

The COVID-19 Pandemic and Nature-Based Solutions (NBS) in cities:

Impacts, threats and opportunities for NBS mainstreaming

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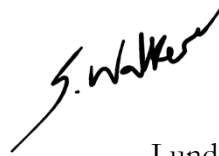
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The end of one chapter marks the beginning of a new one!



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Abstract

Cities are increasingly exposed to a number of urban challenges including natural disasters and poor public health. This has prompted cities to build urban resilience through various innovations; one such innovation encompasses Nature-Based Solutions (NBS) due to their ability to address multiple challenges. Whilst the COVID-19 pandemic has exaggerated the need for cities to build resilience, the role NBS could play has yet to be explored. This multiple case-oriented study focuses on five cities based around Europe (Barcelona, Győr, Malmö, Newcastle and Utrecht) to investigate the impact of the COVID-19 pandemic on NBS in each city (Research Question (RQ) 1). In addition, this research explores how urban challenges are reimagined (RQ2) and identifies impeding and supporting factors to mainstreaming NBS as a result of the pandemic (RQ3). Data is collected through the review of the Urban Nature Atlas, a database of over 1000 NBS in 100 cities, and by conducting 20 interviews with practitioners and researchers involved with the case-study cities. Two analytical frameworks were adopted to explore the types of UC cities are exposed to and the impeding and supporting factors to NBS mainstreaming. Both an in-case analysis of each city and a cross-case analysis between the five cities is performed to identify similarities and differences with how the pandemic has impacted NBS. The findings suggest that the impact of the pandemic on each city relates to the type and severity of restrictions implemented. As such, strict lockdowns initially led to NBS being underused resulting in increased biodiversity, whereas a lack of restrictions was associated with a substantial increase in NBS use and resulted in several unintended consequences. For practitioners, the pandemic has reinforced the connection between access to nature and public health benefits. Other opportunities to mainstream NBS could be identified through the increase in appreciation for nature from citizens and additional resources made available for NBS projects in cities. As such, this research makes important contributions to academic knowledge and practice. It is one of the first studies to examine the impact of the pandemic on NBS in cities, and it also offers concrete pathways (or “stepping stones”) for NBS mainstreaming post-pandemic. To turn these stepping stones into action, additional research is required; such research should primarily engage with ways to improve the monetary valuation of NBS and the related public health benefits.

Keywords: Nature-Based Solutions, Urban Challenges, Urban Resilience, the COVID-19 pandemic.

Executive Summary

Problem Definition and Research Questions: Cities are increasingly exposed to a number of urban challenges (UC) including natural disasters, biodiversity loss and poor public health. These challenges are expected to be exaggerated as a result of urbanisation and climate change, prompting cities to pursue urban resilience (UR)¹ (Almenar et al., 2021). As efforts to build UR have increased, Nature-Based Solutions (NBS)² have frequently been adopted to allow several UC to be addressed, through the use of nature. NBS are recognised for their potential to build UR to both short-term (e.g. natural disasters such as flooding) and long-term UC (e.g. climate change) (Nesshöver et al 2017). The emergence of the COVID-19 virus at the beginning of 2020 has placed further pressure on the resilience of cities, resulting in lockdowns, quarantines and social distancing requirements. This has emphasized the need for cities to build UR to future pandemics and to other UC. Due to the recognised benefits of nature, the use of NBS to address UC has been reinforced as a result of the pandemic. Additionally, the pandemic has been identified as an opportunity to build back better and address other UC. However, although the potential of NBS is recognised, questions continue to arise regarding the specific role NBS will play and whether discussions around NBS will lead to real, tangible changes being seen in cities.

An extensive need for research on the impacts of the pandemic on cities is required. Currently, very little is known about how the COVID-19 pandemic may have impacted NBS and how the pandemic may have supported or impeded NBS mainstreaming³. This thesis focuses on how the COVID-19 pandemic has impacted on NBS in these five cities across Europe; Barcelona, Győr, Malmö, Newcastle and Utrecht. Three main research questions are asked:

- RQ1: *What impact has the COVID-19 pandemic had on the use of Nature-Based Solutions in cities?*
- RQ2: *How do practitioners and researchers discuss the potential of Nature-Based Solutions to build back better from the COVID-19 pandemic and to other Urban Challenges?*
- RQ3: *How has the COVID-19 pandemic impeded or supported the mainstreaming of Nature-Based Solutions?*
 - RQ3a: *What barriers and enablers existed to the mainstreaming of Nature-Based Solutions prior to the COVID-19 pandemic?*
 - RQ3b: *What threats and opportunities to the mainstreaming of Nature-Based Solutions have arisen as a result of the COVID-19 pandemic?*

Methodology: This thesis adopts a case-oriented research approach performing an in-case analysis of each of the five cities, followed by a cross-case analysis between them. These cities were selected based on their involvement with the NATURVATION project and several other selection criteria. The RQs were formulated following a literature review. To answer these, twenty semi-structured interviews were performed, 8 of which were with practitioners (working in the municipalities of each city) and 12 of which were with researchers (who had worked with the case-study municipalities on NBS). Nineteen interviews were performed online and one interview was performed over the phone. A review of the NATURVATION Urban Nature Atlas⁴ database was also used to identify changes to NBS sites throughout the pandemic and provide information on NBS sites in each city.

¹ Urban Resilience refers to the need for cities to: i) *absorb* changes or stresses; ii) to *adjust* to disasters and shocks without damage to existing relationships and structures; iii) to *adapt* or *transform* to changes and; iv) to *organise, thrive* and *grow* during times of instability and disruption

² Nature-based Solutions refer to actions to protect, sustainably manage and restore natural or modified ecosystems, that allow societal challenges to be addressed effectively, whilst simultaneously providing benefits to human well-being and biodiversity.

³ NBS is still considered a niche solution. Therefore, mainstreaming refers to making the use of NBS as a solution to challenges more conventional or more widely accepted.

⁴ NATURVATION Urban Nature Atlas available from: <https://www.naturvation.eu/atlas>

For RQ1 the NATURVATION Urban Nature Atlas and interviews were used to determine how the COVID-19 pandemic had impacted on NBS in each city. For RQ2 and RQ3 interviews were used to assess NBS potential to UC (RQ2) and threats and opportunities that may have arisen to mainstreaming NBS as a result of the COVID-19 pandemic (RQ3). For RQ2, an analytical framework identifying the most common types of UC NBS can address was used based on the work of Almenar et al., (2021) and Ershad Sarabi et al., (2019). For RQ3, an analytical framework was also adopted that identified barriers and enablers to the mainstreaming of NBS, based on the work of van der Jagt et al., (2020), Ershad Sarabi et al., (2019) and van der Jagt et al., (2017). This helped identify impeding or supporting factors to NBS mainstreaming to be identified both i) prior to the pandemic (RQ3a) and ii) during/following the pandemic (RQ3b). This comparison was required to identify what changes to these factors may have occurred as a result of the COVID-19 pandemic.

Key Findings: Restrictions introduced at the beginning of the pandemic initially led to a decline in the use of NBS; however, following the easing of these restrictions, cities typically saw a substantial increase in the amount of people using urban and peri-urban NBS. This led to a number of unintended consequences; with fewer people visiting sites of NBS towards the beginning of the pandemic, opportunities for the city to rewild were provided. Biodiversity increased due to a lack of maintenance and fewer people using the sites. This was short lived however, with a number of detrimental impacts being recorded following the easing of restrictions related to the COVID-19 pandemic. A substantial increase in the amount of people using sites increased the amount of litter, led to more incidents of accidental fires and disruption to biodiversity as a result of noise and citizens walking off designated parks. Restrictions also limited the amount of work that could be done with NBS between the municipality and other stakeholders due to being moved online. This led to delays with projects and some cancellations as a result of the collaborative components of the NBS process becoming more complex.

The implementation of NBS in each city had traditionally been used to address challenges with water management, biodiversity loss and public health concerns. With climate change acknowledged as an increasingly relevant challenge by each city, work continued with addressing these three UC. In particular, the anticipated increase in the severity, duration and number of floods was identified as motivating municipalities to continue working with NBS. The COVID-19 pandemic had little impact on how municipalities discussed the potential of NBS to address these UC. The pandemic did however, emphasize the potential of NBS to be able to address UC related to public health and the unequal distribution of greenspace. Both aspects had been highlighted by the pandemic, motivating municipalities to mainstream NBS to address these UC. In particular, working with NBS to address UC related to mental health were highlighted; prior to the pandemic NBS were primarily recognised for their physical health benefits e.g. for the ability of NBS to filter toxic air emissions. However, due to restrictions limiting peoples access to nature, the mental health benefits were also emphasized. Restrictions also highlighted the unequal distribution of NBS to some socio-economic groups, especially within the private sphere. This has prompted consideration of how the COVID-19 pandemic could be used as an opportunity to address this.

Participants noted how prior to the pandemic NBS were not prioritised enough in discussions; both by leadership - which resulted in less resources being allocated to mainstreaming NBS - but also by practitioners - making it harder to convince people to mainstream NBS. The pandemic has moved NBS up the agenda and provided more support for integrating NBS projects into developments due to the emphasis of NBS public health benefits. Additionally, an increase in appreciation of nature from citizens could lead to opportunities to implement a number of bottom-up NBS initiatives to green cities and address challenges associated with the unequal distribution of greenspace. Factors that impeded NBS mainstreaming were also

identified, including how NBS are recorded by traditional accounting systems (which typically record NBS as a cost). This larger issue will need to be addressed to support NBS mainstreaming. Monetary valuation techniques were suggested as a method to address this; however, additional research is required to improve the legitimacy of these techniques. For opportunities related to the pandemic to be utilised, more data on the public health benefits of NBS are required, as is the experimentation of NBS projects. A lack of both of these aspects threaten to allow opportunities presented by the COVID-19 pandemic to be fully utilised. Recognition existed that opportunities did exist however, with participants optimistic that this would lead to several changes with how NBS are viewed, discussed and worked with. For some cities this had already led to some tangible NBS projects being implemented and discussions around the further mainstreaming of the concept.

Conclusion: The COVID-19 pandemic has created a number of opportunities which can support the mainstreaming of NBS. Additionally, with the pandemic continuing, the demand and appreciation for NBS from citizens is expected to continue growing. It is hoped that this will prompt municipalities to keep working to mainstream NBS. However, for opportunities presented by the COVID-19 pandemic to be realised, improvements in data monitoring, monetary valuation techniques and citizen participation in projects will be needed. This was reflected in the identification of the five stepping stones required for mainstreaming NBS for public health, which were identified as;

- Alignment with Strategic Priorities
- Facilitating Community-Based Actions
- Advancing Valuation Models
- Improving Data and Monitoring
- Establishing Demonstration Projects.

Practitioners seeking to implement NBS for public health and utilise opportunities presented by the COVID-19 pandemic should pursue the alignment of these five stepping stones.

Limitations of this research were identified with focusing on five cities which were included in the NATURVATION project, as all had worked with NBS in the past. Additionally, a focus on practitioners and researchers was recognised as leaving out other stakeholders which have an important role in NBS mainstreaming in cities. Thus, future research could attempt to cover other stakeholders and measure their views on NBS. Opportunities also exist to explore how cities that have less experience with NBS may have been affected by the COVID-19 pandemic; for example, questions could focus around i) whether an increase in public value for nature can also be identified within cities that traditionally have lower per capita rates of greenspace – and to what extent this has influenced demand for greenspace. Questions could be asked covering cities across a wider geographical context (including those outside of Europe), or socio-economic context to allow a more comprehensive understanding of how the COVID-19 pandemic could be used to increase NBS in the city to be generated. As a relatively recent phenomenon however, there is a need for research related to several aspects of the impact of COVID-19 on NBS. This research has only touched the tip of what is a new and emerging field of research needed to explore how the COVID-19 pandemic has impacted, and may impact, on cities.

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Abbreviations

COVID-19- SARS-CoV-2

EC- European Commission

ED- Eco-system Disservices

EU- European Union

ICLEI- International Council for Local Environmental Initiatives

IUCN- International Union for Conservation of Nature

OECD- Organisation for Economic Cooperation and Developments

NBS- Nature-Based Solutions

NGOs- Non-Governmental Organisations

RCN- Resilient Cities Network

SDGs- Sustainable Development Goals

TMNs- Transnational Municipal Networks

UC- Urban Challenges

UN- United Nations

UR- Urban Resilience

WHO- World Health Organisation

WWF- World Wildlife Fund

1 Introduction

By 2030, 60% of the world's population is expected to live in cities, with this increasing by a further 10% by 2050 (United Nations, 2018). This urbanisation is expected to intensify the number and magnitude of Urban Challenges (UC) that cities are exposed to; challenges including poverty, poor public health and biodiversity loss (Keivani, 2010). UC will be further exacerbated by the results of climate change. Rising global temperatures are expected to increase sea levels, the number and magnitude of extreme events such as floods, droughts and storms increasing and the faster and wider spread of tropical diseases and viruses, placing additional pressure on public health (Almenar et al., 2021; Kabisch et al., 2016). Thus, the need for cities to address UC and reduce risks through enhancing the resilience of vital infrastructures, whilst also tackling increasing greenhouse gas emissions, is critical (Bush & Doyon, 2019; United Nations, 2019).

In pursuing resilience, cities are frequently exploring the concept of Urban Resilience (UR) (Sanchez et al., 2018). More recent definitions refer to this from a systems perspective, captured by Meerow & Newell (2019, pg.39) who interpret resilience as “*the ability of an urban system - and all its constituent socio-ecological and socio-technical networks - to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity*”. Thus, the concept has come to capture the need for urban systems to be able to thrive during and following times of instability. But for cities to adapt and become more resilient different forms of governance and collaborations between different stakeholders from around the world will be required (Collier et al., 2013; Frantzeskaki et al., 2017; Shamsuddin, 2020). Additionally, new technologies, innovations and tools will need to be utilised to enable cities to adapt and achieve flexible systems of resilience (Jha et al., 2013; Sanchez et al., 2018).

In response to UC, cities are increasingly incorporating “nature” into solutions to improve UR (Lafortezza et al., 2018). Nature-Based Solutions (NBS) is one of such tools, going beyond traditional ecosystem management to address UC. NBS are often inspired by, imitated from or supported by nature, ranging from the direct utilisation of natural system processes to more engineered solutions that involve some level of human intervention to utilise natural processes (Depietri & McPhearson, 2017). In covering a wide range of different forms, NBS have become an umbrella term for other related concepts such as green and blue infrastructure (Dorst et al., 2019; Nesshöver et al., 2017; Pauleit et al., 2017), ecosystem services (Escobedo et al., 2019; Keesstra et al., 2017; Potschin et al., 2016), ecological engineering (Dhyani & Thummarukuddy, 2016; Pauleit et al., 2017) and eco-system based approaches (Pauleit et al., 2017; Renaud et al., 2016). Due to the common issues these concepts address, they both overlap and complement each other (Pauleit et al., 2017).

Numerous applications of NBS addressing UC already exist in various cities across the world. Examples include the planting of trees and plants along streets to capture rainwater and reduce the risk of flooding; the use of green roofs to address air quality issues, improve biodiversity and reduce urban temperatures; and the regeneration and construction of parkland to provide spaces for citizens to socialise and exercise, improving both physical and mental health (See Appendix A for a more comprehensive list of the types of NBS) (Bayulken et al., 2021; Staddon et al., 2018). Municipalities play a key role in the planning and implementation of these NBS due to the strategic direction and resources they provide (van der Jagt et al., 2017b). Compared to NBS, conventional approaches to addressing UC have often focused on the use of grey infrastructure (sea walls to protect spaces from flooding, etc.) however, these typically address one specific challenge without providing additional environmental or social benefits. In contrast, NBS are recognised for utilising nature to address multiple challenges, whilst also providing simultaneous environmental and social benefits, e.g. by addressing long-term challenges such as

climate change (Bush & Doyon, 2019; Nesshöver et al., 2017). NBS can typically provide these benefits at a lower-cost whilst also helping to build long-term UR (European Commission., 2014). As a result, NBS have been promoted as an effective solution to numerous UC by the European Union (EU) e.g. via the European Green Deal, which emphasizes the need for climate-proofing, resilience-building and prevention and preparedness. Investment in NBS is acknowledged as a key component of these strategies (European Commission, 2019).

Interest in NBS has grown further since the emergence of the new coronavirus SARS-CoV-2 (COVID-19). Since its identification in early 2020, the COVID-19 virus has swept across the World leading to a full-scale pandemic and bringing devastating consequences (Singh & Singh, 2020). Cities in particular have been hit hard, with 90% of reported cases taking place in urban areas (United Nations, 2018). This has placed enormous pressure on the resilience of cities, with many showing a clear lack of the basic capacities required to be able to respond to disasters (Sharifi & Khavarian-Garmsir, 2020). In an attempt to contain the virus, cities have adopted a variety of responses that intend to reduce human interaction including prohibiting private and public gatherings, restricting public transportation, imposing strict curfews and even complete lockdowns enforced in some cities (European Centre for Disease Prevention and Control, 2021). But whilst the COVID-19 pandemic continues, attention has begun to turn to how cities can build back better; both to future pandemics and to other UC (OECD, 2020; WHO, 2021).

The COVID-19 pandemic has prompted a reassessment of how cities are planned and designed (Sharifi & Khavarian-Garmsir, 2020). The need to not only recover from the pandemic but to also build back better and improve urban sustainability has been highlighted by a number of different actors (OECD, 2020; WHO 2020; WWF, 2021). Thus, focus has turned to the opportunities the COVID-19 pandemic has presented to adapt city infrastructure to become more resilient (OECD, 2020; WWF, 2021). In recognition of the multiple benefits NBS can provide, the mainstreaming⁵ of the concept in cities has been suggested as a potential solution to increase UR; to the impacts of the current pandemic, future pandemics and to other UC such as climate change. However, although the potential of NBS has been recognised in building UR, questions continue to arise as to the specific role NBS could play and whether discussions around NBS as a result of the COVID-19 pandemic will lead to real, tangible changes being seen in urban development⁶ (Lee et al., 2020).

1.1 Problem Definition

Although the potential that NBS have to be able to address UC has been recognised, there remains a gap between the theoretical benefits of the concept and the actual possibilities of implementing and utilising NBS in urban development (Albert et al., 2020). To address this, the EU Research and Innovation policy agenda has emphasized the need to strengthen both the knowledge base on NBS and identify capacities to improve the up-scaling and replication of NBS (European Commission, 2020b). Projects exploring these aspects have been supported through the Horizon 2020 fund for Research and Innovation (European Commission, 2013). NATURVATION⁷ is one of such projects, with the aim to gain a better understanding of the potential of NBS and how the concept can be mainstreamed within cities, through identifying potential barriers and enablers (European Commission, 2021b). But whilst an increasing amount of knowledge has been attained on NBS and the potential barriers and enablers that exist to implementation - both as a result of the NATURVATION project and other EU related

⁵ NBS is still considered a niche solution. Therefore, mainstreaming refers to making the use of NBS as a solution to challenges more conventional and more widely accepted.

⁶ Urban Development refers to the improvement of an urban area through building.

⁷ NATURVATION project has been funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730243. For details see: <https://naturvation.eu/>

projects (Green Surge, Grow Green, Nature 4 Cities etc.) - very little is currently known about how the COVID-19 pandemic may have impacted NBS (Nature4Cities, 2019; Olafsson, 2019); how NBS are being re-imagined as a result of the pandemic has yet to be explored, with even less known about how the pandemic may have supported or impeded NBS mainstreaming. Thus, research is required to explore whether any opportunities have arisen to overcome barriers and exploit enablers to mainstream NBS further. This research will attempt to identify this and contribute to knowledge on the design-implementation gap, through exploring opportunities and threats to NBS mainstreaming through the lens of the COVID-19 pandemic.

In exploring this, this research is intended to enable researchers to better understand the impact of the COVID-19 pandemic on cities. As a relatively recent phenomenon, there is an extensive need for research in several areas relating to the COVID-19 pandemic and how it has affected urban development. Current literature has mostly focused on exploring the short-term impacts of the pandemic from a public health perspective or exploring other environmental impacts such as air quality changes (Cheval et al., 2020; Kumari & Toshniwal, 2020; Sharifi & Khavarian-Garmsir, 2020). Thus, a better understanding of how the pandemic has impacted on cities in the long-term is required, specifically exploring how urban development may have been impacted. Exploring the impact of the pandemic on NBS forms one aspect of this and will provide some indication as to the long-term impacts of the pandemic.

Despite recent studies exploring how access to greenspace can improve UR to pandemics, the contribution NBS can make has not yet been directly investigated. Recognition does exist however, primarily in grey literature in which NBS have been recognised as limiting the spread of viruses through providing open spaces that improve ventilation, air quality and physical and mental wellbeing (Harvey, 2020; McGrath et al., 2020; Mell, 2020; Thompson, 2020). Recognition also exists by a range of actors such as Transnational Municipal Networks (TMNs) and international organisations such as the International Union for Conservation of Nature (IUCN) and the World Wildlife Fund (WWF) (IUCN, 2021; WWF, 2021). These actors have identified recovery strategies for the COVID-19 pandemic as an opportunity to implement tools and processes which can facilitate UR and sustainability within cities; for example, strategies highlighted by C40, the International Council for Local Environmental Initiatives (ICLEI) and the Organisation for Economic Cooperation and Developments (OECD place NBS as a core method to recover sustainably from the pandemic and increase UR to climate change. NBS are framed as a solution-to-all in being able to provide green jobs, address greenhouse gas emissions and improve public health (C40 Network, 2020; ICLEI, 2020; OECD, 2020). However, although this opportunity has been acknowledged by several actors, a lack of knowledge exists on whether municipalities are intending to utilise any opportunities created by the COVID-19 pandemic and if they are, how. Little research has explored how municipalities are discussing NBS in response to the pandemic; whether there is increased support for measures and whether this could materialise into tangible changes within cities. Given the position municipalities are in to influence the number of NBS projects occurring in cities, this research also intends to explore how municipalities are discussing NBS due to the COVID-19 pandemic.

1.2 Research Questions

The overall aim of this thesis is to explore whether the COVID-19 pandemic has provided opportunities to mainstream the NBS concept in five cities based across Europe; Barcelona Győr, Malmö, Newcastle and Utrecht. These five cities have been identified based on their geographical, political, demographic and economic differences, and due to their involvement with the NATURVATION project.

Based on this, three research questions (RQ) have been formulated to guide the research;

RQ1: *What impact has the COVID-19 pandemic had on the use of Nature-Based Solutions in cities?*

To understand what opportunities the COVID-19 pandemic has presented to mainstream NBS an understanding of how the pandemic has impacted NBS in each city will need to be understood.

RQ2: How do practitioners and researchers discuss the potential of Nature-Based Solutions to build back better from the COVID-19 pandemic and to other Urban Challenges?

Identifying the UC that are being discussed by practitioners and researchers will provide an indication of how the COVID-19 pandemic may have impacted on how people are discussing the ability of NBS to address specific UC.

RQ3: How has the COVID-19 pandemic impeded or supported the mainstreaming of Nature-Based Solutions?

RQ3a: What barriers and enablers existed to the mainstreaming of Nature-Based Solutions prior to the COVID-19 pandemic?

RQ3b: What threats and opportunities to the mainstreaming of Nature-Based Solutions have arisen as a result of the COVID-19 pandemic?

This RQ seeks to identify how the COVID-19 pandemic has impacted the mainstreaming of NBS in cities. Before exploring how the pandemic has impacted these, an understanding of factors that impeded (barriers) or supported (enabled) the mainstreaming of NBS **prior** to the pandemic will be required (RQ3a). This will provide a benchmark and allow a comparison of how the pandemic may have impeded (threats) or supported (opportunities) the mainstreaming of NBS to be identified (RQ3b).

1.3 Scope

To answer the RQs identified it was determined that the five cities which are partners of the NATURVATION project would be used as the case-study cities to be researched: the rationale for selecting these cities has been provided in the methodology under section 3.4.. All cities classified as Urban Regional Innovation Partners (URIPS) of the NATURVATION project are located in Europe and thus, the geographical focus of this research will be on cities based in Europe. All five cities are spread out across the continent with each city located in a different geographic and climatic context. This variation between cities was intentionally chosen to explore the different perspectives on NBS in different contexts across Europe. Furthermore, the choice to focus on the five URIP partner cities was made based on the following criteria; i) differences in the COVID-19 pandemic response, ii) variations in the context of each cities (population density etc.), iii) access to available material in English and iv) access to established contacts working at the municipalities which provided an opportunity for interviews.

From each city 3 or 4 individuals were interviewed; participants included those working at the municipality or in a research position working in partnership with the municipality. For the context of this research a municipality was defined as the urban administrative authority having corporate status and powers of self-government over an area. This differs to a city which is used to describe an area of a large physical human settlement (Dijkstra et al., 2019). A list of criteria was created to identify relevant municipalities which should be included in this research; this primarily focused on municipalities which had been included in one of the major EU research and innovation programmes on NBS however, access to participants was also considered.

Further clarification of the conceptual boundaries of the research are required by defining the concept of NBS. Although increasingly referred to in both academic literature and policy documents several definitions of NBS exist (a review of definitions can be seen in Appendix B).

For the purpose of this research a broader definition of NBS has been taken from the European Commission (EC). This definition has also been utilised by the project this research intends to contribute to; The NATURVATION project (NATURVATION Project, n.d.). Although this definition of NBS has been defined as the conceptual boundary it should be noted that interviews also highlighted overlapping concepts and the participant used these interchangeably.

The temporal scope of this research was a fixed time period; interviews were performed between February and April and thus the bulk of the data collected represents attitudes and perspectives during this time period. Due to the changing nature of the COVID-19 pandemic, it is therefore acknowledged that this research captures attitudes and views that may later change. Background information (secondary data) providing context on the city was collected during this same period although this includes data that dates back to when the analysis of cities and NBS projects were performed by researchers on the NATURVATION project i.e. between 2017-2020. Despite the time difference it was still deemed relevant to include this data in the study as this provided context to NBS in each of the case-study cities.

1.4 Ethical Considerations

Consideration was given to identifying potential risks that may occur throughout the research process and beyond the publication of findings. All risks identified were addressed through various mitigation techniques (see Appendix C for a full outline of risks identified).

As numerous interviews were performed the potential harm to participants was assessed; minimal harm was anticipated; however, several procedures were implemented to address any concerns. All participants involved in the research did so on a voluntary basis and were informed of the opportunity to withdraw from the study at any stage of the research process. A description outlining the nature of the research and how findings would be used was also provided to ensure that participants were accurately informed about the purpose of the research. Participant anonymity was also applied throughout as it was recognised that participants may prefer to remain anonymous. Thus, participants included in the study have not been named or directly referenced; instead a reference number for each participant has been used. Recordings made of each interview were stored ONLY on the authors laptop (this excluding cloud services) which is password protected. No notes, transcripts or guides identified the respondent directly. This ensured that any issues with data security were further addressed. This information was communicated to participants at several stages of the research process including at;

1) The Introduction to the Research Project

During the initial email, participants were notified about the purpose of the project through an information document. Consent was attained through a Consent Form (See Appendix D) which informed participants that their involvement was voluntary.

2) The Interview Briefing (as seen in Appendix E)

Prior to the interview beginning, a 2-minute verbal briefing was presented to the participant to reiterate the purpose of the research and the participants right to withdraw. Consent to record the interview was also confirmed.

3) Interview De-brief (as seen in Appendix F)

A written email was sent to participants outlining how the data would be stored and analysed. The participants position on anonymity was also reiterated.

4) Final Publishing of Results

Lastly, if any quotations were made linking back to a particular participant, email consent was requested before the publishing of the thesis.

High methodological standards were ensured through the review of methods by the thesis supervisor and other peers. Although supported by the NATURVATION project, the thesis was written and developed by the author independent of any external organisation. Thus, the conclusions drawn from the research are exclusively the result of the authors own interpretation.

1.5 Audience

The impacts of the COVID-19 pandemic on cities remains relatively unexplored due to its recentness. Thus, this research serves a broad audience, contributing to an emergent literature theme which explores the long-term implications of the COVID-19 pandemic on cities and urban development. This study intends to provide insights to researchers of the NATURVATION project, case-study municipalities studied and urban planners on how NBS are being discussed during the COVID-19 pandemic. It is hoped that an exploration into how municipalities are discussing NBS will provide an indication as to whether the pandemic could, or already has, provided an opportunity for NBS mainstreaming. Additionally, it is hoped that the identification of impeding or supporting factors to NBS mainstreaming that may have arisen as a result of the COVID-19 pandemic could facilitate NBS mainstreaming. Thus, this research will also be of relevance to all agents interested in facilitating NBS implementation in cities; researchers, municipalities, policy makers, TMNs and actors in the non-profit sector.

1.6 Disposition

The structure of this research paper is outlined below;

Chapter 1: Introduction provides background to the research topic outlining the problem definition, the aim and research questions, the scope and ethical considerations.

Chapter 2: Background and Literature Review presents a review of literature on UC, UR and NBS. The overlap between these concepts is then explored, with how NBS can address UC and build UR outlined. Barriers and enablers to NBS implementation are then reviewed, with the theme of the COVID-19 pandemic then discussed.

Chapter 3: Methodology explores the methods adopted to collect and analyse the data. It presents the case-oriented research design and explains the process of the case-study city selection process, conducting the interviews, data coding and analytical frameworks adopted.

Chapter 4: Results presents the findings collected from the interviews and review of the NATURVATION Urban Nature Atlas database. The section is divided into each city, exploring the cities response to the COVID-19 pandemic and how response impacted NBS. An exploration of how each city views NBS potential to UC, barriers and enablers to NBS implementation and the threats and opportunities to NBS are then outlined.

Chapter 5: Discussion connects the RQ to the description and analysis of the data. Through the in-case and cross-case analysis of cities, the impact of the COVID-19 pandemic on NBS are discussed. The potential of NBS to address UC is then explored using a analytical framework. An analytical framework is also adopted to discuss the barriers, enablers (prior to the pandemic) and opportunities and threats (during and expected in the future) to mainstreaming NBS.

Chapter 6: Conclusion summarises the main conclusions of the thesis in relation to each RQ. Practitioner recommendations are then made with the stepping stones required for mainstreaming NBS for public health discussed. The limitations of the study are then outlined with suggestions for future research then made.

2 Background and Literature Review

This literature review is intended to provide background on the major concepts covered by the research; thus, this chapter is split into sections exploring: 1) UC and UR; 2) NBS and their role in UR and; 3) the COVID-19 pandemic and the impact on UR in cities. The final section pulls these three concepts together to discuss how NBS could be used to increase UR to the COVID-19 pandemic, future pandemics and other UC such as climate change.

2.1 Urban Challenges and Urban Resilience

UR is increasingly discussed by municipalities but the question remains; what should cities do to become resilient? And how? This section will explore the various UC cities are exposed to and how municipalities have responded to address these.

2.1.1 Urban Challenges and city response

Cities globally are frequently having to adapt to an ever-increasing number of UC; factors that limit or compromise the capacity of urban areas to respond and conserve, protect, and adapt infrastructures and systems (Keivani, 2010; Almenar et al., 2021). Whilst the existence and magnitude of these is notably context specific, many cities share exposure to similar types of UC, related primarily to increasing urbanisation and a rapidly changing climate (Almenar et al., 2021). UC can relate to both sudden shocks including natural disasters (e.g. floods, droughts) and to gradual stresses such as climate change or resource depletion. These are both the result of, and are expected to be exaggerated by, urbanisation, climate change and globalisation (Tall & Brandon, 2019; Zimmermann et al., 2019). The number of and significance of these UC has been explored extensively in research. Almenar et al., (2021) provides one of the most comprehensive studies on this through the review of over 300 documents from contexts around the world. In doing so, a list of 18 UC and 58 associated sub-challenges are identified. Recognition is given to how different types of UC and how these are prioritised differ within certain contextual conditions; however, some indication of the most common UC are identified, including physical health (39% of papers), mental health (29%), climate change (29%), water management (22%) and the urban heat island effect and heatwaves (15%).

These challenges have also been recognised by several international organisations; agendas from the United Nations (UN) Sustainable Development Goals (SDGs) and the OECD Sustainable Cities have brought attention to UC, provided access and information to allow cities to address these and further encouraged cities to achieve ambitious goals to address challenges (OECD, 2018; United Nations, 2016). Regionally, bodies such as the EU have also adopted various agendas to address UC and promote sustainable cities. The EU's Urban Agenda outlines several priority areas for cities to address, with the EU committing to the passing of better laws, improving funding programmes and creating opportunities for sharing knowledge to aid cities in tackling UC (European Commission, 2020b). Thirteen “priority themes” are outlined (as seen in Figure 2-1) reflecting various UC cities are encouraged to address.

Whilst being the hotspot for UC, cities are also recognised as centres of commerce, scientific research and innovation providing access to resources and opportunities to effectively address UC (Hammett, 2020). Additionally, part of the solution to addressing UC lies in how cities are planned, governed and provide services to citizens (United Nations, 2020). As a result, cities are increasingly innovating with socio-technological systems, funding mechanisms and different forms of governance to address UC. Through combining different approaches, cities are addressing a number of UC simultaneously; for example, several partnerships within cities have provided funding opportunities to identify new tools to allow natural disasters, biodiversity loss and climate change to be addressed (Bush & Doyon, 2019; Shamsuddin, 2020). Thus, numerous initiatives now seek to not only resolve a single urban challenge, but tackle multiple challenges through the design of cities that are sustainable, responsive and adaptive – to build cities that

are resilient – both to the UC currently identified, but also to those currently unanticipated that may arise.

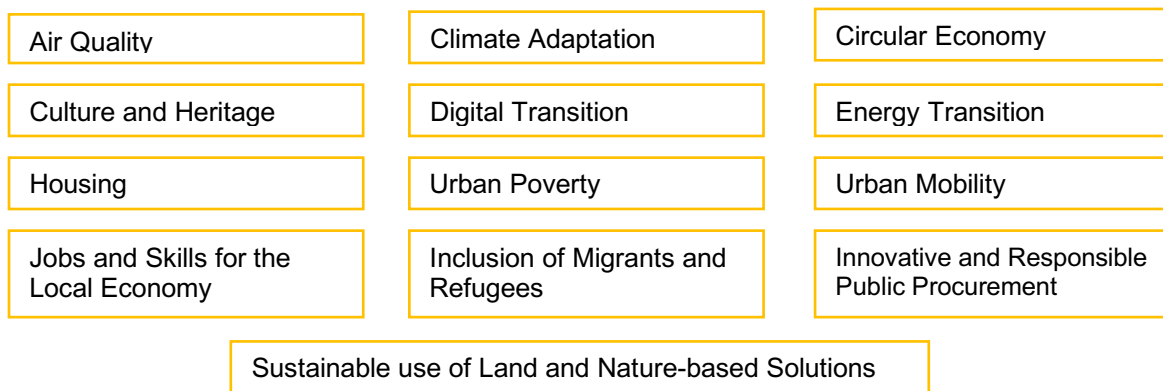


Figure 2-1. European Commission Urban Agenda; Priority Themes for Cities

Source: Priority areas identified from European Commission, (2020b)

2.1.2 Urban Resilience

In recognition of the increasing magnitude, frequency and duration of the UC cities are exposed to, and in alignment with local, national and international aims and targets, cities are increasingly pursuing the concept of UR (Jha et al., 2013; Meerow & Newell, 2019; Staddon et al., 2018). The term has come to emphasize the need for cities to: i) *absorb* changes or stresses; ii) to *adjust* to disasters and shocks without damage to existing relationships and structures; iii) to *adapt* or *transform* to changes and; iv) to *organise, thrive* and *grow* during times of instability and disruption (Bush & Doyon, 2019). The latter aspects have been emphasized more recently as the term has developed, with the need for flexible and adaptive systems becoming more prevalent as the unpredictability and magnitude of UC increases (Shamsuddin, 2020). In literature, attention is given to both the short-term recovery to challenges including flooding, and to long-term resilience which describes the need for cities to become more adaptive and flexible to challenges including climate change. Although acknowledged as vital for cities, long-term resilience is typically more complex to develop due to requiring policy-makers to envisage future land-uses and technologies and commitment to strategies which is typically complex due to short-term electoral cycles. This is presented by Sanchez et al., (2018) who present one of the more comprehensive reviews of UR literature (reviewing content across several contexts), to identify recovery from short-term disasters (flooding etc.) as providing opportunities to re-build cities into an optimised or improved system – or “bounce forward”.

As municipalities attempt to build UR to different UC (shocks and stresses etc.) a number of initiatives have been launched at international, regional and local levels to enable key building blocks of resilience to be identified and shared (European Commission, nd). In acknowledging that building UR could provide opportunities to reduce the environmental impact of cities (and the contribution they make to climate change) a number of TMNs promote opportunities for cities to build UR to both shocks and stresses, whilst also reducing their environmental impact. Organisations such as the International Council for Local Environment Initiatives (ICLEI), the Resilient Cities Network (RCN), the C40 network and Eurocities provide cities with advice to develop new resilience strategies by providing knowledge on indicators, practices, financing and platforms to address UC and reduce environmental impacts (C40 Network, 2021; Eurocities, 2021; Hammett, 2020; ICLEI Global, 2020.). A number of TMNs, and other agents, have highlighted the use of nature to tackle UC – although arguably not innovative, their application within the urban environment to address particular challenges has re-arisen as a recent concept in planning discussions (C40 Network, 2020; ICLEI, 2020; Resilient Cities Network, 2020). This

is notably the result of growing recognition that the application of nature in cities provides multiple benefits and contributes to multiple aspects of building UR (Cohen-Shacham et al., 2016; Laforteza et al., 2018). In particular, the use of NBS as a solution to short-term and long-term UC has become more widely acknowledged (Sanchez et al., 2018).

2.2 Nature-Based Solutions (NBS) in cities & their role in Urban Resilience

In growing recognition that NBS play an important role in building UR, this section explores NBS and the different UC they can address. This section begins by exploring the concept of NBS and how their application can build UR in cities. How municipalities work with NBS is then discussed with a review of the barriers and enablers to the implementation of NBS explored. The section finishes by discussing NBS mainstreaming. In exploring these themes, context is provided on how NBS have been discussed and implemented prior to the COVID-19 pandemic. Thus, establishing this background intends to provide some indication as to how the pandemic may have changed how municipalities are discussing and working with NBS. Relevant literature has also been drawn on to form an analytical framework to guide the collection of the data for RQ2 and RQ3 (discussed further in section 3.7).

2.2.1 NBS & overlapping concepts

Although the purpose of this research is not to explore the definition or the discourse of the NBS concept, some clarification is required due to the varying definitions of NBS that exist in research. Thus, a review of various definitions was performed (see Appendix B) with the definition proposed by the EC (European Commission, 2020a) being adopted for this research as a result of; i) the broadness of the definition making it relevant to multiple disciplines; ii) the explicit acknowledgement that NBS can be used as an effective strategy to increase the resilience of cities and; iii) the acknowledgement of NBS as an umbrella term for other concepts (Table 2-1). This highlights how NBS overlaps with concepts such as green infrastructure and ecosystem-based services, concepts more commonly understood by several municipalities due to departments working with other concepts for longer (Dorst et al., 2019; Nesshöver et al., 2017).

For this project, NBS has been defined as *“...solutions to societal challenges that are inspired and supported by nature, which are cost-effective, provide simultaneous environmental, social and economic benefits, and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions”*

Table 2-1. Overlapping concepts with NBS

Concept	Description
Ecosystem-Services	Interventions designed to supply immediate, and long-term, ecosystem-based benefits for human wellbeing whilst helping to ensure sustainable provision of ecosystem services (Escobedo et al., 2019; Keesstra et al., 2017).
Green Infrastructure	A strategically planned network of natural/semi-natural areas with other environmental features designed to deliver a range of ecosystem services' in rural and urban settings (Dorst et al., 2019; Nesshöver et al., 2017).
Natural Capital	Approaches based upon valuing and sustaining the finite capacities of the living and non-living assets of the natural environment by seeking to minimize/prevent environmental degradation (Almenar et al., 2021).
Ecosystem-Based Management	Focuses on assessing the trade-offs in achieving multiple and competing goals including building upon ecosystem services and the factors that affect the production and delivery of those services (Pauleit et al., 2017; Renaud et al., 2016).

Source: Definitions sourced from Bush & Doyon, (2019).

2.2.2 The use of NBS to improve Urban Resilience

With an increased understanding that NBS provide multiple economic, social and environmental benefits there is emerging research exploring the connection between NBS and UR. Often these studies frame NBS as building UR towards specific UC (Bush & Doyon, 2019); UC related to climate change, coastal resilience, water management and public health are frequently identified as areas where NBS can tackle challenges, this aligning with Almenar et al., (2021) identification of major UC (discussed in section 2.1.1). Ershad Sarabi et al., (2019) provide a summary of these, identifying the UC NBS are most commonly implemented to address - as can be seen in Table 2-2. Through the provision of NBS and their associated ecosystem services, Jennings & Bamkole, (2019) highlight how parklands and other NBS can provide opportunities for recreation and social interaction. These can reduce stress levels and lead to faster recovery from psychological events, whilst increasing community cohesion and physical and mental health (Kolokotsa et al., 2020, Cohen-Shacham et al., 2016). NBS can make urban areas more resilient to natural disasters, such as storms, with green roofs and parks providing spaces to collect stormwater, re-initiate natural sedimentation processes, and mitigating runoff by stabilising slopes (Kabisch et al., 2016; Kiss et al., 2019). NBS have also been identified as providing opportunities for climate change adaptation and mitigation through increased carbon sequestration (Cohen-Shacham et al., 2019) and further reducing pressures on peripheral natural areas; for example, using parkland for wastewater can facilitate carbon sequestration whilst also allowing water to be treated closer to residential sources. This can provide closer-to-home recreational opportunities that diminish the need to travel for contact with nature, and address UC by improving air quality and reducing the urban heat island effect (Burlington, 2017; Kolokotsa et al., 2020).

In addition to the recognition that NBS can address different UC, their ability to also build resilience to gradual changes, chronic stresses, sudden changes or imminent disasters (or a combination of them all) has further added to their increased recognition (Bush & Doyon, 2019; Jennings & Bamkole, 2019). However, whilst often identified as addressing particular challenges, in application NBS allow UR to be built to a number of these simultaneously. For example, the provisions of parklands in cities can act as buffers to natural disasters such as flooding, provide spaces for socialising which can increase public health and also provide carbon sequestration services to reduce city CO2 emissions (Depietri & McPhearson, 2017; Elmqvist et al., 2015). The simultaneous benefits of NBS have been captured by Bayulken et al., (2021) who provide a comprehensive study exploring NBS. Findings from the review identify four particular areas of interest in which NBS can effectively, and simultaneously, contribute to UR; these include improving urban quality-of-life, resilience in the context of climate change, improved waste management and improved water quality. Staddon et al., (2018) explores additional solutions; these include: green corridors to increase biodiversity, green roofs for climate change adaptation and to reduce urban temperatures (through reducing the heat island effect); the regeneration of abandoned industrial land by afforestation or park creation; rain gardens for stormwater regulation and parks and lakes for promoting human health (Lafortezza et al., 2018).

Table 2-2. Types of UC NBS are most commonly employed to address in Cities

Climate Change Mitigation and Adaptation	Water Management
Coastal Resilience	Green Space Management
Air Quality	Urban Regeneration
Participatory Planning and Governance	Social Justice and Social Cohesion
Public Health and Wellbeing	Economic Opportunities and Green Jobs

Source: UC identified from Ershad Sarabi et al., (2019).

Compared with conventional, engineered adaptation measures – such as grey infrastructure – that are often associated with higher costs, inflexibility and conflicting interests, NBS are more cost-effective and flexible (Bush & Doyon, 2019). As a result, NBS can often effectively address UC for a longer period of time and at a lower cost than grey infrastructure. Additionally, NBS also typically act as decentralised, distributed systems of infrastructure service provision, which are usually inherently more resilient than large, centralised grey infrastructure (Kiss et al., 2019; Laforteza et al., 2018). These aspects have further contributed to the growing recognition of the concept to building UR by municipalities however, despite this, a gap remains between the theoretical benefits of the concept and actual implementation (Albert et al., 2020). Kabisch et al., (2016) identify a lack of understanding on how specific urban NBS can lead to particular benefits as contributing towards this implementation gap. Additionally, research exploring what barriers exist to NBS implementation in specific contexts is needed to further encourage municipalities to work with NBS. Complexities also arise with how municipalities engage with NBS in terms of integrating the concept into discussions, planning and the implementation of projects (Almenar et al., 2021; Albert et al., 2019).

2.2.3 Municipality engagement with NBS

Municipalities are increasingly working with NBS as a result of exposure to UC and local ambitions to tackle certain UC and goals in multi-level governance. At an international level, initiatives such as the SDGs encourage Sustainable Cities whilst, within the EU this has been adopted into several initiatives including the Urban Development Network and SMART cities (European Commission, 2021a). Additionally, a number of targets have been outlined in relation to climate change and biodiversity which place additional pressures on member states, their cities and each municipality, to address UC and reduce greenhouse gas emissions and biodiversity loss. The promotion of these initiatives by the EU has also led to several policies being implemented at a national level which outline requirements – to varying degrees – which further encourage municipalities to adopt NBS (European Commission, 2021b).

In engaging with NBS, municipalities are typically interacting with new forms of urban governance and partnerships (Kiss et al., 2019; van der Jagt et al., 2017b). When attempting to implement NBS into urban areas, knowledge from policymakers, researchers, urban planners and citizens should be explored to enable relevant UC to be addressed and innovative solutions to be identified (van der Jagt et al., 2017). This requires new forms of collaboration that utilise knowledge between cross-departmental functions of the municipality and partnerships with external stakeholders. During the consultation process, facilitating public participation with various stakeholders such as neighbourhood associations, NGOs, researchers and community representatives is vital to ensure NBS are effectively implemented (Nesshöver et al., 2017). Additionally, ensuring that NBS are brought into discussions during the planning process is imperative both by having a representative of NBS who pushes the concept in discussions but also through alignment with policy documents that call for active participation from different stakeholders. For example, in some municipalities NBS may only play a marginal role within strategic planning documents making it harder to draw attention to NBS during the consultation and planning process. In response to this, some national level policies and instruments have been implemented to promote different forms of public consultations at the local level. This can improve opportunities for partnerships and transdisciplinary collaborations during the NBS process, aiding the development and implementation of NBS (Kabisch et al., 2016; Nesshöver et al., 2017).

An additional outcome of the EU policy agenda on sustainable cities has also been the introduction of a number of EU research and innovation programmes which place NBS at the core of sustainable cities; various projects including Nature4Cities and NATURVATION explore NBS implementation in different contexts (Nature4Cities, 2019; NATURVATION Project, n.d.). For the NATURVATION project, particular attention is given to exploring how

municipalities work with NBS to identify specific methods, tools and processes which support NBS implementation, whilst also attempting to identify barriers that impede implementation. This has contributed to a number of partnerships between different stakeholders in various cities to discuss, plan and implement NBS. Researchers of the project work with individuals within departments of the municipalities (planning departments, park management etc.) to facilitate NBS implementation and identify opportunities for mainstreaming the concept (NATURVATION Project, 2021a, 2021b, 2021c).

2.2.4 Barriers and enablers to NBS implementation

In response to the growing recognition of NBS as an effective solution to multiple UC and several complexities with mainstreaming NBS, research has attempted to identify barriers to NBS implementation and identify factors, known as “enablers”, that can support mainstreaming (Ershad Sarabi et al., 2019, 2020; Wamsler, et al., 2020). Some studies have assessed these factors in specific contexts acknowledging the wider cultural, social and economic environment (O’Donnell et al., 2017), whilst others have attempted to summarise the most common barriers and enablers through the review of multiple case studies (Almenar et al., 2021; van der Jagt et al., 2017). Ershad Sarabi et al., (2019) provides one of the more comprehensive studies exploring this, listing the most common types of barriers and enablers found in NBS implementation. Barriers such as: i) uncertainty regarding the NBS implementation process; ii) uncertainty regarding the effectiveness of NBS solutions and; iii) inadequate financial resources are identified as the most common barriers whereas: i) partnerships amongst stakeholders; ii) effective monitoring and evidence and; iii) monetary valuation systems of NBS are identified as the most common enablers. A full list of these can be viewed in Table 2-3.

Table 2-3. Common barriers and enablers to NBS mainstreaming

Barriers	Enablers
Inadequate financial resources	Partnerships among stakeholders
Path dependency	Knowledge sharing mechanisms and technologies
Institutional fragmentation	Economic instruments
Inadequate regulations	Plans, acts and legislations
Uncertainty regarding implementation process and effectiveness of the solutions	Education and training
Limited land and time availability	Effective monitoring and valuation systems for implementation process and benefit
	Open innovation and experimentation
	Combining NBS with other urban elements and grey infrastructures
	Appropriate planning and design

Source: Barriers and Enablers derived from (Ershad Sarabi et al., 2019)

Recognition also exists that some factors can act as either barriers or enablers to NBS mainstreaming, depending on context. This is commonly identified for the monetization of the value of nature; typically, concerns arise that any attempt to monetize the services provided by nature may undervalue nature itself (van der Jagt et al., 2017). In contrast however, through monetizing nature NBS is considered more accessible to stakeholders who may otherwise be reluctant to invest into conservation efforts (O’Donnell et al., 2017; van der Jagt et al., 2017). Other factors influencing NBS mainstreaming are also typically context specific, including unwanted, or negative impacts as a result of NBS – commonly referred to in literature as “eco-system disservices” (ED) (Kabisch et al., 2016). Ecological gentrification is an example of this describing how the implementation of greenspace can increase the rate of rents due to the improved attractiveness of an area. This has been linked to some social groups being displaced

and subsequently excluded from any benefits provided by NBS (Faivre et al., 2017; Kabisch et al., 2016).

Research has also explored barriers and enablers to specific challenges, with Kabisch et al., (2016) exploring impeding and supporting factors for climate change mitigation and adaptation. Several factors identified overlap with the general barriers identified by Ershad Sarabi et al., (2019) however, these are prioritised differently. For example, fear of the unknown and the need to gather more evidence on NBS successes are identified but are more prominent in the climate change context. In acknowledging that these factors differ depending on the context and with the primary UC municipalities want to address, research has focused on exploring what factors exist specifically for certain municipal aims or to address certain UC; barriers and enablers in the context of climate change and adaptation are the most common context to have been studied (Ershad Sarabi et al., 2019; Wamsler, et al., 2020); however, research has also explored factors in the context of increasing resilience to natural disasters (Young et al., 2019).

As part of the NATURVATION project, van der Jagt et al., (2017) explores potential factors influencing NBS mainstreaming based on case studies reviewed through the NATURVATION project. Building on this, van der Jagt et al., (2020) discuss these factors within the context of Innovation Systems literature, in which NBS are recognised as promising innovations with the potential to facilitate wider urban transformations. In contrast to listing aspects as either barriers or enablers these are listed as the “variables and factors” required to facilitate a faster transition to a more sustainable society. In doing so, a theoretical framework of urban nature-based innovations system is created, with a more flexible model that acknowledges the different contexts NBS are being implemented in, and the different UC NBS can address. In designing a theoretical framework that allows stakeholders to identify variables and factors that could impede or support NBS implementation, opportunities to mainstream NBS can be identified.

2.2.5 The mainstreaming of NBS in cities

Despite recognition that NBS are critical to addressing UC, the need to shift them from being perceived as “niche” solutions, to “mainstream” solutions, is still required (NATURVATION Project, 2021b). Thus, through the NATURVATION project opportunities for NBS mainstreaming have been explored through the identification of 5 pathways in which various lessons are outlined to aid practitioners in mainstreaming NBS (NATURVATION Project, 2021c). The pathways suggested are based on the systematic collection, analysis and review of NBS mainstreaming across a number of cities and include lessons based on the use of NBS to address Climate Change; Biodiversity Loss; Economic Regeneration; Social Inclusion and the Sustainable Development Goals. Each report explores how the mainstreaming of NBS can be supported through the particular pathway pursued and what is required to support NBS mainstreaming. The pathways are broken down into several “stepping stones”, which highlight actions related to policy, finance or urban development. Based on real-world examples, these stepping stones provide interested parties with knowledge on what key actions are required to mainstream NBS (NATURVATION Project, 2021c, 2021a).

In total, the stepping stones identified in each pathway are summarised as several finance, governance, policy or urban development related aspects that need to be considered – the stepping stones for climate change can be viewed in Figure 2-2 (a full list of the stepping stones can be found in Appendix G). The extent to which one stepping stone is relevant depends namely on the pathway itself; for example, stepping stones prioritised in the climate change pathway may differ to that of biodiversity and/or the social inclusion pathway. Additionally, there are multiple ways stepping stones can be aligned within a pathway depending on what the main aim for mainstreaming is; within climate change different stepping stone alignments depend on whether NBS mainstreaming is to: 1) position NBS as a promising climate strategy; 2) invest in NBS to reduce climate risk; 3) integrate actions towards coordinates climate change

response and wider sustainability benefits and; 4) learn by doing (Tozer & Xie, 2020). In identifying various stepping stones and how they should be aligned, not only are barriers and enablers of NBS acknowledged but several opportunities are identified to mainstream NBS. Additionally, in providing numerous options within each pathway there is an acknowledgement of the differences in cultural, social and economic contexts between cities, as well as the goals each city and municipality wants to achieve.

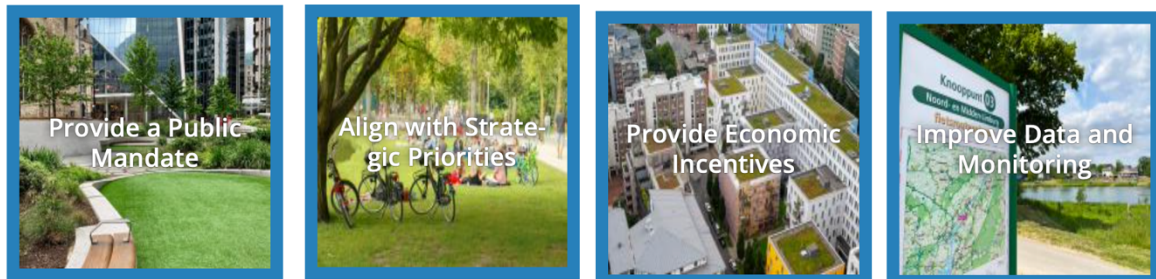


Figure 2-2. Key Stepping Stones required for mainstreaming NBS for Climate Action

Source: Stepping Stones taken from (NATURVATION Project, 2021a)⁸.

As has been acknowledged however, often NBS are implemented to address more than one UC in a particular urban setting. Within the pathways suggested some acknowledgement is given to this with the development of different stepping stone alignments in each of the pathways; however, research has also begun to explore stepping stone alignment for a combination of different pathways; for example, if a municipality wants to introduce NBS to address UC related to both climate change AND a lack of biodiversity (7:A, personal communication, 16th March 2021). Further research is still required to consider other potential combinations of pathways, as is a focus on the alignment of stepping stones required to facilitate NBS implementation to improve public health; poor public health is commonly identified as a major UC (see section 2.1.1) whilst NBS have frequently been cited as being able to effectively address UC related to public health (see section 2.2.2). However, the alignment of which stepping stones are required to facilitate this has not been reported. Thus, further research is required to identify which stepping stones are needed to align for the mainstreaming of NBS for public health. Additionally, due to the COVID-19 pandemic, added interest has been generated around how NBS could address UC related to public health and what stepping stones are required to mainstream NBS for this (7:A, personal communication, 16th March 2021).

2.3 The role of NBS in building Urban Resilience to Pandemics.

In attempting to identify what impact the COVID-19 pandemic has had on cities, this section explores research on current impacts. Studies that explore how COVID-19 has already influenced urban areas are reviewed to establish a knowledge base. Additionally, gaps in current research are presented to highlight the need for research related to COVID-19 and urban design.

2.3.1 The COVID-19 pandemic and Urban Resilience

Whilst continued investment has been made into building up the resilience of cities, the emergence of the COVID-19 pandemic has further highlighted vulnerabilities in urban systems. This has provoked multiple questions around the feasibility of current forms of governance, production, education, consumption, recreation and urban development and further prompted interest in UR post-COVID-19, to future pandemics and other UC (Honey-Roses et al., 2020; ICLEI, 2020; OECD, 2020; Sharifi & Khavarian-Garmsir, 2020). The unprecedented

⁸ Permission to use content related to the Stepping Stones and associated visuals was received by the original author.

disruptions caused by the pandemic have forced reconsiderations into what resilience could look like. A number of “temporary” changes are expected to become a more permanent, “new normal”, influencing how cities operate. For example, the movement from structured work cultures with fixed locations and working hours has transitioned to a more flexible working-from-home type workstyle through laptops and phones (Bayulken et al., 2021). This has led to large expanses of office buildings being left empty for extended periods of time – and if the trend continues following recovery, this could become a permanent change to the fabric of cities. Fewer people in the city centre for work could lead to opportunities to repurpose empty office buildings and the re-emergence of suburbs as city hubs, also providing people with more contact to green infrastructure. Thus, this could lead to opportunities to build UR and engage citizens to protect greenspaces, potentially contributing towards increased UR (Honey-Roses et al., 2020; Rice, 2021; Sharifi & Khavarian-Garmsir, 2020).

Due to the COVID-19 pandemic, a renewed focus on how cities can become more resilient to the spread of viruses and pandemics has arisen; Pisano, (2020) identifies “disruptive factors” that lead to the virus spreading. High population density and social inequalities are identified, both of which result in poor quality housing, poor public environment, poor sanitation facilities, and insufficient ventilation systems. All of these have been linked to increases in outbreak risks and thus, can hinder the prevention and the control of viruses. Furthermore, Pisano, (2020) highlights the connection between poor air quality and COVID-19 deaths, with the scarcity of green open spaces contributing to the spread and intensity of the virus. This is supported by Aggarwal et al., (2020) and Neiderud, (2015), who demonstrate that poor ventilation can lead to higher doses of the virus and thus, lead to more severe reactions to the COVID-19 virus. In identifying these factors, a number of areas are shown where UR could be built to mitigate against the impacts of future pandemics. The inclusion of larger and open spaces in urban design is one of the methods suggested, in recognition that these can be used as temporary storage spots for resources, as patient receiving spots and address challenges of poor ventilation. In contrast, a lack of open space can result in the overall scale of the city’s treatment to be reduced, with the potential for coping with disasters being compromised as a result (Sharifi & Khavarian-Garmsir, 2020). Pisano, (2020) identifies a solution to this; transitioning towards a “15-minute city”, in which all major amenities are accessible to all social groups within 15 minutes. Access to greenspace is included as a fundamental component of this.

Given the type of UC NBS can address and the benefits they can provide, their ability to build UR to pandemics has mostly been speculated, with current research primarily exploring the benefits of access to the broader concept of “nature” during the pandemic (Mell & Whitten, 2021; Pouso et al., 2021; Soga et al., 2021). Although not directly investigating NBS this does provide some indication as to how access to greenspace has contributed, and could contribute, to UR to pandemics such as the COVID-19 pandemic. Of the research that exists exploring the impacts of the pandemic on urban greenspace, discourse surrounding public health is dominant (Ahmadpoor & Shahab, 2021; Gillis, 2020; Rice, 2021; Soga et al., 2021). During the pandemic, lockdowns in a number of countries placed significant pressure on peoples physical and mental health as restrictions prevented people from their day-to-day lives (Pouso et al., 2021). In response to this, a sharp increase in the amount of people accessing greenspace for walking, cycling and running (and other outdoor activities) was identified in cities (Bayulken et al., 2021; Sharifi & Khavarian-Garmsir, 2020; Zander et al., 2020). Both this contact with nature, and the possibility to exercise outside, were identified as helping people cope better with the impacts of lockdown, especially strict lockdowns in urban areas (Pouso et al., 2021).

Whilst the positive benefits of greenspace have been highlighted during the pandemic, this has also shown stark inequalities between various socio-economic groups and access to greenspace. A number of studies have highlighted how citizens living in lower income areas have less access to greenspace, either having to walk further or drive to access this. Additionally, the quality of

the greenspace provided is often worse, being maintained less and leading to less desirable areas to visit (Ahmadpoor & Shahab, 2021; Bayulken et al., 2021; Jabareen & Eizenberg, 2021). In recognition that these areas are also typically more densely populated, attention has turned to how the COVID-19 pandemic could be used as an opportunity to address inequalities with improving access to various services. This is highlighted by Sharifi & Khavarian-Garmsir (2020) who perform one of the few reviews of how the pandemic has impacted cities in the short term but also how impacts could shape future urban design. The authors identify four main areas or urban design where the pandemic has impacted: 1) environmental quality; 2) socio-economic impacts; 3) management and governance and; 4) transportation and urban design. Of these, the most dominant theme (based on the number of studies, not by its relative significance or magnitude) is identified as environmental quality and improvements in water and air quality. The findings identified suggest a need to change how urban design is viewed and include more greenspace in cities to ensure equal distribution (Jabareen & Eizenberg, 2021; Jon, 2021).

For how cities are planned, designed and function, the COVID-19 pandemic has highlighted how significant access to nature can be for the public during times of instability and crisis. The need to conserve existing spaces of nature and provide new areas that facilitate physical exercise and mobility have been emphasized (Ahmadpoor & Shahab, 2021). For example, during the pandemic in many areas total travel by cars decreased with people choosing to bike and walk more (Sharifi & Khavarian-Garmsir, 2020; Zander et al., 2020). This could lead to opportunities to redesign streets to free up space for pedestrians and cyclists, enabling several public health objectives to be addressed (Honey-Roses et al., 2020). The pandemic has also demonstrated how urban green space can provide citizens with a refuge service, both during the pandemic over the short-term, but also in the long-term through enhanced resilience against similar events in the future (Samuelsson et al., 2020). Arguments exist that to facilitate effective social distancing during pandemics, cities need to allocate more space to open public spaces. This may require redesigning streets to increase the amount of nature in cities. Such reconfigurations could also provide opportunities to achieve additional public health, biodiversity and climate change adaptation co-benefits contributing to resilience against other stressors (Rice, 2021).

Although researchers and stakeholders have shared optimism that the COVID-19 pandemic could lead to changes in urban design, little research has explicitly explored what the long-term impacts could be for implementing greenspace and whether municipalities are actually intending to utilise any opportunities that may have been created by the pandemic; and if they are, how? Speculation would suggest that there is increased support for NBS and greenspace in cities but this is – at the moment - mostly speculation. Therefore, research is required to identify whether increased support for measures also exists within municipalities and whether this could materialise into tangible changes within cities in the long-term.

2.3.2 Summary

Cities are frequently exposed to UC, prompting them to become more resilient. Thus, UR literature has focused on how UR can be attained in different city contexts and the most pressing UC. The role that NBS can play in building UR has also been recognised, with literature exploring the potential NBS has to be able to address specific UC. However, barriers to implementation still exist leading to research attempting to identify what is required to mainstream NBS and the different pathways to achieve this. The COVID-19 pandemic has had a devastating impact on cities however, could also provide cities with opportunities to build back better, more resilient to UC and mainstream NBS further. However, whilst acknowledgement exists that NBS can address UC, little research has explored how municipalities are discussing NBS in light of the pandemic and whether they have intentions to implement NBS in recognition of their benefits.

3 Methodology

This chapter intends to provide the reader with clarification on the research approach adopted. The chapter begins by outlining the research design and then discussing the research philosophy of the study. The use of a case-oriented approach is then justified, followed by an explanation of how cities explored in this research were identified. The methods used for collecting the data, tools used to analyse the data and the theoretical framework relevant to each of the RQs are reviewed. Lastly, reflections are made on the validity and generalisability of the research.

3.1 Research design

To explore how the COVID-19 pandemic has impacted on the mainstreaming of NBS within cities and the threats and opportunities created to mainstream NBS, a targeted study of cities was identified as the most suitable option to answer the RQs; thus, a qualitative comparative case-oriented approach was adopted, as this enables detailed qualitative information to be collected from each city and the contexts to be compared to explore what relationships, and why relationships, may occur (Perry & Bellamy, 2011). For further clarification on the use of a case-oriented research design refer to section 3.3.

The research process of collecting and analysing data has been simplified in Figure 3-1. Research Design (a more comprehensive version of this can be seen in Appendix H – Research Process). As has been demonstrated in the figure, the research process was iterative with changes made throughout.

This research explores the concept of NBS. As was discussed in section 2.2.1, NBS can be used as an umbrella term to cover other related concepts such as green infrastructure and nature-based innovations. This research project has acknowledged the interchangeable use of the terms when performing interviews due to the similarities between the concepts and the lack of familiarity that may still exist with the NBS term at differing municipalities across Europe (Creswell, 2018; Yin, 2014).

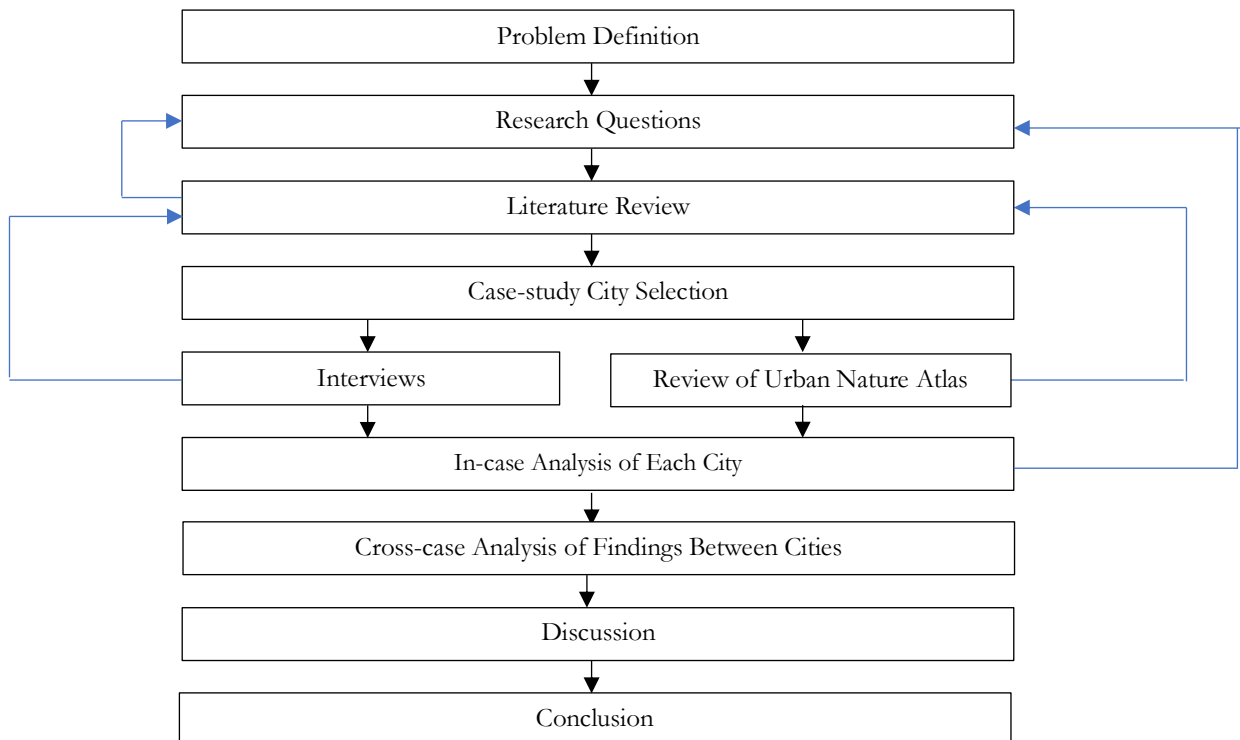


Figure 3-1. Research Design

Source: Authors own elaboration.

3.2 Research philosophy

This research adopts an interpretivist research philosophy in an attempt to understand how the COVID-19 pandemic has impacted on particular cities around Europe. An important aspect of the interpretivist research philosophy is the aim to understand a phenomenon on a deeper level and explore the complexities of the phenomenon in its unique context, in contrast to collecting data and attempting to generalise understanding to the population (more commonly associated with positivism) (Pham, 2018). As this research attempts to understand different attitudes and understandings of how the COVID-19 pandemic has impacted on various cities, and how NBS is now discussed by certain municipalities, it was recognised that different interpretations of the phenomenon may exist. A number of factors could influence people's perception of reality and thus, a research approach that acknowledged different interpretations was deemed a relevant philosophical position to adopt (Yin, 2014). In adopting an interpretivist research philosophy, it is acknowledged that other aspects of the research design will be influenced; for example, the type of research design adopted and the methods used to collect and analyse data.

3.3 Case-oriented research

The use of a case-oriented research design is often used when a cross-case analysis of a program, event, activity, process or one or more individuals is required over a specific period of time and within a number of specific contexts (Perry & Bellamy, 2011). Thus, as this research intended to explore the impacts of a specific event (the COVID-19 pandemic) on different cities (the cases), a case-oriented approach was utilised. In contrast to a case-study research design, the case-oriented approach stretches beyond in-case analysis to also facilitate comparisons between certain responses of particular variables, or the analysis of particular patterns, between cases (Perry & Bellamy, 2011). As an analysis of various cities was required to collect a diversity of responses and opinions on how municipalities and practitioners may have reacted, responded or be discussing NBS differently, this approach was deemed most suitable. Due to the highly context specific nature of NBS it was also acknowledged that a research design that allows for contextual factors to be recognised in data collection and analysis would be required. This is frequently recognised as an advantage to using a case-oriented research design with Ragin (2015) noting that the use of a case-oriented approach can allow a more holistic examination and understanding of specific real-life events. Additionally, a case-oriented research design is recommended for when it is necessary to collect qualitative and in-depth data to questions to describe social phenomena. For this reason, the use of a case-oriented research design, and case-study research design, have frequently been adopted by the NATURVATION project and other projects to strengthen the understanding of NBS (Davis et al., 2018).

The decision to identify a number of cities was made due to recognition that similar or contrasting findings may be found between different cities. As it noted by (Yin, 2014), the use of multiple cases can provide a greater spectrum of representation of social phenomenon as findings and conclusions are based on a wider number of studies. Thus, this was adopted for this research in recognition that attitudes towards NBS could either align or differ across the different city contexts. Although by focusing on a number of cases more time is required to explore each case comprehensively, a case selection process enabled a succinct number of cities to be explored within the research time frame. This ensured that enough time was provided to explore each of the cases in detail and provide a snapshot of each of the city contexts.

3.4 Case selection process

In adopting a case-oriented research design the selection of cases is required. For this research, a case selection process was followed to identify which cities to focus on; this process has been described below.

When adopting a case-oriented research design three choices for selection exist (Perry & Bellamy, 2011); 1) the method of agreement in which two or more cases displaying similar outcomes are identified 2) the method of difference in which a number of cases that display a number of different characteristics are identified and 3) the indirect method of difference, in which a number of cases are identified that have both similarities and differences. Although this research has attempted to identify cases which align closer to the indirect method of difference (3), it should be noted that a number of other criteria were used to determine which cases should be collected. These are outlined below.

Stage 1: Cities in Europe

When deciding on the geographical scope it was decided that cases should be within Europe. This was decided due to two aspects;

- 1) Since the introduction of the Horizon Europe Research and Innovation project NBS have been high up on the EU agenda with a high level of interest surrounding NBS implementation and the increase of NBS within cities to address UC, such as to increase biodiversity and climate change mitigation (European Commission, 2020b). As a result, the concept has been adopted and promoted by a number of agents including the EU and TMNs such as C40 and ICLEI which has led to the promotion of the concept.
- 2) Additionally, higher interest in the concept has led to funding opportunities; all countries within the EU have access to funding available from the European Union Horizon Project as well as additional sources from other agents (European Commission, 2020b)

As a result of these two aspects, a number of rich examples of NBS – with detailed information on a number of NBS projects – exist within the European context. Various aspects of NBS (such as barriers and enablers) have been explored in detail by a number of research funded projects such as NATURVATION, Green Surge or Nature for Cities (Nature4Cities, 2019; Olafsson, 2019; Wamsler, et al., 2020). Thus, the familiarity of the concept and identification of various NBS projects identified Europe as a suitable geographical area to focus on.

Stage 2: The NATURVATION Project

As this project intends to contribute to the NATURVATION project only cities within the scope of the project were considered.

Over 100 cities were explored as part of the NATURVATION Urban Nature Atlas with these being based all around the World (NATURVATION Project, 2021d). These cities were systematically selected according to a set of criteria including the use of cities that represented varied urban environments (demographics, governance structures, land-use, urban morphology, geographical size etc.) and environmental conditions (temperatures, rainfall, coastal or river location, proportion of green space, climate vulnerability etc.). Cities represented a range of different performances (based on the above criteria).

Stage 3: Selection of the Urban Regional Innovation Partners

From the 100 cities selected by the NATURVATION project it was deemed necessary to narrow down the number of cities to 3-8 to ensure that enough time was provided to explore each city comprehensively. A minimum number of cities was also set as the purpose of this research was to explore similarities and differences between different cities thus requiring a few cities to be included at a minimum.

Following this, an interview was held with an expert (7:B) who had contributed to the formulation of the NATURVATION Urban Nature Atlas – an online map identifying NBS projects globally - and thus, had a comprehensive knowledge on the number and diversity of NBS projects in Europe. The expert interview was performed to narrow down which cities

would be the most relevant to study. After discussions on potential cities to select, it was decided to focus on 5 of the 6 Urban Regional Innovation Partner cities (URIP); as shown in Figure 3-2.



Figure 3-2. Map of Europe: The 5 Case-study Cities of Barcelona, Győr, Malmö, Newcastle and Utrecht

Source: Map taken from Google, (n.d.)

URIP cities include six cities based across Europe which are partner cities working on the NATURVATION project. Each city has convened in establishing urban-regional innovation partnerships (URIP) between the urban government, business and civil society organisations in which the concept of NBS is researched, discussed and implemented. As the URIP cities are collaborators in the NATURVATION project, each city has been researched extensively within the project. As a result, an increased amount of material exists on NBS activities in each city with the majority of this being available in English. Additionally, as the URIP cities have been heavily researched the stakeholders of each city are more familiar with the term NBS and have a deeper understanding of the concept and how NBS can support the environmental and socio-economic performance of cities (7:B). This was identified as an important criterion during the expert interview, as it was acknowledged that this understanding may enable each city to better reflect on what has changed during the pandemic and the potential effects of this on NBS.

Additionally, during the interview with the case-study expert it was also discussed how each of the URIPs represented variations in geographical contexts around Europe as well as in their response to the COVID-19 pandemic. These variations were also identified as relevant aspects to explore should they potentially influence how the pandemic has impacted on NBS. Variations in size, governance structures, economic development and demographics were also recognised.

Although all 6 URIP cities were originally identified as cases for this research the city of Leipzig, Germany was removed due to a lack of access to primary data. Thus, 5 cities were explored for this research; the cities of Barcelona, Győr, Malmö, Newcastle and Utrecht.

Stage 4: Identification of municipalities

Having identified which cities will be used as cases, the last step of the selection process included identifying which municipalities should be explored.

Several different municipalities were established in each city – this differed with each of the cities selected - however, those selected for this research were identified based on whether they had been included in one of the major EU Research and Innovation Programmes on NBS, such as NATURVATION. Having been involved in various NBS projects, municipalities were more familiar with the NBS concept either through having assessed NBS and refused implementation, implemented NBS in the past, were currently implementing NBS projects at the time of the research or planning to implement NBS in the future. More commonly, municipalities covered more than one option. The selection of the municipalities also depended on whether individuals of each municipality were possible to reach. It was preferred to gain first-hand information through interviews with individuals working at the municipalities or researchers who had worked with the municipalities. Thus, access to these individuals was of high priority.

3.5 Methods for data collection

For data collection, this thesis draws on a combination of interviews, online documents and the NATURVATION Urban Nature Atlas database. Methods utilised are described below.

3.5.1 Literature review

A literature review was performed to provide context and insight into the various concepts that were relevant to the research topic. These included concepts such as Urban Challenges, Urban Resilience and Nature-Based Solutions. In recognition that NBS can be used as an overlapping term to describe other concepts a number of different search terms were used when identifying relevant literature in a number of different combinations. A full list of search terms and examples of combinations searched for can be seen in Figure 3-3 below.

1) Concept A + 2) Concept B + 3) The Factor +4) The Phenomena	Combination Examples
1) Nature-based Solution / Green or Blue Infrastructure / Eco-system Services Greenspace / Natural Capital / Eco-system based Management.	- (1) NBS + (2) UR - (1) + (2) + (3) - (1) + (4)
2) UR / UC / City Resilience Building	- (1) + (2) + (4)
3) Barriers /Enablers / Opportunities / Threats	- (2) + (4)
4) COVID-19 / COVID Pandemic / Post-COVID	- (3) + (4)

Figure 3-3. Search formula used for the identification of material

Source: Authors own elaboration.

The literature review was performed using the databases Scopus, LUBSearch (the Lund University search engine for academic research) and Google Scholar to identify electronic resources including online journal articles, textbooks and policy agendas. A variety of grey literature including reports and websites was also drawn on due to the lack of research exploring the COVID-19 pandemic and impacts on urban design and NBS. Material was drawn from a number of disciplines including urban studies, environmental planning, landscape and urban planning, sustainability science, UR planning, and public health literature. Although the history of the concepts was briefly explored, some of the literature identified was excluded from the search based on the date of publishing – for NBS and UR this was before 2001. The concept of NBS and similar concepts (e.g. green infrastructure) are very recent thus, making it unnecessary to account for a longer period of time. Literature was also identified through the snowball principle in which relevant sources were identified from reviewing the bibliography of papers and through interviews.

To determine the relevance of the sources used in the literature review, once a search had been completed the abstract was first skimmed. Following this, the abstract, introduction and conclusion were further skimmed to identify the most relevant papers. As a result of this process, a total of 82 papers were identified relevant to the concepts and themes of the study. Despite primarily being written in March 2021, this process was iterative and the literature review was updated with relevant sources throughout the period of February 2021 – May 2021. This was in acknowledgement of: a) the recentness of the COVID-19 pandemic which has resulted in a number of publications exploring impacts on cities frequently being released and; b) additional sources being identified as a result of the interviews that were performed, often to discuss the context of the city. All content collected from the literature review was placed into a synthesis matrix which enabled relevant content to be more easily identified.

3.5.2 Stakeholder interviews

To answer the RQs identified and align with the case-oriented research design interviews were chosen as the main data collection method. These were performed during February-April 2021 with practitioners working at the municipalities of the cities selected. Interviews with researchers who had worked with municipalities on NBS were also performed. These were deemed relevant to include due to providing an additional perspective on NBS potential and also assisting with data triangulation. Participants were purposefully identified for interviews based on their involvement with NBS projects in their respective cities. Some interviews with participants revealed additional individuals of interest to interview and thus a snowball sampling method was also adopted (see Appendix I for additional details on the participants of the study; however, it should be noted that participants were not, and are not, directly referenced at any point during the research in accordance with the ethical considerations outlined in section 1.4). Each participant was provided with a reference number which has been used and only the city has been referred to, to allow content to be placed within context still.

In total, 20 interviews were performed (8 with practitioners and 12 with researchers). Interviews 7:A and 7:B were not connected to a particular city; instead, interview 7:A was used to discuss the alignment of stepping stones for public health and gain a general perspective of the impact the COVID-19 pandemic had had on NBS, whilst 7:B was used to determine which cities would be most applicable to research and to provide a general perspective on the potential opportunities provided by the COVID-19 pandemic to mainstream NBS. Both interviews were with practitioners and researchers who had comprehensive knowledge on NBS and potential impacts as a result of working on the NATURVATION project. The remaining 18 interviews took place with the 5 cities based across Europe. In total, 19 interviews were performed online using zoom/google meets/Microsoft teams and 1 of which was by telephone. Participants represented a range of different municipal departments (resilience, biodiversity, development, park maintenance etc.) and had a range of different backgrounds (architecture, environmental management, administration). All researchers had been involved with the NATURVATION project and NBS in their corresponding city.

Prior to the interviews taking place emails were sent out to the participants. An interview was then arranged for either online – via Skype, Zoom, Microsoft Teams or Google Meet – or by telephone. All participants received an interview guide prior to the interview; as has been recognised by (Yin, 2014) this provides the participant with an opportunity to reflect better on each question and prepare, thus potentially providing more valuable insight to the research topic. Although it was acknowledged that this prevented the “element of surprise” for some questions, this was not deemed likely to impact significantly on the results, as few questions required information that may have required this element. All interviews were semi-structured in nature, utilising a number of open-ended questions to encourage the participant to speak freely. As is recognised by Yin (2014), a semi-structured interview style allows participants to prepare answers to questions beforehand, which can help conversation. This aspect was

considered important as it was recognised that most participants spoke English as a second language and thus, may have preferred time to prepare answers. A semi-structured interview also provided opportunities to ask further questions that could provide additional insight into new themes mentioned by the participant. The questions asked related to different aspects of the RQs and can be viewed in the Interview Guide (as seen in Appendix E); some questions were edited depending on whether the interviewee was working directly for the municipality or as a researcher working with the municipality. All interviews were done in English and were recorded and transcribed using the software HappyScribe; most of the interviews took between 45 – 60 minutes however, a transcript of approximately 50 minutes was primarily produced due to editing which removed participant introductions, the interview debrief and the removal of any interruptions (participant had to respond to external environment or were coughing.).

3.5.3 Review of the NATURVATION Urban Nature Atlas

To assess how the COVID-19 virus had impacted on NBS within each of the cities researched, a review of the NATURVATION Urban Nature Atlas COVID-19 Project was explored; this was a spreadsheet outlining content on if, and how, NBS projects had been impacted on by the COVID-19 virus and whether projects remained open during the pandemic. This was included in this study to provide additional data triangulation. Content for the spreadsheet was collected in summer 2020 and thus only provided details up until September 2020. Data for the atlas was collected by several researchers within the NATURVATION project and was used to describe how the pandemic had impacted on each city in the Chapters 4. Results and 5. Discussion. As the database is not publicly available this has been referenced as a personal communication.

The researcher also attended an online conference on Park Management during the COVID-19 pandemic hosted by World Urban Parks. This provided details on how urban greenspace had been impacted during the pandemic providing some relevant insight into the topic. As the conference was out of the scope of this research it was not included in the results however, it was used to shape the search for literature and identify potential themes to ask participants on.

3.6 Methods for data analysis

To analyse the qualitative interview data thematic analysis was performed. Thematic analysis is commonly used to analyse qualitative data due to its flexibility and ease of understanding (Creswell, 2018). Additionally, thematic analysis is argued as a useful method for examining the perspectives of different research participants, highlighting similarities and differences that may exist, and generating unanticipated findings (Given, 2008; Nowell et al., 2017). As this aligns with the RQs (e.g. examining perspectives of NBS as a result of the COVID-19 pandemic) and the desire to compare differences and similarities in perspectives, thematic analysis was adopted to analyse the qualitative data produced by the interviews. This process involved the identification, segmentation, categorisation and summarisation of the data to capture important concepts within the data set (Creswell, 2018). This process is described below.

The process of thematic analysis involved the use of a computer-assisted qualitative data analysis software program called NVivo. The use of such a system enables data to be stored, indexed, sorted and coded providing the researcher with a more organised and rigorous system to analyse the data. As a result, the use of the software to code and analyse data was deemed feasible for this research. Additionally, the researcher had experience working with NVivo. In answering the RQs a system of coding was also recognised as being an appropriate method for data analysis; NVivo is set up to facilitate the coding process and thus, can enable a more efficient data analysis. The process of coding was guided by Creswell (2018) and Leech & Onwuegbuzie (2011) and can be seen in Figure 3-4 below. This process was performed for 18 of the 20 interviews; two of the interviews (7:A and 7:B) were not related to specific cities and so were excluded from the coding process.

The coding structures were first based on analytical frameworks discussed in Chapter 2 (#1). The process of coding then began by sorting through the transcripts attained from the interviews and then reviewing all of the text included on the transcript (#2). The most relevant pieces of text were highlighted and labelled relating to specific themes, with the remaining text deemed less valuable and excluded (#3). In this context “relevance” was determined by whether parts of the text related to one of the RQs identified.

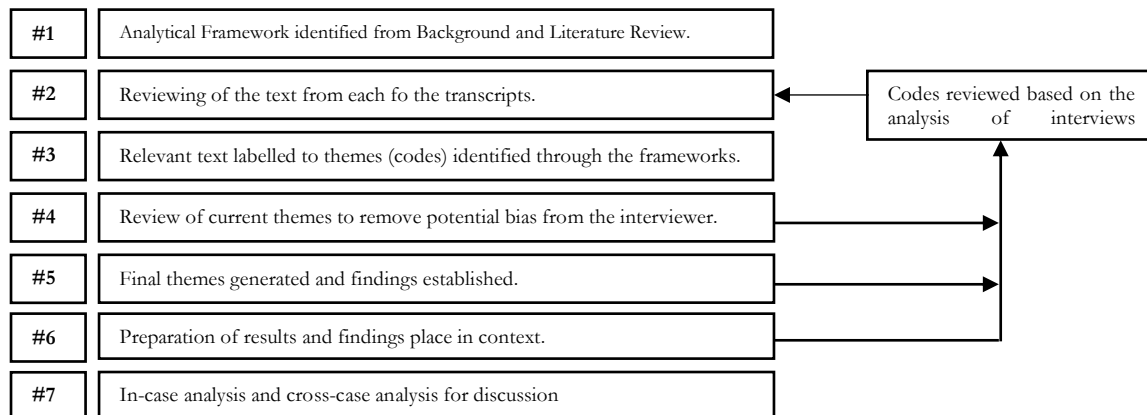


Figure 3-4. Process used for the coding of transcripts

Source: Authors own elaboration.

The following step involved a review of current themes (#4). In recognition that the creation of the themes could be biased as they were a creation of the researcher, themes were reviewed by another individual with limited knowledge on the research project. Two random, anonymised interview transcripts were provided to the individual with the purpose of the project explained. They were then requested to go through the interview and identify themes they deemed most relevant. A cross comparison was then made with the researchers own themes, with some of these edited to reduce potential bias. Following this process, the final codes were established and themes were then generated to identify major findings (#5). These were then considered in relation to the literature, the frameworks discussed and the context (city, etc.) (#6). The final stage of the analysis involved the researcher’s interpretation of these results in which first an in-case analysis was performed and then, a cross-case analysis; both of which are presented in Chapter 5. Discussion (#7).

The analytical frameworks identified for RQ2 and RQ3 were also used to guide the analysis of the data. For RQ2 this involved codes that explored common UC municipalities were exposed to. For RQ3 this involved codes based on the breakdown of barriers and enablers from the theoretical framework outlined above.

3.7 Units of analysis and analytical frameworks adopted

For RQ2 and RQ3 analytical frameworks were used to aid the collection, organisation, coding and analysis of the data. A framework was not adopted for RQ1 as this RQ was exploratory in nature and required a more inductive approach to identifying themes (due to little literature exploring the impacts of the COVID-19 pandemics specifically on NBS). This section provides details on the formation of the frameworks used for RQ2 and RQ3 and the different categories of analysis for each of the frameworks that were developed in this study. The analytical frameworks adopted for this research are presented in Table 3-1.

Table 3-1. Table showing the connection between the RQs and the analytical methods adopted

Research Question	RQ1: <i>What impact has the COVID-19 pandemic had on the use of Nature-Based Solutions in cities?</i>	RQ2: <i>How do practitioners and researchers discuss the potential of Nature-Based Solutions to build back better from the COVID-19 pandemic and to other Urban Challenges?</i>	RQ3: <i>How has the COVID-19 pandemic impeded or supported the mainstreaming of Nature-Based Solutions?</i> RQ3a: <i>What barriers and enablers existed to the mainstreaming of NBS prior to the COVID-19 pandemic?</i> RQ3b: <i>What threats and opportunities to the mainstreaming of NBS have arisen as a result of the COVID-19 pandemic?</i>
Framework Identified	N/A	Based on 1) Ershad Sarabi et al., (2019) 2) Almenar et al., (2021)	Based on: 1) van der Jagt et al., (2020) 2) van der Jagt et al., (2017) 3) Ershad Sarabi et al., (2019).
Relevant Section of LR	Section 2.3.1 COVID-19 & UR	Section 2.1 UC & UR Section 2.2.2 The use of NBS to improve UR Section 2.3.1 COVID-19 & UR	Section 2.2.4 Barriers and Enablers to NBS implementation. Section 2.3.1 COVID-19 & UR
Unit of Analysis	NBS Municipality	NBS Municipality	NBS Municipality
Category of Analysis	Type of Impact	Urban Challenges	Barriers & Enablers (<i>prior to COVID-19</i>) Threats & Opportunities (<i>during or after COVID-19</i>)

Source: Authors own elaboration.

For each RQ the main units of analysis will be: i) the *NBS* implemented in each case city and ii) each *Municipality*. Additionally, each of the RQs also identified a number of categories of analysis to allow data to be collected and compared. For Chapters 4. Results and 5. Discussion the RQs and categories of analysis were used to guide the structure of writing: the i) *UC* that NBS can address within each of the cities is first discussed. A chronological structure is then adopted to discuss the ii) *barriers* and iii) *enablers* to NBS implementation prior to the COVID-19 pandemic, and then how these may have potentially changed discussed as iv) *threats* and v) *opportunities* as a result of the COVID-19 pandemic.

For this research the terms *barriers* and *enablers* are used to describe past factors that either impeded or supported NBS implementation prior to the COVID-19 pandemic. The terms *threats* and *opportunities* instead focus on present factors that either impeded or supported NBS implementation as a result of the pandemic OR future factors which may potentially affect NBS implementation as a result of the COVID-19 pandemic.

3.7.1 Analytical framework for RQ2; NBS potential to address current and future Urban Challenges

To analyse UC, the analytical framework was developed based on the work by Ershad Sarabi et al., (2019) and Almenar et al., (2021). These studies were deemed as the most relevant for this study due to i) the review of literature performed which identified and summarised a number of UC across a wide-range of different contexts and ii) the consideration of these in relation to NBS to identify those most relevant to the RQ.

Both papers explored these two aspects to different extents; Almenar et al., (2021) provides a more comprehensive review of literature examining over 300 sources and from a wider range of contexts. In doing so, a list of 18 main UC and 58 sub-challenges are identified although notably, not all are identified as challenges NBS can address. This is in contrast to the 10 main UC identified by Ershad Sarabi et al., (2019) who explores UC exclusively within the context of NBS however, reviews a smaller amount of literature and provides a much broader categorisation without outlining or describing sub-categories. As a result, both papers were drawn on to design the analytical framework. In referring to the framework suggested by Ershad Sarabi et al., (2019) UC specifically to NBS were identified which provided a more relevant categorisation of UC. These were cross-checked with the work done by Almenar et al., (2021) to ensure that all relevant UC could be identified. This led to the adding of sub-challenges which provided stricter outlines to the categories and prevented any overlap when coding the data. Additionally, Almenar et al., (2021) also provides an analysis of which UC are most relevant within the context of Europe; as the geographical scope of this research is on cities in Europe, this was identified as a relevant aspect to consider when discussing the results.

Table 3-2. The different UC NBS are most commonly adopted to address. Table created from synthesising UC identified from two papers.

Main Challenge	Sub-Challenge
Climate Change Mitigation and Adaptation	High Greenhouse Gas Emissions
	Urban Heat Island and Heatwaves
Water Management	Flooding Risk
	Wastewater Management
	Freshwater Shortages
Coastal Resilience	Sea level rise
Biodiversity Loss	Loss and Degradation of Habitats
	Lack of Ecological Connectivity
Socio-spatial Equity	Lack or unequal distribution of NBS
Public Health and Wellbeing	Lack of Air Quality
	Lack of Soil Quality
	Lack of Leisure Opportunities
	Urban Stress
Urban Decay	Degeneration of Areas
Green Growth	Lack of Employment, Job Development

Source: Main challenges derived from Almenar et al., (2021) & Ershad Sarabi et al., (2019)

3.7.2 Analytical framework for RQ3; impeding and supporting factors to NBS mainstreaming

To identify the impeding or supporting factors that may exist for NBS mainstreaming a number of journal articles were also reviewed in section 2.2.4. The analytical framework used for this RQ was based on three papers including: 1) van der Jagt et al., (2020) ; 2) van der Jagt et al., (2017) and; 3) Ershad Sarabi et al., (2019). Each paper identified barriers and enablers to NBS implementation although with some notable differences. Thus, a synthesis of impeding and supporting factors from each paper was used to produce the analytical framework for this RQ. This was also applied when identifying threats and opportunities as it was acknowledged that these factors would remain applicable and may have been limited or exaggerated due to the COVID-19 pandemic. For any new threats or opportunities that may emerge the categorisation

and analysis of data would be formulated through the interviews as no analytical framework for these currently exists.

The first two papers included were identified due to the comprehensive categorisation they present of barriers and enablers to NBS mainstreaming. Notably, both are written by the same author however, differ in that van der Jagt et al., (2020) look at barriers and enablers within the context of Technological Innovation Systems to propose a framework for Nature-based Innovation Systems, whereas van der Jagt et al., (2017) identify several variables, or factors, which can influence innovation for urban sustainability. The van der Jagt et al., (2017) paper identifies some additional factors considered relevant to include for this research; e.g. “Awareness” and “Sense of Urgency” (as seen in Table 3-3), both of which could relate to the COVID-19 pandemic. These factors were then cross-referenced with the report presented by Ershad Sarabi et al., (2019) who also provide a) a number of barriers based on a comprehensive review of over 300 literature sources and b) provides some kind of indication on what the most common types of barriers and enablers are with NBS mainstreaming. As a result, all three papers were synthesized to create the framework for RQ2 and the descriptions of the factors provided were used as the basis for the analysis. As above, the process of coding and identification of barriers and enablers from the interviews was also influential in the final categories identified.

Table 3-3. The different factors and sub-factors which can impede or support NBS mainstreaming. Each sub-factor can work as either a barrier or enabler depending on the context. Factors coloured in orange have been added from van der Jagt et al., (2017).

Factors	Sub-factor	Description
<i>Cognitive Factors</i>	<i>Awareness</i>	Awareness of the UC that NBS have the potential to address. Awareness of NBS benefits.
	<i>Uncertainty</i>	Reluctance to work with NBS due to being uncertain of results and how to work with the concept.
	<i>Sense of Urgency</i>	A significant event that provokes goals towards UR e.g. natural disasters including storms, flooding.
	<i>Flexibility</i>	The flexibility of institutions to enable faster response to changes. Adaptive governance.
Agency	Leadership & Power	Individuals or organisations working as leaders to promote the uptake of NBS.
	Commitment	Long-term commitment to mainstream NBS by individuals or organisations.
Discourse & Vision		Alignment of NBS with other discourses or visions including sustainable cities.
Strategic Plans, Legislation, Regulation and Policies		Refers to either legislation or strategy that supports the mainstreaming of NBS.
Institutional Set-Up and Governance Structures		Impeding or supporting factors connected to the institutional context. Diffusion of responsibilities between different administration bodies.
Collaboration	Networks, Partnerships & Social Interaction	Cross-departmental and cross-sectorial interactions with a number of stakeholders.
	Participation	Involving and engaging citizens in the planning, development and use of NBS.
Learning	Education & Training	Individuals and organisation are well informed about NBS. Active learning.
	Research	More knowledge required on NBS and relevant fields.
	Experimentation	The use of pilot projects and testing of new innovations.
	Monitoring & Evaluation	The assessment of NBS project outcomes and impacts.
Resources	Knowledge & Human Capital	Expertise and experience of individuals or organisations.

	Financial Factors	Availability of funding for NBS.
	Materials, Tools & Technologies	Technologies or Tools which can impede or support NBS implementation (e.g., monetary valuation tools).
Local Geographical Factors	Built Environment & Urban Amenities	City infrastructures and amenities.
	Environmental Qualities and Climate	Aspects such as natural processes, soil conditions, local fauna and flora can influence the demand for NBS.
	Societal Processes	Refers to current demographics, urbanisation, economic growth.
	<i>Local Culture & Image</i>	Identify of community or city.
	<i>Land & Property Ownership</i>	Refers to private ownership of land and property.

Source: Framework taken from van der Jagt et al., (2020) with additional factors and sub-factors added from van der Jagt et al., (2017) and Ershad Sarabi et al., (2019).

3.8 Research validity, reliability & generalisability

A common critique with a case-oriented research design and the collection of data using interviews is the validity, reliability and generalisability of the data (Perry & Bellamy, 2011). Research validity refers to the accuracy of the findings whilst research reliability indicates the extent to which the results can be reproduced under the same conditions (Ershad Sarabi et al., 2019). Different strategies have been employed in this research to address both validity and reliability issues. These included:

- Triangulation: The design of RQs and discussion of themes were related to established theories and concepts. Additionally, data collection utilised interviews from different sources (practitioners working within municipalities and researchers) and the collection of academic and grey literature to triangulate data sources and data collection methods.
- Member Checking: Findings from each interview were summarised and sent to participants by email with feedback requested to ensure that the author of this thesis had interpreted and recorded participant statements adequately.
- Interview Procedures: Several strategies were utilised during interviews to address challenges of reliability. These included the recording and transcription of interviews to allow for primary data review by the participants, the checking of transcripts for mistakes through the several reviews of each transcript and cross-checking the codes identified.

The ability to generalise results to a wider context is also limited with a case-oriented research design (Creswell, 2018). However, the goal of this research is not to generalise results to the whole of Europe; rather, through observing similarities and differences between the cases identified it is hoped that some assumptions on why differences and similarities may occur could be understood. Additionally, as little knowledge currently exists on the impacts of the COVID-19 pandemic on NBS, studying a range of cities in different contexts could allow the diversity and richness of COVID-19 impacts on NBS to be captured. This could lead to opportunities for more in-depth case studies following the identification of these impacts.

4 Results

This section presents the results collected from the NATURVATION Urban Nature Atlas and the interviews with practitioners and researchers. The findings are collated into five sub-sections below corresponding to the five case-study cities: Barcelona, Győr, Malmö, Newcastle and Utrecht. For each section, a short description is provided describing the context of the city and the municipal response made to the COVID-19 pandemic. How this impacted on NBS within each city is then discussed (RQ1) with the UC that NBS can address within each city then outlined (RQ2). The final section presents the barriers and enablers to NBS mainstreaming prior to the pandemic (RQ3a) to allow threats and opportunities as a result of the pandemic to be identified and discussed (RQ3b). These have been summarised in a set of tables.

4.1 The city of Barcelona

Located in North Eastern Spain, Barcelona is the second largest city with a population of 1.6 million. The city is recognised as a global commercial centre attracting millions of tourists every year (prior to the COVID-19 pandemic) (Ajuntament de Barcelona, 2020). As a result, the city has become a major economic driver and one of the most populated metropolitan areas in Europe. Additionally, with an economy based around the service sector (88% of people who work in the city), there is an intensive use of public space throughout the city; this has placed pressures on urban services and posed challenges to ensure that spaces function correctly. In recognition of several sustainability challenges, Barcelona has been working towards building resilience to multiple UC. High levels of urban densification have continually challenged the city; due to tourism, urbanisation and Barcelona's geographical context (Urban Resilience Hub, n.d.). This has contributed to a densely populated central core, producing a congested traffic network and placing pressure on public health. Additionally, exposure to a series of critical episodes suffered in 2007 (extreme drought risks, rail service disruptions, major power outages and flooding) prompted a response to improve UR by the municipality with Ajuntament de Barcelona introducing a resilience strategy to address various challenges in collaboration with the resilient cities network (Ajuntament de Barcelona, n.d.; Resilient Cities Network, n.d.)

As one of the first countries to see a rapid increase in COVID-19 infection rates, Spain declared a countrywide state of emergency early in 2020, placing strict regulations in place that severely limited people's mobility. Within Barcelona this meant that any kind of activity in public spaces was drastically reduced (Barton et al., 2020). Other activities including running or cycling were banned with fines applicable to those found to be breaking rules. As a result, this led to many people being locked inside of their buildings with the only option to go outside being through the use of private gardens, balconies or rooftops (2:C). Beaches and public parks were closed with organised activities temporarily suspended (NATURVATION Urban Nature Atlas, personal communication, 13th April 2021). Restrictions also prevented people from working outside of their homes (in offices etc.), including those working outside in roles such as park maintenance (2:B). Since the initial regulations were outlined however, restrictions have gradually been relaxed with parks opened up from early July 2020; although restrictions on the number of people gathering within one place still apply and some parks are still closed. Current regulations are still in place limiting the size of social gatherings, outlining a curfew and a county lockdown being enforced, restricting the movement of citizens between counties in Spain and from overseas (Ajuntament de Barcelona, 2021).

4.1.1 RQ1: impacts of the restrictions on NBS in Barcelona

During the initial restrictions all access to NBS was restricted leading to a 90% decline in park use (Barton et al., 2020). This was reported to have had an adverse impact on peoples mental and physical health by participants (2:A; 2:B; 2:C). 2:A commented on the frustration that many people had, and still have, over the restrictions in place and the extra stresses this placed on people during an already turbulent period. 2:C further highlighted how people just seeing some

form of green from their apartment contributed to people's mental wellbeing whilst 2:B speculated that there could be an increase in the amount of people moving towards peri-urban or rural areas in an attempt to improve their access to greenspace. 2:B also noted how this period of strict restrictions had provided opportunities for wildlife to come back to the city. Limitations on people working in the parks meant that many NBS suffered from a lack of maintenance. Thus, this provided a more natural environment for plants, invertebrates, birds and other wildlife to live. Whilst some complaints were made over the visual aesthetic of the overgrown areas, this was speculated to have led to a temporary rewilding of the city and increase in biodiversity (2:B).

Strict regulations were also speculated to have increased the number of people using their apartment building roofs; 2:C noted that these had previously been underutilised due to complexities in providing access, funding and maintenance. However, during the period of strict regulations an increasing amount of people had turned to using these spaces, due to being unable to go to the gym or use other outdoor spaces (2:A; 2:B). Following the easing up of restrictions however, 2:C noted that public spaces and access to NBS began to increase although there was initially some reluctance to use these spaces due to people being afraid of catching the virus. Gradually use of these spaces was said to have increased as people recognised that outdoor spaces were one of few places where physical exercise or socialising could be done (2:A; 2:B). This led to a visible increase in the number of people using NBS (such as parks) both within the city and in peri-urban areas (2:A; 2:B; 2:C). 2:B even noted that this had led to an enormous stress on some of the NBS sites with increases in litter and a number of wildlife disturbances. Whilst an increase in the number of people using these spaces could be seen, no additional resources were provided to assist with the management of these areas (2:B).

The restrictions enforced also had an impact on the planning and implementation of NBS projects (2:A, 2:B, 2:C). Immediately following the introduction of restrictions all work was moved online. For some NBS projects that were being planned, 2B noted how some of these were either delayed or stopped completely. Certain lines of investment originally allocated for projects were also reallocated to be able to deal with the COVID-19 crisis, leading to the number of NBS projects initially being implemented declining. Whilst most work on NBS had been impacted on by the restrictions, work on parks and community gardens has resumed (2:B).

4.1.2 RQ2: the role of NBS in addressing Urban Challenges

Participants highlighted a number of UC that NBS have the potential to address. These have been outlined below; it was also noted that individuals working within the municipality had a more developed understanding of the simultaneous benefits of NBS to address several UC and commented that NBS were often implemented to tackle several UC (2:A, 2:B, 2:C). As per the analytical framework however, these have been divided and discussed separately below.

Biodiversity Loss: The dense urban environment of Barcelona has led to few greenspaces being left in urban development (2:A; 2:B 2:C). 2:B further noted how even small parks around the city sometimes *"don't look like greenspace at all"*. Thus, biodiversity loss has traditionally been identified as one of the main UC in Barcelona, with NBS often implemented to overcome this (2:B); this began in the 1980s with a tree planting strategy however, expanded to other projects following Agenda 21 and the release of the Barcelona Biodiversity Strategy in 2013 (2:B) More recently projects include the construction of community gardens (2:A), eco-corridors (2:C), the regeneration and clean-up of the two main rivers surrounding the city (the Llobregua and the Besòs) and the construction of rooftop gardens (such as the Ferran Sunyer School) which were implemented to improve biodiversity and address other UC (water management) (NATURVATION Project, 2017a). Whilst work with NBS has typically addressed biodiversity loss it is acknowledged that huge opportunities exist for more (2:A, 2:B; 2:C). A biodiversity plan outlines ambitious goals to increase the amount of biodiversity throughout the city with

NBS seen as fundamental in achieving this (2:B). However, with the increasing densification of the city expected due to urbanisation biodiversity loss remains a significant challenge. NBS remains a potential solution given the innovative NBS that can be integrated into urban design, including greenwalls and green roofs to provide a habitat for wildlife in densely populated areas (2:B; 2:C).

Water Management: As was recognised by 2:A & 2:B NBS have also traditionally been employed to address issues with flooding within the city. Initially, this was applied when conventional drainage systems would not be suitable (2:B) however, NBS are now given more preference when implementing drainage solutions and are prioritised more in planning decisions (2:A; 2:B; 2:C). It was further noted that a 10-year plan for the implementation of sustainable drainage systems encouraged the use of NBS over grey infrastructure (2:B). In particular, recognition that NBS were an effective solution to mitigating against storms has grown, given their capabilities to store water (2:A, 2:B). This is now being recognised as more significant given the increased number and intensity of storm and heatwave events. Thus, further consideration of more water efficient storage systems is being promoted, with growing recognition of NBS potential to be able to address these challenges through the use of rain gardens (2:C).

Physical and Mental Wellbeing: With a densely populated central core Barcelona has frequently suffered from a heavily congested traffic network leading to high levels of toxic air emissions and impacting on public health (Resilient Cities Network, n.d.). Prompted by the EU Air Quality regulations (2:B), the city responded by implementing several measures that aim to reduce car use and encourage public transport, cycling and walking. The use of NBS to address air quality challenges is still under-utilised however (2:A; 2:B; 2:C); as was noted by 2:A, this is primarily due to a lack of connection between NBS and the physical health benefits they can provide. Even less of a connection is made between NBS and the mental health benefits (2:B; 2:C). Therefore, the potential exists for NBS to be implemented to address poor air quality and other public health challenges. This has been reinforced since the emergence of the COVID-19 pandemic, in which an increase in the mental wellbeing of citizens who had access to nature in Barcelona has demonstrated why access to NBS can be of value (2:A; 2:B; 2:C). Although this recognition exists, potential remains for this to be actualised (2:A; 2:B).

Climate Change: How Barcelona will respond to climate change is frequently being discussed as a result of increases in the intensity of storms and heatwaves taking place (2:B). The Barcelona Climate Plan outlines strategic goals and actions to reduce GHG emissions with “*Many more green areas*” being outlined as a central line of action (2:A). This, combined with the influence of the biodiversity strategy, has contributed to the consideration of NBS to achieve climate related goals (2:A; 2:B). In particular, attention is focused on the use of NBS to become more resilient to the heat island effect and increasing temperatures (2:A; 2:B; 2:C). This was noted by all participants with 2:B highlighting NBS that attempt to green the streets – often involving the planting of trees - as an effective solution to mitigate against rising temperatures. 2:B further explained how some streets were being completely converted, prohibiting cars and providing space to pedestrians and cyclists (for example, through the superblock design concept). This is recognised as providing additional opportunities for mainstreaming NBS (2:A; 2:B, 2:C) and addressing climate change impacts.

Socio-Spatial Equity: Equal access to greenspace is recognised as an UC within Barcelona (4:A; 4:C). Different districts in the city have different levels of access to both private and public greenspace, leading to the unequal distribution of the benefits NBS can provide (4:D); wealthier areas were recognised as having better access to private and public greenspace (4:A; 4:C). Although NBS encourages the consideration of equal access to greenspace more than other concepts (4:A; 4:C), this is still not prioritised in the planning and implementation of NBS projects. Additionally, the introduction of NBS in the city is believed to contribute to green

gentrification which can displace people from the area (4:A). Thus, more consideration is required to ensure citizens have equal access to NBS; this has been further highlighted as a result of the COVID-19 pandemic in which typically, wealthier areas were reported to have had better access – in particular within the private sphere (2:A). 2:C noted that those with more money could afford to live in buildings with their own garden or balcony and thus benefit from nature more. Thus, there is a need for NBS to be implemented to address this unequal distribution of greenspace within the city (2:A; 2:B; 2:C).

4.1.3 RQ3: impeding and supporting factors to NBS mainstreaming

Factors that both impede and support NBS mainstreaming have been summarised in Table 4-1, with factors prior to the pandemic (*barriers, enablers*) presented in *italics*. Threats and opportunities have been outlined shaded following these to allow a comparison between impeding and supporting factors i) prior to the pandemic and ii) during and potentially following the pandemic. This method of displaying results has been used for all case-study cities.

Prior to the COVID-19 pandemic, participants commented that NBS mainstreaming had been supported due to the alignment of several aspects: i) a “green” mayor who had pushed for NBS and other green initiatives to be implemented (2:A; 2:B; 2:C); ii) strategies and policies promoting biodiversity and climate change mitigation (2:B; 2:C) and; iii) discourse around sustainable cities which placed preference on improving access to nature in the city and reducing car use (for example, through the superblock concept) (2:B; 2:C). This provided an environment that supported the mainstreaming of NBS, with 2:B also pointing out that the strong culture of citizen participation in Barcelona had further facilitated the mainstreaming of NBS. However, barriers were identified with attempting to communicate the NBS concept; participant 2:B commented that departments still worked siloed and so few people understood the concept of NBS, whilst 2:A noted that a lack of connection between NBS and public health benefits still existed. Additionally, the multiple understandings of the concept created confusion when trying to explain what NBS meant to people unfamiliar with the term (2:A; 2:B; 2:C). Other barriers existed with the amount of resources available limiting work with mainstreaming NBS (2:A; 2:B) and with attitudes of practitioners towards NBS; although the benefits of NBS had been recognised by some, 2:B noted that NBS maintenance still appears as a cost in the traditional accounting system making it harder to convince stakeholders of their value. Participants remarked that the environment in Barcelona generally supported NBS mainstreaming however; work with integrating NBS into buildings had recently been pursued (through green roofs etc.) in recognition of issues with densification limiting space for larger NBS projects (2:A; 2:B; 2:C).

Participants highlighted the opportunities that the COVID-19 pandemic has presented through the increase in the appreciation of nature by citizens (2:A; 2:B; 2:C). All participants were optimistic that this would lead to a change with how NBS are included in development projects due to an increase in the connection between NBS and public health benefits (2:A; 2:B; 2:C; 2:D). This further aligned with other sustainable city goals including sustainable mobility which, during the pandemic, had provided opportunities to mainstream NBS as several streets had been closed to allow pedestrians and cyclists to use outdoor spaces (2:B; 2:C). Discussions on making these changes permanent were also taking place (2:B). The COVID-19 pandemic has also emphasized the unequal distribution of NBS which has prompted conversations regarding the implementation of bottom-up initiatives to address this imbalance. Participants acknowledged this as an opportunity to further mainstream NBS (2:A; 2:B). For this to be actualised however, it was noted that funding would be required to ensure that projects could be implemented (2:A; 2:B); towards the beginning of the COVID-19 pandemic funding for NBS projects was reportedly cut to allow investment to be redirected to responding to the pandemic. 2:B further noted that although NBS use had increased significantly, most likely as a result of the COVID-19 pandemic, no additional resources were granted to manage this. In recognition of the demand for NBS, funding for NBS has now reportedly (2:B; 2:C).

Whilst additional funding has been provided for NBS, with work moving online complexities were identified with citizen participation and the inclusion of stakeholders in the planning process of developments. This was expected to continue contributing to delays in projects and missed opportunities to integrate NBS (2:B). Additionally, participants acknowledged that for opportunities to mainstream NBS to be exploited, legislation aimed at the private sector would be needed; in particular, setting a minimum on the amount of NBS or space for balconies would be required (2:A; 2:C).

Table 4-1. Barcelona summary table showing impeding and supporting factors to NBS mainstreaming prior to the pandemic (in italics) and during the pandemic (shaded orange).

Factors	Factors that IMPEDE NBS mainstreaming	Factors that SUPPORT NBS mainstreaming
Cognitive Factors⁹	<ul style="list-style-type: none"> - <i>Lack of connection between NBS and benefits to public health.</i> - <i>Multiple understanding of NBS concept causes confusion with practitioners.</i> - <i>Anthropogenic focus in urban planning which neglects opportunities to mainstream NBS.</i> - Lack of maintenance led to negative impressions of NBS. - Eco-system dis-services due to lack of Maintenance = negative ideas of NBS. 	<ul style="list-style-type: none"> + <i>Flexibility of NBS term allows for term to be easily explained.</i> + Connection between NBS and public health has been emphasized. + Increase in use of NBS suggests an increase in appreciation for nature. + Preference for NBS + Pandemic has highlighted the need for bottom-up initiatives to tackle unequal distribution of NBS.
Agency		+ <i>Support for NBS from current city council which provides opportunities for mainstreaming NBS.</i>
Collaboration	<ul style="list-style-type: none"> - Delays and cancellations of NBS projects due to work moving online. - Citizen participation severely restricted. 	<ul style="list-style-type: none"> + <i>Barcelona has a culture of citizen participation allowing municipality to keep in touch with citizens</i> + Project delays have provided opportunities to rethink developments & include NBS.
Discourse and Future Visions	+ <i>Alignment with discourse around increasing biodiversity, climate change mitigation.</i>	+ Street closures for pedestrians and bikes provide opportunities to mainstream NBS.
Resources	<ul style="list-style-type: none"> - <i>Funding issues due to limited pot of money.</i> - Funding and technical knowledge redirected to COVID-19 response. - No additional funding to manage increase in park use (due to pandemic). - Uncertainty how long NBS funding will remain high for. 	+ Funding for NBS projects later increased.
Institutional	<ul style="list-style-type: none"> - <i>The administrative process to planning is too long, making it vulnerable to cuts.</i> - <i>NBS maintenance still seen as a cost in accounting system.</i> 	
Strategic Plans, Legislation, Policies	<ul style="list-style-type: none"> - Policy aimed at the private sphere required to ensure NBS opportunities from the pandemic are realised. - Demand for NBS may also lead to private developers wanting to include NBS more however, they may also charge more excluding some people. 	+ Plans have facilitated the closing of streets to cars and providing space for NBS.
Local Geographical Context	- <i>Challenges of densification reducing space available for NBS.</i>	+ <i>Catalonia is a self-autonomous region allowing Barcelona to choose where to invest (more for NBS)</i>

Source: Authors own elaboration based on tables presented in Appendix J

⁹ Within the table *italics* refers to impeding (presented as “-”) and supporting (presented as “+”) factors **prior** to the COVID-19 pandemic. **Shaded** text refers to impeding and supporting factors identified **during** the COVID-19 pandemic.

4.2 The city of Győr

Győr is the sixth largest city in Hungary with a population of approximately 130,000 (GeoX, 2015). Located halfway between Vienna and Budapest, the city has one of the most significant traffic and logistic corridors in central Europe. This has enabled Győr to develop into a major economic power, with the city hosting major car manufacturing brands including Audi. Located at the confluence of three rivers Győr has frequently suffered from several floods in previous years. Other challenges centre around growing traffic within the city, a loss of greenspace around the periphery to developments and air quality concerns due to waste incineration and congestion. In addressing these challenges Győr has begun pursuing an ambitious SMART city programme focusing on the energy sector and implementing hard infrastructure to address flooding. This has presented opportunities to extend efforts to the city's natural assets by capitalising on the strengths of the natural environment to address challenges traditionally addressed by grey infrastructure (NATURVATION Project, 2017b).

Following the identification of the COVID-19 virus in March 2020 Győr followed national restrictions by closing non-essential shops and moving work online. Restrictions were introduced on the number of people in groups and the movement of people across the city. Access to NBS remained open although this was initially limited to families with children (NATURVATION Urban Nature Atlas, personal communication, 13th April 2021). As the pandemic went on NBS were eventually opened up to allow physical activity. These have now remained open throughout the pandemic although new restrictions were imposed following a spike in COVID-19 cases in November 2020 limiting group numbers. Currently, restrictions are in place limiting the number of people meeting in large groups and an evening curfew has been implemented. Access to public spaces and NBS continue to remain open for physical exercise and for people to meet in smaller groups. Work has taken place – and continues to take place - online for the majority of industries (About Hungary, 2021)

4.2.1 RQ1: impacts of the restrictions on NBS in Győr

With the implementation of the initial measures access to parks was reduced; however, as was noted by 1:B and 1:C this did not lead to a huge decline in the amount of people using the NBS - including the Bercsényi grove and Kuopio park – which were often underutilised prior to the pandemic. As restrictions began to relax and allowed access to NBS, an increase in the amount of people using the parks could be seen (1:A; 1:B). Other public spaces within Győr also increased, with the number of people using walkways and sit-down areas along the rivers also increasing (1:A). This increase was accounted to a lack of other places within the inner city that people could go out to and explore; in researching how the pandemic had affected the use of public spaces in Győr, 1:A commented that because people couldn't go to shopping malls, or to fitness centres, they spent more time in parks. This had also enabled them to rediscover the value of parks and contributed to their continued use throughout the pandemic. Additionally, people working from home acknowledged these spaces as somewhere they could go to take a break or work remotely from (1:A).

Although a slight increase in the amount of people using NBS sites within the city was identified, the outdoor areas that had seen the largest increase were believed to have been located around the outskirts of the city (1:A; 1:B; 1:C). In particular, Bishops forest saw a substantial increase in use (1:A; 1:B; 1:C). There were mixed impressions on whether this had caused higher amounts of waste or litter within the area (1:A; 1:B) however, other environmental impacts such as increased erosion, increased disruption to biodiversity and increased fires (related to BBQs) could be identified (1:A; 1:C). More park rangers were around to manage this increase in numbers however, this was initially complex to arrange due to work moving online (1:B). All work related to NBS was moved online due to the pandemic (1:A). This has not led to any delays in working with projects (1:A) although it was noted that one project had fallen apart as

collaborating with different stakeholders online made it difficult to continue. Now working online has become more established this problem is less prevalent (1:C).

4.2.2 RQ2: the role of NBS in addressing Urban Challenges

There was recognition amongst participants that Győr had not integrated NBS as widely as the other URIP cities of the NATURVATION project (1:A; 1:B; 1:C). As a result, NBS had primarily been applied to address only a few challenges; a lack of biodiversity and flooding issues within the city. As a result of this however, there were also a number of opportunities presented where NBS could be applied to address UC in the future (1:A; 1:B; 1:C). In particular, challenges related to a lack of biodiversity within the city centre (1:A; 1:B; 1:C), climate change (1:A; 1:B; 1:C), the heat island effect (1:B), increased flooding risk (1:B; 1:C), physical health (1:A; 1:B; 1:C), and the unequal distribution of greenspace were highlighted (1:A; 1:C).

Water Management: Located at the confluence of three rivers Győr has been vulnerable to flooding, with the last major flood in 2013 causing significant damage to the city (1:A). Thus, a number of NBS have been implemented to mitigate against flooding including the regeneration of wetlands upstream (Adyváros Lake Rehabilitation Area), the reconstruction of flood-gates and the expansion of waterways (the Nagy-Pándzsa project) and the maintenance of water regulation sites (Moson Danube Complex Project). Most of the NBS implemented to address flooding have taken place on the outskirts of the city, providing opportunities to implement NBS within the city centre (1:A; 1:B). Participants noted that along the river in the city, there was a preference for grey infrastructure which could have led to the river being much greener (1:A; 1:C). Additionally, public courtyards (which are typically concreted over) could provide opportunities for greening; the latter was seen as an opportunity which could be addressed with bottom-up initiatives. However, it was noted that the need for further flood defences may be lower due to the completion of flood defences in 2019 (1:A). Thus, other UC, such as a lack of biodiversity were considered more relevant for NBS to address (1:A).

Biodiversity Loss: A dense inner city and demand for space for cars has contributed to biodiversity loss and reduced the space available for NBS in Győr (1:A; 1:B; 1:C). Some projects have been implemented to address this, including the addition of gardens to some schools to educate children and improve biodiversity (1:B); however, the demand for including spaces for biodiversity has typically been quite low – from the side of the municipality – due to what is considered an abundance of greenspace surrounding the city which people have access to (Bishops forest) and a higher demand for space for cars and residential (1:B; 1:C). More recently, and with the introduction of a new mayor, more attention has been given to how biodiversity can be increased within the city (1:A). This has led to the implementation of a tree planting project - Lakótelepi fák és kretek – which will lead to the planting of 1000 trees per year along streets in the city (1:B). Other initiatives are being explored with opportunities to green public spaces that are traditionally grey (1:A; 1:B). Thus, opportunities exist to implement more integrated versions of NBS to increase biodiversity within dense parts of the city (1:A; 1:B; 1:C).

Climate Change: Typically, flooding has been addressed by NBS but with increasing temperatures attention has also turned to the heat island effect and heatwaves (1:B; 1:C). This was originally absent as 1:B noted, with some parklands within the city having exposed areas to the sun making them less desirable for people to use. With the growing severity of the problem however, the decision to implement NBS to address poor heat management has become more of a conscious decision (1:B). Recognition of how NBS can tackle climate change mitigation has also become stronger due to the appointment of the new mayor. In working with the municipality, 1:A noted that the new mayor was “*open to every green solution in the city....how can we reduce the effect of climate change?*”. As a result, a stronger connection between NBS and climate change mitigation is expected to lead to opportunities to mainstream NBS within the city (1:A).

Physical and Mental Wellbeing: Although some connection was made between NBS and public health, a stronger connection has been recognised due to the election of a new mayor (1:B). With a background in health, the new mayor has shifted the municipalities priorities to ensure that public health is of top priority. Additionally, there is an acknowledgement that NBS can facilitate this. Thus, this has provided opportunities to mainstream NBS. The pandemic has further emphasized the need for NBS within the city (1:B).

Socio-Spatial Equity: Equal access to NBS has not typically been considered due to the amount of nature available on the outskirts of the city; which is considered to be accessible to all (1:A; 1:C). However, 1:C commented that this should not be a justification to neglect implementing NBS within the inner city. During the initial restrictions implemented as a result of the pandemic, the need for people to have access to NBS was highlighted. Thus, it was noted that additional NBS should be added. 1:B highlighted issues with this however, noting how residential spaces around Bercesényi grove had increased in price with the addition of the park.

4.2.3 RQ3: impeding and supporting factors to NBS mainstreaming

Although Győr had been working with NBS to address some UC there was recognition that several barriers existed to mainstreaming the concept. A lack of commitment from leadership led to challenges with getting NBS integrated into developments (1:B; 1:C). Participants also noted that there was a lack of regulation requiring a certain amount of greenspace being included in projects (1:B). Typically, there was also a lack of awareness of the NBS concept and the benefits that NBS – or even greenspace - could provide (1:B). 1:C reflected on this further noting that perhaps the awareness did exist; however, it wasn't prioritised and people preferred to work with grey infrastructure. When questioned why, the context of Győr was given as an answer, in that the city is surrounded by nature (1:A; 1:B; 1:C) and has a strong car lobby (1:C). Both aspects have provided less motivation to mainstreaming NBS within the city (1:C). This has also contributed to a lack of resources being directed to NBS by the municipality (1:A; 1:B; 1:C). However, with the recent election of a new mayor - who has placed improving public health as a priority– some barriers have been addressed. 1:A reported that an understanding of the benefits of NBS for public health had led to the new mayor asking for green solutions to UC to be prioritised. Data collected from NBS projects previously implemented provided evidence of the benefits of some projects, also increasing support for NBS (1:A; 1:B). Additionally, recognition of current discourse around a lack of biodiversity and climate change further pushed motivations for mainstreaming NBS (1:A; 1:B). Acting on this, new collaborations were initiated with NGOs, who were asked to identify opportunities to integrate NBS into Győr. Additional resources were also directed to mainstreaming NBS (1:A).

Whilst the new mayor had committed resources to NBS mainstreaming it was acknowledged that the COVID-19 pandemic had placed these ambitions on hold (1:A; 1:B). Collaborations with NGOs and the additional resources to be provided to NBS were cancelled, with resources redirected to managing the COVID-19 pandemic (1:A; 1:B). In one case, the movement of work online had led to one project being cancelled as collaboration with multiple stakeholders became too complex (1:C). The more significant challenge was recognised as planning new NBS projects as it was recognised that working online slowed and restricted the creative process (1:A; 1:B). Despite acknowledgement that the pandemic had threatened work with NBS, participants were optimistic due to the opportunities presented by the pandemic. In particular, participants emphasized the newfound appreciation citizens had for nature (1:A; 1:B; 1:C); 1:A reported that in a study they had performed, 60% of people had commented that they would increase their use of the NBS due to the pandemic. The connection between NBS and public health benefits had also been emphasized which, in alignment with the mayors' desire to drive the public health agenda forward, were identified as providing opportunities for NBS mainstreaming (1:A). The pandemics impact on mobility had also led to both threats and opportunities; it was acknowledged that people felt less safe on public transport which could either lead to i)

opportunities to push a modal shift towards walking and cycling or ii) a higher demand for private cars which could lead to fewer opportunities for NBS as space for cars was already in high demand (1:A; 1:C). Participants were hopeful that with the increasing discourse around climate change, public health and biodiversity loss the pandemic would lead to a push for cycling and pedestrian spaces. These could provide opportunities to mainstream NBS (1:A; 1:B; 1:C). Concern was also focused on how NBS sites were being maintained over the pandemic; an increase in the use of these had led to a number of detrimental impacts, which 1:B and 1:C noted were contributing to negative perceptions of some NBS spaces. 1:B reflected that this could put people off from mainstreaming NBS further within the city. All factors that either impede or support NBS mainstreaming are summarised in the table below.

Table 4-2. Győr summary table showing impeding and supporting factors to NBS mainstreaming prior to the pandemic (in italics) and during the pandemic (shaded orange).

Factors	Factors that IMPEDE NBS mainstreaming	Factors that SUPPORT NBS mainstreaming
Cognitive Factors	<ul style="list-style-type: none"> - <i>Lack of awareness of benefits of NBS to address certain UC.</i> - <i>Lack of awareness with NBS term.</i> - <i>Also lack of prioritisation of NBS and preference for grey infrastructure as solution.</i> - Increased use of NBS has led to NBS sites becoming less visually appealing which has led to complaints and could threaten desirability of adding NBS. 	<ul style="list-style-type: none"> + <i>The new mayor has provided drive for mainstreaming NBS. This has been further added to by the pandemic.</i> + In particular the public health benefits of NBS have been emphasized. + Citizen demand for NBS increased – 1:A reported that 60% will use NBS more in future.
Agency	<ul style="list-style-type: none"> - <i>NBS traditionally harder to work with as wasn't being pushed by leadership.</i> 	<ul style="list-style-type: none"> + <i>Election of new mayor has provided opportunities for NBS as he is pro-green.</i>
Collaboration	<ul style="list-style-type: none"> - <i>Citizen consultations were often counter-productive and delayed projects as mostly negative people came out to complain.</i> - Collaborations planned stopped due to the pandemic. 	<ul style="list-style-type: none"> + <i>New mayor has been proactive in establishing collaborations with NGOs to identify opportunities to mainstream NBS.</i>
Discourse and Future Visions		<ul style="list-style-type: none"> + <i>City recently declared that it was aiming to be the healthiest city in Hungary; public health discourse enabling mainstreaming of NBS.</i> + <i>Growing discourse around Greta Thunberg and climate change providing opportunities for NBS.</i> + Fewer people on public transport has increased demand for cycling and space for cyclists = opportunity to mainstream NBS.
Resources	<ul style="list-style-type: none"> - <i>Lack of funds for NBS.</i> - Resources focused on pandemic recovery. 	
Strategic Plans, Legislation, Policies	<ul style="list-style-type: none"> - <i>Lack of legislation on public and private developments including greenspace.</i> 	<ul style="list-style-type: none"> + Strategic plans to become a healthier city have been emphasized as a result of the COVID-19 pandemic.
Local Geographical Context	<ul style="list-style-type: none"> - <i>Historic old town noted as a constraint to implementing green roofs.</i> - <i>Access to NBS on the outskirts of the city used as a justification for not needing NBS in city.</i> - <i>Strong car lobby (space for cars > NBS).</i> 	
Learning	<ul style="list-style-type: none"> - <i>Still a need for more data monitoring to provide evidence in Győr.</i> 	<ul style="list-style-type: none"> + <i>Results from NBS already implemented supported evidence as to benefits. These convinced some stakeholders of their worth.</i>

Source: Authors own elaboration based on tables presented in Appendix J.

4.3 The city of Malmö

Located on the southern west tip of Sweden, Malmö is the third largest city with a population of 350,000 (Malmö Stad, 2021a). Malmö is one of Swedens fastest growing cities with the population expected to grow by 50,000 by 2030. Whilst the population grows Malmö aspires to becoming a sustainable city and a world leader in sustainable urban development. Demand for residential housing has been seen as an opportunity to be able to address an increasing population whilst also addressing social and environmental challenges. To be able to achieve the sustainability targets set by Malmö Stad (Malmö City) the city launched its Environmental Programme in 2009, working to build resilience to several challenges (Malmö Stad, 2021b; NATURVATION, 2017c). Recent investment has been directed into projects that address a lack of biodiversity, a lack of social integration, intense densification and climate change mitigation. In particular, the city has suffered from several flooding events with the last major flood in 2014 causing 600-700 SEK million of damage. This prompted investment into improving water drainage systems including several open stormwater parks across the city (4:D). With climate change expected to increase the severity of major flooding events, the city continues to address flood risk whilst providing residential space for an increasing population.

Sweden had a notably different response to the COVID-19 pandemic in comparison to other countries around Europe, initially embarking on a de-facto herd immunity approach in which few restrictions were made to limit groups on public transport or in public spaces. Restrictions were set to groups of up to 50 people but access to public spaces remained open throughout the pandemic. Thus, the use of community gardens, green roofs and parks were open as per usual (NATURVATION Urban Nature Atlas, personal communication, 13th April 2021). As the pandemic progressed restrictions were introduced limiting opening hours for bars, cafes and restaurants and tighter restrictions on the number of people in groups (reducing to 8 people). During the pandemic, work that could be typically moved online. For industries where online work was not possible, remaining open was allowed (although restrictions on the number of people were enforced). Current measures advise working online at home when possible. Access to NBS and public spaces remain open with limitations only on group size (4:B; 4:C).

4.3.1 RQ1: impacts of the restrictions on NBS Malmö

As few restrictions were initially introduced the majority of NBS projects operated as per normal with continued maintenance taking place (4:A). Sites were also accessible and used by citizens throughout the pandemic; as a result, the number of people using NBS within the city did not increase above what was typically expected (4:B). As restrictions were introduced some sites were provided with additional seating areas and BBQ spots to facilitate any increase in use. Streets were also altered to provide additional outdoor spaces to ensure that people could socially distance more (4:B). However, only a small increase in the use of these areas was seen (4:A; 4:B; 4:D). In contrast, 4:A and 4:B commented on how the use of peri-urban NBS had increased, reflecting that this was likely to result of people working from home, having improved access to these areas (from the suburbs) and wanting to take precautions to stop the virus spreading (with outdoor considered safer). An increase in the use of these spaces led to a number of challenges related to litter, cars parking along roads and disruption to local wildlife (4:B).

With government recommendations to move work online the city of Malmö moved work with NBS online. Limited cuts to funding for NBS projects or the cancellation of projects were made however, some projects were severely delayed due to moving planning of the projects online. At first, this was an unfamiliar format that required getting used to (4:A). Additionally, it was noted that working online made it difficult to collaborate and come up with new ideas and bring them to life (4:A; 4:B). This was something that could only be done through sitting in the room talking to people or visiting the site, further delaying the generation of ideas for NBS (4:A).

4.3.2 RQ2: the role of NBS in addressing Urban Challenges

Following exposure to multiple large-scale flooding events, recognition exists that Malmö is increasingly vulnerable to floods, storms and sea level rise. In combination with public health, these two aspects are often prioritised in the development of NBS projects. NBS potential to be able to address both is also acknowledged although participants noted that the connection between NBS and public health – primarily mental health - is arguably not as strong (4:A;4:B; 4:D). NBS are also implemented to address several other challenges including urban decay, biodiversity loss, climate change and the unequal distribution of greenspace (4:A; 4:B; 4:C; 4:D).

Water Management: Located next to the Öresund strait, Malmö is frequently exposed to storm surges and flash flooding events. With flat topography and climate change increasing the severity of these events, the risk of flooding has become a major UC for Malmö (4:A; 4:B; 4:C; 4:D). Particular reference was made to the 2014 flood which emphasized the severity of the flooding problem and highlighted the need for additional stormwater management to be integrated into the city (4:D). NBS projects previously implemented (for example, the Ekostaden Augustenborg) utilised green roofs, green walls and green open stormwater management systems to store water and mitigate against flash flooding (4:A). These projects demonstrated the effectiveness of NBS in being able to address the challenge of flooding and contributed to the increased acceptance of NBS (4:A; 4:C; 4:D). Thus, a number of other NBS projects were implemented to address the risk of flooding including the implementation of a natural stormwater system at Risebergabäcken which receives 1/5 of the rain in Malmö and Fjärilsparken in which the level of the park was lowered to reduce risk (NATURVATION Urban Nature Atlas, personal communication, 13th April 2021). Flooding risk continues, placing the implementation of NBS to address flooding as a priority for Malmö (4:A; 4:B; 4:D).

Urban Decay: Following the collapse of the textile and shipbuilding industries and economic decline in the 1990s, Malmö suffered from urban decay. To address this, the city of Malmö outlined a number of projects to stimulate urban regeneration with NBS being included in these (4:A). Projects including The Western Harbour transformed an area suffering from decline through new developments and the inclusion of NBS which provided an improved aesthetic to the area and prevented large-scale flood damage (4:B). NBS are now seen as part of the solution to addressing urban decay and are included in projects for their ability to limit flooding, increase biodiversity and improve public health, contributing to urban regeneration (4:A; 4:B; 4:D). A lack of connection between NBS and employment opportunity exists however, highlighting the need for better recognition of the contribution NBS can make to green growth (4:A).

Biodiversity Loss: In recognition of the high-quality soil located on the outskirts of the city, new development has been limited to within current city boundaries (4:A). This has led to increased densification within Malmö and limited the opportunities available for increasing biodiversity (4:B; 4:C). With demand for housing expected to increase, this poses additional challenges for including biodiversity (4:B; 4:C). To address this, Malmö has implemented a number of projects including BiodiverCITY which aims to increase biodiversity through innovative new designs and forms of governance (4:A). The Tree Strategy of Malmö is another project that aims to integrate NBS into streets, outlining ambitions to improve biodiversity and public health (4:B; 4:C). Additionally, opportunities to increase biodiversity exist in setting minimum requirements on greenspace for urban developments (4:A). Although these exist within public projects, there is a need to extend these to private developments (4:B; 4:C). Thus, opportunities to improve biodiversity exist through the integration of NBS in developments.

Physical and Mental Wellbeing: Challenges related to the density of the city also relate to public health (4:A). Thus, the city of Malmö has included good and equal health as a precondition for sustainable development (4:C). Urban regeneration projects have also focused

on improving public health with areas including Lindägen utilising NBS to provide a cleaner natural environment and reduce air emissions for residents. However, 4:D commented that there is still an underdeveloped view of how NBS can contribute to the public health agenda. More attention is required to include social parameters such as physical and mental health in the development of projects and when considering how NBS can benefit projects (4:A; 4:D). With the emergence of the COVID-19 pandemic additional attention has turned to the significance of NBS and the related health benefits provided. Although 4:A felt it was too soon to say, there was some acknowledgement that the pandemic has pushed public health up the agenda when developing projects and thus, also potentially NBS (4:B; 4:D).

Climate Change: Malmö has outlined ambitious targets to become climate neutral and to be supplied with 100% renewable energy by 2030 (4:A; 4:C). The role NBS can play in achieving climate neutrality is recognised in the ability biomass has to be able to store carbon (4:A). Thus, NBS projects have focused on improving the amount of greenspace in the city, primarily combining this with targets to increase biodiversity (4:B). There is also an understanding of the benefits NBS provide to reducing the heat island effect and protecting against heatwaves (4:A; 4:B; 4:C; 4:D). Although this was not recognised as a significant challenge when compared to other UC, there was an understanding that the risk of this may increase as a result of climate change (4:A). The role NBS has to be able to address this is recognised (4:A).

Socio-Spatial Equity: Equal access to NBS is considered to some extent when projects are being implemented; however, this is not prioritised in relation to other challenges (4:B; 4:D). An understanding of why there should be equal access to greenspaces is understood however, and has been further highlighted as a result of the COVID-19 pandemic (4:B; 4:C; 4:D).

4.3.3 RQ3: impeding and supporting factors to NBS mainstreaming

Participants reflected that Malmö has an established relationship working with NBS (4:A; 4:B; 4:C; 4:D). This relationship has been supported by ambitions for Malmö to become a sustainable city, in which strategies towards increasing the amount of biodiversity in the city and reducing impacts from climate change have enabled NBS to be implemented (4:A; 4:B). This was also driven by the sustainable development of new housing stock and the regeneration of areas suffering from urban decay, both of which enabled NBS to be included into development projects (4:A). With some reluctance to implementing NBS, 4:C noted how important it was to have a couple of people within the municipality advocating for NBS in discussions. Being able to communicate the benefits of NBS through using monetary valuation techniques also convinced practitioners of their worth (4:C; 4:D). This was considered especially important due to a lack of understanding with using the term NBS which often arose when speaking to people from some departments (4:A; 4:B; 4:C); however, it was also noted that the flexibility of the term made it easier for people to understand (4:A). Regulation that required a minimum level of greenspace on public developments (4:C) and the availability of funding also supported NBS implementation (4:A; 4:B); however, some barriers to mainstreaming were still identified including reluctance to work with NBS due to each department having their own set of priorities when planning developments (4:C). More concrete data or evidence was reported as being necessary for NBS to be prioritised further; in particular, experiments measuring the public health benefits of NBS and quantifying these with monetary valuation methods (4:A; 4:B; 4:C). This was recognised as being able to potentially overcome the issue of NBS being considered a cost by the accounting system, which was recognised as a barrier to mainstreaming (4:A; 4:C).

The COVID-19 pandemic has provided opportunities to overcome the initial reluctance to implement NBS by emphasizing the connection between NBS and public health benefits; this has provided more weight to arguments to integrate NBS into development projects (4:C), although there was still an understanding that for these to be fully exploited additional hard data demonstrating this connection would be required (4:A; 4:D). 4:A pointed to the opportunities

the pandemic had created for this commenting that “*the city as a classroom*” could allow measurements of NBS benefits to public health to be recorded during the pandemic. Arguments to mainstream NBS have also arisen as a result of the unequal distribution of NBS which was highlighted during the COVID-19 pandemic. This demonstrated how in more dense urban areas of the city access to nature was harder, leading to an unfair distribution of NBS benefits (4:A; 4:B). Additionally, an increase in people working from home also drew attention to how access to NBS in the suburbs and around people’s homes is needed (4:A; 4:C); expectations that work would continue online for the majority of people further highlighted the need for implementing NBS within these areas (4:C). For practitioners, the movement of work online with NBS was reported to have complicated the planning and implementation of NBS projects (4:B; 4:C). 4:C further noted how NBS relies on co-creation and cooperation, both of which had been constrained as a result of work being moved online. A lack of cross-sectorial support was also noted as having been exaggerated as a result of the pandemic, as each department was reported to be dealing with its own set of challenges associated with the pandemic (4:A; 4:B).

The pandemic was reported as leading to an increase in the use of NBS, with participants reflecting that this was due to the increase in appreciation for nature from citizens (4:A; 4:B; 4:C; 4:D). Due to this, additional funding was provided to some projects to aid maintenance and add temporary greenspace that could be used (4:B). There was also recognition that the increase in appreciation of nature from citizens could provide opportunities for bottom-up initiatives to be implemented (4:A; 4:B; 4:D). For all NBS projects citizen participation was acknowledged as being fundamental; the pandemic had demonstrated the need to include citizens throughout the project to ensure that NBS sites are utilised and maintained (4:A). All factors that either impede or support NBS mainstreaming are summarised in the table below.

Table 4-3. Malmö summary table showing impeding and supporting factors to NBS mainstreaming prior to the pandemic (in italics) and during the pandemic (shaded orange).

Factors	Factors that IMPEDE NBS mainstreaming	Factors that SUPPORT NBS mainstreaming
Cognitive Factors	<ul style="list-style-type: none"> - <i>Lack of understanding of NBS concept.</i> - <i>Emphasis on how NBS can be included and provide benefits needed for each department.</i> - Pressure placed on those working with NBS due to unpredictable nature of the pandemic and change in working environment. 	<ul style="list-style-type: none"> + <i>Although lack of understanding, NBS as an umbrella concept makes it easier to explain</i> + <i>Use of monetary valuation techniques makes NBS benefits easier to communicate.</i> + Increase in the appreciation of nature with demands for more bottom-up initiatives. + More weight behind arguments to include NBS into projects due to public health benefits connection to NBS. + Unequal distribution of greenspace highlighted as a result of the pandemic. + Recognition that NBS can contribute to green growth.
Agency		<ul style="list-style-type: none"> + <i>Advocates of NBS convinced others of benefits and contributed to uptake of NBS.</i>
Collaboration	<ul style="list-style-type: none"> - <i>Siloed approach to design and planning the development of projects which wastes opportunities to include NBS.</i> - Movement of work online resulted in delays due to tougher communication. - NBS relies on co-creation and co-operation of which both aspects have been limited by restrictions - Lack of cross-sectorial support and siloed approach exaggerated. 	<ul style="list-style-type: none"> + Delays have provided opportunities to rethink development projects to consider public health more. Opportunities for NBS. + Pandemic demonstrated the need to include citizens more in NBS projects to ensure these are utilised.

Discourse and Future Visions		+ <i>Malmö has a strong vision of becoming a sustainable city.</i>
Resources	- <i>Although funding is not a problem, getting the resources together to get funding is.</i> - <i>Municipalities now have a number of other challenges to respond to due to the pandemic and other priorities.</i>	+ <i>Funding available for NBS.</i> + <i>Additional funding provided to expand and create temporary NBS sites due to increase in demand for these spaces.</i>
Institutional	- <i>Fear to commit to NBS projects due to potential change in government.</i> - <i>Current accounting system shows little monetary recognition of the benefits NBS provide.</i> - <i>Administration process to implementing NBS projects too long – delays progress.</i>	
Strategic Plans, Legislation, Policies	- <i>Although it does exist, more regulation on the amount of greenspace needed aimed at private sector.</i>	+ <i>National policies include recommendations to implement NBS.</i> + <i>Goals for Climate Change, Biodiversity, resilience to floods enable NBS implementation.</i> + <i>Minimum amount of greenspace ensures some level of NBS is included in private projects.</i>
Local Geographical Context	- <i>Densification of city provides less space for NBS.</i>	+ <i>Constant exposure to floods motivated a transition from grey infrastructure to NBS to try and store water rather than just moving it (as per the grey).</i>
Learning	- <i>Reluctance towards the concept as there is not enough concrete evidence of NBS benefits.</i> - <i>Research needed to legitimize monetary valuation techniques (especially public health).</i> - <i>Gap between findings from experiments and how best to apply these in practice.</i>	+ <i>More research needed to reinforce connection between NBS and public health benefits. The pandemic has provided opportunities for this. The city as a classroom.</i>

Source: Authors own elaboration based on tables presented in Appendix J.

4.4 The city of Newcastle

Newcastle upon Tyne (Newcastle) is a city of approximately 300,000 located in North East England (Newcastle City Council, 2021b). Following more recent urban regeneration, Newcastle has developed into a strong technical, digital, medical science and sustainability hub being marked as one of six internationally-renowned Science Cities in the UK. In recognition of several sustainability challenges, the city has outlined a series of ambitious targets including reductions in waste and energy consumption. Newcastle was one of the first in the UK to declare a climate emergency, committing to carbon neutrality by 2030. Frequent flooding within the city centre and low air quality has also placed pressure on the city to address UC (NATURVATION Project, 2017d; Newcastle City Council, 2021c).

Following initial reports of the COVID-19 virus, the UK was kept open with the government pursuing a strategy towards herd immunity. As the virus continued to spread however, in England the government quickly changed its position with a full lockdown from March 2020. This resulted in a number of measures being implemented including the restriction of non-essential travel and the closure of public amenities. Parks remained open during this time; however, limitations on the mixing of households and non-essential travel limited the number of people using public spaces. In summer 2020 the restrictions were relaxed to allow people to exercise outside more and meet up in outdoor spaces. An increase in COVID-19 cases over the summer and intense pressure on the National Healthcare Service led to a second lock-down being implemented in October 2020. This banned all travel, gatherings and inter-household mixing. Work throughout the pandemic was also moved online where possible, with industries that could not be moved online closed. A third lockdown was implemented in January 2021 restricting the movement of people. Currently, restrictions are being relaxed allowing bars and restaurants to re-open. A plan to continue opening up the UK domestically is planned across

the summer of 2021 although international travel still remains restricted (Newcastle City Council, 2021a).

4.4.1 RQ1: impacts of the restrictions on NBS in Newcastle

Due to the initial restrictions implemented, the use of NBS decreased as strict regulations prohibited the movement of people (5:B). 5:A also noted that people were more cautious and stayed away from public areas due to the risk of the COVID-19 virus. During this period of low usage, it was reported that less disruption to wildlife had taken place (5:A). However, as the pandemic went on 5:A reported how restrictions took a toll on people's mental health which gradually drew people back to using the NBS within the city. As restrictions were relaxed this also led to an increase in the amount of people using NBS – an increase that was perceived as exceeding pre-COVID-19 levels (5:A; 5:B; 5:C; 5:D). As was noted by 5:A, this was likely to be as people had fewer options for getting out of the house and so they went to the park or other NBS sites to meet friends, do exercise or just relax. An increase in the amount of people using these spaces led to detrimental impacts; notably, an increase in litter and footpath erosion. Additionally, 5:B commented on how some residents had complained about people using the NBS who were from outside the area, with some people even feeling unsafe using the space as a result. More significant impacts were recorded on peri-urban NBS which saw an increase in use. This led to litter, several accidental fires, footpath erosion and wildlife being disturbed (5:A; 5:B; 5:C). Whilst some car parks providing access to these areas were closed to try and reduce numbers, this only led to environmental degradation as people parked on verges (5:A).

As work had been moved online, some NBS projects were either delayed or cancelled (5:A; 5:B); in attempting to secure funding for an NBS project along the quayside (an area in the centre of the city next to the river), 5:C noted how funding for the project was completely cut off when restrictions were implemented. 5:B commented on how restrictions prevented collaboration which delayed the planning of projects whilst 5:D further noted that for projects already implemented, a lot of activities were placed on hold as a result of restrictions.

4.4.2 RQ2: the role of NBS in addressing Urban Challenges

Following ambitions to become a sustainable city and the outline of a citywide climate change strategy in 2010, Newcastle has been working with NBS to build UR to address several UC (5:A; 5:B). In particular, a series of major flooding events have resulted in NBS being implemented to reduce the risk of flooding (NATURVATION Urban Nature Atlas, personal communication, 15th April 2021). However, as was noted by participants there is also recognition that NBS can provide multiple benefits simultaneously and address UC related to a lack of biodiversity, poor public health related to air emissions, climate change mitigation and urban regeneration (5:A; 5:B).

Water Management: Located next to the River Tyne and 18km from the North Sea, Newcastle has frequently been exposed to floods as a result of heavy rainfall and storm surges. In particular, the 2012 “Toon Monsoon” was accounted for emphasizing the need to address flood risk as a result of widespread damage across the city (5:C). In response, the municipality began to invest into numerous flood mitigation techniques along the river, including into several NBS projects (5:A; 5:B); in recognition that grey infrastructure was contributing to flooding further downstream (as these typically just moved water downstream), more natural solutions were pursued. Projects including the Ouseburn River Restoration Project and the Brunton Park Flood Alleviation Scheme involved the addition of several natural enhancements (embankments added, diverting and widening tributaries) to the river and the surrounding environment to slow the flow of water, increase storage capabilities upstream and improve water quality (NATURVATION Urban Nature Atlas, personal communication, 15th April 2021). Potential remains for NBS to be adopted to further mitigate flood risk; as was noted by 5:B and 5:C, areas

by the side of the river remain covered in grey infrastructure, increasing the risk of flooding. Repurposing these areas with NBS could further protect them from flooding; an opportunity that has grown due to the increased use of these areas during the pandemic (5:C).

Physical and Mental Wellbeing: With the measurement of air quality emissions in Newcastle revealing levels unsafe for citizens the municipality began working on different options to reduce emissions (5:C). Public health also became a main priority in the regeneration and development of the city (5:A; 5:B; 5:C); 5:C commented that a new £50,000,000 project would revamp parts of the city and close a number of roads off to cars, providing additional space for pedestrians and cyclists. Both this and the addition of greenspace were included to address public health goals. The need to reduce unsafe air quality emissions has also led to other opportunities to implement NBS. 5:A remarked how “*trees seem to be the cure for everything at the moment*” in referring to the Newcastle tree strategy which outlines a strategy to green the streets and address UC related to poor air quality, biodiversity loss and urban heat island effect. The narrative surrounding integrating NBS for public health focuses on this air quality aspect however, with a lack of acknowledgement that NBS also provide mental health benefits; this connection has been emphasized since the COVID-19 pandemic (5:A; 5:B; 5:C; 5:D).

Climate Change: With the increasing risk of flooding in Newcastle and the growing discourse surrounding global warming, climate change mitigation has also been prioritised by the municipality (5:C). Thus, Newcastle City Council has outlined a strategy for becoming carbon neutral by 2030; the strategy lists a number of actions required to achieve this including the use of nature-based carbon sequestration solutions to reduce CO₂ emissions. Examples of schemes implemented include the Newcastle Tree Strategy which have attempted to increase the stock of trees within the city (NATURVATION Project, 2017d). In acknowledging the role of nature-based carbon sequestration solutions in mitigating climate change, opportunities for NBS are highlighted (5:C). Additionally, the declaration of a climate emergency in 2019 has further fuelled efforts to address climate change and mainstream NBS (5:B; 5:C). Whilst not traditionally a problem, 5:A also pointed to the emerging challenge of heatwaves that will also need to be addressed in the future. These too will also require actions such as NBS to be implemented to reduce street temperatures (5:A).

Biodiversity Loss: Although Newcastle City Council has typically implemented NBS to increase biodiversity in line with the Biodiversity Action Plan (5:A; 5:B) the need to continue integrating this within the city remains (5:C). For the municipality, this requires more of an integration into the planning of developments with NBS such as green roofs and green walls being adopted (5:A; 5:B). 5:C noted how, in recently reviewing a major development in Newcastle, there was a considerable lack of greenspace. Thus, opportunities for NBS to be able to increase biodiversity exist (5:A; 5:B; 5:C). The introduction of the Biodiversity Net Gain policy will also provide opportunities to increase NBS as private developers are targeted – and required – to increase the amount of biodiversity in their developments (5:C).

Socio-Spatial Equity: As was noted by 5:D there is a need to address the unequal distribution of greenspace in Newcastle, this being emphasized during the pandemic as restrictions limited people’s access. NBS provides opportunities for this to be addressed; however, 5:D highlighted the need to actively engage citizens throughout the planning, implementation and use of NBS projects to ensure that they are utilised.

4.4.3 RQ3: impeding and supporting factors to NBS mainstreaming

Participants noted that work with NBS prior to the pandemic had generally been enabled due to several factors. These included: i) increasing discourse around the topic of climate change which had contributed to Newcastle declaring a climate emergency and outlining a strategy for climate neutrality (5:A); ii) strategies to address other UC including biodiversity loss and public

health such as the Biodiversity Action Plan (5:A; 5:B; 5:C; 5:D); iii) a number of collaborative networks between stakeholders which facilitated discussions around integrating NBS into the city (5B) and; iiiii) regulation that targeted the private sector to increase biodiversity (Biodiversity Net Gain policy) (5:B; 5:C). Although participants noted that there was a good understanding of how NBS can address certain UC amongst practitioners (5:A; 5:B), there was also recognition that a lack of connection between NBS and public health benefits existed (5:D). Additionally, there was confusion around the concept of NBS and how it related to greenspace in cities (5:A; 5:B; 5:C; 5:D). The availability of data demonstrating the benefits of NBS (from the Newcastle Urban Living Lab) was recognised as supporting practitioners in their acceptance of NBS; however, for others, 5:A reflected that NBS are still seen as a resource suck due to the accounting system which frames NBS as a cost. Other barriers to implementation were noted as cuts in funding for NBS (5:A; 5:B), a lack of advocacy for NBS in discussions (5:A) and a lack of engaging citizens throughout the process of implementing NBS (5:D).

As was noted by participants, the COVID-19 pandemic had highlighted the unequal distribution of NBS and the need to include citizens within the planning process of NSB projects (5:A; 5:B; 5:C; 5:D). 5:D emphasized the need for bottom-up NBS initiatives to address the unequal distribution of NBS and to engage citizens; however, also noted that restrictions limiting social interaction could threaten the success of these. Participants also noted that the pandemic had led to an increase in the appreciation and demand for NBS by citizens (5:A; 5:B; 5:C; 5:D); due to this, the municipality had promoted the cities sustainable mobility strategy by closing off space for cars and providing this to pedestrians and cyclists. Direction from the government promoting a green recovery also provided resources for NBS (although 5:B reported funding was initially cut and redirected to respond to the pandemic). Participant 5:C further noted how a number of new stakeholders had come forward expressing interest in working with NBS due to the increase in demand for nature. Although these opportunities have arisen to mainstreaming NBS, the movement of work online was reported to have made collaboration and creativity harder (5:A; 5:C). Additionally, despite a stronger connection between NBS and public health benefits being emphasized as a result of the pandemic (5:A; 5:C), it was acknowledged that more experimentation that both involves citizens and measures the public health benefits of NBS would be required to utilise opportunities (5:A; 5:D). All factors that either impede or support NBS mainstreaming are summarised in the table below.

Table 4-4. Newcastle summary table showing impeding and supporting factors to NBS mainstreaming prior to the pandemic (in italics) and during the pandemic (shaded orange).

Factors	Factors that IMPEDE NBS mainstreaming	Factors that SUPPORT NBS mainstreaming
Cognitive Factors	<ul style="list-style-type: none"> - <i>Confusion around the concept of NBS</i> - <i>People fail to see how socio-equity components fit in with NBS.</i> - <i>Lack of understanding of how NBS can address public health challenges.</i> - <i>NBS still seen as a resource suck.</i> 	<ul style="list-style-type: none"> + <i>Good understanding of how NBS can tackle UC including flooding, biodiversity loss, climate change.</i> + <i>Connection between NBS and public health benefits understood better.</i> + <i>Increase in appreciation for nature. what does this mean for NBS in long-term.</i> + <i>Unequal distribution of NBS highlighted.</i>
Agency	<ul style="list-style-type: none"> - <i>Lack of leadership promoting NBS in municipality.</i> 	<ul style="list-style-type: none"> + <i>New head of Environmental Agency promotes NBS.</i>
Collaboration	<ul style="list-style-type: none"> - <i>Numerous stakeholders meant it was more complex to get projects implemented.</i> - <i>Citizens involved but not engaged with whole process of NBS planning.</i> - <i>Restrictions on the amount of people who can meet up will limit NBS work.</i> - <i>Citizen participation in projects more complex due to online and restrictions.</i> 	<ul style="list-style-type: none"> + <i>Arranging networks with people from all different departments encouraged the integration of NBS.</i> + <i>In recognising the increase in demand for nature a number of new stakeholders have shown interest in working with NBS.</i>

Discourse and Future Visions		+ Newcastle declared a climate emergency and has frequent discourse around climate change. + Opportunities to mainstream NBS have come at a time when discourse around climate change already supports this.
Resources	- Lack of resources for implementing NBS (funding cut for parks by 90%). - Initially access to funding for NBS was restricted as directed to COVID-19 pandemic response.	+ Although initial delays to finance, the pandemic has now led to financing opportunities to mainstream NBS.
Institutional	- NBS seen as a resource suck due to accounting system that views them that way. - Public organisations are siloed in how they work	
Strategic Plans, Legislation, Policies	- Delay with Environmental Bill coming out as a result of the pandemic.	+ Climate Neutrality Strategy supports implementation of NBS. + Alignment with biodiversity action plan, mobility strategy, biodiversity net gain (regulation) – all provide opportunities to mainstream NBS. + National policy for COVID-19 recovery pushing for green recovery.
Local Geographical Context	- Heavily industrialised past has meant grey infrastructure covers large areas of the city.	
Learning	- Still a need for experimental studies that measure the benefits of NBS on public health. - To fully utilise the opportunities presented by the pandemic evidence of public health benefits is needed.	+ Data and monitoring have contributed significantly to the growing acceptance of NBS. Newcastle Living Urban Lab for example.

Source: Authors own elaboration based on tables presented in Appendix J.

4.5 The city of Utrecht

With a population of approximately 350,000 Utrecht is the fourth largest city of The Netherlands (Gemeente Utrecht, 2021b). Despite providing a range of greenspace, Utrecht is expected to see significant population growth by 2024, growing to 400,000. This is expected to place pressure on the municipality to ensure that enough housing is provided to citizens. To meet demand, Utrecht intends to build an additional 49,000 houses within current city limits, this expected to contribute to increased densification and placing pressure on public green spaces. The municipality also acknowledges the need to build resilience to several UC including drought and increased flood risk. This has led to the municipality investing into restoring parts of the original canal structure which were originally removed. NBS projects continue to address a range of UC with ambitions for Gemeente Utrecht (The City of Utrecht) to provide “healthy urban living for all” through optimising green and blue infrastructure throughout the city (Gemeente Utrecht, 2021b; NATURVATION Project, 2017e; Oppla, 2020).

Utrecht began implementing measures to restrict the spread of the COVID-19 virus in March 2020. Restrictions severely prevented people’s mobility throughout the city with all businesses and schools closed, limitations on group size enforced and 1.5m distancing rules applied. National measures also led to restrictions on the use of NBS in cities; access to community gardens, private allotments and public roof gardens were closed, whilst access to some public parks was also reduced (3:B). Following May, restrictions began to relax re-opening up parks and other greenspaces to the public. Social distancing was still enforced within these areas, with rings drawn on pathways to create one-way pedestrian traffic areas (3:A; 3:C) and rings placed in some areas to provide socially distanced sitting areas for citizens (3:B; 3:C). Police officers were also seen patrolling areas to enforce social distancing. Access to NBS remains open for citizens although this remains restricted. Various NBS projects outlined on the urban atlas, including the Garden Factory, Roerplein Pocket Garden and Máximapark continue to take

precautions to limit the number of people using areas; designated one-way pedestrian walking rings continue to be enforced whilst parks are occasionally closed to limit numbers (3:B; 3:C NATURVATION Urban Nature Atlas, personal communication, 15th April 2021). Evening curfews are also enforced to restrict access to public spaces and to parks (Gemeente Utrecht, 2021a).

4.5.1 RQ1: impacts of the restrictions on NBS in Utrecht

Due to the initial restrictions, there was a visible decline in the number of people using the NBS within the city (3:A; 3:B; 3:C; 3:D). In recognition that this may be limiting peoples physical and mental wellbeing, these spaces were eventually opened up (3:B; 3:C; 3:D) leading to an increase in the number of people using these spaces (3:A; 3:B; 3:C; 3:D). 3:C noted that as if overnight the park got increasingly busy. Such a significant increase led to a number of challenges including complexities with enforcing restrictions; due to the number of people using NBS police and park staff had to confront large groups and ask them to disperse. 3:C notes that this led to people occasionally becoming aggressive which placed individuals in a precarious position. To overcome this, some parks were closed altogether; however, this often led to the group moving to another space rather than separating completely (3:A; 3:C). A significant increase in the number of people using the spaces also impacted local biodiversity (3:A; 3:B; 3:C; 3:D). Less undisturbed space was provided for birds and other wildlife as people frequently walked away from public paths (3:C). This was especially evident in peri-urban spaces in which 3:D commented on how a number of deer had been trapped and died as a result of an increase in people interacting with nature. To overcome this, some NBS sites began closing access to citizens once car parks were full; however, this often led to people parking nearby, either illegally on the road or on verges, which further damaged the local environment (3:C; 3:D).

Due to the increased number of people using NBS sites within Utrecht the parks were provided with additional resources to increase the maintenance on the sites (3:C). This included the provision of temporary toilets, extra staff to enforce restrictions and the widening of paths to ensure that citizens could continue to maintain distance when walking (3:A; 3:C). This enabled some of the challenges outlined above to be addressed although this was initially difficult to arrange and manage due to the movement of work online (3:C; 3:D). This delayed the planning and implementation of some NBS projects (3:A; 3:D). An increase in the amount of people working from home also meant that people were using the NBS around their homes more (3:D).

4.5.2 RQ2: the role of NBS in addressing Urban Challenges

The UC that NBS have the potential to address in Utrecht have been outlined below. Participants noted that NBS have been and are currently favoured by the municipality due to their ability to be able to address multiple UC simultaneously (3:A; 3:D). This has enabled them to address biodiversity loss, intensified heat stress, flood risks and citizen physical and mental wellbeing all of which are UC Utrecht has identified (3:A; 3:B; 3:C; 3:D). UC related to biodiversity loss, public health and flood risks have been traditionally addressed by the use of NBS however, more recently this has expanded to climate change mitigation and socio-spatial equity (3:A; 3:B).

Physical and Mental Wellbeing: Driven by the healthy urban living concept several NBS projects implemented have been influenced by goals to improve public health (3:B). As was noted by 3:A and 3:D, in every policy or development being planned health is a leading consideration prompting the inclusion of NBS within the city. It was recognised that NBS provide opportunities to get people moving, to breathe clean air and to reduce noise pollution (3:A; 3:B). 3:B further elaborated that there was an understanding that NBS were not just viewed as helping people who were already ill but were also considered as a preventative solution. Another component of the healthy living concept is the promotion of walking and cycling (3:A;

3:B; 3:D). Utrecht already has a culture of cycling but aligned with the healthy urban living concept roads have increasingly been converted to pedestrian and cycling paths, providing opportunities to implement NBS (3:A; 3:B). Due to an awareness between NBS and public health prior to the pandemic all participants were reluctant that any significant changes would result in additional opportunities for NBS mainstreaming (3:A; 3:B; 3D). 3:B did remark on how a stronger connection between mental health and NBS had been emphasized however, potentially leading to the inclusion of NBS projects moving up on the agenda within discussions.

Biodiversity Loss: The city has a longstanding reputation with working with NBS to improve biodiversity within the city, primarily due to citizen demand and “green” leadership which has pushed for including biodiversity within the city (3:A; 3:B). This has led to NBS projects such as green bus roofs, which include the planting of meadow flowers on top of bus shelters (3:D). Additionally, spaces traditionally planted with lawn are now being turned over to meadows (3:C). Current targets to increase the number of houses built within Utrecht will place further pressure on conserving spaces for biodiversity (3:A; 3:C; 3:D). To prevent urban sprawl the city has committed to building these houses within current city limits; however, as was recognised by 3:D this will make it harder to find spaces for wildlife to live undisturbed. Therefore, challenges will continue to exist in ensuring that both biodiversity loss is minimised and that opportunities to increase biodiversity can be identified (3:C; 3:D). This has presented opportunities to implement forms of NBS that are integrated into urban design including structural greening (3:B). NBS was widely acknowledged as a solution to this given the capacity for NBS to be added to current structures (3:A; 3:B; 3:C). However, for NBS to contribute effectively to biodiversity a deeper understanding of what biodiversity is, is required (3:C; 3:D). This involves a better consideration of native and endangered species in biodiversity plans (3:D).

Water Management: With most of the country lying below sea level and located on a river delta, The Netherlands is prone to both coastal and river flooding (Oppla, 2020); located slightly higher than both Amsterdam and Rotterdam, the risk of Utrecht suffering from major flooding is lower but remains present (3:A; 3:B). As a result, a range of NBS projects have been implemented in an attempt to address flood risk including the recent expansion of the canal into the city centre. Replaced by a road in the 1980s, the Greening of the Historical Centre NBS project included restoring the original canal structure to provide water storage and cleaning capacities (3:B). NBS projects continue to address challenges with flooding in recognition that the risk of flood events will increase with climate change (3:A; 3:B). This includes, and has shifted, to the use of NBS (in contrast to grey infrastructure) in recognition of the potential NBS has in being able to mitigate against flooding and the other benefits they provide (3:A).

Climate Change: NBS have also been implemented in recognition of their ability to address climate change mitigation and adaptation to intense heatwaves and the heat-island effect (3:A; 3:B). The latter have led to NBS projects including the greening of streets (with trees and planters), green roofs and parklands which are anticipated to reduce temperatures at street level (3:A). The implementation of Roerplein park in the city is one such example, being implemented to address urban heat stress and provide local residents with a location to relax (3:A; 3:B). Ambitious climate reduction targets and the objective of becoming climate resilient have provided additional opportunities for NBS to be implemented, with improved air quality goals intended to provide further incentive for implementing NBS (3:A).

Socio-Spatial Equity: Whilst the challenge of unequal access to nature is acknowledged by the city of Utrecht, the implementation of NBS to address this is often neglected due to the prioritisation of other challenges (biodiversity loss, climate change etc.) (3:A; 3:D). 3:B elaborated on this discussing how when planning NBS projects there was a limited awareness on how NBS could be implemented to address the challenge of equal access to nature. In particular, bottom-up initiatives were highlighted, as these typically took place in more affluent

areas of the city (3:B). 3:D pointed out that some bottom-up NBS projects had been implemented in areas considered less affluent however, these had a separate set of challenges that were not anticipated, including a lack of resident knowledge to be able to maintain projects. Significant efforts are being made to address this however, with 3:B referencing the new Spatial Strategy for Utrecht in which goals are outlined for every citizen to be able to view greenspace from their dwelling and have access to some form of nature within 200m. The pandemic was also noted as having emphasized the connection between physical and mental health benefits from NBS and the unequal distribution of these (3:A; 3:B; 3:D). Therefore, potential exists for NBS projects to address the challenge of unequal distribution to nature (3:A; 3:B; 3:D).

4.5.3 RQ3: impeding and supporting factors to NBS mainstreaming

Participants from Utrecht noted that prior to the COVID-19 pandemic the mainstreaming of NBS was typically supported; participants emphasized how current “green” leadership advocated and provided support for the mainstreaming of NBS (3:A; 3:B; 3:D). A high level of commitment from leadership to increase the amount of nature in Utrecht had also led to the allocation of resources that supported NBS mainstreaming (3:A; 3:B). Alignment with other city strategies based on increasing biodiversity and climate change mitigation further provided opportunities to mainstream the use of NBS over grey infrastructure (3:A; 3:B; 3:C; 3:D). In particular, health policies have dominated discussions when developments are taking place. This has enabled NBS to be given preference and integrated into a number of projects (3:A), also as a result of practitioners demonstrating a good understanding of how NBS can provide benefits to public health (3:A; 3:C; 3:D). 3:A did point out issues with using the term NBS however; other concepts such as green infrastructure and eco-system services were more widely understood. Alignment with the mobility strategy in Utrecht and a bike dominant culture have also enabled NBS to be implemented as a result of streets being closed to cars (3:A). The continued discourse around reducing car use, biodiversity loss and climate change are expected to continue to enable NBS mainstreaming (3:A; 3:B).

Although participants believed that NBS was typically supported 3:B and 3:D noted that departments still worked siloed – or collaborated with departments too late in the development process for NBS to be utilised. Additionally, goals to construct 49,000 homes had made finding space for NBS difficult. Whilst NBS that could be integrated into buildings was acknowledged as a solution participant 4:D noted that there was still limited space that could be provided for wildlife that was undisturbed. This challenge was exaggerated due to policy that required a certain amount of car space per residential unit – which was deemed unnecessary in Utrecht due to a strong bike culture (4:D). For NBS to be included more, additional evidence quantifying the benefits of NBS to public health would be needed (3:D).

The COVID-19 pandemic has presented several opportunities to facilitate the mainstreaming of NBS in Utrecht including the increased appreciation of nature by citizens (3:A; 3:B; 3:C; 3:D). With this contributing to an increase in the number of people using NBS, additional resources have been provided by the municipality to maintain current NBS and to enable new projects to be planned (3:A; 3:D); in particular, Utrecht municipality began reaching out to citizens to ask for ideas to green the city. 3:B noted how the most potential lay with these bottom-up initiatives due to the increase in appreciation by citizens. Acknowledgement also existed that NBS had moved up the municipalities agenda, due to the connection between NBS and public health benefits being exaggerated, and the unequal distribution of greenspace highlighted due to the pandemic. Although this has contributed to the increased discussion around NBS some participants were still unsure whether this would lead to a significant difference due to a culture that already supported green initiatives (prior to the pandemic) and strategic goals to increase the amount of housing within the city – which often took precedent over other goals (3:A; 3:B; 3:D). Legislation targeting private developers and the integration of NBS into developments (e.g. green roofs.) was highlighted as a solution to this (3:D). Additional challenges arose with

work moving online, in which planning projects were reported to have become more complex to arrange leading to delays (3:A; 3:B). A lack of national direction on how to recover from the COVID-19 pandemic also led to an initial lack of direction within the municipality on how best to proceed with work on NBS; however, this was eventually overcome by the current leadership in the municipality who encouraged work with NBS (3:A; 3:B). All factors that either impede or support NBS mainstreaming are summarised in the table below.

Table 4-5. Utrecht summary table showing impeding and supporting factors to NBS mainstreaming prior to the pandemic (in italics) and during the pandemic (shaded orange).

Factors	Factors that IMPEDE NBS mainstreaming	Factors that SUPPORT NBS mainstreaming
Cognitive Factors	<ul style="list-style-type: none"> - <i>Confusion understanding the NBS concept.</i> - <i>Although there is a good understanding of NBS benefits, there is a need to convince some people within the municipalities still.</i> 	<ul style="list-style-type: none"> + <i>Good understanding of NBS benefits to citizen health, biodiversity, climate change etc.</i> + <i>Good public acceptance of NBS.</i> + <i>Increase in the appreciation for NBS.</i> + <i>This could lead to citizens taking stewardship position themselves in mainstreaming NBS.</i> + <i>Unequal distribution of greenspace demonstrated by pandemic. Has moved it up the agenda.</i> + <i>Connection between public health and NBS reinforced due to pandemic.</i>
Agency		<ul style="list-style-type: none"> + <i>High level of support from local government promoting biodiversity and climate change.</i> + <i>Long-term commitment to these goals.</i>
Collaboration	<ul style="list-style-type: none"> - <i>Departments are still siloed and collaboration should happen from beginning of projects.</i> - <i>Delays with NBS projects with working online.</i> - <i>Harder to come up with creative NBS ideas when working online.</i> 	<ul style="list-style-type: none"> + <i>Some level of collaboration between departments which provides opportunities to mainstream NBS.</i> + <i>Easier to reach some stakeholders as everything is online now.</i> + <i>In recognition of the need to include participants in the planning process, projects are reaching out more to citizens.</i>
Discourse and Future Visions		<ul style="list-style-type: none"> + <i>Strong ambitions to become a sustainable city – climate change and biodiversity goals act as accelerator towards acceptance of NBS.</i> + <i>Vision of a cycle city and providing space for pedestrians and cyclists (NBS can be integrated).</i> + <i>More space provided to pedestrians and cyclists during the pandemic = opportunities for integrating NBS.</i>
Resources		<ul style="list-style-type: none"> + <i>Support from government = resources for NBS.</i> + <i>Additional funding available for NBS.</i>
Strategic Plans, Legislation, Policies	<ul style="list-style-type: none"> - <i>National policy outlines requirements on car spaces per residence = limits space for NBS.</i> - <i>Policy required to drive integration of NBS into private developments.</i> - <i>Lack of national direction on how to build back from the pandemic.</i> 	<ul style="list-style-type: none"> + <i>Alignment with biodiversity, climate change and mobility strategies provide opportunities for NBS.</i> + <i>Health policies place focus on NBS in the city.</i> + <i>Local leadership did eventually provide some direction to how to move on from pandemic (facilitating work with NBS).</i>
Local Geographical Context	<ul style="list-style-type: none"> - <i>Goals to construct 49,000 homes places pressure on space = less available for NBS.</i> 	<ul style="list-style-type: none"> + <i>The COVID-19 pandemic has shown how important integrating NBS is to ensure housing demands are met but also NBS is provided.</i>
Learning	<ul style="list-style-type: none"> - <i>Bottom-up initiatives not fully realised as residents did not have the correct knowledge on how to maintain these.</i> 	

Source: Authors own elaboration based on tables presented in Appendix J

5 Discussion

This section draws on the results outlined in the previous section to identify similarities and differences between each of the cases investigated. Firstly, how COVID-19 restrictions have impacted on NBS will be reviewed for each city, to address RQ1. Following this, RQ2 regarding UC will be discussed following the analytical framework identified in section 3.7.1. Finally, RQ3 regarding the threats and opportunities presented by the COVID-19 pandemic to implement NBS will be evaluated following the analytical framework identified in section 3.7.2. This section will also draw on results collected on the barriers and enablers to assess how factors impeding and supporting NBS mainstreaming have changed as a result of the COVID-19 pandemic.

5.1 Impact of COVID-19 Restrictions on NBS in cities

In this section the impact of the COVID-19 pandemic restrictions on the planning, implementation, use and maintenance of NBS will be discussed. This will follow the structure of: i) changes to the use of NBS during the pandemic; ii) unintended consequences that arose due to these restrictions and; iii) delays and cancellations on NBS projects due to the pandemic. This structure was adopted following the in-case and then cross-case analysis of cases which allowed these three common themes to be identified. In analysing how the restrictions have impacted on NBS, this research will fulfil its aim to contribute to an improved understanding of the impact the COVID-19 pandemic has had on NBS (RQ1).

5.1.1 Changes to the use of NBS

A change in the use of NBS was reported by all cities throughout the pandemic although notably this differed depending on the type - and severity - of the restrictions implemented. In particular, this connection was most clearly demonstrated in the cities of Barcelona and Malmö following the implementation of measures (or lack of them) at the beginning of 2020 when cases of the COVID-19 virus began to increase: in response to this, Barcelona initiated a strict lockdown limiting people to their homes that was enforced by the police. This led to a 90% decline in the use of parks within Catalonia (2:C; 3:C; 5:A). In contrast, in Malmö few measures were implemented, which allowed people to continue to move freely around the city and meet in other public spaces such as restaurants, cafes and bars. Participants from Malmö initially noted no decrease, or increase, in the amount of people using urban NBS during this period, with an awareness that this was due to no measures being implemented (4:B). This connection could also be seen in other cities towards the beginning of the pandemic with Utrecht and Newcastle also reporting a low use of parks during the initial implementation of restrictions; however, as was acknowledged by some participants (5:A) this was also likely to be due to people being uncertain and afraid of the virus.

Following the initial outline of measures, each city (with the exception of Malmö, as few measures were initially in place) began to relax restrictions to provide access to NBS. Although this occurred at different times across 2020 for each city, the response that followed was similar; an increase in the use of NBS within and/or around the city in peri-urban NBS sites. The cities of Barcelona, Newcastle and Utrecht witnessed a substantial increase in the use of urban NBS sites; parks became full, people were using pathways along the rivers more, community gardens were utilised etc. Participant 3:C even commented how, as if overnight, the park had become increasingly busy. As was recognised by participant 1:A this increase was to be expected given that public spaces were the only spaces open for citizens where some form of social interaction was allowed. However, as was also identified by Bayulken et al., (2021), Sharifi & Khavarian-Garmsir, (2020) and Zander et al., (2020) - who recorded similar increases in the use of greenspace in other contexts - an increase in use was also accounted to people going out to walk, cycle or run as a result of these being one of few activities that were permitted and provided access to the outdoors. Whilst there was some acknowledgement of these motives for an increase in NBS in Győr, participants only witnessed a slight increase in the number of

citizens using NBS within the city; however, instead the use of peri-urban NBS, such as Bishops Forest in Győr, saw larger increases. This could be accounted to two main reasons: the first i) being the unique context of the city, which meant that the forest and other peri-urban NBS sites were easily accessible from most areas of the city (1:A; 1:B; 1:C) and; ii) that sites of NBS within the city (parks) were generally underutilised by citizens prior to the pandemic and were less desirable than larger peri-urban sites (1:B).

All of the cities explored identified an increase in the number of people accessing peri-urban NBS sites; Malmö was unique in this sense, as although no restrictions were in place that limited people's access to restaurants, cafes, bars or shops, an increase in use was still recorded, to the extent that car parks to some sites had to be closed to manage use (4:B). This was a common phenomenon witnessed across all of the cities. 4:B speculated that this was due to work being moved online - and so from home - where the majority of people had better access to peri-urban areas from the suburbs. An increase was also anticipated to have arisen due to an increase in appreciation for nature and as peri-urban NBS spaces became one of few areas where citizens could meet with others to socialise or perform exercise; as was also recognised by Bayulken et al., (2021), Sharifi & Khavarian-Garmsir, (2020) and Zander et al., (2020). Whilst few restrictions limited citizens meeting in shops, bars and cafes in Malmö, an increase in the use of peri-urban NBS was also accounted to people recognising the risk of meeting others and so citizens chose to access these areas more to minimise the risk of spreading the virus, especially when meeting in groups with family and friends (4:A; 4:B).

Following the initial relaxation of restrictions use of urban and/or peri-urban NBS remained high throughout the pandemic for all cities. Although stricter restrictions were implemented again throughout the pandemic following a second and third wave of high COVID-19 cases, access to NBS were kept open to allow citizens to keep using these spaces (1:A; 2:A; 3:C; 5:A).

5.1.2 Unintended consequences

With the initial decrease and proceeding increase witnessed with the use of NBS a series of impacts or “unintended consequences” (5:A) were reported impacting on NBS sites. These could be connected with the implementation of restrictions and proceeding use of NBS by citizens, and so provided an indication of how restrictions impacted on NBS.

The initial restrictions that were implemented by the majority of cities were followed by a decline in the use of NBS. For Barcelona, Newcastle and Utrecht this also led to a lack of maintenance being done on some NBS projects to ensure compliance with restrictions that limited working in groups. Whilst this left parks abandoned for a period of time, this was reported as providing opportunities for nature to come back into the cities, or for cities to “rewild” (2:B). Both Newcastle and Utrecht reported less disruption to natural sites during this period, leading to an increase in biodiversity (3:A; 3:C; 5:A). This was most visible in Barcelona however; with the strictest restrictions implemented for the longest duration, Barcelona reported and emphasized the rapid changes that had occurred with biodiversity in the city. As was witnessed by 2:B;

“So what happened is we had a particularly wet, mild spring, so by the time we actually went back to the green spaces in late May, what we had was these absolutely, completely naturalised green spaces. You know, the grass was long, flowers everywhere, bird nests everywhere, different animals showed up, a vast increase in the presence of various invertebrates. Rare birds came nesting into the city.” 2:B

Additionally, in recognition of the amount of biodiversity that had re-entered the city, conversations were prompted regarding the municipality's overall strategy to greenspace maintenance. An appreciation of the increase in biodiversity led to the adoption of a more naturalised greenspace management technique; whilst the adoption of this had been debated prior to the COVID-19 pandemic, the restrictions that resulted from the pandemic provided a

setting to experiment, allowing everything to grow. This provided the evidence and support required to transition to a more naturalised technique used to manage the greenspaces (2:B). The lack of maintenance on NBS also led to a number of negative impacts however; some invasive species were found to have entered the city whilst some people made complaints around the visual aesthetic of the more “wild” strategy adopted. Some areas of NBS were also restricted to allow biodiversity to continue to prosper however, it was later recognised that this could not be done – due to citizen demand for using the areas (2:B).

Whilst the pandemic led to opportunities for the city to rewild, restrictions on people’s access to NBS and other public spaces had a detrimental impact on public health. This recognition had already begun to emerge in literature with similar findings from Pouso et al (2021) and Bayulken et al., (2021) who identified both the contact to nature and the possibility to exercise outside as increasing people’s resilience to respond to COVID-19 restrictions (quarantines and lockdowns) and other related stresses (deaths, unemployment etc.). This was further emphasized by all the cities explored in this research; the physical and mental benefits of providing access to NBS sites was recognised as part of the reason NBS had remained open following the initial relaxation of restrictions, regardless of future COVID-19 waves. It was further acknowledged that the risk of citizens suffering from poor physical or mental wellbeing outweighed the risk of the COVID-19 virus spreading. As a result, although restrictions typically limited the number of people in groups, NBS remained opened. For the city of Barcelona, it was even noted that “*even the view of greenspace from your house or your balcony was very important during the lockdown*” (2:C) with many residents utilising their rooftops to be able to exercise. This increase in value for accessing NBS and other public spaces contributed to the increase in the use of sites however, which also led to a number of detrimental impacts being inflicted (2:A; 2:B; 2:C).

Following the relaxation of restrictions a substantial increase in the number of people using the NBS and other public spaces placed enormous pressure on each site. This resulted in a range of unintended consequences amongst the cities: in Newcastle it was reported how restrictions limiting people drinking in pubs only pushed people to greenspaces where litter and anti-social behaviour became more common (5:A; 5:B); additionally, in some parks individuals reported feeling unsafe due to the number of people using the parks and a number of these looking out of place within the area (5:D); in Utrecht, a huge number of people coming to the parks led to difficult confrontations between staff and larger groups of people, whilst in Barcelona an increase in litter, noise and wildlife disturbances were recorded (2:B). Particular reference was made to disturbances to wildlife within peri-urban NBS sites. At these locations, an increase in the number of people pushed wildlife away from their natural habitats and closer to urban areas; in Utrecht it was remarked how this had led to some deer being trapped between a railroad and a small area of woodland, leading to some deer dying (3:D). Even when attempts were made to limit people from entering these areas (through closing car parks) use of NBS remained high and degradation remained as people parked along roads (4:B; 5:A). Whilst the number of people using these NBS likely contributed to environmental degradation it was also recognised that: i) a lack of funding for maintenance and; ii) a lack of awareness that these impacts may occur as a result of restrictions (thus the use of the word “unintended”) had also contributed to the magnitude of impacts (2:A; 5:B). As the pandemic continued however, some cities reported receiving additional resources to manage the increase in the use of NBS (Malmö, Győr, Utrecht) with NBS in Utrecht – primarily the parks - reporting that extra funding allowed several alterations to be made to allow the increases in numbers to be managed, including the expansion of pathways to encourage distancing and more park management to enforce restrictions (3:C).

As a result of an initial decrease and proceeding increase in the number of people using NBS sites, it was demonstrated how a number of unintended consequences had arisen as a result of restrictions. Even in Malmö, where restrictions were relatively relaxed (in comparison to the other cities explored), a number of unintended consequences occurred although admittedly,

these were less visible than in cities which had stricter regulations in place (Barcelona, Utrecht, Newcastle, Győr.). Although unlikely anticipated when implementing restrictions this suggests that the COVID-19 pandemic restrictions impacted on the use of NBS.

5.1.3 NBS project delays and cancellations

Due to the restrictions implemented as a result of the COVID-19 pandemic, work involved with planning NBS moved to an online format for all cities. Whilst it was noted that this did allow for some stakeholders to be reached faster (3:A), overall response from participants suggested that this had led to projects being delayed and/or cancelled. It was apparent that some participants felt frustrated with planning NBS projects online; this became more complex, was uninspiring and led to a lack of creativity when designing projects (4:B 5:A; 5:C). Additionally, participants couldn't visit the site to connect with people and understand the space (3:A). As was identified by Nesshöver et al., (2017) typically the process for planning NBS requires a number of different stakeholders (for example policymakers, researchers, urban planners, neighbourhood associations, NGOs, community representatives) to enable relevant knowledge to be attained and NBS to be designed, integrated and implemented effectively. Given that the majority of people were unlikely familiar with working online prior to the COVID-19 pandemic, the movement of this planning process to an online format was likely part of why complexities arose. This was further reflected by 4:B who noted that the NBS process was not designed or yet appropriate for online due to the number of stakeholders involved who were needed to be in one room, altogether, to discuss the project, at multiple stages. Although, people have grown more familiar with working online as the pandemic has gone on, project delays continue as a result of this process (2:B; 3:A; 3:B; 4:B). Working with stakeholders in Győr, 1:C even noted how working online had become too complex for one NBS project contributing to its cancellation at the beginning of the pandemic.

Work on implementing NBS projects was also delayed as a result of the restrictions introduced. Project maintenance and building were limited by restrictions on the number of people being able to work in Barcelona, Győr and Utrecht contributing to delays in projects being implemented (1:A; 2:A; 3:A; 3:D). In Malmö and Newcastle however, the construction industry remained open, allowing work to implement NBS to continue (5:B; 4:D). In Malmö and due to few restrictions being implemented, both maintenance work and the implementation of NBS were allowed to continue. As a result, restrictions on working in person have impacted - and continue to impact - both the planning and implementation of NBS projects in all five cities.

5.2 The role of NBS in addressing Urban Challenges

In this section a cross case analysis of each of the cities will be performed to identify how practitioners and researchers are discussing the potential of NBS to build back better from the pandemic and address other UC. This section is structured around the analytical framework identified in section 3.7.1 in which NBS potential for particular UC is outlined. In identifying how NBS can address UC, an indication of how NBS are being discussed and reimagined as a result of the pandemic will be generated, relevant to RQ2.

Whilst this section discusses the potential of NBS to address particular UC separately, it should be noted that NBS have the potential to address multiple challenges simultaneously. This has been frequently noted in literature (Bush & Doyon, 2019; Shamsuddin, 2020) and was recognised by participants; however, typically participants identified only a few UC that NBS could address based on relevance to their city. In this context “relevance” often reflected current discourse around particular sustainability issues (such as climate change), strategies or goals which directly or indirectly influenced urban development (such as biodiversity strategies) or UC that visibly contributed to significant cost, both in terms of money and to human life (such as flooding). Of the UC listed, NBS had typically been implemented to address water

management, biodiversity loss and public health. Following this, climate change was of significance, with socio-spatial equity and urban regeneration receiving only a brief mention. This mostly aligns with the findings of Almenar et al., (2021), who also noted water management (22%), physical health (39%), climate change (29%), urban heat island and heatwaves (15%) as the UC that NBS could best address. Participants of this research emphasized NBS potential to be able to address water management above other UC – contrasting partially with Almenar et al., (2021)- however, this could have been as a result of the context of each city (each city identified for this study is located in a geographical context vulnerable to flooding). Additionally, NBS potential to address biodiversity loss was not as widely reported by Almenar et al., (2021); however, participants of this research suggested that this was also of top priority for each of their cities.

In asking how participants are discussing the potential of NBS to build back better from the COVID-19 pandemic some UC were identified as being more relevant than others. Participants noted that NBS potential to be able to address water management, biodiversity loss and climate change were largely unaffected by the COVID-19 pandemic; potential was already acknowledged and this had not been exaggerated or limited as a result of the pandemic. For the UC of physical health and wellbeing and socio-spatial equity however, participants noted a substantial difference – primarily in recognition of NBS potential to be able to address both UC. This was primarily due to the restrictions that were implemented in each city, which initially limited contact to NBS and restricted access to cafes, bars, restaurants and shops.

Water Management: Of the UC outlined, NBS were most commonly identified as being able to address challenges related to water management and in particular, flooding. Participants typically referred to a major catastrophic event that had prompted the municipality to begin working with NBS: for example, in Newcastle this was the 2012 “Toon Monsoon” (5:C) and in Malmö this was the 2014 “Storm Arvid” (4:D). The extensive damage caused by the floods prompted municipalities to explore alternatives to conventional flood mitigation (often grey infrastructure) and pursue urban resilience to mitigate against the risk of future events; as was also reported by Almenar et al., (2021) who reported major natural disasters as typically acting as an opportunity to bounce back better. The investment into new flood mitigation strategies contributed to several NBS projects being implemented across each of the cities. These primarily focused on adding, expanding or maintaining existing greenspaces to ensure water could be captured and stored. In Utrecht, this led to an old canal route (that was replaced by a road) being re-constructed (3:A; 3:B). Work improving resilience to flooding continues in each city in recognition that flood risk remains high; with the increasing risk and severity of floods (due to climate change) there is recognition that NBS will be required to address flood risk.

Participants noted a number of opportunities to further mainstream NBS into the city to address flooding, for example, through the integration of NBS along canals which are typically dominated by grey infrastructure in the inner city. Additionally, growing acceptance towards mainstreaming NBS to address flooding was noted by participants; as municipalities have traditionally worked with NBS to address this UC, there is a higher level of acceptance towards integrating NBS into the city. This was captured by 1:A who noted that projects implemented 5 years ago provided the evidence needed to convince people that NBS are effective solutions to flooding. NBS were also recognised as more flexible and cost effective than grey infrastructure (as was noted by the EC, 2013). As a result, the potential for NBS to be able to address water management and flooding remains high across each of the cities; although notably, this is of top priority in Malmö, Newcastle and Utrecht where flooding continues to pose a greater risk. Within Győr and Barcelona other issues were placed above water management although flooding was still acknowledged.

Biodiversity Loss: Municipalities of the five cities have also traditionally worked with NBS to address the challenge of biodiversity loss. This was primarily accounted to a number of biodiversity strategies that prioritised nature in urban design and led to the initial implementation of NBS to tackle biodiversity loss. Challenges now exist with mainstreaming NBS as a result of urbanisation. Increasing pressure is being placed on municipalities to provide enough housing to meet population demands. Additionally, Barcelona, Utrecht, Malmö and Newcastle highlighted restrictions that prevent construction on the outskirts of the city to prevent urban sprawl, requiring construction to take place within current city boundaries and contributing to problems with densification (2:B; 3:D; 4:A; 5:B). Whilst this has reduced the opportunities to include larger NBS (such as parks), opportunities have arisen for the integration of NBS into current infrastructure through greenwalls and greenroofs. This opportunity also exists in Győr; traditionally biodiversity has not been a significant motivation for implementing NBS by the municipality, primarily due to a number of peri-urban NBS sites. As a result, a number of opportunities exist to be able to implement NBS in the city although similar problems occur with a lack of space; in contrast to the other cities however, this is primarily due to a demand for cars (1:C).

Potential for NBS to address a lack of biodiversity exists for all of the cities through the integration of NBS into current infrastructure. Current biodiversity strategies, discourse surrounding increasing biodiversity and demand from citizens continues to push municipalities to include NBS to increase biodiversity. Additionally, participants from Malmö, Utrecht and Newcastle highlighted potential opportunities as a result of new legislation coming out targeting the amount of biodiversity required for new developments (5:B; 5:C). In the UK the Biodiversity Net Gain policy is to require developers to provide evidence that new builds or remodelling's will have a positive impact on the surrounding environment. This will require developers who propose projects to the municipality to provide evidence that benefits to biodiversity will be provided and thus, provide opportunities for NBS. However, whilst NBS are often automatically assumed to contribute to biodiversity as their "green", the need to also consider their contribution on a deeper level is required. As was noted by 3:D the right kind of biodiversity needs to be implemented; for example, supporting native or endangered species, is imperative. This has partly been recognised in Barcelona due to the COVID-19 pandemic; as was discussed by 2:A, an increase in biodiversity during the strict lockdown has led to the municipality adopting a more naturalised maintenance technique which has led to opportunities to increase biodiversity. Thus, potential exists for NBS to increase biodiversity in cities, both in terms of integrating NBS and in how NBS is managed however; efforts should be made to ensure that opportunities to fully utilise biodiversity are not wasted, for example, through ensuring private developers are required to integrate greenspace in urban design, as was highlighted as a solution by participants (1:B; 3:B).

Climate Change: Although work with NBS to address climate change is not as established as NBS for water management or biodiversity loss, each participant noted that climate change had been, and was, being addressed with NBS. In particular, participants noted two sub-challenges; mitigation in the form of carbon sequestration and adaptation to heatwaves and the heat island effect. For climate change mitigation each city had some kind of strategy document outlining ambitions to reduce emissions. These typically highlighted the need to include more green areas in recognition of the capacity for biomass to store carbon (4:A). Thus, the inclusion of this in documents highlighted the importance of including NBS into cities, contributing to a number of NBS projects being implemented. Potential for NBS to be able to address city emissions is expected to continue; Barcelona, Malmö, Newcastle and Utrecht have ambitious targets to become carbon neutral which provide additional opportunities to include greenspace in the city. Strategic ambitions to facilitate carbon sequestration also provide opportunities for challenges associated with heat to be addressed; this was considered a challenge for Barcelona whereas for

Győr, Utrecht, Newcastle and Malmö this was anticipated as a challenge of the future – but admittedly not too far in the future.

As was noted by participants, both the challenges of heatwaves and the heat-island effect are becoming more apparent as temperatures are increasing (2:A; 3:B; 4:A; 5:A). 1:B commented how people are becoming more conscious about wanting to green the city to be able to manage the heat. As a result, the demand for NBS that provide shelter from heat (for example green roofs and urban forest strategies) have become more popular and are expected to continue to grow in popularity due to the recognition that they can reduce temperatures and create microclimates (1:B; 2:A; 5:A). Thus, there is still considerable potential for NBS to be able to address heat related challenges and climate change mitigation. This will be facilitated with the growing discourse around climate change which has pushed citizen demand for action and prompted response a from government. Additionally, and as was noted by 3:A “*Climate change is really an accelerator of the acceptance of nature-based solutions, it's even more or less integrated into policy.*”, reflecting how the potential to mainstream NBS to address climate change has increased as a result of climate change policy integrating NBS and facilitating the mainstreaming of the concept; thus, considerable potential exists for NBS to be able to address climate change.

Physical and Mental Health: Prior to the COVID-19 pandemic, the use of NBS to address challenges related to physical and mental health were already understood by some of the participants; in Utrecht, it was noted how a “healthy urban living” concept had driven work towards NBS due to a recognition of the benefits provided to health and wellbeing (3:A; 3:B). Participants of the four remaining cities also commented that strategies had been implemented which prioritised public health; however, the connection between NBS and public health benefits were not as widely recognised or prioritised in decision-making (1:A; 2:A; 3:D 4:B; 5:A). Public health strategies typically focused on the challenge of poor air quality; unhealthy standards on air emissions, as recognised by the WHO and EU standards, prompted municipalities to work with reducing emissions (1:A; 2:A; 5:C). This led to a number of opportunities to implement NBS (for example, through the pedestrianisation of areas). However, with the exception of Utrecht, participants noted that municipalities generally had an underdeveloped appreciation of NBS, as was captured by 1:C;

“I think one thing I found quite consistently is there's a real disconnect between nature-based solutions and the public health benefits. Maybe from like an air emission perspective, like the impact it has on people's lungs and things like that it is acknowledged. But that's where it's very restricted. Outside of that, it's not really seen as a preventative measure, especially with mental welfare. And I think it's going to have been the most important thing with it [COVID-19].”

With the emergence of the COVID-19 pandemic and proceeding restrictions that were implemented restricting citizen access to; i) initially NBS and ii) to restaurants, bars, cafes and shops, recognition of the importance of access to greenspace has been emphasized. The public health benefits of NBS have been exaggerated from a physical health perspective (e.g. access to NBS to allow exercise to be done) but in particular, the mental health benefits. As was noted by 5:A; “*the whole mental health agenda, the whole thing around open space, green space, being good for people's mental health, I think is going to come into sharp relief as a result of COVID.*”. This was widely reported by all participants, who acknowledged that the COVID-19 pandemic had provided a number of opportunities to implement NBS due to the stronger connection between nature and public health benefits. For Utrecht, there was reluctance that the pandemic would change anything due to the strong connection understood prior to the pandemic however, there was recognition, along with all other participants, that increasing discourse around public health would further strengthen understanding around NBS benefits to public health and NBS potential (3:A; 3:B).

Socio-Spatial Equity: In exploring UC related to socio-spatial equity participants highlighted the unequal distribution of greenspace as a challenge. Typically, this was associated with less affluent areas of the city, where fewer opportunities to interact with nature existed (1:C; 2:B; 3:D; 4:B). Acknowledgement existed that NBS had the potential to be able to address this, with municipalities typically implementing a number of bottom-up NBS initiatives; however, it was noted that these projects typically didn't prioritise addressing the challenge of unequal distribution and so continued to exclude some citizens (3:B; 3:D). This was commonly noted by participants; although recognition of NBS potential to be able to address challenges with unequal distribution to greenspace existed, this was ignored in favour of other environmental and economic parameters in planning and design decisions. Participants had noted that this had changed partially as a result of the COVID-19 pandemic, as recognised by 2:C:

"I think that what COVID-19 has shown very clearly is that what we need is more green space or more nature in cities because the lockdown's have made worse the unequal distribution to greenspace. For example, here in Spain during the first lockdown last year, people couldn't even go to green spaces for just a walk or whatever. So the access to nature was very limited to the private sphere. And here you have a lot of inequality, in general with wealthy residents, as they have access to private gardens or they have access to maybe community gardens, but at least some kind of access to green space or to outdoors."

As the COVID-19 pandemic has progressed, the unequal distribution of greenspace has become more apparent as a result of restrictions. Limitations on mobility and accessing public NBS has shown inequalities in who is able to benefit from the physical and mental health benefits of NBS, as is reflected by 2:C above. In particular, in Barcelona - and applicable to the other cities - it was noted that a number of apartment buildings did not have roof terraces or balconies which resulted in a number of people having no access to NBS. With the physical and mental benefits of nature further recognised as a result of the pandemic, this has demonstrated the need to provide equal access to greenspace for everyone. In this respect, the potential for NBS to be able to address the unequal distribution of greenspace has been realised, with Utrecht recently releasing their updated spatial strategy which highlights ambitious goals to ensure everyone has access to some form of nature within 200m. Within the other cities, the consideration of this UC has moved up on the agenda, leading to potential opportunities for NBS. Potential is seen in integrating NBS further into streets, with a number of bottom-up initiatives needing to be aimed at those located in areas typically denser – in Newcastle this is taking place along streets of terraced housing which typically have paved front and back gardens.

5.3 Impeding and supporting factors to NBS mainstreaming

In this final section, the threats and opportunities presented by the COVID-19 pandemic to the mainstreaming of NBS will be discussed. This will draw on data collected on the barriers and enablers to demonstrate how the pandemic has influenced factors that either impede or support NBS mainstreaming; this will provide relevant content for RQ3. Identifying what threats and opportunities are associated with NBS implementation as a result of the pandemic could contribute to the mainstreaming of the concept and allow any opportunities presented by the COVID-19 pandemic to be exploited.

Cognitive Factors: Of the opportunities discussed, the most widely recognised by participants was a substantial increase in the appreciation of nature as a result of the COVID-19 pandemic. Limitations on; i) access to greenspace and/or ii) access to other public spaces, bars, cafes and restaurants had resulted in NBS being one of few places that people could use to exercise, relax or socialise. As a result, citizens had come to appreciate access to NBS substantially, with 3:C noting; *"A lot of people are saying - when they sit or work outside – that they are really thankful to our park workers that they can be in the park. And so, they walk to my colleagues and they say; Thank you. Thank you so much."* The wider acknowledgement of the physical and mental health benefits of access to NBS during the pandemic were also acknowledged; in Barcelona this was typically emphasized

due to the stricter initial restrictions that banned access to NBS, with 2:C noting that *“even the view of green space from your house or your balcony was very important during the lockdown.”* Thus, the acknowledgement of the mental health benefits of NBS further contributed to a higher appreciation of greenspaces, with 2:A reflecting that *“I think that for sure, people have realized how important nature is for us and how bad we feel when we cannot get in contact with nature.”*

For practitioners, this has shown a more obvious connection between NBS and the physical and mental health benefits they can provide; whilst a lack of awareness between this connection was typically reported as a barrier to NBS mainstreaming both in literature (Ershad Sarabi et al., 2019; Kabisch et al., 2016) and by participants (1:B; 2:A; 2:B; 3:A; 5:D), the COVID-19 pandemic has emphasized this connection and provided opportunities to address this. This was considered only part of the challenge in mainstreaming NBS however; participants also noted how practitioners generally had an awareness of NBS benefits to public health however, often struggled to include these, or ignored these, to ensure other design aspects (such as space for parking, residential) were prioritised and included into urban developments (1:C; 4:A; 5:A). This is another barrier that the COVID-19 pandemic has provided opportunities to overcome; due to the acknowledgement of the physical and mental health benefits, NBS have been prioritised – or are expected to be prioritised – more. For those advocating for NBS to be integrated into urban planning and design, this connection has added substantial weight to their arguments to include NBS with 1:C noting that *“I would say among the many, many arguments and weapons and you know, impact models and whatever we have already in store to convince decision makers to have more nature, COVID has given us an extra push.”* This has already materialised in some projects; 4:A noted that for projects that were placed on hold (as a result of the pandemic), it was recognised how the design could be reimagined to provide more benefits from a public health perspective, leading to opportunities to include NBS. As a result, the COVID-19 pandemic has created opportunities to mainstream NBS, with participants noting that decision-makers were generally more willing to listen; these opportunities should be utilised whilst practitioners are more open to listening with participant 4:D noting how the COVID-19 pandemic has presented *“a window of opportunity”* for mainstreaming NBS. Additionally, the pandemic was even recognised as *“the new flood”* by participant 4:D; in discussing when work with NBS began, 4:D highlighted how the catastrophic damage caused by Storm Arvid (in Malmö) had prompted the municipality to work with NBS. Comparisons were made with the COVID-19 pandemic, with speculation made that perhaps the damage caused by the pandemic would inspire municipalities to re-evaluate how public health should be considered in cities and lead to opportunities to further mainstream NBS. Some indication of this can already be seen with all cities noting how the pandemic has emphasized the connection between access to NBS and public health benefits.

An acknowledgement that citizens may be demanding more greenspace in cities has also led to consideration of how this could influence urban design in the private sector; as was reflected by 2:C *“Yeah, I think COVID will also even modify the way that the buildings are built in Barcelona in the sense that now for sure, people will want flats with a little balcony or even if it can be bigger than a balcony like a terrace - or things like that.”* Thus, in recognition of the demand for greenspace developers may integrate NBS further; however, it was also noted that this could lead to the exclusion of citizens from accessing greenspace; participants from all cities commented on how the COVID-19 pandemic had also demonstrated significant inequalities in who had – and has - access to NBS and the associated physical and mental health benefits. In all cities, the unequal distribution of NBS was already acknowledged as a UC prior to the pandemic; however, due to restrictions limiting how far citizens could travel, vast inequalities have been emphasized further (1:B; 2:C; 3:B; 4:D; 5:D). As a result, this has moved the challenge of unequal access to nature further up the agenda, with municipalities prompted to act;

“As time has gone on, I think covid-19 and the fact that it's highlighted such deep inequalities across societies, perhaps galvanized the community and spurred them [the municipality] on to do a bit more in terms of urban

greening. So things are moving forward and they are preparing for potentially coming out of this current lockdown and starting up new initiatives.” (5:D)

Renewed interest from practitioners to provide equal access to greenspace has led to opportunities to mainstream NBS further. Complexities are still acknowledged connected to how this can be achieved however, with 4:D noting that “*we know that it's not a fair distribution of greenspaces and parks...but it's not easy to solve - what is the solution towards that? Because you can't build in developed areas. You can't really put in a new park unless you take something out*”. Discussions on how this can be addressed have also focused around concerns that ED could threaten the success of NBS mainstreaming; participants noted how any implementation of greenspace could lead to green gentrification and the further exclusion of some citizens from accessing greenspace. Thus, although opportunities for NBS mainstreaming exist, practitioners will need to consider how these can be effectively implemented to ensure that NBS are equally distributed. The implementation of bottom-up NBS initiatives has been suggested as a potential solution to this; with an increase in appreciation and demand for nature in cities from citizens, bottom-up NBS initiatives could be an opportunity to mainstream NBS. Additionally, it was recognised that these could be used to target areas where a lack of NBS currently exist; 5:D pointed out initiatives that targeted dense, concrete streets of terraced houses and provided ideas and resources to owners to green these. However, these initiatives will require resources and collaboration between different stakeholders to minimise ED such as green gentrification. Regulation that prompts NBS to be integrated into private developments was also provided as a solution to this. This was believed to make some level of NBS compulsory in developments, so all citizens have access to this rather than only those who can afford to pay for a garden or balcony (2:B). This would not address the challenge of access to greenspace in existing residential structures however, with other greening solutions needing to be adopted for this.

Collaboration: A lack of collaboration was commonly reported as a barrier to NBS mainstreaming prior to the pandemic. In particular, participants noted how there was still a siloed approach to planning and development between municipal departments which limited opportunities to mainstream NBS (2:B; 3:D; 4:A). The COVID-19 pandemic has exaggerated this; as was noted by 4:A; “*it [NBS mainstreaming] relies on co-creation and co-operation, so COVID has been a barrier in that respect and not being able to have physical meetings*”. It was further noted that departments became more siloed as a result of having to direct all their attention to the COVID-19 pandemic which limited cross-sectorial support (3:D; 4:A). Thus, restrictions implemented limited interaction between departments and left fewer opportunities to mainstream NBS. These restrictions had also typically limited the amount of citizen participation in the planning of NBS projects; with work moving online, interacting with citizens became more complex leading to challenges with collaboration. However, with the COVID-19 pandemic highlighting the vast inequalities in who has access to NBS, the significance of including citizens in the design, planning and implementation process has been emphasized. As was noted by 5:D;

“It's no good for NBS to just be there. People need to be actively involved to really get the benefits out of it, especially when we think about the severity of climate related health impacts and how they are going to be disproportionately high on those communities that don't have access to green...so I really question how NBS can deliver on the health and well-being benefits for society if we don't design them specifically with communities that are meant to benefit?”

Participants noted that municipalities had typically recognised the need to include citizens in the planning process of NBS more, as a result of the COVID-19 pandemic (1:A; 2:A; 2:B; 3:B; 4:A; 5:D). For example, in Utrecht this had led to a project which asked school children to send in their ideas for “green projects” which would be integrated into areas of the city. Although efforts were being made however, attempts to engage with citizens was still complex due to work remaining online. On reflecting on what this meant for the future of NBS mainstreaming, 5:D

commented that *“If NBS are meant to be enabled in such a way that they can improve social cohesion amongst communities, I question how they can actually do that if people are having to socially distance. So in terms of participation in projects, I suspect that a lot of that's been put on hold and will remain on hold due to restrictions.”*. Thus, the movement of work online and continued restrictions has threatened the work done with NBS mainstreaming, with 2:B noting that some collaborations were completely stopped due to restrictions. However, with a newfound appreciation for nature from citizens some opportunities have arisen; as was noted by 5:C a number of new stakeholders had come forward since the pandemic to show interest in working with NBS, primarily to capitalise on the newfound appreciation for nature. This has brought additional resources which has acted as an opportunity to mainstream NBS.

Agency: The unpredictability of the COVID-19 pandemic and the impact this has had, has often led to confusion on how best to respond (3:A; 4:A; 5:B). Thus, national and regional direction guiding municipalities has been absent, delayed and inconsistent; for those working with NBS, this initially meant it was harder to know how to work with NBS during the COVID-19 pandemic (4:A; 5:B). However, strong leadership and commitment to mainstreaming NBS from each city has aided NBS mainstreaming. As was noted by participants of each of the cities, leadership that supported green initiatives was an enabling factor to mainstreaming NBS. Whilst this had not arisen as a result of the COVID-19 pandemic, support from this leadership had allowed work with NBS to continue and guidance on how to do so. Additionally, participants noted that leadership that supported these initiatives prior to the pandemic were also more receptive to how NBS were used and are needed (due to the physical and mental health benefits). This supported opportunities to continue working with NBS mainstreaming.

Discourse and Future Visions: The COVID-19 pandemic has provided additional opportunities to align with discourse around sustainable cities to mainstream NBS. Prior to the pandemic, NBS already fit in with current discourse around “green cities” that increased biodiversity and climate change mitigation. Additionally, discourse around sustainable mobility centered around reducing space for cars and adding space for pedestrians and cyclists. This also provided opportunities to increase the amount of NBS integrated into streets. As 3:A noted; *“we are trying to reduce the motorized traffic and give more [space] to pedestrians and cyclists in the inner city. And then we have space for more trees and pocket parks and so on. So, yes, we tried to reduce the traffic...and make more space green.”* All cities had implemented a sustainable mobility strategy which aimed at reducing space for cars and increased space for pedestrians and cyclists. In particular, Barcelona had implemented several “Superblocks” which is a concept in which inner roads are closed to cars and replaced with temporary parks, cycleways and pedestrian walkways. This provided opportunities to include NBS.

As a result of the COVID-19 pandemic, the need to have more space available for pedestrians and cyclists has been emphasized (1:B; 2:B; 3:A; 4:C; 5:C). With citizens having to remain local and requiring access to local spaces to walk and socialise, participants acknowledged the need to provide more space to citizens to both move and socialise safely. Additionally, the use of public transport was considered unsafe by many leading to alternatives being explored (and typically a bike was considered a more feasible option than a car) (1:B; 3:B; 4:B; 5:A)). As a result, demand has increased for walking and cycling networks. Malmö responded to this by providing additional spaces by closing streets, with 3:D noting that *“in the inner city they made more room for the restaurants to have terraces outside and they closed streets to give more space for bikes. And people really appreciated that.”* Participants from Barcelona, Utrecht, Győr and Newcastle also noted how this increase in demand had been identified as an opportunity to further sustainable mobility strategies. As was noted by 2:A; *“I think at least what they are talking a lot about now is taking cars out from the city and having more space for people to walk. And I think that that's the main thing that COVID has shown us. And I guess a lot of the cities in the world - we don't have enough space for us to walk safely at two metres distance from others.”* Providing more space to pedestrians and cyclists has also provided

opportunities to mainstream NBS through integrating NBS into streets; for example, the temporary closing of streets to cars can allow temporary plant beds to be added. With an acknowledgement that COVID-19 won't be disappearing "overnight" by participants, demand for these spaces is also expected to increase, providing additional opportunities to mainstream NBS. As 2:A summarised:

"I think, yes, it has been an opportunity to get more green spaces and get more nature in the city...I think it has made us aware about how much space we have for motorized vehicles and how much space we do not have for other things. So in that sense, I think that's the main opportunity - to start rethinking all the street grids."

Strategic Plans, Legislation & Policies: Participants frequently noted strategic plans, legislation and policy as a significant enabler in mainstreaming NBS prior to the pandemic. Barcelona and Utrecht placed specific emphasis on the release of biodiversity strategies which outlined ambitious goals to increase biodiversity and provided opportunities to integrate NBS into the city (3:A; 3:D). The cities of Győr, Malmö and Newcastle also recognised these however placed more emphasis on climate change goals (1:A; 4:A; 4:D; 5:B; 5:C). As was noted by 2:C *"the biodiversity strategy or the climate change action plan, they provided opportunities to really consider nature and nature-based solutions or green infrastructure as something that's really relevant to address some of the sustainability challenges that the city is facing"*. Legislation set to address climate change or biodiversity targets have also provided opportunities to mainstream NBS; for example, participant 5:C highlighted the release of the Biodiversity Net Gain policy which would require new English developments to demonstrate a 10% increase in biodiversity in or near development sites. This is anticipated to provide opportunities to mainstream NBS in the city of Newcastle. With the benefits that policy can provide to mainstreaming NBS acknowledged, several participants from Győr, Utrecht and Barcelona noted that there was a need to introduce more stringent legislation on including NBS. A lack of incentive for private developers to include NBS still exists which 1:B reflected on;

"I think it's my view that any kind of development that happens in the city should be considered from the perspective of how it can accommodate natural elements...And I think they should be enforced by law, because municipalities, they just don't have the power to enforce a change of approach in private developments." (1:B)

Thus, participants commented that if NBS really are to be mainstreamed, an increase in legislation that tackles challenges associated with private property law would be required (1:B; 2:B; 3:D 4:B 5:B). The COVID-19 pandemic was speculated as potentially providing opportunities for this, due to increases in the value of nature which could place pressure on local, regional and national government to ensure NBS are included (for example, ensuring that all apartment buildings come with balconies or roof gardens as was discussed in the case of Barcelona). Currently, this has not amounted to much however, primarily due to legislation and policy focusing on other priorities related to the COVID-19 pandemic. Newcastle was an exception to this though; 5:C highlighted the release of policies and strategies that outlined a "greener" recovery. These provided funding which could be used to mainstream NBS within cities and so contributed to the actual implementation of an urban park and floating garden located on the quayside (next to the river) in Newcastle. Thus, in the future, and in response to the increase in value of NBS in cities, an increase in the amount of legislation being introduced which aims at increasing biodiversity and supports the mainstreaming of NBS was expected.

Institutional Setups and Governance Structures: Two main barriers were reported by participants to NBS mainstreaming prior to the COVID-19 pandemic: i) the administrative and bureaucratic process of planning and implementing NBS and; ii) the current national, potentially global accounting system. The former was identified as being complex and time consuming, making NBS projects vulnerable to resource cuts and cancellations; an aspect which the COVID-19 pandemic was recognised as exaggerating. However, this was not unique to NBS

projects, with the COVID-19 pandemic leading to the majority of projects or developments being placed on hold or cancelled as all resources were channelled to respond to the pandemic (1:C; 2:A; 3:A; 4:B; 5:C). The latter (2) referred to challenges in how NBS value was perceived by stakeholders. As was noted by 5:A “*And I think that whole maintenance issue of green spaces is something that municipalities within the U.K. struggle with because, you know, they are seen as a drain on resources rather than a resource in themselves...I just think you need to change the way the conversation happens about them.*”. Thus, participants from Newcastle and Barcelona both highlighted the broader challenge of how NBS were typically identified as a cost, which made it harder to argue their worth to stakeholders. This was summarised by 2:B, who reflected;

“the main problem is when you put money towards investment in projects, that's considered investment from an accountancy point of view, that's the European rules or even the global rules. But if you spend money on maintenance, that's expenditure. And there is always money for investment because that generates debt and banks are more than happy to lend you money, but whenever you want to actually manage something in the long-term, they say, oh, no, no that's expenditure. So we are in this situation where everything is going in the direction of NBS providing green jobs, but the financial system does not enable you to take into account the benefits of nature.”

Thus, it was recognised that attempting to communicate the true value of NBS was complex, due to the current set up of the accounting system. Whilst the COVID-19 pandemic has (currently) led to no changes to this, participants recognised how the increase in value and appreciation for nature could lead to: i) more recognition of the value of NBS that - although may not be able to be monetized – may lead to more of a willingness to work with NBS and ii) more interest in trying to change the accounting system so the value of NBS can be better represented through the use on monetary valuation methods (4:A; B).

Learning: In addressing the challenge of capturing the value of NBS in the accounting system, participants pointed to the development of monetisation techniques that value NBS and their related eco-system services (4:B). Although these have enabled some benefits to be better communicated to stakeholders (as was noted by participant 4:B and in the literature review by O'Donnell et al., (2017) and van der Jagt et al., (2017)), currently these are recognised as being unable to reflect the “true” value of nature. To overcome this, participants pointed out the need for more research to explore the benefits of eco-system services and monetisation techniques that could be used to monetise the value of these (4:A 4:B; 4:D). Specific emphasis was placed on this due to the COVID-19 pandemic; for the opportunities presented by the pandemic to be fully realised (e.g. an increase in demand for nature in cities from citizens), participants noted that improved monetisation techniques would be needed to build arguments and convince other stakeholders (4:A; 4:C).

The monitoring, evaluation and provision of supporting evidence for NBS projects was considered fundamental in enabling the acceptance of mainstreaming NBS. This was emphasized by 1:A who noted “*What we can say is that when the project ended, we also had the project results which we sent to the city and they were also really thankful and said, OK, this is really, really interesting*” and which led to the gradual acceptance of future NBS projects (1:B). Participants from all cities acknowledged the weight that having good data could contribute to arguments to mainstream NBS; however, in doing so, also reflected that a lack of this still existed demonstrating NBS benefits to public health. Participants from Győr, Malmö and Newcastle commented on how stronger connections between NBS and their benefits to public health were required to facilitate NBS mainstreaming; it wasn't enough to just see these, some quantifiable method to articulate this was also required. 4:A placed particular emphasis on the COVID-19 pandemic as an opportunity to do this; in recognising the connections between NBS and public health as a result of the pandemic they reflected that “*the city is our classroom, especially when taking a step further with the possibility to talk about health connected to green infrastructure.*”. Thus, the COVID-19 pandemic has

both highlighted the need for more research to demonstrate the connection between NBS and public health whilst also providing opportunities for this to be measured.

The COVID-19 pandemic has also demonstrated both the need for, and opportunities to, educate citizens on how to interact with nature. Participants from all cities reported widespread environmental degradation to NBS as a result of an increase in the use of these sites. Degradation such as litter and accidental fires, also point to a segment of the population who either don't care about nature or who don't know how to interact with it. 3:D reflected that this was likely the result of citizens feeling disconnected or out of touch with nature as a result of a lack of it within cities. Thus, when people have been forced to come into contact with it (as a result of the COVID-19 pandemic restrictions) environmental degradation has arisen. The COVID-19 pandemic has drawn attention to this and the need to educate and re-educate citizens on how to interact with nature. This was captured by 3:D who noted that *"we not only need to revild our cities but we also need to revild our citizens."* This will be increasingly important for the implementation of bottom-up initiatives; participant (5:D) noted how for bottom-up initiatives that may arise from the COVID-19 pandemic citizens must understand how to work with nature to ensure initiatives are fully utilised. Additionally, the re-education of citizens stretches to those working within the municipality; as was commented by 2:B *"we need to start thinking - as part of our process of reimagining NBS - our relationship with the land. There has to be a deeper understanding of its educational values. So how we structure education is a subject that needs to be reflected on."*

Resources: The availability of resources have had a major influence on mainstreaming NBS. This was recognised prior to the pandemic, in which the cities of Barcelona, Győr and Newcastle all reported a lack of finance as a barrier to mainstreaming NBS. In particular, participants from Newcastle noted that funding had been cut by approximately 90% following government austerity measures, forcing several NBS projects to be placed on hold (5:A; 5:B). The COVID-19 pandemic initially exaggerated the lack of funding for these three cities, with participants commenting that funding had been cut and channelled into the COVID-19 pandemic response. 2:B also noted how technical knowhow was also directed away from NBS projects to respond to the pandemic. With the exception of Győr, funding did eventually increase however; both Malmö and Utrecht were exceptions to this, reporting that funding for NBS had remained high throughout the pandemic. This is likely to be a combination of fewer restrictions (in the case of Malmö) and green leadership (for both cities) which already provided financial support for mainstreaming NBS (3:A; 3:B; 4:B).

An increase in the use of urban NBS and an increase in the value of nature was accounted as contributing to an increased amount of funding provided to most of the cities. Increases in funding were noted by participants with 2:B noting *"that in general, I think there's been a lot more money that has been made available for changing the public space, as in the streets"* and 5:C adding that *"I'm just thinking pre-pandemic the biggest barriers were really governance and finance. And I think we've got over that a little...the pandemic is going to have given a good kick up the backside, basically, and shone the light on the need for it."* Thus, increases in the amount of funding being provided to departments to increase the amount of NBS could lead to further opportunities for mainstreaming. In the case of Newcastle, this already has; both 5:B and 5:C highlighted the conversion of a temporary NBS project (a pop-up park) to a permanent fixture in recognition of the increase in demand for NBS. Additionally, a floating garden is planned to be added to an area of the river by the city contributing to NBS mainstreaming. Thus, the increase in funding within these cities could provide additional opportunities to mainstream NBS; the extent of which will be determined by the length of time funding will be provided. As was the case with Barcelona, concerns exist that budget cuts may re-appear to threaten work with mainstreaming NBS (2:A).

Local Geographical Context: Various barriers and enablers arose with each of the cities however, similarities could be drawn between each of the cities struggle for space to mainstream

NBS. In Győr, the mainstreaming of NBS came up against the issue of space due to a strong car lobby in the city, as reported by 1:C *“But whenever you try to do the right thing and remove a parking lot from a neighbourhood and plant a bunch of trees or native vegetation, there is going to be a massive opposition because people do not want to walk 30 meters to their car. So, they would rather not have the greenery.* Speculation as to why this existed related partially to the cities identity and history linked with car manufacturing (1:C). For the remaining cities, a lack of space for NBS was reported as a result of urbanisation and demand for housing (2:B; 3:B; 4:A; 5:C). With all of the cities committing to build within current city boundaries this led to conflicts with how space would be used. For NBS, this has been perceived as both an impeding and supporting factor to mainstreaming NBS, as was reflected by 2:C

“Yeab, I think for Barcelona and in similar cities which are characterized by compactness and density - it is really difficult to build or to design new green spaces in the sense of like parks, because there is no space. So the only solution with these kind of interventions is transforming a street into green corridors and transforming the buildings into like greening the roofs or the facades or changing it a little bit - so creating more community green spaces, in facilities like schools and things like that.”

Integrating NBS into building design has been highlighted as one of the most effective ways to address this and mainstream NBS (1:A; 2:B; 3:B; 4:B; 5:C). All cities had begun integrating NBS to different extents in recognition of this, with Utrecht implementing green bus roofs for example. With the COVID-19 pandemic, discussions on increasing NBS in the city have also increased; both the need within the inner city but also in the suburbs. As was reported by Honey-Roses et al., (2020) and Rice, (2021), and by some participants (4:A), an increase in the number of people working from home has also led to an increase in demand for NBS around the suburbs. This has also provided opportunities to mainstream NBS throughout the city and free up space within the inner city, providing more space to integrate NBS into building design (2B) Thus, the COVID-19 pandemic may have created opportunities to mainstream NBS further although, with the pandemic and government response consistently changing, the full extent to which these opportunities will exist is still unknown.

6 Conclusions and Recommendations

This final chapter outlines the key findings of this research in relation to the three RQs. Based on these findings, recommendations have also been suggested to provide direction to practitioners on how to further exploit opportunities to mainstream NBS. This chapter is concluded with the limitations of the study and areas for future research outlined.

6.1 Key findings

The COVID-19 pandemic has caused global, national and local disruption since its emergence in March 2020. This has led to devastating impacts on countries and cities all around the world. This research has explored one aspect of this impact, demonstrating: i) how the pandemic has affected the use of NBS in the five cities of Barcelona, Győr, Malmö, Newcastle and Utrecht; ii) how NBS are being discussed as a result of the COVID-19 pandemic to build back better and to address other UC and; iii) what threats and opportunities may have arisen as a result of the pandemic to mainstream NBS in cities. In exploring these RQs, this research presents one of the first insights into how NBS have been impacted on by the COVID-19 pandemic. For practitioners, this provides an indication of the role NBS have played and could play during pandemics and the potential benefits they could provide for UR. This research has also shed light on the knowledge-implementation gap by exploring impeding and supporting factors to NBS mainstreaming through the lens of the pandemic. This has also presented opportunities for additional research; as will be discussed in section 6.4.

A number of key findings were identified based on a review of literature and interviews with practitioners and researchers in each city. These included:

RQ1: A change in the use of NBS; for the cities of Barcelona, Győr, Newcastle and Utrecht a reduction in NBS use was witnessed as a result of lockdown measures that limited citizen mobility. Malmö was an exception to this, due to few restrictions being implemented at the beginning of the pandemic. Following the easing up of restrictions, a substantial increase in the use of NBS was recorded across all cities in either, or both, urban and peri-urban NBS sites; Barcelona, Newcastle and Utrecht recorded substantial increases in the use of urban NBS, especially parks, due to people having few alternatives. In both Malmö and Győr this increase was focused around peri-urban sites of NBS. An increase in the use of NBS remains high as a result of restrictions that continue to limit where people can go and due to restrictions on the numbers of citizens in public spaces.

The change in the use of NBS has led to a number of unintended consequences. The initial restrictions implemented were identified as leading to opportunities for wildlife to rewild the cities; in particular, Barcelona recorded a number of benefits to biodiversity which arose due to limited disruption as a result of restrictions. However, following the initial restrictions an increase in the use of NBS caused environmental degradation in the form of litter and widespread disruption to wildlife. Even when numbers visiting NBS sites were attempted to be controlled, a number of detrimental impacts were inflicted. Whilst, an increase in numbers contributed to environmental degradation to sites of NBS, it was also recognised that a lack of funding to manage this also contributed. Some cities (Utrecht and Malmö) received additional funding to manage sites in recognition of this.

RQ2: Traditionally, cities had worked with NBS to address UC related to water management, biodiversity loss and climate change. As the risk of these challenges still exists (primarily flood risk due to climate change) cities were continuing to work with NBS to address these challenges. Discourse around sustainable cities was also recognised as driving city ambitions to address these UC; however, all cities described issues with trying to convince stakeholders to adopt

NBS. The COVID-19 pandemic had little influence on emphasizing the connection between NBS and their ability to address water management, biodiversity loss and climate change; however, public health and the unequal distribution of greenspace were exaggerated.

To build back better from the COVID-19 pandemic, NBS was recognised as providing opportunities to address UC related to public health and the unequal distribution of greenspace. The pandemic demonstrated why access to NBS is vital for peoples physical and mental health. As a result, all cities discussed the expectation that NBS would be considered and included more in discussions due to the pandemic; Utrecht was an exception to this however, noting that a strong connection between NBS and public health prior to the pandemic meant that NBS was already considered. The challenge of providing equal access to NBS was also recognised as a challenge, with the pandemic highlighting the unequal access to NBS and associated benefits. Due to this, the use of NBS to address this UC had moved up the agenda in all cities.

RQ3: The COVID-19 pandemic has created several opportunities to mainstream NBS, primarily linked to the increase in appreciation of nature during the pandemic. Restrictions limiting access to NBS emphasized the connection between NBS and associated benefits to public health. This has provided more weight to those advocating for the mainstreaming of NBS. This has also contributed to the additional allocation of resources to NBS projects, resulting in the mainstreaming of NBS; in Newcastle, participants highlighted the permanent implementation of a riverside park and floating garden in recognition that demand for outdoor greenspace has, and likely will, continue to increase. The increase in demand for urban NBS has also led to opportunities to implement bottom-up initiatives which exploit current appreciation for urban nature. Additionally, bottom-up initiatives were recognised as being able to address the challenge of unequal distribution of greenspace by providing those who typically do not have the resources, to implement smaller forms of NBS (e.g. green gardens).

The pandemic has also highlighted the need to not only rewild cities but to also rewild citizens; environmental degradation to NBS sites has reinforced the need for bottom-up initiatives that re-educate citizens on how to interact with nature. An increase in appreciation for and increases in the current resources allocated to NBS could provide opportunities for this to be utilised. Participants also reflected that municipalities should be providing citizens with more exposure to nature, with the need to integrate NBS further into urban design suggested; challenges associated with the densification of inner cities, typically as a result of urbanisation, continue to limit the amount of space available for NBS projects. Thus, the integration of NBS into building design through green roofs, green walls and community gardens was recognised as a solution to this. The COVID-19 pandemic had provided additional opportunities for this with the increase in appreciation for nature recognised as an opportunity to drive stricter regulations aimed at the private sector that integrate NBS. Additional opportunities to mainstream NBS may arise from sustainable mobility strategies which outline ambitions to reclaim streets for pedestrians and cyclists, providing more space for NBS. The COVID-19 pandemic has provided additional opportunities for this, with a number of roads closed and provided to pedestrians and cyclists.

Whilst a number of opportunities for mainstreaming NBS were identified, the extent to which these will be realised will depend on restrictions and whether these limit collaboration. Currently, restrictions make interaction between municipal departments and citizen participation more complex, delaying NBS projects and potentially threatening to cancel some. Additionally, although the connection between public health and NBS has been reinforced as a result of the COVID-19 pandemic, participants highlighted the need to increase the amount of research demonstrating this connection. In particular, participants commented on the reliability of monetary valuation techniques to capture the higher value of NBS benefits. The pandemic has provided opportunities for this, with the city being recognised as a classroom to both measure the impacts of the pandemic on public health and providing opportunities for this.

6.2 Recommendations for mainstreaming NBS for public health

Whilst a number of opportunities for mainstreaming NBS were acknowledged as a result of the COVID-19 pandemic, for opportunities to be fully exploited the alignment of several stepping stones is needed. Thus, this section brings together knowledge on the stepping stones outlined in Section 2.2.4 and 2.2.5 in the literature review, with the main findings of this study to provide an indication of the alignment required to facilitate the mainstreaming of NBS for public health.



Alignment with Strategic Priorities: A number of opportunities to mainstream NBS can be identified through commonalities with other strategies; primarily strategies around climate change, biodiversity and water management. Demonstrating that NBS can contribute to more than just public health and fits in with these discourses can facilitate mainstreaming. National regulation related to other discourses can also provide opportunities for mainstreaming NBS further.



Facilitate Community-Based Action: For NBS benefits to public health to be fully realised the involvement of the community in bottom-up initiatives is required. NBS projects that not only include citizens in the planning and implementation process but also keep them engaged will have the greatest impact. Additionally, projects can provide support for NBS related projects providing opportunities for mainstreaming the concept further. COVID-19 has generated demand for greenspace from citizens; this opportunity should be exploited.



Advancing Valuation Models: To communicate the public health benefits of NBS to stakeholder's, valuation models should be utilised. These allow NBS to be viewed as more than just an expense in the traditional accounting system and can increase the acceptance of NBS. Existing models provide an indication of public health savings making the communication of NBS benefits easier; however, research is required to improve the modelling and performance metrics could increase the valuation of these solutions.



Improve Data and Monitoring: Cities should develop evidence of the performance of NBS and the benefits provided to public health. Through the effective monitoring and assessment of these benefits data on public health benefits can be generated contributing to a more developed argument as to why NBS can benefit public health. The COVID-19 pandemic has provided an opportunity to explore this and could be utilised to demonstrate significance.



Establish Demonstration Projects: Demonstration projects will be required to offer tangible examples of how NBS can work in practice to provide public health benefits. This can build knowledge and confidence about their contribution to public health goals. These should include the participation of the community to ensure that NBS benefits are received and can be measured, also relating to improved data and monitoring to ensure effective measurement to build the case for NBS.

Figure 6-1. Stepping Stone alignment required for NBS mainstreaming for public health

Source: Stepping stones taken from (NATURVATION Project, 2021a)

6.3 Limitations of the study

In adopting a particular research design to perform this research, it is acknowledged that some limitations may exist. These limitations have been discussed below.

With having adopted an interpretivist research philosophy, the risk exists that the researchers own biases may exist both in the collection and the interpretation of the results. Bias could have arisen in the way in which questions were framed to participants during interviews, whilst researcher imposition may have also occurred due to the researcher's own interpretation of the world influencing how the results were interpreted. To address this, the author attempted to reduce potential biases through the use of data triangulation and through supporting findings with references to other literature, theories and/or frameworks. It should be acknowledged however, that this risk may still exist with the research.

In defining a particular temporal scope, it is also acknowledged that data was collected at a particular point in time and within a specific context. Thus, the results generated from the study reflect the participants views at the time in which the interview was performed. Whilst this is, by nature, a fundamental component of both research and a case-oriented research design, it is acknowledged that *when* the study is undertaken may produce differences in the results generated. As a relatively recent phenomenon that is currently still ongoing, new knowledge on the COVID-19 pandemic is frequently being published, changing our understanding of how the virus has, and continues, to effect individuals and cities; therefore, it could be that if this study was undertaken in a few years different results may be generated. Thus, this study has been undertaken in a rapid, unpredictable context and consequently, can only draw conclusions on what is known at the time the study was performed. However, this may still offer use to future studies attempting to explore the historic development of the pandemic on NBS.

In performing interviews as the main data collection technique, it is acknowledged that the reliability of the results could be influenced by the participants knowledge of NBS and the participants willingness to speak. As many of the participants were interviewed in their professional capacity and were discussing a very relevant topic, participants may have also been wary about what information was "permitted" to be shared. Whilst the researcher attempted to address this issue through the use of participant anonymity, it was recognised that participants may still feel restricted in what, and how, they discussed NBS. An additional consideration was that of the language used; interviews were carried out in English which, for the majority of participants, was their second language. As a result, some participants may have found it harder to express their views and answer questions. Attempts to address this were made through the use of simple phrasing for questions and sending questions to the participant prior to the interview taking place. However, as interviews were semi-structured, unlisted questions were asked which could have led to this issue arising.

By focusing on the cities classified as URIPs of the NATURVATION project (Barcelona, Győr, Malmö, Newcastle and Utrecht) it is acknowledged that some biases may exist in various aspects of the study. Although these cities differ in many aspects their connection to the NATURVATION project may result in a deeper knowledge of NBS and more favourable attitudes towards NBS. This aspect was considered and discussed with other researchers of the NATURVATION project and was deemed to be of only a minor cause for concern in terms of what it could mean for biases towards perspectives and attitudes to NBS. Nonetheless, it is acknowledged that this could still influence how each municipality views NBS. To address this, the context of each city was explored in this research however, a deeper analysis of the city's context could have enabled further biases to be identified and discussed.

Lastly, a focus on practitioners and researchers also neglects other perspectives on NBS from other agents involved with urban planning. Although this study wanted to specifically focus on

practitioners and researchers - due to their influence in implementing NBS in cities - it is acknowledged that other agents also have influence over urban design. These perspectives were not explored through interviews in this research as some indication of these perspectives exists online, through web articles, or strategy plans etc. Some of these have been explored in section 2. Background and Literature Review however, it is still acknowledged that through excluding these agents from interviews some perspectives may not have been included in this study.

6.4 Future research

Findings from this research have provided an indication as to how municipalities are discussing NBS as a result of the COVID-19 pandemic and how they intend to utilise the opportunities presented to mainstreaming NBS now and following the pandemic. However, for opportunities to be actualised additional research is required exploring the impacts of the COVID-19 pandemic on cities in other contexts.

This research focused on 5 cities involved with the NATURVATION project as URIPS, in recognition that municipalities that have worked with NBS in the past would better recognise any impacts, threats or opportunities that may have arisen as a result of the pandemic. Thus, opportunities exist to explore how cities that have less experience with working with NBS may have been affected by the COVID-19 pandemic; for example, questions could focus around: i) whether an increase in public value for nature can also be identified within cities that traditionally have lower per capita rates of greenspace – and to what extent this has influenced the demand for greenspace; ii) has this increase in appreciation prompted the municipality to begin working with the concept of NBS or allocating additional resources to begin implementing NBS projects? and; iii) An exploration into whether the same threats and opportunities may exist, which may also reveal additional opportunities to allow the NBS concept to be mainstreamed further in cities of different sizes and in different contexts. Each of these questions could be asked covering cities across a wider geographical context (outside of Europe), or socio-economic context to allow a more comprehensive understanding of how the COVID-19 pandemic could be used to mainstream NBS and provide opportunities to study and identify opportunities to overcome the knowledge-implementation gap that exists with NBS mainstreaming.

Further exploration is also needed to assess the relationship between the pandemic restrictions and the influence this has had on how NBS is valued by citizens – both during the pandemic and post-pandemic. Some indication of this was generated by this research but a deeper understanding of this relationship is required to enable opportunities presented by the COVID-19 pandemic to implement NBS to be fully exploited. For example, i) attempting to identify whether people visited NBS as a result of a newfound appreciation for nature or whether this was because these were the only accessible spaces to them. Additionally, ii) an exploration into how access to nature has helped some people overcome major life changes that have taken place as a result of pandemic (loss of family members, job loss, the uncertainty of the pandemic) or iii) How people's perception of what nature is has changed as a result of the pandemic – and how this compares in different contexts. Understanding these aspects could enable municipalities to better understand how the COVID-19 pandemic has impacted on citizen perspectives of nature and design cities that align with their demands.

Lastly, with the pandemic still ongoing and new findings on how this is influencing - and could influence - the fabric of urban life frequently identified, there is potential to explore practitioner, researcher and citizen value for NBS as the pandemic continues. Although the pace of vaccination programmes around the world are increasing, with the threat of mutations it could be that the COVID-19 virus will be around for longer still – so questions around what does this mean for how NBS are used in cities? or what does this mean for how NBS are valued? For how cities are designed? can continue to be asked.

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Appendix A – Types of Nature-Based Solutions

Category	Subcategory	Explanation
(External) building greens	Green roofs	Roof vegetation on thin substrate either with varying degrees of irrigation and management; vegetation established either artificially or by seeding or planting or naturally; can include perennials, grasses, small trees, rooftop farming, mosses, succulents, few herbs and grasses
	Green walls or facades	Including e.g. ground-based climbing plants intended for ornamental purposes or plants growing in facade- bound substrate (e.g. containers or textile-systems)
	Balcony green	Plants on balconies and terraces which are planted mostly in pots.
Urban green areas connected to grey infrastructure	Alley and street trees/hedges/greens Railroad bank and tracks House gardens Green playground/ school grounds Institutional green space Green parking lots Riverbank greens	Trees planted in alleys or along roads and paths, either solitary or in rows. Hedges along roads or paths. Non- tree, mostly shrubby or grassy verges along roads.
		Green space along railroads
		Areas in the immediate vicinity of private houses cultivated mainly for ornamental purposes and/or non-commercial food production Green areas intended for playing or outdoor learning.
		Green spaces surrounding public and private institutions and corporation buildings
		Parking lots which are surrounded by or interspersed with trees, grass patches, flower beds, bushes, or other vegetation
		Green space sideways the rivers, streams and canals, usually with foot or bike paths
Parks and (semi) natural urban green areas	Large urban park or forest Pocket parks / neighbourhood green spaces Botanical garden Green corridor	Larger green (forested) area within a city intended for recreational use by urban population; can include different features such as trees, grassy areas, play- grounds, water bodies, ornamental beds, etc
		Small green areas around and between buildings which are vegetated by ornamental trees, shrubs, grass; often in residential areas, but also between other building types
		Educational and ornamental areas planted with large diversity of plant species.
		Networks of linked landscape elements that provide ecological, recreational, and cultural benefits to the community
Allotments and community gardens	Allotments	Small garden parcels cultivated by different people, intended for non-commercial food production.
	Community gardens	Areas which are collectively gardened by a community for food and recreation.
	Horticulture	Land devoted to growing vegetables, flowers, berries, etc
Green indoor areas	Indoor vertical greeneries (walls and ceilings)	Including e.g. ground-based climbing plants intended for ornamental purposes or plants

	Atrium	growing in facade- bound substrate (e.g. containers or textile-systems) inside of a building
		Green area surround/enclosed in a building, planted mostly with ornamental plants
Blue areas	Lake/pond River/stream/canal/estuary Delta Sea coast Wetland/bog/fen/marsh	Natural and artificial standing water bodies containing freshwater with (semi)natural aquatic communities; banks are artificial/managed or natural
		Natural and artificial running water bodies containing freshwater (or in the case of estuaries, mixed fresh and saltwater) with (semi)natural aquatic communities; banks are artificial/managed or natural
		Landform at the mouth of a river formed by sediment deposits
		Contact areas between the sea and the land of different characteristics (e.g. sand beaches, cliffs, coast- al dunes)
		Areas with soil permanently or periodically saturated with water and characteristic flora and fauna
Green areas for water management	Rain gardens Swales / filter strips Sustainable urban drainage systems	Shallow, vegetated basins that collect and temporarily store rainwater runoff from rooftops, sidewalks, and streets or allow for its infiltration
		Vegetated and gently sloped pit or shallow drainage channels for filtering surface runoff
		Systemic approach to manage drainage in and around properties, often combining green and grey components; can include e.g. green roofs, permeable surfaces, infiltration trenches, swales, detention basins, etc
Derelict areas	Abandoned and derelict spaces with growth of wilderness or green features	Recently abandoned areas, construction sites, former industrial areas, etc with spontaneously occurring pioneer or ruderal vegetation

Table based on NATURVATION Nature-Based Solutions Data Collection Guidance Manual

Appendix B – Definitions of Nature-Based Solutions

Author	Definition
International Union for Conservation of Nature	“Nature-based solutions are actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits. They are underpinned by benefits that flow from healthy ecosystems and target major challenges like climate change, disaster risk reduction, food and water security, health and are critical to economic development.”
European Commission	“...aim to help societies address a variety of environmental, societal and economic challenges in a sustainable way. They are actions which are inspired by, supported by, or copied from nature.” “...are solutions to societal challenges that are inspired and supported by nature, which are cost-effective, provide simultaneous environmental, social and economic benefits, and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions”
BiodivERsA	“NBS refers to the use of nature in tackling challenges such as climate change, food scarcity, water resources, or disaster risk management, encompassing a wider definition of how to conserve and use biodiversity in a sustainable manner. By going beyond the threshold of traditional biodiversity conservation principles, this concept intends to additionally integrate societal factors such as poverty alleviation, socio-economic development and efficient governance principles.”
Bush & Doyon (2019)	“Nature-based solutions has emerged as a concept, or umbrella term, for ecosystem-based approaches to address the societal challenges of climate change, natural disasters, food and water security, human health and well-being, and economic and social development. Nature-based solutions address these societal challenges through the delivery of ‘ecosystem services.’”
NATURVATION	“NBS are defined as deliberate interventions seeking to capture and use the distinct properties of natural systems to address UC while simultaneously providing environmental, economic, and social benefits when building resilience”
DG Research and Innovation Expert Group	“NBS are living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits.”

Appendix C - Ethics Assessment

Questions	Explanation	Mitigation
<p>Does the research entail handling personal information concerning any of the following?</p> <ul style="list-style-type: none"> a) race or ethnic origin, b) political views, c) religious or philosophical convictions d) trade union membership e) health or sex life f) legal offences involving crimes g) criminal convictions, h) procedural coercive measures or administrative detention. 	<ul style="list-style-type: none"> a) No b) Maybe – personal opinion could come into how participants value NBS and their attitude towards the municipality. c) No d) No e) No f) No g) No h) No 	<p>This will be mitigated by offering participants anonymity should they require.</p>
Does the research entail a physical intervention on a living human being or a deceased person?	No	N/A
Is the research conducted according to a method which: <ul style="list-style-type: none"> a) aims to affect the research subject physically or mentally? b) entails an obvious risk of harming the research subject physically or mentally? 	No No	N/A
Does the research concern studies on biological material taken from: <ul style="list-style-type: none"> a) living human and traceable to that individual? b) a deceased person for medical purposes and traceable to that individual? 	No No	N/A
Has the researcher considered participant consent?	Yes	Through the introduction of the project a document will also be sent requesting participant consent.
Has the researcher considered participant confidentiality?	Yes	Yes – direct names and details will not be used in the research.
Does the research include potential issues with data security?	Yes	Yes, through data security – data will not be stored on any cloud services and ONLY on a password protected laptop.
Has the researcher considered the participants right to withdraw?	Yes	Yes – participants will be informed of the right to withdraw on multiple occasions.
Will the research be done with other organisations involved?	No	This project will feed into aspects of the NATURVATION project however, will not be directly influenced by the organisation (the topic and research design is the authors own).
Is the researcher working within the limit of their competence?	Yes	Studied units which include the analysis of Nature-based Solutions, Urban governance and sustainable cities.
Could the results of the research be harmful to the reputation, dignity or privacy of the subjects?	Yes	Some of the information revealed by participants could be harmful. Thus, participant anonymity will be granted.

Appendix D – Information Sheet & Consent Form

URBAN NATURE-BASED SOLUTIONS: COVID-19 and IMPACTS ON URBAN DESIGN.

INFORMATION SHEET

Description of the Research Programme

The impacts of COVID-19 on cities remains relatively unexplored due to the recentness of the pandemic. Thus, this research will explore the long-term implications of COVID-19 on cities and urban design with specific interest in Nature-Based Solutions (NBS).

Nature-Based Solutions (NBS) can be defined as deliberate interventions that can be inspired by or support nature in addressing UC, such as climate change mitigation, water management, land-use and urban development (Bulkeley et al, 2017). Common examples include park developments, green roof development, community gardens, green areas for water management, green indoor areas, green corridors, and greening streets.

The implementation of Urban NBS can provide multiple benefits to address UC, such as climate change and biodiversity loss. For example, the creation of park which can provide health benefits and mitigate flooding impacts. In recognition of the role NBS can play in building UR this research will investigate whether COVID-19 could be used as an opportunity to mainstream the NBS concept. Thus, the project aims to examine, test and advance knowledge about COVID-19 and NBS across 6 cities: Barcelona, Newcastle, Utrecht, Malmö and Győr. Our objectives are to understand:

1. How municipalities view the potential of NBS in recovering from the COVID-19 pandemic.
2. What barriers and enabling factors currently exist to NBS implementation.
3. What opportunities may have arisen as a result of COVID-19 to facilitate NBS mainstreaming

The collected material will be used to produce a MSc Student Thesis. The research will result in an academic publication, The research results will be accessible online.

Data Management

All the data for this project is collected and stored in accordance with the General Data Protection Regulation (GDPR) 2016/679 of the European Union. More information about GDPR implementation at Lund University can be found: lunduniversity.lu.se/gdpr. All the research materials, including the participants' data will be securely stored during the thesis process (until 28/06/2021) at a protected shared virtual space of Lund University - LU Box, which provides password access only to the individual working on the paper. (At any stage of the research project, the research participants have a right to gain access to their own personal data, request its correction or deletion or limitation to processing of data as well as they can file a complaint about how their personal data is used.

CONSENT FORM

This form is to ensure that you have been given information about the research project being performed and to give you opportunity to confirm that you are willing to take part in this research. For all activities below, please indicate which applies to you:

<input type="checkbox"/>	I have been familiarised with the NBS project, I have had the possibility to ask questions and I have received satisfactory answers to my questions
<input type="checkbox"/>	As a research participant, I am aware of my right to withdraw participation at any time
<input type="checkbox"/>	I give my consent that the interview can be audio- and video-recorded , transcribed, and analysed
<input type="checkbox"/>	I give my consent to be identified by my municipality or research institution
<input type="checkbox"/>	I understand that the results of the research will be presented so that no information can be traced to me personally
<input type="checkbox"/>	I give my consent that a record of my interview can be safely stored for future reference

Note: Your participation is voluntary. As an interviewee, you do not have to answer all the questions that are asked; you reserve the right to refuse or cease participation in the interview process without stating your reason and may request to keep certain materials confidential.
Please, sign below to confirm your consent:

	Participant(s)	Researcher(s)
Name(s)		Samuel Walker
Signature(s)		
Date(s)	XX/OX/2021	XX/OX/2021

For any enquiries regarding this research, please contact:

Samuel Walker

MSc Student

The International Institute for Industrial Environmental Economics, Lund University
PO Box 196, 22100 Lund, Sweden,

Email:

Telephone: (+46) 760343787

Appendix E – Interview Guide

An interview guide was created as an aid to guiding the interview. It was acknowledged that this may alter during the interview and thus, following the respondent was prioritised over strictly following the guide.

Interview Briefing

0-3 Minutes

Many thanks again for agreeing to participate in my thesis study.

Before starting the interview, I'll just need to read out and confirm the following with you.

- 1) The purpose of this research will be to explore how the COVID-19 pandemic has impacted on NBS and how the pandemic has affected barriers and enablers to NBS mainstreaming.
- 2) Findings from this interview will be transcribed and analysed using the software NVivo. All data collected will be stored securely on my laptop which will only be accessed and reviewed by me. Reference will be made to these findings in the final thesis however, your name and position will not be referenced.
- 3) Should you have any questions at any point during the interview regarding the handling of data please do let me know at the end of the interview.
- 4) Please note you are welcome to withdraw at anytime during the interview and from the research study, should you desire.

Questions

Date

P1) Participant Introduction / Background to NBS Projects

5 Minutes

Q1) Please could you briefly describe your role in the municipality/organisation and how your work is related to NBS?

Q2) Do you have any strategic approaches (e.g. strategies, policies, action plans) for NBS and/or goals for NBS implementation within the municipality and/or city?

- a) What were the drivers behind wanting to implement NBS?
- b) What UC were NBS implemented to address?

P2) Response of Municipalities to COVID-19

10 Minutes

Q3) How has the COVID-19 pandemic impacted on the use of NBS?

Q4) Has the municipality introduced any rules or policies towards NBS initiatives as a result of the pandemic?

- a) If yes, what kind of rules or policies? For what reason were they introduced?

Q5) Has the municipality provided any support (advice, funding, staff) to NBS initiatives during the pandemic?

P3) Work with NBS during COVID-19 Pandemic

15 Minutes

Q6) How has your work with NBS projects been impacted by the COVID-19 pandemic?

- a) In which ways has this been negative?
- b) Were there any positive impacts?

Q7) What **barriers** to NBS implementation did you identify PRIOR to the COVID-19 pandemic?

- a) Has the COVID-19 pandemic exaggerated or allowed you to overcome any of these barriers?

Q8) What **opportunities** for NBS implementation did you identify PRIOR to the COVID-19 pandemic?

- a) Has the COVID-19 pandemic restricted or allowed you to utilise any of these opportunities?

Q9) Has the COVID-19 pandemic provided any additional barriers or opportunities to further implementing and mainstreaming the NBS agenda?

P4) Future of NBS

10 Minutes

Q10) How do you see the role of NBS in the city of X in the post-pandemic world?

- a) Do you plan to continue your strategic work with NBS after the pandemic?
- b) Will there be a higher or a lower demand for NBS among citizens of X?
- c) Will certain forms of NBS be preferred more than others? If yes, which types and why?
- d) How are you planning for a potential higher demand for NBS in the city?
Investment into existing NBS projects for expansion? Re-purposing urban sites?

Q11) Do any city-wide COVID-19 recovery packages, strategies or policies proposed and/or implemented by the city of X as a whole, include NBS?

- a) If they do, how is NBS included? What issues are they expected to address?

Q12) What role do you see NBS playing in building UR to UC including future pandemics?

P5) Wrap Up

0-3 Minutes

Q13) Is there anything more you would like to add on the topic or any other sources or information on the matter?

Finally, do you know of any other relevant contacts who could be contacted?

Appendix F –De-brief

Participant Debrief

Emailed out to Participant

Many thanks again for agreeing to participate in my research study exploring how COVID-19 has impacted on cities - with specific interest on Nature-Based Solutions (NBS). Please be assured that the data collected will be stored securely on my laptop ONLY and will not be shared with anyone else. Information gathered from the interview will be used in the thesis.

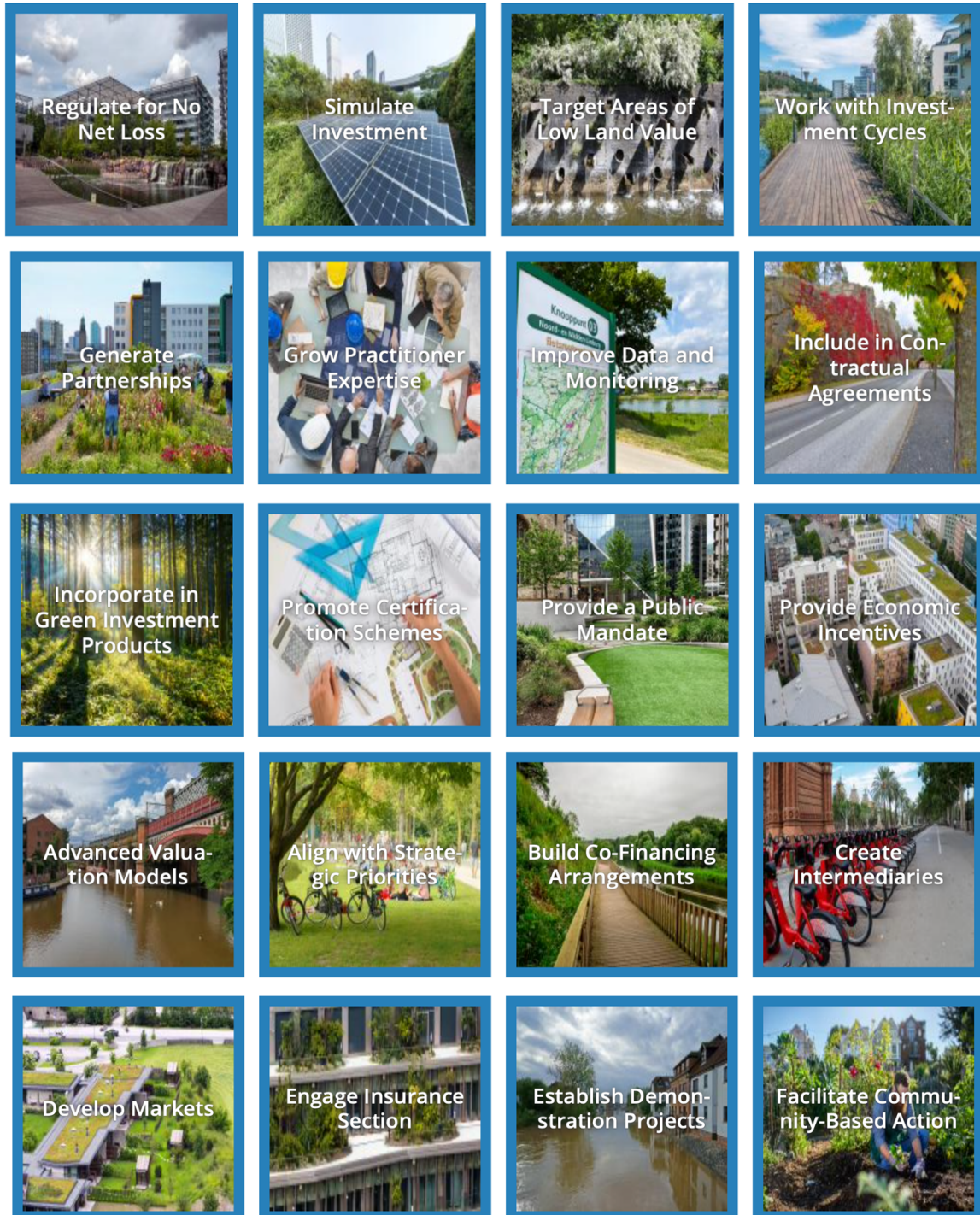
As mentioned, direct reference to your name and the role you work in will not be made within the thesis – you will remain anonymous throughout. Should you prefer to withdraw from the study instead please do contact me again on this email. before the 01/05/2021.”

Many thanks.

Kind regards,

Samuel Walker

Appendix G – Stepping Stones for NBS mainstreaming



Source: <https://naturvation.eu/mainstream/key-stepping-stones>

Permission to use the content of the stepping stones and the associated visuals was received from the original author.

Appendix H – Research Process

<p>Research Questions</p> <p><i>Define RQ to be explored.</i></p>	<p>RQ1: <i>What impact has the COVID-19 pandemic had on the use of NBS in cities?</i></p>	<p>RQ2: <i>How do practitioners and researchers discuss the potential of NBS to build back better from the COVID-19 pandemic and to other Urban Challenges?</i></p>	<p>RQ3: <i>How has the COVID-19 pandemic impeded or supported the mainstreaming of Nature-Based Solutions</i></p>
<p>Literature Review</p> <p><i>Explore relevant concepts.</i></p>	<p>Sources: Including peer-reviewed articles, grey literature (newspaper articles and websites).</p> <p>Keywords: Nature-based solutions, implementation of nature-based solutions, green and blue infrastructure, ecosystem services, urban sustainable development, urban challenges, urban resilience, city resilience, nature-based solutions and urban resilience, COVID-19, resilience to public health.</p>		
<p>Case Selection</p> <p><i>Identify which cities to focus on.</i></p>	<p>Identifying which cities to study was determined by a number of selection criteria outlined in the methods section.</p> <p>Cities identified included; Barcelona, , Malmö, Newcastle & Utrecht.</p>		
<p>Literature for Description and Analysis</p> <p><i>Review literature to explore context of each city.</i></p>	<p>Primarily applicable for RQ1.</p> <p>An online review of current literature to determine municipality response.</p> <p>Sources: articles, reports and websites.</p>		
<p>Interviews</p> <p><i>Perform interviews with individuals working at municipalities.</i></p>	<p>Interviews were performed with 3 - 4 individuals who either worked directly with the municipality OR as a researcher working/had worked in collaboration with the municipality.</p> <p>RQ1: Review of the NATURVATION Urban Nature Atlas</p>		
<p>Analytical Method</p> <p><i>Analyse content collected from interviews</i></p>	<p>In-case Analysis Nvivo</p> <p>Cross-case Analysis</p>	<p>In-case Analysis Nvivo Theoretical Framework</p> <p>Cross-case Analysis</p>	<p>In-case Analysis Nvivo Theoretical Framework</p> <p>Cross-case Analysis</p>
<p>Discussion</p>	<p>Structured around 3 core themes identified in analysis.</p> <p>i) Use on NBS ii) Unintended Consequences iii) Delays and Cancellations on projects.</p>	<p>Structured around UC identified.</p> <p>For example, Water Management, Climate Change, Public Health.</p>	<p>Structured around impeding and supporting factors. For example, Agency, Cognitive factors, Collaborations.</p>
<p>Findings & Conclusions</p>	<p>Following the analysis of the results, findings were outlined and discussed with reference made back to the theories explained and content described in the literature review.</p>		

Appendix I – List of Interviewees

No.	Participant Code	City	Position	Date of Interview	Date of Transcription
1	1A	Győr	Researcher	05/03	08/03
2	1B	Győr	Researcher	01/04	01/04
3	1C	Győr	Researcher	12/04	13/04
4	2A	Barcelona	Researcher	10/03	10/03
5	2B	Barcelona	Practitioner	15/03	15/03
6	2C	Barcelona	Researcher	07/04	07/04
7	3A	Utrecht	Practitioner	11/02	12/02
8	3B	Utrecht	Researcher	12/03	15/03
9	3C	Utrecht	Practitioner	02/04	02/04
10	3D	Utrecht	Practitioner	30/03	30/03
11	4A	Malmö	Practitioner	11/03	11/03
12	4B	Malmö	Practitioner	17/03	17/03-18/03
13	4C	Malmö	Researcher	21/03	22/03
14	4D	Malmö	Researcher	31/03	31/03-01/04
15	5A	Newcastle	Practitioner	01/03	01/03
16	5B	Newcastle	Researcher	12/03	12/03
17	5C	Newcastle	Practitioner	17/03	17/03
18	5D	Newcastle	Researcher	26/03	26/03-27/03
19	7A	N/A	Researcher	16/03	17/03
20	7B	N/A	Researcher	31/03	31/03

* The number given to each interview was used as a reference corresponding with the transcript uploaded onto Nvivo.

* All interviews took place over Zoom/Google Meets/Microsoft Teams with the exception of 3C which was a telephone interview.

Appendix J –Tables of barriers, enablers, threats and opportunities for RQ3

Barcelona: Barriers and Enablers (prior to the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	- Although there is an increased understanding of the simultaneous benefits of NBS there is a need for UC to be thought of more holistically. (B). - Multiple understandings of the NBS concept exist which has created some confusion for practitioners working with the concept. (B). - Although this confusion exists, the flexibility of the term also allows for flexibility and for it to be easily explained to individuals who haven't worked with the term before. - Anthropogenic focus in planning developments still. (B).	2:A; 2:B 2:A; 2:B; 2:C 2:A 2:B; 2:C
Agency - Leadership and Power - Commitment	- Support of NBS from current city council who promote the use of green solutions and provide resources for this. Current mayor has pushed for more biodiversity, climate change action, reduced car-use which has provided opportunities for NBS to be mainstreamed. (E)	2:A; 2:B; 2:C
Collaboration - Networks and Partnerships - Participation	- Barcelona has a culture of citizen participation which aligns with NBS project planning, implementation and use. This also allows the municipality to “keep in touch” with what citizens want. (E). - Decisions are still made by architects who aren't always receptive to citizen demands. (B). - Municipality is still working quite siloed which restricts input from other departments that may encourage the use of NBS. (B). More cross-department work is required and a more systems approach to design (E)	2:B 2:B
Discourse and Future Visions	- Alignment with the vision of NBS with increasing the sustainability of the city through increasing biodiversity, improving climate change adaptation and mitigation. Systems like BREEM are pushing design to sustainable, green, circular projects (E).	2:B; 2:C
Resources	- Funding Issues in general. “Limited pot of money”. (B) - Funding for bottom-up initiatives has increased however, more is required to address unequal access to greenspace (B).	2:A; 2:B
Institutional	- The administrative process to planning and implementing projects is too long and slow. This can make projects vulnerable to resource cuts or cancellations (B). - Those working with NBS sometimes were, and continue to be reluctant to work on projects due to the risk that a new political party may come in and change objectives/cancel projects (B). - NBS maintenance is still seen as a cost to municipalities without much acknowledgement of what the current financial benefits of the space maybe. Current problems with the accountancy system. (B)	2:A; 2:C 2:C 2:B
Strategic Plans, Legislation, Policies	- Strategic plans around biodiversity have been significant in influencing NBS projects. Climate change and traffic regulations have also provided opportunities to mainstream NBS (E).	2:A; 2:B; 2:C
Local Geographical Context - Built Env	- History and continued challenge of densification as a result of urbanisation reducing space available for NBS (B/E). - City location within the self-autonomous region of Catalonia which allows Barcelona to collect its own finances and invest (E).	2:A; 2:B; 2:C 2:B
Learning - Monitoring and	- Research process to measure benefits of NBS takes an extended period of time but the municipality expect new	2A

Evaluation	material every 6 months (B).	
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Barcelona: Threats and Opportunities (that have arisen as a result of the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	<ul style="list-style-type: none"> - The COVID-19 pandemic has emphasized to practitioners the connection between NBS and good physical and mental public health. As a result, this has moved up the agenda when planning projects and the inclusion of NBS in urban design – in general, for example with integrating NBS through planter beds etc. but also through concepts such as the Superblocks. (O) - A visible increase in the number of people using parks is apparent since restrictions have been relaxed. An increase in the amount of people using their roofs for activities, balconies and peri-urban natural areas also suggests an increase in appreciation and demand for nature. (O) <ul style="list-style-type: none"> - People are likely to demand better access to greenspace in the city and around where they live. (O) - Preference for cars reduced during the pandemic as people value greenspace more. (O) - COVID-19 has highlighted the unequal distribution of NBS based on socio-economic aspects. This has emphasized the need to implement NBS to improve people’s access to nature and shifted it higher on the agenda when planning developments. (O) <ul style="list-style-type: none"> - In particular opportunities for bottom-up initiatives have been highlighted, with the need to include citizens in projects to ensure projects can be fully utilised. (O). - Restrictions on park maintenance led to complaints over how NBS projects were managed as these were considered unsightly or contributed to allergies. Therefore, this and other eco-system disservices need to be addressed to facilitate NBS mainstreaming (T). 	2:A; 2:B; 2:C. 2:A; 2:B; 2:C 2:A: 2:C 2:B 2:A; 2:C 2:A; 2:C 2:A; 2:B; 2:C
Collaboration - Networks and Partnerships - Participation	<ul style="list-style-type: none"> - Work on NBS projects has moved online which has slowed down the process of planning and implementation (T). In particular, citizen participation has been severely restricted. (T) <ul style="list-style-type: none"> - This has also provided opportunities to rethink current development projects however. And how NBS can now be included. 	2:B
Discourse and Future Visions	<ul style="list-style-type: none"> - Prior to COVID-19 there was already alignment with sustainable city goals however, the pandemic has emphasized the need for this more. In particular, discourse around sustainable mobility; space for bikes and pedestrians and less space for vehicles has been highlighted as a result of the pandemic. This has led to a number of streets being temporarily provided for pedestrians and provided opportunities for NBS. (O). 	2:B; 2:C
Resources	<ul style="list-style-type: none"> - Funding cuts initially led to the cancellation of some NBS projects as certain lines of investment were redirected to COVID-19 response (T). Technical knowledge was also redirected to respond to the pandemic (T). - Although an increase in the number of people using the parks has been seen, no additional funding has been provided to aiding with the maintenance of the parks. (T) - However, funding going towards implementing new NBS projects has now increased slightly providing additional opportunities to increase NBS within the city (O). 	2:A; 2:B 2:B 2:B 2:B; 2:C

	- There is uncertainty whether this investment will continue however, due to the recognition that the pot of money available following COVID-19 will be limited due to a severe lack of economic activity, most notably tourism, a significant industry to Barcelona. (I).	2:A; 2:B; 2:C
Strategic Plans, Legislation, Policies	- At the moment many developments are directed by policy in the private sphere – as the provision of balconies or greenspace is not currently required, this has led to a lack of balconies or green roofs in developments. Therefore, for NBS to be actualised, changes to urban design policy are required. (I). - A demand for greenspace may encourage developers to include balconies and green roofs more (O) but this may ultimately continue to exclude certain socio-economic groups as developers charge more for this. (I).	2:A; 2:C 2:A; 2:C
Local Geographical Context	- Spain has struggled with economic activity since X. Concern that the COVID-19 pandemic may have pushed Barcelona back exists and that this may limit the amount of work being done with NBS. (I).	2:C

Győr: Barriers and Enablers (prior to the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	- There was a lack of awareness of how NBS could be used to address certain urban challenges which meant grey infrastructure was often used. (B) - 1:C noted that actually, individuals in the municipality knew the benefits of NBS however, often had to prioritise other solutions due to other priorities and the current discourse of the leading government which favoured grey infrastructure. (B). - Some people unaware of the NBS term which has meant it is harder to convince people to implement it. One particular issue is people were questioning what it was a solution to? (B) - However, following the NATURVATION project this issue is expected to be addressed as the project has provided individuals with comprehensive knowledge on what NBS is. (E)	1:B 1:C 1:B 1:A
Agency - Leadership and Power - Commitment	- Prior to the change in mayor there was a lack of advocacy within the municipality for NBS to address urban challenges; often, grey infrastructure was prioritised. This resulted in fewer opportunities to implement NBS. The mayor was interested in NBS occasionally but not committed. (B) - With the introduction of a new mayor, there has been more support towards green solutions to various challenges. It is too soon to say whether this will materialise into tangible actions however, it provides direction and opportunities for NBS. (E)	1:B; 1:C 1:A
Collaboration - Networks and Partnerships - Participation	- New mayor has been proactive in establishing relationships with NGOs to identify opportunities to include NBS in the city and identify NBS that can address relevant urban challenges. (E) - Collaboration with young architects to bring in knowledge on green infrastructure and how this can be integrated into streets. (E) - Opening up project consultations to citizens “brought all the angry people out” which made the implementation of the NBS project more complex. (B).	1:A 1:A 1:C
Discourse and Future Visions	- Since the introduction of the new mayor there is more of an alignment with sustainable cities. The mayor had declared (prior to COVID-19) that he wants Győr to become the cleanest city in Hungary pushing the public health agenda. (E)	1:A

	- Growing discourse around climate change and Greta Thunberg has led to more an awareness for citizens and an stronger advocacy for space for nature in the city. (E)	1:B
Resources	- Identifying funds for NBS has been an issue. (B).	1:A; 1:B; 1:C
Strategic Plans, Legislation, Policies	- There is still a lack of legislation encouraging private developers and public departments to include NBS in projects. (B)	1:B
Local Geographical Context - Built Env	- The inner city consists of a lot of old buildings where opportunities for greenspace – including green roofs – is limited. This has led to complexities with integrating NBS. - Access to a variety and large amount of access on the outskirts of the city comes up as a justification for not implementing more NBS in the centre. (B) - With a strong automotive industry in Gyór there is still a strong lobby for car use in the city. This means that if space is available, it often goes to parking, roads etc. This has reduced the amount of opportunities available for NBS. - Very few options to be able to influence what is happening on private land. Few incentives for including NBS. (B)	1:A 1:B; 1:C 1:B; 1:C 1:C
Learning - Data and Monitoring - Experimentation	- Results from NBS already implemented was provided to the municipality. As a result of this being provided to the municipality, there has been more of a willingness to work with NBS in the future. (E) - This is why there is still a huge need for data in the case of Gyór; more data monitoring is needed to build the case around NBS. (B).	1:A 1B

Gyór: Threats and Opportunities (that have arisen as a result of the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	- A new mayor + a newfound appreciation for NBS as a result of COVID-19 have provided opportunities to integrate NBS into the city of Gyór further. (O) - In particular the public health aspect has come into focus. The new mayor is particularly interested in promoting the public health agenda and COVID-19 has further demonstrated the need for this. As a result, this could provide opportunities to implement NBS. (O) - Citizen demand for NBS within the city centre has increased as a result of restrictions which i) made people value access to nature more and ii) led to people using these spaces as no other options were available. (O) - 1:A reported that 60% of the people interviewed claimed that they would use the park more in future. (O) - An increase in the use of NBS sites around the outskirts of the city has led to the areas becoming less visually appealing; they look dirty. This could change people’s opinion on the value of having NBS and threaten the desirability of having these spaces. (T) - COVID-19 has provided an additional push to the argument of why NBS is important to include in cities, and to convince decision makers why it should be included in designs. (O)	1:A; 1:B; 1:C 1:A 1:A; 1:B 1:A 1:C
Collaboration - Networks and Partnerships	- Following the new mayor coming into power a number of collaborations with NGOs and young architects were initiated in an attempt to integrate NBS into the city more. However, COVID-19	1:A

- Participation	put a stop to this. (I)	
Discourse and Future Visions	- COVID-19 has made people feel less safe on public transport (due to the spread of the virus) which has resulted in a lot of people cycling instead. This has created a demand for more cycle paths which could also lead to opportunities to mainstream NBS. (E)	1:A
Resources	- The mayor had ambitions to integrate NBS into the city however, with COVID-19 the majority of resources have now been directed into other projects. (I) - Whilst this hasn't led to too many delays with projects this has slowed down the development of future projects – for the time being. (I)	1:A 1:A; 1:B
Learning	- A high level of litter and environmental damage to NBS areas as a result of COVID-19 has demonstrated the need to educate citizens on how to interact with nature. This is required to facilitate the implementation of NBS projects. (I).	1:B; 1:C
Local Geographical Context	- Such a strong lobby for cars existed before the pandemic however, this has also been emphasized as a result of people feeling uncomfortable taking public transport. Therefore, this could limit the amount of support for NBS from citizens. (I)	1:A

Malmö: Barriers and Enablers (prior to the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	- There is a lack of understanding with the use of the term NBS outside of departments that don't typically work with nature. (B) - However, the concept is recognised as an umbrella concept for concepts such as eco-system services which make it easier to explain to developers as there is already some basic level of understanding of these concepts. - There is a need to change peoples opinions in certain departments of the municipality to include NBS more. Priorities are different within each department but attempting to show why NBS should be important is required (B). - The use of monetary valuation techniques to measure some benefits of NBS have enabled them to become easier to communicate to different departments in the municipality. (E)	4:A; 4:B; 4:C 4:A 4:C 4:B; 4:C
Agency - Leadership and Power - Commitment	- Changing people's mindset was originally difficult however, as soon as someone came in and pushed the NBS agenda, there was a lot more reception towards adopting them. (E) - This was considered especially important as you'll never be able to have enough resources to tackle every challenge – you need a charismatic person to push the NBS agenda. (E)	4:C 4:C; 4:D
Collaboration - Networks and Partnerships - Participation	- There is still quite a siloed approach to designing and implementing development projects which mean the ability to implement NBS is sometimes limited (B). As a result there is a need for departments to work together more. (E)	4:A 4:D
Discourse and Future Visions	- Malmö has strong visions of being a sustainable city and developing parts of the city which allow goals related to an increase in the demand for housing to be met sustainably. This provides opportunities for integrating NBS into the city. (E)	4:A; 4:C
Resources	- Getting funding for NBS projects was not seen as a problem (E) however, getting the resources together to be able to get these funds was. (B)	4:A; 4:B
Institutional	- Some reluctance for those working in the municipality to commit to NBS projects due to a fear that a change in government may change	4:A

	<p>priorities on what should be invested in. (B)</p> <ul style="list-style-type: none"> - The way the current accounting system is set up shows maintenance of an NBS site consistently as a cost with very little monetary recognition of the benefits they will provide. This is identified as a problem of the current system being used. (B) - There is a long and complicated administration process to get projects planned and implemented which delays the implementation of projects. (B) 	<p>4:A; 4:C</p> <p>4:A</p>
<p>Strategic Plans, Legislation, Policies</p>	<ul style="list-style-type: none"> - National policies provide direction to the municipality and facilitate the need to implement NBS (E) however, there is a delay in municipalities updating and aligning legislation to national level. (B) - NBS have been considered more in developments as a result of policy which has come outlining goals for climate change, biodiversity, flood mitigation – these are typically challenges that NBS can address and so this alignment has facilitated recognition of NBS as a solution to these challenges. (E) - Legislation regarding a minimum amount of greenspace to be provided on projects encourages developers to include these on their plans when proposing developments to the municipality and being chosen over the competition. (E) 	<p>4:B</p> <p>4:A; 4:B; 4:D</p> <p>4:C</p>
<p>Local Geographical Context</p> <ul style="list-style-type: none"> - Built Env 	<ul style="list-style-type: none"> - Densification of the city in an attempt to meet demand for housing and means that less space is available to implement large-scale NBS projects. (B) - Frequent exposure to floods – especially the recent flood in 2014 – acted as an eye opener to the severity of the challenge and changed how water management was considered; it was no longer just about removing as much water as fast as possible but also about water retention and storage to prevent flooding downcourse. This provided opportunities for NBS. (E) - Property ownership rights limit the potential to increase the amount of greenspace on private plots. (B) 	<p>4:A; 4:B; 4:C; 4:D</p> <p>4:D</p> <p>4:C</p>
<p>Learning</p> <ul style="list-style-type: none"> - Data and Monitoring - Experimentation 	<ul style="list-style-type: none"> - There is reluctance to get on board with the concept as there is not enough concrete evidence on the benefits provided. More data monitoring is required. (B) <ul style="list-style-type: none"> - Although another point made was that some individuals feel it would be still be too difficult to measure impacts to citizen health which is what is required. (B) - More research is required to identify and further legitimize monetary valuation techniques that can demonstrate the public health benefits of NBS and allow these to included into budgets when planning. (B) - Numerous small-scale integrated NBS experiments have been performed to demonstrate the benefits of integrating NBS but there is still a lack of understanding on how best to apply these in practice on a large-scale. (B) 	<p>4:A; 4:B</p> <p>4:A</p> <p>4:C</p> <p>4:D</p>

Malmö: Threats and Opportunities (that have arisen as a result of the COVID-19 pandemic)

Variable	Description	Source
<p>Cognitive Factors</p> <ul style="list-style-type: none"> - Awareness - Uncertainty 	<ul style="list-style-type: none"> - There has been an increase in the value and appreciation for nature from a citizen perspective with demands to have more bottom-up initiatives implemented. (O) - For those working in the municipality there is more weight behind arguments to include greenspace into projects as a result of the pandemic and mainly from a public health perspective. (O) <ul style="list-style-type: none"> - This has also facilitated the implementation of temporary green 	<p>4:A; 4:B; 4:C; 4:D</p> <p>4:C</p> <p>4:A</p>

	<p>projects, closing off roads and providing areas for people to sit and meet with friends. (O)</p> <ul style="list-style-type: none"> - The movement of work online as a result of restrictions has resulted in a delay of some development and NBS projects being planned and implemented (I) This has also however, provided opportunities to rethink the design and consider the public health aspect - and how projects could be designed better – more. This has provided opportunities to include NBS. (O) - COVID-19 has presented a number of additional challenges that municipalities have to respond to. This has meant that NBS have fallen in their prioritisation. (I) - COVID-19 has further drawn attention to the unequal distribution of greenspace in some areas in Malmö. Thus, this has presented opportunities to get NBS implemented. (O) - Awareness that NBS projects can keep the economy ticking over during the pandemic – create green growth etc. providing opportunities to implement additional projects. (O) - COVID-19 has forced some people to slow their pace of life down which has provided more time for reflection, “living in the now” and enjoying simple pleasures such as nature. Perhaps this will lead to a greater appreciation of nature in the long-term. (O) 	<p>4:B</p> <p>4:C</p> <p>4:A; 4:B</p> <p>4:D</p> <p>4:D</p>
<p>Collaboration</p> <ul style="list-style-type: none"> - Networks and Partnerships - Participation 	<ul style="list-style-type: none"> - The pandemic has demonstrated the need to include citizens in NBS projects more to ensure they utilise the sites. Thus, NBS projects have been including citizens more, with a stronger understanding of the value of citizen participation. (O) - NBS relies on co-creation and co-operation of which both aspects have been limited by work moving online. There are fewer options for creativity that restrict NBS and other development design. (B). - Lack of cross-sectoral support has been initially a barrier to NBS implementation however, this has been further exaggerated as a result of COVID-19 due more work, change in the way of working etc. (I) 	<p>4:A</p> <p>4:A; 4:C</p> <p>4:A; 4:B</p>
<p>Discourse and Future Visions</p>	<ul style="list-style-type: none"> - Since COVID-19 there have been initiatives to increase the number of spaces on streets for bikes. This has also provided additional spaces for NBS in the future. (O) 	<p>4:B</p>
<p>Resources</p>	<ul style="list-style-type: none"> - Additional funding was provided to expand some greenspaces and create new temporary spaces for people to meet and socialise. Some discussion around these spaces becoming permanent. (O) 	<p>4:B</p>
<p>Strategic Plans, Legislation, Policies</p>	<ul style="list-style-type: none"> - Local municipality is lacking strategic direction from national government on how to recover from COVID-19. This could be an opportunity to invest in green growth and implement more NBS projects but little direction has been provided. (I) 	<p>4:A</p>
<p>Learning</p>	<ul style="list-style-type: none"> - Concern that the opportunity presented by COVID-19 to mainstream NBS may not be realised as a result of a lack of connection between NBS and public health benefits. This was accounted to a lack of data supporting how NBS could contribute to increased public health. (I) 	<p>4:A; 4:D</p>
<p>Local Geographical Context</p>	<ul style="list-style-type: none"> - Working from home has led to an increase in the amount of people using greenspaces in the suburbs. This demand has demonstrated a need for better greenspace provision around these areas, presenting opportunities to implement NBS. (O) - A combination of a lack of space for NBS AND an increase in the demand for greenspace has led to practitioners looking for opportunities to integrate NBS into developments more (structural greening, biophilic design etc.). (O) 	<p>4:B; 4:D</p>

Newcastle: Barriers and Enablers (prior to the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	- Confusion around the concept and how it relates to other concepts including greenspace. - Additional challenge is people fail to see how social-equity is a part of NBS and so this component is often neglected. (B) - Good understanding of how NBS can tackle urban challenges including climate change, water management & physical health. (E) - Lack of understanding of how NBS can address other challenges however, including socio-equity, mental health. (B) - Although the benefits of NBS are acknowledged greenspace is still seen as a resource suck by many of those working within the municipality. There has to be a change in how people perceive greenspace. (B)	5:A; 5:B; 5:C; 5:D 5:D 5:A; 5:B 5:D 5:A
Agency - Leadership and Power - Commitment	- Lack of leadership of NBS within the municipality leading to opportunities being missed for implementing projects. (B) - Additionally, a newly appointed head in the Environmental Agency has allowed the concept to be pushed and raised peoples knowledge. (E)	5:A 5:C
Collaboration - Networks and Partnerships - Participation	- Organising networks with people from a range of different backgrounds brought different perspectives and those with different priorities together. This encouraged the integration of NBS into developments. (E) - Although it was recognised that arranging projects with multiple partners meant it was more complex “to get things done”. (B) - Although there is some involvement of citizens in projects this is often to “tick a box”; citizens need to be actively engaged throughout the whole process of the project to ensure the site is used to its full potential. (B)	5:B 5:A 5:D
Discourse and Future Visions	- Newcastle declared a Climate Emergency which led to the city setting up a committee to come up with ideas to become climate neutral. This has also provided more opportunities for NBS to be implemented throughout the city. (E)	5:A
Resources	- Resources for implementing NBS an issue (funding for parks cut by 90%). (B)	5:A; 5:B
Institutional	- NBS are seen as a resource suck; the underlying issue with this is the current set up of the accounting system which places maintenance of greenspace as a cost, or gives a lower value to green. (B) - Changes in national government make it difficult to commit to NBS plans which often take 3-4 years to plan and actualise. (B) - Still a lack of connection between how NBS can help address urban challenges in certain organisations; example given was water regulation service and lack of NBS to control flooding. (B)	5:A; 5:C 5:A 5:D
Strategic Plans, Legislation, Policies	- Climate Neutrality Strategy highlights the need for carbon sequestration within the city which also supports the implementation of NBS. (E) - Alignment also with Biodiversity Action Plan, Mobility Strategy, Biodiversity Net Gain (which targets the private sector) – all provide alignment and opportunities for NBS (E)	5:A; 5:B 5:A; 5:B; 5:C
Local Geographical Context	- Heavily industrialised history has meant grey infrastructure (especially around the river) has been prioritised making it more complex to include NBS. (B)	5:A
Learning - Monitoring and Evaluation	- Data and monitoring have contributed significantly to the growing acceptance of NBS within Newcastle. The urban lab has enabled evidence to be collected on how emissions can be cut significantly	5:A; 5:B

	<p>from banning car travel, which led to more support for initiatives that address reducing cars in some areas of the city. (E)</p> <ul style="list-style-type: none"> - Data from flooding also demonstrated why it's important to look at recovery through a health lens. (E) - Still a need for more experimental studies that specifically monitor the health benefits of NBS to build arguments. (B) 	<p>5:C</p> <p>5:D</p>
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Newcastle: Threats and Opportunities (that have arisen as a result of the COVID-19 pandemic)

Variable	Description	Source
<p>Cognitive Factors</p> <ul style="list-style-type: none"> - Awareness - Uncertainty 	<ul style="list-style-type: none"> - Due to the COVID-19 pandemic, public health colleagues working in the municipality have understood the connection between NBS and public health benefits more, leading to a realisation that more NBS should be included in projects. (O) - There has been a significant increase in how people are valuing NBS and greenspace as a result of the physical and mental benefits that are provided. This can be seen in the <ul style="list-style-type: none"> - The municipality has already considered what this may mean in the long-term; for example, the construction of houses with gardens or apartments with roof gardens. (O) - The unequal distribution of greenspace has been highlighted as a result of COVID-19. The rule that everyone is allowed to leave their home for daily exercise around their home showed how people living in dense neighbourhoods with little access to greenspace had poor options to walk. Many did not leave their homes as a result. Additionally, the unequal distribution of greenspace was highlighted further with organisations such as the National Trust – which own a large amount of greenspace – but which one can only be entered if paying to be a member. It has demonstrated the need for more greenspace in the city. (O) - There is an understanding that COVID-19 could be used as an opportunity to invest in NBS to stimulate green growth. Also, due to a demand in outdoor spaces, people want green city centres and shopping centres. (O) 	<p>5:A; 5:C</p> <p>5:A</p> <p>5:A; 5:B; 5:C; 5:D</p> <p>5:C</p> <p>5:A; 5:C</p>
<p>Collaboration</p> <ul style="list-style-type: none"> - Networks and Partnerships - Participation 	<ul style="list-style-type: none"> - Restrictions on the amount of people allowed to interact will continue to limit the amount of work that can be done with NBS work, in particular bottom-up initiatives in areas where greenspace is most needed. (I) - Since COVID-19 more stakeholders are interested in getting various NBS projects planned and implemented. This has given more weight to funding applications and increased access to funding. (O) - Working online on NBS makes creativity on projects a lot harder. Additionally, some employees have been furloughed* which has meant delays to some projects. (I) - Citizen involvement in projects is more complex. (I) 	<p>5:D</p> <p>5:B; 5:C</p> <p>5:A; 5:C</p> <p>5:D</p>
<p>Discourse and Future Visions</p>	<ul style="list-style-type: none"> - Conversations around NBS and green infrastructure as a result of COVID-19 have also come at a time when conversation on climate change is taking centre stage. This has provided alignment and opportunities to mainstream NBS. (O). - There is an understanding that COVID-19 will not disappear overnight and, as a result, demand for outdoor spaces will continue to increase. This will provide opportunities for NBS. (O) 	<p>5:A; 5:B; 5:C</p> <p>5:A; 5:C</p>
<p>Resources</p>	<ul style="list-style-type: none"> - Access to funding was restricted as a result of COVID-19; The National Environmental Investment Fund provided finance for NBS however, was delayed due to COVID-19. (I) 	<p>5:B</p>

	<ul style="list-style-type: none"> - NE1 an organisation representing businesses in the centre of Newcastle decided to cancel a temporary greenspace project as a result of COVID-19. However, following the ongoing situation of the pandemic it was later decided to permanently implement a garden area and floating bed on the river. Thus COVID-19 had contributed to new NBS projects. (O) - Municipality resources were also directed to COVID-19 to help handle the pandemic. This meant delays and cancellation to NBS projects. (I) 	5:B; 5:C 5:A
Strategic Plans, Legislation, Policies	<ul style="list-style-type: none"> - National policy released by government is directing municipalities to a green recovery. (O) - Delays with Environmental Bill coming out as a result of COVID-19 which slowed projects down. (I) <ul style="list-style-type: none"> - However, this delay is expected to have some benefits as with the newfound appreciation many now have for nature, the bill is likely to have a larger impact. (O) 	5:A 5:B
Learning	<ul style="list-style-type: none"> - To fully utilise the opportunity presented by COVID-19 there needs to be more experimentation and data monitoring on the potential citizen health benefits of NBS. (I) 	5:D

Utrecht: Barriers and Enablers (prior to the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	<ul style="list-style-type: none"> - Challenges arise with the use of the concept within the municipality Still; confusion over what is meant by “NBS” and how this differs from other concepts. (B) - Within the municipality there is a good awareness of how NBS can be beneficial for public health, biodiversity, climate change etc. and thus, this can facilitate NBS implementation. (E) <ul style="list-style-type: none"> - There is still a need to convince people of the benefits of NBS to push NBS further up the agenda when planning developments (B) - The municipality is flexible in its approach to managing NBS in response to citizens; complaints were originally made over a lack of biodiversity on lawns. As a result, lawns were left for longer to let flowers grown or replaced by meadows. This increased public acceptance of NBS. (E) <ul style="list-style-type: none"> - Although it was noted that some people felt that when the flowers wilted this looked ugly. Negative opinion on NBS. (B) 	3:A; 3:B; 3:C; 3:D 3:A; 3:B; 3:D 3:D 3:D
Agency - Leadership and Power - Commitment	<ul style="list-style-type: none"> - High level of support for promoting biodiversity, climate change adaptation and increasing greenspace per capita by the current Mayor and parties governing the city. This has facilitated the mainstreaming of NBS (E) Additionally, this has allowed more resources to be allocated towards green initiatives and into projects such as NBS. (E) <ul style="list-style-type: none"> - Past and future commitment of Utrecht municipality to achieving biodiversity and climate change targets has also facilitated NBS implementation. (E) 	3:A; 3:B; 3:D 3:C 3:A; 3:D
Collaboration - Networks and Partnerships - Participation	<ul style="list-style-type: none"> - With planning NBS projects there is some level of cross-department collaboration which facilitates the effective implementation of projects. (E) - For development projects there is also some level of cross-department collaboration which can provide opportunities to increase NBS being implemented. (E) <ul style="list-style-type: none"> - Opinions exist that departments are still too siloed though and that collaboration should be from the start of planning projects rather than halfway through when it’s harder to alter designs. (B) 	3:A 3:A; 3:D 3:D

Discourse and Future Visions	<ul style="list-style-type: none"> - Utrecht has strong ambitions to become a sustainable city; climate change and biodiversity goals act as an accelerator towards the acceptance of NBS. (E) - Utrecht has a strong cycle culture which is expected to continue to grow. The municipality has responded by providing more cyclepaths and pathways for pedestrians. This also provides aligns with visions of increasing greenspace along streets provided to pedestrians and cyclists. (E) 	<p>3:A; 3:B; 3D</p> <p>3:A</p>
Resources	<ul style="list-style-type: none"> - The finance required for NBS projects does not seem to be a problem and allows multiple projects to be implemented. (E) - Resources for parks is also high allowing for spaces to be well maintained. This has contributed to a positive perception of greenspaces. (E) 	<p>3:A; 3:C</p> <p>3:C</p>
Institutional	<ul style="list-style-type: none"> - Municipality is still working quite siloed which restricts input from other departments that may encourage the use of NBS. (B). More cross-department work is required and a more integrated approach to design (E) 	3:D
Strategic Plans, Legislation, Policies	<ul style="list-style-type: none"> - Alignment of various targets and strategies (biodiversity strategy, climate change goals, spatial strategy etc.) which has provided opportunities for NBS to be implemented. (E) - National policy made it obligatory for cities with a population larger than 100,000 to create a biodiversity action plan which outlines how the city will increase biodiversity. This prompted consideration of NBS more. (E) - Health policies also bring consideration of NBS into focus more due to recognised benefits of nature. (E) - National policy outlines requirements on car parking, setting a minimum number of spaces per development. This prevents more space from being provided to NBS and is outdated. (B) - Developments are required to include spaces for birds within their designs. This was set as a “knock-out indicator” and so developers began to go beyond this and integrate additional NBS. (E) <ul style="list-style-type: none"> - Additional legislation is required to drive the integration of NBS into projects. (E) 	<p>3:A; 3:B</p> <p>3:B</p> <p>3A</p> <p>3:D</p> <p>3:D</p>
Local Geographical Context	<ul style="list-style-type: none"> - Goals to construct 49,000 homes in the next couple of years places pressure on the municipality for space, limiting the amount available for NBS. (B) 	<p>3:A; 3:B; 3:D</p>
Learning - Education and Training.	<ul style="list-style-type: none"> - Bottom-up NBS initiatives were not fully realised as residents did not have the knowledge on how to maintain certain garden spaces. This led to the project being stopped. (B) 	3:D

Utrecht: Threats and Opportunities (that have arisen as a result of the COVID-19 pandemic)

Variable	Description	Source
Cognitive Factors - Awareness - Uncertainty	<ul style="list-style-type: none"> - Since restrictions have been relaxed there has been a visible increase in the number of people using NBS for access to parks and other greenspace. This suggests an increase in the value and appreciation for NBS. It was even noted that some citizens are walking up to park maintenance staff to openly express their gratitude for being able to access the greenspace. (O) <ul style="list-style-type: none"> - This could be used as an argument to increase the amount of greenspace in the city. (O) However, as Utrecht is already working a lot with trying to increase greenspace it could lead to an increase in people taking a stewardship position themselves (community gardens etc.) – bottom-up initiatives. (O) 	<p>3:A; 3:B 3:C; 3:D</p> <p>3:C</p> <p>3:A; 3:B</p> <p>3:B</p>

	<ul style="list-style-type: none"> - COVID-19 has highlighted the unequal distribution to greenspace for some citizens within Utrecht. There was acknowledged that some people were using NBS and public green spaces as they had no other option available. Therefore, COVID has presented opportunities to address this challenge and moved it further up on the agenda in planning discussions. (O) - The connection between greenspace and public health and wellbeing was already acknowledged prior to COVID-19 but this has been emphasized as a result of the pandemic. (O) 	<p>3:B; 3:D</p> <p>3:A; 3:B</p>
<p>Collaboration</p> <ul style="list-style-type: none"> - Networks and Partnerships - Participation 	<ul style="list-style-type: none"> - In recognition of the growing demand for greenspace as a result of COVID-19, Utrecht is being proactive in working with citizens to identify and develop future projects that include NBS. One example of this was that during the pandemic school children were asked for ideas on what “nature” projects could be included in the city. (O) - With work moving online work on NBS projects has been able to continue (O) however, there are significant delays with some of these projects as citizen participation is more complex to arrange now. (T) <ul style="list-style-type: none"> - Planning projects is also more complex in that it’s harder to be creative or bounce ideas of other people. You want to see the space you’re working with, how it connects to the wider environment. This is complex to do online. (T) - For existing NBS it is also more complex to arrange working in groups due to current restrictions. This prevents maintenance work from being done on projects. It also prevents people from working together on projects including community gardens (T) 	<p>3:A; 3:D</p> <p>3:A; 3:B</p> <p>3:D</p> <p>3:C</p> <p>3:A</p>
<p>Discourse and Future Visions</p>	<ul style="list-style-type: none"> - During the pandemic more space has been provided to pedestrians and cyclists with some roads turned to single-lane or streets completely closed. Also space given to restaurants and outdoor eating areas. There is potential for these streets to remain in this new state which could provide opportunities to integrate NBS into design. (O) - The spatial strategy recently released acknowledged how COVID-19 has changed the ways in which people work, in that working from home has become more common. This has meant that more spaces are needed for meeting and leisure closer to people’s homes. This change has presented opportunities for NBS in recognition that demand for greenspace around these areas has increased. (O) 	<p>3:A; 3:B</p> <p>3:B</p>
<p>Resources</p>	<ul style="list-style-type: none"> - Additional funding has been provided to facilitate the planning and implementation of NBS projects – project mentioned above in <i>Collaborations</i> given more funding to actualise projects. (O) - Additional resources have also been provided to current NBS projects – for example, the parks - to ensure that sites can deal with the increase in the number of people using sites. 	<p>3:A; 3:D</p> <p>3:C</p>
<p>Strategic Plans, Legislation, Policies</p>	<ul style="list-style-type: none"> - Lack of national direction on how to proceed with COVID-19 and where money should be invested. This is leading to money being invested into “default” industries rather than in green projects. (T) 	<p>3:A; 3:B</p>
<p>Local Geographical Context</p>	<ul style="list-style-type: none"> - With densification resulting in less space being available for greenspace and COVID-19 increasing demand for greenspace, there is an acknowledgement that this needs to be integrated more in developments in the form of green roads, green walls etc. (O) 	<p>3:D</p>