Bridging Urbanization and Green Development: The Case of Järfällas Regional City Core

Project Sustainable Urban Planning - Assessments, Plans and Processes

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Abstract/Abstrakt

English:

As urban areas expand and densify, balancing green and grey infrastructure becomes critical to ensure sustainable development and ecological resilience. This report explores how Järfälla Municipality can strengthen its green infrastructure (GI) and ecosystem service (ES) provisioning to meet long-term sustainability goals, including addressing climate change and enhancing biodiversity. By integrating a literature review, policy review, and interviews with representatives from municipal departments, the study identifies key strategies for improving urban ES and land-use planning in Järfälla.

The findings underscore the importance of a holistic and interdisciplinary approach to urban planning. Strategic assessments of ES are pivotal for understanding the capacities and deficiencies within Järfälla's GI. Continuous mapping and evaluation of GI can inform land-use decisions and help prioritize interventions before development occurs. The report highlights nature-based solutions (NBS) as effective tools for addressing identified gaps, such as restoring underutilized green spaces and converting impermeable surfaces to multifunctional residential areas. Enhancing GI connectivity and weakening the barrier effect from major urban barriers, such as the highway and train tracks, is recommended to mitigate habitat fragmentation and promote biodiversity.

Collaboration across municipal departments emerged as a critical success factor. Stakeholders emphasized the need for coordination from planning through implementation to balance competing priorities. This is especially important given that the densification targets of the municipality are aligned with regional mandates and agreements, which place significant pressure on the local urban ecosystems.

Additionally, the report addresses potential trade-offs between biodiversity and usability, noting that green spaces must serve both ecological and social functions. Strategies such as vertical development, targeted restoration efforts, and integrating NBS into housing projects are proposed to harmonize these objectives.

By adopting a strategic, context-specific approach to GI and ES management, Järfälla can enhance its ecological resilience, contribute to Agenda 2030 goals, and position itself as a model for sustainable urban development. This study offers actionable insights for policymakers and urban planners aiming to balance growth with environmental stewardship.

Svenska

I takt med att städer expanderar och förtätas uppstår det kritiska behovet av att balansera grå och grön infrastruktur för att uppnå socio-ekologiskt hållbar tillväxt. Denna rapport undersöker förutsättningar för hur Järfälla kommun kan stärka sin gröna infrastruktur och sina ekosystemtjänster för att möta långsiktiga hållbarhetsmål. Genom en litteraturstudie, granskning av kommunala handlingar och informella intervjuer med kommunanställda hållbarhetsstrateger, planerare och en ekolog har arbetet identifierat strategier för ett mer robust arbete kring ekosystemtjänster och markanvändning.

Resultaten understryker vikten av en holistiskt, interdisciplinärt inriktad stadsplanering. Strategisk utvärdering av ekosystemtjänster är avgörande för att ge insikter om Järfällas gröna infrastrukturs brister och tillgångar. Genom kartering och undersökningar kan

markanvändningsbeslut underbyggas och åtgärder prioriteras innan byggnation påbörjas. Rapporten lyfter fram naturbaserade lösningar som ett effektivt verktyg för att hantera brister i den gröna infrastrukturen, såsom att restaurera underutnyttjade grönområden och omvandla hårdgjorda ytor till multifunktionella bostadsområden. Att stärka länkarna inom den gröna infrastrukturen och minska barriäreffekter, från urbana hinder såsom motorvägen och järnvägsspåren, rekommenderas för att motverka habitatfragmentering och främja biologisk mångfald.

Samarbete mellan kommunens olika avdelningar identifierades som en avgörande framgångsfaktor. Behovet av samordning från planeringsstadiet till genomförandet för att balansera motstridiga prioriteringar betonades av de inblandade. Detta är särskilt viktigt med tanke på att kommunens förtätningsmål grundas i regionala mandat samt riskerar betydande påfrestningar på de lokala urbana ekosystemen.

Dessutom belyser rapporten potentiella avvägningar mellan biologisk mångfald och användbarhet med hänsyn till grönområden som måste tjäna både ekologiska och sociala funktioner. Strategier såsom att bygga på höjden, restaureringsinsatser av grönområden och integrering av naturbaserade lösningar i bostadsprojekt föreslås för att harmonisera dessa mål.

Genom att anta strategiskt och kontextspecifikt implementering och förvaltningen av grön infrastruktur och ekosystemtjänster kan Järfälla stärka sin ekologiska resiliens, bidra till Agenda 2030-målen och positionera sig som en förebild inom hållbar stadsutveckling. Denna rapport erbjuder handfasta insikter för beslutsfattare och stadsplanerare som strävar efter att balansera tillväxt och hållbarhet.

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1 Introduction

The denser areas of Järfälla, a municipality in the Stockholm metropolitan region, poses an interesting case for the challenge on how to balance goals of more housing while maintaining biodiversity and the urban ecosystem service (ES) provisioning. With mainly protected green wedges of regional importance on either side the green infrastructure (GI) within the municipality is of great importance (Järfälla Municipality, 2024). With urbanization and population growth, the prioritization of what land to build on becomes increasingly difficult and the decisions about land use and development ever more complex.

Urban population increase comes with two land cover alterations attached, densification and urban sprawl (Hysa, et al., 2024). Both of which can disrupt urban ecosystems vital for delivering ES such as air purification, climate regulation, and recreation.

This causes urban ecosystems having to compete for space as grey infrastructure covers a large proportion of the land surface (Gómez-Baggethun & Barton, 2013, drawing on Pickett et al., 2001). Urban ecosystems include all green and blue spaces in the urban structure, in peripheral areas and the urban hinterland that provide ES to the urban area (Gómez-Baggethun & Barton, 2013). ES are crucial to sustainable development and human wellbeing at global, national, regional and local levels. A decline in biodiversity as well as a reduction of urban ecosystems will negatively affect the urban ES provisioning (C/O City, 2016) and could diminish resilience and the capacity to handle future shocks (Gómez-Baggethun & Barton, 2013).

Urban sprawl can jeopardize the future of cities' peripheral areas (Hysa, et al., 2024) and is often driven by factors such as unsystematic land development, preference for single-family homes, as well as a lifestyle that needs more space per person and relies on cars (Artmann et al., 2019). Compact or dense cities on the other hand, are often argued to be a more sustainable urban form (Artmann et al., 2019; Jim et al., 2018). In the case of Järfälla large peripheral conservation areas and ecologically valuable land limits the available land access and alongside their development objectives, this encourages for densification within the municipality borders.

However, as urban sprawl and densification are contributors to both habitat loss and habitat fragmentation, decelerating, and ultimately reversing, biodiversity loss constitutes a major challenge for governance and planning on different scales (Güneralp et al., 2013; Soga, et al., 2014). This raises the crucial question of how green and grey infrastructure should be developed to best protect biodiversity and the array of ES supported.

Formulating goals and strategies aimed towards the SDGs can be useful for consensus and to ensure that nations and regions across Europe are working in the same direction. A qualitative study by Maes, et al. (2019) found linkage between 39 SDG targets and the conservation and maintenance of urban ecosystems and other research highlight a strong relationship between urban ES provisioning through urban GI and its potential to aid goal achievement on different scales (Herath & Bai, 2024). But how to navigate the road towards reaching the objectives set from these strategies is another issue.

This report will explore strategic planning and assessments of urban ecosystems and GI, as well as the integration of Nature-based solutions (NBS) in the urban fabric as possible remediations for balancing conflicting development goals. Examples of NBS in the urban fabric that this report will touch upon are pocket parks, green walls and green roofs.

1.1 Aim and research questions

The aim of this project is to assess the two green connections identified by Järfälla municipality crossing the dense area of Jakobsberg. They will be examined in terms of connectivity as well as accessibility. The project also aims to assess the conditions for future grey, and green infrastructure and how to combine the two objectives. The project strives to offer suggestions on how to balance densification with GI through evaluation and strengthening of the green structure. This can be achieved through a strategic focus on ES and NBS. In order to achieve that, the importance and challenges related to the green connections will be addressed at different scales, from regional to local urban and then focusing at the architectural scale.

Research Questions:

1. How can strategic assessment of ecosystem services motivate the enhancement of green infrastructure and the incorporation of nature based solutions in development?
2. How can the design of the built environment support biodiversity and ecosystem services in dense urban areas?
3. How should Järfälla municipality balance grey and green infrastructure in Jakobsberg?

1.2 Delimitations

This report is focused primarily on green structures within the urban fabric emphasizing the three concepts GI, ES, and NBS in urban areas. This allows for an examination of how land-based environments contribute to urban resilience, wellbeing, and biodiversity through ES provisioning. As well as how these environments are directly affected and influenced by land use changes.

The work is geographically centered on the regional development core of Jakobsberg-Barkarby in Järfälla municipality. Specifically, it is focused along the green connections crossing this area identified by the municipality shown in Figure 1. This area has been selected based on its denser urban structure, regional interest and presence of high natural values. While examples from other regions, such as Upplands Väsby, are referenced for comparative evaluation insights, these are not the primary focus.

This report excludes detailed assessments of green space usability, cultural or recreational values, and economic analyses of ES and NBS. Semi-structured interviews were conducted with municipal representatives. While these offer valuable insights, they reflect specific departmental perspectives and may not represent all stakeholders such as the everyday users of green spaces. The study excludes detailed urban designs or implementation plans and instead, it focuses on strategic recommendations.

Current urban planning documents and strategies are being referenced in this report e.g., Järfälla's Comprehensive Plan for 2050 under development, and it does not account for future policy updates or long-term ecological shifts beyond the 2050 vision. This report uses Järfällas categorisations of green spaces for its evaluation and has selected the higher value tiers of spaces categorised as; ecologically sensitive, green space within green connections, major parks, highest/very high natural values and nature reserves (Järfälla Municipality, 2024).

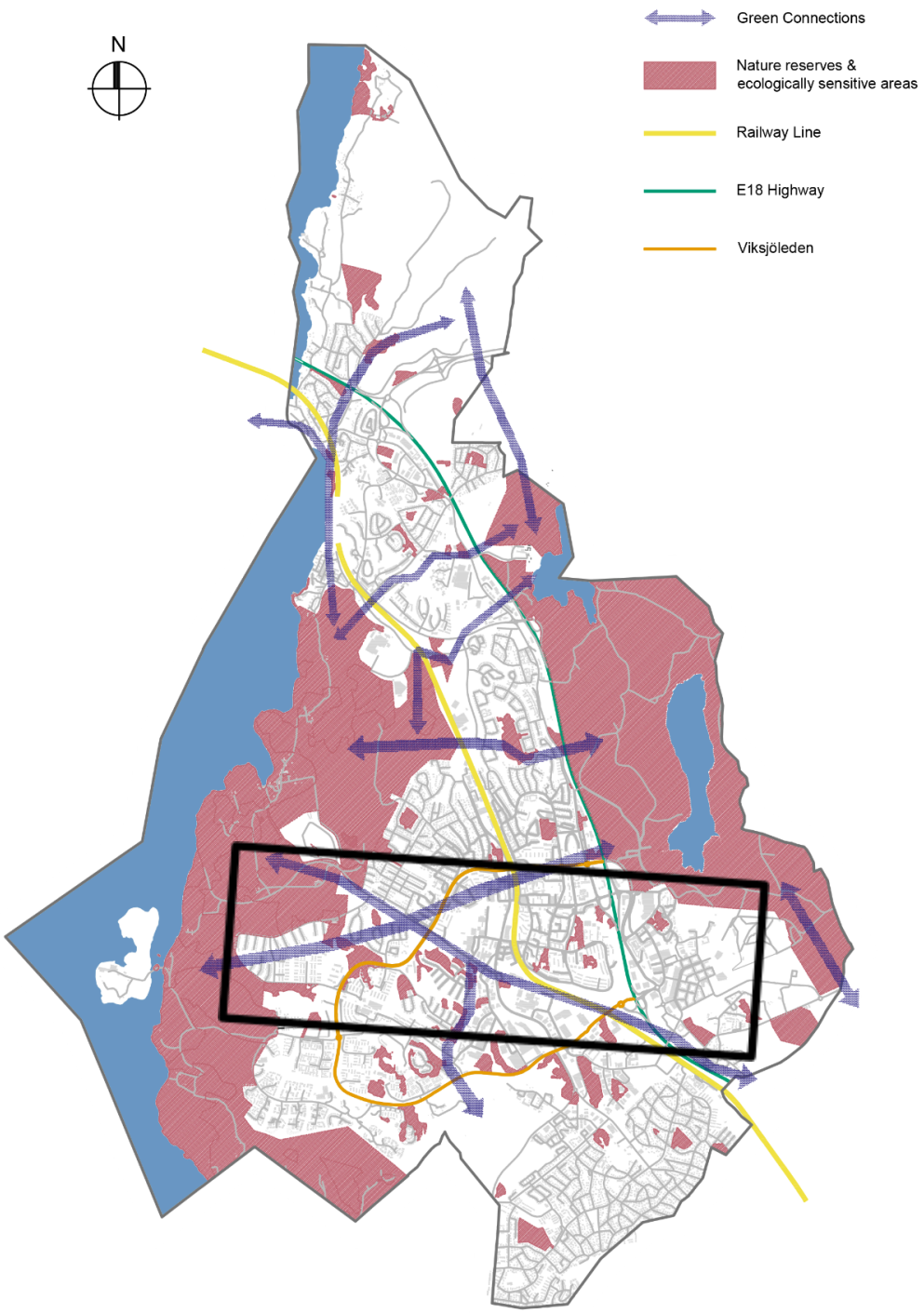

Figure 1- The area of focus with scale of 1:60.000 (recourse: adapted from Järfälla Municipality GIS data)

2. Methods - Mixed methods case study

The study uses a mixed methods case study approach which integrates quantitative and qualitative methods to comprehensively understand the relationship between urban densification and the ecosystem services. Quantitative spatial analyses assess connectivity and accessibility of green spaces, while qualitative methods, including literature reviews, policy document analyses, and semi-structured interviews, provide contextual insights into local challenges and strategies. This mixed methods approach ensures a holistic understanding of the research problem, combining measurable data with narrative depth to address the sustainability goals at a local scale.

2.1 Literature Review

The theoretical background of this project is built on a literature review structured around five related themes, ES, dense urban areas, GI, NBS and spatial assessment. These themes were chosen specifically to address the research questions, focusing on the interplay between urban densification, biodiversity, and ecosystem services. The scientific literature was gathered from the Scopus database combining keywords relevant to those five themes, such as ecosystem services, green infrastructure, urbanization, nature-based solutions, etc.

The focus of this report is the municipality of Järfälla in Sweden, however the literature background draws from case studies in many areas around the world. This choice is motivated by the fact that urbanisation challenges are faced all over the world, so a variety of examples and solutions can be relevant to ES provisioning.

2.2 Policy and Planning documents

In addition, the report uses local and regional planning documents to understand the local context and challenges, as well as the relationship between goals on local level to agenda 2030 goals. The policy and planning documents reviewed for this research include Järfälla's Comprehensive Plan currently under development (Järfälla Municipality, 2024), the Environmental Plan (Järfälla Municipality, 2023b), the Green Structure Plan (Järfälla Municipality, 2018a), and the Action Plan for Increased Biodiversity (Järfälla Municipality, 2018b).

While focused on Järfälla context and issues, this report draws on cases and studies performed elsewhere as well. Motivated by the fact that other examples could be inspiring in terms of ES provisioning and urbanization challenges. This being so, especially some policy and planning documents of the municipality of Upplands Väsby have been reviewed based on this municipality´s similar spatial conditions and their comprehensive work on mapping of ecosystem services (Ekologigruppen & Upplands Väsby municipality, 2015), Development Plan for Ecosystem Services (Ekologigruppen & Upplands Väsby municipality, 2016a), and Strategies and methods for mapping Ecosystem Services (Ekologigruppen & Upplands Väsby municipality, 2016b).

2.3 Interviews

Participants consented to informal online meetings with one or several groups of students with topics related to their specific field/department. The aim of the interviews was to gain contextual insights on Järfälla municipality´s work addressing the third research question on how to balance grey and green infrastructure in dense urban areas and identifying the challenges in this regard. Questions were prepared accordingly. The results are presented

anonymously, only using work titles. In total for this project, three interviews using a semi-structured approach were conducted with representatives from different departments of Järfälla municipality. The Semi-structured format allows the researcher flexibility to include unexpected information (McCallum, et.al., 2019) and the methodology was useful to understand their working perspective around balancing densification with GI as well as protecting and enhancing biodiversity through green connectivity.

Three interviews with representatives from different departments of the municipality were conducted. The first interview was conducted with two sustainability strategists (social and environmental), the second with spatial planners and the third one was with the municipality ecologist. All the interviews were conducted remotely over zoom. The interviews' primary questions and themes are added in the Appendix.

2.4 Mapping and Spatial analysis

To address the research question on assessing connectivity and accessibility of green infrastructure, a spatial analysis was conducted using GIS data provided by Järfälla municipality. An evaluation framework has been developed and used to examine the fragmentation of green spaces, see section 4.2. In line with the delimitations of this report the assessment does not go further into depth on the qualitative aspects of green spaces, such as detailed user experience or specific ecological conditions.

The maps of significant green spaces were compiled into a single map using AutoCAD. A buffer zone analysis using 250m was applied on the green space, measuring the distance to assess whether the 500m threshold for biodiversity connectivity, identified in the literature, was met. It was derived that this threshold would also serve the requirements of accessibility for residents as 250m subdued the 300m distance recommended in literature.

Gaps in connectivity were identified, and specific plots with potential for improving the connectivity within specifically Jakobsbergs GI were proposed for development, ensuring alignment with Järfälla's sustainability objectives.

While the qualitative aspects of green spaces (e.g., user experience or specific ecological conditions) were beyond the scope of this study, the spatial analysis provided actionable insights for strengthening Järfälla's green structure based on the municipality´s previous studies and categorisation of green spaces.

3 Contextual background

Järfälla municipality exemplifies the tension between rapid urbanization and ecological preservation in metropolitan regions such as Stockholm. A recent comprehensive study by Hysa, et al. (2024) has found that the ES potential in such European capital metropolitan regions is decreasing. Stockholm, along with neighbors Oslo and Helsinki are among the areas that while holding a high potential for ES, are also experiencing the fastest accelerating decline in ES potential due to land use changes of urban and peri urban ecosystems. As of 2018, the Stockholm region was the fastest growing urban area in Europe (Järfälla Municipality, 2018a), and Barkarby-Jakobsberg in Järfälla has been identified as one of the regional city cores prime for development in the regional development plan (Region Stockholm, 2018). Hence this area requires strategic planning to balance housing demands with environmental resilience.

The municipality has grown from smaller railway towns along the train tracks, that today are the commuter line with stations Barkarby, Jakobsberg, and Kallhäll (Järfälla Municipality, 2018a). The municipality has a tradition of safeguarding nature and cultural values and is flanked by two of the Stockholm region´s important green wedges and nature reserves, Järva and Görveln. The municipality's GI is crucial to the ecological relationship between these two areas (Järfälla Municipality, 2024). Under the Stockholm agreement Järfälla committed to provide 14 000 new housing units by 2035 (Järfälla Municipality, 2024). Providing this number of housing units is an ongoing challenge, while safeguarding green space needed to build resilience, ES provisioning and biodiversity.

Järfälla has since the late 90s made efforts to work with available tools for GI and first brought the term ecosystem services (ES) into their comprehensive plan for 2030 adopted in 2014 (Järfälla Municipality, 2018a). Although frequently referring to ES and green structure in the draft version of the 2050 comprehensive plans goals and strategies (Järfälla Municipality, 2024), the holistic depth is missing. Although it is apparent that the concept is understood, and the term is to some extent being applied to the existing green structure it is often used in generic statements . Less apparent are the current and future ES needs for the municipality, or how to prioritize among green spaces when deciding on land-use issues. It is important to fully understand the given context when determining the most suitable NBS or GI action (Herath & Bai, 2024).

Järfällas development orientation sits on a foundation of the development goals, national goals and regional goals (Järfälla Municipality, 2024) However, at times such goals can be inherently contradictory (Hysa, et al., 2024) and not always straightforward to apply to the local context. The agenda 2030 goals are used as guidelines for target visions and strategies. The 16 national environmental goals are addressed in the local environmental plan (Järfälla Municipality, 2023b), where they are linked to the SDGs as well as local objectives. The regional development plan (Region Stockholm, 2018) is an important foundation for the local comprehensive plan, as Järfälla houses one of the regional city development cores. As well as for aiding in inter-municipal collaboration and decision making regarding forinstance public transport and the regional housing provisioning (Järfälla Municipality, 2024).

Figure 2 shows 8 of the global targets (United Nations, 2015) selected for the scope of this study. These are identified as strongly related to biodiversity, urban ES and urban development in a Swedish municipality. The three goals are included in five out of Järfällas six environmental goals (miljöplanen, 2023), and goal 4.5, Rich biodiversity, is the local environmental goal mainly related to this project. In addition to these three goals, it has also been connected to goal 2, Zero hunger, goal 6, Clean water and sanitation, and goal 14, life below water. However these additional three are not addressed in this project.

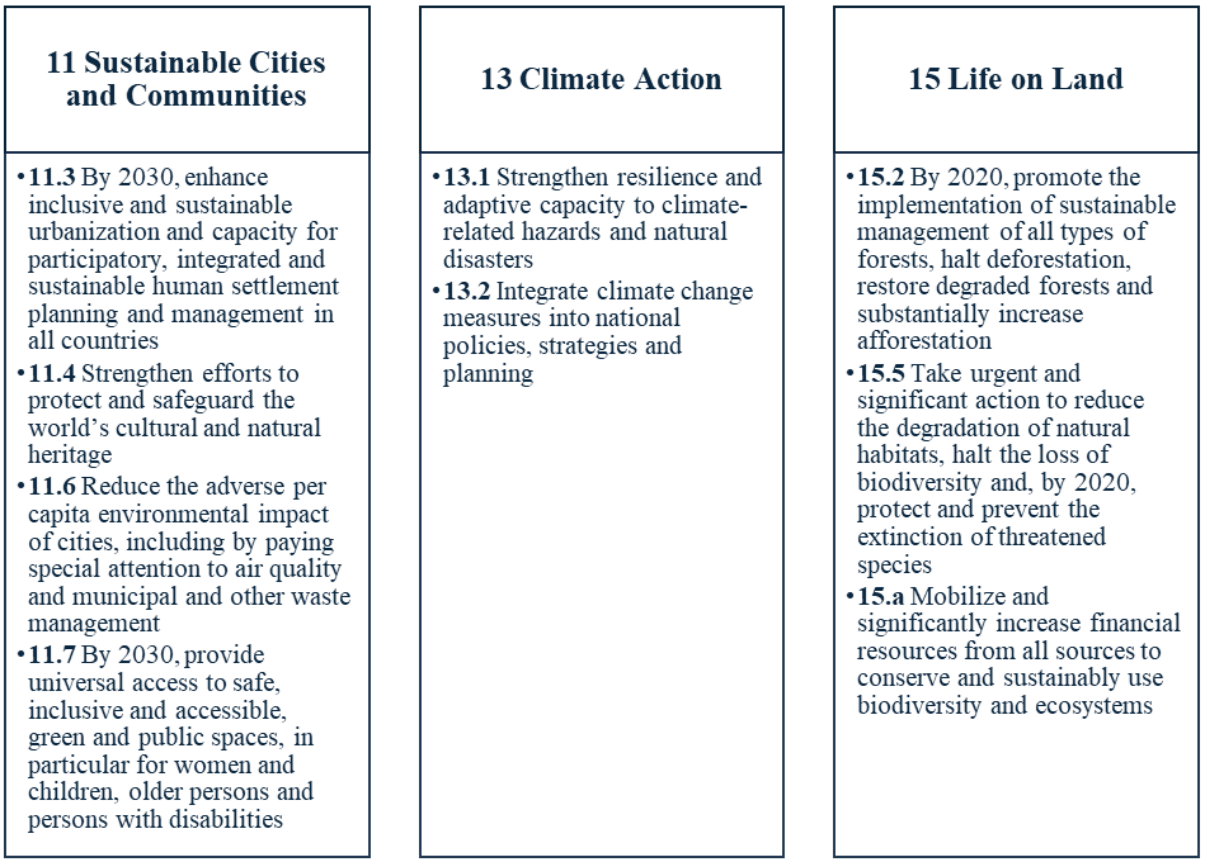

Figure 2- The main Sustainable Development Goals and Sub-goals addressed through this project (United Nations, 2015).

4 Theoretical background

4.1 Urban ecosystems and concepts

Grey infrastructure encapsulates those surfaces in the urban environment that could be referred to as the man-made physical components, buildings and hardened surfaces primarily constructed from materials like concrete, asphalt and metal, including structures such as roads, bridges, buildings, and utility systems (Qi et al., 2019). Essentially these structures intrude on urban ecosystems, hindering their natural ability to provide ES.

Various ES provided by GI in the urban context have been brought to attention in research. Sandstrom (2002) highlights the role of green space in recreation, for improving the local climate, and maintaining biodiversity. Haaland & van den Bosch (2015) adds that urban green space also has benefits in terms of social interaction, aesthetics and cultural heritage, as well as ecological functions and crucial habitats for biodiversity. Access to green space can improve a sense of community, encourage physical activities, and increase human well-being (Galecka-Drozda et al., 2021). In dense urban structures, regulating and cultural ES have been shown to be most important, such as air purification, reduction of noise pollution, urban cooling, recreation and the positive impacts on human health and wellbeing (Gómez-Baggethun & Barton, 2013).

One category of ES often neglected is the supporting one, perhaps it is taken for granted. In this category we find underlying services that do not deliver any products nor directly regulate or change any environmental states (Price, 2014). Such as the water and nutrient cycles, soil formation and photosynthesis. Needless to say that these are in fact a prerequisite

for life and the deliverance of ES from any of the other three categories, provisioning, regulating and culture and recreation (C/O City, 2016).

Urban ES are dependent on urban ecosystems, these are often strategically planned natural or semi natural areas referred to as GI (European Commission, 2013). The concept of "infrastructure" captures how urban ecosystems are vital to ES deliverance at different scales, from building, street and neighborhood all the way to regional (Gómez-Baggethun & Barton, 2013). Recent literature points out that the strategy behind nature-based approaches, such as intentionally planned GI and NBS, is to mitigate impacts from hazards and enhance socio-ecological resilience (McNabb, et al., 2024). NBS are defined as actions to achieve desired outcomes through being inspired by, supported by, or copied from nature (European Commission, 2015). The objectives of NBS are to enhance sustainable urbanization, restore degraded ecosystems, develop climate change adaptation and mitigation as well as to improve risk management and resilience. Typically, through interventions aimed to enhance the properties of an area´s GI and ES provisioning, such as green roofs, green walls, planted parks and community gardens (Augusto, et al., 2020).

However, in assessment studies of urban ecosystems and ES, the local, urban scale is underrepresented (Hysa, et al., 2024) and the field of urban ecosystems was still largely unexplored in 2013 (Gómez-Baggethun & Barton, 2013). About a decade later a common critique raised towards studies of GI and ES is still the lack of urban assessments (Hysa, et al., 2024) with considerations to insurance value for resilience and non-economic socio-cultural values (Gómez-Baggethun & Barton, 2013). Available studies have an isolated focus on singular ES (Gaglio, et.al, 2023; Gómez-Baggethun & Barton, 2013; Herath & Bai, 2023) and their bio-physical benefits (Gómez-Baggethun & Barton, 2013).

4.2 Assessment of urban green spaces

Assessing urban green spaces and their ES is essential for sustainable urban planning and urban biodiversity. Such evaluations help quantify ES, identify gaps in GI, and guide the prioritization of land use. However, this type of data is not always available and costly to bring forth, and as such there must be clear guidelines on the quantification and ranking of urban ES to guide the assessment (Kaczorowska, et al., 2016). A study by Bolund and Hunhammar (1999) underscores the importance of employing both spatial and ecological assessments to optimize the design and management of urban green space. The study revealed that urban ecosystems in Stockholm contributed significantly to urban sustainability.

Upplands Väsby in the Stockholm region is a municipality, much similar to Järfälla, flanked by two green wedges and divided by large barriers. In addition to mapping their GI and ES (Ekologigruppen & Upplands Väsby municipality, 2015), they have produced a development plan for ES provisioning with the mapping as a base, providing an overview of priority areas and areas to develop in the physical space (Ekologigruppen & Upplands Väsby municipality, 2016a). This overview also includes thematic descriptions of ES in the local context and can help guide future land-use decisions to better accommodate conflicting goals.

Various approaches have been developed to evaluate urban green space, each offering unique insights into their structure, function, and accessibility. Methods for spatial assessment include both quantitative and qualitative approaches, where quantitative assessments involve measurable data and qualitative assessments seek a more strategic and holistic understanding of the values urban ecosystems provide.

4.2.1 Quantitative assessment

Quantitative methods focus on measurable data to evaluate the structure, function, and spatial characteristics of urban green spaces. One commonly used approach is the application of spatial metrics, which analyze elements such as patch size, connectivity, and edge-to-area ratios. These metrics are particularly useful in understanding habitat fragmentation and connectivity, as well as assessing the capacity of green spaces to support biodiversity and ecological flows (Anteneh et al., 2023). For example, a patch's size and distance from other green spaces directly impact its role as a habitat and connectivity for species movement. Similarly, Morphological spatial pattern analysis classifies and analyzes the geometric and spatial properties of landscape elements, identifying core areas, edges, and isolated patches (Guinaudeau et al.,2023). It helps identify the major 'stepping stones' for species and is crucial for understanding habitat accessibility and connectivity.

At the architectural scale, for instance the Biotope Area Factor (BAF), developed in Berlin, quantifies the proportion of ecologically effective surfaces in urban areas, aiding in sustainable land-use planning (Landschaft Planen & Bauen et al., 1990; Peroni et al., 2019). The BAF assigns weighted values to land surfaces based on their ecological contribution. For example, natural green areas receive the highest scores, while impervious surfaces score the lowest (Landschaft Planen & Bauen et al., 1990; Peroni et al., 2019). In Sweden, the BAF factor has been adapted into the green space factor (Grönytefaktor GYF), used by Järfälla municipality to support the work of implementing greenery and ES into development districts (Järfälla Municipality, 2023a). NBS can help improve the result in this assessment method as they contribute positively to the overall assessment of the district.

Several quantitative methods also assign economic value to the benefits provided by urban ecosystems. These methods are useful since the loss of urban ecosystems often contribute to economic costs in one form or another (Gómez-Baggethun & Barton, 2013; TEEB, The Economics of Ecosystems and Biodiversity, 2010) and monetary valuation could help bring the concept of ES into political discussions where it still is poorly understood (Kaczorowska, et al., 2016). The Avoided cost methods, as one example, relates loss of urban greenery to increased energy costs from cooling during the summer season (Gómez-Baggethun & Barton, 2013). Similarly, economic consequences also arise from health problems related to the loss of ES (Bolundand & Hunhammar, 1999).

4.2.2 Qualitative assessment

Assigning monetary and non-monetary value of urban ecosystems through quantitative methods can be insignificant in terms of ES, as their perceived value is site specific and differs across the world (Bolund and Hunhammar, 1999). Qualitative approaches provide a more holistic understanding of green spaces by focusing on their ecological, social, cultural, and aesthetic values. For instance, green spaces can foster social interaction, promote mental health, and provide a sense of community identity, benefits that are challenging to measure through quantitative models alone (Bolund & Hunhammar, 1999). Qualitative assessments complement quantitative approaches by addressing the socio-ecological and resilience dimensions of green spaces. So methodologically, a qualitative identification and valuation of ES could be a great input to quantitative methods often neglecting the benefits of ecosystems.

The ES assessment performed by Bolund and Hunhammar (1999) maps and evaluates the ES benefits provided by urban ecosystems. Their comprehensive assessment aimed to quantify and evaluate the non monetary benefits and values of various greenery. By highlighting areas delivering critical ES, while identifying those needing restoration the study demonstrates that urban biodiversity directly enhances ES provisioning.

4.2.3 Connectivity assessment

Connectivity in urban green spaces is fundamental to addressing the ecological and social challenges posed by dense urbanization. High-density urban environments, such as Järfälla's Jakobsberg-Barkarby region, highlight the critical need for connected GI to mitigate the effects of habitat fragmentation and urban sprawl (Gómez-Baggethun & Barton, 2013; Zhou et al., 2024). Connectivity not only addresses ecological requirements but also improves urban liveability for residents by ensuring easy access to nature and enhancing physical and mental well-being (Irvine et al., 2010). One such threshold where connectivity is identified to be lost for most urban biodiversity is identified as 500-meters (Zhou et al., 2024), and for urban residents, the distance to assess qualitative green space from one's residence should not exceed 300m (C/O City, 2016).

One framework for enhancing connectivity in urban planning is the pattern language approach developed by architect Christopher Alexander. In the context of ecological connectivity, the framework emphasizes the spatial arrangement of urban green spaces as "stepping stones" that facilitate species movement and habitat continuity across fragmented landscapes (Zhou et al., 2024). By focusing on patterns that promote accessibility, safety, and aesthetic appeal, the framework seeks to enhance the overall quality of urban life. It also highlights the importance of human-scale design and the integration of natural elements.

Ecological connectivity is essential for maintaining biodiversity and ensuring the movement of species across urban landscapes. Fragmented green spaces hinder these natural processes, reducing the effectiveness of urban GI and ES deliverance. As such, proximity-based analyses are valuable for maintaining ecological connectivity. Furthermore, by incorporating elements like linear parks, and green walls this pattern language approach connects isolated green patches, enhancing the overall urban ecological network.

4.3 Nature based solutions as remediation

Economic incentives often drive cities to prioritize the revenue from built environments, leading to the reduction or elimination of parks and green areas in the urban fabric. This has a negative impact on quality of life by limiting access to recreational spaces within walking distance (Haaland & van den Bosch, 2015; Artmann et al., 2019). The loss of green spaces is not only a matter of public health, but also a threat to biodiversity. Dense urban development often results in habitat degradation, and the fragmentation of green spaces can accelerate biodiversity loss (Galecka-Drozda et al., 2021). Even in countries like Sweden, where the importance of preserving urban green spaces is recognized, gaps in expertise and competing priorities, such as economic growth, can hinder effective conservation (Standstrom, 2002) challenging planners even more.

As mentioned in section 4.1, NBS imitate natural processes in order to provide similar environmental, social and economic benefits. Formulating an overarching definition about NBS has proved difficult due to the different ES they provide, the methods of implementation and arguments around what constitutes a natural environment (Castellar et al., 2021). NBS examples include variations of green/blue technologies, green urban spaces, behavioural changes and engineering techniques and the wide breadth of what constitutes a NBS means there are different ways to categorize them. The following section of this report will focus on urban parks, green roofs and green walls and how they benefit the urban environment and green connections in the urban fabric. Due to the fact that urban parks have an aerial imprint in the urban fabric, while green walls and green roofs can be installed on the envelope of already existing grey infrastructure the categorizations defined are NBS with an spatial imprint and NBS without an spatial imprint.

4.3.1 Nature based solutions with spatial imprint

When assessing ES services in Stockholm it was found that street trees and urban forests were particularly effective in air filtration, removing approximately 1,300 tons of air pollutants annually (Bolund & Hunhammar, 1999) . Additionally, green spaces played a pivotal role in microclimate regulation, with parks and urban forests reducing ambient temperatures by up to 1–2°C during summer months mitigating the urban heat island effect. Noise reduction was another critical service, with vegetation such as dense forests and park areas by creating natural sound barriers. The study recommended prioritizing the conservation and enhancement of larger green spaces by spatially explicit planning for the distribution of urban green space.

Xie et al., (2019) performed an ES value assessment of 40 urban parks in Wuhan, serving as a practical model for any city facing rapid urbanization. The assessment found that larger parks with diverse vegetation types provided significant ES values. Parks with tree canopy coverage exceeding 30% showed significantly better benefits in carbon sequestration compared to those with less coverage. Smaller, fragmented parks offered limited ecological services, but were deemed valuable for accessibility and microclimate regulation. The study concluded that biodiversity is a key driver for higher ES value in urban settings.

Pocket parks, also known as mini parks, are urban green spaces that can be found in dense urban environments due to the lack of available open space (Ghamsary et al., 2023). When strategically located, these green areas provide essential ecological, recreational, and aesthetic benefits within a neighborhood or a city. They come in different shapes, sizes and morphologies. Socially, green pockets improve livability by offering residents spaces for social interactions, relaxation and exercise. For instance, research by Irvine et al. (2010) highlights the psychological benefits of nature exposure, including lower levels of anxiety and depression. By promoting physical activities and providing stress relief green spaces contribute significantly to public health and well-being. Particularly in dense settlements where access to larger nature reserves is limited, urban pocket parks play an important role. In support of biodiversity, pocket parks can be strategically placed to enhance connectivity facilitating the movement of species and pollinators (Järfälla Municipality, 2018b; Zhou et al., 2024).

These findings highlight the importance of integrating accessible green spaces into the urban GI to amplify its overall benefits.

4.3.2 Nature based solutions without spatial imprint

The rigidity and prioritization placed upon grey infrastructure significantly hinders the provision of ample free space that can be utilised for urban green spaces. In this regard, two very effective NBS are green walls and green roofs, since they are incorporated on the envelopes of grey infrastructure and therefore have no spatial imprint, while providing similar environmental benefits. (Besir & Cuce, 2018; Aleksejeva et al., 2024; Francis & Jensen, 2017).

A study conducted in Sydney, Australia, assessed the fauna diversity between a conventional roof and a green roof over one year. The green roof attracted four times more avian species and more than seven times the arthropod species compared to the conventional roof. The study found that new plant species emerged in the green roof as a result of avian and wind dispersal (Wooster et al., 2022). Another study conducted in the city of Opole, in Poland, evaluated the difference in biodiversity variety between vertical surfaces with green facades

and nearby plain walls. The study concluded that green facades can be beneficial for avian species and a variety of arthropod families. Older green facades with denser foliage created a safe place for birds to build their nests and while the number of insects was lower in green facades the represented variety of arthropod species was much higher (Oloś, 2023). This is supported by another study, which highlights that along with age, the choice of plant species can increase the variety of invertebrates (Salisbury et al., 2023). Finally, another study that highlights the importance of green roofs for urban biodiversity was conducted in the city of Zurich, Switzerland in 2014. The study identified that green roofs could act as connection points between fragmented ground level parks supporting local insect species, such as bees. This could potentially increase the pollination range of those insects and enhance the local flora biodiversity (Braaker et al., 2014).

Finally two important variables that should always be considered for encouraging growth of flora and fauna that supports pollination vital for ecological balance is the building height and size. Higher buildings are not less effective and the larger the area and plant variety of a green roof or wall, the more species it will attract (Aleksejeva et al., 2024).

This section shows that green roofs and green walls are highly valuable for urban environments when it comes to biodiversity enhancement and connectivity.

5 Results

5.1 Literature review

In compact cities, the quality of green spaces, including their design and ecological diversity, can help compensate for their limited availability (Artmann et al., 2019). A focus only on quantity can lead to unused, valueless green spaces (Haaland & van den Bosch, 2015). Enhancing existing green spaces, improving access, and creating multifunctional environments that serve social, ecological, and economic purposes are key strategies for dense urban areas. Connectivity between green spaces within GI is essential to promote biodiversity and address urban environmental challenges (Artmann et al., 2019; Augusto et al., 2020).

5.1.1 The compact city model and its dual impact

The compact city model has gained popularity as an urban planning approach as it is thought to enhance accessibility to jobs and services, provide efficient public transport, promote cycling and walking, and improve social integration and interaction (Jim et al., 2018). Additionally, geographic constraints, such as the nature reserves present in Järfälla, and high land prices limit outward expansion (Jim et al., 2018). By concentrating development within city boundaries, densification helps protect lands that hold significant conservation or landscape value (Jim et al., 2018). However, while urban densification offers several benefits, it poses many challenges, particularly in balancing grey infrastructure with green spaces.

The preservation and enhancement of existing green spaces become critical to counteract the negative impacts of urbanisation and preserving biodiversity. It is not only about the protection of individual species, but also the genetic diversity within species that is crucial for resilient life that will evolve and adapt with new conditions (C/O City, 2016). Maintaining biodiversity requires a wide range of ecosystems supporting habitats and natural processes (C/O City, 2016). Additionally, access to greenery improves the quality of life for residents by providing recreational opportunities and fostering community well-being (Lee and Maheswaran, 2011). As such, qualitative urban green spaces are essential components of

urban ecosystems and with adapted maintenance and design they can provide habitats that support biodiversity (Järfälla Municipality, 2018b), and provide ES deliverance.

Adapted maintenance and design require in-depth knowledge and understanding of the local context. Assessing urban green spaces is crucial to better understand the existing conditions and gaps in their efficiency. Hence, strategic ES assessments ultimately inform policy makers and urban planners, guiding the development and maintenance of GI and green spaces.

Although urban research increasingly shifts towards a more holistic view around ES, acknowledging integration across disciplines (Maes, et al., 2019), largely there is a lack in addressing the urban space as socio-ecological in both science and practice. But also in identifying the importance of addressing a multitude of different spatial scales (Hysa, et al., 2024). This is surprising, since green space is viewed as an essential and affordable tool to improve social conditions and well-being for residents negatively affected by urbanization (Galecka-Drozda et al., 2021).

However there is not only a science-practice gap (Kaczorowska, Kain, Kronenberg, & Haase, 2016; Herath & Bai, 2024), but also what could be referred to as environmental fatigue among stakeholders (Kaczorowska, et al., 2016). This can possibly be explained by the fact that ES when considered holistically tend to be understood as too complex by practitioners and are easier understood with a singular focus (Kaczorowska, et al., 2016). Another contributing aspect may be the many limiting factors that often inhibit a larger scale urban GI project, such as funding, space availability, maintenance, responsibility division, institutional collaboration and lack of supportive policy frameworks (Herath & Bai, 2024). Stakeholders within planning[1] state that the consequences from land use changes to remaining biodiversity, human wellbeing and ES provisioning needs to be better understood (Kaczorowska, et al., 2016). For practitioners such as municipal planners to gain a better understanding both improved collaboration among departments and supportive documents derived from strategic ES assessment could be highly useful.

5.1.2 Contextual challenges and insights from Upplands Väsby

In Järfällas policy documents (Järfälla Municipality, 2024; Järfälla Municipality, 2023b; Järfälla Municipality, 2018a; Järfälla Municipality, 2018b) the GI is mapped, some ES potentials and areas to protect are identified along with general strategies. The more in depth work of Upplands Väsby has resulted in an outline for implementation and management strategies on how to seize the opportunities with ES and develop the ES potential in the municipality, both short- and long-term (Ekologigruppen & Upplands Väsby municipality, 2016b). Their strategies hold a focus on building insurance value in preparation of future uncertainties, as well as a socio-ecological focus accounting for multiple recreational values while acknowledging other ecosystem functions such as biodiversity.

For instance green investment needs have been identified along both E4 highway and the commuter train tracks where impermeable surfaces constitute a large part of the land surface (Ekologigruppen & Upplands Väsby municipality, 2016a). Overall, these supportive planning documents show a holistic view on urban ES, where the most important aspects are addressed as well as synergies and interdependencies for the municipality as a whole.

In Järfälla, the urban ecosystem value of green space within the dense urban area is currently considered on a case-to-case basis in terms of land allocation for new development (Järfälla

[1] Public administration, private consultancies, developers and NGOs

Municipality, 2024), making it exceptionally hard to disregard economic incentives from grey development and the selling of land. Although it won't fully alleviate the conflict of grey versus green development, strategic ES assessments similar to the work of Upplands Väsby could help guide decisions in earlier stages as well as support formulation of new goals and strategies for long term development. Decision outcomes are also guided and regulated by environmental law and nature protection, where local, regional, national and even to some extent EU considerations are taken into account (Naturvårdsverket, 2024). But where there are no clear guidelines, the axiological, ontological, and epistemological positions shared will determine the value of and prioritization of urban ecosystems in land-use decision making (Gómez-Baggethun & Barton, 2013; The Economics of Ecosystems and Biodiversity (TEEB), 2010).

By adopting a similar approach as Upplands Väsby, Järfälla would gain a more holistic understanding of values and potential in their GI and of areas considered for development. Aiding the work with GI and ES to target both local objectives as well as agenda 2030 goals. Not only will strategic managed green structures strengthen resilience and the adaptive capacity to climate-related hazards and natural disasters (SDG Goal 13.1), but also address goals such as reducing natural habitat degradation and halting the loss of biodiversity (SDG Goal 15.5). This focus and more strategic assessments would promote the implementation of sustainable management of urban ecosystems as well as motivate restoration of degraded ones (SDG 15.2).

5.1.3 The beneficial capabilities of nature-based solutions

An overarching strategy that can significantly aid in achieving GI connectivity and enhancing the quality of the urban structure as a whole is the integration of NBS in the urban fabric. Supporting this connectivity can be a useful tool in combating the fragmentation of green spaces and enhancing their capacity to maintain biodiversity in the urban context.

To effectively implement NBS, a close collaboration between different stakeholders is needed. Such stakeholders include planners, developers, municipalities and the residents, but also expert consultants. With effective collaboration, the implementation of these solutions can significantly improve environmental quality, resilience and social equity in urban structures (Sarabi et al., 2019).

5.2 Interviews

The three interviews conducted with representatives from different departments of the municipality provided a better understanding of the multilayered challenges faced by the municipality as well as for other stakeholders that are part of the ongoing processes. As previously mentioned the municipality aims to increase densification around the public transit stations, develop the regional city core of Barkarby – Jakobsberg, enhance connectivity between the two green wedges and increase the amount of natural protected areas. This brings forth the challenge of acquiring the necessary income to cover the cost of these goals, while balancing the development of grey infrastructure with the preservation and enhancement of the local environment.

Currently, the municipality´s identified green connections are visualised as arrows in the comprehensive plan (Järfälla Municipality, 2024), but the intention is to develop the visualisation and description so as to go into deeper detail before finalising this new version of the comprehensive plan. The two connections that pass through the regional development core and are the focus of this report were identified based on natural landscape traits that were

already present in the area. One extends from Barkarby to Jakobsberg along the train tracks and Mälarvagen, it follows Bälsta creek that stretches along this area. The fact that land around this creek is mostly unsuitable for construction due to the risk of subsidence and the creek itself has aided in creating a conducive environment for the natural development and preservation of a green connection. The municipality's goal is to strengthen this connection in terms of flood prevention, but also in favor of the local biodiversity. One way to achieve this is through the restoration of the water quality in the creek which is currently degraded.

The second green connection stretches along a part of Viksjöleden and at one point intersects with the previous green connection. The reasoning behind this connection is because it currently includes an alley of trees with patches of greenery between them, which can be strengthened. At present the municipality is mapping green infrastructure through multiple techniques to get a better understanding of which areas of the green connections need to be strengthened to combat the fragmentation of the natural landscape and enhance biodiversity in the urban fabric.

As far as the big barriers are concerned, referencing the highway and the railway tracks that divide the urban structure and the nature reserves, the ecologist's suggestion is to provide stepping stones between those two barriers, weakening them and enabling biodiversity to travel through them. Such measures could include the enhancement of the existing underground passages with greenery.

A conflict that was highlighted by the municipality's spatial planners is that a lot of the land in the two green connections is municipally owned, which creates the dilemma of whether to sell this land and acquire more revenue or publicly fund its development in a more environmentally friendly way. The integration of NBS in private developments would offer a way out of this conundrum, however the current market conditions and their high cost make it difficult for the municipality to include them as preconditions during the selling process. Among the NBS that were presented earlier in this report, pocket parks were the preferred solutions from an ecological point of view since they provide multiple ES, with green roofs following them. Even so, the municipal ecologist pointed out that once the benefits of such solutions are clearly communicated, more often than not, developers seem agreeable in implementing them. In any case, a key factor that was highlighted in the interviews is that there needs to be constant and better communication between the municipal departments from the early stages of planning and decision making to achieve the most favorable results.

5.3 Assessing urban ecosystems and green infrastructure

As previously mentioned in section 4.2, quantitative methods alone are not enough to determine the best course of action for green investments. Balancing land allocation for new development with the protection of landscapes is vital for sustainable growth and will also require the assessing and tracking of urban ecosystem conditions and benefits. Integrated into policy and planning frameworks these assessments can help determine ecosystem health and value (Maes, et al., 2019), ES potential (Hysa, et al., 2024), and the types and quantities of ES that are needed in the local urban context (Kaczorowska, et al., 2016). It could even be said that such assessments are vital in transferring knowledge of urban ES into practice and dealing with the inadequacy of current tools (Herath & Bai, 2024).

In Järfälla, the Green Space Factor (GYF) serves as a baseline tool for assessing green and grey space ratios in urban developments. However, this tool is considered somewhat of a minimum requirement in terms of not compromising on greenery, and should be supported with other assessment methods (Järfälla Municipality, 2023a). The pattern framework could

complement the GYF by incorporating more qualitative spatial dimensions of connectivity. By combining these quantitative metrics with qualitative insights, it becomes easier to prioritize areas of conservation, guide restoration efforts, and enhance green connectivity. These evaluations ensure that green spaces continue to deliver diverse benefits, balancing the demands of grey and green infrastructure in Jakobsberg.

Where it is not possible to conduct in-depth qualitative studies of individual green spaces or the green connections under the scope of this report, it is known that some studies have been performed by the municipality and that they have categorized and mapped green space accordingly (Järfälla Municipality, 2024). As per the delimitations of this report the lower tiers of green spaces were ignored in the following assessment.

As highlighted in section 4.2.3, green spaces should be accessible within 300 meters of dense residential areas and should not be fragmented beyond 500m. Based on these findings a 250-meter buffer zone was applied around areas defined as ecologically sensitive, green spaces within green connections, major parks, highest/very high natural values, and nature reserves (see Figure 3). This process identified where the distance between green spaces exceeded the 500-meter threshold. The green areas in the map (Figure 3) provides an overview of the zones outside of the 250 buffer, showing where there is a lack of qualitative green surfaces, hereafter referred to as ecological gaps.

Identifying these focus areas ultimately helps balance the grey and green infrastructure in Jakobsberg and provides a foundation for sites to look closer at. The black circle in figure 4 highlights where ecological gaps interact with the two green connections and the larger barriers within our focus area. It was motivated to address this area in more detail due to its dense built environment and the presence of several ecologically valuable spaces. It became obvious that especially along the northern green connection green spaces are currently fragmented and that the centre of Jakobsberg constitutes an ecological gap. Something that has to be addressed for better connectivity between the two nature reserves Järva and Görvel

While this assessment provides a baseline measure for ecological contributions, broader spatial and ecological assessments are needed to address the municipality’s long-term sustainability challenges.

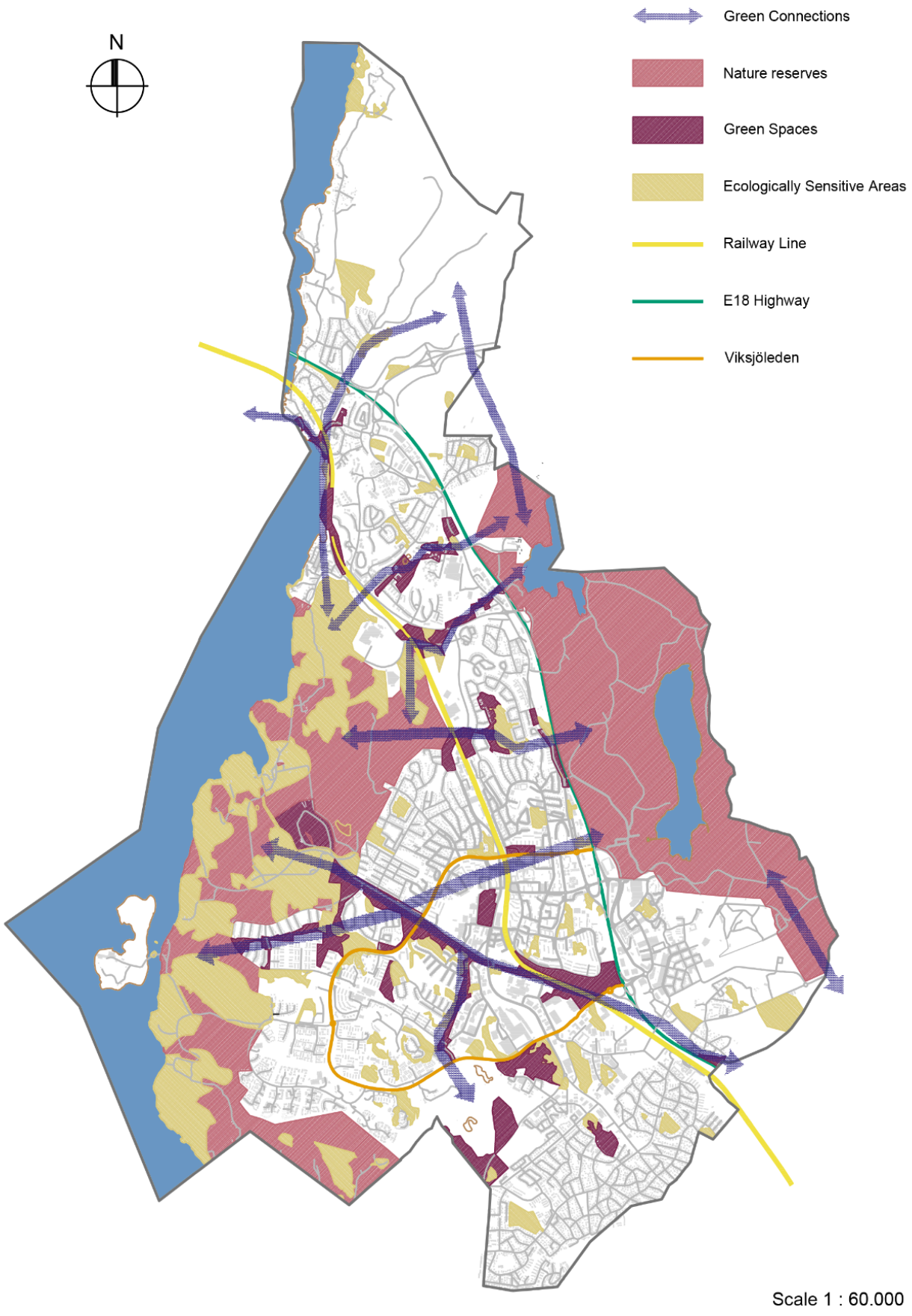

Figure 3- The categorization of green spaces in Järfälla municipality along with the green connections and barriers.

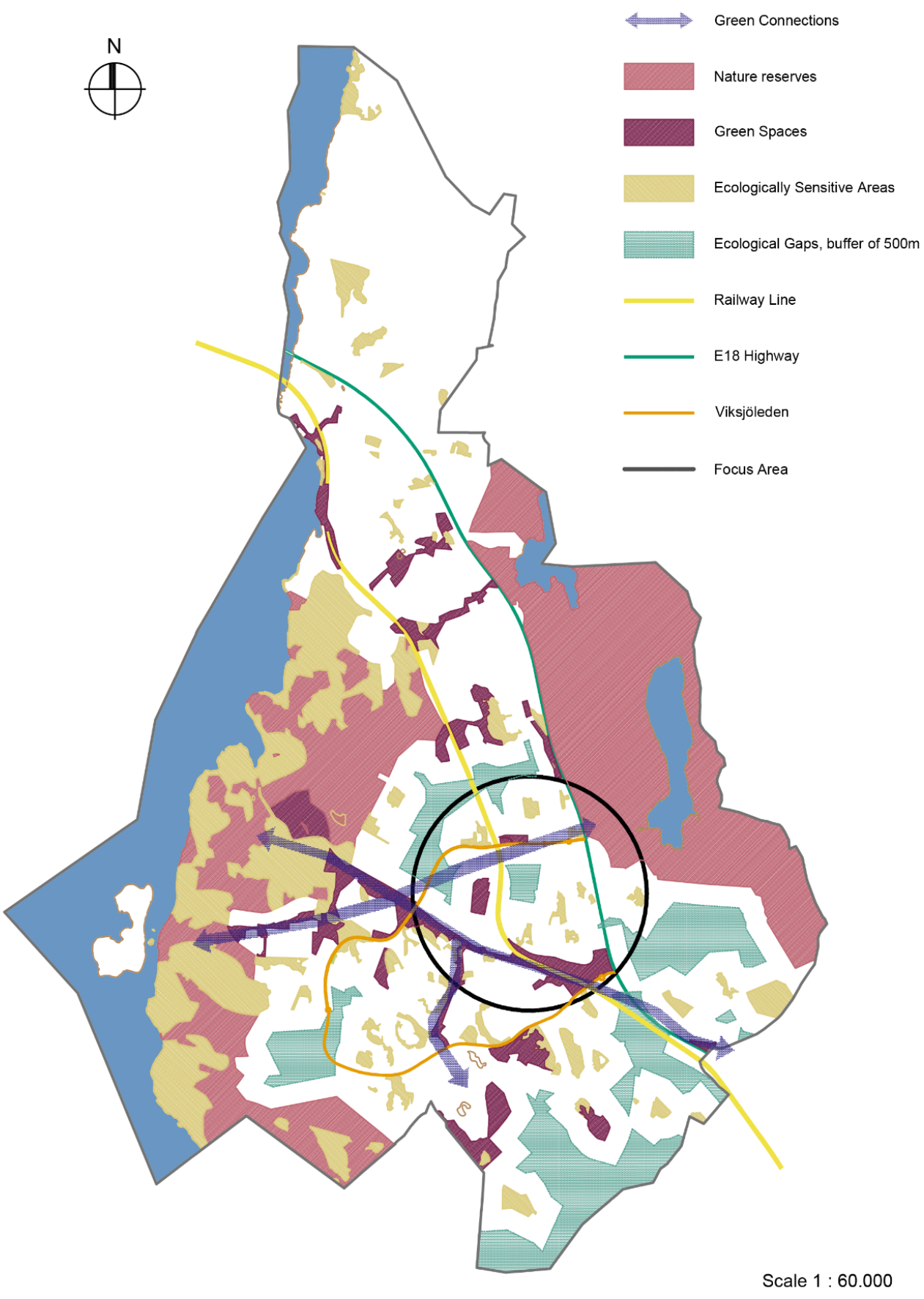

Figure 4- Spatial assessment of the range of influence of green spaces in Järfälla, using the 500 meters as a buffer zone. The black circle represents the area of focus on Jakobsberg.

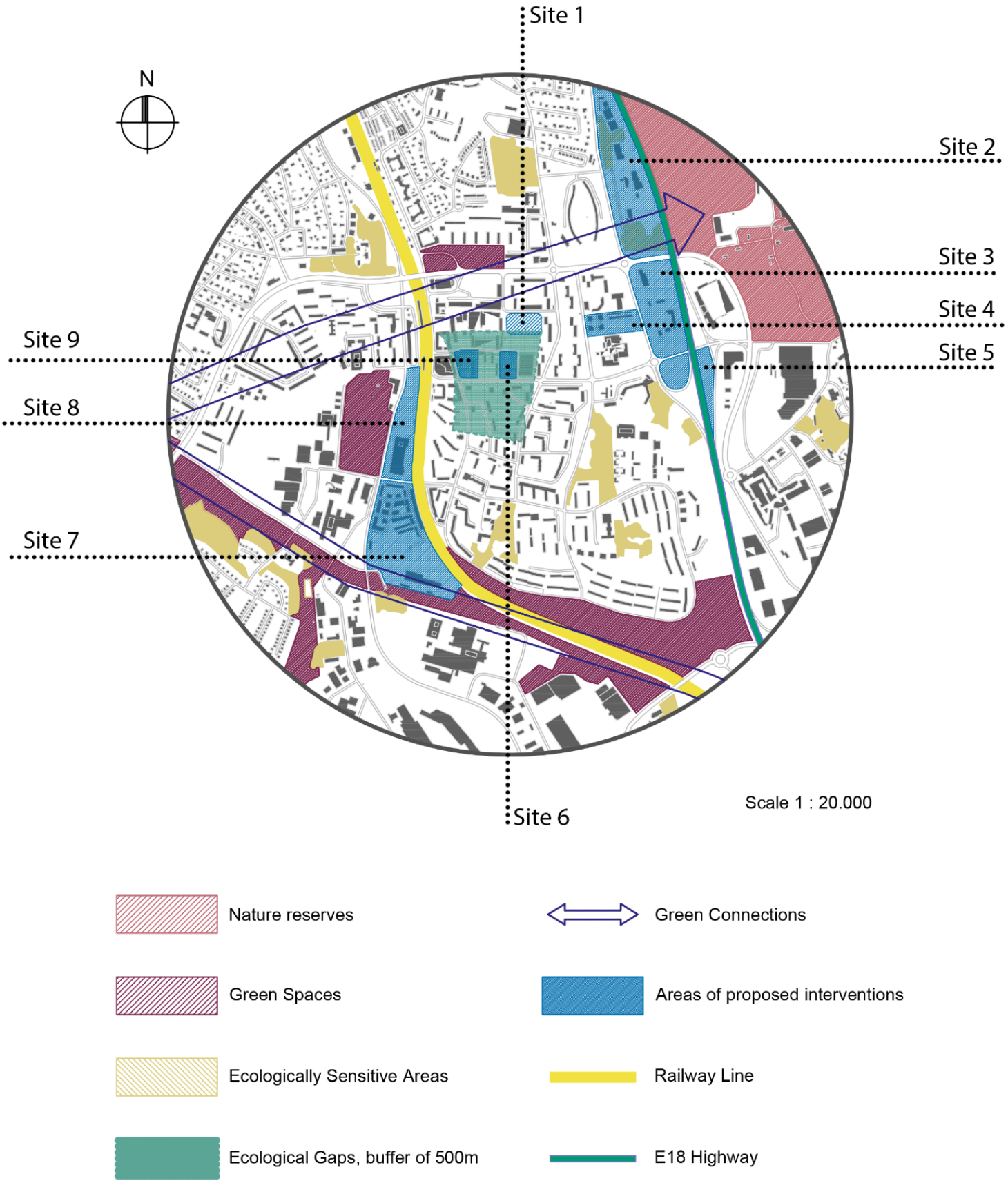

Figure 5- Location of proposed sites within the focus area (References 1, 6, 9: The authors, 2024; Other references: Google Earth Street View, December 2024)

6 Recommendations

Following mapping of ecological gaps the focus area was investigated in terms of planned developments, detailed plans under development, detailed plans ripe for an update and sites with other potential for improvements through NBS. Nine sites were identified based on their potential for urban development, ES and biodiversity support . They were categorised as; plots with green history, plots undergoing plan procedure and plots with potential for development. The following section will describe the condition of each site and the potentials identified through this project. The sites are numbered for further reference in the text (see Figure 5).

6.1 Identified sites and suggestions

In section 4.3, NBS was divided into two categories, with and without a spatial imprint, and in Järfällas action plan for increased biodiversity, the word park is generally used synonymously with public green spaces (Järfälla Municipality, 2018b). In the following chapter when referring to a park or nature area in a detailed plan, this is synonymous to areas planned for NBS with a spatial imprint.

6.1.1 Plots with green history

This category includes two sites identified through historical maps as formerly green or under-developed. They were selected based on their potential to weaken the barrier effect of E18 highway as well as for regulating ES such as carbon sequestration, noise reduction and improved air quality.

Site nr 2: Between Enköpingsvägen and E18.

This site was once much greener, consisting largely of woods, but has in recent years been primarily used for industrial purposes including a supermarket (see Figure 5). Given its stretch along E18 highway, incorporating NBS is crucial to mitigate the barrier effect and reduce noise and pollutants from the road. Industrial areas traditionally occupy large areas of grey infrastructure, with both large and low buildings as well as parking lots and loading docks surrounding them. To enhance ES provisioning, NBS without a spatial imprint should be integrated to both old and new buildings in the area to compensate for the loss of historic greenery. The low buildings with flat roofs have great potential to be converted into green roofs and the grassy stretch closest to the highway could be replanted with trees selected for their noise and pollutant reducing abilities.

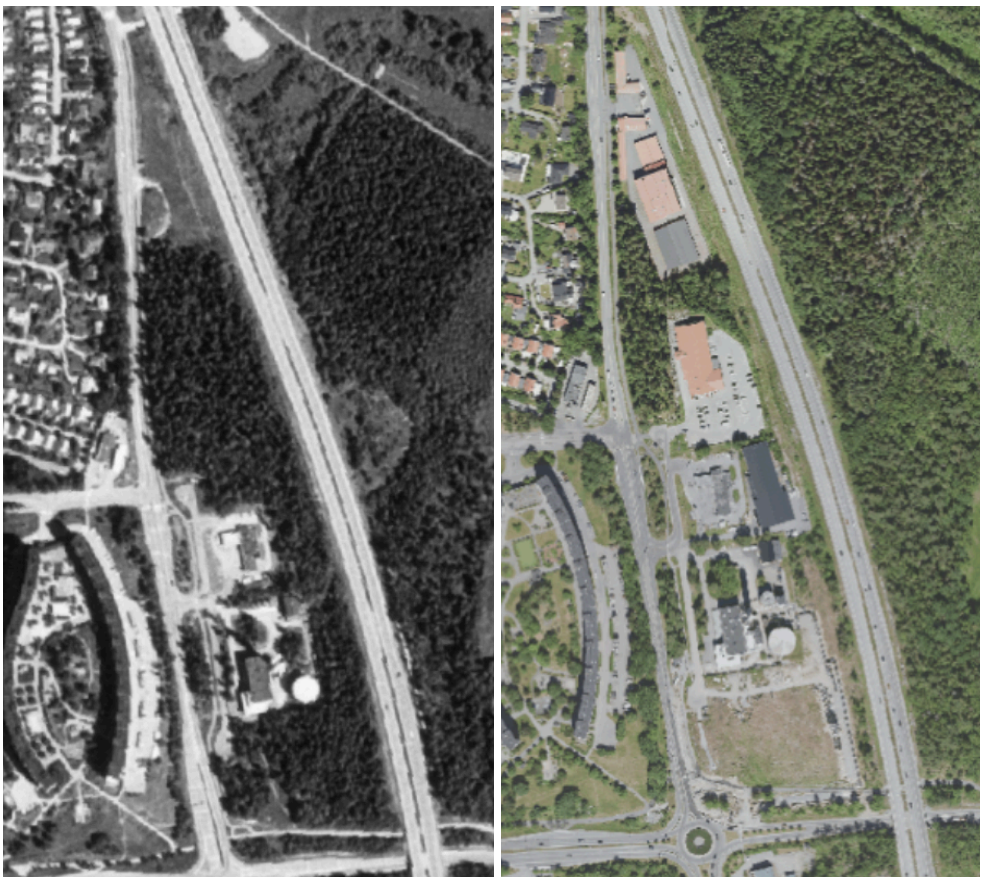

Figure 6- left: The satellite view of site 2 in 1995; right: The satellite view of the site in 2023 (Reference: Järfällakartan, n.d.)

The southern plot in this site is located in the connection point of the north of the two green connections and Jörvälns nature reserve, although divided by E18. The site is currently being developed into the new Arvid Nordqvist coffee factory (Arvid Nordquist, n.d.). Its detailed plan dictates both nature and park development to be included as NBS with a spatial imprint on the site (see Figure 7). These green spaces should cater to the specific ES needed to improve the connectivity and biodiversity support along the north of the two green connections and that can be identified through strategic ES assessment.

Figure 7- top: Satellite view of the site between Enköpingsvägen and the E18 (Reference: Google Maps, 2024); bottom: The detailed plan of the site accessed through Järfällakartan, n.d

Site nr 3: Between Unionsvägen and E18.

Up until 1995, this area held much more greenery, as shown in Figure 8, but later development has significantly reduced the tree canopy coverage in the area. Currently the area houses industrial facilities and the local fire department, limiting opportunities for any extensive nature restoration. The conditions are similar to site nr 2 and so are the solutions. By incorporating small-scale NBS on the land surface within the existing grey infrastructure the ES potential of the area could be partly restored. Additionally, green roofs and living walls can be implemented to improve air quality, and enhance biodiversity. These solutions can be integrated into existing building envelopes, making them suitable for already developed sites.

Figure 8- left: The satellite view of site 3 in 1995; right: The satellite view of the site in 2023 (Reference: Järfällakartan, n.d.)

6.1.2 Plots undergoing plan procedure

In this category, three new detail plans which are being developed in central Jakobsberg will be analysed.

Site 7: Söderdalen Area.

Historically, Söderdalen served as agricultural land before transitioning to industrial use. It is now being redeveloped into residentials and a park area aiming to enhance the southern green connection along Bällsta Creek. This transformation will contribute to improving ecological connectivity and provide access to a new park for residents (see Figure 8).

When developing new green spaces like parks, it is important to consider how this space can help aid the movement of plants and animals between different natural areas. The space also holds the potential to support the environment by providing important ES and can be seen as compensating for the earlier loss of agricultural land. For a purposeful and multifunctional design of this park area, strategic ES assessment and qualitative methods inviting residents' point of view would be useful.

Figure 9- top: Satellite view of the site in the Söderdalen area (Reference: Google Maps, left: 1995, right: 2024); bottom: The detailed plan of the site

Site 8: Kvarnvingevägen

The site on Kvarnvingevägen is situated right next to the railway tracks which are one of the big barriers in the area. Just next to the site there is a larger green space of natural value that should be purposefully maintained and enhanced. Currently the site houses a hardened surface that is used as a parking lot with few street trees and some grassy areas. In line with its new detailed plan this site is going to be developed. The proposed development includes 600 housing units with multifunctional ground floors featuring stores and office spaces (see Figure 10). The new development will be replacing the existing buildings and the parking lot. As the site is adjacent to the train tracks, it is important to include NBS along the train tracks to weaken the barrier effect and filter noise pollution while enhancing the green space that is across the site. It is also suggested that the new housing block includes a yard and considered other forms of NBS without an imprint in its design.

Figure 10- Top: Satellite view of the site in Kvarnvingevägen (Reference: Google Maps, 2024). Bottom: The proposed plan for the site in Kvarnvingevägen (Reference: Järfälla's Municipality, n.d.b)

Site 9: BRF Allmogen

BRF Allmogen, is a corner addition to the residential block east of Allmogevägen, situated within the ecological gap it becomes extra important to consider qualitative green space in the area. The development will replace some mature urban trees and a parking lot currently on the site (see Figure 11). The rendered image of the development that is presented below does not indicate any greenery to compensate for the loss of the existing trees in the streetscape, and the yard will be cut off and private. By incorporating NBS such as a green roof or a green wall, the loss of urban trees can be compensated and the GI in the area could be enhanced in terms of biodiversity, balancing the densification. The loss of parking space is accommodated through a parking garage in the building.

Figure 11- Top: The development of the BRF Allmogen (Reference: Järfälla's Municipality, n.d.a). Bottom: A satellite view of the plot were the development will take place (Reference: Google Maps, 2024)

6.1.3 Plots with potential for development

In this section we present two sites with potential for development located in Jakobsberg and some open green areas which can be improved to enhance biodiversity. The two sites with potential for development consist of hardened surfaces in the shape of parking lots. Both those sites have the potential to contribute both to additional housing and improvements to the GI at the same time. The open green areas are situated next to the E18 highway, which limits their potential for housing development. However, if effectively utilized, they can serve as biodiversity bridges, helping to mitigate the highway's barrier effect and supporting ecological connectivity.

Site 4: Parking Lot north of Jakobsbergs health care centre

The first site is located along Birgittavägen and is currently a parking area serving the adjacent residentials in BRF Beckasinen as well as catering to those visiting the health care center. Most of the parking spaces are open, however on the northern part of the site there are two rows of covered parking spaces for residents. The current development of this site was based on a detailed plan which dates back to the early 1990s (see Figure 12). The central position of the site in Jakobsberg, the urban densification challenges faced by the municipality and the need to enhance green connectivity in the area make it a spot that could be redeveloped based on the current needs of the municipality.

This site is bordered by a school on the north part and a large road and construction companies on the east side which makes it susceptible to noise pollution. The creation of a park along those borders would minimise noise pollution and the incorporation of NBS such as green walls on any future development would enhance this effect further.

The parking area on this site occupies a large space in one level that could be reduced to accommodate for the development of both housing and green spaces. As an example the residential parking garages and carports could be equipped with green roofs and the parking lot could be converted to new housing development where parking could be accommodated in multilevel garages, possibly including underground.

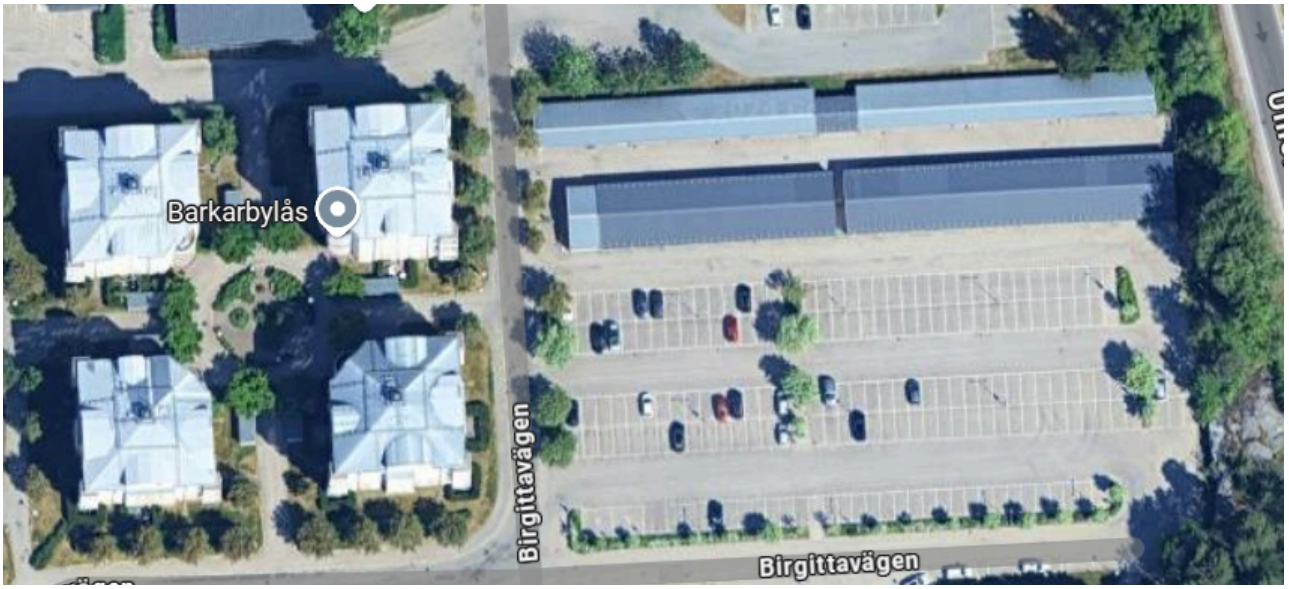

Figure 12- Satellite view of site 4. (Reference: Google Maps, 2024)

Site 6: Parking lot west of Tornervägen

This site is located along Tornervägen in very close proximity to Jakobsberg centrum and the railway station. The current detailed plan of the plot allows for the development of housing and multi-functional ground floors hosting facilities such as stores and office spaces. On the northern side of the plot the detail plan has accommodated for the preservation of the current tree alley (see Figure 13). This is one of the two sites that fall into the identified ecological gap and for this reason the addition of greenery in this site is very important for the creation of a network of green spaces.

According to municipality representatives the development of this site was underway but is currently hindered due to some bureaucratic issues that need to be addressed. The 5 year implementation period of this plan has passed and it is possible to change its direction. However, as it already accommodates for new housing development and a green accessible courtyard that should be public it is unlikely that it will be changed if the conflict of its development can be resolved. When it is time for the development the incorporation of NBS in the form of a green roof inside the courtyard is an important addition, the grey and green infrastructure of the site would be improved, while addressing the ecological gap at the same time.

While the site is not owned by the municipality, which may limit direct influence over the incorporation of NBS in future developments, the municipality can still use mechanisms such as the green space factor to encourage property owners to adopt these measures. This approach would allow for a balance between urban development and GI.

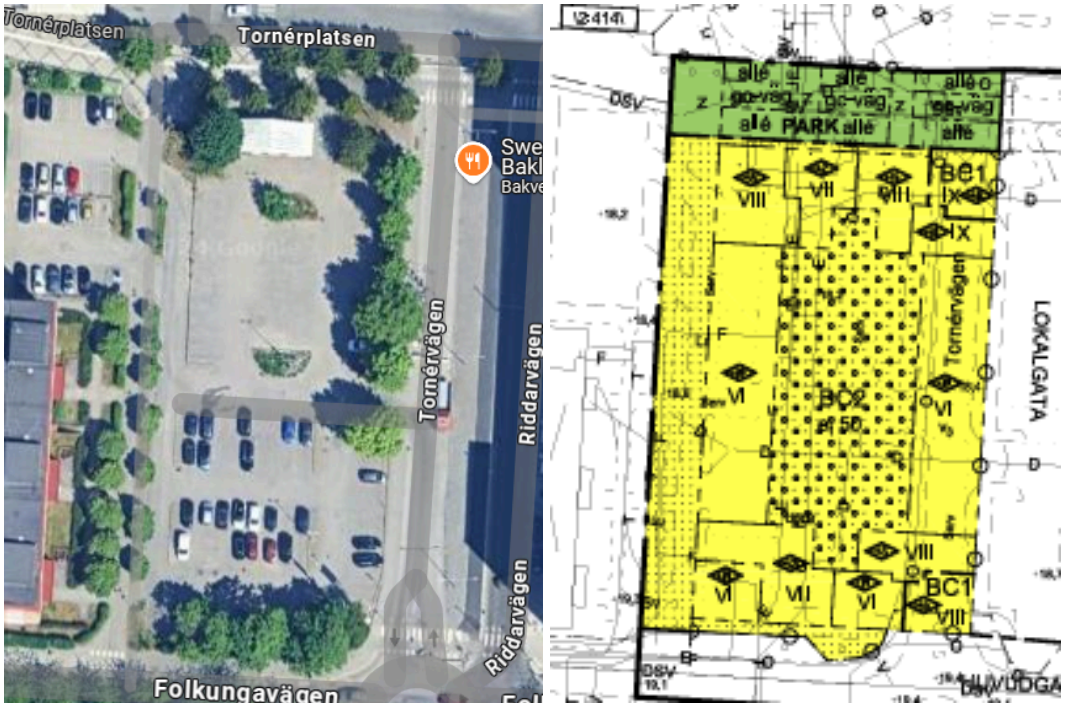

Figure 13- left: Satellite view of the site 6 (Reference: Google Maps, 2024); right: The detailed plan of the site

Site 1: Riddarparken

Riddarparken is located right next to Jakobsberg Centrum and is a prevalent element in Järfälla. Most of the surface area of the park is covered by grass with a few trees around its periphery and some hardened surfaces that create paths for pedestrians. The park is equipped with seating areas for local residents, a playground, and a water element that operates during

summer time. On the surface the park looks like a well functioning green space in the middle of the municipality, It is however weak in terms of ES provisioning as well as for many recreational purposes especially during the winter months (see Figure 14). The incorporation of more functions and the enrichment of the perennial flora including wintergreen plant species could potentially better support ES and strengthen the GI in the area.

Figure 14- Left: Satellite view of Riddarparken (Reference: Google Maps, 2024). Right: Riddarparken during autumn (Reference: The authors, 2024)

Site 2: Green Space along E18 highway.

The final plot is a green space consisting of grass along the margins of the E18 highway. In terms of safety and visibility it might not be feasible to add dense and high greenery in the interchange area, but low maintenance perennials with potential to aid pollinators and reduce pollutants would enhance the ES provisioning in these types of areas. Furthermore, the addition of green envelopes on the existing buildings close to the highway can significantly reduce the noise pollution and create biodiversity bridges for the local pollinating insect species (see Figure 15). Finally, by incorporating more diverse greenery in the underground connection of Folkungavägen, possibly making it wider, species movement can be facilitated even further.

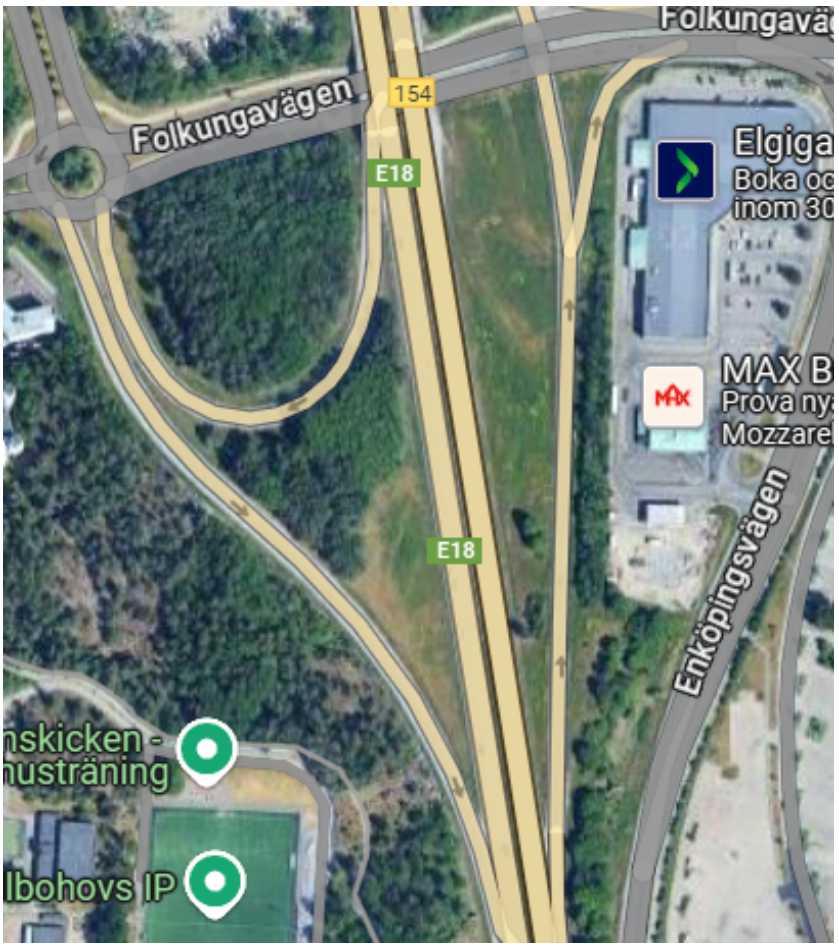

Figure 15- left: Satellite view of the site 5 (Reference: Google Maps, 2024)

6.2 Summarised suggestions in response to strategies

While the previous section provided some spatial examples on how to improve connectivity, this section takes a closer look at the municipality´s strategies related to green space and densification (Järfälla Municipality, 2024). To reach the objectives set up in terms of these strategies and aid goal achievement in local, regional and even global level, our results have been summarized into four more concrete game plans.

Interdisciplinary collaboration among departments. The results from interviews showed that there is a need for more collaboration between departments and research highlighted the importance thereof for holistic results. As different departments have different expertise and work with different goals, balancing land use decisions requires multiple inputs. Improved collaboration would aid all strategies related to densification and green spaces.

Strategic ES assessment. Can provide supportive guides in terms of policy documents that provide an outline for implementation and management strategies of urban ecosystems. With continued mapping and evaluation of green structure and spaces, their potentials and insurance value, assessments can be of help when prioritizing land use, before a site has been selected for development. Essentially strategic ES assessment is supporting the realisation of all the strategies related to densification and green spaces as it provides a foundation of contextual knowledge in terms of where and where not to work with certain actions.

NBS (imprint). A focus on restoring degraded areas and strengthening weak areas such as open grass spaces. A specific focus can be on strengthening greenery along train tracks and highways to weaken barrier effects and improve air quality . In dense areas this game plan explores possibilities such as pocket parks and high quality yards, a necessity in terms of the strategy to increase the tree canopy cover in both existing areas and new neighborhoods.

NBS (no imprint/integrated). In already dense development green connectivity can be improved through green roofs and walls. The game plan encourages building higher, building on sites close to where the green connections are already strong and to compensate for losses through integrated NBS in new development of multi-functional housing. To provide an example this game plan supports the objectives of the strategy to utilize the potential of rooftops for energy production, stormwater management, outdoor spaces, and additional structures well.

Table 1 shows a selection of Järfälla municipality's strategic measures towards a resilient municipality that were found related to densification and green spaces (Järfälla Municipality, 2024). They were then paired with the SDGs related to the aim of this report, as well as the suggested combination of game plans to aid implementation of the objectives presented in the strategy.

Järfälla´s strategies related to green spaces & densification	**Game plan:**	**SDG target**
Increase the proportion of protected natural areas and safeguard regions that are vital for drinking water supply and food production.		3.9, 13.1, 15.2
Preserve and strengthen carbon sinks, including by protecting and restoring wetlands.		11.6, 13.1, 15.2
Enhance accessibility to high-quality meeting places, water, and greenery.		11.7, 15.5, 15.a
Increase the tree canopy cover in both existing areas and new neighborhoods.		11.6, 13.1, 15.2, 15.5
Preserve areas that are free from light pollution and noise.		15.2, 15.5, 11.7
Reduce the impact of barriers and transform traffic routes into streets that prioritize people and greenery.		11.3, 11.6, 13.1, 13.2
Conserve the municipality's land and prioritize building on already developed land		11.4, 11.7, 15.2, 15.5
Preserve and enhance the character of places based on their unique conditions by adding value and adhering to an overarching vision.		11.3, 11.4, 11.6, 13.1, 13.2, 15.2, 15.5, 15.a
Utilize the potential of rooftops for energy production, stormwater management, outdoor spaces, and additional structures.		11.3, 11.6, 11.7, 13.1, 13.2, 15.5
When addressing new needs, prioritize re-purpose, adding on, or expanding existing structures.		11.3, 11.6, 13.2, 15.5
Promote multifunctional utilization of buildings, facilities and spaces.		11.3, 11.6, 11.7, 13.1, 15.5
Promote access to local services, meeting places, and opportunities for active recreation within a 15-minute walking distance from residential areas.		11.3, 11.7
Develop a new regional city core, thereby contributing to both municipal and regional housing provisioning.		11.3, 11.6, 11.7, 13.1, 13.2, 15.5
Enable dense, transit-oriented built environments that create the conditions for vibrant local centers.		11.3, 11.6, 11.7, 13.1, 13.2, 15.5

Table 1- *Strategic measures towards a more resilient Järfälla (Järfälla Municipality, 2024) and how to address them.*

7 Discussion

The research and policy documents reviewed for this research emphasize the necessity of adopting a holistic approach to address urban challenges. This approach involves acknowledging the complexity of integrating all ES and fostering interdisciplinary collaboration within municipal planning processes. Given that no single individual can possess expertise in every relevant field, the importance of interdisciplinary collaboration emerged as a recurring theme in both the literature and interviews.

This project was conducted with certain limitations and assumptions. For instance, the recommended 500-meter distance between green spaces, while supported by various references, represents a simplification that does not account for the diverse habitat requirements of different species of flora and fauna. Additionally, time constraints and limited access to primary data limited the possibility to verify the classifications of green spaces within the municipality. As a result, the categorisations from the comprehensive plan were used without an in-depth understanding of the underlying nuances within each category. This shallow understanding can be attributed to the use of all municipal data and policy documents. If the project would include perspectives from residents or NGOs this could have provided a fuller picture.

A thorough understanding of the local context is crucial for the success of urban planning initiatives, particularly those focused on ES. This project underscores the importance of tailoring strategies to Järfälla's specific needs and characteristics, providing a foundational framework for the municipality to build upon. However, potential trade-offs must also be considered. For example, efforts to enhance biodiversity may lead to conflicts where certain species make green spaces less appealing or functional for human use. Striking a balance between biodiversity objectives and human usability is essential to ensure that green spaces remain beneficial for both ecological and social purposes.

8 Conclusion

To equip Järfälla to effectively handle climate change and other community crises through enhanced ecological resilience, strengthened ES, and increased self-sufficiency by 2050 (Järfälla Municipality, 2024), it is essential to identify and better understand the insurance value of the municipality's ecosystems. Achieving this requires continuous mapping and assessment of the capacities and deficiencies within Järfälla’s GI to ensure its long-term quality and ES provisioning. Such strategic ES assessments can also act as valuable tools for prioritizing land-use decisions, enabling informed choices before specific sites are selected for development.When deficiencies are identified, implementing NBS can help mitigate the issue.

Additionally, fostering close and transparent collaboration between the municipality's departments is crucial. This collaboration should begin in the early planning stages and continue through the implementation of strategic plans to ensure the municipality meets its targets efficiently. Insights from interviews with municipal representatives highlighted this necessity, as different departments often work toward diverse objectives. Balancing land-use decisions requires the integration of these varied perspectives to achieve optimal outcomes.

Regarding the municipality's densification targets, which align with regional development mandates, the suggestions recommended in this report aim to strike a balance between green and grey infrastructure. These game plans include prioritizing vertical development, such as building higher or adding floors, as well as developing sites where the green connections will remain strong. Additionally, converting impermeable surfaces, such as parking lots, into multifunctional housing that incorporates NBS can contribute to improved urban sustainability. Enhancing green infrastructure along train tracks and highways is also recommended to mitigate their barrier effects. Finally, underutilized areas, such as open green spaces, could be enhanced through purposeful fauna to strengthen green connectivity and maximize both ecological and social benefits.

7 References

Alberti, M. (2005) 'The Effects of Urban Patterns on Ecosystem Function', International Regional Science Review, 28(2), pp. 168–192. Available at: https://doi.org/10.1177/0160017605275160.

Aleksejeva, J., Voulgaris, G., & Gasparatos, A. (2024). Systematic review of the climatic and non-climatic benefits of green roofs in urban areas. *Urban Climate*, *58*, 102133. https://doi.org/10.1016/j.uclim.2024.102133

Artmann, M., Kohler, M., Meinel, G., Gan, J., & Ioja, I. C. (2019). How smart growth and green infrastructure can mutually support each other—A conceptual framework for compact and green cities. *Ecological Indicators*, 96, 10-22. https://doi.org/10.1016/j.ecolind.2017.07.001

Arvid Nordquist. (n.d.). *Om Arvid Nordquist Vi bygger Sveriges första rosteri i trä*. Retrieved January 3, 2025, from https://www.arvidnordquist.se/om-arvid-nordquist/nya-rosteriet/

Anteneh, M.B., Damte, D.S., Abate, S.G., & Gedefaw, A.A., (2023) 'Geospatial assessment of urban green space using multi-criteria decision analysis in Debre Markos City, Ethiopia', *Environmental Systems Research*, 12 https://doi.org/10.1186/s40068-023-00291-x

Augusto, B., Roebeling, P., Rafael, S., Ferreira, J., Ascenso, A., & Bodilis, C. (2020). Short and medium-to long-term impacts of nature-based solutions on urban heat. *Sustainable Cities and Society*, *57*. https://doi.org/10.1016/j.scs.2020.102122

Besir, A. B., & Cuce, E. (2018). Green roofs and facades: A comprehensive review. *Renewable and Sustainable Energy Reviews, 82*, 915-939. https://doi.org/10.1016/j.rser.2017.09.106

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics, 29*(2), 293–301. https://doi.org/10.1016/S0921-8009(99)00013-0

Braaker, S., Ghazoul, J., Obrist, M.K., & Moreti, M. (2014). Habitat connectivity shapes urban arthropod communities: the key role of green roofs. *Ecology*, *95*(4), 1010–1021. https://doi.org/10.1890/13-0705.1

C/O City, (2016). *Urban Ecosystem Services: Let nature do the work,* u.o.: A Summary of C/O CITY By Varis Bokalders and Maria Block, Edita Bobergs.

Ekologigruppen & Upplands Väsby municipality, (2015). *Kartering av ekosystemtjänster i Upplands Väsby kommun: Underlag till utvecklingsplan för ekosystemtjänster,* u.o.: Upplands Väsby kommun.

Ekologigruppen & Upplands Väsby municipality, (2016a). *Utvecklingsplan för ekosystemtjänster i Upplands Väsby kommun: Översiktliga prioriteringar inför fortsatt planarbete,* u.o.: Upplands Väsby kommun.

Ekologigruppen & Upplands Väsby municipality, (2016b). *Strategier och metoder för kartering av ekosystemtjänster: Förstudie Ekologisk utvecklingsplna för Upplands Väsby,* u.o.: Upplands Väsby kommun.

European Commission, (2013). *Green Infrastructure (GI) — Enhancing Europe's Natural Capita,* u.o.: u.n.

European Commission, (2015). *Nature-Based Solutions & Re-Naturing Cities,* Luxembourg: Publications Office of the European Union.

Francis, L.F.M., & Jensen, M.B. (2017). Benefits of green roofs: A systematic review of the evidence for three ecosystem services. *Urban Forestry & Urban Greening, 82*, 167-176. https://doi.org/10.1016/j.ufug.2017.10.015

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity. *Biology Letters, 3*(4), 390–394. https://doi.org/10.1098/rsbl.2007.0149

Gałecka-Drozda, A., Wilkaniec, A., Szczepańska, M. and Świerk, D., (2021). Potential nature-based solutions and greenwashing to generate green spaces: Developers' claims versus reality in new housing offers. *Urban Forestry & Urban Greening*, 65, 127345. https://doi.org/10.1016/j.ufug.2021.127345

Gaglio, M., Muresan, A. N., Sebastiani, A., Cavicchi, D., Fano, E. A., & Castaldelli, G. (2023). A "reserve" of regulating services: The importance of a remnant protected forest for human well-being in the Po delta (Italy). *Ecological Modelling*, *484*, 1-11, https://doi.org/10.1016/j.ecolmodel.2023.110485

Ghamsary, E.S., Karimimoshaver, M., Akhavan, A., Goruh, Z.A., Aram, F., Säumel, I. & Mosavi, A. (2023). Locating pocket parks: Assessing the effects of land use and accessibility on the public presence. *Environmental and Sustainability Indicators, 18,* 100253. https://doi.org/10.1016/j.indic.2023.100253

Gómez-Baggethun, E. & Barton, D. N., (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Econo*

Haaland, C. and Konijnendijk van den Bosch, C., (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening*, 14(4), 760-771. https://doi.org/10.1016/j.ufug.2015.07.009

Herath, P. & Bai, X., (2024). Benefits and co-benefits of urban green infrastructure for sustainable cities: six current and emerging themes. *Sustainability Science.* 10.1007/s11625-024-01475-9

Hysa, A., Löwe, R. & Geist, J., (2024). Ecosystem services potential is declining across European capital metropoiltan areas. *Scientific Reports,* 14(Nr. 89003), pp. 1-19. https://doi.org/10.1038/s41598-024-59333-8

Irvine, K. N., Warber, S. L., Devine-Wright, P., & Gaston, K. J. (2010). Understanding urban green space as a health resource: A qualitative comparison of visit motivation and derived effects among park users in Sheffield, UK. *International Journal of Environmental Research and Public Health, 7*(3), 887–918. 10.3390/ijerph10010417

Järfälla Municipality. (n.d.a). *Barkarbyfältet—Mogetorp*. Retrieved January 3, 2025, from https://www.jarfalla.se/byggaboochmiljo/stadsutvecklingochdetaljplaner/pagaendedetaljplanerochprojekt/brfallmogen

Järfälla Municipality, (2018a). *Grönstrukturplan Järfälla,* u.o.: Järfälla kommun.

Järfälla Municipality, (2018b). *Handlingsplan för ökad biologisk mångfald i Järfälla kommun,* u.o.: Järfälla kommun. Dnr: Ten 2016/695

Järfälla Municipality, (2023a). *Järfälla Grönytefaktor: Handbok för grönytefaktor för kvartersmark i Järfälla kommun,* u.o.: Järfälla kommun. Version 1.1

Järfälla Municipality. (n.d.b). *Järfällavägen/Kvarnvingevägen*. Retrieved January 3, 2025, from https://www.jarfalla.se/byggaboochmiljo/stadsutvecklingochdetaljplaner/pagaendedetaljplanerochprojekt/jarfallavagenkvarnvingevagen.4.7fb23d7c165bb7ad89d76848.html

Järfälla Municipality, (2023b). *Miljöplan 2023-2030 för Järfälla kommun med bolag*, u.o.: Järfälla kommun

Järfälla Municipality, (2024). *Översiktsplan Järfälla 2050, Samrådsversion 2024-04-02,* u.o.: Järfälla kommun. Dnr: Kst 2021/94.

Jim, C.Y., Konijnendijk van den Bosch, C. and Chen, W.Y., (2018). Acute challenges and solutions for urban forestry in compact and densifying cities. *Journal of Urban Planning and Development*, 144(3). https://doi.org/10.1061/(ASCE)UP.1943-5444.000046

Kaczorowska, A., Kain, J.-H., Kronenberg, J. & Haase, D., (2016). Ecosystem Services in urban land use planning: Integration challenges in complex urban settings: Case of Stockholm. *Ecosystem Services,* Volym 22, pp. 204-212. https://doi.org/10.1016/j.ecoser.2015.04.006

Landschaft Planen & Bauen, Becker, Giseke, Mohren, & Richard. (1990). *The biotope area factor as an ecological parameter – Principles for its determination and identification of the target*. Berlin: Senate Department for Urban Development and Housing. Retrieved from https://www.berlin.de/sen/uvk/_assets/natur-gruen/landschaftsplanung/bff-biotopflaechenfaktor/auszug_bff_gutachten_1990_eng.pdf

Lee, A. C. K., & Maheswaran, R. (2011). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health, 33*(2), 212–222. https://doi.org/10.1093/pubmed/fdq068

Materials for Mitigating Building Cooling Needs (pp. 307-324). Woodhead Publishing https://doi.org/10.1016/B978-1-78242-380-5.00011-X

McCallum, D., Babb, C., & Curtis, C. (2019). Doing Research in Urban and Regional Planning: Lessons in Practical Methods. The Natural and built environment series. Rutledge, Taylor & Francis.

Maes, M. J., Jones, K. E., Toledano, B. M. & Milligan, B., (2019). Mapping synergies and trade-offs between urban ecosystems and the sustainable development goals. *Enviromental Science and Policy,* pp. 181-188.

McNabb, T., Charters, F. J., Challies, E. & Dionisio, R., (2024). Unlocking urban blue-green infrastructure: an interdisciplinary literature review analysing co-benefits and synergies between bio-physical and socio-cultural outcomes. *Blue-Green Systems,* 6(2), pp. 217-231.

Naturvårdsverket, 2024. *Olika former av naturskydd.* [Online]
Available at:
https://www.naturvardsverket.se/amnesomraden/skyddad-natur/olika-former-av-naturskydd/
Accesed: 2024-11-11

Oloś G. (2023). Green facades support biodiversity in urban environment – A case study from Poland. *Journal of Water and Land Development, 59* (4)*,* 257 – 266. DOI: 10.24425/jwld.2023.148450

Peroni, F., Pristeri, G., Codato, D., Pappalardo, S. E., & De Marchi, M. (Year). Biotope area factor: An ecological urban index to geovisualize soil sealing in Padua, Italy. *Sustainability*, *12(1)*, https://www.mdpi.com/2071-1050/12/1/150

Price, C., (2014) Regulating and supporting services and disservices: customary approaches to valuation, and a few surprising case-study results. N Z J For Sci 44:S5. https://doi.org/10.1186/1179-5395-44-S1-S5

Qi, J. D., He, B. J., Wang, M., Zhu, J., & Fu, W. C. (2019). Do grey infrastructures always elevate urban temperature? No, utilizing grey infrastructures to mitigate urban heat island effects. *Sustainable Cities and Society*, *46*, https://doi.org/10.1016/j.scs.2018.12.020

Region Stockholm, (2018). RUFS 2050-*Regional Development Plan for the Stockholm Region.* Regionledningskontoret.

Salisbury, A., Blanusa, T., Bostock, H., & Perry, J.N. (2023). Careful plant choice can deliver more biodiverse vertical greening (green façades). *Urban Forestry & Urban Greening*, *89*, 128118. https://doi.org/10.1016/j.ufug.2023.128118

Sandstrom, U. G. (2002). Green infrastructure planning in urban Sweden. *Planning practice and research*, *17*(4), 373-385. https://doi.org/10.1080/02697450216356

Soga, M., Yamaura, Y., Koike, S. & Gaston, K., (2014). Land sharing vs. land sparing: does the compact city reconcile urban development and biodiversity conservation?. *Journal of Applied Ecology,* Vol 51, pp. 1378-1386. 10.1111/1365-2664.12280

The Economics of Ecosystems and Biodiversity (TEEB), (2010). *Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB,* Malta: Progress Press.

United Nations, (2015). *Transforming our world: The 2030 Agenda for Sustainable Development (A/RES/70/1).* [Online]
Available at: https://sdgs.un.org/goals Accesed: 2024-10-25

Wooster, E.I.F., Fleck, R., Torpy, F., Ramp, D., & Irga, P. J. (2022). Urban green roofs promote metropolitan biodiversity: A comparative case study. *Building and Environment, 207* Part A, 108458. https://doi.org/10.1016/j.buildenv.2021.108458

Xie, Q., Yue, Y., Sun, Q., Chen, S., Lee, S.-B., & Kim, S. W. (2019). Assessing the ecosystem service values of urban parks: A case study in Wuhan, China. *Sustainability, 11*(22), 1678. 10.3390/su11226519

Zhou, S., Nijhuis, S. and Dijkstra, R. (2024) 'Towards a pattern language for green space design in high density urban developments', Journal of Urban Design, 29(5), pp. 576–597. Available at: https://doi.org/10.1080/13574809.2023.2300505.

8 Appendix

The following section includes the dates of the interviews, the participating interviewees from the municipality and the questions that were asked. The names of the interviewees are omitted.

Interview 1 (Conducted remotely over Zoom)
Interviewees: Sustainability strategists with different expertise at Järfälla municipality.
Date & Time: Tuesday 22 October 2024 at 14:30-16:00
Questions:

1. We have several documents from 2017-2018, are there any other or newer versions/documents you would recommend? Perhaps any new development programs etc.? Are there GIS maps available? The documents we have already identified are the following:
    a. EKOLOGISKT SÄRSKILT KÄNSLIGA OMRÅDEN I JÄRFÄLLA KOMMUN 2018.
    b. Översiktlig klimat- och sårbarhetsanalys för Järfälla kommun 2017.
    c. Naturvärdesinventering Järfälla kommun 2017.
    d. Grönstrukturplan 2018
2. Since there can be conceptual differences between for instance environmental networks and green infrastructure, what is your definition of the green connections "Gröna samband"?
3. What is the reason behind choosing these two green connections? Mainly the north of the two stretches partly along Viksjöleden, which is also a barrier. Are there any plans on how to develop/strengthen these connections?
4. How do you go about barriers (north south) such as E18 and the train tracks? For instance, we know there is an ecoduct crossing the tracks further north.
5. In relation to development and preservation, what are your thoughts on the governing structure around nature preservation? Is it helpful or restricting?
6. In regard to ecosystem services and building resilience for the future, to what extent is this included and prioritized in plans? (insurance value)
7. When the plans are realized, do you feel that these environmental values are still being implemented or is there a gap between planning and implementation? If so, why?

Interview 2 (Conducted remotely over Zoom)
Interviewees: Spatial planners with different expertise at Järfälla municipality.
Date & Time: Tuesday 29 October 2024 at 09:00-10:00
Questions:

1. Are there any new development programs going on? Or any big construction projects? Are there GIS maps available? (Any updates to Utvecklingsprogram för Jakobsbergs centrala delar-2016)
2. Do you see any connection between the enhancement of the built environment through green infrastructures/nature-based solutions and social segregation? And if so, is the municipality taking any measures to alleviate this?

3. URBAN FORM OF JARFALLA? Before, Today and tomorrow.
    a. Has there been a study of the municipality's 'Urban form' that had a significant impact on the development of Järfälla as it is today?
    b. What kind of Urban form would you suggest is the best in terms of environmental sustainability?
    c. Are there any such perspectives that have been implemented or are to be implemented in the district?
4. We have seen that you have already done some work with green roofs in the municipality, specifically the "IoTak - smart roofs for a faster climate transition" initiative. What have you learned from this experiment and are you planning to integrate such solutions in the future development of the municipality? Similarly for green walls.
5. How do you see the connection/interaction between urban development and environmental planning?
6. In relation to development and preservation, what are your thoughts on the governing structure around nature preservation? Is it helpful or restricting?

Interview 3 (Conducted remotely over Zoom)
Interviewee: Ecologist at Järfälla municipality.
Date & Time: Tuesday 26 November 2024 at 13.00-14:00
Questions:

1. What was the reasoning behind choosing the two green connections passing through the regional city core and what is the importance of the green space within them?
2. How does the municipality plan to improve the connectivity between the green wedges through those connections? Is there any thought about Including nature-based solutions in the urban fabric? (Green roofs, green walls, pocket parks etc.)
3. What type of assessments have been made on these green spaces to evaluate their value? Maybe in terms of ecosystem service provisioning and potentials? Spatial patterns and distances?
4. Are there any prevalent conflicts in terms of grey infrastructure and green infrastructure along these connections?
5. What is the municipal plan in terms of tackling the two barriers of the highway and the railway tracks?