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RESEARCH

Ensuring Ecosystem Service Provision of Urban Water Nature-Based Solutions in Infill Areas: Comparing Green Factor for Districts and SWMM Modeling in Scenario Assessment

Elisa Lähde[1] · **Niklas Dahlberg**[2] · **Paula Piirainen**[3] · **Antti Rehunen**[2]

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Abstract

This study aims to explore the measurement of potential synergies between water management objectives and other ecosystem services generated by Nature-Based Solutions (NBS) in the context of urban planning. The research also investigates the comparative benefits of two analytical methods, Storm Water Management Model (SWMM) and green area factor for districts (GAFD). The study employs Malmi district in Helsinki, Finland, as a case study, examining five distinct NBS scenarios with varying degrees of integration. The results affirm that NBS can indeed enhance ecosystem services provision and stormwater management. The comparative analysis of the two methods, reveals that scenarios with high green factors exhibit effective flood risk reduction, while those with low green factors struggle to manage water, emphasizing the importance of balancing green and built elements in urban planning for optimal flood risk reduction. Furthermore, the study underscores the advantages of the two methods: GAFD offers simplicity and lower expertise requirements, generating valuable insights into ecosystem services, while SWMM provides precise stormwater management data. The findings emphasize the significance of diverse NBS combinations that harness the multifunctional aspects of green infrastructure, highlighting the need for integrated urban planning. The utilization of GAFD analysis provides a comprehensive districtwide perspective in a flexible manner, thereby improving the comprehension of the interconnected nature of urban green spaces.

Highlights

- Nature-based solutions (NBS) support urban stormwater management in infill areas.
- Green Area Factor for Districts (GAFD) is a practical tool to compare NBS options.
- GAFD and SWMM modeling results on stormwaters are comparable for common rain events.
- NBS size, quality and diversity reduce peak flows and enhance ecosystem services.
- Assessment of scenarios with the GAFD tool helps to identify multiple benefits of NBS.

✉ Elisa Lähde
elisa.lahde@aalto.fi

Extended author information available on the last page of the article

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1 Introduction

In the realm of urban planning and ecosystem services, it is evident that human-induced climate change is causing a multitude of challenges for urban environments, including heightened risks of flooding, drought, and heat, as well as disruptions to habitats and biodiversity (Schröter et al. 2005). This, in turn, emphasizes the growing need for climate adaptation strategies within urban planning (IPCC 2022). Adaptation is emerging as a crucial approach for mitigating the exposure and vulnerability of urban areas to the adverse effects of climate change.

Biophysical structures and related functions provide a variety of ecosystem services and related co-benefits including climate adaptation through stormwater detention and filtration, climate and disturbance regulation, and erosion prevention (Haase et al. 2014; European Commission 2015). Furthermore, the richness and diversity of biophysical structures play a pivotal role, as communities with a greater variety of species tend to exhibit better resilience in the face of disturbances (Montoya and Raffaelli 2010). However, urbanization often disrupts the provision of ecosystem services due to a range of interlinked pressures, such as the loss or degradation of natural areas, soil sealing, and the densification of built-up areas (Kabisch et al. 2016), which, in turn, pose significant challenges to ecosystem functionality, climate adaptation, and overall human well-being in urban settings.

In response to these challenges, Nature-Based Solutions (NBS) have emerged as a promising approach to enhance the provision of ecosystem services and related co-benefits in urban areas. NBS in an umbrella concept that can be defined as actions, "[…] which are inspired by, supported by or copied from nature […]" (European Commission 2015, 4). In this context, following an internationally agreed definition of UNEP (2022), NBS are defined as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits".

Urban NBS can take various forms, including floodplain forests, diverse park areas that include several habitats, constructed stormwater ponds or wetlands, biofiltration areas, restored water areas such as stream banks and vegetated walls and roofs. The versatility of NBS enables their deployment to address a wide range of urban needs and situations, with their scale and applicability influenced by factors such as the level of urbanization and land use (Krauze and Wagner 2019; Kuller et al. 2018). However, NBS integration can be constrained in densely built areas, where limited available land may challenge their implementation (Simperler et al. 2020). The suitability of NBS also varies according to specific urban environments (Kuller et al. 2017).

NBS are widely used in urban water management since, in rapidly urbanizing and densifying built-up areas, where they play a pivotal role in maintaining the urban hydrological cycle (Oral et al. 2020). In areas with high soil sealing, NBS help reduce and manage stormwater by promoting evaporation, infiltration, and water storage, while simultaneously providing offering multiple benefits, such as stormwater quality management, mitigation of the heat island effect as well as many social and economic benefits (Cohen-Shacham et al.

2016). Given the projected increase in heavy rainfall events due to climate change (Groenemeijer et al. 2016), NBS are increasingly considered a cost-effective and efficient approach for climate adaptation, often surpassing traditional drainage system enhancements, especially when considering their myriad of co-benefits (Le Coent et al. 2021).

One of the distinguishing advantages of NBS lies in their capacity to deliver co-benefits and multiple functions simultaneously. Multifunctionality, which is "an integration and interaction between functions" (Roe and Mell 2013, p655), enables a single NBS to serve multiple purposes such as storm-water management, better regulation of building temperatures, reduced urban heat-island effects, and increased urban wildlife habitat (Oberndorfer et al. 2007).

While the multitude of benefits offered by green structures is widely acknowledged, integrating multifunctionality into the planning process remains a challenge (Lähde et al. 2019; Hansen and Pauleit 2014, p527). The concept of multifunctionality is applied in design in varying ways and designers often interpret multifunctionality differently (Hansen et al. 2019). Knowing the relationship between NBS and related benefits enables selecting optimal features to achieve specific goals and planning outcomes (Kim and Song 2019; Alves et al. 2019), but the complex, dynamic nature of urban ecosystems complicates planning and development, requiring a deep understanding of the interaction among residents' needs, the built environment urban green structures and the related ecological functions (McPhearson et al. 2016; Martín et al. 2020).

To strengthen multifunctional green structures that enhance residents' well-being and urban resilience, urban planning must not only consider the location and characteristics of green areas, but also identify and prioritize various ecological processes and functions that underpin ecosystem services (Andersson et al. 2021; Hansen et al. 2019). This involves developing a nuanced understanding of how NBS can support different goals and planning outcomes in a repeatable and affordable manner.

In previous literature, the importance of standardized approaches to assess the multiple benefits of NBS has been emphasized. Additionally, the potential of NBS projects to contribute to achieving urban sustainability goals has been highlighted. It has been noted that the valuation of intangible benefits of NBS, such as increased recreation and well-being, and enhanced biodiversity, still lacks a common framework (Sørup et al. 2019; Hansen et al. 2019). This underscores the necessity for standardized approaches in evaluating these benefits. Furthermore, it has been argued that research in this area primarily adopts a case-by-case approach, lacking a shared holistic method for benefit assessment (Viti et al. 2022). Such an approach could ensure a more integrated and replicable assessment of NBS benefits, thereby facilitating their broader implementation (Davis and Naumann 2017).

In the pursuit of this understanding, we address a critical research gap by examining the potential synergies between water management goals and the broader co-benefits of NBS. Our study focuses on the development of a novel method for assessing these synergies and their implications for urban planning. By utilizing scenario analysis in the context of Malmi district, Helsinki, a representative urban area undergoing transformation due to ongoing urbanization, we explore five distinct NBS scenarios.

In our research, we employ innovative tools to analyze the NBS scenarios and uncover the multifunctionality of urban stormwater-related NBS. We employ both The United States Environmental Protection Agency (USEPA) Storm Water Management Model (SWMM) (Rossman 2015) and green area factor for districts (GAFD) to evaluate and compare the impact of NBS on stormwater management. While SWMM is a well-established urban stormwater runoff model (Krebs et al. 2016; Guan 2016), GAFD is a relatively new tool that offers a districtwide perspective, which aligns with the interconnected nature of urban green spaces and the conservation of biodiversity (Niemelä 1999). GAFD is particularly intriguing as it provides a novel approach to estimate the influence of NBS on stormwater management and the broader provision of ecosystem services. By comparing the results obtained from GAFD with those generated through traditional SWMM modeling, we aim to shed light on the potential advantages and drawbacks of these methods for urban planning purposes.

In essence, our research bridges a significant gap in the field of urban planning and NBS integration by developing and evaluating a new method for assessing the multifaceted co-benefits of NBS in urban environments. Understanding the multifunctionality of urban green spaces facilitates the justification of design and construction investments in NBS, even when their costs exceed those of traditional solutions. Furthermore, assessing the capacity of water management-related NBS to deliver various co-benefits will provide insights into achieving a balance between climate mitigation and adaptation in urban infill development. Through the case of Malmi district, we aim to not only provide insights into the potential synergies between water management and broader ecosystem services goals but also to advance the understanding of how innovative tools like GAFD can enhance the planning and decision-making process in urban development.

2 Case Area Description and Methods

The train station located in the center of the case area (Fig. 1) has historically served as the heart of the Malmi district, Helsinki, Finland. The surroundings of Malmi station have undergone a transformation, transitioning from a rural village in the nineteenth century to an industrial agglomeration and eventually becoming a suburban area. The current urban structure of Malmi district began to take shape during the 1960s, with most of the construction occurring in the 1980s. It presents a typical suburban composition of the time with relatively low block houses (3–5 storeys) and paved public spaces. In the city of Helsinki master plan (2016) the district has a role as a growing center of Northeast Helsinki and a rail traffic hub. The number of residents is expected to increase noticeably.

Green spaces in the central Malmi area are notably scarce, primarily concentrated in proximity to residential apartment buildings and detached houses. From the perspective of additional development, the area is nearly fully developed, leaving few undeveloped plots available. Creating additional space for replenishment could be achieved, for instance, by demolishing or expanding existing structures and substituting above-ground parking facilities with multi-story parking structures. However, this also implies constrained opportunities for augmenting the green infrastructure.

The existing vegetation in the area (Fig. 2) follows typical patterns found in urban areas. Green spaces are generally well-defined, meticulously maintained, and exhibit clear organization. Notably, areas around the station display extensive lawn spaces, neatly trimmed shrubs, and limited spontaneous vegetation. Furthermore, there is a prevalence of impermeable surfaces in the vicinity of the station. Most of the green spaces and parks in the area adopt a dual-layered composition, featuring a combination of trees and lawns. The plant species commonly found in these green areas and parks are representative of Finnish urban environments, including varieties such as linden, maple, bird cherry, and fruit trees.

Malmi district's strategic goals align with sustainable urban planning, emphasizing climate resilience, greenery, and ecology (Malmi vision 2020; Malmi design principles 2021). Furthermore, the ambitious climate policies set forth by the city of Helsinki, with

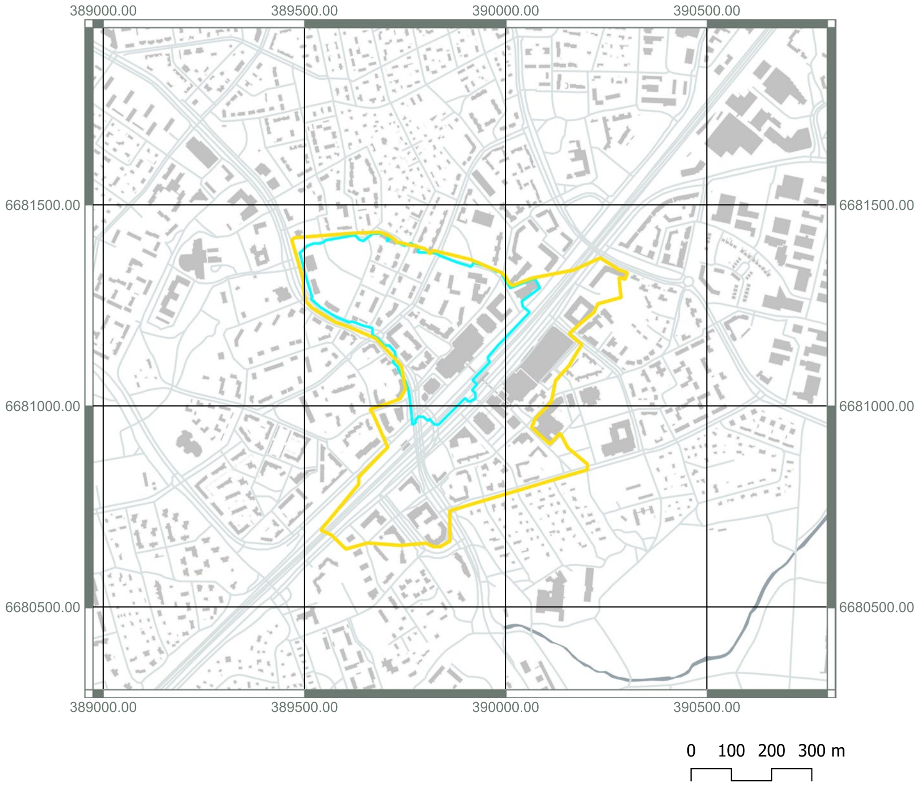

Fig. 1 Case study site, Malmi district in Helsinki with coordinates. Yellow color indicates the area of GAFD analysis, turquoise the area of SWMM analysis. SWMM model follows a catchment area, GAFD analysis was larger to ensure sufficient extent of analysis. Source: City of Helsinki (2021), Orthophotographs of Helsinki

the goal of carbon neutrality by 2035, underscore the need to balance climate mitigation with adaptation in urban development (Helsinki city strategy 2018). This duality necessitates careful consideration, as infill construction can reduce green areas and disrupt ecosystem services, even as it curtails urban expansion into periurban regions.

2.1 Land-use Scenarios

For our analysis, we created five scenarios for the central Malmi district, each illustrating different combinations of NBS solutions. The primary goal was to assess the variations in NBS selection and their resulting effects. We also aimed to examine the alignment of results between two tools: the well-established SWMM modeling and the emerging GAFD analysis.

These scenarios were partly informed by existing development visions and plans outlined by the city of Helsinki, particularly the Malmi vision (2020). We also engaged in discussions with urban planners in a collaborative workshop with the City of Helsinki to identify potential areas for various future land uses. During the workshop, participants

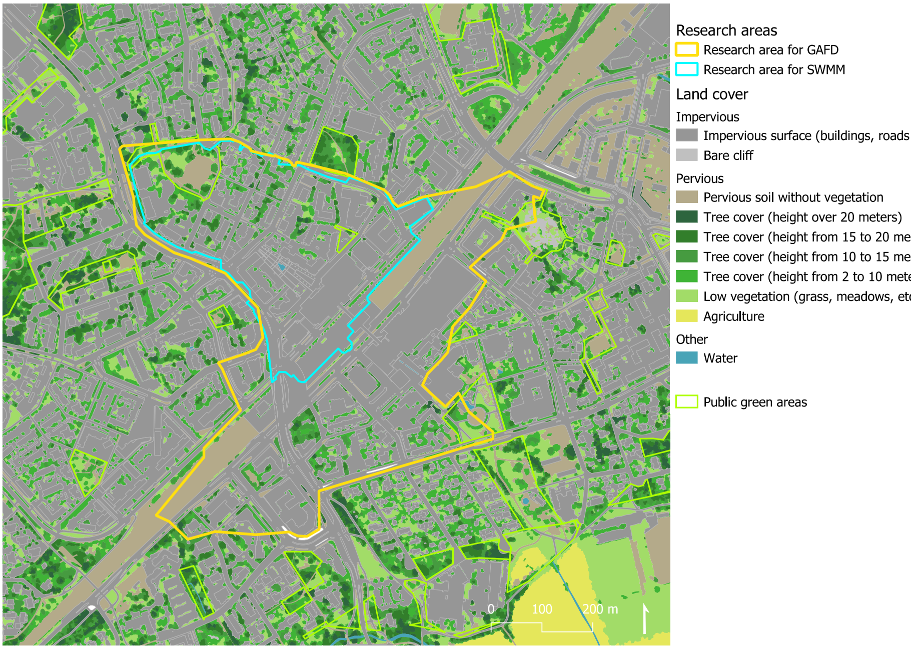

Fig. 2 Green infrastructure and public green areas of Malmi illustrated with land cover. Source: City of Helsinki (2014) Register of public areas in the City of Helsinki; HSY 2018, Regional land cover dataset: HSY and municipalities in the region 2018; background materials for HSY dataset: National Land Survey of Finland (2018); Finnish Transport Agency; Digiroad (2018); Agency for Rural Affairs (2018)

highlighted the importance of discussing not only climate adaptation solutions but also delving into the details of parking facilities and street functionality.

Our analysis considered both quantitative and qualitative changes in the green structure encompassing public green areas (such as parks, squares, streets), private yards, and vegetated roofs. Changes in public green areas focused on squares and parks and were based on Malmi design principles (2021). Alterations on private yards are based on Helsinki municipality's plan for infill construction and rearrangement of some apartment blocks.

The five scenarios are categorized into two groups: scenarios 1 and 2, further divided into a, b and c versions (clarified in Table 1). In scenarios 1a and 1b, referred to as the "business as usual" models (Fig. 3), the direction of land use planning remains largely unchanged. Yard areas in these scenarios of the blocks are decked with parking taking place underneath. Yard's green structures are modeled as biofiltration basins, effectively diverting runoff to the stormwater network without infiltration on the yards. In addition, these scenarios include a reservation for the Viikki-Malmi express tramway. Scenario 1b also assumes the utilization of vegetated roofs, modeled with a 100 mm thick growth layer.

In contrast, scenarios 2a, 2b and 2c, adopt a nature-based approach (Fig. 4), prioritizing ecosystem services. These scenarios do not include a reservation for the Viikki-Malmi expressway and significantly enhance both quantity and quality of green areas. Street green solutions, designed for stormwater management, include sustainable drainage systems, such as biofiltration areas and rain gardens. These scenarios aim for various ecological benefits, such as promoting diverse vegetation and creating

Table 1 Characteristics of five different scenarios

	Characteristics of public areas	Characteristics of private areas	Changes in public areas	Changes in private areas	Used NBS and total surface area of them	Critical parameters affecting ES compared to other scenarios
1a, the business as usual	Very little public parks or other green spaces, public parks and greens places near the railway station consist of mainly lawn and limited number of different tree and shrub species, some vegetation along the streets and footpaths (mainly lawn or common ornamental shrubs used in Finland (e.g.barnyard currant, snowberry), city squares are made of impermeable surfaces without vegetation, impermeable surfaces on parking lots, reservation for Viikki-Malmi express tramway.	Private yards are mainly decked and have lawn or shrubs, the green structures of the yards are modelled as biofiltration basin, and no infiltration occurs on the yards. Green roofs on buildings that have green roof potential, green roofs are modelled to have a 100 mm thick growth layer.	Some of the green elements especially on the sides of streets and footpaths as well as trees are lost due to Viikki-Malmi tramway.	Infill construction reducing existing vegetation and permeable surfaces on plots.	35 994 m2	

Table 1 (continued)

	Characteristics of public areas	Characteristics of private areas	Changes in public areas	Changes in private areas	Used NBS and total surface area of them	Critical parameters affecting ES compared to other scenarios
1b, business as usual with green roofs	Very little public parks or other green spaces, public parks and greens places near the railway station consist of mainly lawn and limited number of different tree and shrub species, some vegetation along the streets and footpaths (mainly lawn or common ornamental shrubs used in Finland (e.g.barnyard currant, snowberry), city squares are made of impermeable surfaces without vegetation, impermeable surfaces on parking lots.	Private yards are mainly decked and have lawn or shrubs, the green structures of the yards are modelled as biofiltration basin, and no infiltration occurs on the yards. Green roofs on buildings that have green roof potential, green roofs are modelled to have a 100 mm thick growth layer.	Changes to 1a: Increase in the surface area of vegetated areas, because of the added green roofs. The new green roofs are thought to be grass-surfaced.	Changes to 1a: Increase in the surface area in vegetated areas, because of the added green roofs. The new green roofs are thought to be grass-surfaced. Most of the new green roofs are in private areas.	More permeable and vegetative surface on the roofs. 176 171 m2	The area of vegetative surface is increased from 35,994 m2 to 176,171 m2 because of the green roofs.

Table 1 (continued)

	Characteristics of public areas	Characteristics of private areas	Changes in public areas	Changes in private areas	Used NBS and total surface area of them	Critical parameters affecting ES compared to other scenarios
2a, NBS enhanced version	The quality of public green areas is enhanced with vegetation and larger scale of species, parking is directed to centralized parking facility near shopping centers and railway station and the new free space is used for green areas and vegetation, parts of the previously impermeable squares are replaced with vegetation.	Private yards are connected to the ground instead of decked solutions, yards have more solutions to help stormwater management, more pollinator friendly areas and more diverse plant species. Different height of plants (trees, shrubs, herbaceous plants).	Changes to 1a and 1b: Increased diversity in vegetation, more vegetative surface in the ground level, more NBS solutions for stormwater management, more permeable surfaces in squares and public areas.	Changes to 1a and 1b: Increased diversity in vegetation, more vegetative surface in the ground level, more NBS solutions for stormwater management, more permeable surfaces in squares and public areas.	Biofilters, rain gardens, filtration connected to the ground, pollinator friendly plant species and habitats, shading trees in impermeable areas (or adding shade to previously mainly impermeable areas), increasing noise absorbing surface. 44 788 m2	PRIVATE YARDS: The surface of pollinator-friendly area is increased the amount of biofilters is increased and detention areas is increased, the amount of multi-layered vegetation (that has at least 2 layers) is increased. PUBLIC AREAS: The amount of bio-filters detention areas is increased, surface of pollinator-friendly area is increased.

Table 1 (continued)

	Characteristics of public areas	Characteristics of private areas	Changes in public areas	Changes in private areas	Used NBS and total surface area of them	Critical parameters affecting ES compared to other scenarios
2b, NBS enhanced version with vegetated roofs	The quality of public green areas is enhanced with vegetation and larger scale of species, parking is directed to centralized parking facility near shopping centers and railway station and the new free space is used for green areas and vegetation, parts of the previously impermeable squares are replaced with vegetation. Green roofs added with 200 mm thick growth layer.	Green roofs added with 200 mm thick growth layer. Private yards are connected to the ground instead of decked solutions, yards have more solutions to help stormwater management, more pollinator friendly areas and more diverse plant species. Different height of plants (trees, shrubs, herbaceous plants).	Changes to 2a: green roofs, increase in pollinator friendly areas, increase in stormwater management elements.	Changes to 2a: Green roofs added.	Biofilters, rain gardens, filtration connected to the ground, pollinator friendly plant species and habitats, shading trees in impermeable areas (or adding shade to previously mainly impermeable areas), increasing noise absorbing surface. 184 965 m2	PRIVATE YARDS: The area of vegetative surface is increased the same amount as in 1b, the surface of pollinator-friendly area is increased from the 2a, The amount of biofilters is decreased and the amount of detention areas instead is increased compared to 2a, PUBLIC AREAS: The amount of biofilters detention areas is increased in some parts compared to 2a, The surface of pollinator-friendly area is increased.

Table 1 (continued)

	Characteristics of public areas	Characteristics of private areas	Changes in public areas	Changes in private areas	Used NBS and total surface area of them	Critical parameters affecting ES compared to other scenarios
2c, green-intensive version with vegetated roofs	The quality of public green areas is enhanced with vegetation and larger scale of species, parking is directed to centralized parking facility near shopping centers and railway station and the new free space is used for green areas and vegetation, parts of the previously impermeable squares are replaced with vegetation. Green roofs added with 200 mm thick growth layer.	Green roofs added with 200 mm thick growth layer. Due to reduced on-side parking the amount of vegetative yard surface area is doubled. Private yards are connected to the ground instead of decked solutions, yards have more solutions to help stormwater management, more pollinator friendly areas and more diverse plant species. Different height of plants (trees, shrubs, herbaceous plants).	Changes to 2b: reduced on site-parking and replacing that with diverse vegetation.	Changes to 2b: Reduced on site-parking and replacing that with diverse vegetation (doubling the vegetative surface in private yards compared to 2a and 2b) and increasing the pollinator friendly area and the surface for rain gardens and biofiltering basins.	Biofilters, rain gardens, filtration connected to the ground, creating pollinator friendly plant species and habitats, shading trees in impermeable areas (or adding shade to previously mainly impermeable areas), increasing noise absorbing surface. 191 363 m2	PRIVATE YARDS: The amount of ground connected vegetative area in private blocks is increased due to removing parts of onsite parking.

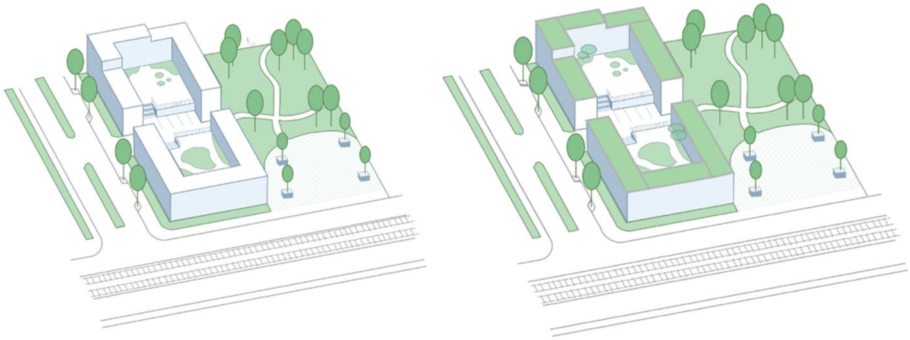

Fig. 3 Scenarios 1a (business as usual, BAU) on left and 1b (BAU with vegetated roofs) on right

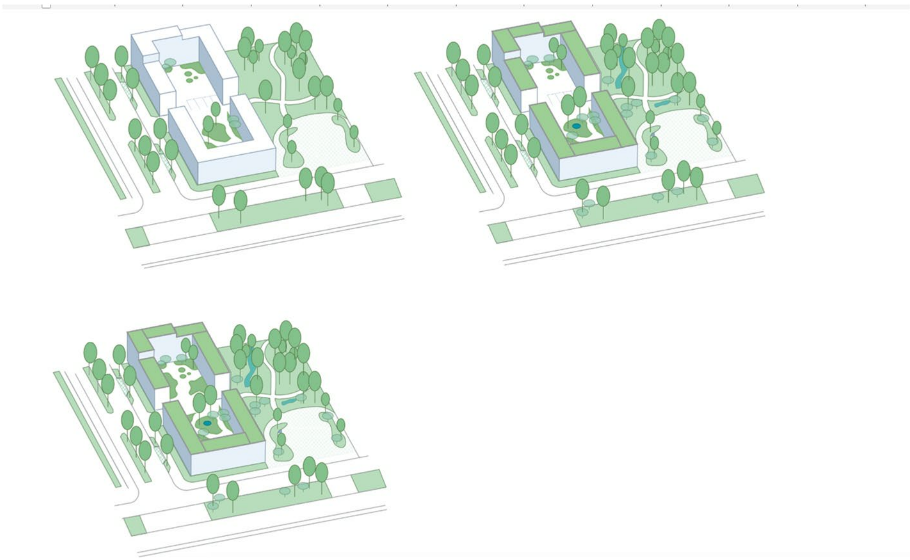

Fig. 4 Scenarios 2a (NBS enhanced version) above left, 2b (NBS enhanced version with vegetated roofs) above right and 2c (green-intensive version with vegetated roofs) below

pollinator-friendly environments. In scenarios 2a and 2b, yard areas are situated on the ground, and parking is directed to separate parking facilities, such as the nearby shopping center. The vegetated areas on the ground-based yards have thicker soil, supporting a more diverse range of plant species, including larger trees. Approximately 20% of yard green areas are transformed into biofiltration basins with thicker growth and storage layers compared to scenarios 1a and 1b.

In these scenarios, land use is modeled similarly to scenario 1a in the stormwater model, but green areas within the yards have infiltration connections to the ground. Biofiltration basins are introduced on the yards and along the streets; previously, simple vegetated surfaces and rain gardens were incorporated on a local square. Scenario 2b contains green roofs across the entire available vegetated roof potential, modeled with a 200 mm thick growth layer.

Scenario 2c, known as the “green-intensive” version, reduces on-site parking even further, replacing current on-ground parking areas with vegetated spaces. In addition, 20% of the vegetated roof area is allocated for intensive stormwater structures, such as detention pools, while the remaining 80% is designated for pollinator-friendly surfaces. On the yards, the growing medium of the vegetated areas is thick, supporting diverse plant species, and 30% of these areas are designated as habitats to support pollinators, such as meadows.

2.2 Green Area Factor Analysis

The term "green factor" pertains to the ratio of built-up areas to vegetative areas within a study site. A vegetative area denotes a space where vegetation thrives, characterized by permeable soil. This encompasses spaces like parks, forests, meadows, as well as features such as vegetated roofs, green walls, and other constructed surfaces with vegetation. In the method, all vegetated areas and water areas that have a positive contribution for the biodiversity and ecosystem services of the site are calculated in the eco-efficient surface area.

The green factor methodology was initially introduced in Berlin in 1989 for residential plots and has since been adapted and customized to various cities, each having its own set of green coefficients and variations tailored to local zoning regulations (Vartholomaios et al. 2013). However, the fundamental ecological objectives of green factor methods remain consistent, focusing on fortifying, conserving, or enhancing the ecological elements and urban ecosystems within an area (Vartholomaios et al. 2013). In Addition, the implementation of green factor methods in cities like Berlin, Stockholm, and Oslo has shown that they lack the explicit use of an ecosystem services assessment framework for preference weighting or relative valuation of green and blue elements (Stange et al. 2022).

In contrast, the concept of the green factor for districts originated in Sweden, building upon the foundation of a plot-specific green factor (COCITY 2018). The toolsheet for GAFD is openly available on projects website http://www.cocity.se/verktyg/. While primarily designed for mapping eco-efficient public green areas, structures, and street spaces, our research also incorporates private yards. This inclusion is significant as it supports the creation of larger urban green spaces and the establishment of ecological corridors that benefit wildlife, such as bats and birds (Vergnes et al. 2013). This particular tool was selected for this research due to its alignment with the development goals of the Malmi district and the challenges posed by urbanization.

The GAFD is a Microsoft Excel based tool, in which different green structures and NBS elements are identified and their surface area is calculated. Based on an element scoring system, the value for each ecosystem service is calculated by weighing the surface areas that generate them. The element weight factors are given by the Excel tool and they are based on the element’s potential to deliver a certain ecosystem service (COCITY 2018).

This method is versatile and applicable to areas of varying types and sizes within the city. It allows for the consideration of the same element multiple times in the calculation if it contributes to the provision of diverse ecosystem services. In addition to accounting for the total green and water area within the study area, the GAFD tool incorporates the following ecosystem services: 1) habitat provision, 2) noise reduction, 3) stormwater management, 4) microclimate regulation, 5) pollination and 6) recreational use and health.

Each ecosystem service theme comprises specific, precisely identifiable elements. For example, for the stormwater management the following elements have been delineated and their surface areas quantified: 1) areas designated for stormwater purification and detention, 2) permeable, plant covered surfaces, 3) temporary flooding areas covered by vegetation,

4) structures intended for stormwater purification and detention, 5) trees thriving on paved surfaces and 6) facilities designed for rainwater collection for irrigation. Each of these elements is assigned a distinct weight factor employed to multiply the corresponding surface area. In the case of stormwater elements, these weight factors vary from 0.7 (pertaining to areas and structures designated for stormwater purification and detention) to 0.2 (related to trees and rainwater collection facilities).

Eco-efficiency points are allocated to the assessment area based on the presence of these elements and their respective surface areas. In practice, the author of the analysis looks for NBS elements using GIS analysis, measures each element's total surface area and saves the information to an Excel file. There, the surfaces are automatically multiplied by an element-specific weighting factor. From the areas thus formed, the total area is added up, which is divided by the area of the review area, and this is the green coefficient of the site. Additionally, apart from the final green factor score, the outcomes of the computation are visualized through thematic maps, offering insights into the distribution of identified green structure elements with respect to the analyzed ecosystem services.

The GAFD was employed to assess alterations in the value of ecosystem services concerning two distinct factors: 1. The impact of the expansion of NBS surface area (difference between 1a and 1b, as well as difference between 2a, 2b, and 2c) on ecosystem service production. 2. The influence of variations in the quality of NBS (difference between 1 and 2a, and difference between 1 and 2b) on ecosystem service production.

The analysis in this study primarily relies on pre-existing geospatial data, which has been used in its original form or subjected to various combinations or modifications to align with the specific requirements of the calculations. The spatial data primarily originates from publicly available sources, including Helsinki Region Environmental Services, the City of Helsinki, Finnish Environment Institute, Natural Resources Institute of Finland and Geological Survey of Finland. In addition, a field visit was conducted within the case area. During the field visit, various aspects, such as the general characteristics of the vegetation in public green areas and factors related to recreational amenities, such as presence of pleasant and green walking paths, were meticulously documented. The field visit provided invaluable insights into the quality of the green infrastructure. However, it is essential to acknowledge that data generated through this method is not absolute but is contingent on certain assumptions.To estimate the potential of vegetated roofs, we used Helsinki Region Environmental Services (HSY) data (2016). HSY has compiled a dataset identifying roofs with the potential for vegetated installations. These potential vegetated roofs possess a sufficiently flat surface, yet lack any observed vegetation. In addition, the dataset includes attribute information indicating the extent of impermeable surfaces within a 100-m radius around the building. The values in this attribute range from 0 (areas allowing water permeability) to 1 (areas completely impermeable to water).

2.3 SWMM Modeling Analyses

This study employed SWMM to model water quantity and impact of the scenarios on stormwater management. The SWMM was selected, because it is the most commonly used tool in Finland for urban stormwater analyses. The SWMM model scenarios were a combination of altered land use cases due to planned infill construction (as depicted in paragraph Land use scenarios) and current land-use cases (HSY 2018) in areas where no infill construction was planned. In addition, a 2×2 m digital elevation model (DEM) from the National Land Survey of Finland and drainage system information from HSY were utilized in catchment delineation and model construction.

Since model calibration and validation data were not available, land-use was discretized in the greatest possible detail using the available land use information and DEM to acquire as realistic runoff representation when possible. In some studies, detailed land-use discretization has been shown to improve the performance of uncalibrated models to estimate runoff quantity to be even comparable to calibrated ones (Warsta et al. 2017; Petrucci and Bonhomme 2014), at least in model domains of similar size. Although this does not omit the need for calibration (Tschaikner-Gratl et al. 2016), we considered the use of the uncalibrated model to be adequate enough since the aim for the modeling was to inspect changes between imagined future scenarios, not to estimate the current reality. Another uncertainty in this situation is related to the selection of input parameters. However, considering that the decisions regarding how to represent certain land-use changes in the future scenarios in SWMM are somewhat subjective, there is no correct set of input parameters for this study. The parametrization of land-use and different NBS (LID-structures in SWMM) utilized information from several previous SWMM modeling studies from Helsinki and surrounding areas, as compiled by Holt et al. (2018).

The precipitation input for the stormwater modeling was a one-hour design storm with three different return periods: 2 years (13.8 mm/h), 10 years (22.8 mm/h) and 100 years (36.6 mm/h) were used. Design storm precipitations were used because there was a lack of suitable rainfall data in the study location and the modeling did not represent the current state but rather a future scenario. The precipitation amounts were acquired from the "Intensity and frequency of short-duration rainfall in Finland '' -visualization tool (Climateguide.fi 2014). The design storm curve was constructed by averaging real rainfall events across Finland and the curve was fitted so that the rainfall intensity increased from 0 to the maximum in 30 min, after which it decreased again until it ended at 60 min, which is similar to the alternating block method. The modeling time period was 6 h to allow for the runoff to pass through the catchment. Because the studied precipitation and model time scales were short, evaporation was not considered in the model. For infiltration, the Green-Ampt method was used with parameters (Table 2) taken from a SWMM modeling study by Niemi et al. (2019), which was performed in a nearby area with a similar soil type as according to the soil map of the Geological Survey of Finland.

The impact of the scenarios on water quantity was compared as changes in peak flow, total runoff volume from the catchment, and flooded volume from the drainage system. Scenarios 1b, 2a, 2b, and 2c were compared against the "business as usual" infill construction scenario 1a.

Table 2 The infiltration parameters

Properties	Value
Saturated hydraulic conductivity (mm/h)	24.965
Suction head (mm)	55.832
Maximum moisture deficit	0.35

3 Results

3.1 Green Factor for Districts

The green factor—a numerical value that reflects the benefits produced by the area's vegetated area in relation to the total area—was calculated for each scenario. The higher the multiplier, the more benefits it produces. However, the factor itself does not reveal, for example, how the areas that support and produce ecosystem services are distributed within the study areas.

The green factor values of the scenarios varied between 0.51 and 1.67. To enable a scenario comparison, we calculated the green factor for existing land use, represented as "0" in Fig. 5, which presents all the green factor results. By comparing the green factors, we can determine which scenario has the greatest impact on the production of the analyzed ecosystem services.

In Fig. 5, the results of the analysis are straightforward: all the calculated scenarios, except 1a (value of 0.51) had higher green factor values than the existing scenario 0 (value of 0.58). Scenario 1a is a "business as usual" model, and its overall greenery was lower than that of the existing situation. Furthermore, a few additional green elements are not effectively providing ecosystem services or other co-benefits, which is reflected in the green factor. Scenario 2c, which possessed the highest amount of added NBS, had the highest green factor value (value 1.67).

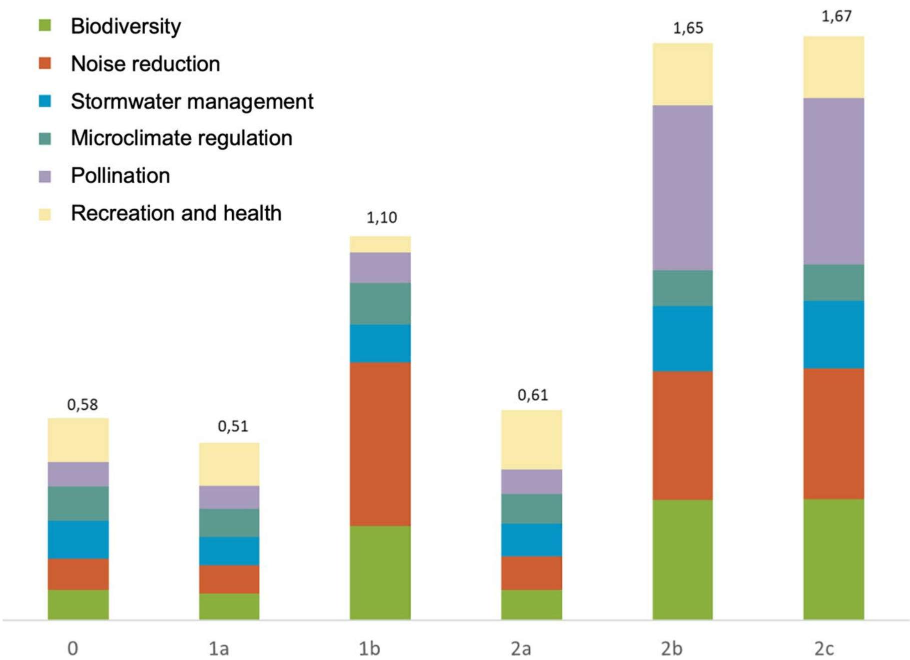

Fig. 5 Measured benefits of different scenarios presented with bar charts. Each hatch presents one of the measured co-benefits delivered by NBS (biodiversity or ecosystem services). Background materials for calculations: COCITY (2018); City of Helsinki (2013; 2014; 2015; 2017; 2018; 2019; 2020a, 2020b; 2021a, 2021b); HSY (2016; 2018)

The GAFD was used to calculate the change in the value of ecosystem services in relation to two different factors: 1) the increase in NBS surface area (variation between 1a and 1b and variation between 2a, 2b and 2c); and 2) the change in the quality of NBS (variation between 1 and 2a and variation between 1 and 2b).

The resulting green area factors are able to articulate that as the surface area producing ecosystem services increases, the amount of produced ecosystem services also increases. There is a significant difference between scenarios 1a and 1b (0.59 units), between scenarios 2a and 2b (1.04 units) and scenarios 2a and 2c (1.06 units). This increase is mostly explained by expanded vegetated roof surface areas, which have a particular impact on habitat provision, noise reduction, and pollination services.

Another result is the improvement of green factors as the quality of NBS is increased. The qualitative difference is moderate between scenarios 1a and 2a (0.1 units), but significant between scenarios 1b and 2b (0.55 units). The impact on ecosystem services provision can be detected, especially in the categories of health and recreation and pollination.

These results reflect alterations in design such as the use of more diverse vegetation and stormwater management structures on streetscapes and the creation of environments suitable for pollinators in scenarios 1b and 2b. However, it is important to point out that the ecosystem services produced by the different scenarios were not evenly distributed; for example, there was a strong emphasis on noise reduction or pollination in some scenarios. Scenarios 2b and 2c had a strong emphasis on pollination because pollination-friendly vegetation made up 20% of the area of the vegetated roofs. This vegetation enhances local biodiversity, stormwater management, and noise reduction. On the case site, there were many large and busy streets and a railway, creating a need for noise reduction that vegetated roofs could offer. In particular, in scenario 1b, the vegetated roofs were assumed to be quite shallow, decreasing the productivity of analyzed ecosystem services (pollination, biodiversity, and stormwater management) other than noise reduction.

3.2 Stormwater Modeling

All scenarios had an impact on the modeled water quantity. The values for peak flow, total outflow volume and flooded volume and their relative changes compared to scenario 1a are displayed in Figs. 6, 7 and 8. Total runoff and flooded volume were reduced in all rainfall probabilities. Generally, the highly green-buffed scenarios 2b and 2c were best at reducing water volume, followed by the extensive vegetated roof scenario in 1b, followed by scenario 2a. Only for the 100-year rain condition did scenario 2a outperform 1b for total outflow, referring to the ability of NBS combinations to delay large water masses better than simple large-scale vegetative roofs that would be filled with water in heavy rain situations.

For peak flow (Fig. 6), the proportional differences between the scenarios decreased with increasing rainfall severity. With the 100-year return period rain event, the differences between scenarios 1a and 2a were practically non-existent, and even the extensive vegetated roofs produced only less than a 10% reduction for peak flow. The ability of street NBS (scenario 2a) to reduce peak flow was limited for less severe rainfall events, while scenarios 2b and 2c produced peak flow reductions of up to 46%. On the other hand, for less severe (10-year) rainfall events, the reduction of peak flow in scenario 2b was higher than the summed reduction in scenarios 1b and 2a.

For the total runoff amount (Fig. 7) and node flooding (Fig. 8) the differences were more pronounced between the scenarios. Scenario 2a decreased runoff by 13–14% and scenarios 2b and 2c decreased runoff by 32–53% for all rain events. Regarding the total runoff in the

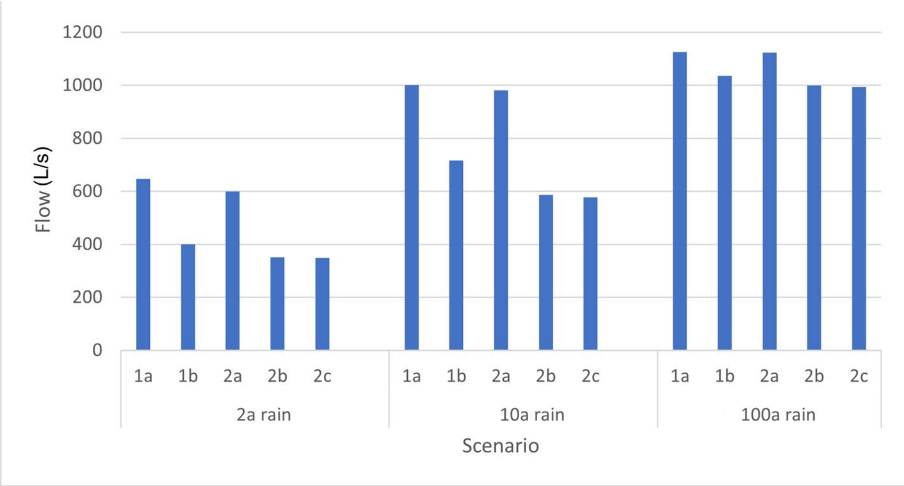

Fig. 6 Peak flow at the downstream end of the modeled catchment for the modeled scenarios and rain events. Background materials for calculations; Climateguide.fi (2014), City of Helsinki (2013; 2014; 2015; 2017; 2018; 2019; 2020a, 2020b; 2021a, 2021b); HSY (2016; 2018)

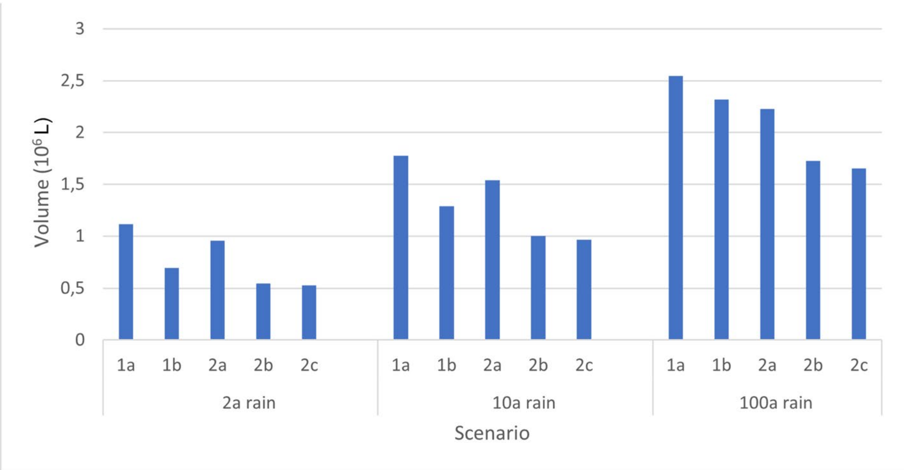

Fig. 7 Total runoff volume at the downstream end of the modeled catchment for the modeled scenarios and rain events. Background materials for calculations; City of Helsinki (2013; 2014; 2015; 2017; 2018; 2019; 2020a, 2020b; 2021a, 2021b); HSY (2016; 2018)

model, it should be noted that the amount of water that overflowed from the stormwater inlets was assumed to leave the system and not pool over the inlets. If the flooded water were fed back into the stormwater network, when the capacity allowed, the differences between the scenarios would increase for those instances where node flooding occurs. This would also change the order of "goodness" of the scenarios in the 100-year rain event to be more similar to the peak flow results. This decision to disable node ponding has a much smaller effect on the runoff peak, and for this reason, the runoff peak was used as a

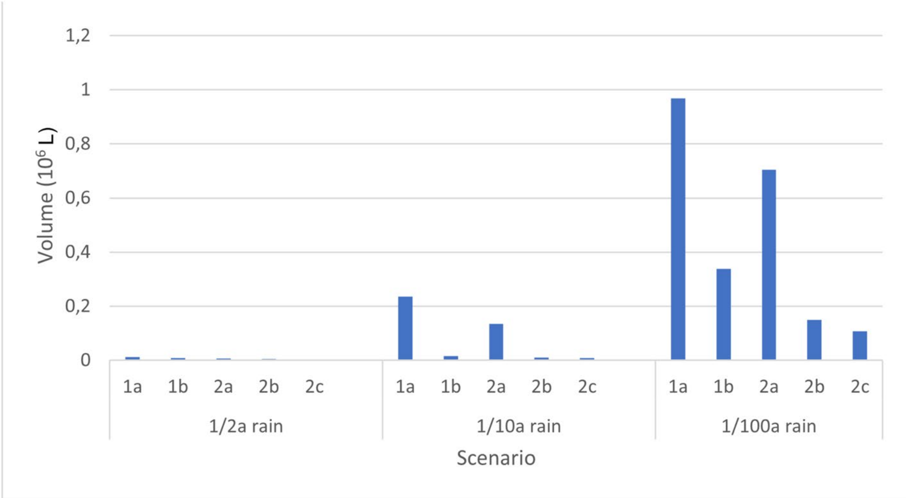

Fig. 8 Total flooded volume from nodes (manholes) in the modeled catchment regime for the modeled scenarios and rain events. Background materials for calculations; Climateguide.fi (2014), City of Helsinki (2013; 2014; 2015; 2017; 2018; 2019; 2020a, 2020b; 2021a, 2021b); HSY (2016; 2018)

reference point when inspecting the correlation of the green factor with stormwater modeling. Peak flow also showed the least variability in the results among the three metrics when running the model with varying input parameters for land use and LID-structures.

Node flooding practically does not occur during a 2-year rain event during the recurring rain condition. This is expected since this is within the normal planning capacity of a traditional stormwater network. A clear improvement was observed in node flooding between scenarios 1a and 2a for the other rain events. Extensive vegetated roofs are also able to prevent flooding better than street biofiltration basins, and the combined scenarios 2b and 2c eliminate node ponding flooding very efficiently for the severest rain events.

3.3 Comparison of GAFD and Stormwater Modeling

Using the results from both the Green Area Factor for Districts (GAFD) analysis and the Storm Water Management Model (SWMM) modeling, we were able to perform a comparative analysis, to shed light on the relationship between these two approaches. Figure 9 serves as a visual representation of this comparison: the GAFD results are displayed along the vertical axis, and the peak flow, measured in L/s (10-year return period rainfall), is depicted on the horizontal axis.

The pattern observed in Fig. 9 underscores the significance of this comparative analysis. The scenarios are linearly aligned, which agrees with our expectations. This alignment highlights a critical finding: scenarios characterized by a high green factor (as seen with 2c and 2b) exhibit a remarkable ability to curtail peak flow, resulting in a significantly reduced risk of flooding. Conversely, scenarios featuring a low green factor (such as 2a and 1a) struggle to manage stormwater effectively, ultimately leading to a substantially higher peak flow and an increased flood risk.

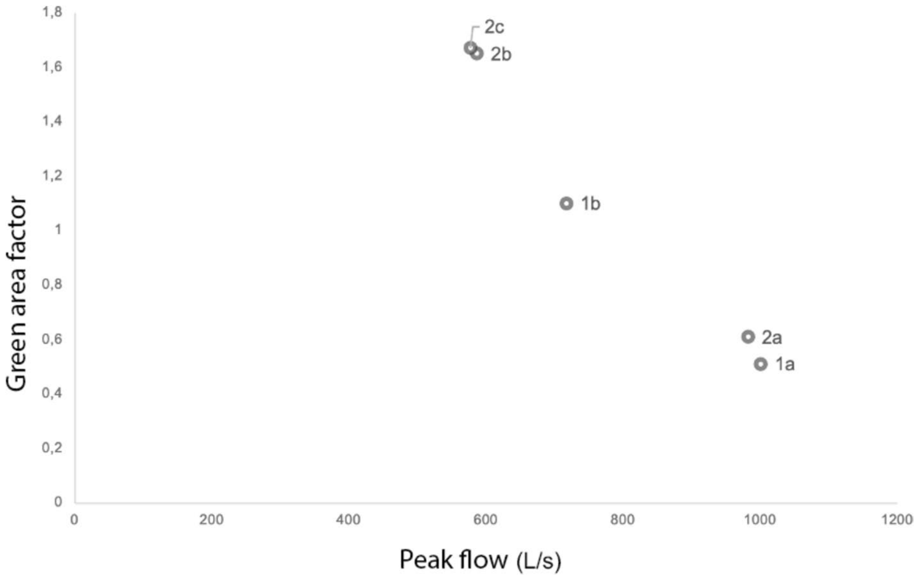

Fig. 9 Comparison of GAFD results on the vertical axis and SWMM results (peak flow from 10-year return period rainfall) on the horizontal axis

Scenario 1b, which is characterized by a moderate green factor, demonstrates an intermediate capacity for water management. This finding suggests that the green factor plays a pivotal role in determining the effectiveness of stormwater management. Additionally, it underscores the importance of finding a balance between green and built elements within urban planning to achieve optimal flood risk reduction.

Peak flow was selected as the key metric for evaluating the correlation between stormwater modeling and GAFD. This choice was motivated by the observation that peak flow exhibited the least variability in the results across various model settings and input parameters. This stability in the peak flow metric reinforces its reliability as a means of assessing the relationship between these two vital tools, strengthening our understanding of their interdependence in the context of urban planning and flood risk mitigation. A mediocre 10-year rain event was used in the comparison because the differences between scenarios were less visible in the 100-year rain events.

4 Discussion

4.1 Comparison of GAFD and SWMM Results

In this article, we employed both the Green Area Factor for Districts (GADF) and SWMM to assess the impact of NBS on stormwater management in urban areas. By comparing the results of these two methods, we addressed a gap in urban planning and NBS integration, offering a new approach to assess the co-benefits of NBS. This research enhanced our understanding of the multifunctionality of urban green spaces, justified NBS investments, and provided insights into achieving a balance between climate mitigation and adaptation in urban development, as demonstrated in the Malmi district case study.

Two sets of scenarios were studied: scenarios 1 and 2, each with a, b, and c versions. In scenarios 1a and 1b (business as usual), land use remains largely unchanged, featuring decked yard areas, parking underneath, and biofiltration basins. Scenario 1b adds vegetated roofs. In contrast, scenarios 2a, 2b, and 2c prioritize ecosystem services. They lack a Viikki-Malmi expressway reservation, enhance green areas, and use sustainable drainage systems. Yards are on the ground in 2a and 2b with thicker soil, more diverse plants, and biofiltration basins. The GAFD was used to calculate the change in the value of ecosystem services for each scenario in relation to two different factors: 1) the impact of a NBS surface area increases; and 2) the impact of increased quality of NBS. In addition, the SWMM was used to calculate the values for peak flow, total outflow volume and flooded volume for each scenario.

Based on these analyses, it can be concluded that the addition of NBS in urban areas has a positive impact on the production of ecosystem services and stormwater management. The green factor values calculated for each scenario showed the self-evident fact that as the area producing ecosystem services increased, the amount of ecosystem services increased. In particular, the addition of vegetated roofs in scenarios 1b, 2b, and 2c had a significant impact on habitat provision, noise reduction, and pollination services.

All scenarios had an impact on the modeled water quantity, but the highly green-buffed scenarios 2b and 2c were best at reducing water volume, followed by scenarios 1a and 2a. The differences between the scenarios decreased with increasing rainfall severity. For less severe rainfall events, diversifying NBS can improve peak flow reduction more than only having vegetated roofs or street NBS. For total runoff amount and node flooding, the differences were more pronounced between scenarios, and scenarios 2b and 2c decreased runoff by 32–53% for all rain events. The superiority of scenario 1b over 2a is most likely due to the manifold area of vegetated roofs (0.348 ha) compared to the street NBS (0.043 ha), as Fiori and Volpi (2020) also noted that the area covered by NBS impacts their effectiveness.

As seen in both the GAFD and SWMM results, having varied NBS that are distributed more broadly in the catchment increases the overall performance for both urban water management and the provisioning of ecosystem services. Similar results have been produced by Oral et al. (2021) for the maintenance of urban water balance with NBS. Prior research by Fiori and Volpi (2020) revealed that the effectiveness of NBS for urban flood management depends on several factors, most notably the area they cover, their distribution within the catchment and their hydraulic properties. Different NBS installed in different locations of the runoff path all retain water in different ways, which leads to attenuated and delayed runoff peaks, compared to only focusing on a single solution such as vegetated roofs. In this study, the optimal distribution of NBS for water retention was not considered in the planning of the scenarios, and flood management could be improved by more careful consideration of the NBS and catchment properties (Fiori and Volpi 2020; Hadi Pour et al. 2020).

The comparison between the results derived from the GAFD analysis and the various rainfall scenarios simulated using the SWMM reveals that GAFD appears to exhibit a stronger alignment with the outcomes of less severe rain events, specifically those corresponding to the 2-year and 10-year return period events. This suggests that GAFD is particularly effective in capturing the impact of NBS on stormwater management when dealing with relatively moderate rainfall conditions.

However, as we move towards more extreme rain events, such as the 100-year return period event, the distinctions in the stormwater modeling results between different scenarios become less discernible. This phenomenon can be attributed to the sheer volume of water involved in such severe weather events, which can overwhelm the capacity of NBS to provide substantial flood mitigation. This observation aligns with prior research findings indicating that NBS excel in addressing pluvial flooding during common rain events but face limitations in coping with short-duration, heavy rainstorms (as highlighted by Huang et al. 2020).

It is worth noting that urban drainage networks are typically designed to manage rainfall events within a certain magnitude, usually ranging from 2- to 30-year return period events. Therefore, it is a positive aspect that performance of GAFD is in line with general planning guidelines for urban water management. However, it is important to acknowledge that these infrastructure design guidelines can be subject to revision as climate scenarios evolve, flood risk assessments are updated, and adaptation measures are refined. This underscores the need for ongoing evaluation and adaptation of urban planning strategies to address the evolving challenges posed by climate change and urbanization.

4.2 GAFD and Urban Planning

The research question concerning how potential synergies between water management goals and other ecosystem services-related benefits created by NBS can be measured is refined by the goal of determining the differences between accurate stormwater modeling methods and an overall ecosystem services analysis, and their potential benefits for urban planning. Given that the GAFD is a tool designed for early-stage urban planning, its alignment with more common rain events is appropriate.

Furthermore, in infill construction areas such as Malmi, it is very costly to increase the capacity of the drainage system to accommodate increased runoff from newly added impervious surfaces or due to climate change. Huang et al. (2020) recommended combining the existing gray infrastructure with contributing NBS in different alternative combinations and evaluating their performance. The GAFD can serve as a valuable tool for water management during the initial phases of urban planning. Clear advantages of the GAFD for urban planning include its simpler data requirements, lower expertise required compared to the SWMM modeling, and delivered additional results (overall ecosystem services knowledge), thereby addressing the criteria outlined in previous studies for a comprehensive approach to assessing NBS benefits (Viti et al. 2022; Kourtis et al 2021; Alves et al. 2019).

The comparison of scenarios highlights the significance of transport connections and parking facilities for the availability of space for NBS. Organizing parking in separate buildings and saving space for ground-based vegetation increases stormwater retention capacity and other ecosystem benefits compared to decked surfaces or paved parking areas. While previous studies (e.g., Simperler et al. 2020) have considered the role of settlement structures, their approaches could be strengthened by an analysis of the transport systems and their land use.

Infill development typically increases the gradient of disturbance in the area, limiting the amount of applicable NBS and emphasizing the reliability of solutions and environmental security (Krauze and Wagner 2019). In densified areas, NBS can be introduced as new green elements or systems, such as the introduction of vegetated roofs in the scenarios display. However, as noted by Krauze and Wagner (2019), this requires integrated planning and careful consideration of NBS from the early stages of the planning and design process.

Our results indicate that the GAFD is particularly good at identifying changes in the surface area of NBS. Thus, it is an especially functional tool for testing design principles and alternatives in the urban planning process. Its special advantage is its holistic perspective: it produces a sufficiently accurate picture of the co-benefits produced by the various alternatives with reasonable effort and simultaneously time increases the understanding of NBS multifunctionality. However, in terms of water management solely, the results produced by the GAFD are only indicative and for accurate planning, measurement purpose-built modeling tools, such as the SWMM are still needed. The benefits of the SWMM include its ability to accurately portrait the catchment land cover and drainage network and acquire precise knowledge of the stormwater management capabilities of the area. However, the SWMM requires a great amount of background information and workload to create a model. Therefore, it may not be a cost-effective solution in the early stages of urban design, where multiple possible future situations are compared.

Both the GAFD and SWMM are based on the examination and scoring of land areas. Examined land units can be very detailed and have different characteristics. Focusing on land areas makes it easy to connect calculations to urban planning and to use spatial planning data in the assessment. NBS are included in the examination by coding land areas with certain NBS parameter values. The creation of NBS alternatives through the modification of areas and their characteristics is easy, and the impacts of alternatives can be seen on the level of the whole area, which is practical in planning. The definition of parameter values significantly affects the results, which is important to note during interpretation.

4.3 Limitations

Although the GAFD can recognize the multifunctionality of a green structure and present it in a clear form, the method also has limitations and uncertainties. Some of the limitations concern the incompleteness of the method regarding its non-standard calculation method and some of the data used in the calculation. These shortcomings reduce the reliability of the method. The interpretability of elements is affected by the non-standard calculation method: users of the tool should value similar areas in the same way, but currently, the method leaves too much room for subjective interpretation. In addition, there is not enough research to determine minimum green factor levels for different types of areas. Therefore, it is not possible to state what a sufficient green coefficient would be for a certain type of area.

Another limitation is that geospatial data are not always up-to-date. In addition, geospatial data can differ in their accuracy; for example, there is considerably less information on private plots than on those owned by the city. Due to the lack of geospatial information, field visits were used as supplementary sources of information in the case study, which made it possible to obtain valuable information about the quality of green structures. However, the data produced in this way are not absolute but based on assumptions. Consequently, there are not necessarily comparably accurate data for the calculation of surface area or quality of the elements of the green factor. Furthermore, geospatial data is produced for a specific purpose, and the data needed for the GAFD calculation is not always directly available, instead, it must be produced by modifying existing data. This increases the uncertainty of the calculation and also imposes additional research needs.

One can also discuss how the differing analyses area has affected the results, because SWMM model follows a catchment area and GAFD analysis was larger to ensure sufficient extent of analysis. Verifying whether the slight size difference of the analysis areas affects the results of the comparison, for example for the alignment shown in Fig. 9, would require further research.

5 Conclusions

In conclusion, the comparison of the Green Area Factor for Districts (GAFD) and Storm Water Management Model (SWMM) results provides valuable insights into the potential synergies between water management goals and ecosystem services provided by Nature-Based Solutions (NBS) in urban areas. The findings demonstrate that the addition of NBS can have a positive impact on the production of ecosystem services and stormwater management. To implement NBS and increase the climate resilience of urban environments, a tool that can evaluate the qualities of existing or future green structures is needed.

When comparing the results of the GAFD and different rainfall scenarios in SWMM, it was clear that the GAFD is better aligned with less severe rain events, while its efficiency is limited in short-duration very heavy rainstorms. Nevertheless, GAFD serves as a useful tool for early-stage urban planning, aligning with general guidance for urban water management and allowing for the evaluation of different NBS combinations and their performance.

The calculated green factor values for the different scenarios clearly indicate that as the surface area of NBS increases, the amount of ecosystem services also increases. Specifically, the inclusion of vegetated roofs in certain scenarios significantly influenced habitat provision, noise reduction, and pollination services. Moreover, diversifying NBS proved to improve peak flow reduction compared to relying solely on specific NBS elements such as vegetated roofs or street NBS.

The superiority of scenarios with varied NBS distributions over single optimized solutions highlights the importance of combining multiple NBS to enhance system resilience and overall performance in urban water management and ecosystem service provisioning. The effectiveness of NBS is influenced by factors such as their surface area, distribution within the catchment, and hydraulic properties. Therefore, careful consideration of NBS and catchment properties is necessary for improved flood management and provision of ecosystem services.

Additionally, the availability of space for NBS, particularly in relation to transport connections and parking facilities, plays a significant role in their performance. Organizing parking in separate buildings and preserving ground-based vegetation can enhance stormwater retention capacity and ecosystem benefits. Furthermore, integrated planning and early-stage consideration of NBS are crucial in densified areas.

Despite its advantages as an urban planning tool, the GAFD also has limitations and uncertainties. These include its non-standard calculation method, the subjective interpretability of elements, incomplete data, and inaccuracies in geospatial information. Addressing these limitations and conducting further research are necessary to enhance the reliability and applicability of the GAFD in urban planning and to determine appropriate green factor levels for different types of areas.

In conclusion, the comparison of the GAFD and SWMM results highlights the importance of diverse NBS combinations, the multifunctional nature of green infrastructure, and the need for integrated planning in urban areas. By recognizing the potential synergies between water management goals and other ecosystem services and addressing the limitations of current methods and data, urban planners can effectively utilize NBS to create sustainable and resilient cities.

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Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing Interests None of the authors have any competing interests.

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Authors and Affiliations

Elisa Lähde[1] · Niklas Dahlberg[2] · Paula Piirainen[3] · Antti Rehunen[2]

[1] Department of Architecture, School of Arts and Design, Aalto University, Helsinki, Finland

[2] Built Environment Solutions Unit, Finnish Environment Institute, Helsinki, Finland

[3] Centre for Economic Development, Transport, and the Environment, Tampere, Finland