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Municipal Practices for Integrated Planning of Nature-Based Solutions in Urban Development in the Stockholm Region

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Abstract: Urban planning is assumed to play an important role in developing nature-based solutions (NBS). To explore how NBS is addressed in urban development, municipal planning practices are analyzed based on three case studies in the Stockholm region of Sweden. Through focus group discussions, interviews and document studies, the planning and implementation of NBS and their intended contribution to regional green infrastructure (GI) and social and ecological qualities are investigated. The results show that the planning and design of urban green spaces engages the local community. Moreover, different conceptual frameworks are used to strengthen an ecological perspective and nurture expected outcomes, in particular ecosystem services and GI. Through competence development and collaborative approaches, the co-creation of innovative solutions for public and private green spaces is promoted. However, institutional conditions, e.g., legal frameworks and landownership shape the planning process and can challenge the ability to enhance social and ecological qualities. An assessment of the planning processes indicates a strong focus on ecosystem services and local GI, while the potential to contribute to regional GI differs widely between cases. The study concludes that a knowledge-driven and integrative planning process can foster the potential of NBS for green and sustainable cities.

Keywords: green infrastructure; municipal planning; ecosystem services; shared governance; co-creation; public-private collaboration; competence development; land development



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1. Introduction

Worldwide, urban green spaces are under pressure as a result of the expansion and densification of urbanized areas, the exploitation of land for the development of buildings and roads, and the altering of landscapes and ecosystems [1]. The transformation of urban areas poses a threat to the social and ecological qualities that urban green spaces provide in terms of ecosystem services, biodiversity and wellbeing [2–4]. Hence, preserving green spaces is a pressing global challenge [5] that calls for urban responses that can invert the trends and accelerate change towards both local and global sustainability [6]. From a policy perspective, the crucial role of urban green space in future urban development is recognized in the UN 2030 Agenda, which is particularly addressed in Sustainable Development Goal 11, *Make cities and human settlements inclusive, safe, resilient and sustainable* [7].

In response to the decline of urban green space, nature-based solutions (NBS) has emerged as a concept to operationalize an ecosystem services approach within spatial planning [8]. NBS is a relatively new concept, but gained momentum when it was launched as a major research area by the European Commission (EC) in 2015 [9] to improve the implementation capacity through research and innovation activities [10]. This engagement has yielded a diversity of results, but revealed certain key challenges e.g., the refinement of the NBS concept in relation to other established concepts, a deeper understanding of potential conflicts with investment interests, and the risk for gentrification [11].

The reading of the NBS concept vis-à-vis related concepts (Table 1) is a recurring theme in the scientific literature and an important aspect in the communication with stakeholders [12]. As a clarification of the definition, the EC added that NBS must benefit biodiversity and support the delivery of a range of ecosystem services [13], which implies a call for added social and ecological qualities. As an umbrella concept, NBS is intended to ‘sweep up’ all other concepts for sustainability interventions that employ nature [14]. Hence, NBS integrates existing approaches, e.g., ‘ecosystem services’ and ‘green-blue infrastructure’, with assessments of the social and economic benefits of resource-efficient and systemic solutions that combine technical, governance, regulatory and social innovation [15]. This means that NBS embraces all types of measures that aim to foster social and ecological qualities of urban green spaces, strengthens green infrastructure (GI) and/or supports urban resilience.

Table 1. Definitions of core concepts.

Concept	Definition
Nature-based solution (NBS)	Solutions that are inspired and supported by nature which are cost-effective, simultaneously provide environmental, social and economic benefits, and help build resilience; such solutions must benefit biodiversity and support the delivery of a range of ecosystem services and bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions [13]
Green Infrastructure (GI)	A strategically planned network of natural and semi-natural areas, designed and managed to enhance biodiversity as well as deliver ecosystem services [16]
Ecosystem Services	Ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being [17]
Green Space Ratio	The ratio between the “eco-efficient surface” and the entire surface of the plot or property [18]
Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems [19]

GI can be defined as a strategically planned network of natural and semi-natural areas, designed and managed to enhance biodiversity as well as to deliver ecosystem services [16,20]. In an urban context, NBS can be integrated in urban landscapes, e.g., by mitigating the loss of green spaces in order to further GI and thereby contribute to multiple dimensions of urban sustainability [21]. However, there is no consensus on how to design GI for promoting biodiversity and ecosystem services [22–24], but major efforts on developing GI are currently being undertaken and methodological frameworks for selecting appropriate green space designs are suggested [25]. Therefore, integrating NBS to nurture biodiversity and ecosystem services is associated with major uncertainties.

Although NBS has been endorsed to contribute to sustainable communities [26], translating the concept into legal and institutional systems to support implementation remains challenging [11]. Since the design of green spaces is contingent upon local circumstances, NBS practice is embedded in local settings and often connected to new urban development. Therefore, urban planning is reckoned to play an important role in achieving the integration of NBS in cities [27] and to merge social and ecological systems [2]. The integrative approach fosters the multifunctional nature of NBS [28] and requires collaboration across disciplines and governmental domains [14]. While the focus may initially be on developing a joint vision and a design that meets diverse and often contradictory objectives for the NBS, the collaboration also needs to align activities, financial commitments and responsibilities for the development and maintenance of urban green spaces. This implies that institutional conditions, e.g., legal frameworks, governmental responsibilities and land ownership, are important in developing NBS, which shapes the planning process and the ability to deliver social and ecological qualities. Hence, planning administrations need to adapt to prevailing conditions to ensure a collaborative and integrated planning trajectory

that is broader than statutory planning procedures and advances to the anticipated goals for the NBS and the urban development project. Accordingly, urban planning should be understood as the governance of place, which necessitates a collaborative and deliberate approach that includes both the qualities of place and of process [29]. In this manner, municipal planning processes can provide a framework that enables shared governance for the development of NBS [30]. In the collaborative approach, active involvement of the local community and NGOs should be encouraged to empower citizens in the development of their local environment and equip them with knowledge about developing, operating and maintaining NBS [31]. Grounded on these preconditions, urban planning can enhance the merger of competencies and perspectives in the design and implementation of green spaces and leverage the potentials of NBS.

In response to the identified need to integrate NBS in institutional systems, this paper explores how NBS is addressed in municipal planning and urban development, and in what way the siting and design of green spaces benefit from policy frameworks for NBS, GI, ecosystem services and biodiversity. In addition, the paper focuses on the collaboration between municipal authorities and other stakeholders aiming to promote the integration of high-quality NBS in urban development. The paper is based on three empirical studies in the Stockholm region of Sweden. From an international perspective, the Swedish planning system is highly decentralized, with a planning monopoly for municipalities [32]. This means that Swedish municipalities have an important role in integrating environmental and sustainability issues in local planning [33] and enabling NBS.

This paper aims to analyze municipal practices for sustaining and developing GI, biodiversity and ecosystem services through NBS as part of urban development and to identify expedient pathways for the planning and implementation of NBS. More specifically, the aim is to understand the drivers for NBS, i.e., what qualities the planning strives for and how these benefit GI and support the delivery of ecosystem services. The following research questions are addressed in this paper:

1. What social and ecological qualities does the development of green space aim at and how are these qualities embedded in the planning process?
2. How does the planning process govern the design and implementation of green spaces in urban development projects to ensure the desired qualities of NBS?
3. How are the NBS-related conceptual frameworks of green infrastructure, biodiversity and ecosystem services used in urban planning and development and how do they enhance the social and ecological qualities of green spaces?

2. Materials and Methods

The research is based on a study of urban development projects in three municipalities in the Stockholm region, i.e., Stockholm, Täby and Upplands Väsby, see Figure 1. The City of Stockholm is the capital of Sweden, and with almost one million inhabitants the largest among 26 municipalities in the region [34]. During the last two decades, the city has focused on developing central areas through infills and extensive brownfield developments close to the inner city [35], and this has raised concerns about the loss of green spaces in central areas. A study of changes in nonurban land cover in the City of Stockholm shows that the quantity of green spaces decreased by 2% between 2003 and 2018 [36]. Täby and Upplands Väsby are both commuter municipalities located north of Stockholm. Within the municipal borders, there are large coherent rural areas and peri-urban green spaces with social and ecological qualities which contribute to the regional GI. Urban development takes place primarily in the central parts of both municipalities where green space is fragmented [37,38].

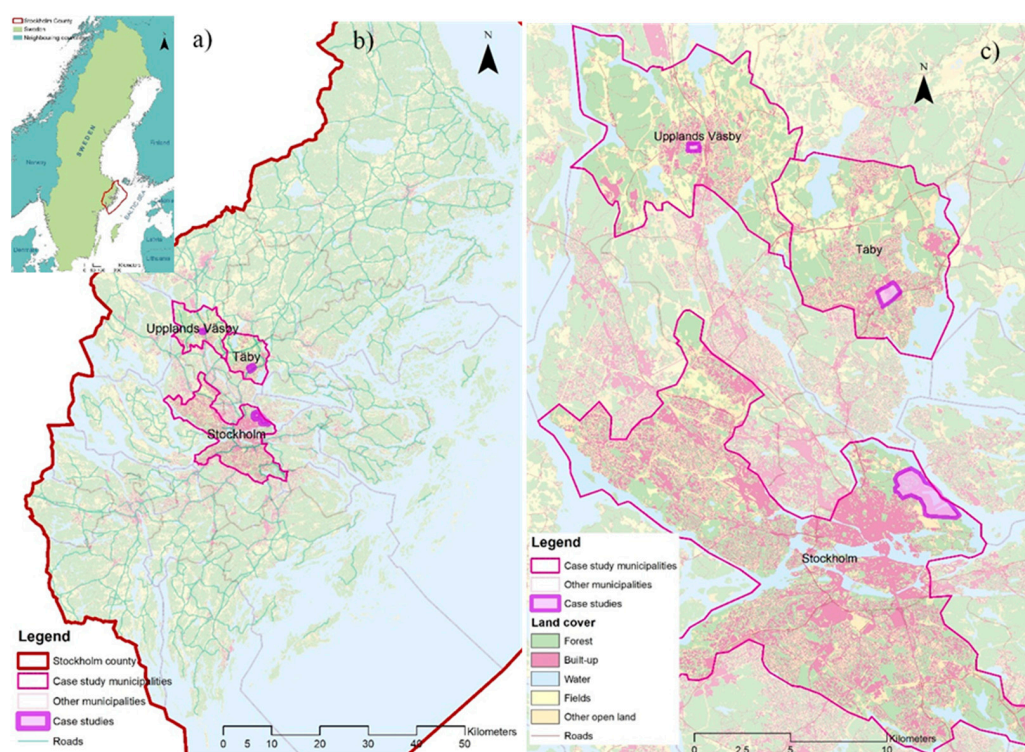


Figure 1. Study area with case studies: (a) Stockholm county in Sweden, (b) case studies and their municipalities in Stockholm county, and (c) zoom-in on case studies and their municipalities. Spatial data © Lantmäteriet and © EuroGeographics.

To achieve the aims of the paper, the planning processes of the three urban development projects are analyzed to gain an understanding of how municipal agencies run the process of developing NBS within urban development in collaboration with other public and private stakeholders. The results of the analyses are used to examine how the detailed design of the NBS evolves as part of the overall project planning to identify approaches for interdisciplinary collaboration and conceptualization of NBS that contribute to the drafting of the project and to single out mechanisms that are employed to ensure the implementation of the NBS. The study covers a planning period of 10 years and does not include an evaluation of the final NBS because the development of green spaces is still in progress.

The paper is based on the results from two research projects. The first, ISSUE (Integrated Sustainable Strategies for Urban Environments), is a transdisciplinary research project that studied local planning practices for sustainable development in urban and peri-urban areas. Through the collaboration between researchers and practitioners, knowledge was collected in a series of focus group discussions [39] regarding existing challenges and preconditions for novel planning practices that enhance sustainable urban development [40]. These focus group discussions took place in different thematic think-tanks, among which one focused on social sustainability and another on planning practices for sustainable development. The transdisciplinary think tanks included urban planners and environmental planners from different units of the municipal administration of Täby, Stockholm and Upplands Väsby, as well as sustainability experts from consultancy firms, sustainability specialists and business developers from private developers, and researchers in urban planning and sustainability analysis from KTH. The think tanks met three to four times per year over a period of three years to discuss predefined questions on the basis of ongoing sustainable urban development projects within the participating organizations. The co-production of knowledge was based on an incremental and iterative approach that included a sequence of research activities to deepen the understanding of key issues

related to sustainable urban development [40]. In addition, a series of semi-structured interviews [41] were conducted with 17 representatives from the municipalities of Täby, Upplands Väsby and Nacka (i.e., environmental planners, urban planners, development engineers and building permit officers) and private developers (i.e., business developers and specialists), to collect individual opinions on tools and approaches to strengthen the ecosystem services in detailed development planning [42]. The focus group discussions and interviews were documented by participating researchers. Within ISSUE, the case studies from the municipalities of Täby and Upplands Väsby that are presented in this paper were discussed in the thinktanks.

The other research project that feeds results into this paper is ‘Sustainability, regulation and roles from detailed development plan to building permit’. This research studied opportunities and obstacles for promoting sustainable urban development in the planning and land development process [43]. Four urban development projects were studied in the research, including Stockholm Royal Seaport, which is included in this paper. For each project, one environmental planner and one urban planner that were significantly involved in the municipal planning process were interviewed. In addition, a group interview was conducted with four representatives from the real estate industry to collect their experiences and perspectives on contemporary practices for sustainable urban development, in particular in Stockholm [44].

Besides experiential knowledge that was obtained from the focus group discussions and interviews, studies of literature, and official documents (such as planning documents, investigations and online resources), were conducted to collect factual information on the three urban development projects.

3. Regional Green Infrastructure Initiatives in Stockholm County

Stockholm County is the fastest-growing region in Sweden with 2.3 million inhabitants and is expected to increase its population by 50% until 2050 (Stockholm County Council 2018). To meet the ongoing regional growth, a large number of urban developments are initiated in the municipalities. To guide local development, the Regional Development Plan (RUF 2050) for Stockholm presents a vision that has been prepared and discussed with the municipal authorities and other actors. The latest regional development plan was adopted in 2018 by Stockholm County Council [45] that in 2019 changed its name to Region Stockholm.

Within Stockholm County, two different initiatives for regional GI coexist, each with a different focus and responsible authority. The first is the Stockholm green wedges that are promoted by Region Stockholm and have been part of regional planning and policy since the 1990s [46]. These ten green wedges create contiguous green spaces that extend from the countryside in Stockholm County (ca 30–50 km from the city center) to the center of the City of Stockholm. In addition, a number of large green-blue areas with high recreational, ecological and cultural qualities are outlined, as seen in Figure 2. As a planning concept, the green wedges have been important for the planning of the spatial development of the region since maintaining a coherent regional GI has been in focus. Some parts of the green wedges are vulnerable and defined as weak connections. Strengthening these weak connections is deemed to be vital for binding together the green wedges and their green core areas to secure recreational paths, creating access to larger strolling areas, and maintaining ecological connectivity [45,47,48].

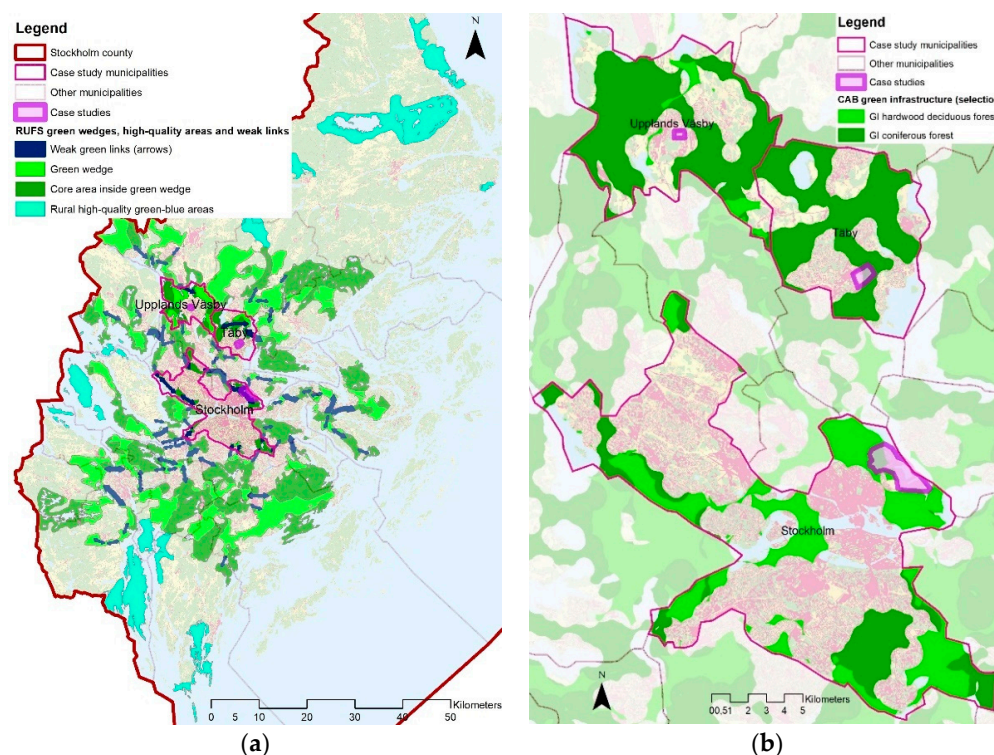


Figure 2. The location of the case studies in relation to the GI initiatives in Stockholm County. (a) RUFSGI comprising green wedges, rural high-quality areas and weak links. (b) an illustration of parts of the Stockholm CAB GI, showing main corridors for hardwood deciduous forest (light green) and coniferous forest (dark green) within and around the three case studies and their municipalities. Spatial data © Lantmäteriet, [45,49].

The second regional GI is based on the EU Biodiversity Strategy [50,51] and the EU strategy and guidelines on GI [16,20] for which guidelines were developed by the Swedish Environmental Protection Agency [52]. The Stockholm County Administrative Board (Stockholm CAB), which is the State representative in Stockholm County, is responsible for developing the regional GI that consists of ecologically functional networks of habitats, structures, natural areas and landscape elements that are designed, used and managed to maintain biodiversity and promote ecosystem services [49]. In 2019, the Stockholm CAB published a regional action plan for GI that sets priorities among different nature conservation activities, and concretizes goals and approaches to the different areas.

As shown in Figure 2a, the case studies in Upplands Väsby and Täby are situated in urban central positions within the municipalities, and not in direct contact with the RUFSGI or its weak links. However, the Stockholm case is situated within or very close to a weak link and can therefore directly be used to strengthen it. Regarding the Stockholm CAB GI (Figure 2b), the situation is different. Upplands Väsby is not connected to either of the selected GI components, i.e., coniferous forest and hardwood deciduous forest, while the Täby case study is situated within the coniferous forest link. The Stockholm case is very strategically located to strengthen the hardwood deciduous forest link.

Both regional GI initiatives value ecological qualities in terms of biodiversity and ecosystem services, but the Stockholm green wedges include a wider range of functions [53], e.g., recreation, health and attractiveness [45], which are linked to the conurbation of the Stockholm metropolitan area. In this regard, the Stockholm green wedges differ from the regional GI that is coordinated by the Stockholm CAB, which is based on a mapping of ecological qualities for the entire county while social qualities are subordinated. Accordingly, the action plan focuses on measures that foster biodiversity and ecosystem services, both in protected areas and in everyday landscapes [49]. Both regional GIs overlap

geographically and the regional authorities collaborate in the planning of measures, gaining from the longstanding work with the green wedges and the actor networks that have been set up for many of the wedges.

This shows that both Stockholm CAB and Region Stockholm have important roles in conceptualizing regional GI and sharing knowledge on the social and ecological qualities of the different components that are part of it. Several protected areas are included in the regional GIs and cannot be exploited. However, for the remaining areas, regional authorities rely heavily on the municipalities for the maintenance, planning and implementation of NBS. Hence, the municipal responses affect to a large extent the long-term development of the regional GIs.

4. Planning for NBS through Urban Development

To control the right to develop or change land use, all EU countries use different planning instruments to balance development and the protection of land in the public interest [54]. In Sweden, the Planning and Building Act [55] regulates land use planning and provides legal tools, such as detailed development plans and building permits that allow municipalities to control land use and thereby protect green spaces from development or allocate sites for NBS. The municipal practices for sustaining and developing ecological and social qualities in urban development through NBS are contingent upon the location and conditions of the development site, the solutions that are considered, and the terms for implementing selected measures.

An important condition is land ownership. Private landowners have the right to develop their property in line with the provisions in the detailed development plan. In the plan, the municipality can articulate the need to foster ecological and social qualities on the development site, but it cannot stipulate binding detailed instructions related to ecosystem services, green roofs, or other types of NBS on private land [56].

The detailed development plan also applies to the development of municipal property. A large share of green spaces in urban areas, such as parks, common land and roadsides, is developed on publicly owned land, which allows municipalities to fully control land use and cater for ecosystem services in urban settings. However, municipalities also use land ownership to facilitate and control urban development, and thus public property is sold to private actors for housing purposes through land allocation [57]. When selling land to private developers, municipalities can attach conditions to the land transfer that have far-reaching requirements in a civil agreement. In this way, municipalities can put demands on developers to create green spaces with ecological and social qualities on the building plot [43]. Hence, land ownership enables municipalities to push for NBS in projects that are developed by the private actors and raise the sustainability targets beyond the ambitions of the detailed development plan.

Most of the urban development in the Stockholm region takes place in or adjacent to built-up areas through densification at locations with good accessibility to public transportation [45]. In central locations, this may affect weak links within the GI when parks and green pockets are transformed into housing areas [47,49] but the development of sites close to weak links also provides opportunities for strengthening GI using NBS. To nurture the planning of NBS in urban development projects there is also a need for expertise and political commitment at the municipal level as well as for local policies for green spaces that are embedded in other policies and within the municipal organization. Such policies may primarily address public space, but can also include domestic gardens that contribute to urban GI [58].

Numerous urban development projects that involve NBS have been initiated in the last two decades in the Stockholm region. To gain a deeper understanding of the planning trajectories for NBS as part of urban development, three projects have been selected that represent recent urban developments with a focus on sustainability in different municipalities in Stockholm County, see Figure 1 and Table 2. All three projects are centrally located in their respective municipality. The first project is the Stockholm Royal Seaport, which is a

development area in the City of Stockholm, located adjacent to the Royal National City Park and 5 km from the inner city. It is the largest ongoing urban development in Sweden, which accommodates at least 12,000 new homes and 35,000 workplaces and serves as a model of good practice for sustainable urban development [59].

Table 2. Key characteristics of project areas included in the case studies.

Development Area	Stockholm Royal Seaport	Täby Park	Fyrklövern
Municipality	Stockholm	Täby	Upplands Väsby
Type of development	brownfield development	new development	urban renewal/densification
Key figures	12,000 dwellings, 236 ha	6000 dwellings, 70 ha	2000 dwellings, 27 ha
Milestones	2009 Detailed development plan first stages	2010 Municipality starts planning with landowners	2011—Väsby Labs: broad 2013 dialogue
	2010 First version of sustainability program	2013 Structure plan: shared vision landowners	2014 Land allocation using the point system
	2011 Launching of the competence development program	2015 Municipal plan program Täby Park	2015 Detailed development plan public space
	2012 First residents move into new dwellings	2015 Sustainability program: shared program landowners	2016 Development plan for ecosystem services
	2019 Implementation connectivity link from Hjorthagens park	2017 Detailed development plans first stages for housing development	2021 Start implementation of park
Land ownership	100% municipal	80% private, 20% municipal	100% municipal

The second project is Fyrklövern (Four Leaf Clover) in the municipality of Upplands Väsby, in which a mixed housing area with 2000 dwellings will be developed next to the city center. It is the largest development project in the municipality of Upplands Väsby in 30 years and aims to build “a modern small town” [60].

The third case study is Täby Park in the municipality of Täby. This site is a former horse race track that is being transformed into a new urban district with 6000 dwellings and green links. According to the vision for Täby Park “*Everything, from the design of the district, to the construction phase and the operation must be characterized by sustainability*” [61].

The development of Fyrklövern and Täby Park started in 2010 and should be framed in the wider context of the debate on the planning ideal that emphasizes density, multifunctionality and city life. In this debate, city centers that represent the ideal of the mixed city are depicted as attractive, while suburbs are portrayed as dull [62]. Against this background, Täby municipality decided in 2010 to shift from suburban to city-like development [63] and Upplands Väsby municipality initiated a broad public dialogue within Väsby Labs to discuss the transformation of Fyrklövern [64]. The planning of the Stockholm Royal Seaport started after the turn of the millennium and was built on the experiences from the development of Hammarby Sjöstad [65].

5. Three Case Studies of NBS in Urban Development

5.1. Stockholm—Stockholm Royal Seaport

Since the 1990s the city of Stockholm has been developing several new multi-family housing districts with a sustainability profile on former brownfield areas around the inner city, such as Hammarby Sjöstad and the Stockholm Royal Seaport. Through the years, the municipality has broadened the sustainability focus for these developments from waste and water management to climate neutrality, social sustainability and ecosystems services.

As the municipality owns the land in both project areas, it can control the development and ensure the fulfillment of set sustainability goals.

The municipal sustainability strategies and goals for the ongoing projects in the Stockholm Royal Seaport area are specified in the Program for sustainable urban development [66]. The goals are used to define the requirements and criteria in land allocation competitions that are announced for each of the construction phases. Developers are invited to submit bids that were assessed on basis of the criteria. Because of the attractive location of the development site, the municipality usually receives a number of competitive bids and can select the contribution that fulfills the requirements and criteria in the best way.

As part of the competence development program for the Stockholm Royal Seaport, the municipality organizes a variety of activities such as workshops, seminars and innovations projects [67]. These activities intend to increase and exchange knowledge on sustainability challenges and best practices among developers, suppliers, consultants and public administrations, but also to develop new solutions in collaboration with academia and industry. In such a way, these open dialogues foster the introduction of sustainable solutions in urban development and enhance the innovative capacity of the entire sector in the Stockholm region.

Since the Stockholm Royal Seaport is located next to a narrow passage that connects the northern and southern part of the Royal National City Park, the new urban district is expected to provide ecological qualities to strengthen ecological connectivity [66]. Hence, the urban design, the public parks, and private courtyards are assessed on their merits related to ecological connectivity, the provision of ecosystems services, and the green space ratio (see Table 1) of the development plots.

The comprehensive approach that is applied in the development of green spaces in the Stockholm Royal Seaport includes multiple urban design principles to enhance ecosystems services and NBS, e.g., multifunctional green areas, strengthening ecosystems and their connectivity, local stormwater management, urban gardening, and green buildings and roofs. The progress and goal fulfillment is monitored and the latest annual sustainability report highlights that all inhabitants have access to a park within 200 m and that all developments meet the required green space ratio [67]. Moreover, the report presents some of the green spaces that have been completed, which are designed as green corridors to nourish the local ecosystem by focusing on oak and amphibian habitats (see Figure 3). This NBS was already mentioned in the detailed development plan from 2009. Although the site was affected by soil pollution, its role as an ecological link between the Royal National City Park and Hjorthagens Park was highlighted [68].



Figure 3. (a) Main connectivity links between Hjorthagens Park within the development area of Stockholm Royal Seaport and the Royal National City Park. (b) Example of a green space in the development area that is designed as a connectivity link. Source: (a) City of Stockholm and (b) City of Stockholm/Flickr 2019, Creative Commons license.

Citizens are involved in the planning and development of the Stockholm Royal Seaport, partly through social media and consultation meetings and partly through participation in joint activities such as urban gardening and pop-up parks [67]. These activities increase knowledge and promote engagement and cooperative responsibility among residents for maintaining the ecological qualities of these sites.

5.2. Upplands Väsby—Fyrklövern

In 2011, the municipality of Upplands Väsby initiated Väsby Labs to conduct a broad dialogue with citizens, developers and other stakeholders with the aim to provoke innovative ideas for the renewal of a centrally located area called Fyrklövern [64]. In the area, a moisture-damaged school building was torn down, which opened up new development in the area. The dialogue generated many ideas that were used to define quality criteria for the development of Fyrklövern [69]. The municipality owns the land, but due to its peri-urban location in the Stockholm region, it tends to be more difficult to attract developers to invest in the municipality of Upplands Väsby compared to centrally located municipalities. However, a number of invited developers participated in the co-creation activities within Väsby Labs.

To kickstart the development process, the municipality set up a point system for the assessment of project proposals through which developers could gain a rebate on the land price for projects that meet the quality criteria that were identified in Väsby Labs. In the prospect of a discount on the land price, 14 developers that submitted a bid for housing development in Fyrklövern signed contracts [69]. The discount created room for developers to test innovative solutions related to urbanity, energy efficiency, co-creation and citizen involvement. A discussion on the detailed planning, which encompassed both the individual projects and the development of Fyrklövern, was initiated with the developers of the winning bids. This process of co-production and joint commitment among parties facilitated the development of the area in line with the quality criteria.

In the detailed development plan, the municipality designated land for the development of a new park at a central location in the area using grown-up trees from other parts of the development site [70]. Besides the new park, a walking passage will be created through the housing area (see Figure 4b). These green spaces are presumed to contribute to the overall ambitions for the area related to social cohesion and safety by creating a permeable structure with different public spaces to accommodate diverse social qualities [71]. Although not explicitly addressed in the point system, adding ecosystem services into the area is a focal issue for the development of both public and private green spaces in Fyrklövern. The public green space and the private courtyards make up a coherent NBS that supports ecosystem services with fruit trees, rain beds, opportunities for gardening and arrangements for social activities.



Figure 4. (a) Development area of Fyrklövern. Source: Upplands Väsby municipality. (b) Illustration of public and private green spaces, which are designed to deliver a variety of ecosystem services and connected by a walking passage through the housing area. Illustration: Funkia.

Due to its location in the central urban area of Upplands Väsby, the NBS in Fyrklövern is poorly connected to the regional GI. However, the Municipal Development Plan for Ecosystem Services [72], which describes proposals for priorities of ecosystem services for the entire municipality, marks out the central urban area as being in a high need for green investments, specifically those related to risks for flooding. The survey of ecosystem services also identifies Fyrklövern as a potential area for developing ecosystem services, e.g., for measures to strengthen the local pollinators network [38]. Hence, the Development Plan for Ecosystem Services is a valuable resource in the planning of NBS in urban development.

5.3. Täby—Täby Park

The municipal comprehensive plan for Täby municipality from 2010 marks a shift from suburban towards a city-like development [63]. Following this plan, the municipality aims to achieve a cohesive urban development in the central parts of Täby, among others in Täby Park, which is a former racecourse that will be transformed into an urban district [73]. The land is mostly owned by four private developers with the exception of 20% of the area that is owned by the municipality. Accordingly, the area is developed on the landowners' terms within the constraints of the municipal detailed development plan. To coordinate the planning of the site, the municipality and the other landowners collaboratively developed a structure plan that describes a shared vision for the area and was approved in 2013 but was not binding on the parties. The plan expresses the intention to develop a city park to enhance ecological qualities and connect to surrounding areas, which was supported by the 3000 participants in dialogue that followed the presentation of the structure plan [73]. In addition, the partners developed a sustainability program, which describes a joint policy for social and environmental aspects of the development. The program is updated prior to the detailed development plan for each of the planning stages. Hence, the planning of Täby Park is to a large degree a collaborative achievement of the municipality and private partners.

In preparation for the detailed development plans, the municipality drafted a plan program, which presents an elaborated plan for Täby Park and links the proposed development to different local and regional policy documents. The program presents a plan for local GI that consists of an interlinked network of parks (see Figure 5b). The local GI is supposed to nurture multiple ecological qualities but is also considered to offer social qualities such as playgrounds for schools, outdoor experiences, and sports [73]. However, the environmental impact assessment of the program points at the isolated location of the development area and foresees that the natural environments that are saved will be impacted by high recreation pressure [73]. This means that existing ecological qualities will to a limited extent contribute to the local and regional GI.

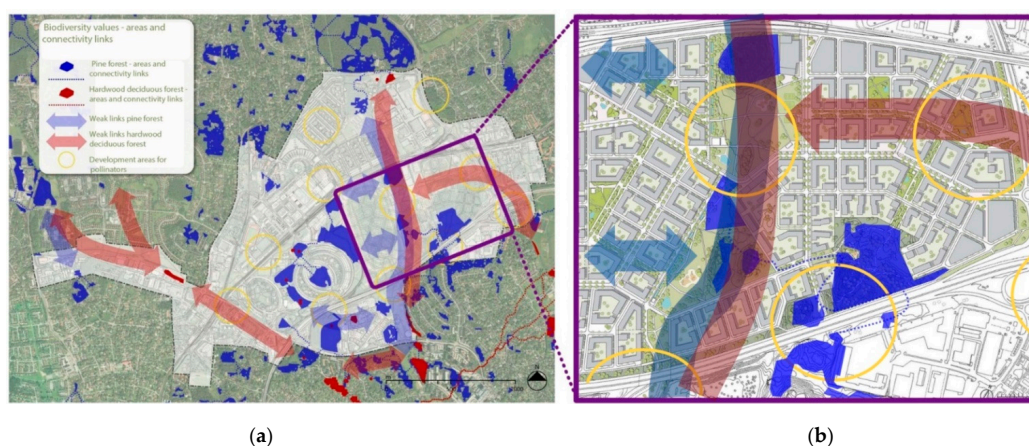


Figure 5. (a) Habitats (filled shapes) dominated by pine forest (blue) and hardwood deciduous forest (red) with connectivity links (dashed lines in corresponding colors) in the central parts of Täby after implementation of existing plans. Arrows indicate a potential for strengthened connectivity for pine forest (blue), hardwood deciduous forest (red) and wild bees (yellow rings) [37]. (b) Illustration plan for Täby Park with biodiversity values added [73].

While some of the existing natural environments are incorporated in the planned city park and other parks, most of the green space will be newly-created. The sustainability program underlines the prominence of a coherent local GI as a major quality of the area, which is developed on municipal land and on private land that is transferred to the municipality [74]. The sustainability program specifies the green space ratio for both public space and private development sites. Based on the analysis of connectivity within the local GI, the municipality anticipates that the created NBS in Täby Park will facilitate the dispersal of species tied to pine forest and hardwood deciduous forest, as well as wild bees [37], see Figure 5a.

6. Governance for NBS in Urban Planning and Development

The three projects that were presented in the previous section describe municipal governance practices for the planning of green spaces as part of urban development in the Stockholm region. Based on the scope and the intended outcomes as to biodiversity and ecosystem services, these projects are examples of NBS, although the concept is not explicitly mentioned in the planning documents. All three projects share an ambition to create multifunctional green spaces that contribute to social and ecological qualities, both in a very local context and from a municipal or regional perspective. An analysis of the planning trajectories of the three projects in the Stockholm region provides some significant insights as to what factors enable the integrated planning approach that caters to NBS.

6.1. Agenda for NBS in Urban Planning and Development

Urban development is generally considered a threat to urban green spaces as it mainly focuses on residential development while the planning of green spaces ends up in a subsidiary role [75]. Even though the projects that are presented in this paper also focus on housing development, the results show that urban development also offers opportunities to preserve and create green spaces. In the case studies, the intention to create green spaces within the new developments was expressed early in the process, but initially as part of the urban design. The concept of the multi-functional mixed city that guided the developments of Täby Park and Fyrklövern presupposes access to parks and green pockets in the neighborhood as a necessary function for integration [76,77]. This is reflected in the point system that was used in Fyrklövern for the assessment of the developers' bids, where green space is evaluated as part of urbanity [78]. Besides urban design principles, public opinion played a role in putting green space on the agenda, either through consent, as in the case of Täby Park, where the proposed city park was endorsed in a public dialogue [73], or through criticism, as in the case of Stockholm Royal Seaport, where the detailed development plan from 2005 was substantially revised after public consultation to minimize ecological impacts [68]. In Fyrklövern the public discussion within Väsby Labs was initiated before a plan was drafted. This points to a strong public engagement in the development of NBS. In addition, it demonstrates the enabling role of the urban planning process to enhance public dialogue, either within the scope of formal procedures or as part of local initiatives, although the contribution of citizen participation to the democratization of urban governance is subject to debate [79,80].

The conceptualization and design of NBS in urban planning requires multi-disciplinary cooperation to bridge different fields of expertise [15], and to let ecology become a frame for decision making [81], relevant expertise needs to be represented in the planning process. When and how different competencies or municipal departments are involved in urban planning depends on the internal routines, which vary between municipalities [40]. In the municipalities of Täby and Upplands Väsby, these routines ensure that environmental planners partake in the detailed development planning, but their involvement in early and more informal phases of the planning process is in most projects not secured [42]. As a consequence, ecological and other types of expertise may be overlooked when the structure and the scope of the urban development project are framed. This can explain why GI, ecosystem services, and biodiversity are more thoroughly addressed in the later planning

stages of Fyrklövern and Täby Park. For the Stockholm Royal Seaport the situation is different due to its location next to the Royal National City Park. The first version of one of early detailed developments was heavily criticized by experts and NGOs, which resulted in increased attention to actions to mitigate impacts on the local and regional GI.

6.2. Enabling the Implementation of NBS

Implementing NBS on public property is normally not a problem as long as formal requirements are met and funding is secured. All case studies have examples of such green space developments, in particular along streets and pathways, but also public parks and green pockets within the residential areas. Although NBS often focus on public space, research has shown that domestic gardens also can support ecosystems services and biodiversity, provided that individual owners adopt sustainable garden practices [82–84]. In addition, gardeners expand their understanding of and attachment to their local environment and enhance involvement in stewardship [85]. Therefore, combined planning of green space on public and private property in urban development can generate synergies and increase the ecological and social qualities of green space in the area.

Municipal authorities in Sweden do not have the regulatory means to demand a specific design of buildings or green spaces through building permits. Thus the implementation of NBS that is not part of public green space can only be guaranteed through voluntary commitments of developers that are formalized in agreements. In Täby Park this was achieved through negotiations between the private landowners and the municipality. In the cases of Fyrklövern and Stockholm Royal Seaport, developers were invited to submit competitive bids in land allocation competitions that met stated quality and sustainability criteria. The bids presented in most cases included innovative solutions for green building, stormwater management, urban gardening, etc., but they were merely business offers. Depending on the additional cost that the criteria entail, the project calculations require an attractive location and a low land price or a high density, as in the case studies, but on less profitable locations the number and quality of the bids decreases as well as the probability for the implementation of NBS on private property. This implies that a market-driven hybrid governance approach where for-profit actors participate in the realization of sustainable urban development cannot assure an equal distribution of urban NBS benefits across the country [86].

In line with common practices, the municipalities of Stockholm and Upplands Väsby drafted a detailed development plan and conducted public consultation prior to the land allocation. However, following the neo-performative model, the plan was not approved until after the reconciliation of the plan and the development projects [87]. Accordingly, the municipal authorities and the developers of the winning bids discuss the proposed projects to align them with the municipal goals and policies. These discussions are normally completed within two years and offer an arena for the co-creation of NBS and other actions that foster sustainable urban development. The discussion involves only participants from the municipal organization and the housing developers and can thus be described as a formal co-creation process with the primary purpose of value creation and sustainable practice [88]. Although the process encompasses a lot of negotiations, the meeting between the parties involved can open new perspectives or solutions, such as in Fyrklövern, where the co-creation process resulted in actualizing semi-public gardens that are designed to deliver ecosystem services and the walking passage connecting these gardens, which is regulated in the land allocation agreement between the municipality and the developers. In the planning of the Stockholm Royal Seaport, research shows that conflicts over sustainability requirements emerge during the negotiations, but through conflict resolution the parties co-create sustainable value [89], e.g., the implementation of a local GI on public and private property that is included in the land allocation agreement. In Täby Park the process also focuses on value creation, but due to private land ownership, the terms for the formal co-creation process differ. The drafting of the detailed development plans, which is based on the joint vision in the structure plan, runs parallel to the discussions on the

joint sustainability plan. This means that the new neighborhoods are designed through collaborative planning within a context of deliberations on sustainable urban development.

Aside from value creation, the co-creation processes involve important elements of learning together [88]. A customized program for knowledge building fosters commitment and a shared understanding as part of a collaborative process [90]. The drafting of the sustainability plan for Täby Park was supported with seminars and activities to foster knowledge sharing and learning. Within the competence development program in the Stockholm Royal Seaport, a large number of seminars and meetings were organized and several research projects were initiated, e.g., a state-funded project with other stakeholders to develop methods for integrating ecosystem services in urban development, which generated knowledge for the planning and realization of a multifunctional local GI that is designed to enhance connectivity [91]. Competence development supports the co-production of situated knowledge among participants, which increases their ability to impact societal change processes [92].

6.3. Framing the NBS in Urban Planning and Development

In the case studies, NBS is embedded in a vision of developing multifunctional public and private green spaces in urban areas that deliver ecosystem services and strengthen local and regional GI. To design the green spaces and analyze their potential impacts, the municipalities primarily use three conceptual frameworks, i.e., GI, ecosystem services, and green space ratio. NBS is commonly associated with ecosystem service and GI [9]. To what extent these frameworks can create NBS that deliver the anticipated social and ecological qualities in the three case study areas is too early to assess, since only parts of the projects have been realized. Hence, a detailed assessment of the generated qualities after implementation that is supported with quantitative analyses would be needed to gain a thorough understanding of the actual contribution of the conceptual frameworks to foster social and ecological qualities. Nonetheless, the role of the three frameworks in the planning of NBS in urban development can be evaluated.

Ecosystem services is highlighted for its ability to bridge communication challenges between different stakeholders and to provide an integrated framework to adapt complexity to local planning practice [93]. In this manner, ecosystem services have served as a tool to identify tangible local measures in Fyrklövern and the Stockholm Royal Seaport that respond to challenges and needs in urban development, e.g., climate change adaption and stormwater management. By emphasizing the connection between measures and expected social and ecological qualities, ecosystem services prove to provide a valuable framework for ensuring the integration of ecological knowledge into local spatial settings. In Fyrklövern, ecosystem services are also used as an analytical framework for mapping ecological development needs [72] that is integrated into the municipal comprehensive plan and used to motivate the NBS in Fyrklövern [42]. However, as a regulatory tool in urban planning, municipal authorities in Stockholm and Täby use green space ratio to define green space requirements for building plots that are developed by private actors, which leaves the selection of tangible measures to developers. Although the green space ratio does not cope with spatial and ecological relations, it promotes social and ecological qualities, including ecosystem services, by giving higher weights to certain types of green space, e.g., the preservation of grown-up trees and sensitive biotopes [94]. The City of Stockholm monitors the use of green space ratio and ecosystem services in the development of the Stockholm Royal Seaport.

GI is another central framework that can offer guidance on practices to integrate NBS into urban planning [14]. In the case studies, GI was primarily employed to describe interconnected local green spaces, e.g., along the walking passage in Fyrklövern. Although the green spaces are not linked to the regional GI initiatives, Fyrklövern can contribute as a hub for pollination between local green spaces [38]. In Täby Park and the Stockholm Royal Seaport, GI focuses not only on interconnected local green spaces but also on connections to surrounding areas and regional GI initiatives, see Figure 2. The strategic location of the

Stockholm Royal Seaport entails a potential and a need to strengthen connectivity links with both the Stockholm CAB GI as well as the RUFSGI. However, to create durable links, more than a physical connection is required because the green spaces that compose the link need to offer specific habitat conditions as in the Stockholm Royal Seaport, where investments are made that aim to strengthen connectivity for amphibians and oak related species. Hence, it remains unclear whether the local GIs contribute to the regional GIs and biodiversity. For Täby Park, the environmental impact assessment of the plan program expressed concerns regarding the impact of recreation on ecological qualities [73], and the planned local GI suffers from different barriers that give rise to fragmentation. In the Stockholm Royal Seaport, the project organization monitors connectivity and the dispersal of oak-living insects but the ongoing land development will continue to put pressure on existing green spaces that may counteract the potential benefits of the NBS. Nevertheless, GI provides an important framework for the planning of NBS that allows for addressing connections between green spaces and regional GI, but ecological relations that enhance connectivity and biodiversity are associated with great uncertainty.

The potential benefits of green spaces for delivering social qualities and enhancing well-being are well documented, e.g., [3,95–97]. In the case studies, these benefits are often implied, as the anticipated social qualities are not specified in the planning documents, which focus more on functions, i.e., recreation, playgrounds and meeting points for social interaction. In addition, proximity is highlighted, e.g., in the Stockholm Royal Seaport where access to green space within 200 m is used as an indicator to follow up the sustainability goal of “ecosystem services for a resilient and healthy urban environment” [66]. In Fyrklövern the goals and conditions for the local GI connect to the urban quality objectives for urban development, which manifests in the significant role of the green spaces in creating social qualities in urban neighborhoods.

The analysis of the case studies reveals the complementarity of the three conceptual frameworks in the planning and development of NBS. Ecosystem services are used in the planning and design of green spaces while GI provides a tool to address local and regional connectivity in planning as a means to enhance biodiversity and spatial structures. The greenspace ratio plays, above all, a role as a regulatory tool to promote ecosystems services on private property. The need for all of these frameworks has been demonstrated in the case studies.

7. Conclusions

The planning for dense cities has focused attention on multifunctional land use from city to site-level planning across Europe [76], which calls for an integrated approach to urban development to capture the complex relations and interactions in urban socio-ecological systems. Although the role of urban planning to address multifunctionality is widely recognized, there is a need for planning approaches that accommodate urban complexity and are oriented towards providing solutions for urban sustainability [14]. The results from the case studies in the Stockholm region provide empirical insights into the planning and development of multifunctional and interconnected urban green spaces through the collaboration between municipal agencies and for-profit housing developers. The municipal practices that were studied include both public and private green spaces and focus on the search for NBS that integrate biodiversity, climate change adaptation and social qualities. Although the results of the research are based on the Swedish planning context, the findings can be transferred to countries with a similar planning system in North-Western Europe [87]. Moreover, there are components of the municipal planning practices that apply to situations in different planning settings.

The results from the empirical studies in Stockholm County clarify the role of urban planning in actualizing NBS to ensure the connection with and adaptation to local knowledge, conditions, and needs, which embeds the NBS in the local context. As the results from the research show, citizens express a large interest in the development of green spaces, and the planning process offers an institutional context to involve the local

community in the design, development and stewardship of NBS. Through an area-wide perspective on urban development, a comprehensive approach to multifunctionality and urban sustainability can be applied. However, urban planning and development entail the balancing of interests, which is not always in favor of NBS.

In accordance with the results of the study, municipal authorities express in an early stage of the planning process the intention to create social and ecological qualities by developing NBS in the form of a local GI, thereby increasing biodiversity and fostering ecosystem services. The municipal practices to meet these ambitions are mainly based on three pillars. First, they involve a collaboration between public and private actors, e.g., landowners and developers, by establishing a dialogue on goals, challenges and alternative solutions to gain a joint understanding of how urban development can promote anticipated qualities of green spaces. However, the incentives to set up a dialogue and agree on a coherent vision differ between projects depending on land ownership and land price. The second pillar of the municipal strategy is to pursue activities for competence development that support the collaborative planning process with insights from other projects and research, and establish an arena for knowledge exchange and innovation. These activities may involve consultants or academics, but can also be part of a research project that is aligned with aspects of ongoing projects. Third, they enable the integration of ecological knowledge that is supported by conceptual frameworks that facilitate the planning of green space. Among these, GI and ecosystem services play an important role in urban planning by providing a common language for analyzing and communicating how proposals for NBS foster social and ecological qualities of green space. In the case studies, municipal agencies benefit from existing regional GI initiatives that provide knowledge on existing ecological qualities and a structure to which local green spaces can be linked, but the potential to contribute to regional GI differs widely between cases. From a longer-term perspective, experiential knowledge and a continued focus on developing GI can enhance biodiversity and create a resilient GI in the Stockholm region. Municipalities that include these three pillars in their urban planning processes gain better preconditions for developing NBS that contribute to a green and climate-resilient urban development.

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