

Article

Designing Nature as an Infrastructure—A Multi-Level Spatial Strategy for Designing Nature-Based Solutions in Copenhagen to Enhance Urban Climate Governance

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Abstract

Copenhagen is often regarded as a pioneer city in climate change adaptation and green-blue infrastructure deployment. However, when addressing extreme environmental problems such as heavy rainfall flooding and urban heat island effects, many interventions remain site-specific and insufficiently connected across spatial scales. This article investigates how Nature-Based Solutions (NBS) can be structured as an integrated spatial infrastructure system to enhance climate resilience and urban livability in Copenhagen. The research combines theoretical analysis, comparative project studies, GIS-based spatial analysis, and a multi-criteria evaluation matrix. Building on this method, a multi-scalar framework for NBS interventions is developed, which consists of site prioritization at the Meso scale, development strategies at the Micro scale, and NBS spatial design at the Nano scale. With the assessment criteria adapted from the UNalab project Nature-Based Solutions Technical Handbook Factsheets, the results demonstrate that Nano-scale design strategy can enhance green connectivity, create new inclusive urban public spaces, transform existing industrial areas, and improve new streets and parks for climate resilience. The Meso-scale distributed measures deliver localized benefits such as infiltration and flood buffering, while the most effective strategies integrate cross-scalar NBS interventions within a connected network. The case of Nordhavn is analyzed through multi-criteria selection and multifunctionality assessment as a qualitative process for a better demonstration of the practical application of NBS prioritization and spatial design analysis.

Keywords: nature-based solutions; climate resilience; spatial analysis; GIS-based framework; sustainable development; city of Copenhagen

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1. Introduction

Today, urban areas worldwide are increasingly vulnerable to environmental challenges and climate change impacts such as global warming, flooding, urban heat island effects, and biodiversity loss—all of which threaten cities' resilience and long-term sustainable development [1]. To address these challenges, cities are integrating nature-based solutions (NBS) into their planning and development strategies to enhance climate

adaptation, improve ecological health, and elevate human well-being [2]. As defined by the European Commission as “actions inspired by, supported by or copied from nature that aim to help societies address a variety of environmental, social and economic challenges in sustainable ways” [3], NBS have been widely implemented to increase urban resilience and national climate adaptation policies for addressing the above climate hazards. During their implementation, numerous studies have explored how cities evaluate their environmental and social impacts for NBS decision making.

Following this path, cities are increasingly experimenting with NBS to improve urban ecosystems as alternatives to “hard” and “gray” approaches for mitigating and adapting to the challenges posed by climate change and rapid urbanization. NBS, as integrative and systemic approaches, work with nature, and generate multiple ecosystem services while addressing environmental, social and economic concerns [3]. They can function as a supplement to and improvement of the conventional gray infrastructure in responding to extreme climate pressures and changing urban needs. For example, Caldarice et al. [4] frames NBS as urban climate shelters that transform schoolyards into multi-hazard refuges against climate challenges [4]. They reviewed six European projects—Paris, Barcelona, Madrid, London, Amsterdam, and The Hague—to highlight how NBS can be applied for addressing different climate change issues such as heat, rainwater absorption and multi-hazard resilience.

Castán Broto and Westman [5] also show that urban climate governance has gradually evolved from early optimism about the role of cities to a more practical concern about the action of implementation, coordination and evaluation [5]. Instead of being understood only as green add-ons, NBS are gaining more attention as a systemic planning and design tool for urban governance. Their design and implementation are often associated with strong collaboration across various social sectors. As part of a co-design, co-implementation, and co-maintenance process, NBS link local governments, civil society, and private actions to form a bottom-up governance framework [6]. They provide cities with inclusive methods for not only climate issues but also spatial, social, ecological, and economic challenges.

Among these studies, Copenhagen, Denmark’s capital, has been recognized as the 2014 European Green Capital for its excellence in eco-innovation and sustainable transportation [7]. As a leading city in planning quality and sustainable development, Copenhagen integrates blue–green infrastructure and climate adaptation measures [8]. These elements are crucial for addressing urban resilience challenges and achieving long-term environmental development goals [9].

Suffering from the heavy cloudburst in 2011, Copenhagen adopted a citywide approach for climate adaptation and extreme weather. The Cloudburst Management Plan [10] divided the city into seven major cloudburst catchments and prioritized the implementation of NBS measures with a minimum time frame of 20 years [11]. In each catchment, different forms of blue–green infrastructure, such as a courtyard, a basin, or a temporary basin, have been adopted for more effective and localized climate resilience impacts. For example, Grønningen Bispeparken, designed by SLA, located in the social housing district in Copenhagen, integrates 18 sculpted retention basins, redesigned lawns, diverse planting schemes and multifunctional public spaces, which can retain up to 3000 m³ of stormwater during intense rainfall [10]. During normal climate conditions (no extreme floodings or flash flood situations), these basins provide inclusive open spaces for social cohesion. In terms of ecosystem services, the project contributes to stormwater regulation, temperature mitigation and biodiversity support through native vegetation.

Known as the first climate-adapted neighborhood in Copenhagen, Sankt Kjelds transformed from a gray and car-oriented district into a green and multifunctional public environment [12,13]. It consists of green streets, a permeable plaza and over 500 newly

planted trees. Its effectiveness is evaluated through heat reduction (canopy cover and albedo changes), infiltration capacity, and increased biodiversity. A surrounding levee and hydraulic gates enclose the park during heavy rain, while sunken sports fields, basins, and gardens temporarily store floodwater. In dry periods, these same features appear as lawns, playgrounds, and gardens, keeping the park fully usable.

Despite Copenhagen's reputation for already designed and implemented NBS and well-established processes, the practical application of NBS still faces key issues regarding strategic prioritization, spatial positioning, and evaluation. Specifically, how to select the right NBS projects in urban environments remain unclear. What criteria guide project setting and type, and how can we measure outcomes from the perspectives of climate resilience and sustainability? Filling these gaps is vital for refining Copenhagen's strategy and replicating its model in other cities.

A growing body of literature has applied GIS-based multicriteria decision analysis (GIS-MCDA), including weighted-overlay and citywide neighborhood prioritization approaches, to identify optimal locations for individual NBS types: for street trees, green spaces and buffer strips aimed at carbon sequestration [14]; for open green space siting based on soil, meteorological and geological suitability [15]; and for flood-oriented NBS deployment in high-density urban landscapes [16]. These studies provide a robust, quantitative basis for single-type, single-scale site selection, but do not address how citywide prioritization should connect to neighborhood-level design and site-specific typology choice [17]. This is the gap addressed by the present study, which proposes a cross-scalar sequencing framework—from Meso-scale prioritization to Micro-scale design, to Nanoscale NBS selection—rather than a single-scale quantitative suitability model.

Based on this, this research article poses the question: how can a structured and spatially grounded framework be developed to guide the selection and prioritization of NBS in Copenhagen by synthesizing existing planning strategies and contextual analysis? The aim is to develop a structured framework to guide the selection, prioritization, and design of NBS in Copenhagen to support the city's broader goals of climate resilience and sustainable urban development. The whole process is based on an analysis of multiple levels of spatial mapping, to introduce NBS implementation in Copenhagen (Meso scale), Nordhavn (Micro scale), and Green Loop (Nano scale). A specific site selection score matrix was developed using analytical SWOT criteria towards identifying a common framework for all selected sites.

2. Materials and Methods

This article uses a mixed-method approach including policy planning analysis and GIS-based spatial assessment techniques. Considering the complexity of urban systems and the multitude of factors influencing climate resilience [9], this methodology was developed to identify climate challenges, evaluate spatial and socio-environmental conditions, prioritize areas for interventions, and formulate NBS strategies at different spatial scales. A weighing framework was developed using a numerical value for each criterion identified from the GIS-based analysis and the SWOT based on previous projects (see Section 3.1.4). Although the framework was applied to Copenhagen, it also provided a structured planning process that can be adapted to other urban contexts.

Policy and planning content review the key planning and policy documents that guide the development of Copenhagen, including the Finger Plan (1947), A metropolis for people (2009), the Cloudburst Management Plan (2012), the Copenhagen Climate Adaptation Plan (2015), the Copenhagen Way (2025), and other documents [18–20]. This step helps clarify how NBS are currently framed within the city's governance structure and planning system and identify relevant values and strategies.

Geographic Information System (GIS) were adapted to comprehensively understand Copenhagen's planning structure. By analyzing layers such as built-up area, green and blue infrastructure, ecological elements, population distribution, transportation accessibility, and future projects, a spatial profile of the city was constructed. Additionally, specific indicators such as climate vulnerability (flood risk zones and heat island effect areas, ecological potential (green space coverage), socio-spatial needs (population density and social vulnerability), and planning compatibility (underutilized land and re-development zones) were assessed to support the identification and prioritization of locations suitable for NBS. The analysis did not treat the indicators as a universal scoring system with fixed weights but used them as context-sensitive spatial evidence to support comparison and priority setting in Copenhagen.

The methodology was applied across the Meso, Micro, and Nano scales. At the Meso scale, the analysis identifies the highest-potential areas for interventions based on climate vulnerability and spatial opportunities. At the Micro scale, neighborhood and site-specific conditions were examined in greater detail. At the Nano scale, the studies explored how individual NBS elements could be incorporated into streets, open squares, buildings and other urban components. We used multi-objective optimization between all built-environment components for connecting energy efficiency, daylight availability, glare constraints, and thermal-visual comfort with broader urban climate adaptation and human comfort criteria in the Nano scale evaluation [21,22]. This multi-scale process established a transferable sequence that considers climate risks, urban conditions, and socio-spatial needs for decision making. The analysis was based primarily on geospatial datasets obtained from official municipal platforms and publicly accessible sources, including Københavns Kommune (Copenhagen Municipality), OpenStreetMap, ArcGIS Pro-version 3.7.1, and other public resources. The data sources, spatial resolutions, and process procedures for each figure are specified in the corresponding analytical sections.

3. Results

This part is developed using three levels of analysis, the Meso, Micro, and Nano scale, which involves analyzing and understanding the spatial context in Copenhagen for NBS interventions.

3.1. Copenhagen—Meso Scale

This stage involves analyzing and understanding the spatial and social context in Copenhagen on a larger scale. It aims to develop NBS selection criteria based on various comparisons of each neighborhood and then select the highest-potential neighborhood for NBS interventions.

3.1.1. Background Information

As Figure 1 shows, Copenhagen, the capital of Denmark, is located between the North Sea and the Baltic Sea, making it a vital gateway for trade, cultural exchange, and political cooperation between Central Europe and the Scandinavian region. The Greater Copenhagen area, also known as Metropolitan Copenhagen, is a large commuter belt that has a “densely populated trace back to the Finger Plan” [23], which established several fingers of train lines, railroads, and metro lines to realize urbanization from central Copenhagen (Figure 2).

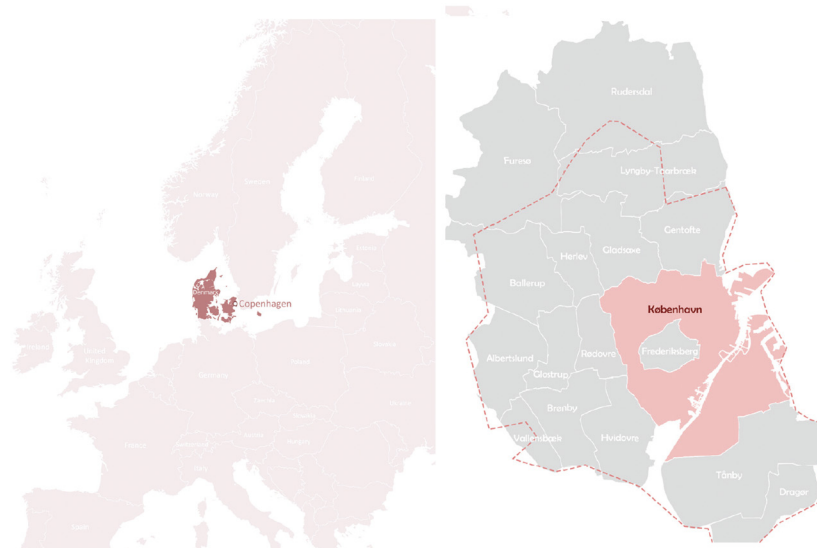


Figure 1. Location of Denmark across Europe (left), Copenhagen and surrounding municipalities (right). Source: authors' illustration.

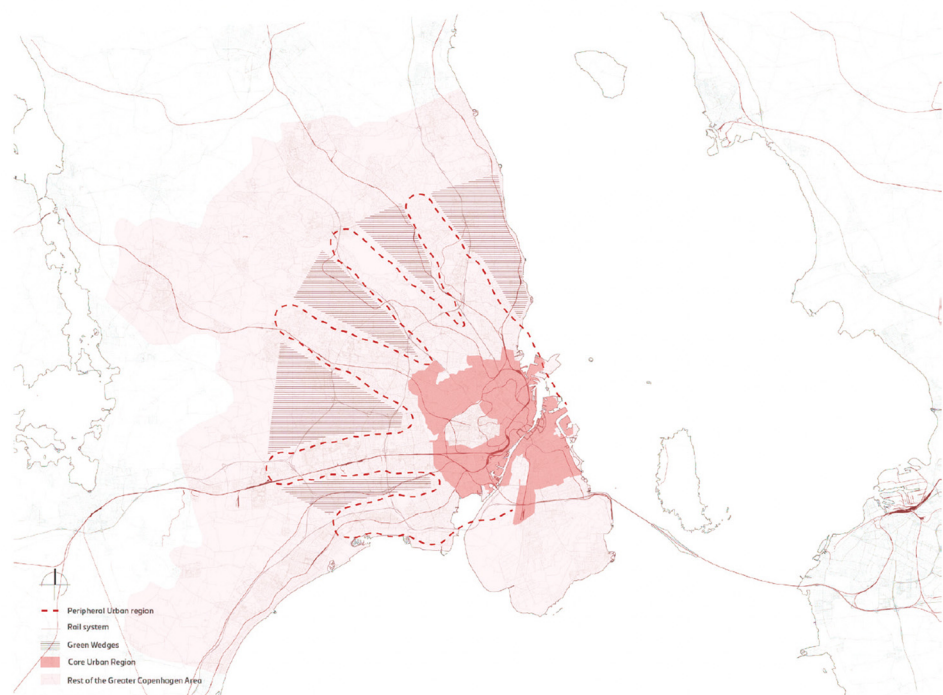


Figure 2. Copenhagen urban structure with Finger Plan. Source: authors' illustration.

Based on urban boundary delineation, Copenhagen is subdivided into 10 official districts and 67 neighborhoods (kvarterer) (Figure 3). These maps display the administrative boundaries of each district and neighborhood, with each serving as a unit for urban analysis, planning, and social spatial data management. It provides the municipality with a finer scale to support planning processes related to housing, transportation, green infrastructure, and climate adaptation.

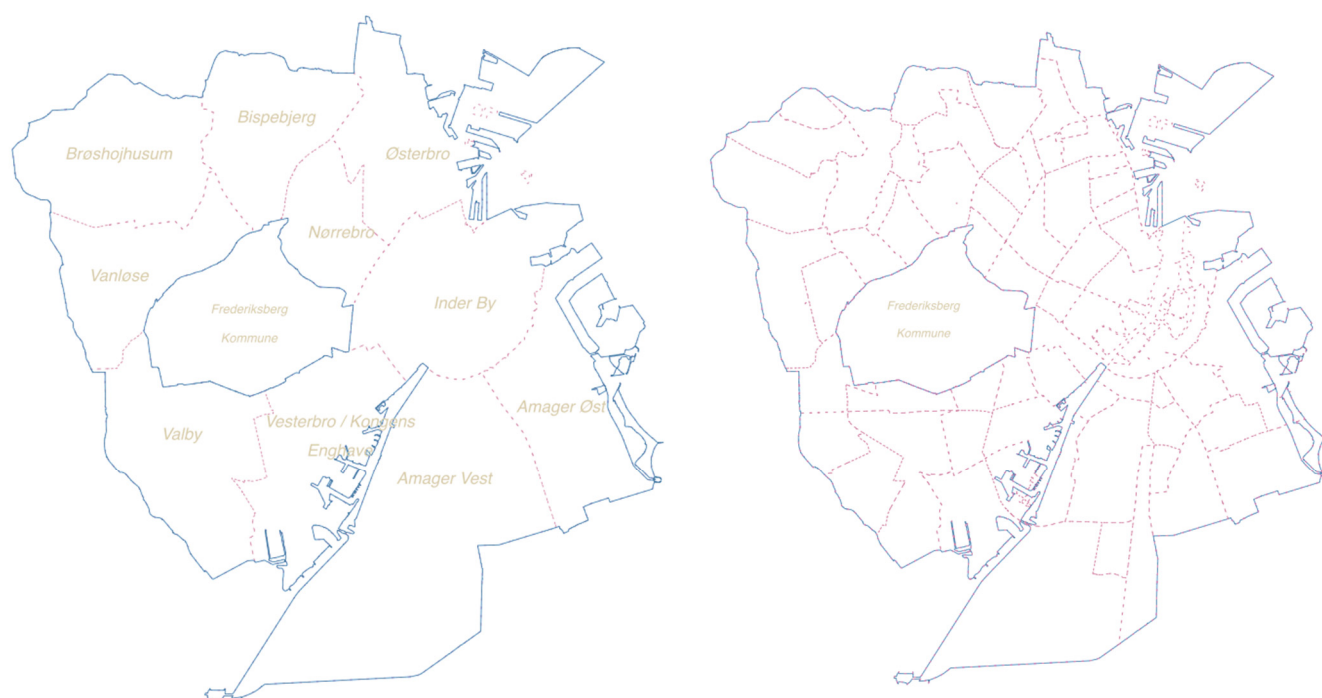


Figure 3. Urban district boundaries (**left**) and neighborhood boundaries (**right**) in Copenhagen. Source: authors' illustration based on Copenhagen Municipality.

3.1.2. GIS-Based Analysis

This stage builds on the analysis of existing urban structures and contexts. Different indicators are compared within the same base map to guide the selection criteria of intervention areas. During this process, elements such as built-up areas, green and blue infrastructure, cities' environmental issues, accessibility, future projects, and social context are under comprehensive consideration.

- Land Use (Built-up Areas)

The map (Figure 4) illustrates the distribution of the main functions for land use. The residential area is mainly located in the inner part of the city. The commercial area with mixed-use functions is mainly concentrated in certain areas to ensure easy access to the inhabitants. The industrial area mainly includes the peripheral area of the city, specifically the Nordhavn area. The South Island in Copenhagen includes an airport, which can be reached through public transport. The recreational area is evenly distributed across the city to ensure easy access to inhabitants. The development area in Copenhagen includes the waterfront area, specifically the area in Nordhavn, which will be transformed into a new mixed-use area through extensive reclamation.

- Building Volume Density (Built-up Areas)

To enable easier comparisons, a grid with cells of 250 m by 250 m was drawn over the whole area of the municipality. For each cell, the total volume of buildings (calculated by multiplying the floor area by height) was calculated and then divided by the area of the cell to obtain a value measured in cubic meters per square meter (m^3/m^2). This is essentially the density of the buildings in each cell, namely the volume of buildings per unit area. The results show that the areas with high-density building development are Amager, Nørrebro, and Ørestad, which may lack sufficient green areas, potentially resulting in overheating. The key findings on building density (see Figure 5) reveal the following:

- Central areas: high density, low spatial capacity;
- Peripheral areas: lower density, higher flexibility;

- Uneven distribution of intervention potential.

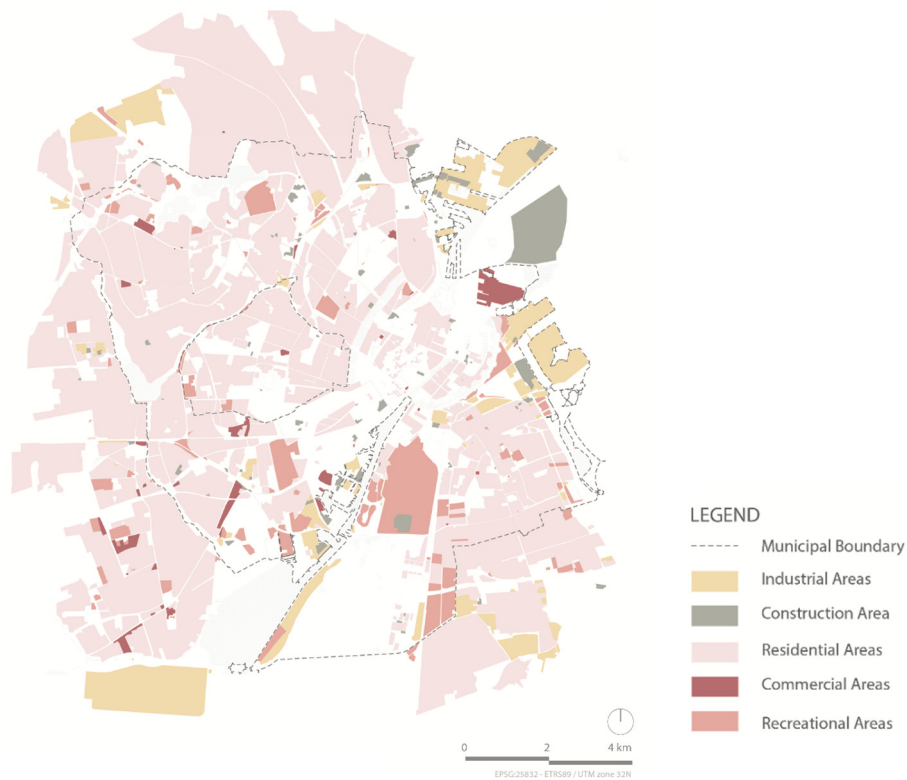


Figure 4. Land use areas in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

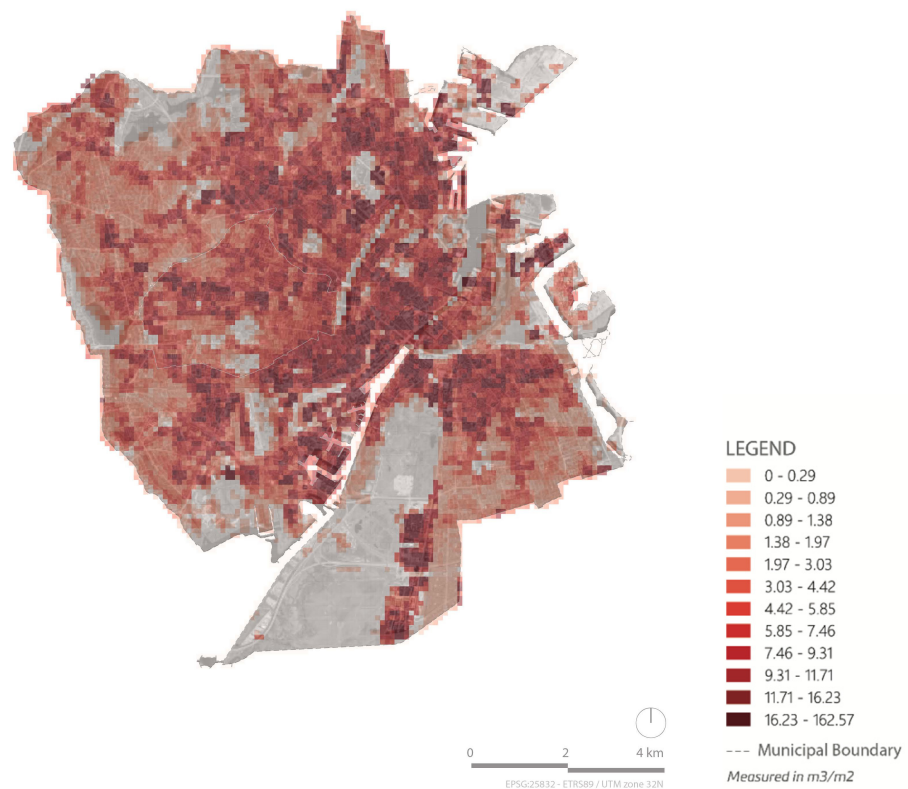


Figure 5. Building volume density in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- Green areas and agricultural land (Green and blue infrastructure)

The majority of Copenhagen remains unexploited in terms of open space. Forests, coastal areas, farming regions, and other green spaces are mostly located along the boundaries of Copenhagen, especially in the south. Public green space, which includes parks, lawns, and play areas, can be found throughout Copenhagen. Though there are larger open spaces and forests in the outer regions, such as Amager and Brønshøj, the green space in the inner regions remains smaller compared to the rest of the city. Though there have been attempts to improve green space, the increasing population and density of Copenhagen continue to heighten the need for quality green space. Copenhagen's future development hinges on maintaining and strengthening the balance between the built and natural environments. Protecting farmland and enhancing multifunctional green spaces are essential for ensuring long-term ecological resilience, improving urban Microclimates, and providing public access to nature (see Figure 6).



Figure 6. Green land use in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- Green area typologies (green and blue infrastructure)

The green infrastructure in Copenhagen varies in terms of function and type. The percentage maps show that grasslands and parks are the dominant types of green infrastructure in Copenhagen. The majority of these are located in the southern ecological zone.

Forests are mainly located in Ørestad and the northwest, acting as a boundary between urban and rural areas. Parks, allotments, and green infrastructure act as important recreational areas in Copenhagen, especially in the central part of the city. Many of the royal parks and gardens have been maintained in this area, hence their importance as recreational spots (see Figure 7).

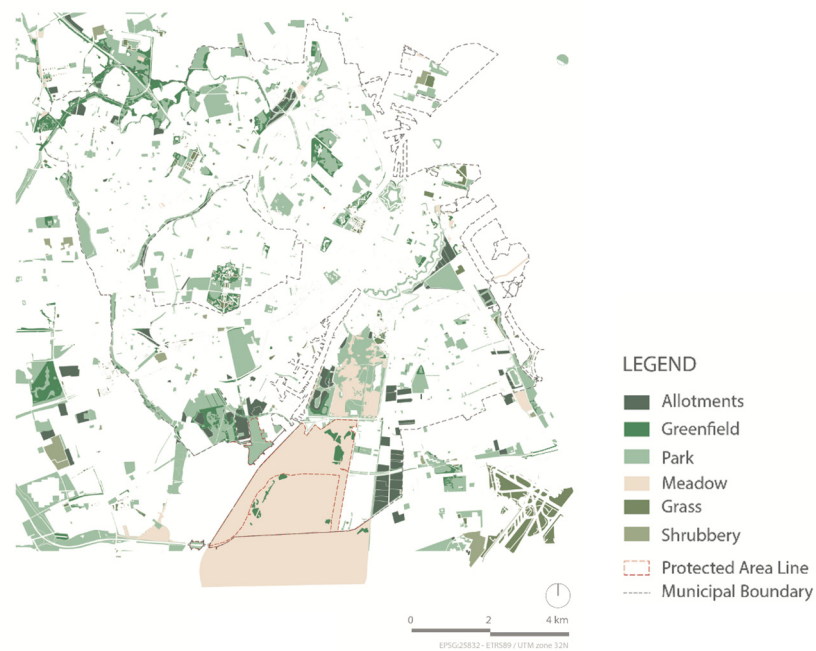


Figure 7. Spatial distribution of green typologies. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- Green space rate per neighborhood (green and blue infrastructure)

The green ratio in the perimeter block area is relatively low, just like in Christianshavn or other historical neighborhoods. The green ratio in the suburban area shows a relatively higher rate of integrating garden spaces with courtyard spaces. The newly developed areas, such as Ørestad, also show moderate green coverage. This shows that the problem of green coverage in Copenhagen is still a concern. Improving green coverage at the neighborhood level is very important in building resilience to future heat stress events (see Figure 8).

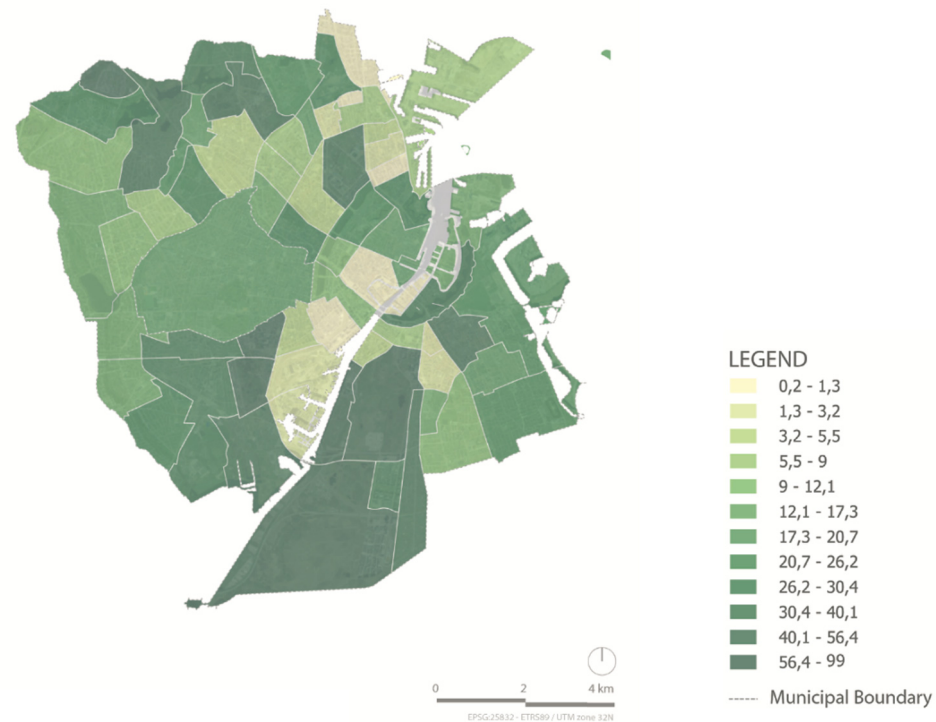


Figure 8. Green space rate per neighborhood in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- Blue system (green and blue infrastructure)

Copenhagen's blue system comprises harbors, lakes, canals, and coastal zones. These areas are integral to the city's visual identity and play a crucial role in water management, recreation, and maintaining ecological balance. The city's main bodies of water include the central lake chain—Sankt Jorgens So, Peblingesøen and Sortedams So—which marks the edge of the historic city center. There are also extensive coastal waters along Kalvebod Fælled and Amager Strandpark. Smaller streams and protected river zones mainly stretch across the western and southern edges of the municipality, providing natural corridors for biodiversity and flood control. As well as their technical role, Copenhagen's blue areas provide residents with drinking water. Waterfront promenades, harbor baths and accessible lakesides also provide opportunities for recreation and socializing. Residents particularly enjoy the waterfront spaces in the summertime, when many festivals are held around the water bodies (see Figure 9).

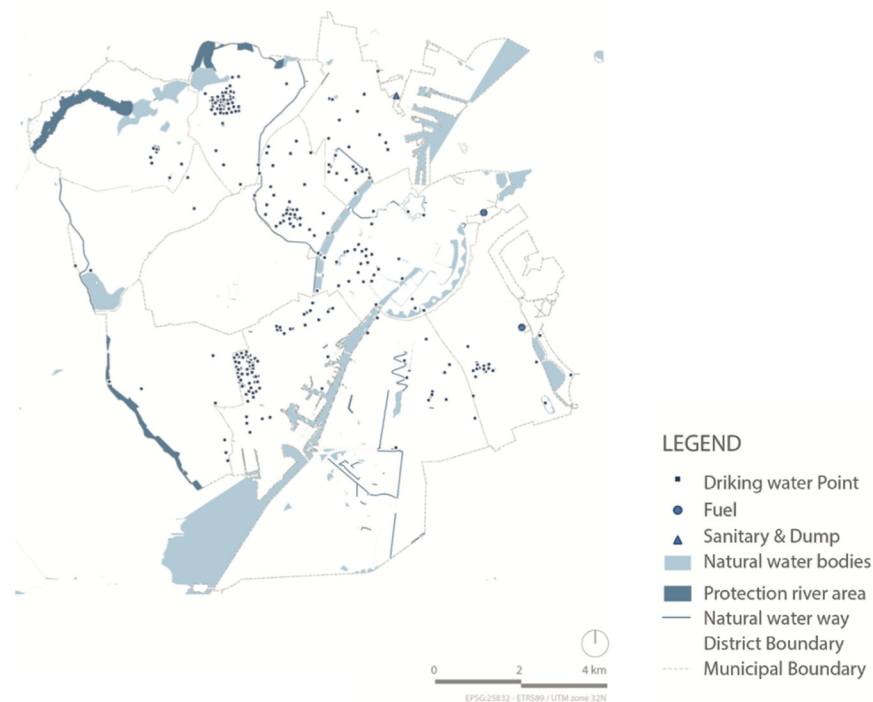


Figure 9. Blue infrastructure in Copenhagen. Source: authors' illustration based on information from GeoDenmark.

- Urban Heat Island (City Diagnosis)

Like most cities, Copenhagen is challenged by the urban heat island effect. The maps in Figure 10 show land surface temperature variations annually between 2017 and 2020. Even though the city has close to 100,000 trees, higher temperatures occur in dense urban cores like Indre By, Vesterbro, and Nørrebro, as well as major transport corridors and industrial zones. The UHI maps are based on Landsat 8/9 TIRS, with a 30 m resampled spatial resolution and annual mean temperature values from 2017 to 2022. (Data Source: DHI A/S, Agem Alle 5, DK-2970, Horsholm, Denmark.)

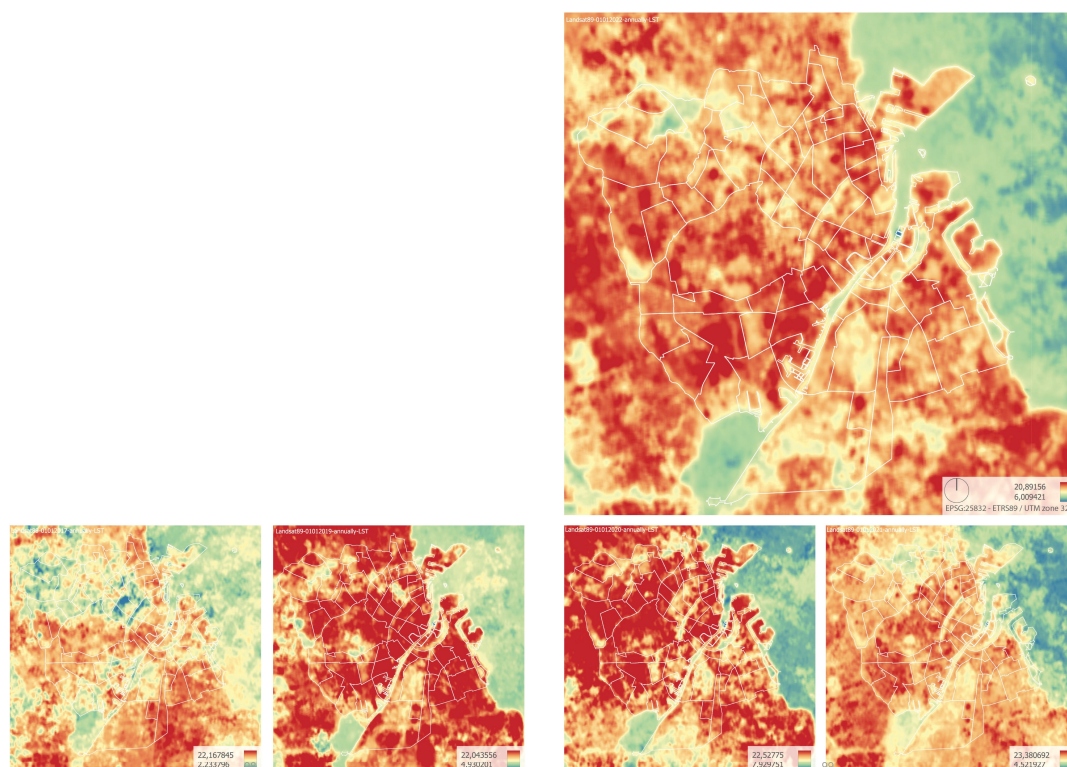


Figure 10. Urban heat island in Copenhagen. Source: authors' illustration based on information from DHI Satlas Team. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- **Flooding (City Diagnosis)**

Like many other coastal cities, Copenhagen is facing challenges related to unpredictable rainfall and flooding. The map in Figure 11 illustrates the potential extent of flooding during a 100-year rainfall event in 2110. The data, derived from GeoDanmark's hydrological simulations based on a high-resolution LiDAR elevation model, estimates surface water depths across the city with a 10 m grid resolution. The results reveal a clear spatial pattern: the harbor front, reclaimed land, and lower industrial areas are the most exposed, while the inner and northern districts remain relatively elevated and secure. The gradient from light to deep blue captures not only water depth but also the city's topographic memory—how historic coastlines and filled lands continue to define vulnerability today. This understanding is essential for linking Copenhagen's flood-risk zones to long-term adaptation strategies and the placement of blue–green infrastructure in the urban fabric.

- **Climate Adaptation (City Diagnosis)**

The map in Figure 12 shows the distribution of future adaptation projects under the Cloudburst Management Plan in each catchment. These projects mainly consist of a courtyard, a basin, and a temporary basin, which aim to use minimal intervention while striving for more effective and localized impacts. In addition, some areas will focus on cleaning existing waterbeds to improve their capacity to handle rainfall and rising flood risks. Most of the projects are situated near water bodies and natural systems.

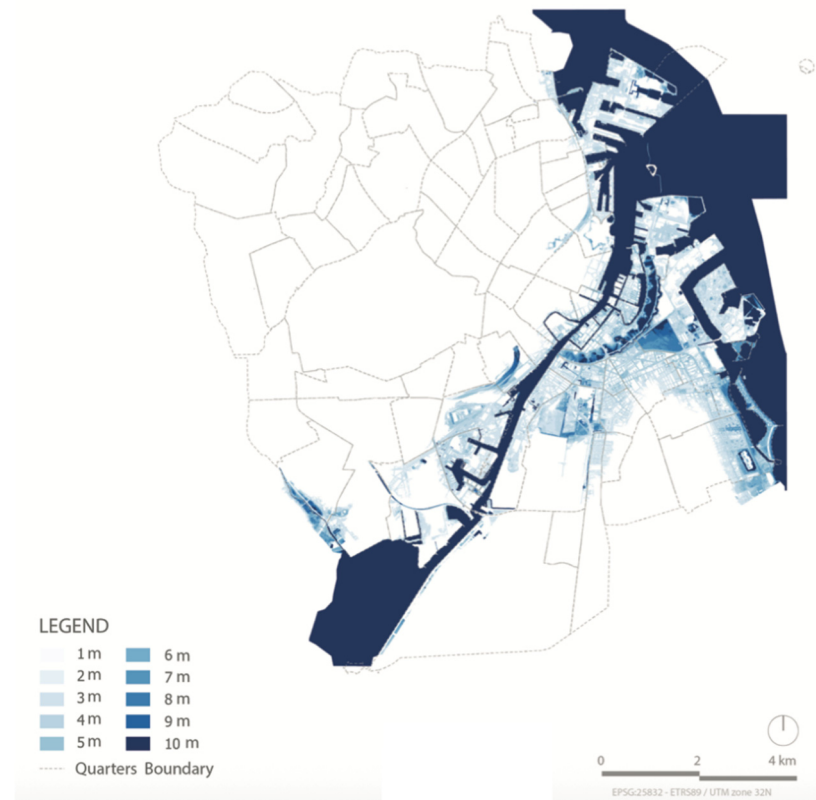


Figure 11. Flooding during 100-year rainfall in Copenhagen. Source: authors' illustration based on information from DHI Satlas Team.

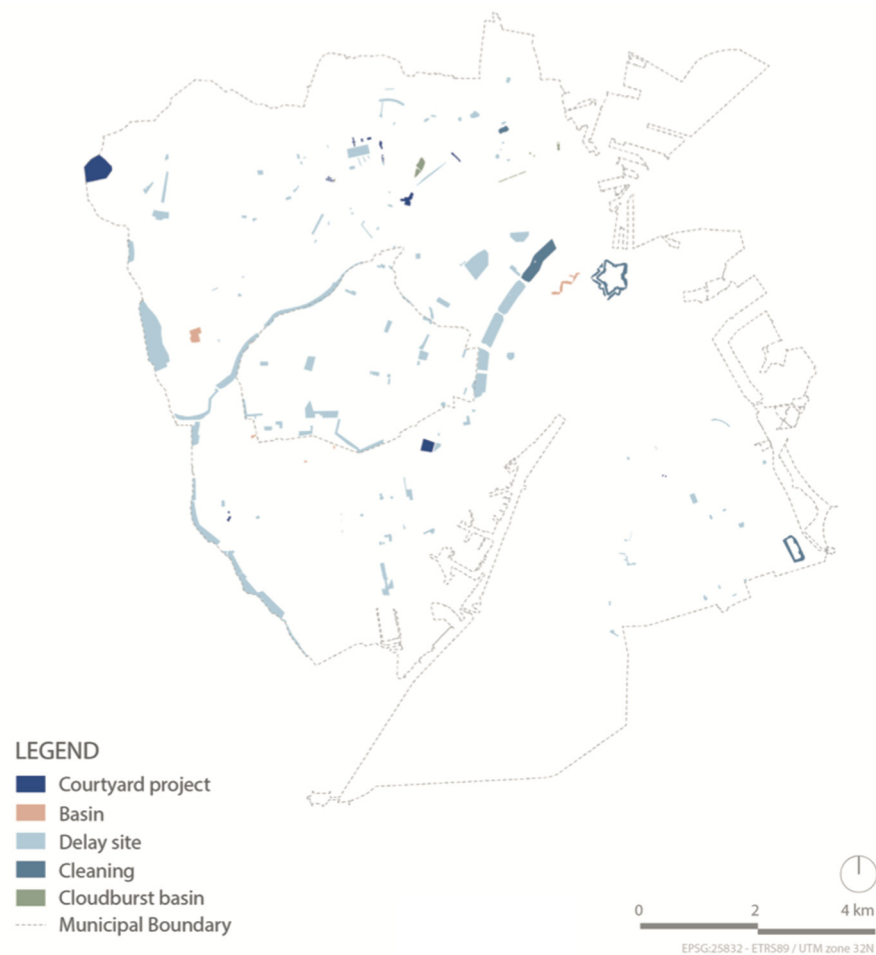


Figure 12. Futural adaptation projects in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/>.

- Public Transportation System (Accessibility)

The city has a well-developed infrastructure of transport systems, including the metro and the railway system. This has been incorporated into the daily lives of the people. The city has been primarily designed as the core of the Greater Copenhagen Area under the Finger Plan. The above maps depict the infrastructure of the city. The airport is in Amager; the journey to the city takes only 10 mins using the metro line connecting the airport to the city. Regional railway lines connect the city to other municipalities and the interregional cross-border to Malmö, Sweden. With the presence of such infrastructure, the fragmentation of green spaces is also a problem (see Figure 13).



Figure 13. Public transport network in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- Cycle network (Accessibility)

Copenhagen's goal is ambitious, aiming for 75% of all trips to be made via walking, cycling, or public transport, while leaving a maximum of 25% for car travel. This is the basis for the development of a hierarchical cycle network consisting of cycle highways, routes, and paths, as well as rest areas. It can be for long-distance commuters from the suburbs or for daily-life leisure activities. Moreover, Copenhagen's approach is to manage the timing of all the traffic lights on bike routes to ensure a "green wave" that is synchronized to the speed of a bike. This ensures that a bike cannot hit a red light and thus makes the experience faster and more attractive than driving a car (see Figure 14).



Figure 14. Cycle network in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/>.

- Population Density (social and cultural context)

The map in Figure 15 shows that the highest population concentrations are found in compacted perimeter blocks like Vesterbro, Nørrebro, and Amagerbro. In these areas, providing quality open green space for the dense neighborhoods could improve the quality of life, help regulate the space to the densest Microclimate, and provide refuge from heat stress.

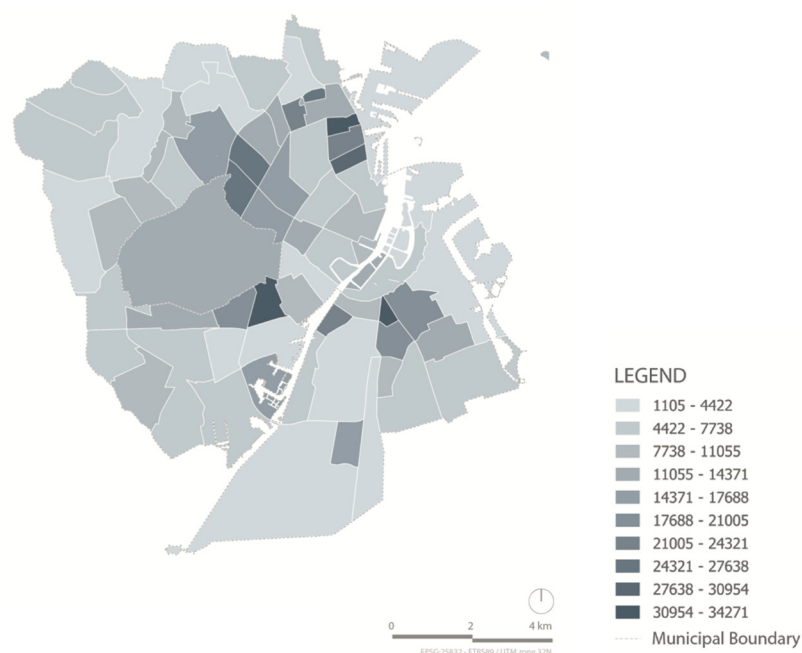


Figure 15. Population density per neighborhood in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/>.

- Immigration and intercultural programs (social and cultural context)

Being the most livable city in the world, Copenhagen is the destination for many people with varying migration backgrounds. Around 22% of the population are migrants from other European countries and non-Western countries. The map in Figure 16 indicates that the highest rates of immigrants are recorded in Vesterbro South, Ørestad City, Husum North, and Amager.

Most of the facilities are concentrated in the city center, including the language schools, which could be beneficial to all inhabitants. Family Integration Support is also spread across the entire city, integrating education, labor, and the community. This strategy helps strike a balance between social inclusion and local identity, making diversity an integral part of the city's fabric.

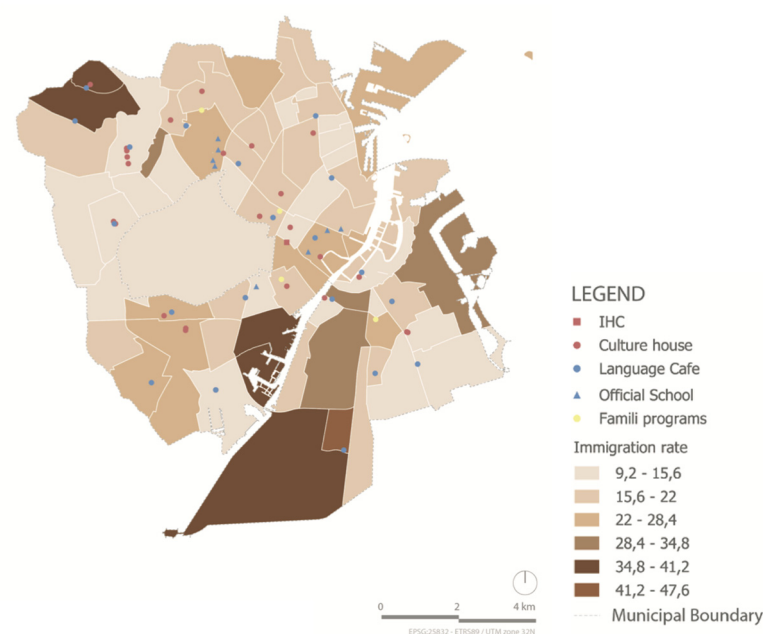


Figure 16. Immigration rate and culture in Copenhagen: cultural context analysis. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

- Urban districts (current and future projects)

Copenhagen has many ongoing and planned projects (see Figure 17 and Table 1) aimed at strengthening resilience, improving mobility, and enhancing public life. Many of these initiatives focus on integrating natural systems into urban structures, primarily through the creation of new parks, coastal protection measures, and public squares. Some former industrial and harbor areas are also being transformed into mixed-use districts with green corridors and blue spaces, such as Enghave Brygge, Nordhavn and Amager Fælled.

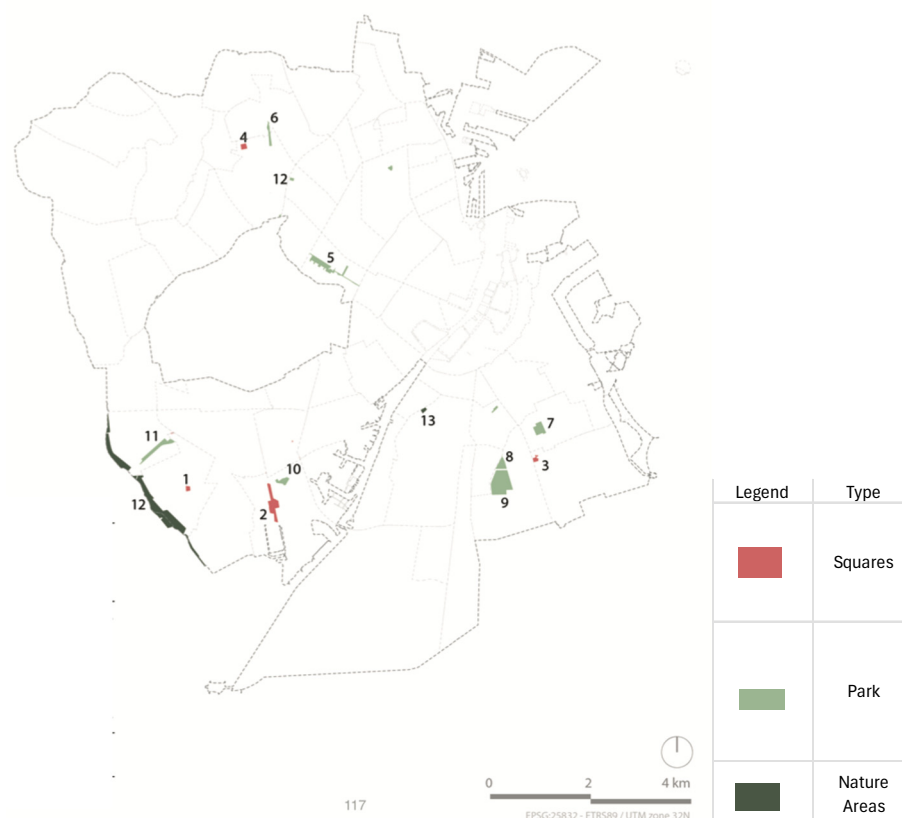


Figure 17. Current and future projects for urban districts in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/>.

Table 1. Information on current and future projects for urban districts. Source: authors' elaboration based on information from Copenhagen Commune. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/>.

Number	Name	Expected Start	Expected End	Status	Description
1	Det centrale byrum	2018.1	2024.04	Finished	This is a new, green and unifying urban space that blurs land registry boundaries by bringing together private and public areas and inviting neighbors
2	Karens Minde Aksen	2016.1	2022.12	Finished	This project combines beautiful nature and modern solutions for handling rainwater. The park is designed to protect Copenhagen from flooding and was developed in collaboration with local citizens [24].
3	Sundbyøster Plads	2018.06	2022.06	Finished	This area serves as a gathering point.
4	Degnstavnes legeplads	2020.03	2021/2024	Finished	The area renewal upgraded existing 2021 playground equipment. The playground is climate-adapted and functions as a delay area during cloudbursts; this project was completed in 2024.
5	Hans Tavsens Park og Korsgade	2025 fall	2028 Spring	Under construction	This area will be transformed into a coherent green area that supports both current and new recreational activities and invites new nature experiences. And it will be able to collect cloudburst water.
6	Grønningen-Bispeparken	2018.05	2023.05	Finished	This project combined climate and urban spaces. The green areas in the north and south were upgraded to a safe and local gathering place.
7	Sundby Kirkegård	2018.12	2023.08	Finished	Together with residents and local stakeholders, work has been done to create new meeting places, connections, art, better housing and new networks in the neighborhood.
8	Englandsparken	2018.12	2023.1	Finished	
9	Sundby Id-ratspark	2020.03	2023.1	Finished	

10	Pio Parken	2016.1	2023.03	Finished	Pio Parken is a new park that brings together the outdoor areas of El-lebjerg School. The urban nature has been strengthened through the planting of many different species of plants, bushes and trees.
11	Kulbaneparken	2017.05	2021.12	Finished	At Kulbaneparken, nature, play and history come together in exciting ways.
12	Harrestrup Å i Vigerslevparken	2013.02	2027.04	Under construction	Harrestrup Å is to be transformed from a sewage canal into a natural watercourse and recreational area with nature experiences on and along the river. It will be designed to handle cloudbursts.
13	Artillerivej	2018.12	2022.05	Finished	The plan is for the school garden to be visited by schoolchildren from the School at Islands Brygge, who will use the school garden as an extra classroom for outdoor education.

- Climate adaptation (current and future projects, see Table 2).

The city is also expanding its climate adaptation network; in particular, there are significant efforts made along the waterfront to address the risk of flooding. As part of the guidelines, the Cloudburst Plan (see Figure 18 and Table 2) also proposed the implementation of new basins, coastal reinforcement, and the use of landscaped solutions to address the issue of stormwater, which also promotes the concept of adapting to the effects of sea level rise and flooding due to heavy rainfall.

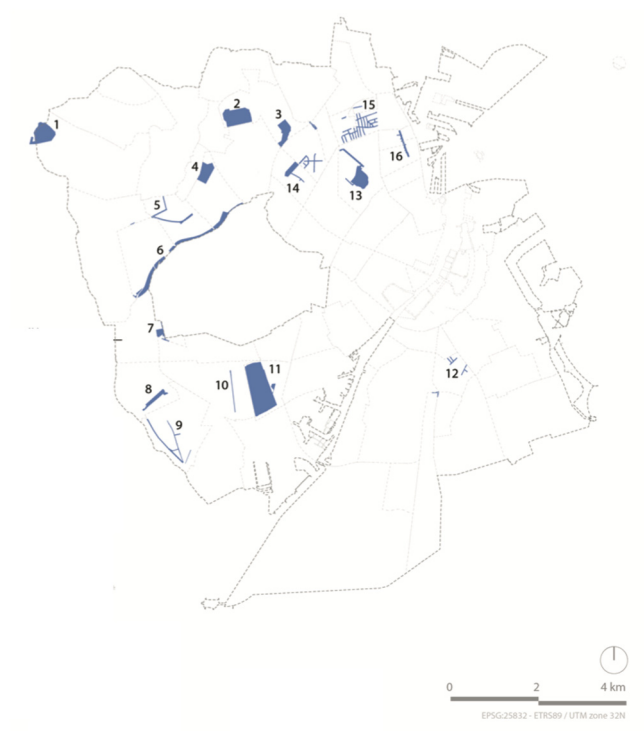


Figure 18. Current and future projects for climate adaptation in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geo-data/hent-geodanmark-data/>.

Table 2. Information on current and future projects about climate adaptation. Source: authors' elaboration based on information from Copenhagen Commune. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/>.

Number	Name	Expected Start	Expected End	Status	Description
1	Kagsmosen	2013.02	2027.03	Ongoing	Cloudburst protection of Kagsmosen (KV88)
2	Bispebjerg Kirkegaard	2021.04	2026.08	Ongoing	Cloudburst protection of Bispebjerg Kirkegaard (BIR29 and BIR30)
3	Lersøparken, skybrudsprojekt	2016.05	2026.11	Ongoing	Cloudburst protection of Lersøparken (BIR 7.1)
4	Bellahøj Camping og Hulgårdsvej	2023.12	2026.08	Ongoing	Cloudburst protection of Bellahøj Camping (BIR4.2 og BIR4.3)
5	Sallingvej	2018.02	2026.07	Ongoing	Cloudburst protection and restoration of Sallingvej (KV51)
6	Grøndalsparken, skybrudssikring	2017.06	2030.01	Ongoing	Cloudburst protection and restoration of Grøndalsparken, skybrudssikring (KV53)
7	Skellet (Gåsebæksvej)	2022.01	206.02	Ongoing	Cloudburst protection and restoration of the Skellet (KV57)
8	Kulbaneparken	2017.06	2020.05	Finished	Establishment of Kulbaneparken cloudburst protection, urban space and staffed playground.
9	Kirsebærhaven og Gl. Køge Landevej	2020.12	2026.07	Ongoing	Cloudburst protection of Vigerslevej, Kirsebærhaven and Gammel Køge Country Road (KV37A og KV39)
10	Trekronergade	2020.08	2024.04	Finished	Cloudburst protection of Trekronergade and speed reduction on Trekronergade at Freinetskolen (KV66)
11	Vestre Kirkegård, skybrudsprojekt	2013.02	2024.09	Ongoing	Cloudburst project in Vestre Cemetery (KV69)
12	Kornblomstvej (AM28)	2023.02	2026.07	Ongoing	Street trees and greening on Kornblomstvej in synergy with cloudburst project
13	Cloudburst protection in Fælledparken	2017.05	2026 Winter	Finished	The municipality of Copenhagen is working to protect the city against flooding during future heavy rains. The community park will continue to be a green gathering point with space for play, ball games, relaxation and fellowship.
14	Mimersgade (BIR8.3)	2021.12	2029.08	Ongoing	Cloudburst protection and restoration of Mimersgade as well as street trees, more urban nature and cycle paths on Hamletsgade
15	Ydre Østerbro Vest, klimatilpasning	2016.05	2026.04	Ongoing	In the coming years, we will renew the streets in the Climate District in Østerbro so that they can handle the increasing amounts of rain in the future. At the same time, the plan is to reduce through-traffic in the neighborhood so that cyclists and pedestrians can feel safer
16	Strandboulevarden, skybrudsprojekt (OS1)	2015.04	2026.03	Ongoing	Everyday rain and cloudburst water is handled on the surface of Strandboulevard, including water from side streets. This is done with consideration of the existing boulevard character, traffic flow, parking spaces, solutions for existing trees and accessibility.

- Traffic system (current and future projects)

As the map in Figure 19 shows, mobility and accessibility are equally prioritized. The extension of metro lines and improvements to hierarchical traffic systems aim to create a more connected and low-carbon city.

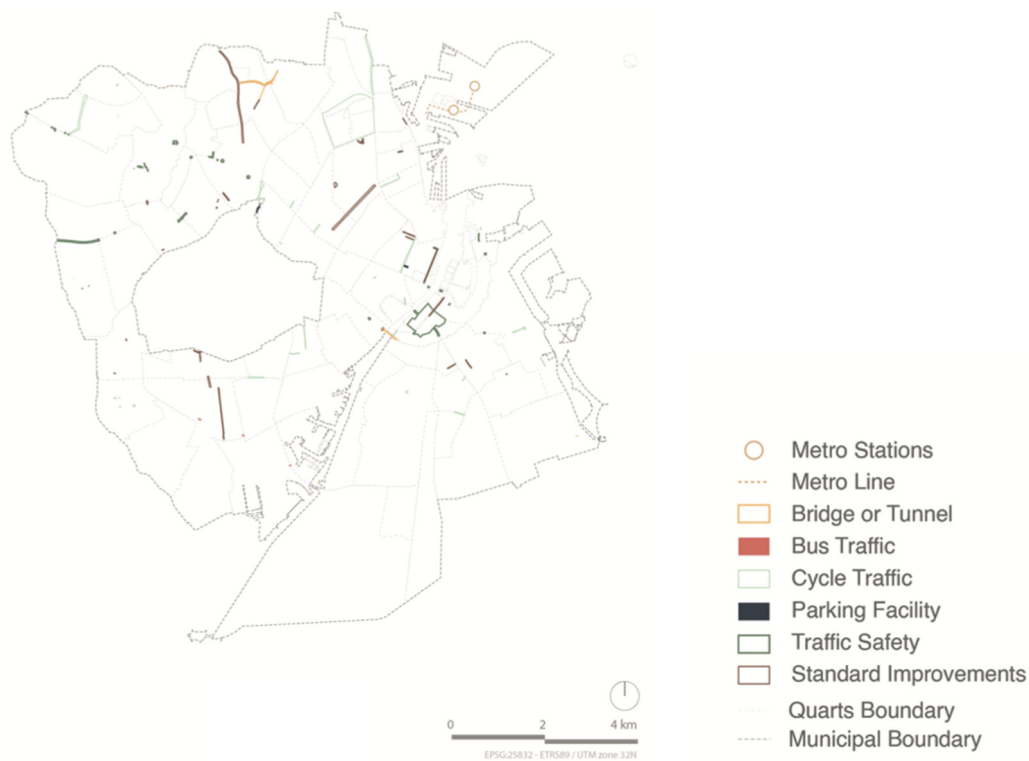


Figure 19. Current and future projects for traffic systems in Copenhagen. Source: authors' illustration based on information from GeoDenmark. <https://www.geodanmark.dk/anvend-geodata/hent-geodanmark-data/> (accessed on 25 March 2026).

3.1.3. SWOT Based on Previous Analysis

The diagram in Figure 20 builds on the spatial SWOT analysis of Copenhagen and translates it into a visual representation of the environmental conditions in the city. It incorporates the findings from the previous diagrams, which included the heat islands, vegetation cover, building density, flood risk, and social factors.





Figure 20. SWOT distribution in Copenhagen. Source: authors' illustration.

By conserving existing green and blue spaces and establishing regulations to prevent their transformation into commercial and residential areas, Copenhagen provides all residents with high-quality shared spaces that include water bodies, forests, and public green zones. Particularly for the large ecological zone in Amager, this protected area not only maintains numerous ecological features but also supports the natural system, offering significant benefits to the local community.

However, as one of the biggest cities in Scandinavia, Copenhagen also encounters challenges with advanced technology. More high-rise buildings are worsening the urban heat island effect for residents, and increasing building volume density makes the neighborhood more crowded and causes a lot of inconvenience for people. Moreover, well-developed transportation infrastructure also brings significant issues like noise and air pollution. All these elements influence citizens' daily lives.

On the positive side, Copenhagen has many abandoned and neglected areas, often hidden between residential or commercial zones. Some of these have already been designated as redevelopment areas, and more localized projects will be established to improve quality. This way, more district functions will be enhanced, and services for the surrounding neighborhoods will be better. Additionally, the municipality also pays attention to climate adaptation to address environmental challenges.

Under the guiding documents, such as the Cloudburst Management Plan, various climate projects are underway. In the future, many traffic renovations will take place, including multiple mobility systems. These upcoming projects will present both opportuni-

ties and challenges. Like the regeneration of Nordhavn, moving from industrial areas to mixed-use areas will provide more housing for citizens, but it needs to be well planned with the distribution of green spaces and the construction of a new metro line. Moreover, some areas are prone to flooding, which increases the requirements for governments and urban designers to consider various elements before deciding.

In one word, Copenhagen, like other cities, also faces conflicts over demand for more commercial buildings and the need to preserve open spaces for green regeneration. The biggest threats stem from rapid urbanization and population growth, which impact citizens' quality of life.

3.1.4. Site Selection Through Weighing Criteria

After SWOT, several characteristic and potential intervention areas were posed, and their key challenges were distinguished. For selecting a specific site for the analysis and design strategy, a weighing process was conducted. During this process, different indicators were considered such as environmental performance, urban structure, accessibility, social and cultural context, and NBS potential. The following parts reveal the specific scoring rules.

- Weighing indicators

The weighting focuses on the ability of urban spaces to be influenced or designed for NBS, with an emphasis on architectural and morphological adaptability. The analysis shows that urban structure as well as adaptation and NBS potential are the most influential factors, as they indicate the ability of the current design to support adaptation and retrofitting. The factor of environmental performance represents the environmental arguments for adaptation, while accessibility as well as social and cultural context serve as secondary considerations to ensure that the adaptation fits with the community.

Environmental Performance (0.35): This served as the foundation for which NBS interventions are necessary. Among these factors, flood risk (0.12) and heat island intensity (0.10) stand out the most, as these factors directly relate to the climate adaptation issues NBSs attempt to alleviate. Green–blue coverage (0.08) assists in understanding the existing capacity, and ecological connectivity (0.05) keeps green and blue spaces connected to each other. The importance of this factor is lower, as it assists in site adaptability but does not determine it.

Urban Structure (0.25): This category reflects the need to evaluate the physical and morphological adaptability of urban fabric. Indicators such as population density (0.09) and building volume (0.09) are prioritized because they define how easily existing urban forms can be retrofitted or reorganized to host NBS interventions. Land use diversity (0.07) remains a relevant metric for identifying multifunctional and flexible urban environments, though its relevance is slightly lower because it represents potential rather than direct spatial capacity.

Accessibility (0.10): Accessibility indicators are assigned moderate weightage because they influence the integration and functioning of NBS. Once implemented, public transport and cycle connectivity are assigned the same weightage, 0.05, because both are important in developing accessible and inclusive green–blue systems.

Social and Cultural Context (0.05): This part is more focused on how malleable urban space is, without as much emphasis on the social and cultural context. While figures like green space per person (0.02) and social mix (0.02) refer to issues of inclusiveness and fairness to an extent, this is not as important to this part of the analysis. Community facilities (0.01) is given the lowest weighting as it is mostly about social experience rather than practical feasibility.

Adaptation and NBS potential (0.25): This category is directly linked to the research goal of identifying where and how NBS can be incorporated into the landscape [25]. The highest value of all indicators is associated with retrofit suitability (0.17), as it assesses how easily existing infrastructure can be adapted to accommodate nature-based solutions. The adaptation projects (0.08) indicator complement this by identifying locations where existing initiatives for NBS implementation are already supported.

- Selection Criteria

Following the SWOT analysis, seven areas were identified as potential intervention areas: Nordhavn, Guldbergskvarteret, Husum, Valby Sydvest, Vesterbro Central, Ørested City, and Sundholmsvej. These areas face a variety of social, economic, and environmental problems (see Figures 21 and 22).



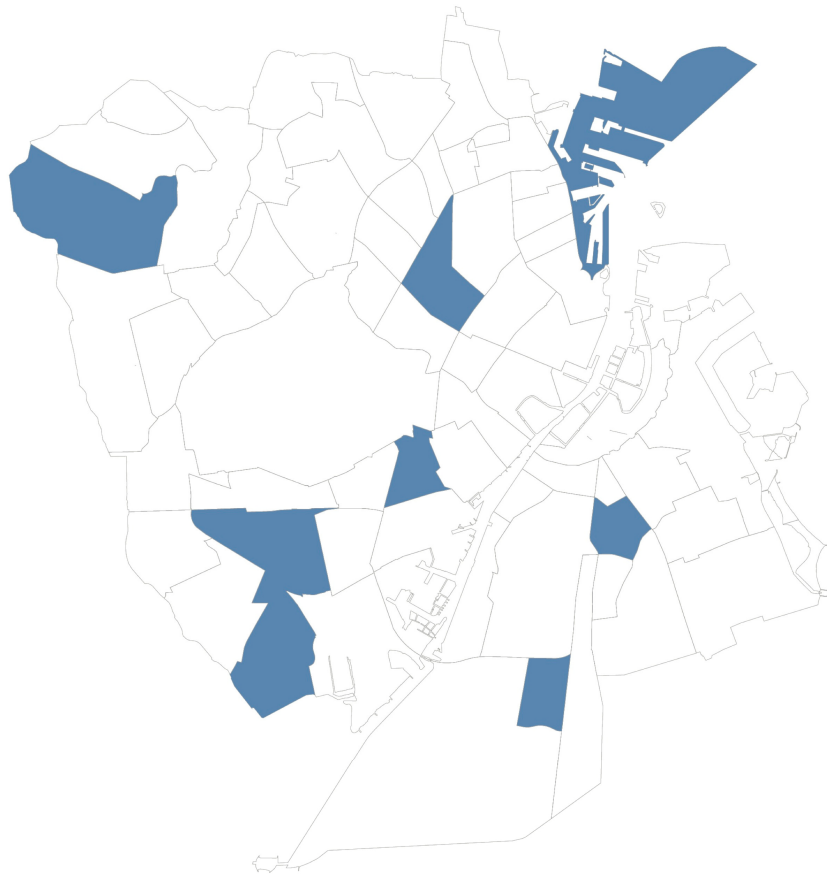


Figure 21. Potential site and key challenges. Source: authors' illustration.

Scoring		High	1	■	■	■				
		Medium	0.5	■	■	■				
		Low	0	■						
Indicator		Weight								
	Environment Performance	Green-Blue Coverage	0.08	■	■	■	■	■	■	
		Heat Island Intensity	0.10	■	■	■	■	■	■	■
		Flood Risk	0.12	■	■	■	■	■	■	■
		Ecological Connectivity	0.05 (0.35)	■	■	■	■	■	■	■
	Urban Structure	Land Use Diversity	0.07	■	■	■	■	■	■	
		Population Density	0.09	■	■	■	■	■	■	■
		Building Volume	0.09 (0.25)	■	■	■	■	■	■	■
	Accessibility	Public Transport	0.05	■	■	■	■	■	■	
		Cycle Connectivity	0.05 (0.10)	■	■	■	■	■	■	■
	Social & Cultural Context	Green Space per Person	0.03	■	■	■	■	■	■	
		Social Mix	0.01	■	■	■	■	■	■	■
		Community Facilities	0.01 (0.05)	■	■	■	■	■	■	■
	Adaption & NBS Potential	Adaption Projects	0.08	■	■	■	■	■	■	
		Retrofit Suitability	0.17 (0.25)	■	■	■	■	■	■	■
Score		1		0.695	0.435	0.525	0.66	0.595	0.485	0.56

Figure 22. Score matrix according to selection criteria. Source: authors' illustration.

Priority areas are identified based on weighted spatial indicators combining environmental performance, urban structure, and accessibility scores. Nordhavn is identified as the primary intervention site as it has the highest composite score and strategic spatial potential. The numerical conversion of low, medium, and high ratings was evaluated as 0, 0.5 or 1, respectively. The aggregation of the final score equals the sum of the indicator weights multiplied by the total value of the site rating. For instance, Nordhavn scored 3 points for environmental performance; hence, its value score is 0.26 out of 0.35 points.

The final score is highest for Nordhavn, with an overall value of 0.695. This score reflects its good performance on environmental issues, flexible urban layout, and high potential to retrofit with NBS. The district has significant climate challenges and opportunities for improvement, which make it an ideal candidate for further analysis. As such, Nordhavn is selected as the area of primary focus for further analysis and design development.

3.2. Nordhavn—Micro Scale

This chapter introduces the Nordhavn neighborhood, the selected site for the Micro-scale strategy. It provides a brief overview of its historical transformation, urban development, current context, and environmental challenges. Additionally, it emphasizes the green–blue infrastructure, the existing open spaces, different types of cultural and recreational amenities, and proposed future projects. Finally, it concludes with a synthesis map that will guide the definition of NBS strategies based on the SDGs (Sustainable Development Goals).

3.2.1. Historical Development

Nordhavn is one of the largest redevelopment projects in Northern Europe. It is transforming a former industrial harbor into a dense, mixed-use, climate-adaptive urban district. Building on Copenhagen's long planning tradition, the development combines sustainable mobility, energy-efficient buildings, and robust public space strategies. Designed to accommodate 40,000 residents and 40,000 workers, the district will form a major extension of the city along the waterfront.

Nordhavn was therefore chosen as the subject of this study because it is a prime example of Copenhagen's latest approach to sustainable urban development. As the district is still under construction, it is possible to directly study how climate adaptation, blue–green infrastructure, and new mobility systems are integrated into real planning decisions. Nordhavn also offers a variety of different scales, from large infrastructural features to housing clusters, providing an ideal testing ground for the application and evaluation of NBS within an active urban transformation process.

- Late 19th Century

As Copenhagen expanded its port infrastructure, Nordhavn began to take shape. The Freeport area was developed to support the growth of maritime trade, marking the district's transformation from a coastal fringe to a strategic industrial harbor.

- Mid-20th Century

Throughout the mid-1900s, Nordhavn expanded to include new basins, warehouses and rail links, strengthening its position as one of Copenhagen's primary industrial gateways. Large areas were dedicated to shipping, logistics and fuel storage, creating a landscape characterized by cranes, silos and harbor engineering.

- Late 19th Century (2009–2017)

Following the political agreement of 2005 and the masterplan of 2008, Nordhavn entered its active redevelopment phase. Significant projects such as the UN City, the Silo,

new housing blocks and improved transport links indicated a shift towards creating a mixed-use, sustainable neighborhood on former industrial land (see Figure 23).

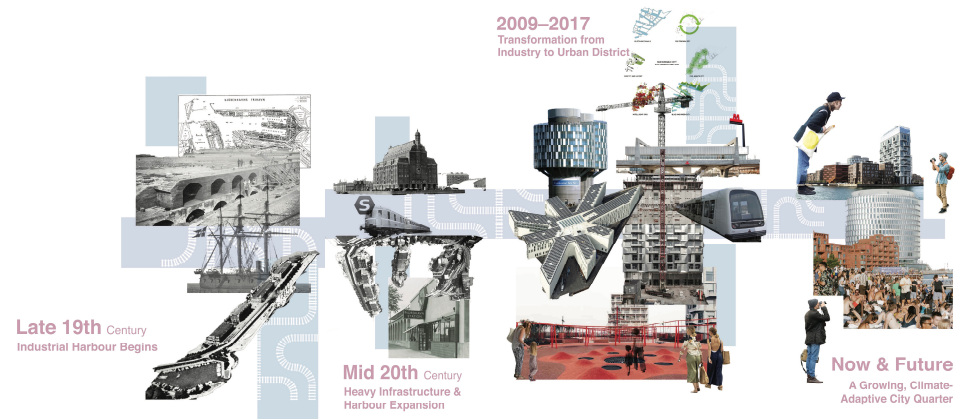


Figure 23. Key historical elements in the development of Nordhavn. Source: authors' illustration.

- Present and future

Today, Nordhavn is one of Europe's largest urban development areas. It is aiming to accommodate 40,000 residents and create 40,000 jobs. The district is continuing to evolve, with new metro connections, energy-efficient buildings and climate-adapted public spaces, reflecting Copenhagen's long-term vision for a resilient, waterfront city [26].

3.2.2. GIS-Based Analysis

- Building functions

The area of Nordhavn offers a varied mix of uses, which reflects the evolution of the area from being a working harbor to becoming a new urban area. The built-up area combines residential, office, school, educational, and other facilities. At the same time, large areas of the harbor area remain in use as industrial sites or in development. Especially in the northern part of the area, there are still large logistics, warehouses, and construction sites that continue to bring life to the harbor economy.

- Green and blue infrastructure

In the south, in the Århusgade, Sundkaj, and Fortkaj areas, green spaces have already been included in the urban planning. There are parks, pocket parks, courtyards, playgrounds, and waterfront recreation spaces all around the completed residential blocks. These form a network of public spaces that you can walk to every day. The Lüders rooftop garden is certainly an important point, as are the sports facilities and harbor baths, which are perfect for a workout outdoors just by the canal.

Further north, the green spaces are more fragmented. Much of the area is still undeveloped or used for things related to the harbor, which is shown on the map as large areas of brownfield, grass, or open land. These areas are not yet public parks, but they have a lot of potential for development as green spaces in the future.

Currently, Nordhavn has compact and well-planned green spaces in the south and large undeveloped areas in the north. As development continues in the area, the green spaces in the district's future are expected to build on these foundations and extend the current network of green spaces across the entire district (see Figure 24).



Figure 24. Built area and building functions of Nordhavn. Source: authors' illustration.

- Culture, education and recreation

The majority of community-oriented facilities, such as sports facilities, cafes, small commercial centers, and primary school, can be found in the southern part of the area around Århusgade and Sundkaj. This area offers the highest concentration of daily activities, which are supplemented by playgrounds, local shopping, fitness centers, and the Lüders rooftop sports facility, creating a lively community space within walking distance of most residents.

In the northern part of the area, the situation looks different. Cultural and educational facilities are spread out here, and only a few isolated community centers can be found in the midst of large industrial and construction sites (see Figures 25 and 26).



Figure 25. Green infrastructure in Nordhavn. Source: authors' illustration.

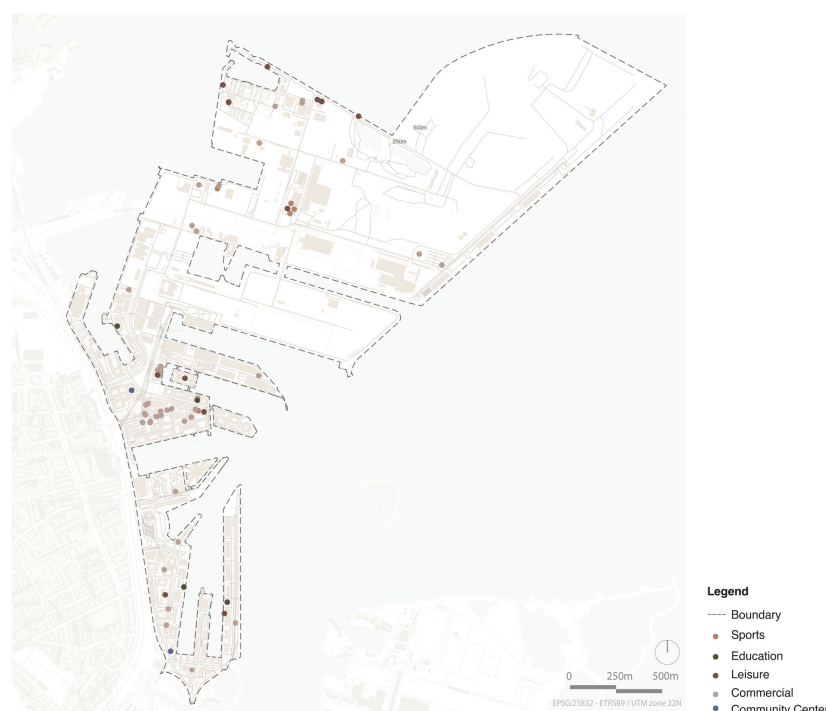


Figure 26. Interesting cultural, educational, and recreational points in Nordhavn. Source: authors' illustration.

- Accessibility

The M4 metro line is the most important transport route in Nordhavn, with Orientkaj and Nordhavn stations providing fast, reliable access to the city center. There are bus routes, ferry connections, and a network of cycle paths that stretch across the peninsulas to support this infrastructure. Most of the houses and businesses are very close to a bus or train stop, so public transport is a big part of life in the area (see Figure 27).

Despite its strong structure, the area still has transitional characteristics. The industrial roads in the north are not yet well-integrated with pedestrian and cycling routes. Large blocks of undeveloped land disrupt north–south connections, and the perimeter roads near the container terminals create long edges that reduce walkability, which may generate a sense of disconnection between the northern part and the more active mixed-use neighborhoods in the south.

- Environmental challenges

From the map in Figure 28, there are a number of areas that are still at great risk of being flooded due to their lower height and location near the harbor. There are a number of paved and unpaved surfaces in the new areas, which can get hotter during the warmer season. The residential areas located in the southern part of the area are more compact and are showing signs of being more vulnerable to the urban heat island effect.

Noise level:

It can be said that the area around Nordhavn is also vulnerable to high noise levels, which can be a major environmental pressure on the area. The construction activities and the service road running through the central spine area produce the same level of noise, which affects the current residential areas and the new construction areas to be developed in the future. The areas located in the northern part of the area, where industry still dominates, have a lot of open space and high noise levels produced by industry, which can be

a major environmental pressure on the area. The residential areas located in the southern part of the area have to deal with a higher level of urban noise caused by normal transportation such as the above-ground metro and cars.



Figure 27. Current transport system in Nordhavn. Source: authors' illustration.



Figure 28. Environmental challenges in Nordhavn. Source: authors' illustration.

- Future projects

Over the next few years, Nordhavn will be shaped by several strategic developments that mark its transition from an active harbor to a fully integrated urban district. Levantkaj

is going to be the next big mixed-use neighborhood, with housing, offices, cultural facilities and public spaces replacing today's port areas. The old tunnel factory in the center of the district is going to be turned into Tunnelfabrikken, a cultural and community center with workspaces, sports facilities, food culture, and a community program. Further north, the creation of Nordør—the New Coastal Nature Park will introduce a 30-hectare landscape of coastal nature, recreation, and ecological restoration, becoming Copenhagen's first large-scale park in decades.

In addition to those projects, a series of mobility and infrastructure upgrades will be implemented in Nordhavn. The metro network will be expanded, bus routes will be improved, and future tunnel connections will be established to strengthen links between new neighborhoods, the city center, and nearby districts such as Østerbro. Together with the planned Green Loop and improved cycling paths, these changes will create a more connected, accessible, and resilient district (see Figure 29).



Figure 29. Future projects in Nordhavn. Source: authors’ illustration.

4. Discussion

In this section, we develop an understanding of all the comprehensive analyses we carried out on Copenhagen, especially on the neighborhoods of Nordhavn after possible implementation of designed NBS. The multi-scale results presented above are not simply additives. Continuous, Meso-scale green-blue infrastructure operates as a network: because it is connected across a catchment, it distributes stormwater retention and cooling capacity beyond its own footprint and reduces the risk that runoff or heat is merely displaced into adjacent, untreated areas. Nano-scale interventions operate on a different logic: they address pedestrian-level exposure, shade, and daily amenity at points a citywide network cannot reach on its own. Read together, the Nordhavn results suggest that the two logics are complementary rather than substitutable—a finding that motivates

the cross-scale framework developed here and returns as the central argument of the Conclusions.

- Combined analysis

The combined analysis also reveals how environmental risks, social activities, and projects overlap and define the areas that require intervention.

Flooding and noise are still mainly concentrated along the harbor routes, while the southern parts are now starting to suffer from overheating due to the denser population. The central and northern parts still lack sufficient cultural and recreational offerings, while the large areas of the port are still undeveloped, restricting movement and access to public spaces.

The future projects of the Green Loop, new links for mobility, Levantkaj, Tunnelfabrikken, etc., are expected to help address these imbalances. Better north–south connections and a more balanced distribution of green spaces remain important for improving overall livability and climate resilience across the district (see Figure 30).

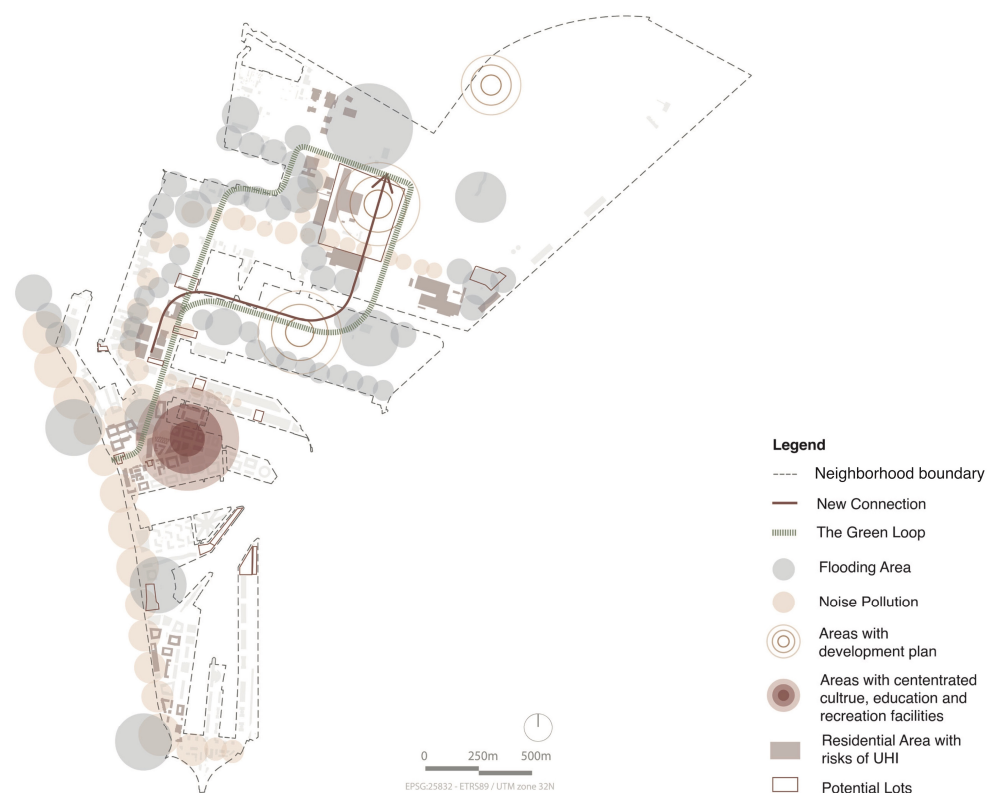


Figure 30. Combined analysis for Nordhavn. Source: authors' illustration.

4.1. Design Guideline—Micro Scale

- Build climate resilience against flooding and heat risks

Blue–green infrastructure—such as stormwater parks, bioswales and permeable surfaces—is being integrated across Nordhavn to absorb rain and prevent street flooding.

According to the Nordhavn Structure Plan (2018), parts of the site are created by land infill. New channels are being created to bring water further into the city. The channels provide more access to water and flood adaptation by allowing water to be stored. The water system comprises water edges, channels, basins, and inner pools. Each of them has a different function. The channels are used to bring water into the district. The basins are used to store water. The inner pools are also used for leisure and water storage. This provides flood adaptation by slowing down the flow of water during heavy rainfall and enhances the presence of water in everyday urban spaces (see Figure 31).

- Foster sustainable mobility and connectivity

Nordhavn's "Green Loop"—a continuous network of bicycle lanes, pedestrian paths and public transit links—has been designed to connect all parts of the district with minimal environmental impact.

The green structure is developed through two main approaches, combining large-scale landscape connections with finer green elements integrated into the urban fabric (see Figure 32). Nordhavns Park and Strandholmen are connected to form the main recreational green areas of Nordhavn. These spaces are further linked to the rest of the district through continuous green connections, extending the green structure towards the southern parts of the city. Another approach is a series of green stripes running from east to west. These stripes combine blue and green elements to create cross-site connections, link edge to edge, and introduce a varied urban landscape where water and greenery are closely integrated into everyday spaces (see Figure 33).

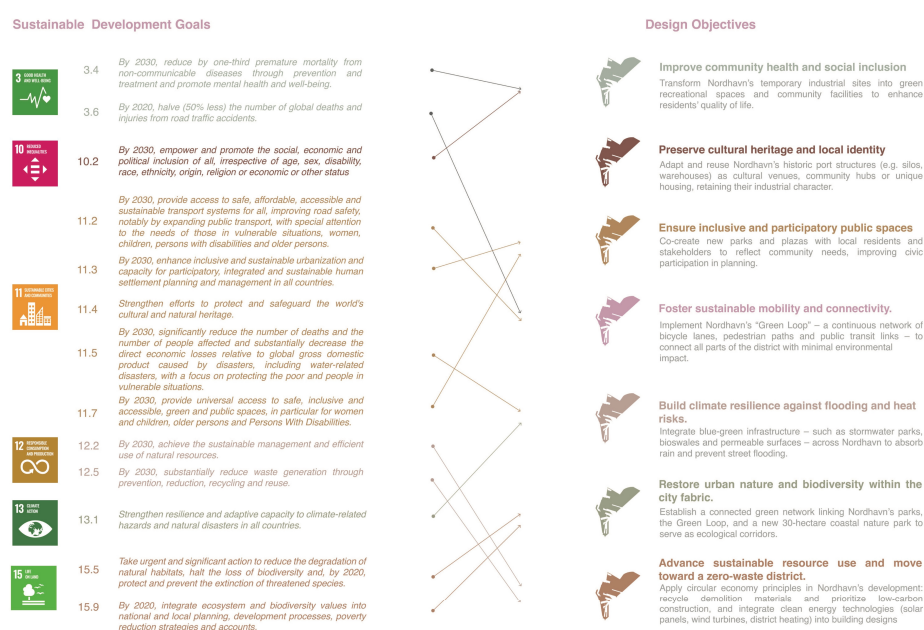


Figure 31. Design guidelines combined with SDGs. Source: authors' illustration.

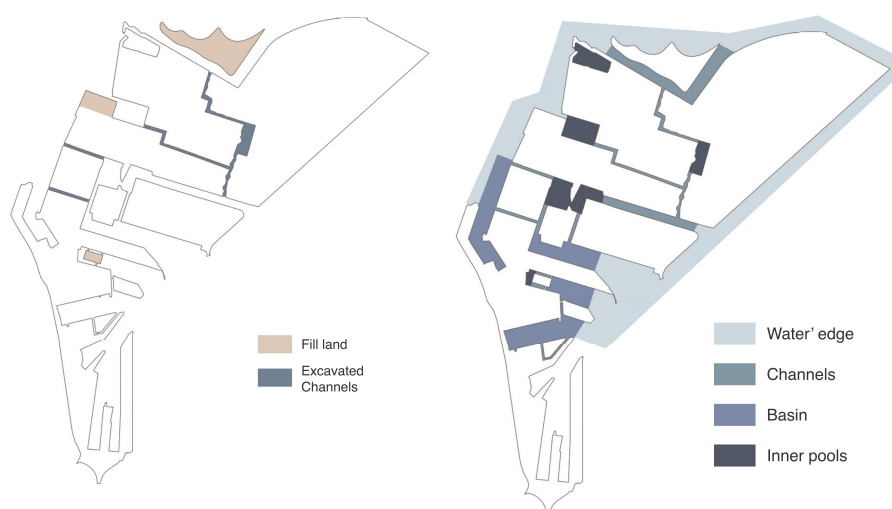


Figure 32. Land infill and excavated channels (left) and water system typologies (right) in the future plan. Source: authors' illustration based on the Nordhavn Structure Plan.



Figure 33. Main green and blue space connections (**left**) and striped, green connections (**right**) in the future plan. Source: authors' illustration based on the Nordhavn Structure Plan.

Nordhavn is planned with a well-defined road network, with main roads entering from Sundkrogsgade to the south and Nordhavnstunnel to the west. Sundkrogsgade is the main road, with smaller local roads serving to distribute local traffic within each neighborhood. This ensures accessibility while at the same time minimizing traffic pressure in the neighborhoods.

The Green Loop is the primary infrastructure for public transport, cycling, and walking in Nordhavn, while at the same time creating a continuous landscape of green. The Metro line serves as the primary public transport system. Metro stations are integrated as key urban spaces, functioning not only as transit nodes but also as important public areas (see Figure 34).



Figure 34. Road structure (**left**), Green Loop mobility system (**middle**), and metro system- black line (**right**) in the future plan. Circles refer to 5 mins buffer around metro stations. Source: authors' illustration based on the Nordhavn Structure Plan.

- **Preserve cultural heritage and local identity**

Nordhavn's historic port structures (e.g., silos, warehouses) are adapted and reused as cultural venues, community hubs or unique housing, retaining their industrial character.

The existing edges, including hard urban edges, natural waterfront edges, and stone edges, all play a role in how buildings, landscape, and water come together. They create different spatial qualities, with evidence of the area's industrial and maritime past.

In this area, various important destinations will be defined. These include parks, waterfronts, and cultural and urban destinations in general. These destinations are then linked together with routes like street, greenspace, and water links along the edges, with art, materials, and programming added to tell local stories and celebrate diversity (see Figure 35).

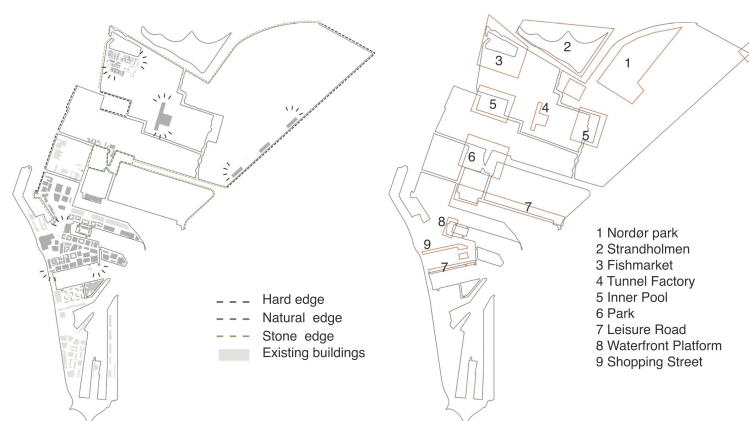


Figure 35. Existing structure (**left**) and special destinations (**right**) in the future plan. Source: authors' illustration based on the Nordhavn Structure Plan.

- Ensure inclusive and participatory public spaces
new parks and plazas are co-created with local residents and stakeholders to reflect community needs, improving civic participation in planning [14].
- Restore urban nature and biodiversity within the city fabric.

A connected green network linking Nordhavn's parks, the Green Loop, and a new 30-hectare coastal nature park has been established to serve as ecological corridors.

The 5 min city concept essentially means that daily living happens within a short distance of walking or cycling. With reference to Nordhavn, this concept focuses on the different metro stations that act as the core node of each neighborhood. With this concept, small pocket parks and other functional elements will then be strategically distributed around each metro station. This ensures that all the activity hubs will be created along the paths used in daily living. With this concept, small urban spaces will improve the livability of each small living unit (see Figure 36).

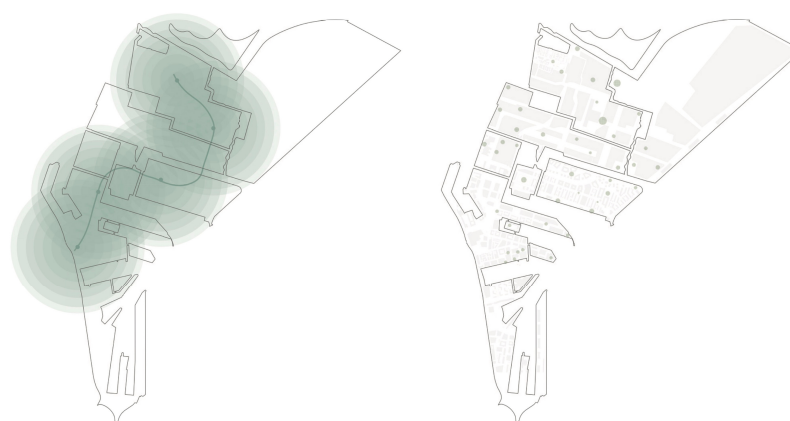


Figure 36. Five-minute neighborhood reachable with metro (**left**) and pocket parks and open spaces' locations (**right**) in the future plan. Source: authors' illustration based on the Nordhavn Structure Plan.

- Conclusive guideline

The aim of the plan is to enhance the green connections, balance new development with environmental resilience, and support daily life in Nordhavn. It links new districts like Levantkaj and the Tunnelfabrikken area to the Green Loop, creating one big network of parks, public spaces, and environmentally friendly routes. In the north, they are reclaiming empty industrial plots to create new parks and green spaces, while in the south,

the plan is to create new community spaces and public areas to increase social activities. At the same time, it is tackling important environmental challenges like flooding, overheating, and noise with blue–green solutions on the main streets.

4.2. Green Loop—Nano Scale

After a thorough systemic analysis of Nordhavn, this section outlines the neighborhood scale design strategy to enhance green connectivity, create new inclusive urban public spaces, transform existing industrial areas, and improve new streets and parks for climate resilience. Following the presentation of the general aims, it elaborates on how strategy is manifested on three levels: place identity, green and blue infrastructure, and slow mobility.

4.2.1. Strategy

As per the above analysis and the design guidelines, the map in Figure 37 represents a synthesized spatial strategy that incorporates the approved or ongoing projects into the continuous Green Loop. The Green Loop aims to improve the connectivity of the green spaces, public routes, and the water areas of the city. The water element has also been integrated into the spatial framework of the area to improve the adaptation of the environment to the effects of the climate, thus improving the blue connections or the island-like spaces that can be developed [27,28].

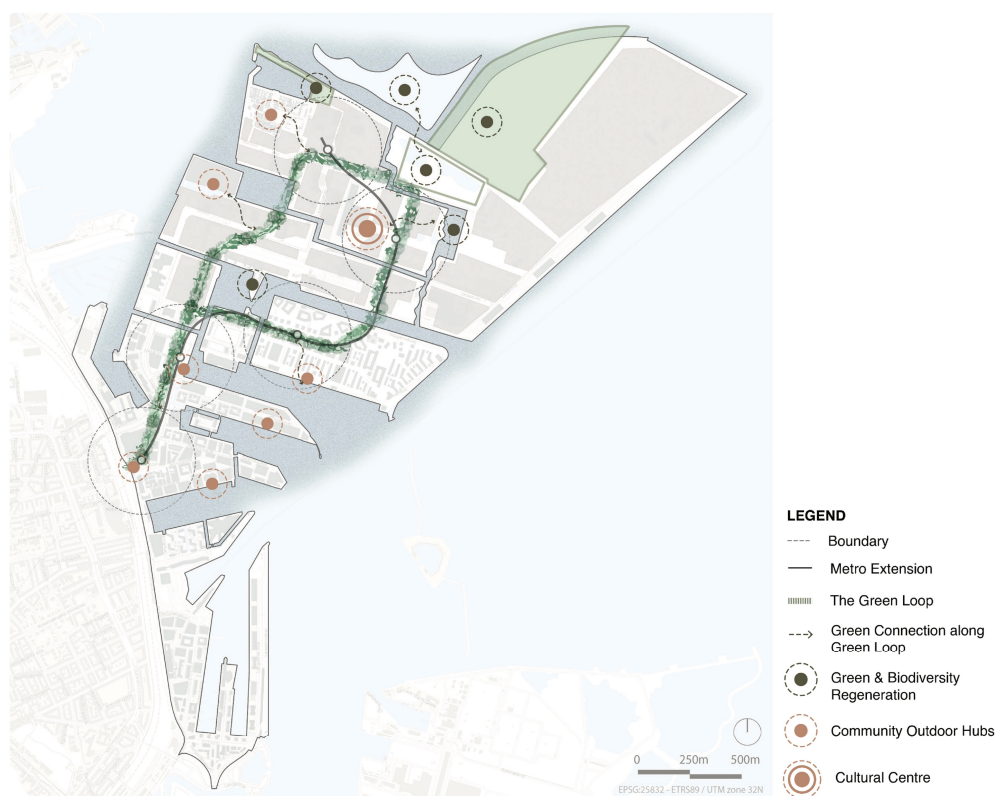


Figure 37. Conclusive guideline distribution in Nordhavn. Source: authors' illustration.

4.2.2. Masterplan

This masterplan has been developed based on the Nordhavn Structure Plan (2018)—a revision of the Structural Plan from 2009—and adapted to support the subsequent node-based design explorations. The masterplan is structured around a continuous loop that integrates public mobility, blue–green infrastructure, and public space as a unified sys-

tem. Water bodies and canals subdivide the site into a series of smaller islands, creating spatial units that are inherently suited to climate adaptation (see Figure 38).

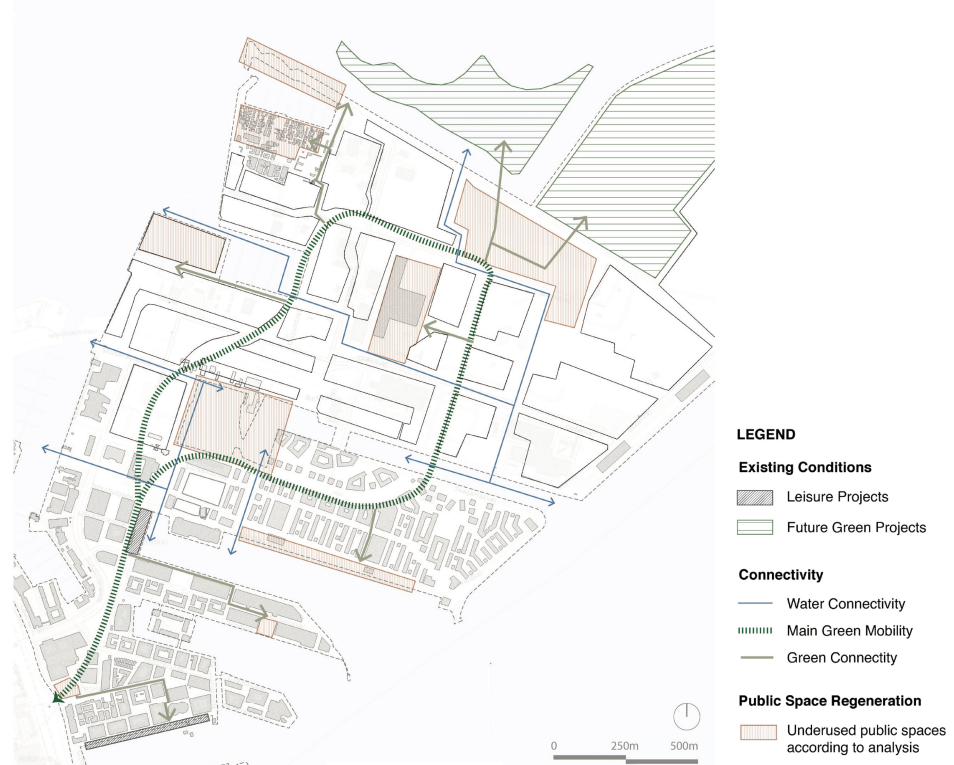


Figure 38. Distribution of proposal strategies in Nordhavn. Source: authors' illustration.

This island-based structure allows blue–green elements to be distributed across the site, supporting flood mitigation, stormwater retention, and the reduction in urban heat. Instead of treating water as a boundary, the masterplan uses it as a structuring element that links mobility, landscape, and urban form (see Figure 39).

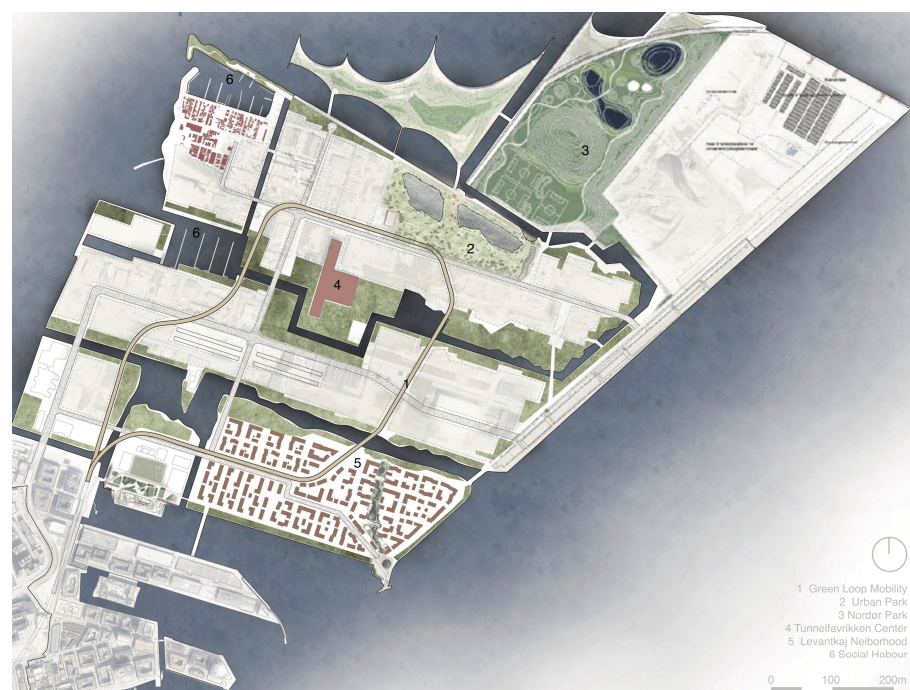


Figure 39. Masterplan framework of Nordhavn. Source: authors' illustration based on the Nordhavn Structure Plan and previous analysis.

4.2.3. NBS Strategies

NBS were selected according to the specific environmental and spatial structure. Generally, they address the issues of stormwater management, flood resilience, urban cooling, and biodiversity, while at the same time supporting public living. As for water management, it is mainly focused on the areas along the waterfront, where “inner blue pools, soft coastal edges, and permeable surfaces” manage water flow, creating public spaces along the harbor (see Figure 40).

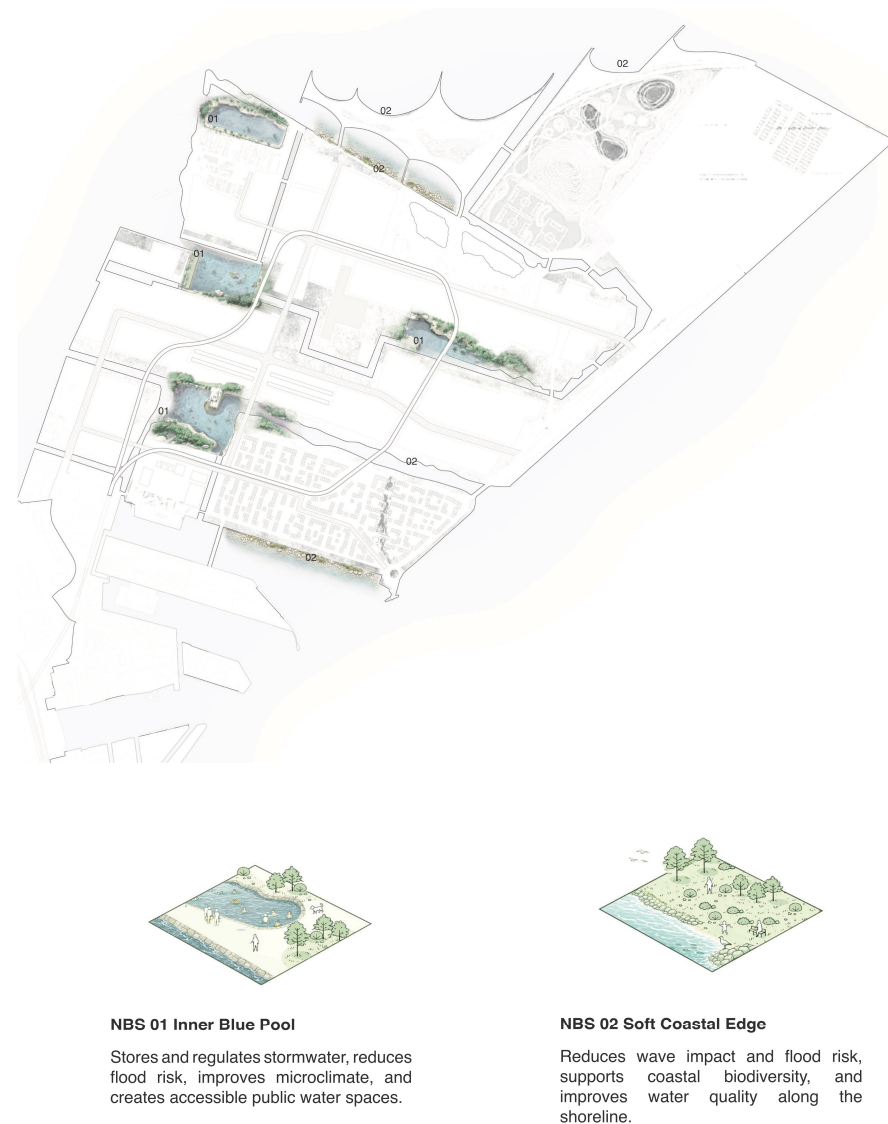


Figure 40. NBS typologies proposal 1 in Nordhavn. Source: authors' illustration.

Large open and underused areas are transformed into urban parks, ecological forests and open grounds that strengthen the green network, support ecological functions and provide recreational spaces (see Figure 41).



Figure 41. NBS typologies proposal 2 in Nordhavn. Source: authors' illustration.

In denser urban areas, smaller-scale interventions such as urban gardens and green corridors will be used for improving the Microclimate and comfort within building clusters (see Figure 42).



Figure 42. NBS typologies proposal 3 in Nordhavn. Source: authors' illustration.

The green noise barrier can improve noise comfort in buildings along with the mobility system (see Figure 43).

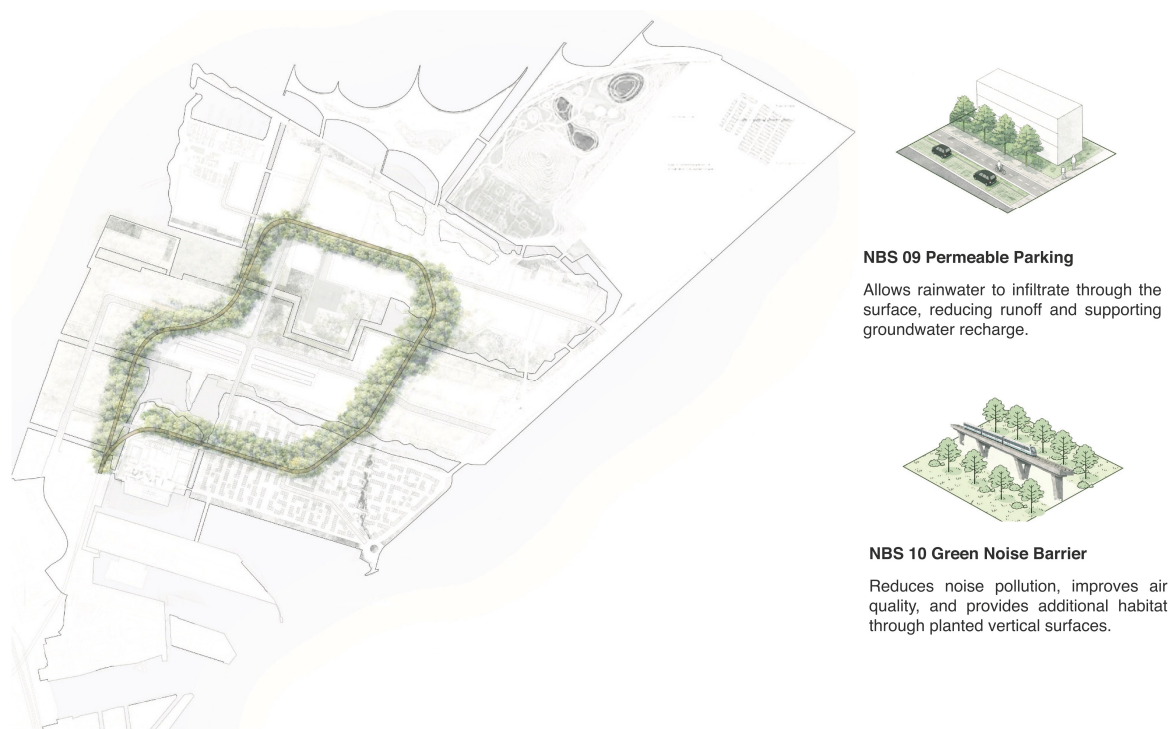


Figure 43. NBS typologies proposal 4 in Nordhavn. Source: authors' illustration.

4.2.4. Mobility System

The mobility system is centered on a green–blue loop that connects slow-moving travel, public transportation, and daily life in public spaces.

It celebrates soft modes like walking and cycling, with metro stations functioning as local mobility hubs. The green–blue loop is dynamic, adjusting to the city's changing circumstances, passing through parks, squares, densely populated residential areas, and along water edges. As a result, spaces designed for moving people become spaces to rest, play, and interact with others. Parts of the green–blue loop are emphasized to illustrate how areas moving people blend with natural spaces, including plant life, shaded areas, soft ground, and spaces that react to water (see Figure 44).

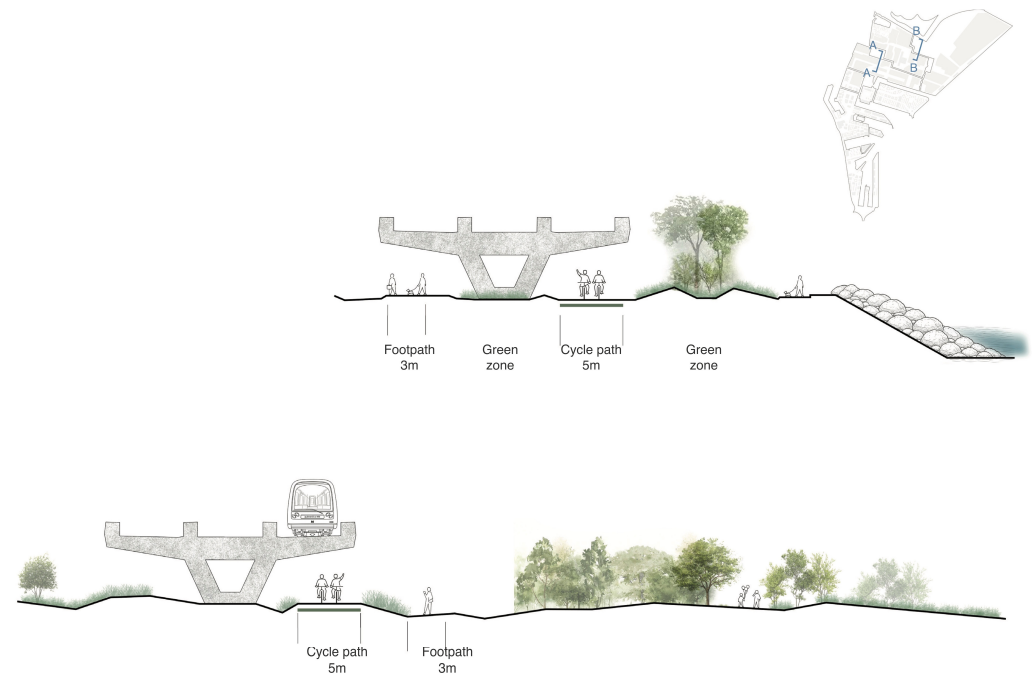


Figure 44. Section A: the loop along water (**top**); Section B: the loop through park areas (**bottom**). Source: authors' illustration.

This loop reinforces Nordhavn's 5 min city structure by linking everyday destinations through a readable, accessible and landscape-based network (see Figure 45).

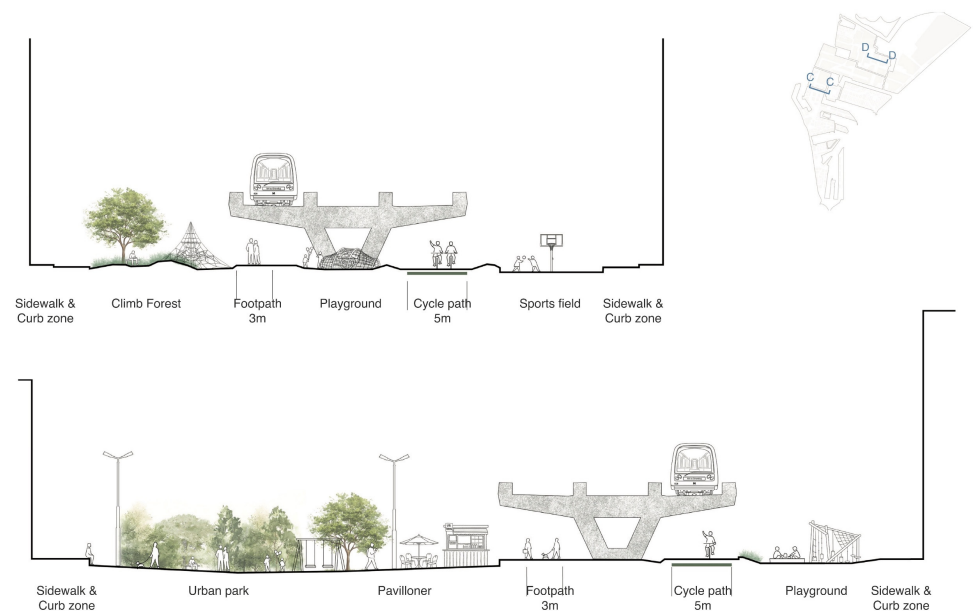


Figure 45. Section C: the loop's local public spaces (**top**); Section D: the loop in an urban context (**bottom**). Source: authors' illustration.

4.3. Evaluation of NBS Potential

Performance and Multifunctionality

The performance of the proposed NBS, (see Figure 46) is evaluated using an evaluation framework inspired by the UNaLab project. It is used to express the potential contribution of different interventions to climate adaptation, biodiversity, and social cohesion.



Figure 46. Functions and impacts of main design of nature-based solutions in green and blue. Source: authors' illustration.

This framework considers interventions along several relevant functional dimensions, including climate, water, air, biodiversity, amenities, and CO₂ sequestration. Using these dimensions, the approaches developed in the earlier design stages are examined in terms of their potential multifunctional performance, as opposed to single-function approaches.

The ratings presented in Figure 47 above are qualitative and literature- and expert-based rather than spatially specifically measured. They were derived by adapting the functional descriptors of the UNaLab Nature-Based Solutions Technical Handbook Factsheets [29] to the specific morphological, hydrological, and social conditions of Nordhavn, through an interpretation carried out by the authors and cross-checked against comparable EU NBS technical guidance [23,30] and the EUFORICC indicator set [31]. Each typology was assessed on the same six functional dimensions—climate regulation, water management, air quality, biodiversity, amenities, and CO₂ sequestration—using a qualitative low/moderate/high scale (0, 0.5 or 1) rather than weighted numerical scores. No primary field measurements (e.g., infiltration rates, temperature monitoring, or biodiversity surveys) were collected for this study, and the evaluation should be read as an indicative, comparative screening tool to support transparent design decision-making rather than as a validated quantitative multicriteria model (see Table 3 below).

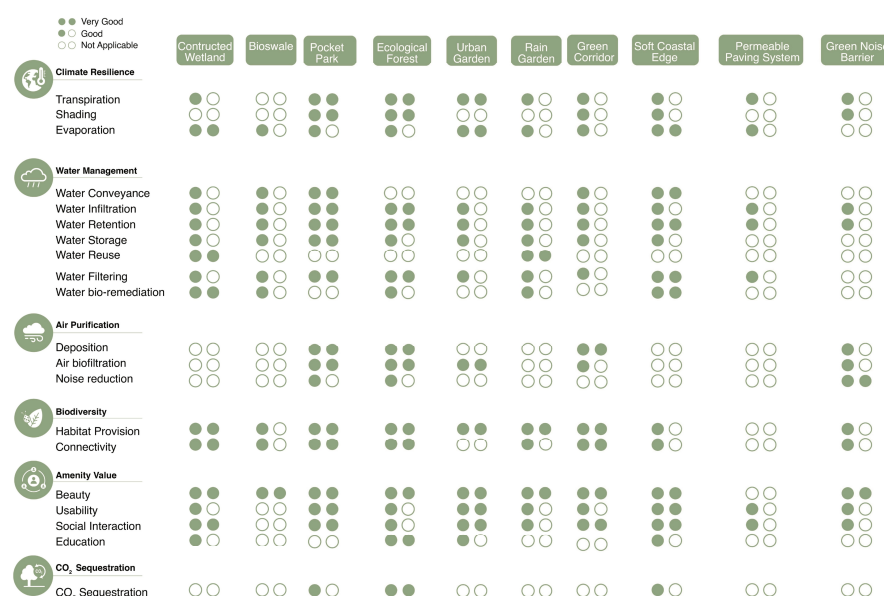


Figure 47. Potential expected performance and functions of the proposed solutions based on literature and expert-based evaluation. Source: authors' illustration based on the Unalab Project, <https://unalab.eu/en/documents/unalab-NBS-technical-handbook-factsheets> (last accessed on 21 July 2026).

Table 3. A summary table stating, for each of the ten NBS typologies indicated, its primary scale(s) of application and the site condition that makes it a potential solution—drawn directly from the design rationale already presented in Sections 4.2.3 and Performance and Multifunctionality and Figure 46. Elaboration by the authors.

NBS Typology Indicated	Primary Scale(s)	Site Suitability Rule
Ecological forest	Meso/Micro	Large open or underused areas (e.g., former industrial land) with space for canopy establishment
Green corridor	Meso/Micro	Continuous linear space connecting parks, districts or the Green Loop
Constructed wetland	Micro/Nano	Low-lying waterfront or underused land with capacity for water retention
Soft coastal edge	Micro/Nano	Waterfront edge condition, adjoining harbor or canal
Pocket Park	Micro/Nano	Small residual or underused plots, typically within a 5 min walk of a metro station
Urban garden	Nano	Residential clusters or community plots in denser blocks
Bioswale	Nano	Linear space along streets or parking areas with conveyance function
Rain garden	Nano	Small plots adjacent to buildings or streets with localized runoff
Permeable paving	Nano	Streets, parking areas and plazas
Green noise barrier	Nano	Along mobility corridors, roads or the metro line

The constructed wetland has shown good results in managing water and climate resilience in retention, filtering, and bioremediation. It also has biodiversity, amenities, and

educational value. The bioswale has shown its effectiveness in the management of local water management through conveyance, infiltration, and retention. The strength of the bioswale lies in its small-scale application.

The pocket parks have strong localized climate regulation and amenity value, making them useful for daily living and social interaction. Their biodiversity and water management performance are average but effective. The ecological forest has strong performance in climate resilience and biodiversity, especially shading, evapotranspiration, and habitat creation. In addition, it can provide air purification and CO₂, and sequestration on a larger spatial scale. Urban gardens have both social and ecological components, with moderate performance in terms of their environment, although they are essential in daily urban life. The main purpose of rain gardens is to provide water management, including infiltration, retention, and filtration. They have low performance in terms of amenities and biodiversity. Green corridors have strong performance in biodiversity and connectivity and play a role in climate regulation. Their main value is connecting ecological and social space across an urban area. Soft coastal edges have high performance in water management, especially regarding infiltration, retention, and bioremediation. They also play a role in climate adaptation and have an amenity value by integrating ecological processes with public space.

Permeable paving systems are mainly beneficial in terms of water management. Their ecological and social contribution is low. They are effective as distributed technological measures. Green noise barriers have the advantages of noise reduction, air purification, and climate regulation. Their ecological contribution is moderate. They also have the added amenity value of improved environmental quality.

4.4. Transferability and Contextual Adaptation of the Framework for Decision-Making Support

While the framework was developed through its application in Copenhagen, its transferability does not depend on the direct replication of specific spatial conditions and datasets. Instead, its transferable contribution lies in the multi-scale analysis process of climate risks, urban structure, environmental conditions, and potential opportunities for NBS. Therefore, its application in Copenhagen serves as a methodological model showing which dimensions should be examined when developing an integrated climate-adaptation strategy.

In this way, the framework works as an adaptable planning model instead of a fixed technical template. It provides other cities with a structured basis for determining which environmental, spatial, and social dimensions should be considered and how these indicators can be connected across scales. Therefore, this contextual adaptation does not lack transferability, and it provides necessary conditions for meaningful application.

4.5. Comparative Positioning and Cross-Scale Trade-Offs

Compared with existing NBS planning frameworks, the multi-scale strategy proposed here differs in scope rather than in the typologies it employs. Frameworks such as the UNaLab Nature-Based Solutions Technical Handbook and comparable EU technical guidance [23,30] were developed primarily to characterize and communicate the performance of individual, already-implemented interventions at project or site scale; they are not structured to guide upstream, citywide site selection. Regenerative-urbanism approaches [21] and NBS living-lab implementation models [32] similarly emphasize co-design and iterative experimentation at the neighborhood scale but do not explicitly nest site prioritization within a citywide spatial logic. Copenhagen's own policy instruments illustrate a related but distinct scalar logic: the Cloudburst Management Plan [10] divides the city into seven catchments and prioritizes interventions chiefly on hydrological grounds, corresponding broadly to the Meso scale used here, while district-level documents such

as the Nordhavn Structure Plan [33] operate at what this study treats as the Micro and Nano scales, detailing green–blue infrastructure, mobility, and public space for a single district. Neither instrument makes explicit how the two levels connect. What the present framework contributes is not a new set of NBS typologies—bioswales, rain gardens, pocket parks and constructed wetlands are already well established in the literature [10,23,30] and in Copenhagen’s own practice [12–16,33]—but a replicable method for linking citywide prioritization (climate vulnerability, ecological potential, socio-spatial need, planning compatibility) to site-level design and evaluation, an articulation that is not made explicit in either the UNaLab framework or Copenhagen’s existing planning documents.

This cross-scale strategy also entails trade-offs that are not fully explicit in the results presented above. Flood mitigation and heat reduction do not always co-benefit equally from the same typology: soft coastal edges and permeable paving perform strongly on infiltration and stormwater conveyance but contribute comparatively little shading or evapotranspiration, whereas ecological forest patches deliver the strongest heat mitigation and biodiversity outcomes but take longer to establish and require larger areas than are always available in denser waterfront blocks. Biodiversity and social accessibility can also be hindered: habitat-rich typologies such as constructed wetlands and green corridors benefit from minimizing disturbance, which can involve restricting public access or channeling it onto boardwalks, whereas amenity-oriented typologies such as pocket parks and urban gardens maximize daily accessibility and social use at some cost to ecological complexity. Maintenance and governance feasibility scale differently again from ecological performance: continuous elements such as the Green Loop and green corridors generate networked benefits, including connectivity and cumulative stormwater buffering, precisely because they cross multiple ownership boundaries and public–private interfaces, which raises the long-term coordination and maintenance requirements consistent with the collaborative-governance challenges documented for Copenhagen by Hofstad et al. [34]; small-scale, single-site interventions such as rain gardens or bioswales are comparatively easier to govern and maintain locally but do not, on their own, generate the systemic benefits of a connected network. These trade-offs suggest that the choice of NBS typology and scale should be treated as a deliberate design and governance decision, weighed against the specific priorities of a given site, rather than as a straightforward maximization of ecological or climatic performance.

5. Limitations and Future Research

The methodology used in this study employs spatial information that can be measured in order to investigate climatic risks, urban morphology, distribution of green and blue elements, land use and socio-demographic factors for decision making. Although the above-mentioned factors are analyzed through the same base map, there is no consolidation of the factors into one set of quantitative indicators, weights and thresholds. This allows the framework to be used for the purposes of developing a structured and replicable planning process but not for quantitative comparisons between different cities. Building on this qualitative foundation, two extensions would substantially strengthen the empirical credibility of the framework. The first is methodological: converting the Meso-scale indicators into a GIS-MCDA/AHP weighted-overlay composite vulnerability index, following recent applications of this approach to NBS siting [14–16], would allow site prioritization to be reproduced and tested against alternative weighting schemes through sensitivity analysis. The second is empirical: once the proposed Nordhavn interventions are implemented, field monitoring—temperature loggers, runoff measurement, biodiversity surveys, and resident-satisfaction surveys—would allow the qualitative performance screening presented in Section Performance and Multifunctionality to be validated, or re-

vised, against measured outcomes. Neither step was possible within the scope of the present, pre-implementation study, but both are identified here as the direct next stage of this research.

This limitation results from the sensitive context and implies that all indicators that have been used within the entire process may differ depending on the local environment. In future research, it is possible to enhance the framework by developing a common set of measurable indicators and a transparent calculation process with the flexibility for local calibration and integration of collaborative governance measures [35,36].

6. Conclusions

This study proposes a multi-scale spatial framework—combining GIS-based spatial analysis, comparative project review, and a qualitative multi-criteria evaluation—to support the selection, prioritization, and design of NBS in Copenhagen, structured across Meso- (citywide prioritization), Micro- (neighborhood design), and Nano- (site-specific NBS typology) scales. This research has been developed to explore which framework may guide the selection and prioritization of NBS in Copenhagen for better climate resilience and urban livability. With the incorporation of spatial analysis, multi-criteria evaluation and site-specific design, the framework has effectively been developed to respond to the initial question posed.

As discussed above, on the Meso scale, the study has clearly shown that GIS-based spatial analysis may provide a strong foundation to support the identification of areas in which NBS may be most needed and most effective. By incorporating various environmental risks, ecological conditions, and accessibility to green spaces and social conditions [34,37], the framework may move beyond isolation and opportunism and support a more strategic evaluation and prioritization process. When it comes to Micro and Nano scales, more detailed spatial analysis and site-specific design have been proposed. Moreover, the framework guides the proposal of NBS typologies and their spatial configuration. One possible aspect to develop for future research would be to propose further evolution of metrics and indicators used to facilitate the integration of NBS into embedded urban planning policies, such as in [3,28,31,38]

The Nordhavn case study has clearly shown that the efficiency of NBS depends on the scale and the spatial arrangement. On the Meso scale, the continuous forms of green infrastructure play an important role in mitigating the effects of climate change. The efficiency of the green infrastructure is systemic because it influences the environment beyond its boundaries. However, it is also clear that large-scale strategies are not sufficient on their own to fulfill the requirements of daily life. At the Micro or Nano scale, bioswales, pocket parks, permeable pavement, street trees, etc., have a role to play in improving efficiency and performance in daily life. The study has also shown that the most efficient strategies are the combination of different scales of intervention within one spatial system. Thus, it is not just the scale of intervention that is important; it is also the spatial logic of the interaction between the green infrastructure and the city.

Overall, the proposed framework established a strong link between data-driven analysis and spatial design. It supports the development of more effective and sensitive NBS planning and contributes to climate resilience and urban livability in Copenhagen and, subject to the contextual adaptation discussed in Section 4.4, in other cities facing comparable challenges.

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I.H.M., visualization, Y.L.; supervision I.H.M.; project administration, I.H.M.; funding acquisition, I.H.M. All authors have read and agreed to the published version of the manuscript.

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