Importance of implementing sustainable streetscapes

Green urban nature-based solutions for resilient cities

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2024

Document Version:
Publisher's PDF, also known as Version of record

Importance of implementing sustainable streetscapes in the local micro-geography

- Green urban nature-based solutions for resilient cities

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Acknowledgement

The research behind this study was supported by Interreg project SHARE-North Squared - Growing Shared Mobility in Housing Developments and Living as a Service:

SHARE-North Squared (SN^2) aims to increase the sustainability, resource and spatial efficiency of real estate developments as well as the affordability of housing by integrating shared mobility as a means of supporting multimodal travel behaviour and for reducing car ownership, car dependency and the demand for parking.

SHARE-North Squared is an Interreg North Sea project co-funded by the European Union. The project was approved in 2022 and runs until 2026. The SN^2 partners are City of Bremen (DE), GEWOBA (DE), Mpact (BE), Autodelen.net (BE), City of Helsingborg (SE), Lund University (SE), City of Aarhus (DK), Tækker (DK), City of Utrecht (NL), AM (NL), City of Stavanger (NO), Kolumbus (NO), Gustave Eiffel University (FR), City of Mechelen (BE), Woonland (BE) and Housing Europe (BE).

Keywords

Sustainable streetscapes, Urban nature-based solutions, sustainable development, micro-geography, ecosystem services, resilient cities, SHARE-North squared.

Innehåll

1. Introduction

1.1. Background

The world's cities are more densely populated and more interconnected than ever before. While this brings increasing social and economic advantages, this also brings increasing vulnerabilities – today's new normal requires models of governance that mitigate risk and respond to evolving challenges. Streets are part of our public spaces. Rather than being public spaces for human-oriented uses, streets are often dominated by car use. Using streets for transportation will remain a necessity even as transportation modes evolve, but shifting towards thinking of streets as places that host activities, nature-based solutions and where people spend time as opposed to just pass through will help create updated and engaging spaces for the benefit of a wider audience than cars alone.

There is yet limited research on how nature-based solutions provided by ecosystem services can advance urban development and increase attractiveness of sustainable cities. To respond to this gap, this study is based on data from in-person interviews with urban planners and researchers together with an on-site field study in four European cities that in different approach contribute to urban resilience in deprived urban environments, both in neighborhoods and city centers.

Based on findings, the study draws following conclusions, that the importance of urban nature-based solutions provided by ecosystem services in the streetscape micro-geography in European cities is complex and multifaceted. By considering these concepts together, planners and practitioners can develop more holistic and effective strategies for addressing the challenges, both of urbanization and urban planning development in Europe.

Nature-based solutions in the urban streetscape helps resilient cities to absorb, recover and prepare for future shocks (economic, environmental, social & institutional). Resilient cities promote sustainable development, well-being and inclusive growth. Today's new normal requires models of governance that mitigate risk and respond to evolving challenges. Business-as-usual models of decision-making will therefore not generate the flexibility essential for us to thrive in the face of the stresses of the future cities in 21st century.

1.2. Problematization

In general, space and place are important concepts of the overall theme of value of public urban streetscape. But – these concepts doesn't mean exactly the same. Space is something abstract, without any actual substantial meaning. While place refers to how people are aware of or attracted to a certain piece of space. A place can therefore be seen as space that has a meaning. Many of our cities have allowed streets to become heavily dominated by private vehicles, so that those streets have lost their primary purpose, which is to attract people, that attract investment and finally to attract spending.

Global climate change is not an abstract future risk, it is already underway. Serious consideration needs to be taken of local climate change mitigation and adaptation action. Urban natural ecosystems play an important role in this process, as they provide the basis for life through multifunction's (water and climate regulation, air pollution regulation, food production, provision of recreation space, etc). Hence, many cities are facing a broad range of

challenges related to climate change (Gössling, 2009). Nevertheless, extreme weather conditions is just one of many challenges facing cities and destinations, both now and in the future. Higher temperatures, rising sea levels, wetter winters, heavier downpours, and risk of drier summers are other challenges to be faced in European cities (Heely, 2011; Johansson & Nilsson, 2021).

This constitutes a real challenge regarding reducing the environmental pressures on the society (IPCC, 2014). Nature-based solutions (NBS) in the local micro-geography focuses on the detailed analysis of spatial patterns and processes at a very small scale, typically at the level of individual streetscapes, parks and dedicated green urban space and specific vegetation corridors (Kulczyk et al, 2014).

This study identifies factors that influence the distribution of services within a specific local geographic area due to understand how the characteristics of small-scale geographic features interact with larger-scale patterns of urban development, and how these interactions shape the social, economic, and environmental characteristics of a given city.

Vegetation provides a wide range of beneficial ecological services that are of particular importance in the urban environment for making sustainable and resilient cities. Hence, the full range of benefits provided by urban green infrastructure and green space, such as trees and vegetation are often unnoticed, unappreciated, and most often undervalued in sustainable urban development (IPBES, 2022). Recognizing and identifying these benefits can help cities to make right decisions about how to best manage sustainable cities.

According to The Millennium Ecosystem Assessment (MEA, 2005) there is a need to provide knowledge to local frameworks, and to examine possible services that ecosystems can deliver, according to four defined categories: provisioning, regulating, supporting and cultural services. Hence, in recent years, climate change has accelerated the rate of local biodiversity loss (IPBES, 2022). There is therefore an urgent need to complement these efforts by restoring ecosystems and enhancing ecological connectivity (Chan et al, 2021) both for the environment itself, and for people living and visiting (Beatley, 1995).

Further understanding of the important sustainable benefits provided by green urban infrastructure can also help to inform local land use changes and reduce potential impact through planned intervention to avoid loss of important urban ecosystem services (Kulczyk et al, 2017). Such information can even be used to help make better planning management decisions. Nevertheless, in most cities' streetscapes, the benefits provided by such urban ecosystem services is often poorly understood. Consequently, these benefits from natural ecosystem services are often undervalued in decision making processes (Schubert et al, 2017; Beery et al, 2016).

As many of benefits provided by urban ecosystems are often not marketable, they are generally undervalued. This may lead to wrong decisions about management and maintenance of important urban green infrastructure, especially in urban development areas (Johansson & Nilsson, 2021). This study aims to identify the importance of green urban ecosystem services as natural-based solutions for sustainable urban development in a European perspective. The work is important in determining how to implement natural-based

solutions (NBS) in order to provide sustainable green urban strategies in local micro-geographies to support further sustainable and resilient urban development.

2. Literature review

2.1. Importance of sustainable streetscapes

A street is not just a means of getting from A to B - as well as giving access to local businesses, mobility hubs and residential properties; it also provides places to stop, meet, rest or play. In reality, streets therefore have many other functions. They form vital components of residential areas and greatly affect the overall quality of life for local people. Places and streets that have stood the test of time are those where traffic and other activities have been integrated successfully, and where buildings and spaces, and the needs of people, not just of their vehicles, shape the area. Experience suggests that many of the street patterns built today will last for hundreds of years. We owe it to present and future generations to create well-designed places that will serve the needs of the local community well. We all live, work and move through streets in our day to day lives, and we should feel secure in doing so.

Finding an attractive balance requires a holistic design approach, focusing on both the natural and built fabric of the street, seeking to improve the overall quality of the space and especially its visual effect. A world-class urban streetscape successfully balances the needs of all users, particularly pedestrians, factoring-in accessibility, inclusivity, safety, vibrancy, and resilience. So, what makes an excellent streetscape design? And how do planners and designers achieve that balance between form and function to create streets that enable easy passage through and access to different amenities?

Designing vibrant streetscapes demands consideration at the design stage, or, if it is a regeneration project, specific interventions may be needed. Ideal spatial characteristics include wide pavements and pedestrian-only zones, often allowing businesses to through outdoor seating or a parklet approach to outdoor socializing. From a climate perspective, streets for today (and tomorrow) must be designed to deal with increasingly extreme weather events. A good streetscape design builds in green infrastructure, robust drainage and permeable paving elements to ensure the streetscape can withstand increasingly extreme weather events, such as excess surface water and strong UV light.

We also understand the benefits of ensuring that the different functions of streets are integral to their design from the outset. But we need to do more to recognize the role that streets play in the life of a community, particularly the positive opportunities that they can bring for social interaction. To achieve this we need strong leadership and clear vision. Importantly, we need to tackle climate change, and helping and encouraging people to choose more sustainable ways of getting around will be key.

A clear distinction can be drawn between streets and roads. Roads are essentially highways whose main function is accommodating the movement of motor traffic. Streets are typically lined with buildings and public spaces, and while movement is still a key function, there are several others, of which the place function is the most important. Streets should therefore not be designed just to accommodate the movement of motor vehicles. Streets should be

attractive places that meet the needs of all users. on meeting the needs of pedestrians, cyclists and public transport users, so that growth in these modes of travel is encouraged.

2.2. Sustainable cities and urban development

Sustainable urban development refers to the process of creating and managing resilient places in a way that minimizes negative impacts on the environment and maximizes benefits for local communities (Cheshire & Hay, 1989). This process often unconsciously involves the use of nature-based solutions to enhance the attractiveness of a city (Costanza & Daly, 1992). The physical, social/cultural, political, and ecological dynamics of a city of course differ all over the world (Childers et al, 2013). Due to these differing dynamics, solutions to climate challenges need to be applied and considered at a local level where the individual dynamics can be understood and sustainably addressed in the right context (Berkes & Folke, 1998).

Greater mobility, the information boom and the increased knowledge sharing between people have facilitated the development of urban structures and led to higher levels of urban sustainability demand in Europe in recent years (Cohen & Cohen, 2019). Cities are ideal for short breaks, and normally offer a wide range of cultural experiences, which perfectly match general trends in travel behavior (Richards, 2014). Many cities also become more attractive through constantly developing green urban values and consequently enhancing their competitiveness.

Crowding, congestion, waiting time at attractions, emissions and pollution caused by over-consumption of space in cities are negative effects of uncontrolled planning development, which threaten the local preservation of the environment, heritage, social and cultural values and maintenance of a quality of life for citizens (Önder et al, 2017; Timur & Getz, 2009). Cites are therefore impact drivers of changes in both global climate and local natural ecosystems (Costanza et al, 1997).

Land-cover changes in recent years have considerable impacts on temperature and precipitation in and around urban areas (Seto & Shepherd, 2010). Nevertheless, in some parts of Europe there is an observed increase in regional precipitation due to overconsumption of urban space, while in other regions there is a measurable decline in precipitation. Any region's economic competitiveness and security depends directly on sustainable use of local natural resources (Maes & Jacobs, 2017).

2.3. Relevance of resilient cities

Over usage of cities, affects spatial land use patterns that puts further pressure on urban natural ecosystem services functionality and human well-being both for visitors and citizens (Kabisch et al., 2017). For instance, it is estimated that by 2050, 70 % of the world's population also will be living in cities (Önder et al, 2017), expected to increase to over 80 % by the middle of the century. This corresponds to 36 million new urban citizens by 2050. It is therefore of high importance to assess the economic values of blue-green infrastructure in urban development processes (Wild et al., 2017). Both urban planners and sustainable destination developers need to have an open approach to collaborative governance of nature-based solutions that allows learning with and about new appealing designs, perceptions and images

of nature from different urban actors, allows forming of new institutions for operating and maintaining NBS to ensure inclusivity, livability and resilience (Frantzeskaki, 2019).

NBS provide sustainable, cost-effective, multi-purpose and flexible alternatives for various objectives by working with nature, rather than against it, and can further pave the way towards a more resource efficient, competitive, and greener local economy (Gómez-Baggethun et al, 2010). Application of NBS in urban planning can therefore offer cities both risk management and resiliency, climate change adaptation, improvements of degraded ecosystems, and sustainable cities (Escobedo, 2018).

Such important solutions bring of course more diverse nature and natural features and ecological processes into cities mainly through locally adapted, resource-efficient, and systemic interventions. NBS are proliferating in European cities over the past years as viable solutions to urban challenges such as climate change, urban degeneration, and aging infrastructures (Frantzeskaki, 2019). Nature-based solutions have become a valid alternative for infrastructure development and infrastructure update in cities (Fink, 2016). Hence, NBS are solutions to restore ecological flows in cities that increase resilience of a city (Escobedo, 2018).

2.4. Natural ecosystem services and local climate regulation

Ecosystem services as mentioned, refer to the benefits that people derive from natural ecosystems, such as clean air and water, food, and recreation (Bolund & Hunhammar, 1999). Urban NBS can enhance the provision of ecosystem services in cities, such as by creating green spaces that provide habitat for wildlife or by reducing the amount of stormwater runoff that enters waterways.

Sustainable urban development can also enhance the provision of ecosystem services in attractive destinations, such as by promoting activities that support local agriculture, or by developing trails that allow visitors to experience natural areas while minimizing impacts on the environment. Vegetation has therefore a significant positive effect in reducing the rate of flow of water through the urban landscape, e.g., through presence of forest, parks, lawns, streetscapes with roadside greenery, streams, rivers, waterbodies (Chan et al, 2021).

Hence, trees and overall greenery in urban environments provide many sustainable benefits especially also in climate regulation i.e. carbon storage and cooling effects provided by vegetation (Ziter et al, 2019). Trees can, as an example, also filter air pollution, lower greenhouse gas emissions, protect top soil, decrease surface runoffs, reduce noise pollution, improve water quality, provide habitats for fauna and contribute numerous other biodiversity benefits (Chan et al, 2021).

One of the many effects of climate change that cities must deal with is extreme rainfall, so the expansion of green urban infrastructure should help absorb even more rainwater and prevent both flooding and sewer overflows, which also can mean contamination of the water supply (Moll & Petit, 1994). With more extreme precipitation, there must be more surfaces that will absorb and filter stormwater. Street trees and vegetation help to beautify city streets, which also can help improve mental and physical health of both citizens and visitors and make more livable cities (Nilsson & Johansson, 2021).

2.5. Nature-based solutions (NBS) provided by urban ecosystem services

Urban nature-based solutions (NBS) are interventions that use natural systems and processes to address urban challenges such as climate change, air pollution, and social inequality (Nalau & Becken, 2018). These solutions are often implemented at a micro-geographic scale, within specific neighborhoods, or specific areas of a city. Hence, nature-based Solutions are concrete actions to protect, manage, and restore both natural and modified ecosystems, and that address relevant societal challenges and simultaneously benefiting both people and nature. NBS target major urban challenges like climate change, disaster risk reduction, food and water security, biodiversity loss and human health, and are critical to sustainable economic development (Scott et al, 2012).

NBS can help tackle climate change and advance urban sustainability by using nature to deliver social, ecological, and economic benefits (Wickenberg et al, 2021). NBS can be described as an overall umbrella concept for biodiversity and natural ecosystem services (Nesshover et al., 2017). NBS should not be considered as "optional luxury" in cities (Montgomery, 2013; Frantzeskaki, 2019). NBS can therefore be seen as solutions to infrastructure re-development and advancement.

According to Wickenberg et al (2021) NBS is set to respond to the effects of climate change (e.g., flooding, urban heat, biodiversity loss), they have to gain acceptance, be integrated in urban planning and align with other urban policies, e.g. providing housing and schools, creating jobs, and resolving social inequalities. For NBS to be meaningful in terms of delivering positive impacts in cities, we need better understanding of how implementation is embedded in NBS frameworks (Wickenberg et al, 2021).

3. Aim & Scope

There scope of this study is to bring knowledge about sustainable transformation in the quality of streetscapes. This requires a fundamental culture change in the way streets are designed and adopted, including a more collaborative approach between the design professions and other stakeholders. The aim is therefore to understand the role of nature-based solutions in urban streetscapes.

4. Methods

The conceptual approach in the study is based on data from multiple sources: in-person interviews with urban planners, managers and researchers within the field of subject, and on-site field visits and case studies. Author own knowledge and experience interacts with the knowledge of others when interpreting new meanings and perspectives within a given discourse. Hence, this study has been based on author own experiences from working within and researching with cities in different national contexts.

4.1. In-person interviews

A qualitative approach consisting of semi-structured interviews with stakeholders such as urban planners, researchers and practitioners in European cities was conducted during 2023. Relevant stakeholders were selected through purposeful sampling due to select participants based on specific criteria, or purpose, that aligns with the research question and objectives. The method of homogeneous sampling was used, which involves selecting participants who share common characteristics or experiences in the field of sustainability. Furthermore, this can help to ensure that the sample is focused and can capture depth of understanding on the topic of sustainable urban development.

This approach resulted in eight interviewees with relevant stakeholders (Table 1). Hence, interviewees and organization have been anonymized to ensure confidentiality (Lavrakas, 2008). The limited response rate can be partially explained by challenges in finding stakeholders with multidisciplinary knowledge in the field of natural based solutions, urban ecosystem services, sustainable cities and urban development. In relation to the relatively homogenous nature of interviewees and their high level of multidisciplinary expertise, a sample size between 6 to 12 interviewees was considered reasonable (Guest et al., 2006). Consequently, this was also confirmed as few new approach, themes or perspectives emerged in latter interviews, with respondents repeating information raised in previous interviews, indicating collecting saturation rate was reached.

Interview theme questions were presented to respondents prior to the interviews. Interviews lasted between 30-60 minutes and were recorded with the participants' permission. Following data collection, interviews were transcribed, and an interpretive reading was also undertaken. All transcripts were transcribed and coded by the author. The coding approach was mainly due to explore the respondent's perspectives in-depth, identify the recurrent themes, and to highlight nuances and differences between respondents permitting theoretical triangulation (Oppermann, 2000). Theoretical triangulation was used to increase the validity and reliability of the research findings and to provide a more comprehensive understanding of the research topic.

Table 1. Profiles of interview participants

Participant	Area of expertise
Participant A	Urban planner with focus on local ecology in Sweden
Participant B	Urban planner with focus on sustainability in Sweden
Participant C	Urban planner with focus on strategic planning in Germany
Participant D	Urban planner with focus on sustainability in The Netherlands
Participant E	Urban planner with focus on destination development in Sweden
Participant F	Urban planner with focus on regional transport planning in Scotland
Participant G	Researcher with focus on sustainable urban planning in Germany
Participant H	Researcher with focus on sustainability in Sweden

4.2. Case studies and on-site observations

In this study, NBS across four European cities which focusing on sustainability issues were identified, visited, and analyzed. The European cities specifically studied are Bremen (Germany), Edinburgh, (Scotland), Amsterdam (The Netherlands) and Budapest (Hungary). What makes mentioned case studies stand out, is the balanced focus between natural urban ecosystem services and social benefits in contrast to many published cases on NBS that have a weighted focus merely on the climate benefits.

Addressing the study as a case study approach based on an on-site field visit, allow to investigate complex phenomena in real-world settings to gain a deeper understanding of the actual factors that contribute to green urban nature-based solutions for sustainable urban development in micro-geography. The four studied European cities are identified to address similar challenges and finding local solutions of climate change.

By studying different case studies in each destination, the study can contribute to identify patterns and relationships that may be present across different contexts and develop more robust and generalizable theories (Johansson & Nilsson, 2021). On-site observations enable to collect data directly from the source. On-site observations also allow to contextualize research findings within a broader social, economic, and ecological context of the settings being studied. Description of selected case studies:

4.2.1. Bremen

Bremen, a city in northern Germany, has a long history of sustainable urban development, with a focus on creating livable and walkable neighborhoods, and promoting sustainable mobility and cycling. The city has also invested in green infrastructure, such as parks and green roofs, to enhance the quality of life for citizens and visitors.

Bremen has developed a sustainable strategy report (Bremen, 2020) that emphasizes responsible travel practices and minimizes negative impacts on the environment and local communities. Bremen has several parks, gardens and green spaces, including the Bürgerpark, the Rhododendron Park, the Botanika, the Rose Garden and the Heidbergsee. The city also boasts a few nature reserves, such as the Teufelsmoor reserve, the Schöneberger Heide and the Wümmeniederung. Bremen is also home to the oldest zoo in Germany, the Tiergarten Bremen (WFB, 2020).

4.2.2. Edinburgh

Edinburgh, the capital city of Scotland, has made significant efforts in recent years to promote sustainability and to protect the local environment. Hence, Edinburgh has a strong focus on sustainable urban development, with a commitment to creating walkable and bike-friendly neighborhoods, promoting green spaces, and reducing car traffic. Also, Edinburgh has developed a 2050 sustainable city vision that emphasizes responsible travel practices and minimizes negative impacts on the environment and local communities (The City of Edinburgh Council, 2018).

Edinburgh is also investing in climate adaptation measures to prepare for the impacts of climate change, such as increased flooding and extreme weather events. The city has

implemented a range of measures to improve water management and reduce the urban heat island effect (The City of Edinburgh Council, 2022).

4.2.3. Amsterdam

Amsterdam, the capital city of the Netherlands, is known for its long and strong commitment to sustainability and has implemented a range of initiatives to promote sustainable development and to develop the local environment. Amsterdam has adapted a sustainable strategy for climate adaptation that emphasizes responsible travel practices and minimizes negative impacts on the environment and local communities (The City of Amsterdam (2020b). The city has implemented a range of initiatives to promote sustainable development, reduce carbon emissions, and protect the environment, and has set ambitious targets for renewable energy, sustainable urban development, and climate adaptation (The city of Amsterdam, 2020a).

4.2.4. Budapest

Budapest, the capital city of Hungary, has also made significant efforts to promote sustainable urban planning and development. Budapest has for example implemented a range of sustainability initiatives, including a bike-sharing program, a waste management system that emphasizes recycling and composting, and a program to promote sustainable food choices in public institutions (ICLEI, 2016).

Budapest is renewing many city parks to improve quality of life, thanks to a reduction in the heat island effect, increased biodiversity, greater habitat connectivity, improved risk management, and better air quality (Gál, 2015). More accessible green spaces and leisure activities may also enable citizens to have a more active lifestyle and engage in more outdoor activities. This can reduce potential risks to physical and mental health (Kereszters-Sipos & Koller-Posztos, 2016).

More time spent outside can result in improved social interactions between different social and age groups (Faragó et al, 2010). NBS also play a crucial role in key policy documents such as the Budapest 2030 Long Term Urban Development Concept, the Integrated Urban Development Strategy 2020, the Budapest Green Infrastructure Strategy, and the Budapest Environmental Program 2017-2021 (ICLEI. 2016).

All mentioned cities considered NBS as potential alternatives to grey infrastructure for improving the robustness of future urban infrastructures. However, there is yet limited research on the ways the knowledge on nature-based solutions can advance urban development and attractiveness of sustainable cities and streetscapes. To respond to this gap, the study conducted a multi-case study transdisciplinary research in mentioned four cities in Europe that set up NBS that directly contribute to urban resilience in deprived urban environments, both in neighborhoods and city centers.

5. Findings

5.1. The role of nature-based solutions for sustainable streetscapes

Nature-based solutions can be seen as a certain type of approaching local sustainable development in which that uses mainly natural processes and ecosystems to address both environmental and social challenges (Ziter et al, 2019). These kinds of solutions include restoring old natural urban ecosystems and creating new green infrastructure, but also conserving already existing biodiversity (IPCC, 2014):

"Nature-based solutions can be seen as being powered by nature and restoring natural flows in cities which is of course of high importance" – Participant B

By restoring natural flows, NBS help cities to beneficially reduce impact on the overall environment, increasing local resilience to climate change, and also improve public health and quality of urban life (Berkes & Folke, C, 1998; Scott et al, 2016):

"We must further assert the positive impact of nature-based solutions to urban place-making and with that said also to become sustainable cities or at least try to become sustainable" – Participant C

Nature-based solutions in the micro-geography can be used to create and improve public spaces, reduce urban heat island effects, improve water quality, and increase biodiversity (Chen et al, 2019). To mitigate the negative impacts of heat island effects, cities can implement a range of strategies, including increasing green spaces and vegetation, improving building design and materials, and implementing cool pavement technologies to reduce surface temperatures. Heat island effects can also have a negative impact on sustainable cities, as high temperatures can make visitors uncomfortable and reduce the appeal of outdoor activities.

Increasing green spaces and vegetation, providing shaded areas for visitors, improving building design and materials to reduce heat absorption, and implementing cool pavement technologies to reduce surface temperatures could create a more comfortable and enjoyable environment. These kinds of ecological solutions have been shown to reduce overall stress levels, encourage physical activity, and improve mental and physical health. They also can create spaces for social interaction and help to create a sense of local community (Berkes & Folke, 1998). In short, nature-based solutions can be seen as an effective way to improve the overall quality of life in urban areas:

"Small-scale greening projects could induce broader transformation of city's green infrastructure, which might be more extensive and economical than the one achieved via the conventional top-down planning" – Participant A

Small-scale greening restoration and development projects can help to improve overall urban green infrastructure by enabling the integration of a variety of green elements into the city- and streetscape, such as green spaces (Schubert et al, 2017a). Additionally, these greening projects can help to reduce the amount of hard surfaces within the city, allowing, for example, better stormwater management and improved water quality. Furthermore, these kinds of projects can also foster greater public engagement in the planning and development process,

enhancing community-level support for green infrastructure initiatives (Schubert et al, 2017b):

"Green spaces moderate the relationships with people and create new experiences between people and nature" – Participant A

Nature-based solutions (NBS) that use nature and its processes to address societal challenges, such as climate change, biodiversity loss, and environmental degradation (Escobedo, 2018). NBS can enhance the quality of the natural environment, which is a primary attraction for tourists. By protecting and restoring ecosystems, cities can offer unique and also authentic experiences that are beneficial to both citizens and visitors:

"By enhancing the natural environment, sustainable streetscapes can offer unique and authentic experiences to visitors while generating economic benefits for local communities and protecting the environment" – Participant D

For every Bremen resident there are 44.9 square metres of green space. These are areas that haven't been built on and that are used mainly for recreational purposes, such as parks, playgrounds and allotments (WFB, 2020). This makes Bremen the greenest city in Germany with around 70 percent more green space per inhabitant than for example Hamburg or Berlin. According to WFB (2020) there are almost 47 square metres of water per Bremen resident. No other German city with more than 400,000 citizens has as much water as in Bremen:

Pictures from left to right: Bodenfilter Bürgerweide and Herdentorswallmühle in Am Wall (authors own pictures).

In the past, urban water management was all about collecting rainwater runoff efficient and lead the water as fast as possible to canals and other water bodies which lead to severe flooding. These problems can be solved by NBS collecting the rainwater in multifunctional vegetations areas for the water to evaporate, retained, and used or channeled locally into surface water. Bremen is one of the few federal states in which rainwater harvesting and green roofs have been locally promoted for many years. Bürgerweide cleaning rain water and contaminated water from nearby in an overgrown soil filter and then lead over to a large pond in the close by Bürger park.

The Am Wall Windmill (Herdentorswallmühle or Mühle am Wall) was built 1898 and is an important and iconic touristic building in central parts of Bremen, Germany. The windmill is in

the middle of a city park that once was constructed on the ground where the original fortifications of the city once stood. Today the building is heritage listed and tourists may enter the building after a nominal charge. The city park where the windmill is located is called Wallanlagen Park and is ideal for enjoying a walk and taking in the scenic views. Parks located in urban areas are a valuable resource that enhances the quality of life. They provide numerous benefits for both individuals and communities, and it is important to ensure that they are maintained and preserved for future generations. Urban parks provide habitat for a wide range of plant and animal species. They help to preserve local biodiversity and provide opportunities for environmental education.

5.2. Importance of green spaces in the local micro-geography

Green spaces in the microgeography provide an important space for people, both locals and visitors, to come together and interact with one another, creating a sense of community. Green spaces can generally also create new experiences between people and nature, providing opportunities for people to appreciate and connect with the natural environment (Jansson, 1994). Additionally, these benefits can help to create positive relationships with people and nature:

"I think that nature-based solutions need to be designed in such a way that lessons for their effectiveness can easily be replicated into other locations and this is also important to understand" – Participant A

Nature-based solutions can be designed with a focus on some sort of replicability, so that when they are implemented, the lessons learned can easily be shared and replicated in other locations and perhaps in other contexts. Additionally, there should be a focus on creating an evidence base to back up the effectiveness of the solution. This evidence can be used to help inform decision-makers in other locations and help them decide whether to implement a similar solution and what potential effects it will gain (Schubert et al, 2017a; Schubert et al, 2017b):

"All sizes of nature-based solutions can contribute to more livable and resilient cities" – Participant C

Smaller-scale nature-based solutions in the microgeography such as urban green spaces, vegetations and community gardens can contribute to more livable and resilient cities. These kinds of smaller-scale solutions can also help to support urban biodiversity, improve air quality, reduce urban heat island effects, and provide recreational and educational opportunities to citizens. They can also help to reduce stormwater runoff and improve water quality. At a perhaps a larger scale, nature-based solutions can be incorporated into urban planning and future infrastructure design (La Rocca, 2014). Large-scale green infrastructure can also provide local habitat for wildlife, improve air quality, and provide recreational opportunities for citizens in a bigger picture. In addition, these larger-scale solutions can create green corridors that connect different parts of a city which is of high importance for biodiversity (Chen et al, 2017):

"There are often trade-offs to be made between environmental goals and the objectives of maintaining relationships between tourists and citizens and the local community" – Participant F

As part of Edinburgh's 2050 City Vision, the City of Edinburgh Council is working on an innovative 30-year strategy for managing natural spaces in a sustainable way that supports parks and greenspaces services. In promoting health and wellbeing, the city of Edinburgh is collaborating with a variety of stakeholders to maximize the multi-use and accessibility of greenspaces. The city will also work on developing a natural capital account to put a financial value on the several benefits the city receive from greenspaces (The City of Edinburgh Council, 2022). As a part of Edinburgh's 2050 City Vision (The City of Edinburgh Council, 2018) Edinburgh is also aiming on becoming a thriving city. Edinburgh is home to many beautiful parks and gardens, including some of the most prestigious private parks in Scotland.

Many of these parks are open to the public, including Queen Street Gardens, Princes Street Gardens, Inverleith Park, and the Royal Botanic Garden Edinburgh. Other private parks in Edinburgh include the grounds of the Royal High School, the gardens of New Town, the Dean Village Garden, and the gardens of the National Museum of Scotland. However, in Edinburgh, especially the very place specific phenomenon of Edinburgh New Town and West End's private parks tends to follow a discussion on whether the limited access to perceived urban green areas a serious injustice:

Pictures from left to right: Charlotte square and St. Andrew square (authors own pictures).

Charlotte Square is a garden square in Edinburgh, Scotland, as a part of the New Town, designated as a UNESCO World Heritage Site. A statue of Prince Albert stands in the centre of Charlotte Square, in front of West Register House. The central open space is a private garden, available only to owners of the surrounding properties except for the last three weeks in August each year Charlotte Square gardens are the site of the Edinburgh International Book Festival.

St Andrew Square is also a part of a garden square in Edinburgh, located at the east end of George Street. The garden, as a part of the collection of New Town Gardens, are owned by a number of private owners, and opened to the public in 2008. City parks provides green space in most often dense central areas which improve air quality and reduce the urban heat island

effect. Parks provide space for people to engage in physical activities such as jogging, walking, cycling, and playing sports. This helps promote healthy lifestyles. City parks provide a space for people to come together and engage in social activities such as picnics, different kind of festivals, and concerts. This helps to build a sense of community and social cohesion.

5.3. Trade-offs between environmental goals and maintaining sustainable streetscapes

Local communities may be willing to accept some presence of streetscape development in their area if it brings economic benefits, but this can come at the cost of damaging the environment (Edwards, 2008). It is not always easy to see the connection:

"Degraded ecosystems are not capable of providing many services which are crucial for both health but also local economical benefits" – Participant E

Nevertheless, another trade-off is between sustainability and profitability. Cities may need to compromise on sustainable practices in order to remain competitive and generate profits, while local communities may be willing to accept environmental degradation in order to benefit from the economic gain of local consumption (Scott et al, 2012).

And finally, there is a trade-off between conservation and enjoyment. Tourists may want to enjoy activities such as swimming, boating, hiking, or other activities that can negatively affect the environment. Conservation efforts can conflict with the enjoyment of tourists and the economic benefits they bring to local communities (Edwards, 2008):

"Urban development, if done unsustainably is one of the main drivers of biodiversity loss" – Participant H

The growing population of the Netherlands is expected to over 18 million by 2035, one million more than today. The greatest increase will occur in Amsterdam, where the population is expected to grow by more than 150,000 by 2035. This represents a growth of almost 20% compared to 2019 (PBL, 2019). Amsterdam also attracting a growing number of tourists every year. The Netherlands Bureau for Tourism and Conferences expects that, by 2030, the city will have 32 million visitors (per year) (NBTC, 2018):

Pictures from left to right: Streetscapes in Amsterdam with NBS drainage system (left) and greening of local street (right) (authors own pictures).

5.4. Urban development and the impact on local biodiversity

Urban development can have a major impact on biodiversity loss (Everard, 2017). When cities are built without consideration for the environment, they can disrupt ecosystems and destroy important habitats (De Groot et al, 2002). This can lead to reduced populations of species, particularly those that rely on those specific habitats to survive (Bolund & Hunhammar, 1999).

Additionally, urban development can also fragment habitats and by that reduce the amount of space available for species to roam (Keane et al, 2014). This can lead to further population declines and ultimately in the extremes, to species extinctions. To prevent this, urban development needs to be done in a more sustainable manner, with consideration for how it will affect the environment and its species (Nevens et al, 2013). This includes using green technologies, preserving natural habitats, and protecting species when possible.

"Population growth in cities makes infrastructure needs in urban areas particularly high and places enormous pressure on the environment" – Participant B

As cities become more populated, the infrastructure needs to accommodate the increased population, which can put a burden on existing infrastructure and existing resources (IPCC, 2014). This can lead to increased pollution, increased traffic, and increased strain on natural resources. In order to address these issues, cities must invest and prioritize in sustainable infrastructure and transportation, such as more public transportation, green infrastructure, and renewable energy sources (Palo et al, 2016). Additionally, cities must invest in strategies to reduce waste and improve air quality, such as encouraging recycling and reducing emissions from vehicles (Beatley, 2000).

"Building with, rather than against, nature has direct benefits for cities" – Participant G

Building with nature can help cities to reduce the impacts of for example extreme weather events, protect against flooding and erosion, improve air and water quality, and create vibrant green spaces for people to enjoy (Gómez-Baggethun et al, 2010). Incorporating natural features into urban planning can also help cities become more resilient to climate change, as green infrastructure can help absorb and reduce the impact of flooding, storm surges, and extreme weather events (De Groot, 2002):

"Building with nature also supports investments in other sustainable infrastructure, such as mobility, water, and energy, by increasing their resilience and effectiveness" – Participant A

Green spaces, such as parks, gardens, and green streetscapes, are essential for urban development as they provide a range of benefits for citizens and visitors alike (The Swedish Environmental Protection Agency, 2021):

"Green urban spaces provide important social benefits for citizens and visitors. They offer a space for relaxation and recreation, which can improve physical and mental health. They also provide opportunities for social interaction and community building, which can help to create a sense of place and foster a strong community"- Participant G

5.5. Importance of sustainable streetscapes in the micro-geography

Ecosystem services refer to the benefits that humans derive from natural ecosystems, such as clean air, clean water, fertile soil, and biodiversity (Everard, 2017). These services are critical for human well-being, and they are particularly important for sustainable streetscapes (Church et al, 2017). Ecosystems also provide beautiful landscapes and livable environments that attract tourists and provide opportunities for recreational that are a major reason why many people choose to visit certain destinations:

"The cities depend on healthy and diverse ecosystems to attract visitors. Ecosystem services provide a range of benefits that are crucial both for tourism and for people living here" – Participant F

Overall, the importance of ecosystem services for streetscapes cannot be overstated. Without healthy and diverse ecosystems, cities would suffer, and many popular travel destinations would lose their appeal. It is therefore essential to protect and preserve natural ecosystems to ensure the sustainability:

"Ecosystems help regulate the climate by absorbing carbon dioxide, producing oxygen, and reducing the effects of extreme weather events. This is important also for resilient cities because climate is a major factor reaching the sustainable development goals" – Participant F

Urban gardens and green spaces are nature-based solutions specifically for cities. According to IPCC (2014) urban green spaces reduce environmental hazards, improve the quality of life of the urban regions, and improve citizens' wellbeing:

"Growing trees is a somewhat simple solution to absorb carbon dioxide through the process of photosynthesis. And as a nature-based solution tree planting also improving biodiversity, soil, air, and water quality" – Participant H

The maintenance, restoration, and sustainable use of ecosystems therefore form the basis of "nature-based approaches" to climate change mitigation and adaptation. The degradation of natural ecosystems can have negative impacts on the climate.

NBS can effectively complement existing technical approaches and in some cases even replace them – Participant G

Budapest city's average temperature has risen by 1.5 °C since the 1970's, and temperature models project a further rise of 4-6°C by 2100 which is a challenge for both citizens and visitors (Buzási, 2014). To address these challenges, Budapest has drafted several strategic documents, in which NBS are promoted to improve the environment, sustainability, and quality of life (ICLEI, 2016):

Pictures from left to right: Andrássy út and Vajdahunyad Castle (authors own pictures).

Andrássy Avenue (Andrássy út) is a boulevard in Budapest from 1872. The avenue is one of Budapest's main shopping streets and was built to connect the inner-city parts with the City Park. Trees in boulevards or along city streets are important for providing shade. Trees offer shade to pedestrians, reducing the heat island effect. This helps to keep people cool in hot weather and can also reduce the amount of energy needed to cool buildings adjacent to the boulevard. Trees absorb pollutants from the air and produce oxygen, helping to improve air quality. They can also reduce noise pollution by acting as a sound barrier between the street and nearby buildings. Hence, trees add natural beauty to boulevards and streetscapes, making them more visually appealing. They can also increase property values in adjacent areas.

Vajdahunyad Castle (Vajdahunyad vára) is a castle in the City Park of Budapest. Today, it is the Museum of Hungarian Agriculture, the biggest agricultural museum in Europe. Green walls, are becoming increasingly popular in urban areas and have a number of benefits such as for example absorbing pollutants from the air and produce oxygen, helping to improve air quality in urban areas. Green walls can help to insulate buildings, reducing the amount of energy needed to heat and cool them. This can help to lower energy costs and reduce greenhouse gas emissions. Green walls can also enhance the aesthetic appeal of buildings, making them more visually appealing and attractive.

6. Conclusions

Green spaces are important for urban development as they provide a range of environmental, economic, social, and cultural benefits. They contribute to the overall attractiveness of a city and provide important values for both citizens and visitors. Understanding the local dynamics of NBS in the micro-geography provides insights into the specific social, economic, and environmental conditions that exist within small geographic areas. By understanding these local dynamics, especially policymakers and planners can make more informed decisions about how to allocate resources and design programs that address the unique needs of different communities. Micro-geography can help identify the specific environmental impacts of urban development projects, such as for example the construction of new housing development areas. This information can be used to develop more sustainable development practices that minimize negative impacts on the environment. Therefore, NBS compliment and supports the existing infrastructure of cities. It also provides a supportive infrastructure

to public transportation by reducing outdoor air temperature and providing shade under intense heat which else restricts people from walking, cycling, and waiting in transit stops. It also supports water management in cities by providing clean water, allowing water to infiltrate the ground, and restoring groundwater. Moreover, also improve energy efficiency by reducing consumption.

United Nations Sustainable Development Goals (SDG) strives to ensure that cities are inclusive, resilient, and sustainable. Thus, it contains multiple different targets related specifically to urban sustainability: adequate housing, access to sustainable (public) transport systems, protection of natural and cultural heritage, reducing the environmental impacts of cities, disaster risk management and also protection from disasters, climate action, and also important about access to green and public spaces.

Hence, the Paris Agreement invites cities to scale up their efforts to reduce emissions and build climate resilience (United Nations Framework Convention on Climate Change, 2016). Subsequently, cities can contribute to the targets to increase urban green and blue spaces to support human well-being, reduce pollution, and maintain and enhance nature's benefits for air quality, water management and protection from extreme weather events. For cities to be sustainable, the infrastructure itself also must be sustainable.

Therefore, sustainable infrastructure systems are "planned, designed, constructed, operated and decommissioned in a manner that ensures economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire infrastructure life cycle (Bechauf, et al, 2022). By recognizing the value of ecosystem services, cities can develop in a way that balances economic, social, and environmental concerns and promotes sustainability in following ways:

Natural resource management: Ecosystem services can be used to guide natural resource management decisions in urban development. For example, maintaining healthy parks and vegetation can help to prevent soil erosion, maintain clean water supplies, and provide opportunities for recreation, which can all benefit sustainable streetscpapes:

Climate change adaptation: Ecosystem services can help cities adapt to climate change impacts. For example, trees in streetscapes can help to protect cities from heat island effects.

Social benefits: Ecosystem services can also provide social benefits for local communities and visitors. For example, access to green urban spaces and local nature can improve mental and physical health, while opportunities for recreation can promote social cohesion and community building.

Based on these findings, the study draws following conclusions, or lesson learned that the importance of urban nature-based solutions provided by ecosystem services in the micro-geography and sustainable urban development in European cities is complex and multifaceted. By considering these concepts together, planners and practitioners can develop more holistic and effective strategies for addressing the challenges, both of urbanization and development in Europe. on the importance of implementation of nature-based solutions in urban streetscapes:

- nature-based solutions need to be appealing to both citizens and visitors,

- nature-based solutions create new green and important urban environments,

- nature-based solutions requires diversity and learning from both social and technical innovation, and

- nature-based solutions require collaborative governance between many relevant stakeholders.

Implementing sustainable streetscapes at the micro-geographical level is crucial for several reasons, as it contributes to creating healthier, more resilient, and environmentally friendly urban environments.

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