, the rehabilitation of degraded areas, the need for recreational spaces (Veról et al., 2019).

In urban areas, the main focus may be on restoring lateral connectivity with levees and tributaries, increasing the river's freedom, restoring its natural drainage system, rebalancing geomorphological dynamics, minimizing water pollution and soil contamination, and reactivating river-owned areas. Instead of typical, localized drainage systems, a combination of flood risk management and river restoration efforts might provide an efficient solution for urban rivers. River regeneration may be seen as one of the strategies to be employed to achieve the greater objective of sustainable urban water management in a sustainable drainage system strategy (Veról et al., 2019).

The rationale for URR is not only based on the value of the river; such regeneration can offer a city the opportunity to increase the value of riverside properties, revitalize neighborhoods that have suffered from flooding or proximity to a degraded river, improve the quality of life for residents, and reduce water-related hazards(Gusmaroli, 2008).

Based on these premises, namely state-of-the-art analyses of urban river regeneration strategies, the Marconi River Park has been created.
The Marconi district is a commercial area rich in services, stores, very well connected to the city by both the presence of the subway and public surface transportation. What it lacked was greenery, due in part to the fierce building construction that overwhelmed it since the 1950s, with spots characterized by high-rise buildings and extremely busy streets. Just under the Marconi Bridge, at Lungotevere of Pietra Papa, since October 2022 there is now the new waterfront

park, which has not only regenerated the riverbank but revolutionized the relationship between citizens and the area itself (Chessa, 2023).

The land bordering the area on the right bank of the Tiber River, known as the Lungotevere of Pietra Papa, takes its name from the properties once owned here by the Papa or Papareschi family, which had an important settlement discovered here around 1915, thanks to a Tiber flood that destroyed the banks, causing five suburban thermal environments to emerge along the right bank with walls that reached the river bank, used as a swimming pool. The area has seen, in recent history, important transformations: in modern times, in fact, the place, from probably cultivated countryside, has seen the growth of the Marconi district and bridge, which have determined the development of a new part of the city. The latter, perhaps with its river, never confronted itself adequately and never considered it a structural resource, as it did in ancient times (Chessa, 2023).

The opening of Marconi Waterfront Park was achieved thanks to the synergy between institutions and a protocol signed by the Region, the Municipality, and the City Council for the management and maintenance of the areas (including Tevere Magliana Park). Specifically, as of January 1, 2023, the Municipio XI has been entrusted with routine and extraordinary maintenance on the water tanks, checking the condition of the furniture and play areas, verifying the functioning of the facilities, cleaning the pavements, clearing brushwood from the floodplain areas and embankments, emptying trash cans, maintaining the paths and fences, taking care of the plants, and planting new trees (Roma Capitale, 2022).

The Marconi waterfront park is the city's second river park, which has transformed an abandoned place into a rich, equipped, green place with a playground, outdoor gym, a plaza with water games, a pier with an area dedicated to marsh flora, a large dog area and a refreshment kiosk. Among other things, the park is widely accessible, given the presence of an access ramp for bicycles and people with disabilities.

2.3.3 The Park Project and the Arboreal and Shrub System (Ossigeno Project)

The modifications of the river margin and the morphological changes brought about by water erosion and the human work were interpreted in the project as a "topographic" and figurative matrix that shapes and organizes the spaces (Regione Lazio, n.d.).

The previously abandoned area of about 3.5 hectares was a large landfill with extensive squatter settlement that required significant cleanup and reclamation (Figure 7). Now it has become an overlook park, for public and flexible use whose facilities and accommodations are mainly located on the first high floodplain at the base of the earthen embankment along the Lungotevere of Pietra Papa, in front of the remains of the Popes' harbor that allowed people to reach the "Basilica of St. Paul Outside the Walls" by navigating the Tiber and using the structure of the existing Roman dock. The density of the neighborhood, which lacks squares and meeting spaces, led to the provision of a large waterfront park to carry out different kinds of activities (festivals, markets, shows), regenerate the natural environment and ecosystem, and finally be a gathering point for the local community (Occhionero, 2021)(Regione Lazio, n.d.).

Figure 7 - Area subject to reclamation, Dr. Tullio Interview, follow-up material

According to the Lazio Region prospectus (Figure 8) and Dr. Tullio's contributions, the park appears to consist of:

- arrangement of the promenade overlooking the Lungotevere di Pietra Papa alongside the bike path;
- a new access from the Pietra Papa Promenade with a pedestrian ramp for people with disabilities;
- a path that connects the end of the ramp with a central space, with misting water features, a kiosk, a sand play area for children, seating and deck chairs, and a kiosk;
- improvement of the existing driveway and bicycle access and a 2.5-meter wide section of pathway to allow access for service and rescue vehicles and a parking space for service vehicles;
- a delimited dog area;
- a large play area called "science play area" with games related to balance, sound and movement;
- an environmental education area located under an ancient poplar tree;
- the planting of a riparian forest with species that have a great capacity to purify the soil and with low Voc (Volatile Organic Compounds), planted thanks to the Ossigeno project (planting that extends throughout the park).
- the plant arrangements for lighting, drainage and water supply for the irrigation system;
- an overlook pier on the river in front of the Popes Harbor.

Figure 8 – The Marconi waterfront park project, Dr. Tullio Interview, follow-up material

A description of the interventions, discussed with Dr. Tullio, now follows.

The Pietra Papa riverfront promenade

The removal of the existing fence makes it possible to rethink the relationship between the floodplain area and the city. The project, as already anticipated, intends to put in place a series of devices to encourage maximum functional and visual interaction between the city and the river.

To this end, the project envisioned the widening of the current sidewalk, in those places where this is possible, gaining space at the top of the embankment and flanking the current asphalt sidewalk with a rammed earth sidewalk, draining, and created with a different granulometric stratification modeled on the so-called Saulò used in Barcelona's public spaces. This pavement is cut by 2-meter-wide strips made with lawn protectors and gravels that accommodate the planting of trees (planted by the Ossigeno project of the Lazio region) oriented to open and close visual wings to direct the user's observation. Coupled with this, based on a clearing plan (also on the left bank), in fact, a series of panoramic overlooks were designed from which to observe not only the river environment below but also the landscape surrounding the basilica of St. Paul on the other bank. The fence was replaced by a parapet with corten steel posts and a wooden handrail that is supported by a continuous concrete curb to contain the flow of water and sand downstream.

The existing curb supporting the fence was partly demolished and its surface redefined to demarcate the paved stopover space from the bike path. A height difference of 5 cm and the slope toward the floodplain of the stopover area also prevented sand from flowing onto the track. A number of seats have been placed in the wider spaces that will allow resting in the shade of the trees. The two "heads" of this new spatial area are bordered by paving made with a totally draining cementitious binder.

Accessibility and connections: the new downhill ramp

Due precisely to the characteristics just described, the descent ramp to the park begins near the Marconi Bridge, with a constant 7% slope, and leads to the first floodplain. The ramp, 1.50 m wide, carved out in overhang from the existing embankment, is supported by a counterscarping made according to the techniques of embankment rings and according to the indications deduced from the geological report. The body of the ramp is made of dry-edged material, rolled to the compaction required by technical regulations, to form counter slope berms. The ramp provides run-off water collection spaces on the right and left sides of the path, drainage cement mix paving with corten steel curbs (to reduce maintenance), and 1.5-meter resting shelves every 10 meters, as required by current legislation.

The ramp is protected downstream by a parapet, the same as that of the belvedere above, and the paving, like that of the path below, is in draining material (hydrodrain) laid on an underlying ballast made of quarry split and corten steel curbs. The path below, in continuity with the ramp leads to the paved central area, maintaining the width of 1.5 meters.

As for the service driveway access, the existing pathway has a width of about 2.50 meters and is currently made of beaten dirt and has some erosion situations due to water runoff. For this reason, several breakwater and rainwater collection gutters and surface treatment with well-rolled broken quarry have been constructed. This entrance and passageway have a remote-controlled bar, operable by the managers of the area, while allowing pedestrian passage. The passage of service vehicles related to the maintenance and operation of the kiosk are regulated and are related to the specific and momentary service. At the base of this entrance, however, there is an area for parking in case of need of the janitors and managers of the park, or for temporary activities that require the arrival of vehicles.

The central paved area

The paved area constituting the park square occupies a total area of 1389 sq. m., to which is added a 275 sq. m. sand play area for children. The paving is articulated in irregularly shaped "clumps" detached from each other by 50-cm bands of lawn protectors with gravel. Such paving is-as in the ramp and pathway-in 100% drainage material and the casting will be contained between corten steel curbs. This is a central place, intended for resting and conviviality, where there is seating and water mist play on the floor and served by a prefabricated and removable kiosk with pergola and attached services for whose functionality. The kiosk has a 172-square-meter service area behind it for loading and unloading conveniently screened and protected by groups of 1/1.2-meter high shrubs. This service area is paved with limestone sand laid on a draining subgrade ballast.

The play area is dedicated to younger children and is sand, on a ballast of draining subgrade, with wooden curbs: a protected and "soft" space where they can move freely and safely near the "central square." The path coming from the ramp, entering the playground area, will turn into a kind of wooden walkway, changing finishing material. Different color solutions were used between the paths and the square.

The water features

A series of 9 misting kits for entertainment were allocated at the existing concrete pavement. To do this, the existing pavement was cut for the necessary plant connections and the placement of 9 manholes to accommodate the sprinklers and LEDs for backlighting. A welded pvc sheet waterproofs the surface and directs the fallout water to two collection grates that lead it to a 10,000-lt cistern with a recirculation pump. This system allows water reuse but with a necessary direct adduction system for renewal and quality of the water used. The excess water from the cistern is conducted to the river, passing through an area of marsh plants (planted with other contract) that will perform a purifying function before release.

The facilities

The project included the necessary plant arrangements for:

- the water supply of 3 drinking fountains (one for the plaza and toddler play area, one for the dog area, and one for the science playground area);

- the electrical connection with only the provision of the corrugations that serve:
  - for public lighting of the paths and the high terracing only (only in the high terracing so as not to create light pollution in the riparian area refuge of many species);
  - to power the misting water features;
  - to feed the kiosk;
- the drainage sewer connection, for which the provision and burying of the necessary piping for the cistern overflow and the connection of the wastewater from the fountains to the irrigation cisterns was planned. With the kiosk in the service area, provision was made for the discharge of the kiosk toilets to an Imhof pit, made according to the layout of the kiosk;
- The purpose of the irrigation system is to ensure the rooting of escarpment shrubs and trees in the floodplain area and to be used as needed in subsequent years. An underground tank system with a low height (1.20 m) but high capacity of 20,000 lt was buried and anchored. The tank is fed by reclaimed water from the fountains in the park. Water distribution is through drip wings with self-compensating drippers and thus through a system with high distribution efficiency and low consumption.

The dog area

This area for now only provided for the construction of the fence and drinking fountain. Trees and seating were then arranged.

The Ossigeno Project and the tree and shrub system

Ossigeno was born in 2019, the Region's project to plant new native trees and shrubs in Lazio to make it increasingly green, attentive to the challenges of air quality and care for the land, green areas and parks. Ossigeno kicked off with the involvement of schools, universities, hospitals, senior centers, protected natural areas, cultural institutes, historic residences, museums, libraries, state property, ATERs, IPABs, and many others who took up the Lazio Region's call to host the first trees (Regione Lazio, 2019).

On November 21, 2019, on National Tree Day, the project went into full swing with the planting of the first 5,000 trees and shrubs from the Aurunci Mountains Regional Park Vivarium. The planting was taken care of by volunteers from Civil

Guard Associations and Protected Natural Areas staff with regional technical support and continued until December 2019 and then abruptly stopped due to the epidemiological emergency from Covid-19. But with the approval of Regional Council Resolution No. 378 of June 19, 2020, an important new step forward was taken by publishing a Notice of Expression of Interest through which the best projects could be collected for which preferentially native trees and shrubs could be allocated, to be planted on public land or for public use in regional urban and peri-urban areas (Regione Lazio, 2019).

All of this has initiated a new phase with which to lay the roots for a greener Latium future.

The Ossigeno project is a key component of the Marconi River Park, as the latter has benefited from it for the planting of new tree, riparian (*Figure 9*), floodplain, shrub and mediterranean systems on the embankment escarpments, using the list of species selected by the Ossigeno project. Specifically, the proposed species were selected together with the Ossigeno project managers and, in particular:

Figure 9 3 - Riparian vegetation, Dr. Tullio Interview, follow-up

In the Marconi waterfront park, the planting of:

- 145 trees: for co2 absorption and oxygen production (and partly soil pollutant absorption).[1]

Such trees will constitute:

- a small filter strip towards the street along the sidewalk of the papal stone promenade, shading some benches for parking;
- a riparian forest in the floodplain that combines co2 absorption with soil purification.

- 3200 shrubs: for absorption of pm 10/5/2 and co2- with reduced maintenance and contained water requirements.

Such shrubs will allow:

- carpet embankments by creating a dust-absorbing filter;
- reinforce the embankments;

Such naturalistic installations make it possible to reduce maintenance, because with a "blanket" planting of the planned shrubs, drip wing and a mulching sheet, it will not be necessary to cut the grass or weed species frequently, making only one maintenance intervention per year necessary (only 1 cut, once a year, at the end of winter). At the compositional scale, it should be noted that the new trees are

[1] Species selected for their ability to absorb CO2 and Fine Particulates and for their lower production of VOCs (Volatile Organic Compounds) with maximum CO2 uptake, based on data compiled by the Life+ GAIA (Green Areas Inner-city Agreement) project in the Municipality of Bologna, by the Institute of Biometeorology (Ibimet) of the CNR in Florence.

arranged in spaced rows oriented to open and close perspectives toward the Tiber. The planting spacing between individual trees is 6 meters. In addition, the rows are arranged with a differentiated rhythm so as to generate clearings and spatial openings and more shaded areas, so as to scan and delineate different areas. The planting of the shrubs includes the placement of mulching cloth in the escarpments to contain the growth of the shrub species.

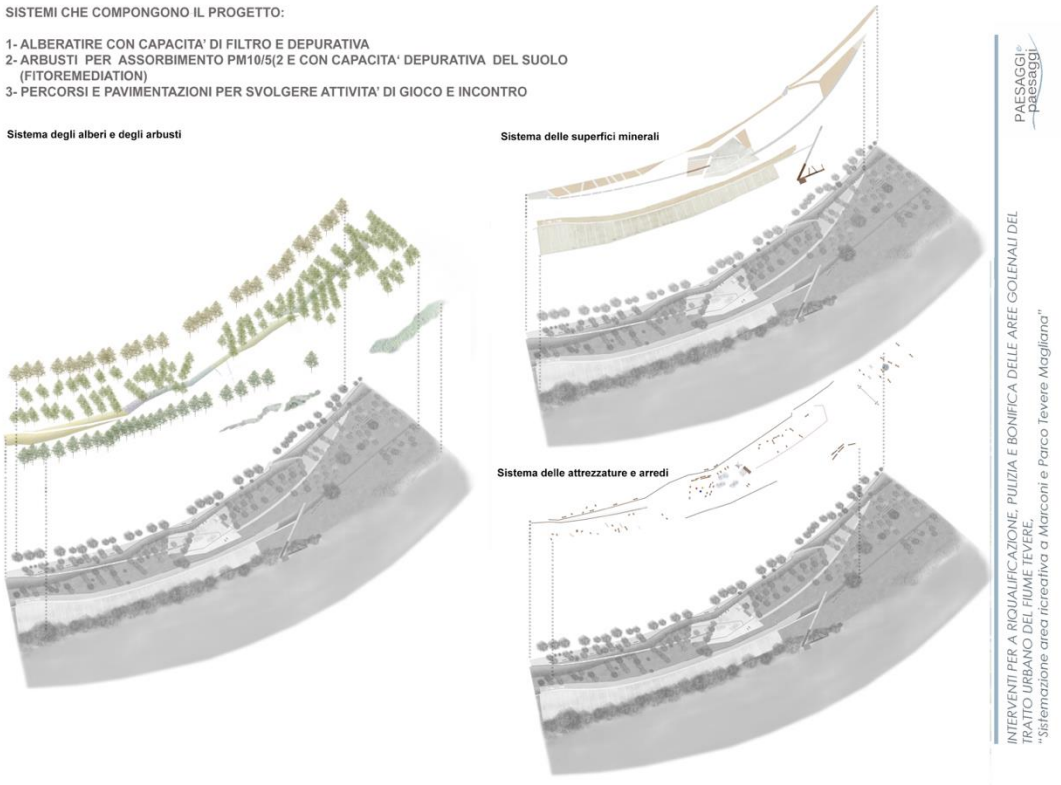

Figure 104 - Systems characterizing the project: trees, shrubs, mineral surfaces, equipment and furnishings, Dr. Tullio Interview, follow-up material

To summarize, by the end of the project, a total of more than 5 thousand shrubs and 200 trees (more than originally planned) were planted in the park, 100% draining pavements were employed, and recirculating water from fountains misted in to cool the air *(Figure 10).* The plants, arranged according to landscaping criteria, in addition to absorbing CO2 and filtering fine dust from the street, form real clearings where physical activity or walking is possible. The installed tree system will help reduce the temperature of the surrounding area by about 3°. Moreover, by using riparian trees that can purify the soil of pollutants and increase the biodiversity typical of the river environment, the project makes a fundamental contribution to the local ecosystem.

Conclusion

Discussion and results

Cities are locations where humans and nature come into close touch, where civilization and biodiversity witness intricate interactions and co-evolution in the form of characteristic urban niches, adaptive gene mutation, and species development(Kabisch et al., 2017).

Many cities have been constructed along rivers owing to the economically and defense-linked geographic location and the availability of water resources and rich soils. Thus, riparian forests, wetlands, and cities have a long history punctuated by synergistic interactions and risk creation. More precisely, river floods imperil persons and their properties, while humans, in turn, degrade wetlands and floodplain forests through construction, surface sealing, groundwater management, and tree cutting. When communities commit to maintaining and protecting wetlands, these environments and their surrounding forests can provide substantial ecological benefits to city residents. Not only do they serve crucial regulatory roles, but they also offer recreational spaces that cater to all demographics, allowing them to immerse in and appreciate the natural world. Moreover, these cool, green spaces are particularly valuable during sweltering summers, contributing significantly to the physical well-being of urban inhabitants. Wetlands and riparian forests, as discussed in the preceding chapter, provide a variety of functions that benefit both society and biodiversity. They are great nature-based solutions for moderating the consequences of climatic stress and climate change that cities are increasingly experiencing, such as heat waves, protracted dry spells, floods, and contaminated sediment deposition. In addition to their role in water flow control, they serve as steppingstones for species of various taxa, as well as a site for the establishment of novel or changed ecosystems and the survival of endangered species.

Wetlands and riparian forests contribute a wide range of ecological services. Because of their constant high groundwater levels, moist soils, and, if they include a forest stand, the leaf-based shade, and transpiration effects, they are exceptionally effective and crucial cooling components in urbanized regions (Haase et al., 2014).

When considering strategies for adapting to climate change, wetlands present a multi-faceted solution. They serve various crucial roles ranging from acting as

carbon reservoirs due to their organic-rich soil, contributing to localized temperature reduction through their alluvial components, and functioning as floodplains to mitigate flood intensity by providing space for water, permitting natural flooding, and offering a water retention mechanism to combat drought conditions.

The need to trigger or regenerate ecosystem services with the introduction of Nature Based-Solution is thus becoming increasingly important both in land-use and urban planning processes and in the definition of interventions at the architectural scale. In such a scenario, which will progressively change the image of cities, the environmental design constitutes an important tool in the search for an appropriate and conscious relationship between the introduction of natural components and the quality of public spaces. In-depth investigations have confirmed the great variability in terms of the effectiveness and efficiency of NBS depending on the application methods, the specific characteristics of the insertion context and the goals underlying the interventions.

In this context, it was examined the importance of an urban waterfront park and how it can contribute to the mitigation of climate effects produced by urban emissions. Following the analysis carried out on the case study, Marconi Park, and after interviewing one of the project leaders, Dr. Tullio, there were identified possible ways in which the park succeeds in mitigating the climate effects produced by urban emissions, particularly those from the heat island represented by the district.

By strategically incorporating green and blue infrastructure, such as wetlands, rain gardens, and tree canopies, a waterfront park can effectively mitigate the impacts of urban emissions. These natural features have the ability to absorb carbon dioxide, filter air pollutants, and regulate local temperatures through evapotranspiration and shading, thereby reducing the heat island effect prevalent in urban areas. Additionally, the park's vegetation acts as a sink for greenhouse gases, contributing to the overall reduction of carbon emissions produced by urban heat islands.

Furthermore, a well-designed waterfront park offers opportunities for stormwater management. Through the implementation of sustainable drainage systems, including constructed wetlands and permeable surfaces, the park can capture, retain, and treat stormwater runoff, reducing the burden on conventional drainage systems. This, in turn, minimizes the risk of flooding, water pollution, and strain on infrastructure during extreme weather events. Beyond climate mitigation, a waterfront park promotes biodiversity and ecological connectivity, serving as a refuge for various plant and animal species. The preservation and restoration of natural habitats within the park enhance urban biodiversity, supporting local ecosystems and strengthening ecological resilience. This, in turn, contributes to the overall health and functioning of urban environments.

Moreover, a waterfront park acts as a catalyst for community engagement and education. By providing accessible green spaces, the park encourages public interaction with nature, fostering environmental awareness and stewardship. The park can serve as an outdoor classroom, offering opportunities for environmental education programs, workshops, and interpretive signage that raise awareness about climate change, sustainability, and the importance of nature-based solutions.

Lastly, the economic and social benefits of a waterfront park cannot be overlooked. Beyond its ecological and social values, a well-designed park attracts visitors, stimulates tourism, and enhances property values in the surrounding area. It can also generate employment opportunities, support local businesses, and contribute to the overall economic development of the city.

In conclusion, a waterfront park, such as the Marconi park; serves as a multifunctional space that not only enhances the aesthetics and recreational value of urban areas but also acts as a critical tool for climate resilience. This kind of park holds immense potential as a nature-based solution for mitigating the climate effects caused by urban emissions. By harnessing the power of green and blue infrastructure, promoting biodiversity, engaging communities, and supporting economic growth, these parks emerge as integral components of sustainable and climate-resilient cities. Embracing the role of waterfront parks in urban planning and policy-making is a crucial step towards creating greener, healthier, and more sustainable urban environments that address the challenges of climate change while improving the overall quality of life for residents and visitors alike.

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Annex

Interview with Dott.ssa Maria Cristina Tullio –Rome, 31/05/23

L: *Describe yourself briefly, what is your job occupation and what role did you play in the project?*

D: I am a landscape architect, president of the Italian Landscape Architecture Association, and I worked with an interdisciplinary group for the purpose of designing Marconi Park.
At the basis of the project is first a great historical investigation of the place, its evolutions and sedimentations to understand how the place has changed over time. The river area in the Marconi district is large in size.

L: *Please describe the project*

D: Regarding the design choices, citizens' requests were taken into consideration, as they had been asking for years to have a green space on the river also because the neighborhood is extremely built up and there are not many green areas.

In the park area there was a terrible settlement, with 700 tons of garbage, the whole area was cleaned, and soil characterization was done, that is, checking if the soil was contaminated, fortunately not. When the excavations were done, a lot of Roman rubble was found, that area was a dumping ground even for the ancient Romans. 1000sqm of 100% draining floor was made so as not to change the water absorption balance of the soil. The upper part, where it is thought water cannot reach, was equipped first. The kiosk is removable when needed (even in case there is a flood). The floors are made of draining concrete, and it was decided to equip the upper part, while the part of the lower floodplain is totally left natural. The only interventions made were the wooden benches for environmental education. A willow grove was also planted; otherwise, everything was left natural, with a natural overlook to the ancient Roman port of the popes. The project also included an overlooking pier on the river. The vegetation present in the lower part is riparian.

In the upper part, the first intervention is the belvedere, separated with a fence from the existing bike path. The vegetation is all riparian type, which has great soil-purifying abilities. The lower part has myrtifolia, the upper part ash trees. In general, they are all species with soil-purifying characteristics, making sure that they filter out water and the debris it carries before it reaches the river substrate. In addition, they are very beautiful plants. There are three types of poplars, two types of ash trees, and willow trees in the lower part. They were not put in with naturalistic intent but inserted in terms of urban planning. For the escarpments, some riparian species were put in. These plants have very low water consumption and are watered very little by recovering water from the park's fountains, which is stored in two cisterns through a recirculation system. As for the soil and lawn, the river's muddy, clayey substrate means that when there is an overflow of the river or otherwise a lot of water, the water drains very slowly because it thus promotes riparian plant life because it maintains the moisture for longer and the cooler temperature of these areas. Grit roll lawn was then put in, a type of lawn that has few water and maintenance requirements. It is not an irrigated lawn.

Climate-wise, shrubs and lawn have a great capacity to absorb particulate matter; all plants absorb CO2 but also emit it. However, they are VOC (Volatile Organic Compounds), reduced-emission types of plants. In addition, their presence lowers the temperature of the area by as much as 3°.

Functions and facilities were then streamlined, there is a children's play area, science play area, a gymnastic area near an escarpment where gorse, a plant that helps in drainage and further reinforce the new escarpment, was planted.

L: *What were the public and private actors involved in the planning of the park*

D: Councillor for Urban Planning Maurizio Veloccia, following the opening of the Magliana Park in 2014, subsequently found funds for the construction of a park in Marconi. The assignment came from the Lazio Region Zingaretti Administration. Urban and citizen participation for the park was done online because of the COVID-19 pandemic, otherwise demonstrations would have been done in the neighborhood. Online associations were met and the local municipality was also involved. This project was communicated to the river contract, so the Tiber agenda association acted

as a liaison with all the actors in the river contract. There were several comparison meetings. Meetings were also held with bicycle associations.

Agenda Tevere, which is an association of associations, promoted the river contract that was approved by the Lazio region and managed by a special office of the Metropolitan City of Rome. Agenda Tevere served to kick off the project. The point of the river contract is to receive input from the public to hand over to an administration that eventually brings forward the projects.

L: *What are the prospects for the park in terms of environmental, economic and social benefits on the Marconi area?*

D: For the environmental perspective the ecosystem services; the riparian plants will induce the growth of other riparian plants and improve the area. Regarding the economic and social ones, the value of houses in the area is increased. The park can provide jobs for example through the kiosk, through the involvement of associations, through bike rental services, involvement of schools for environmental education activities, increased customers for local businesses.

L: *How do Marconi Park and the Ossigeno Project come together?*

The Ossigeno Project is a beautiful project but it has a flaw, it has plants that are too small. For Marconi Park there has been specific collaborative work involving different people. Oxygen funding is for shrubs and trees. The trees have to have a dimension of relationship with humans, they have to be compositional elements, functional to the area.

Following the interview, the Dr. Tullio provided me with additional materials that were included within the thesis, specifically all the images featured regarding the Marconi Park project.

Summary

Nature-Based Solutions (NBS) have gained worldwide recognition for their potential to provide sustainable, cost-effective, and flexible strategies in addressing the critical and complex issues surrounding climate change. Utilizing the inherent capacities of natural ecosystems, NBS focuses on the protection, restoration, and management of these ecosystems to achieve benefits for both people and nature. In the face of the devastating effects of climate change, these solutions represent a comprehensive, interdisciplinary approach that encourages synergistic relationships between natural and human systems, facilitating climate mitigation, adaptation, and resilience.

One of the major advantages of NBS lies in their capacity to absorb carbon dioxide, thus reducing the volume of greenhouse gases in the atmosphere. Forests, wetlands, and other green spaces, for example, sequester carbon while simultaneously providing habitats for a diverse range of flora and fauna. They can also offer ecosystem services, such as freshwater supply, erosion control, and natural disaster risk reduction. Furthermore, NBS have the potential to create healthier, more livable urban environments by moderating temperature extremes, improving air quality, and enhancing urban biodiversity.

In the context of rapidly growing urban areas, NBS are critical in mitigating the impacts of urban heat islands and associated emissions. Urban heat islands are characterized by significantly higher temperatures compared to their rural surroundings, primarily resulting from human activities, extensive concrete and asphalt surfaces, and limited vegetation. This phenomenon contributes to higher energy consumption, increased emissions of greenhouse gases and air pollutants, and exacerbated heat-related illnesses.

This is where the concept of a waterfront park comes into play. As an NBS, waterfront parks provide green open spaces within urban areas, playing a pivotal role in mitigating the impacts of climate change. They serve as green lungs, cooling urban environments, absorbing CO2, and improving air quality, thus reducing the severity of urban heat islands and associated emissions.

Waterfront parks also possess unique features due to their proximity to water bodies. The water can create a cooling effect, helping to regulate the microclimate and further mitigate urban heat island effects. They can also serve as habitats for aquatic and terrestrial biodiversity, promoting ecological connectivity and

resilience in the face of climate change. Furthermore, they provide a recreational and social space for residents, enhancing the quality of urban life and fostering community engagement in environmental stewardship.

The research problem of constraining emissions produced by urban heat islands" is addressed by recognizing the capacity of waterfront parks in mitigating the heat island effect and the resulting emissions. By increasing green coverage and utilizing the cooling properties of water, waterfront parks can reduce ambient temperatures, decrease energy consumption for cooling, and consequently lessen greenhouse gas emissions. The research question "How can a waterfront park effectively mitigate the climate change effects caused by urban emissions?" directs attention to the design and management aspects of these parks. Optimizing the types of vegetation used, their placement and density, ensuring the park's accessibility and usability, and maintaining the health of the aquatic ecosystem can maximize the park's cooling capacity and carbon sequestration potential. Studies focused on this can provide guidelines and recommendations for urban planning and management, contributing to sustainable and climate-resilient cities.

The urgent need for effective climate change mitigation strategies and the promising potential of NbS, particularly waterfront parks, make this research highly significant. By enhancing our understanding of the potential and challenges of waterfront parks in mitigating urban emissions, we can more effectively harness the power of nature for a more sustainable and resilient future.

Case study – Marconi Waterfront Park

Areas along the rivers' banks, lakes and the sea are important places of interaction between the environmental network and densely inhabited parts of the territory. Catalysts of social life, these environmental axes are an important resource for urban regeneration: recognizing their value is the first step toward their redevelopment. Citizens in western metropolises today are attentive to the quality of the environment in which they live and the quality of life. In Rome for example, green and blue zones, particularly that of the Tiber and its surrounding areas, are potentially a great resource for the city's ecosystem. But the inhabitants are only partly aware of the value the Tiber has for the city and therefore do not always recognize the embankment spaces that important role they could play for their well-being. Far more serious is the limited awareness of the river's value to the city by

public administrators, which is the main cause of the advanced state of degradation in which the roman river is in today.

With all their efforts, willing individual citizens have never succeeded in curbing the decline of the urban river area, particularly the Marconi area, caused mainly by the total inadequacy of the complex system that is supposed to administer it. It is therefore necessary today, in the state of degradation in which Rome finds itself, to build an alliance to save the river, a pact between citizens and social innovators, associations, businesses, articulations of organized civil society, schools and administrative, cognitive, cultural and scientific institutions, a collaboration between all parties willing to commit themselves, putting at the service of the community their time, ideas, skills, abilities and useful resources to save the Tiber River and its banks from decay. Only in this way, what is now in many of its stretches a degraded and dangerous space, exploited by illegality and in some cases completely inaccessible, the Marconi River area could once again become a vital space for the city.

Aiming at this goal in the summer of 2021, after clearing the floodplain area of the river near the Marconi neighborhood, the cleanup began to remove the fifteen shacks and the many accumulated garbage that had often been reported to have possible consequences on the healthiness of the river. This reclamation work set the stage for the construction of the new Marconi Waterfront Park.
Marconi Park is Aa new space positioned on the bank of the Tiber with a children's play area, dog area, green lawns, and new green installations (trees and green corridors). The Lazio Region directly carried out the work to create the new park, which has an area of about 3.5 hectares and stretches from Lungotevere di Pietra Papa to Marconi Bridge. The reclamation work of what was effectively a large landfill involved the clearing of a squatter settlement and the cleaning between July and August 2021 of the surface. The operations, which cost about 335,000 euros, enabled the regeneration and redevelopment of the green area.

As a waterfront park, Marconi Park is a nature-based solution, which, embedded in one of Rome's most developed neighborhoods, can perform a function of mitigating the heat island generated by the surrounding area, as well as enhancing, restoring,

co-creating, and co-designing with nature, urban green networks characterized by multifunctionality (environmental, economic, and social) and connectivity.

Therefore, the research question devised, which is the basis of this dissertation, is: *How can a waterfront park effectively mitigate the climate change effects caused by urban emissions?*

In order to answer this question, the scenario within which Waterfront Park Marconi is located was analyzed.

Methodology

The qualitative research methods employed for the study of the Marconi waterfront park project involved a combination of desk analysis and empirical analysis, supplemented by qualitative interviews. The initial phase of the research involved an extensive desk analysis, which included a thorough review of existing literature, reports, and documents related to the project. This helped to establish a solid theoretical foundation and identify key themes and concepts to explore during the empirical analysis phase. The empirical analysis involved conducting a qualitative interview with one of the most relevant stakeholders: landscape architect and designer Masterplan Tevere Maria Cristina Tullio. This interview provided valuable insights into the perceptions, experiences, and expectations of the various public and private actors closely associated with the Marconi waterfront park project. In the interview, it was also possible to get an overview of the park, starting from the reclamation work on the area where the park was established, to its opening. It was essential then to learn about the procedures and types of green installations with their related purposes, which have been implemented within the park. Contributing to the environmental aspect of the park is "Progetto Ossigeno", the Lazio Region project to plant new native trees and shrubs in Lazio. Thanks to the availability of Dr. Tullio, it was also possible to retrieve satellite images that tell the history, evolution, plans, and project areas of interest as well as technical data sheets of each naturalistic and non-naturalistic installation.

The data obtained from the interview was then carefully analyzed to identify patterns, themes, and emergent insights. The combination of desk analysis and

empirical analysis through qualitative interview ensured a comprehensive and holistic research approach and in-depth understanding of the Marconi waterfront park project from multiple perspectives, providing valuable insights for the project's planning and development.

Conclusion and results

To conclude, cities are locations where humans and nature come into close touch, where civilization and biodiversity witness intricate interactions and co-evolution in the form of characteristic urban niches, adaptive gene mutation, and species development.

Many cities have been constructed along rivers owing to the economically and defense-linked geographic location and the availability of water resources and rich soils. Thus, riparian forests, wetlands, and cities have a long history punctuated by synergistic interactions and risk creation. More precisely, river floods imperil persons and their properties, while humans, in turn, degrade wetlands and floodplain forests through construction, surface sealing, groundwater management, and tree cutting. When communities commit to maintaining and protecting wetlands, these environments and their surrounding forests can provide substantial ecological benefits to city residents. Not only do they serve crucial regulatory roles, but they also offer recreational spaces that cater to all demographics, allowing them to immerse in and appreciate the natural world. Moreover, these cool, green spaces are particularly valuable during sweltering summers, contributing significantly to the physical well-being of urban inhabitants. Wetlands and riparian forests, as discussed in the preceding chapter, provide a variety of functions that benefit both society and biodiversity. They are great nature-based solutions for moderating the consequences of climatic stress and climate change that cities are increasingly experiencing, such as heat waves, protracted dry spells, floods, and contaminated sediment deposition. In addition to their role in water flow control, they serve as steppingstones for species of various taxa, as well as a site for the establishment of novel or changed ecosystems and the survival of endangered species.

Wetlands and riparian forests contribute a wide range of ecological services. Because of their constant high groundwater levels, moist soils, and, if they include a forest stand, the leaf-based shade, and transpiration effects, they are exceptionally effective and crucial cooling components in urbanized regions.

When considering strategies for adapting to climate change, wetlands present a multi-faceted solution. They serve various crucial roles ranging from acting as carbon reservoirs due to their organic-rich soil, contributing to localized temperature reduction through their alluvial components, and functioning as floodplains to mitigate flood intensity by providing space for water, permitting natural flooding, and offering a water retention mechanism to combat drought conditions. The need to trigger or regenerate ecosystem services with the introduction of Nature Based-Solution is thus becoming increasingly important both in land-use and urban planning processes and in the definition of interventions at the architectural scale. In such a scenario, which will progressively change the image of cities, the environmental design constitutes an important tool in the search for an appropriate and conscious relationship between the introduction of natural components and the quality of public spaces. In-depth investigations have confirmed the great variability in terms of the effectiveness and efficiency of NBS depending on the application methods, the specific characteristics of the insertion context and the goals underlying the interventions.

In this context, it was examined the importance of an urban waterfront park and how it can contribute to the mitigation of climate effects produced by urban emissions. Following the analysis carried out on the case study, Marconi Park, and after interviewing one of the project leaders, Dr. Tullio, there were identified possible ways in which the park succeeds in mitigating the climate effects produced by urban emissions, particularly those from the heat island represented by the district.

By strategically incorporating green and blue infrastructure, such as wetlands, rain gardens, and tree canopies, a waterfront park can effectively mitigate the impacts of urban emissions. These natural features have the ability to absorb carbon dioxide, filter air pollutants, and regulate local temperatures through evapotranspiration and shading, thereby reducing the heat island effect prevalent in urban areas. Additionally, the park's vegetation acts as a sink for greenhouse gases, contributing to the overall reduction of carbon emissions produced by urban heat islands.

Furthermore, a well-designed waterfront park offers opportunities for stormwater management. Through the implementation of sustainable drainage systems, including constructed wetlands and permeable surfaces, the park can capture, retain, and treat stormwater runoff, reducing the burden on conventional drainage systems. This, in turn, minimizes the risk of flooding, water pollution, and strain on infrastructure during extreme weather events. Beyond climate mitigation, a waterfront park promotes biodiversity and ecological connectivity, serving as a refuge for various plant and animal species. The preservation and restoration of natural habitats within the park enhance urban biodiversity, supporting local ecosystems and strengthening ecological resilience. This, in turn, contributes to the overall health and functioning of urban environments.

Moreover, a waterfront park acts as a catalyst for community engagement and education. By providing accessible green spaces, the park encourages public interaction with nature, fostering environmental awareness and stewardship. The park can serve as an outdoor classroom, offering opportunities for environmental education programs, workshops, and interpretive signage that raise awareness about climate change, sustainability, and the importance of nature-based solutions.

Lastly, the economic and social benefits of a waterfront park cannot be overlooked. Beyond its ecological and social values, a well-designed park attracts visitors, stimulates tourism, and enhances property values in the surrounding area. It can also generate employment opportunities, support local businesses, and contribute to the overall economic development of the city.

In conclusion, A waterfront park, such as Marconi Park, serves as a multifunctional space that not only enhances the aesthetics and recreational value of urban areas but also acts as a critical tool for climate resilience. This kind of park holds immense potential as a nature-based solution for mitigating the climate effects caused by urban emissions. By harnessing the power of green and blue infrastructure, promoting biodiversity, engaging communities, and supporting economic growth, these parks emerge as integral components of sustainable and climate-resilient cities. Embracing the role of waterfront parks in urban planning and policy-making is a crucial step towards creating greener, healthier, and more sustainable urban environments that address the challenges of climate change while improving the overall quality of life for residents and visitors alike.