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Urban planning methods for climate adaptation – using the Green Factor tool

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Abstract

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Abstract

The thesis work studied the reasons for implementing green infrastructure in urban planning and evaluated the Green Factor of two city blocks in Järvenpää, Finland. A literature review was conducted on green infrastructure, nature-based solutions and green infrastructure tools. This included a review on regulations guiding modern zoning in urban areas and on to the effects of implementing green infrastructure into urban areas.

The second part of the work included using the Green Factor tool on two separate city blocks. The objective was to establish the Green Factor baseline for the city blocks and then propose ways to elevate the factor. This included evaluating the usability and practicality of the propositions. The second part included on-site observations, using map tools, comparing zoning plans and lastly, using the Green Factor tool.

The result of the thesis reinforces the practice of using green infrastructure tools in the planning phase of rezoning urban areas, but sheds light on the many-sidedness of using the tool in urban planning.

Keywords

green infrastructure, nature-based solutions, green factor tool, climate adaptation

Contents

1 Introduction

Human-caused climate change has many negative impacts, including damage to people, ecosystems, infrastructure, water and energy availability, food security as well as economy and public health. The rising temperatures expose European cities to extreme heat, droughts and floods, causing changes in precipitation patterns. Many cities and municipalities are implementing adaptation plans to deal with climate risks and promote climate resilient development. (Bednar-Friedl et al. 2022.) However, cities and municipalities are facing another challenge alongside climate change - urbanisation.

Urbanisation is a socio-economical process that converts rural areas into urban habitations. It also rearranges the population distribution from rural to urban areas. This alters the demographic and social structure of both areas. Urbanisation causes changes in land use and population size of urban settlements. (United Nations 2019, iii.) Europeans are increasingly moving to populous cities and coastal areas, with the urban population projected to increase to 84 per cent in 2050 from the 74 per cent in 2015. This means 77 million new urban dwellers. (United Nations 2018, according to Bednar-Friedl et al. 2022.) As the population shifts to urban areas and climate change alters the intensity of precipitation, urban areas are more inclining to floods, extreme heat and other adverse effects of climate change. For people to move to cities, more infrastructure needs to be built. This means changes in land use.

The several types of changes to land-use such as deforestation, intensive monoculture and urbanization, as well as direct exploitation like hunting and overfishing, joined with human-caused climate change and pollution are the effects of the growing population. This contributes to diversity loss. Ecosystem health provides people with essentials for survival such as fresh water, clean air, quality soil and crop pollination. Ecosystems have a significant role in fighting climate change and helping in adapting to its effects. (European Parliament 2020.) To acclimate to climate change, urbanisation and diversity loss, different kinds of rehabilitative and restorative measures need to be adopted. Implementing nature-based solutions may help to create green infrastructure in urban areas.

An angle of multifunctionality in developing urban green spaces can address challenges of urbanisation, protect and improve biodiversity and help in adapting to climate change. This can be achieved with implementing green infrastructure in the planning (Pauleit et al. 2019, 1). In Uusimaa in Finland, built environment needs green infrastructure that can, for example, retain and delay waterflows to prevent flooding. This counterbalances the effects of dense infrastructure development. (Virtanen 2023, 103.)

In this thesis a look is taken into the framework behind implementing green infrastructure. The effects of applying green urban infrastructure to alleviate the effects of climate change, urbanisation and diversity loss is also examined. There are different kinds of tools that measure current situation and help in implementing the principles of green infrastructure in urban planning. Some of those tools are examined in this thesis and a closer look is taken into one, the Green Factor tool. Cities and municipalities can use the Green Factor tool to improve climate change adaptation in urban planning. This is done by promoting the green efficiency of vegetation on city plots, and by maintaining adequate green cover (Integrated Stormwater Management a). It is a way to assess and develop plans to build climate resilient urban areas (Integrated Stormwater Management a). The tool supports and guides in the design of green spaces and stormwater management (Kymenlaakson liitto 2023, 13).

This thesis aims to provide the city of Järvenpää with some insights into the impacts of climate change and the other presented phenomena on a general level, increase climate awareness and present a case for using different tools to aid urban planning.

2 Background of the thesis

2.1 Objectives

The objective of this thesis is to explore urban green infrastructure as part of a solution to changes posed by climate change, urbanisation and biodiversity loss in a general level. The second objective is examining a selected tool created for green infrastructure as a method of designing urban areas. The third objective is to consider the results from using the tool. Although this includes nature-based solutions as local implementation methods for different challenges, this thesis focuses on the tool that the city can use to evaluate the implementation of those nature-based solutions.

The thesis is done for the city of Järvenpää with the guidance and cooperation of LAB University of Applied Sciences. The overarching goal of this thesis is to provide the decision makers and urban planners in the city of Järvenpää insights into the alternatives regarding planning for climate change resilience, biodiversity loss and urbanisation. This particularly includes tools that aid in urban planning.

Besides the literature review focused on green infrastructure, nature-based solutions, and a green infrastructure tool, an on-site observation is conducted on the case city blocks to make the measurements for the selected green infrastructure tool. The thesis explores the usability of the selected green infrastructure tool and a proposition on how to have better scores to better respond to the effects of climate change.

2.2 Methodology

Literature reviews are evidence-based analysis of the chosen subject. The goal of the literature review is to be informative, unbiased collection of current information. This includes conflicting findings and inconsistencies. The aim is to synthetize research findings and propose development proposals on the subject. (Efron & Ravid, 2019, 2-3.) The research method for this thesis is the literature review. It provides an overview of the current state of the topic of green infrastructure to address the issues connected to climate change, urbanisation, and biodiversity loss.

Keywords are chosen so that conducting the literature review becomes possible. After deciding on the keywords, several searches were conducted in academic search databases. The keywords chosen for this thesis were green infrastructure, green infrastructure tool, nature-based solutions, ecosystem services, climate change, and urbanisation. Several searches in LAB Primo, EBSCO databases and Google Scholar were conducted using different combinations of the keywords. Articles, internet sources, reports and books relevant to the thesis were considered and the results are presented in the thesis.

The second part of the thesis is about examining different tools that can be used to help cities implement nature-based solutions and, therefore, green infrastructure, into their urban planning. A closer look is taken at using the Green Factor tool. In Järvenpää, Finland, there are two city blocks that were chosen as a case study for this thesis. Melodiapiha -city block and Virastotalo -city block are observed and measured using measurement tools. The measurement results are then applied to the pre-existing Järvenpää Green Factor tool. This gives a score which indicates how well the area can respond to stormwater management, the development of amenity of residential areas and possibilities of strengthening biodiversity. The results are then compared to the Järvenpää city targets for the Green Factor in different city blocks and plots, and methods to make that score better are evaluated.

3 Concepts regarding sustainable urban environment

3.1 What is green infrastructure?

The European Commission (2013a, 3) defines green infrastructure as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces, (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings."

Nature and natural processes can be protected and enhanced by incorporating green infrastructure to urban planning. On the other hand, nature provides numerous ecosystem services to people, and with green infrastructure those services can be protected and utilised. (European Commission 2013a, 2.)

Grey infrastructure refers to the buildings and utilities, and transportation infrastructure such as roads, railways and metros that define the layout of the city. Without green infrastructure being integrated with it in urban planning, grey infrastructure causes sealing of the soil, fragments the natural systems, increases pollution caused by mobility, and intensifies the consumption of materials and energy. (European Environment Agency 2015.)

There are also other terms for green infrastructure that should be mentioned. In the United Nations Environment Programme (2022, 9-10) green infrastructure is called sustainable infrastructure. It refers to systems that are planned, designed, constructed, operated, and decommissioned to ensure economic, social, environmental and institutional sustainability. Sustainable infrastructure includes grey infrastructure, natural infrastructure or the combination of both, hybrid infrastructure. Hybrid infrastructure or grey-green infrastructure uses natural infrastructure as a complement to the built infrastructure or incorporates natural infrastructure elements into built environments. For example, a green roof is one of these elements. (United Nations Environment Programme 2022, 10.)

Sometimes the terms natural infrastructure and environmental infrastructure are also used in place of green infrastructure. Natural infrastructure is used to refer to the network of natural lands such as wetlands and forests that conserve and enhance ecosystem value and functions while providing benefits to people. Roy (2018) states that natural infrastructure can be naturalized or naturally occurring, while also targeted and managed by humans. It also provides benefits for people, such as climate resiliency. In the United Nations Environment Programme (2023, v) the term nature-based infrastructure is also used to mean green infrastructure. It refers to all ecosystems, including city ecosystems, that are strategically designed and governed to provide services to different infrastructure sectors, while benefitting people and biodiversity (United Nations Environment Programme 2023, v).

There is also the term of climate resilient infrastructure that is defined as planned, implemented and managed infrastructure that is designed to prepare for and adapt to developing climate conditions. It also constitutes of built, natural and hybrid infrastructure and enabling environment. (Organisation for Economic Co-operation and Development 2018, 4.)

To conclude, green infrastructure appears as an umbrella term for a multitude of definitions that are close to one another in terms of sustainability in urban development. These terms describe the different aspects of the same phenomenon. The type of green infrastructure keyword depends on the context and focus of what is studied. If the focus is more on the ecosystem, perhaps the term nature-based infrastructure is more viable. In this thesis the term green infrastructure is used at its most general level. How it mitigates the effects of climate change and contributes to sustainable urban development are considered as universal. Green infrastructure as a term could also refer to natural area-network outside of urban areas. In this thesis, the approach is focused on green infrastructure in urban areas and the European Commission definition of the term is applied.

3.2 Green infrastructure provides ecosystem services

Ecosystem services are internationally defined as ecosystems that contribute to human well-being. These services contribute to the economic benefits and benefits towards different types of human activities. The United Nations System of Environmental Economic Accounting or SEEA for short, categorises these services into three types. Extracting or harvesting from ecosystems is called provisioning services. Ecosystems that regulate biological processes and thus influence things such as climate or hydrological cycles, are called regulating and maintenance services. Lastly, services that contribute to aspects such as health, recreation and cultural rituals are called cultural services, and these are experiential and intangible aspects of ecosystems. (Biodiversity Information System for Europe a.)

As such, ecosystem services provide urban areas with several benefits, from regulating stormwater runoff and flows to regulating the micro-climate of the city, to moderating environmental extremes that are caused by urban heat island phenomena to decreasing noise pollution among other advantages. Ecosystem services also provide spaces for recreation and aesthetic qualities for those spaces, alongside many immaterial benefits essential to human and societal wellbeing. (Gómez-Baggethun & Barton 2013; Elmqvist et al. 2016, according to Geneletetti et al 2020, 3.)

The aspects that ecosystem services provide for urban areas can be called urban ecosystem services.

3.3 Nature-based solutions

The United Nations Environment assembly of the United Nations Environment Programme (2022, 2) declares that nature-based solutions are “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, resilience and biodiversity benefits”. Thus, nature-based solutions are the ones that contribute to both the benefits of people and biodiversity. The declaration continues further to recognize that nature-based solutions have consideration to social and environmental safeguards of e.g. local communities; can be enforced and adapted to local, national and regional details while being consistent with the Sustainable Development Agenda of 2030; are one of the ways to reach the 17 United Nations Sustainable Development Goals, and lastly; can drive sustainable innovation and scientific research (United Nations Environment Programme 2022, 2).

Castellar et al. (2021) in their research regarding nature-based solutions in urban context note that there is a lack of agreement about the definition of nature-based solutions and their specific characteristics. They point out that the model of the nature-based solutions concept does not distinguish it from concepts such as the before mentioned green infrastructure, or urban green space, or ecosystem-based adaptation, all of which nature-based solutions share elements with. Different sets of nature-based solutions are evaluated from the point of view of urban challenges or ecosystem services, which makes defining nature-based solutions more complicated.

Castellar et al. (2021) discuss what it takes to be considered a nature-based solution. They point out that since ‘nature’ is a keyword in the concept, the solution should have a presence of vegetation and employ nature. The solution should also be non-intensive in terms of resources, and the solution should occur in nature. Castellar et al. (2021) noted in their research that nature-based solutions are often regarded as ‘green’ and has it or a related term coined in the name of the solution. However, this element eliminates solutions such as biofiltration through natural porous material and they present an example of a filtration trench. Filtration trenches are often used for sustainable urban drainage, but the requirement of being ‘green’ and implementing vegetation eliminates them from being considered a nature-based solution.

With this in mind, Almenar et al. (2021, 2) point out that nature-based solutions are increasingly being proposed as support for sustainable and resilient urban development. However, this requires the context of the local environment and circumstances regarding the social and economic context, ecosystem services and urban conditions and challenges to be viable.

To conclude, nature-based solutions offer some ways to build urban green infrastructure. However, there are some reservations to consider when doing so. In the other hand, nature-based solutions can lead to creating ecosystem services. These concepts provide solutions to the issues growing cities face today with climate change, urban challenges, and biodiversity loss.

3.4 Framework for sustainable and green urban development

3.4.1 European Union framework

In 2013, the European Union Adaptation Strategy came into effect. Climate resiliency in Europe is the goal of the strategy. It promotes adaptation actions by the member states, provides funding to increase the adaptation capacities and action taking. The strategy aims to improve climate-proofing in the European Union by promoting adaptation in the sectors most prone to vulnerability. The strategy also promotes informed decision making by developing the European climate adaptation platform to address the gaps in knowledge on the subject. The strategy promotes nature-based solutions in urban green spaces to build climate resiliency. (European Commission 2021a, 4-11.)

The European Union Green Infrastructure Strategy was also adopted in Europe in 2013. Its aim is to promote usage of green infrastructure in both rural and urban areas. To further use green infrastructure in Europe, there are two areas that are addressed by the Green Infrastructure strategy: promoting investments in green infrastructure and promoting the knowledge base on it. The Green Infrastructure Strategy complements the European Union Biodiversity Strategy for 2030 by prioritising, restoring and promoting green infrastructure in urban development. (European Commission 2013b, 2-8.)

European Union Biodiversity strategy for 2030 is a bold, comprehensive plan to protect nature. It aims to reverse ecosystem degradation. It aims to grow existing Natura 2000 areas and thus establish large networks of protected areas on land and sea. The biodiversity strategy for 2030 includes the promotion of urban ecosystems. It also focuses on areas with high biodiversity and capability for carbon sequestration and reducing natural disaster impact. (European Commission a.)

The European Union Biodiversity strategy 2030 is part of the Green Deal. Green Deal notes that nature restoration is part of the strategies to mitigate and adapt to climate change. It also promotes nature restoration integration into urban planning. One of the key investment areas of the Investment Plan for Europe in the European Green Deal is sustainable infrastructure, and 30% of the investments are to be dedicated to climate related challenges (Fetting 2020, 7-8).

It is pertinent to mention the European Climate Law: it makes Green Deal goals legally binding. It entered into force in 2021 and obligates the European Union member states to aim for net zero greenhouse gas emissions by 2050. The law affirms that all sectors of economy, for example waste and land use, land-use change, forestry and buildings, should advance achieving climate neutrality by 2050. Carbon sinks are specifically mentioned in the law as essential to climate neutrality. It also mentions restoration of ecosystems as ways of maintaining, managing and enhancing natural carbon sinks and restoration of biodiversity. (European Climate Law 2021/1119, 2, 4-5.)

The European Unions' Nature Restoration Law is part of the EU biodiversity strategy. It entered into force in 2024. It sets binding targets to ensure the restoration of degraded ecosystems. In the European Union area, up to 81 per cent of habitats are in a poor state and one third of bee and butterfly species are in decline. Nature Restoration law obligates the European Union's member states to have binding restoration targets specific to species and habitats. The goal is to restore all ecosystems by 2050. This law specifically mentions urban ecosystems. By 2030, the green urban spaces and tree coverage should increase in their total area and there ought to be no net loss. (European Commission b.)

In the European Union policy domain, green infrastructure is also recognised in other areas. In the Eighth Environment Action Programme that came into force in 2022, the European Union legally agreed upon a common agenda for environment policy. The goal is to support the European Union in keeping within the planetary boundaries by 2050. It builds further upon the European Green Deal by aiming to speed up progress to climate neutrality and a resource efficient economy. It also recognises that healthy ecosystems heavily influence human health and prosperity. The eighth Environmental Action Programme forms the basis for the European Union to achieve the 2030 Agenda and the Sustainable Development Goals by the United Nations. (European Commission c.)

The Water Framework Directive is the main water protection law in Europe (European Commission d). In terms of urban planning, it ensures the integrated approach to water management. Accompanying it is the European Union Urban Wastewater Treatment Directive that aims to protect the environment and human health form the effects of untreated wastewater from urban areas. The Urban Wastewater Treatment Directive was revised in 2022 to include, among other things, the reduction of pollution and improved water quality by reducing urban wastewater pollution. (European Commission e.)

There are also adjacent directives that affect urban planning, such as the Birds Directive and the Habitats Directive. They are the basis of the European Union biodiversity policy. The Birds Directive provides framework for member states to protect biodiversity. Urban sprawl and transport networks affect and reduce birds' habitats, while pollution and inadequate building designs affect the bird population negatively. (European Commission f.) On the other hand, the Habitat Directive aims to protect countless species including mammals, fish, invertebrates, plants, and 230 specific habitat types. The objective is to protect the species and habitat types by maintaining and restoring them to a positive conservation status. (European Commission g.) The Habitats directive affect urban planning since urban planning may affect existing habitats. The Directive is also relevant when urban areas are rezoned.

To implement the laws and strategies from the European Union to the national level, the Urban Agenda of the European Union was established. The goal is to improve existing regulation to include urban areas and their challenges, to support and improve funding for the urban areas, and to share and develop knowledge on the matter. Priority themes include air quality, climate adaptation, culture and cultural heritage, sustainable use, and nature-based solutions. (European Commission h.)

The Kunming-Montreal Global Biodiversity Framework proposes measurable goals and targets that can be monitored, reported on and reviewed to track progress in reaching Sustainable Development Goals. (European Commission i.) From the urban development, biodiversity restoration and green infrastructure point of view, it is to ensure the global players have clear global targets to protect and restore nature while also removing pollution.

To conclude, in the European Union there are several different frameworks, laws and directives that have been developed to ensure that green infrastructure and nature-based solutions are implanted into urban planning. The main idea of the policies and strategies is to create recovery opportunity for biodiversity and to adapt and mitigate climate change effects. Some of the frameworks focus on nature restoration whereas others focus on incorporating green infrastructure and nature-based solutions into urban planning process. There is also an emphasis on research, innovation and funding to promote sustainability and resiliency of societies.

Green infrastructure covers a wide variety of areas and ecosystems. On the international level, having a framework that covers large geographical areas will give member states directive and incentive to protect and rethink the benefits of ecosystem services and biodiversity in their areas. There is also a need to have local policies and effectiveness measurement strategies so that the local circumstances and characteristics can be considered when aiming to protect the ecosystem services and biodiversity of each area. Arnolds and Gundersson (2013) according to Similä et al. (2017, 68) point out that there is need for flexibility in the regulatory framework as green infrastructure has a dynamic nature. There is need for adaptive framework, that can react to new information and changes in the social, economic, and ecological systems.

3.4.2 The Framework in Finland

On the national level, Finland does not have green infrastructure as a construct implemented in the national legislation. However, there are different kinds of legislation regarding nature conservation, land use and resource exploitation which are relevant to green infrastructure. Finland does not have policy tools to enable a systematic and comprehensive development for green infrastructure. However, Finland has a wide and fragmented set of sectoral instruments that affect green infrastructure. The existing nature conservation instruments focus on protecting individual species and areas, but it is insufficient when it comes to protecting biodiversity and ecosystems. (Similä et al. 2017, 12, 32.)

In Finland, the focus is on the qualitative nature of green infrastructure. Finland is sparsely populated and Similä et al. (2017, 32) note that 88 per cent of the surface area of Finland is natural habitats. However, those natural habitats have been profoundly changed. Forestry has changed the structure of forests, drainage has changed peatland water management and living conditions, inland water habitats have changed due to water regulation and infrastructure. This is why in Finland the focus ought to be more in securing biodiversity and ecosystem services.

Similä et al. (2017, 33) also point out that due to the characteristic of Finland’s nature of having extensive lake systems, the term blue infrastructure should be separated from green infrastructure. Blue infrastructure is often directly included in the European Union Green Infrastructure strategies (European Commission j). The other notable characteristic of Finland is the population distribution. The population tends to be centralised in the south and southwest of Finland, an area with extensive biodiversity. In these population hubs, there is a tendency for dense urban structure. This in turn may threaten adaptation to climate change, and climate change mitigation strategies by green infrastructure.

As stated before, Finland does not have green infrastructure implemented in the national policy framework. However, there are many laws and regulations that affect biodiversity, ecosystem services and green infrastructure. The most central policies are the following:

- Land Use and Building Act 132/1999 of which the objective is ensuring building activities in land and water areas take into account favourable living environment while also promoting ecologically, economically, socially and culturally sustainable development. It also aims to ensure stakeholder rights to participate in the preparation process of those activities. The Act also aims to ensure the openness of information on the matters of and use. (Land use and Building Act, section 1.) Regarding stormwater management the chapter 13a has set objectives, but there is no mention of nature-based solutions as an option for stormwater management.
- The purpose of the Environmental Protection Act 527/2014 in terms of urban planning is to promote a healthy, ecologically sustainable and biologically diverse environment; to support sustainable development while also combatting climate change. The act applies to treatment and steering of urban wastewater, reducing noise in urban areas, as well as securing the health of environments. (Environmental Protection Act 527/2014, section 10, 11, 151.)
- The Water Act 587/2011 has the purpose of promoting, organizing, and coordinating the use of water resources to be socially, economically and ecologically sustainable, while also preventing and reducing the negative effects of water. Conveying wastewater is also mentioned in this act. (Water Act 587/2011 Chapter 1, section 1; Chapter 5, section 1, 2.) The Water act does not directly mention urban infrastructure, but conveying stormwater is mentioned, which affects urban infrastructure.
- There are also other acts, such as the Land Extraction Act 555/1981, the Act on Environmental Impact Assessment Procedure 252/2017 and the Act on the Assessment of the Effects of Certain Plans and Programmes on the Environment 200/2005 that pertain to green infrastructure in urban planning or the built environment in an indirect way, but they do not have a clear indication regarding green infrastructure elements in the built environment.

The region or city may have their own, more specific targets that include green infrastructure or nature-based solutions in their city planning. For example, the city of Järvenpää has a roadmap called Resurssiviisas Järvenpää, or resource-wise Järvenpää, that aims to guide towards a low emission city, where material waste is minimized, and natural resources are used consciously. One of the targets is protecting biodiverse urban nature. (Järvenpää 2019, 45.) This would include green infrastructure methods and possibly nature-based solutions.

3.5 Examples of the benefits of having green urban environment

3.5.1 Stormwater management with nature-based solutions in urban areas

More frequent and intense rainfall and storms, caused by climate change, may increase flooding, storm water runoff and soil erosion (European Environment Agency 2021). Alongside urban land-use that has created large impervious surfaces that prevent infiltration to the soil (European Environment Agency 2022a), and drainage systems built for bygone climate conditions (Kautto 2021, 7), the pressure on stormwater management is visible as floods, deterioration of infrastructure, and risks to the safety of people become more prevalent (Kondratenko, Kotoviča, & Reča 2021, 4, 11). In the Baltic Sea Region, which includes the entirety of Finland (European Commission l), heavier and more frequent rainfalls is anticipated (Keep.eu 2023). Urban stormwater runoff is a common source of water pollution in Europe, as the runoff transports pollutants to natural waterways (Müller et al. 2020). Urban areas rely on grey infrastructure stormwater management, which includes leading the water from impervious surfaces to underground sewers as fast as possible. As these drainage systems are often not designed for heavy rainfall and flooding, damage to infrastructure may occur. (Kautto 2021, 7.)

On the other hand, climate change is also causing more droughts. Every year in Europe, 30 per cent of the population is affected by water stress. Therefore, wastewater, rain and surface runoff, and flood water management should consider the many ways water can be used and valued. (Climate ADAPT 2023.)

The challenges that grey stormwater management faces in Water Sensitive Urban Design may be resolved by nature-based solutions that mimic the natural processes of the hydrological cycle (Climate ADAPT 2023). These include capturing the rainwater in its place of falling, reducing and treating the stormwater at its source, and using vegetation to avoid, decrease, convey, and slow down stormwater (Kautto 2021, 9).

Sustainable urban drainage system are impermeable structures that include soil and vegetation. The uptake and passage of water through the soil and vegetation reduce the water runoffs velocity, while also improving water quality with filtration. Having water permeable surfaces on places like footpaths and car-parking areas increase water absorption. Infiltration devices can be installed to allow direct drainage to the ground. Urban public spaces can be designed to hold excess water when it rains. Pressure on drinking water resources can reduce by harvesting water to non-potable uses. (Climate ADAPT 2023.)

As such, these stormwater management solutions may include implementing

- green roofs, green walls, and permeable surfaces as on-source management methods
- canals and rills, ditches and streams, bioswale as conveying systems
- detention and infiltration systems such as stormwater tree trenches and rainwater cisterns. Infiltration pits, rain gardens, filter strips, stormwater planters, infiltration basins, detention basins, ponds and wetlands can be used as well. (Kautto 2021, 9-10.)

The benefits of implementing nature-based solutions to stormwater management in urban areas is not only that the damage to infrastructure is reduced when the quantity of water is mitigated, but there are also ecological, social and economic positive impacts. Nature-based stormwater solutions may reduce noise pollution and urban heat island effect, which can enhance quality of life. Green roofs and green walls for example may insulate buildings, potentially reducing the need for cooling and heating and resulting in lower energy consumption. They also can benefit mental and physical health. (Kautto 2021, 11.) Other benefits may include reduced stress on water resources, enhanced recreational opportunities, enhanced wellbeing and aesthetic effect, and increased biodiversity. Sweden’s project to retrofit drainage system to include nature-based solutions with an EUR 22 million resulted in 50 per cent reduction in urban water runoff while also increasing biodiversity. (Climate Adapt 2023.)

The construction, planning and management of these solutions may result in higher total upfront costs. However, these is a reduction of negative impact on citizens and the buildings in the urban area. Furthermore, there is decrease of unexpected costs such as repairs when an extreme weather phenomenon affects the city. Rainwater fees are lowered when these aforementioned methods are implemented instead of traditional sewage systems. Cost-effectiveness of investments need to be estimated in the local context. They depend on the local climate and environmental conditions such as precipitation levels, the proportion of impermeable surfaces, density of the urban area, and economic factors such as the price of water. Size, technical complexity, and maintenance intensity also affect the total costs. (Climate Adapt 2023.)

Kautto (2021, 11) points out that in the Finnish context, the project TASAPELI aimed to evaluate nature-based solutions for stormwater management planning. In the project it was established that the main barrier for implementing nature-based solutions was in the regulations, governance, organisational interaction and planning practices, and that the political aspect had the most to improve in allowing a more sustainable approach to stormwater management. Implementing nature-based solutions requires a thorough, sustained cooperation between different actors in planning, implementation and funding, as well as a multidimensional and multidisciplinary approach.

3.5.2 Reducing urban heat island effect

Urban heat island effect is the effect of urban environments having a higher average temperature than the rural environs. Urban areas have physical aspects such as land use, urban morphology and construction materials that cause higher temperatures on surface and air. Anthropogenic heat contribution combined with meteorological conditions may also cause higher temperatures in urban areas. (Rizwan et al, 2008; Kleerekoper et al. 2012; Martin et al. 2015 according to Nastran et al. 2019.) This increased temperature not only effect the wellbeing of the inhabitants of the urban area by causing heat stress (Lafortezza et al. 2009 according to Nastran et al. 2019), it also causes issues for urban ecosystems (Luo et al. 2007 according to Nastran et al. 2019) while causing a rise in energy consumption (Rizwan et al. 2008 according to Nastran et al. 2019) and thus causing issues with pollution and social equity (Harlan et al. 2007, according to Nastran et al. 2019).

Increased urban temperatures may cause dehydration, heat-stroke and other physical effects (European Commission 2024). In 2023, over 47 000 people died in Europe due to heat related effects (Gallo et al. 2024). Air quality may also be reduced due to the pollution trapped by the urban heat island effect, and this may carry long-term health implications. These effects affect vulnerable and marginalised groups the most, such as low-income, homeless, children and elderly. Heightened urban temperatures not only affect the health of the urbanites, but it also affects the ecological footprint of the city by increasing energy demand. (European Commission 2024.)

There are several ways to alleviate the heat effect. In terms of green and blue infrastructure, the methods include introducing water elements and flowing water to public areas, promoting urban farming (European Commission 2024), as well as planting trees in urban areas, and having vegetation patches (Marando et al. 2022). Calfapietra (2020,15-16) notes that including green spaces in urban areas decreases wind chill effects in cold climates. For warmer climates, planted trees can reduce thermal discomfort by producing shading. Thermal stress can be reduced by increasing green areas and tree coverage, planting specific types of plants can affect urban heat island effect mitigation efficiency. Combining areas with dense street networks, dense square networks and small green spaces with areas with large green spaces reduce the urban heat island effect. There are other solutions, including green walls and roofs, and vegetated terrains. The narrower the street, the higher the urban heat island effect. Larger trees combined with blue spaces have an increased cooling efficiency.

The temperature difference between areas without green patches or trees, compared to those with them, is between 0.2 and 2 degrees Celsius (Marando et al. 2022). Marando et al. 2022 identified that to achieve a one-degree Celsius drop in temperature in urban areas, a tree coverage of at least 16 per cent is required. However, Iungman et al. (2023) assessed that in Europe, increasing urban tree coverage to 30 per cent would have a cooling effect of a mean 0.4 per cent, which could prevent 2644 premature deaths. The difference in temperature drops between the studies made by Marando et al. (2022) and Iungman et al. (2023) is due to the scope of the area of study: Iungman et al. (2023) focused on the city level, whereas Marando et al. (2022) focused on functional urban area including core city and commuting zones.

Planting trees have an economic benefit. Planting trees and tree nurseries are just a part of the chain that provide work for people and generated EUR 300 billion for the European Union economy in 2011. (European Commission 2021b.) Song et al. (2018) studied the economic benefits of trees in urban areas and noted that trees have positive effect on property value. Tree shading contributes to energy saving by reducing need for air conditioning, cause economic benefit by managing stormwater and by having carbon reduction benefits. Improved air quality, noise reduction, recreation and tourism effects were also among the economic benefits of urban trees. Jones et al. (2024) studied economic value of the hot-day cooling provided by urban green and blue space in the United Kingdom in 11 city regions. They noted that the cooling factor from green and blue infrastructure was 0.64-0.89 degrees Celsius and averted loss in productivity totalling EUR 29.2 million across ten years.

Some cities already have a tree coverage of nearly 30 per cent. These cities would benefit less from planting more trees. Another development axis is the distribution of the trees in cities. This is an environmental discrepancy that urban planners should consider when designing areas. Tree coverage is often lacking in areas that are socioeconomically deprived. Another challenge is the difficulty in achieving a 30 per cent tree coverage in cities with less open public space. However, planting less or encouraging planting in privately owned land could be a venue to consider. Although trees are crucial for creating climate resiliency, combining them with other cooling strategies would be more effective. These strategies include replacing asphalt with vegetated surfaces and using permeable materials. (European Commission 2023.)

There are several benefits to reducing urban heat island effect. The benefits include averted loss of life and reduced productivity, reduced energy needs, aesthetic and economic value.

Nature-based solutions and green infrastructure provide alternatives to adapting to the heat-related effects of climate change while providing co-benefits.

3.5.3 Reducing air pollution

In Europe, one of the biggest environmental risks to public health is air pollution (European Environment Agency 2022b), causing asthma, cardiovascular problems and lung cancer (European Commission k). As European urban areas and density increase having good air quality is a priority. In the European Union member states, 96 per cent of the population is exposed to more types of air pollution concentrations than what the World Health Organization has stated as acceptable for human health (European Environment Agency 2022b). On the other hand, air pollution also affects the urban ecosystems and biodiversity (Branquinho et al. 2015 according to Calfapietra 2020, 5) with, for example, acid rains and nitrogen pollution (European Commission k).

In Finland, the outdoor air quality is generally good. It has also gradually improved. Air emissions have decreased both in Finland and the surrounding regions. Remaining air quality problems are concentrated in urban areas and other built areas. There are local emissions as well as transported pollutants. Traffic and household wood burning cause most of the local emissions. (Finnish Environment Institute 2023.)

Air pollution still causes up to two thousand premature deaths yearly (Ministry of Environment a). However, due to emission reduction measures, the number is estimated to reduce by ten per cent from 2015 to 2030. The European Union has targets to limit the concentration of fine particles and other air pollutants. Although there are short-term pollution spikes, Finland mostly remains under the limits set by the European Union. (Finnish Environment Institute 2023.)

Including nature-based solutions in urban areas is an effective tool to help mitigate air pollution. Trees and plants remove pollutants during the summer, and evergreen species mitigate pollution also during the winter (Grote et al. 2016, according to Calfapietra 2020, 12). As urban areas grow denser, using green roofs and green walls that include herbaceous plants instead of trees is a possible solution for air pollutant removal (Calfapietra 2020, 12).

Including green spaces in urban areas affects ventilation and thus exposes pedestrians to air pollution (Amorim et al. 2013 according to Calfapietra 2020, 15). Contrary to that, epidemiological studies about human health and nature show that green areas have an effect of reducing some disease-causing air pollution exposure. For example, risk of cardiovascular disease mortality rates is reduced in areas with higher residential green areas. Green areas also increase positive effects on mental health. (Calfapietra 2020, 16.) Some studies show that people experience stress reduction when walking in urban green spaces, and cognitive function is enhanced for people in contact with urban green spaces. (Dadvand et al. 2015 and 2019 according to Calfapietra 2020, 17.)

Although nature-based solutions are effective in removing air pollutants, plant tolerance to air pollutants should be considered when planning nature-based urban areas. Air pollutants can damage the physiological status of plants and thus decrease their mitigation potential as well as their ecosystem service potential. (Calfapietra et al. 2015 according to Calfapietra 2020, 6.) The pollen emission and biogenic volatile organic compound emissions of each plant should also be considered. The allergen and pollen potential of most plant species are known. (Carinanos et al. 2015, according to Calfapietra 2020, 6.) Moreover, negative effect on respiratory diseases can be elevated due to the allergenicity potential of some plant species (Calfapietra 2020, 17).

The project ISCAPE investigated urban greenery effect on air quality in open space. It concluded that even though nature-based solutions improve air quality, it can also worsen environmental quality by increasing concentrations of pollutants and by diminishing their dispersion, especially in narrow street areas. Considering the scale in this matter, nature-based solutions in microscale, ranging from 10 to 500 meters, can drive redistributing pollutants. In the macroscale, or the range of kilometres, processes like turbulence in the atmosphere make it complex to estimate the positive effects of nature-based solutions on air quality. Nature-based solutions in terms of air quality may also be hindered by ecosystem disservices. (Calfapietra 2020, 13.)

Calfapietra (2020, 18) notes that it is difficult to determine the direct impact of nature-based solutions on health from the air pollution point of view, as there are many components to the matter and a large-scale implementation of the study would be necessary to evaluate the effects. It is also difficult to link the human experience with nature-based solutions for the same reason.

As shown in these examples, having green infrastructure in urban areas and implementing nature-based solutions into urban environment is an effective way to build a more climate resilient city. The European Environment Agency Report (2021, 65) notes that the scale of nature-based solution implementation varies from small-scale solutions on buildings and streets, to large-scale solutions, such as systematic implementations in urban areas that connect urban areas to the surrounding landscape.

Apart from these provided examples, there are many benefits for having green infrastructure in urban areas. These include benefits to physical health, mental health, economic well-being (Nieuwenhuijsen 2021). Many of the benefits link to one another.

However, for cities and municipalities to effectively evaluate the urban area and what types of climate and urbanisation related threats it is likely to face, how to implement green infrastructure, and to evaluate the effectiveness of nature-based solutions for different challenges, the question of available tools to realise this task comes to question. In the following chapter, some of the tools available are considered.

4 Tools and methods for increasing green infrastructure in urban areas

4.1 Tools in planning urban areas for climate adaptation

Voskamp et al. (2021) reviewed over 70 tools designed for urban planning that aimed to fulfil the needs many cities and urban areas have regarding climate adaptation. Their study identifies challenges related to nature-based solution uptake, selects and reviews the available nature-based solutions tools, and analyses the tool's capabilities to address the challenges faced in implementation. In their study, Voskamp et al. (2021) identified challenges that municipal officers and decision makers face. These challenges can be categorized in the following way:

1. Resource availability, or the lack of financial and other resources. There is a scarcity of funding to implement nature-based solutions and a need in presenting a business case for nature-based solutions and thus obtaining the required financing. Furthermore, absence of space and the number of privately-owned areas, limiting publicly owned space, is seen as a barrier. Tools that have an emphasis on valuation and the financial aspect, tools that provide insight to long term costs and benefits of nature-based solutions, and tools that help in building a case for business, could help in this regard. This includes aspects such as liveability, aesthetic value, biodiversity monetary value.

2. The institutional setting. Politicians not being aware and not knowing about the urgency for the need and possibilities of nature-based solutions is a challenge. The politicians and governmental officials at several levels need proof of the importance, potential and urgency of nature-based solutions. Nature-based solutions often require long-term thinking that might not always be in the interest of the politicians. Existing regulations and legal frameworks that are designed for traditional grey infrastructure can also be an obstacle. Thus, tools that provide examples of successful implementation of nature-based solutions and its valuation could help convince the politicians take action to implement nature-based solutions.

3. Level of expertise, competence and know-how. A third challenge is the lack of information regarding skills needed in mainstreaming nature-based solutions. People find it difficult to learn new methods of working and to deviate from the material they are used to working with. To have customizable tools that provide information on how to use nature-based solutions for different types of issues, could help implement nature-based solutions easier. Thus, there is a need for tools that can provide designers with concrete information on incorporating nature-based solutions, and their

benefits, such as resilience, climate change mitigation and urban heat island effect reduction.

4. Lastly, the challenges of collaborative governance and planning. Challenges exist within the governance when it comes to collaborating with different departments of the city organisation, such as urban planning, and the environmental and innovation departments. It is also necessary to consider different stakeholder views and involvement when discussing nature-based solutions. Tools that can increase stakeholders' engagement, involvement and co-creation are necessary. The output data of those tools should also be accessible to all stakeholders. Tools that help to mainstream nature-based solutions could also help interdepartmental work.

Voskamp et al. (2021) concluded in their study that existing tools can help overcome deficiencies in expertise, and to some degree be helpful in addressing challenges with institutional setting, resource availability, planning and collaborative governance.

The nature-based solution tools available can be categorized by methodologies, catalogues, software, repositories, e-platforms, guidelines and handbooks. Using a tool for urban planning has many benefits, as the tools can provide information and aid in planning processes by simulating the implementation of nature-based solutions, estimating the costs and benefits of applying nature-based solutions, supporting stakeholder involvement and promoting collaboration. The European Union has funded many projects on nature-based solutions in urban areas as research and innovation projects. These help to create more resilient and sustainable urban areas. This has led to many open-source and licenced tools and databases that can be used to help cities implement climate change adaptation methods. (Voskamp et al. 2021.)

These tools include:

- green infrastructure mapping tools that provide information about the connectiveness of areas, the ecosystem services provided, and whether that connectivity plays a part in enhancing biodiversity
- planning green infrastructure tools that provide information regarding mitigating climate change effects
- green infrastructure urban area tools that help plan multifunctional, green urban areas with heightened positive effect on human well-being and connectivity (European Environment Agency 2019.)

Some tools help resolve decision-making conflicts on land allocation between different sectors. There are also tools that help assess the monetary costs of green infrastructure measures that encourage implementing cost-effective green infrastructure alternatives to grey infrastructure. (European Environment Agency 2019.)

However, cities can only use these tools and databases if they are aware of them and know how to use them. Thus, in-depth understanding and training to use the tools effectively is required. Furthermore, tools need to be created with a wide variety of end user backgrounds in mind. Risk assessment, baseline assessment, opportunity mapping, strategic plan development for larger areas, nature-based solutions planning and design with different stakeholders, implementation of the solutions, and maintenance and impact analysis are all different outputs that the tools need to provide. (Voskamp et al. 2021.)

In the Voskamp et al. (2021) study, eventually 44 nature-based solutions tools were identified and analysed out of 72. Of the analysed tools 93 per cent were free to use and open-source, and 86 per cent of the tools were provided in English. Furthermore, 73 per cent of the tools provided qualitative data, 36 per cent spatial data, and 55 per cent quantitative data. In total, 75 per cent of tools provided support for planning and design. 70 per cent were informative, and 50 per cent had an analytical approach, whereas 32 per cent had an inspirational purpose.

41 per cent of the tools could be used in the nature-based solution implementation phase, and 25 per cent of tools could be used to assist in monitoring and evaluation. All tools aimed to support the uptake of nature-based solutions for urban climate adaptation, but there was difference in the specific scopes. There was an emphasis on tools that had to do with floods, rainfalls, heat waves and droughts. Socio-economic benefits were addressed by 66 per cent of tools, and nature and biodiversity benefits by 50 per cent of tools. Out of all the tools, 75 per cent could be used for environmental planning. (Voskamp et al. 2021.)

Voskamp et al. (2021) pointed out in their study that instead of creating new tools, it might be more useful and cost-effective to modify existing tools. Translating the tools would make them available to a larger audience. To incorporate nature-based solutions in urban planning, tools for training for capacity building and resource distribution are essential. Most of the existing tools focus on floods, rainfall, heat waves and droughts, but there are fewer tools for sea level rise, wildfires, landslides and cold waves, as well as tools that include the co-benefits of biodiversity.

To conclude, many tools exist to help cities address climate change adaptation in urban planning. The tool should be selected depending on the need of the city. This depends on what types of threats the urban area is facing, what type and level of stakeholder involvement are aspired to, the financial situation, and what type of governmental environment the city operates in. In the next section, a closer look at a Green Factor tool is taken.

4.2 Green Factor tools

The Baltic Sea region is projected to face heavier and more frequent rains due to climate change, while there also is a trend of building densely in the region. This was noted by The European Union iWater project that ran from 2015 to 2018. The project aimed to improve urban planning and to develop integrated, multifunctional storm water management tools. It addressed the need to increase urban sustainability and urban resiliency as well. (Keep.eu 2023.) The European Union funded-ILKKA-project created the Green Factor Tool in 2014 (Hurme 2020, 2), and the iWater project further develop the tool to include more stormwater management for the city of Helsinki (Integrated Stormwater Management a).

In the iWater project, green areas in urban development are seen to play a fundamental role in adapting to climate change. Green areas reduce the risk of flooding, air pollution and urban heat island effects that built environments tend towards as cities structures become denser. (Integrated Stormwater Management a.)

The Helsinki Green Factor tool is perhaps the most well-known in Finland. Helsinki has started including the Green Factor tool in their zoning plans as mandatory (Helsinki a, 3). Many cities around Finland are using the Green Factor tool as well (Kymenlaakson liitto 2023, 14). Oulu is starting to include it in its city planning (Oulu 2023, 8). Since 2020, Vantaa has also included the Green Factor calculations in their zoning plans (Vantaa a), as well as Järvenpää in 2019 (Järvenpää 2019, 42).

There are several Green Factor tools across the globe, such as the Berlin Green Factor, also known as the Biotope Area Factor, Malmö Green Factor or grönytefaktor, the Seattle Green Factor, and the Toronto Green Standard. (City of Helsinki Environment Centre 2016, 3-4.)

The Green Factor tool should not be mistaken for the green area factor method. The Finnish Environment Institute was part of the Atenas project (The Finnish Environment Institute 2019), which produced the Malmi area Green Factor final report. It states that the green area factor method is designed for an entire city district and incorporates elements such as habitat provision, noise reduction, pollination, recreational use and health, whereas the Green Factor tool is designed for a single plot (Lähde et al. a, 4).

4.3 The Finnish Green Factor Tool

The Green Factor Tool used in Finland is an Excel-based, flexible tool that can be used to evaluate the negative impacts of climate change, and biodiversity. The aim is also to design areas with versatile vegetation and to encourage the utilisation of water-permeable surfaces. The tool also encourages green roofs and facades, trees, and layered vegetation planning. The tool is based on a point system, where different aspects of the area give certain amounts of points. (The Finnish Association of Landscape Industries a.) The tool highlights vegetation and rainwater management solutions in the context of the total plot area. Each type of plot or area in the city has a different target score. (Helsinki a, 3, 5.)

The cities and municipalities that use the Green Factor tool have altered the tool to suit the conditions and characteristics of the area. Järvenpää Green Factor tool is almost identical to the basic one used in Helsinki (Kymenlaakson liitto 2023, 13). In the following chapter, the Järvenpää Green Factor tool is examined.

4.3.1 Entry data

The tool calculates the green score based on pre-defined data points. The data points are the following:

Land use data:

- Residential areas or
- Service and office areas or
- Commercial and business areas or
- Industrial and logistics areas (Järvenpää b).

Yard type data:

- is the area more than 50 per cent of the ground above an underground structure (Järvenpää b).

Surrounding area data:

- Is there a green corridor consisting of a nature reserve, water body or natural vegetation within 50 meters of the plot (Järvenpää b).

Data on the soil type and groundwater:

- Is there at least one meter of permeable soil on top of impermeable bedrock or groundwater (Järvenpää b).

Stormwater solution data:

- What is the estimated average depth of drainage area
- What is the estimated average depth of the retention area on a biofiltration structure
- Is it possible to use the adjacent plot areas for stormwater detention
- How much of the stormwater volume can be redirected to the adjacent plot (Järvenpää b).

Natural area data:

- tree biomass depending on their maximum expected height
- bush biomass
- meadows and pastures
- undergrowth
- open rock
- cultivated soil
- grass
- perennial vines
- green walls (Järvenpää b).

Coating and paving area data (Järvenpää b):

- semi-permeable coating such as grass-and-stone paving
- permeable coating such as gravel and sand.

Stormwater management systems area data:

- rain gardens
- garden roofs
- green roofs
- infiltration trenches
- drainage structures
- drainage basin on vegetation or gravel surface
- ponds
- wetlands
- floodplains with natural vegetation and semi-permanent water surface
- retention and detention basins with vegetation or rock
- retention pits or tanks
- bio-filtration or bio-filtration structures (Järvenpää b).

Elements that provide additional points are:

- diversion of stormwater from impervious surfaces to permeable vegetation on the ground
- diversion of stormwater from impervious surfaces to constructed water features such as ponds and streams
- trees of 25m^2 on the south and south-west side of the building creating shade
- trees of 15 m^2 on south and south-west side of the building creating shade
- fruit trees or berry bushes suitable for cultivation
- tree species and trees that flower, and shrubs that are mentioned in the publication by Helsinki City (2010) with a minimum of three species per 100 m^2
- butterfly meadows
- flowering or scented plants that have aesthetic value
- planter boxes
- permeable surfaces designed for play or sport such as sand or gravel playgrounds
- shared roof terraces with at least 10 per cent of the surface area covered with vegetation
- other areas that support biodiversity and wildlife habitats (Järvenpää b).

When filling in the Green Factor tool, all the element groups should have at least one selected element, except the bonus elements. For each selected element, the area, quantity or volume will be required, depending on type. (Helsinki a, 6.)

The data can be obtained by satellite imagery, observation and measurements, and layout plans of the plot.

4.3.2 Output

The tool calculates the amount of stormwater anticipated on the plot. This amount can be changed, if there are results from a stormwater investigation for the plot. The results chart will show the Green Factor of the plot, the target level for the Green Factor, and what elements were used. (Helsinki a, 7, 9.)

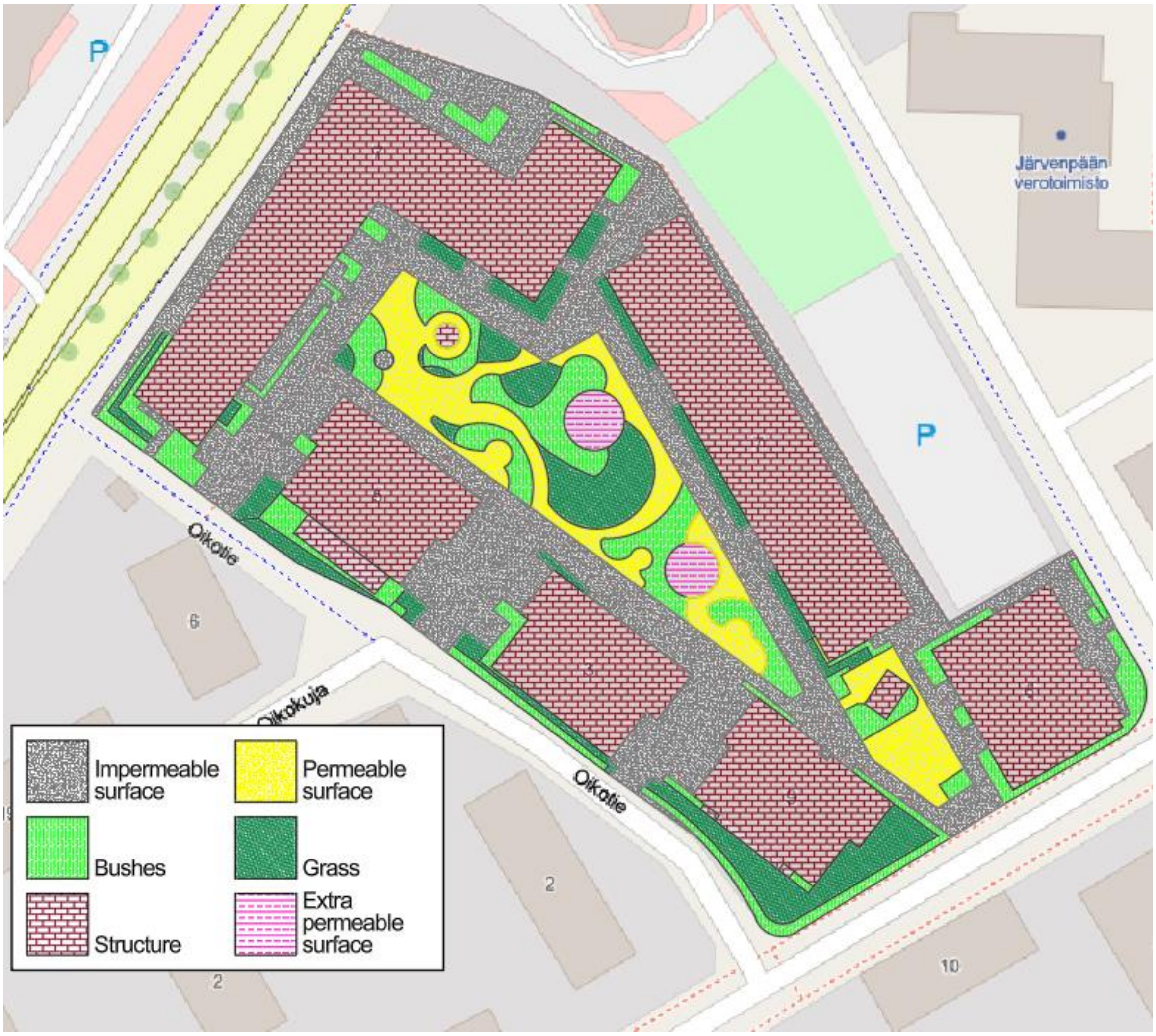
If the Green Factor for the plot is lower than the target level, this will be clearly indicated on the output. The score also shows how much of the surface of the plot is impermeable, and what the stormwater delaying needs are. The amount of stormwater that is not delayed and thus needs to be lead elsewhere, is also indicated on the output. The element types indicate what types and how many elements were used. The output shows the different factors weighted in the calculations, including the ecological aspect, functionality, landscape value, maintenance need and stormwater management. (Järvenpää b.)

More information is provided about how each element in the presented categories affect the scoring. In the ecological aspect, the effect of the vegetation on micro-climate regulation and biodiversity is mentioned. The ability to provide habitats to different species is mentioned for each type of vegetation or stormwater management structure. Functionality in terms of microclimate regulation effects, psychological effects, recreational advantages, and safety are also noted. Landscape value and how much maintenance is needed are mentioned for each element. Lastly, the stormwater management effect is noted for each element. (Järvenpää b.)

4.4 Using the Green Factor Tool in the city blocks of Järvenpää

4.4.1 Melodiapiha -city block

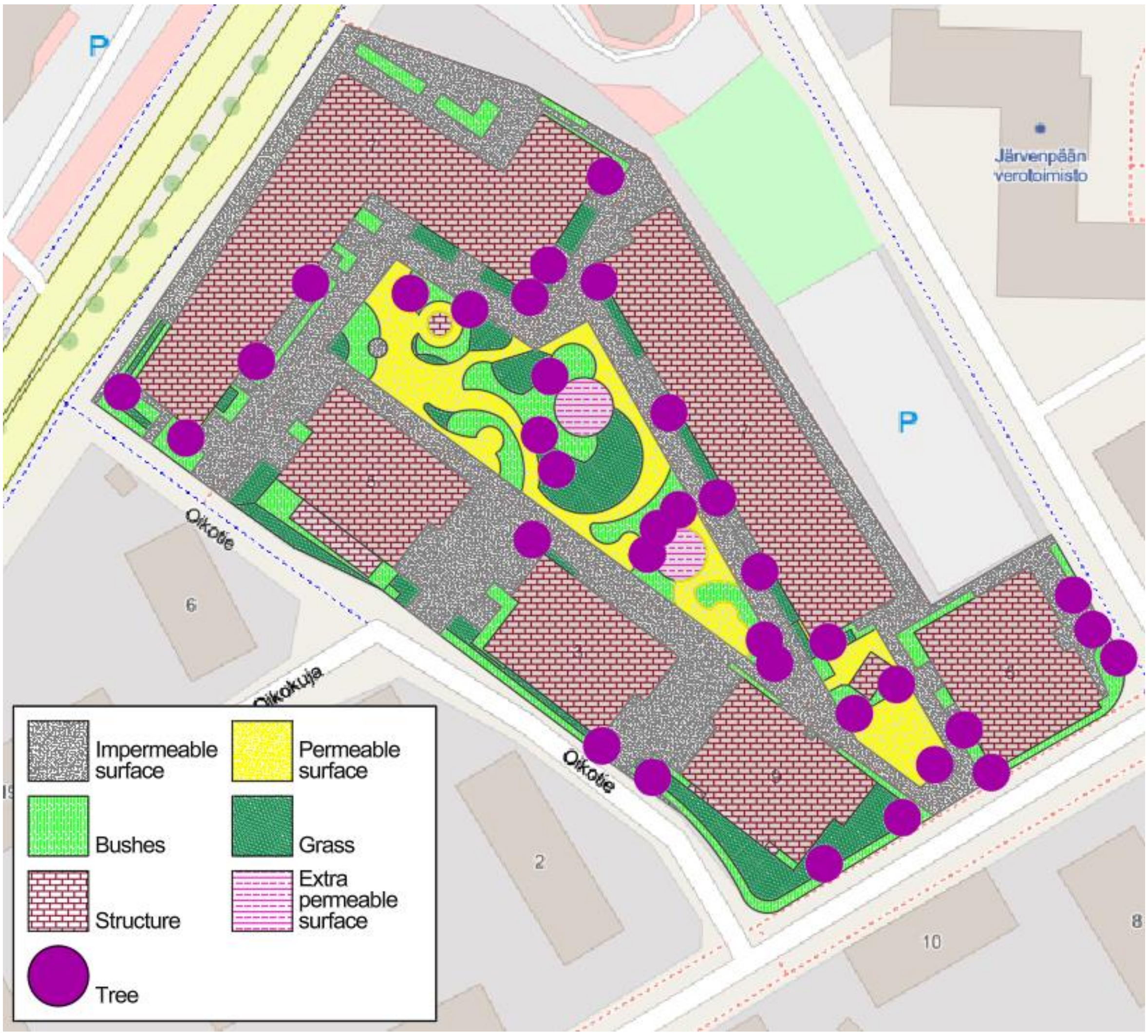
Melodiapiha -city block is a city block in Järvenpää constituted of apartment buildings, business space and a courtyard. The city plan was to build an efficient urban block around the courtyard. The apartment buildings are five to six storeys high. (Ahlfors et al. 2017, 22.) The area is defined between Oikotie, Huvilakatu, Yhteiskouluntie, and Helsingintie in Järvenpää (Google Maps). The small pocket park, parking lot and business on the east side of Melodiapiha -city block were not included in the measurements.



Picture 1: Melodiapiha -city block surface areas (Kalliomaa 2024)

Melodiapiha -city block is on groundwater area (Järvenpään karttapalvelu a). Järvenpää city has been planning on the conservation need of the city block due to its presentability (Ahlfors et al. 2017, 22). Melodiapiha -city block is situated about 350 meters from lake Tuusula and a Natura 2000 – area (Järvenpään karttapalvelu a).

The required data was ascertained using a combination of AutoCAD map 3D, Järvenpää map service, Google maps, Google Earth, and the city block layout documents provided by the representative from the city of Järvenpää. For the grass, bushes and trees, the area was observed, and measurements were taken. In Picture 2 the surface areas are presented without markers for the trees. Trees are omitted from picture 1 for clarity but shown in picture 2.



Picture 2:Melodiapiha -city block surface areas with trees (Kalliomaa 2024)

The land use definition was selected to be residential area. The yard type was a regular yard and not a yard above an underground structure. Information on the groundwater distance to the surface was not directly mentioned in the sources examined, although in the source Järvenpää (2024, 9, 12), it is mentioned for the nearby Virastotalo -city block that the groundwater can be very close to the surface. It is also mentioned in the Järvenpää city Green Factor guide that the permeable ground layer is low (Järvenpää c, 2). There were no green corridors consisting of conservation areas, watercourses or natural vegetation under 50-meter distance. There were no noticed stormwater management solutions in the area. This gave the target value for the Green Factor, which was 0.7. The total plot area was 11870 m^2, and the building area was 4870 m^2. The building floor area was 18490 m^2. There were no changes made to the expected stormwater amounts.

On the provided layout documents, the trees that were designated to be planted were rowan trees, lindens and bird cherries. Rowans can grow up to 12 meters (Kekkilä a), lindens up to 20 meters (Kekkilä b), and bird cherries to 10 meters (Kekkilä c). Trees over and under 10 meters have different effects on the Green Factor. As such, 14 trees were expected to grow to be over ten meters, and 21 trees under ten meters.

Table 1: Different bush species on Melodiapiha -city block

Common name	Scientific name	Finnish name	Size cm	Planting density cm
False spirea	Sorbaria Sorbifolia	Pihlaja-angervo	040-060	80*80
Mountain currant	Ribes Alpinum	Taikinamarja	040-060	80*80
Blue honeysuckle	Lonicera Caerulea	Sinikuusama	040-060	80*80
White Spirea	Spriraea Betulifolia	Koivuangervo	050-070	60*60
Common lilac	Syringa Vulgaris	Pihasyreeni	060-080	100*100
Elm-leaved spirea	Spiraea Chamaedryfolia	Virpiangervo	060-080	80*80
Shrubby Cinque-foil	Potentilla Fruticosa Gold-finger	Pensashanhikki	040-060	70*70
Dwarf mountain pine	Pinus Mugo Pumilio	Kääpiövuori-mänty	025-030	60*60

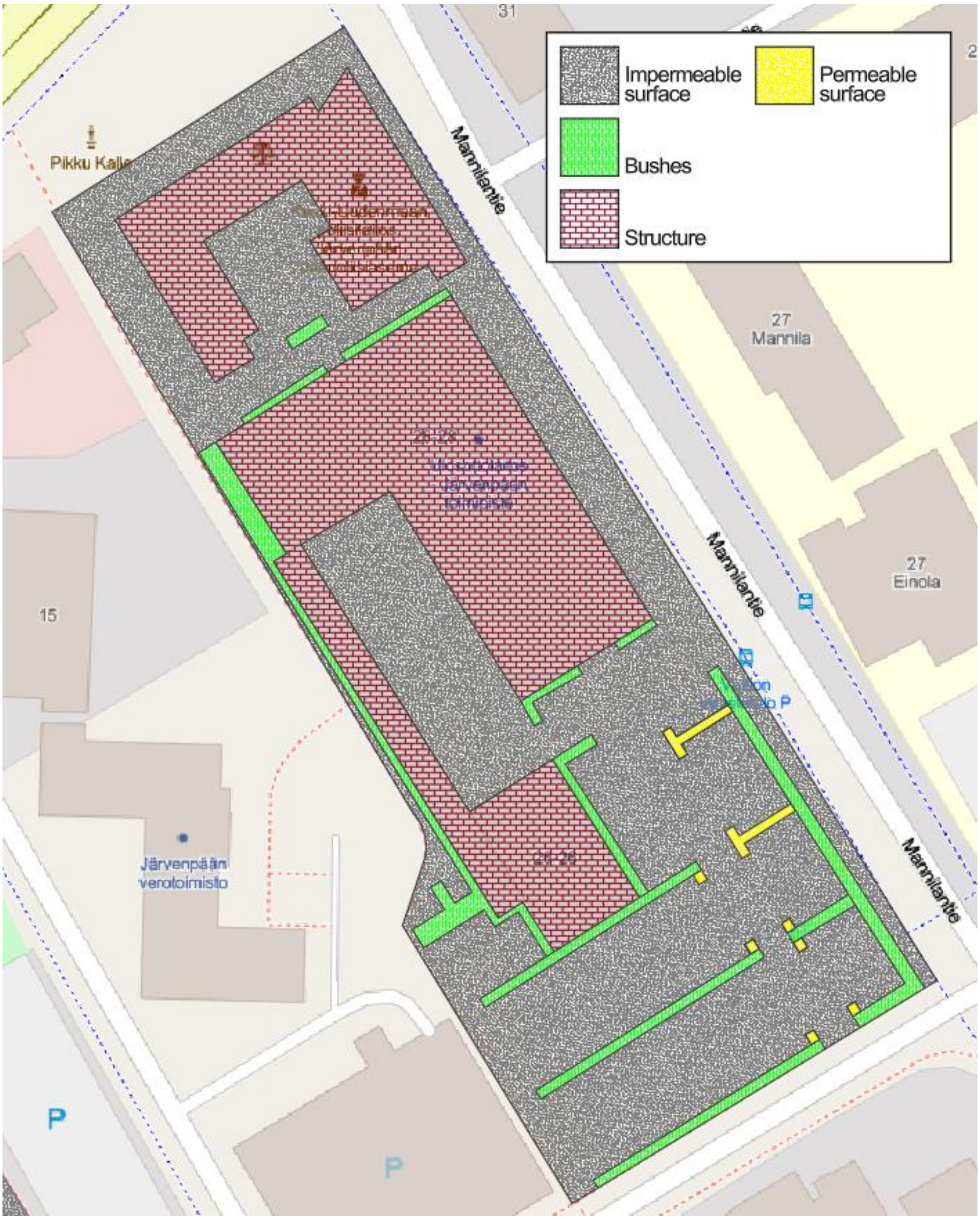
For the bushes, there were no individually quantifiable bushes, but bush areas constituted 1300 m^2. Table 1 presents the types of bushes planted on the plot. There were no semi-permeable surfaces, but there was 890 m^2 permeable gravel and sand surfaces. Imperme-able surfaces cover 8720 m^2, as calculated by the Green Factor calculator.

For the extra elements, there were six small trees providing shading on the southwest and south parts of the plot. In the plot a variety of bushes were used, and the trees and bushes mentioned on the layout plans were also mentioned in the Helsinki City (2010) publication. Play areas constituted 140 m^2. The areas with the minimum of three species per 100 m^2 was understood as the bush areas, since these areas had different tree- and bush species.

With this information, the Green Factor on Melodiapiha -city block was 0.66, under the target 0.70, as seen in Appendix 3. There are several possibilities for error in the calculations. Firstly, while making the observations of the yard, it is possible that tree species were mis-identified and mistaken for species that grow over ten meters, or below ten meters. There were challenges in determining the exact measurements of each element in the drawings, as the provided layouts and the maps used had different measurements, for example for the buildings. There were also other observation challenges: some of the covered areas had permeable gravel for example, below balconies. Some trees and bushes might have not been taken into the measurements, as it was not certain whether they were part of the plot or part of the neighbouring plots.

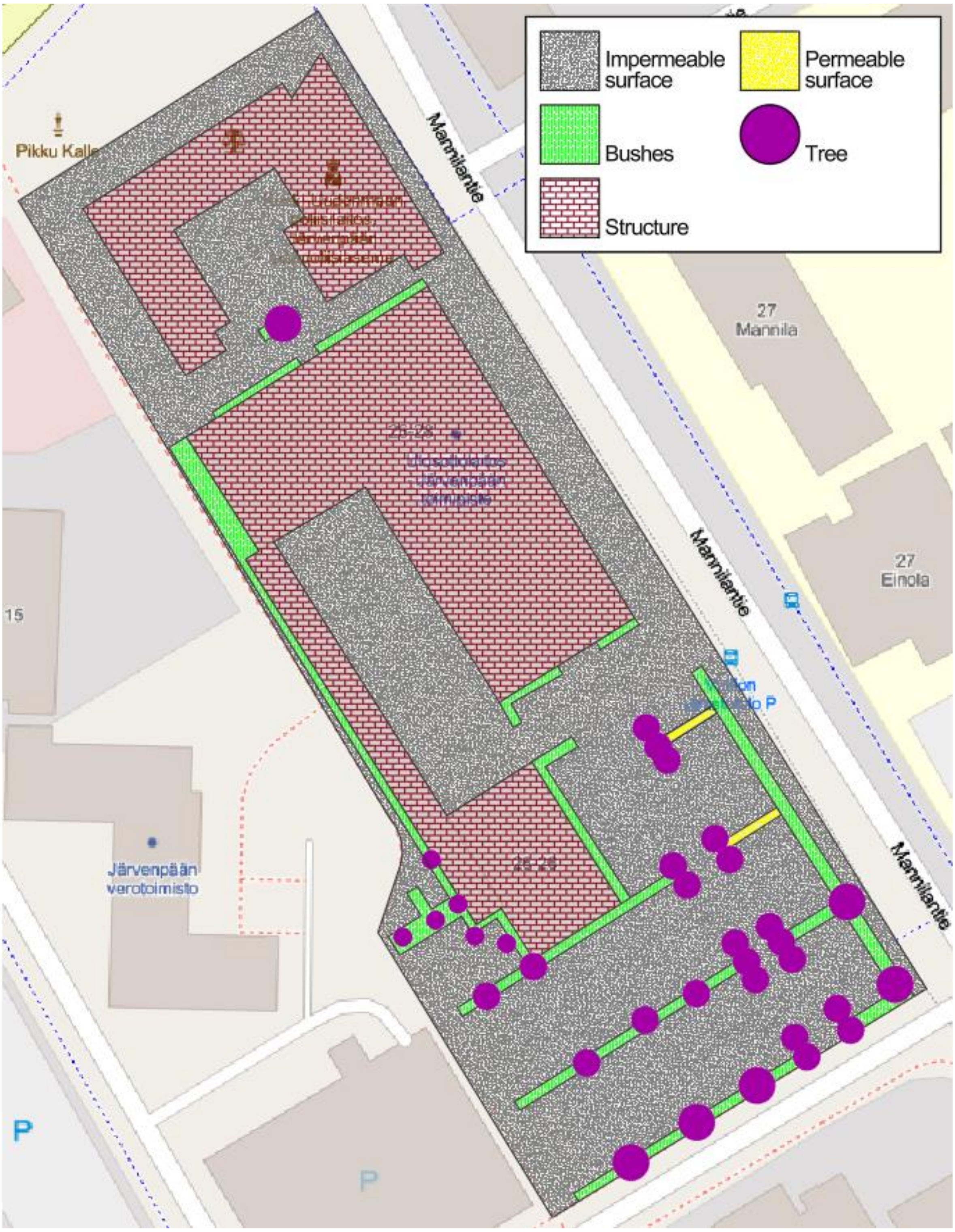
4.4.2 Virastotalo -city block

Virastotalo -city block is situated in Järvenpää on Mannilantie 26-28. On the plot the office buildings, warehouse and maintenance buildings are to be dismantled. However, the government bureau on Mannilantie 28 is a culturally significant subject that is to be preserved. (Järvenpää 2024, 4.) The plot consists of buildings and a parking lot, with trees and some bushes (Järvenpää karttapalvelu a). The area is on groundwater, which is one to two meters from the surface. The ground is clay. In this part of the city, the stormwater is lead to a surface water sewer and stormwater drains. (Järvenpää 2024, 9, 12.) The plot is situated 500 meters from Lake Tuusula and a Natura 2000- area (Järvenpään karttapalvelu a).



Picture 3: Virastotalo -city block surface areas (Kalliomaa 2024)

For the Green Factor, the plot was evaluated using observation, and Google Earth, Google Maps, Järvenpää Map service, and AutoCAD Map 3D. As some of the plot was already under construction during the observation, the map services were used to verify the previous vegetation on the plot by examining old maps and satellite pictures provided by the aforementioned services. Picture 3 presents the surface areas for Virastotalo -city block. The 34 trees are omitted from picture 3 for clarity but shown in picture 4.



Picture 4:Virastotalo -city block surface areas with trees (Kalliomaa 2024)

For this plot the land use was estimated to be service and office building area, as it was not a residential area, nor a business, nor industry or logistics area. The yard type was not a yard above an underground structure. There were no green corridors consisting of conservation areas, watercourses or natural vegetation under 50-meter distance. There were no stormwater management systems in the area. The area covered by buildings was 4470 m^2, the building floor area was 9790 m^2 and the total plot area was 11190 m^2. No changes for the stormwater amounts were made.

This plot was mostly covered with asphalt. Trees had been planted in semi-permeable surfaces and amongst bushes. Trees were observed to be Eurasian aspens, which grow to be 10-15 meters (Helsinki 2022a). However, these trees only live for 50 years (Helsinki 2022a). On the plot, it was observed that there were linden trees that may grow to be 20 meters (Kekkilä b). At the south-east side, there is an English Oak that can grow to be 15-20 meters and live for several hundreds of years (Riikonen & Liikka 2022, 2-3). There were also small coniferous trees and bushes on the plot on the western side, but it was not determined which species they were.

As for Virastotalo -city block, the target for the Green Factor tool was 0.6, as seen in Appendix 4. The score was 0.35. The main office building was built in 1978 (Järvenpään karttapalvelu a), and it is assumed that the parking lot was also built at that time, and the trees were planted then as well. Since the Green Factor tool has only been in use in Järvenpää since 2019, Virastotalo -city block was not designed with the Green Factor tool. Errors in measurements may have occurred while determining the exact area of the plot. The bushes were also not exactly measured and there were variations in height and width. There were trees that had been planted on the eastern side of the plot that were not considered in the Green Factor tool, as they did not seem to be within the plot limits.

5 Propositions and conclusions

For Melodiapiha -city block, there are some suggestions that might raise the Green Factor result. There was 960 m^2 of plain grass areas on the plot, mostly in the courtyard. In Figure 1 the different scenarios for changing the areas of elements or planting trees are presented. Converting all the grass areas to bush would raise the Green Factor value from 0.66 to 0.68. Changing the bush areas to grass would lower the Green Factor value from 0.66 to 0.62. Instead of asphalt pavement, having semipermeable pavement such as porous asphalt or concrete, would lift the Green Factor result from 0.66 to 0.95. Planting ten trees that will grow to be more than ten meters in height changes the value from 0.66 to 0.71. Correspondingly planting ten trees that grow to be less than ten meters in height changes the Green Factor from 0.66 to 0.68.

Turning the recycling shed roof and canopy roof into green roofs did not significantly change the Green Factor result. However, turning the entirety of the apartment building roofs to green roofs would have a significant impact depending on the green roof size and thickness. This would require investigating the carry capacity and water insulation of the roofs and investments into green roofs. Since the area is on clay and groundwater, many of the stormwater management structures cannot be implemented. A rainwater tank might be usable here, but it might be aesthetically less pleasing. Since the area has already been designed and vegetation planted, it might be that residents object to these conversions.

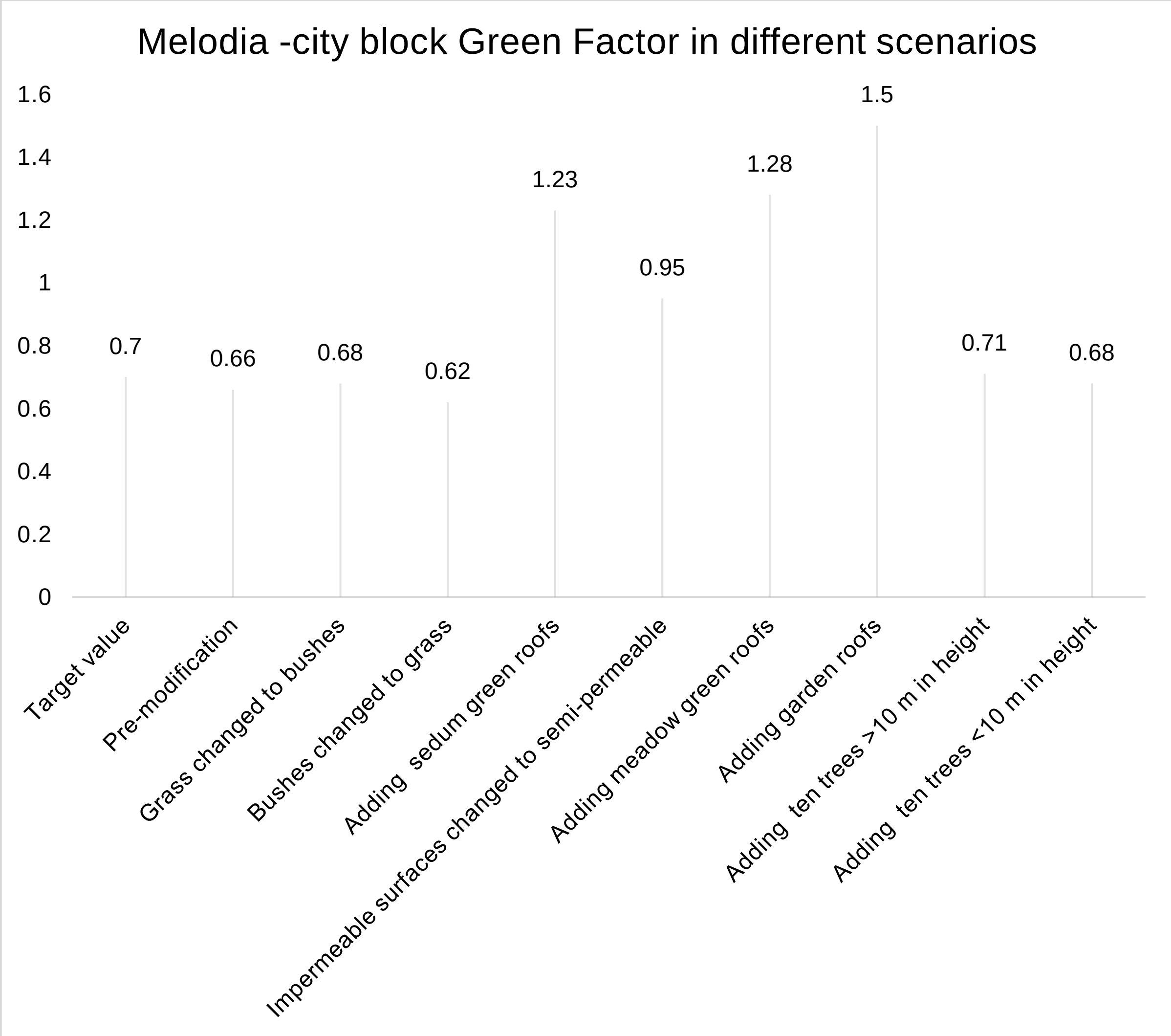


Figure 1: Non-cumulative changes to the Green Factor in Melodiapiha -city block

In Figure 2 different scenarios for changing the areas of elements are presented for the Virastotalo -city block. The most notable among them is changing the impermeable asphalt surfaces to semi-permeable which would change the Green Factor result from 0.35 to 1.02. However, considering the use of the lot as a parking space, having semi-permeable surfaces could pose a risk to the groundwaters beneath the area. Another notable change is adding green roofs and gardens to the buildings, covering the entirety of the roofs, which would elevate the Green Factor from 0.35 to over 0.9. In these measurements adding more trees did not seem reasonable, as the plot is mostly covered with impermeable surfaces and adding more trees amongst the existing ones could impact their ability to thrive.

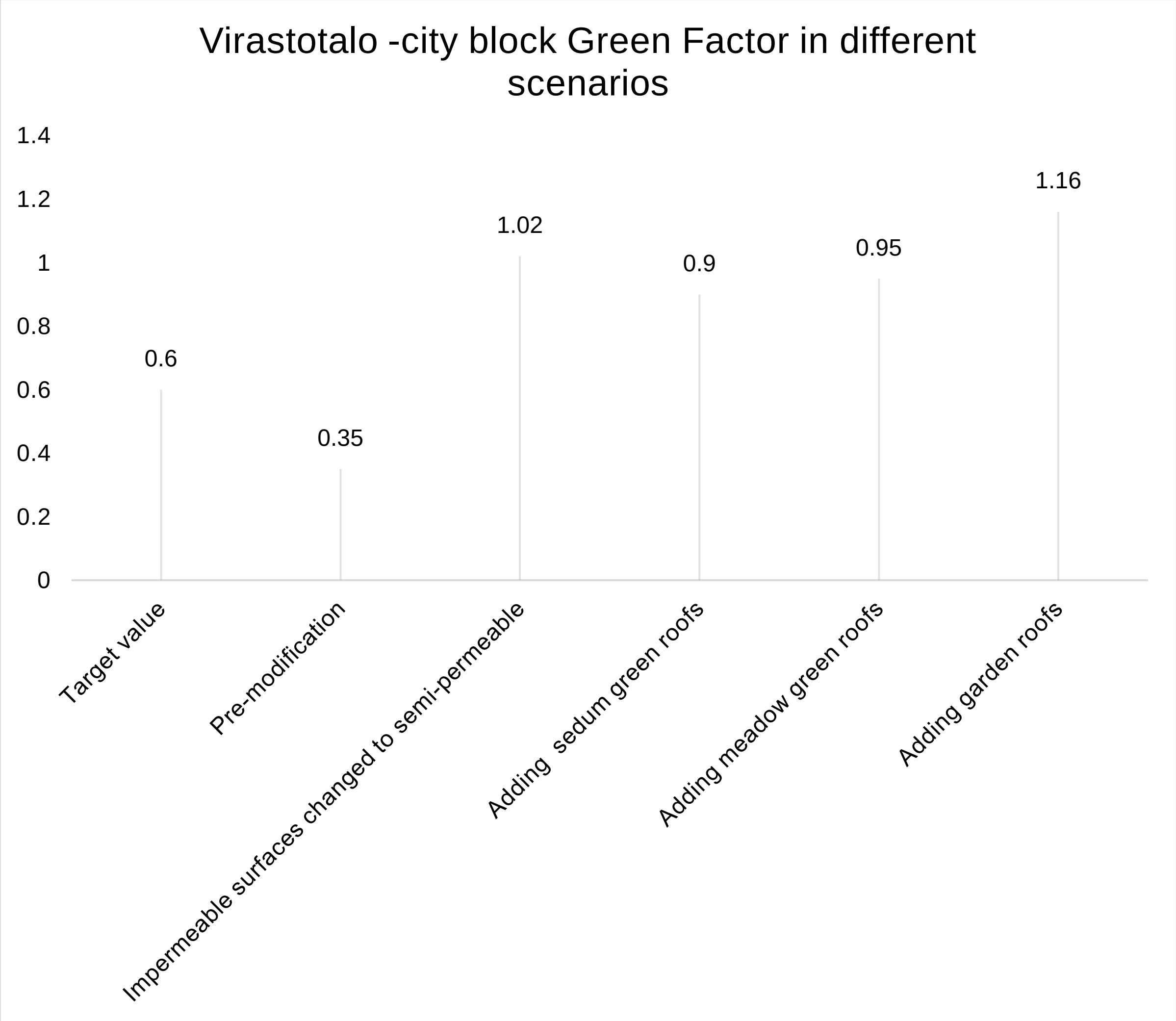


Figure 2: Non-cumulative changes to the Green Factor in Virastotalo -city block

Nevertheless, there is a new plan for the Virastotalo -city block. The new proposal for the area includes a measurement with the Green Factor tool and the proposed area layout has a score of 0.9, with the aim of at least 0.7 (Järvenpää d, 24). Since most of the Eurasian aspen trees in the area are nearing 50 years of age, it is probable that these trees will have reached the end of their life cycle before the proposed construction are finished on the lot. There is a proposition to save the oak in the south-east side of the plot (Riikonen & Liikka 2022, 2), which would be beneficial in terms of carbon sequestration, as oaks can live for hundreds of years. In Appendix 1 The North American myTree calculator result shows that the oak sequesters 582 kg of carbon dioxide in 20 years, or 2133 kg CO_2 equivalent. The common linden sequesters an estimate of 252 kg of carbon dioxide in 20 years and 923 CO_2 equivalent, as seen in Appendix 2. For comparison, the average Finnish person drove 13 790 km on average during the year in 2019 (Konttinen 2019). In the same year, an average petrol car released 0.144 kg of carbon dioxide per kilometre (Autoalan tiedotuskeskus 2023). This results in 1986 kg of carbon dioxide release per one driver per year.

There are 34 trees on the examined area. Since these trees are quite sparsely planted, they do not create a tree canopy cover and likely do not have a significant alleviating impact on the urban heat island phenomenon. There were only a couple of trees producing shading for buildings, so the cooling effect might not be significant. The aesthetic impact and impact on mental health, however, is perhaps more significant than what the trees contribute to alleviating the urban heat island phenomenon, carbon sequestration and air pollution mitigation.

As for stormwater management, on the lot there were stormwater sewer drainage points. However, there did not seem to be any nature-based solutions for stormwater management. Having a semi-permeable, porous asphalt or concrete parking lot would make the Green Factor result better. However, as the lot is to be rezoned and repurposed and the new plans include a better Green Factor tool score, this is not a relevant proposal.

Finally, the Green Factor score in different scenarios presented in Figures 1 and 2 indicate the amount of area that needs to be changed and the number of trees that need to be planted to reach the desired Green Factor targets. Any of these changes would be a significant financial expense and would require a considerable amount of time to be implemented. As such, it is reasonable to consider the effects of having green urban environment when planning urban areas to different types of uses, and to present Green Factor targets and ways to reach them in the pre-reports before making modifications on the land itself.

6 Summary and discussion

To summarise, the aim of this thesis was to provide the City of Järvenpää some insight into benefits of sustainable urban design and bring to attention the tools available for this aim. In this thesis, a look was taken into sustainable urban environment as a solution for the many challenges that cities face today in terms of climate change, urbanisation and biodiversity loss. The framework regarding green infrastructure both on the European and national level were studied. Benefits of having green infrastructure were considered from the point of view of stormwater management, urban heat island effect mitigation and air pollution. This further led to the tools that can be used to evaluate and monitor the solutions that can be implemented to combat these issues.

The second objective for the thesis was providing the City of Järvenpää Green Factor scores for two plots and of to show ways these areas could be modified for different results. For the city of Järvenpää, having a better Green Factor result can be achieved in many ways. Perhaps combining different elements such as a couple more trees and having some areas with semi-permeable surfaces or adding one sedum green roof instead of converting all the roofs for green roofs could give the best results. The results also shed light to the extent of possible changes that need to be done depending on the wanted result.

However, the results provided by the Green Factor tool are comparable between plots of the same parameters. In Järvenpää, this means plots that are on groundwater areas. Comparing results between different cities does not seem viable due to the different characteristics of the cities and the different score setup of each Green Factor tool. The cities set the target for the Green Factor. Thus, the score is dependent on how the target was set.

The other observation is related to the results of scoring. In both Melodiapiha and Virastotalo city blocks, converting the impermeable surfaces with semipermeable surfaces would indicate a better Green Factor score. As the tool itself is used to evaluate biodiversity and stormwater management aspects of the plot, having a high score does not necessarily indicate that the plots capability for enhancing biodiversity is high. It would indicate that the capability for stormwater management is high, but not the biodiversity. This cannot be seen in the score alone. One conclusion for this is that urban design should take into consideration the many different aspects and uses for land-use. These include stormwater management needs, enhancing biodiversity, impacts on aesthetics, people's health, and economic development prospects.

It should be noted that the stormwater management aspect of the Green Factor tool gives an indicative result. Using the tool does not replace the studies and investigations done on the lot by stormwater management experts. The Green Factor tool gives an overview of the stormwater management potential of the lot, but the true management capability is not defined by the tool alone. For example, the location of stormwater drains influence the stormwater management capability, but this is not considered in the Green Factor tool.

To discuss the reliability and ethics of this thesis, there were challenges regarding the literature review and Green Factor tool calculations. There were challenges related to the variety of definitions for green infrastructure and nature-based solutions. There seemed to be an abundance of different definitions for the same matter. However, the tools examined did not have a strong basis of having the same definition. As such, finding the right kind of tool for different aspects of urban planning could be challenging. If iterations of the tools are based on different definitions, the results may also not be as comparable, and the benefits may not correspond to the need. As such, defining what definitions are at use for the tool could improve the usability of the tool. In the definition of the thesis, urbanisation was one of the aspects kept in mind but the effects of it were not particularly outlined.

Aspects affecting the reliability of the thesis is that in the literature review, there was no review of the green infrastructure related agreements between urban regions in the land use, housing and transport agreements, or town and country planning and zoning. The new Building Act that is coming into effect on the first of January 2025 (Ministry of Environment b.) was not examined in the legislative framework of this thesis. The legislative framework was not included as the Building Act has not officially come into action yet. The town and country planning and zoning were excluded to keep the thesis compact, and the urban region agreements for the same reason. Some of the challenges regarding literature review of the Green Factor tool was finding sources about its benefits and the effects on areas designed with the tool and studies about the comparability of using the tool in different cities and municipalities. Taking these aspects into account could have provided a more rounded approach to specifically urban planning with green infrastructure related objectives, but this was not the main focus of the thesis.

Another aspect that was not considered in this thesis was the literature on stakeholder involvement in designing urban spaces. If there were changes to be made in the Melodiapiha -city block, it would be beneficial to study the opinions and propositions of the residents of the area before changes to the lot for a well-rounded approach.

Regarding the reliability of the Green Factor tool results, there were different sources of variability in, for example, in the quantification of different elements on the plots. Finding out the amount of bush in the lot was a challenge since the vegetation was not regular in form. The layout of the plot on paper often did not correlate with the layout at the plot or the layout on the different map programs used. This exposed the calculations to errors. It was not reasonable to measure all the wall lengths of all the structures on the plots, nor all the vegetation in the same manner. The tools selected for the task could also been more useful. The measurements were done by a measuring tape since a laser distance measurement tool was not available. The tree heights were measured using the stick method. At the time this seemed reasonable, as the Green Factor tool required input on whether the trees were over ten meters or under it when full grown, or between 1.5-3 meters. The Green Factor tool instructions did not have guidance regarding areas that had a canopy but also had a permeable surface. There were such areas under balconies, for example. All these points of variation have the capability to alter the true result of the Green Factor tool.

There are many questions left unanswered that could be studied further. How much benefit is there for the city when most of its areas are designed to have a Green Factor of a certain score? What types of tools and methods are currently available in Finland in urban planning, apart from the Green Factor tool variations? Is there some kind of balance between stormwater management and biodiversity-focused design that should be followed in urban planning when using the Green Factor tool? What types of tools and methods are needed in different Finnish cities to implement climate change mitigation methods in urban planning effectively? Perhaps translating some of those tools to Finnish could be useful in mainstreaming the usage of these tools. Perhaps studying how different cities and municipalities determine their Green Factor targets could indicate how comparable the targets are between different cities.

Lastly, there are several aspects to consider when designing urban areas with challenges regarding increasing biodiversity, urban heat island phenomena and climate resilience. For example, many aspects that influence biodiversity are not considered in this thesis. Light pollution prevention and reduction are not considered, even though light pollution has a clear effect on biodiversity (Lucia 2020). There are no tools that have an answer or a point of view to all challenges posed by climate change, biodiversity loss and urbanization. As such, when designing urban areas to consider these challenges, perhaps many different types of tools for different points of view should be used at once.

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Water Act 587/2011.

Appendix 1. MyTree Benefits for English Oak

MyTree Benefits

Over 20 years.

English oak, *(Quercus robur)*

Serving Size: 44.88 cm. diameter
Condition: Excellent
Location: Träskända, Nyland, Suomi
Expected over 20 years: €886.00

Carbon Dioxide Uptake	**€91.69**
Carbon Sequestered[1]	581,6 kg
CO_2 Equivalent[2]	2 132,55 kg
Storm Water Mitigation	**€199.48**
Runoff Avoided	94 309,99 L
Rainfall Intercepted	4 092 156,23 L
Air Pollution Removal	**€594.82**
Carbon Monoxide	966,11 g
Ozone	120 465,4 g
Nitrogen Dioxide	38 295,17 g
Sulfur Dioxide	1 543,86 g
$PM_{2.5}$	29 139,56 g

Benefit estimates are based on USDA Forest Service research and are meant for guidance only. Visit www.itreetools.org to learn more.

See the Project Menu for currency conversions.

+ Read the fine print.

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https://mytree.itreetools.org/#/ben

Appendix 2. MyTree Benefits for Common linden

MyTree Benefits

Over 20 years.

Common linden, *(Tilia x europaea)*

Serving Size: 28.65 cm. diameter
Condition: Excellent
Location: Järvenpää, Uusimaa, Suomi
Expected over 20 years: €448.56

Carbon Dioxide Uptake	**€39.70**
Carbon Sequestered[1]	251,78 kg
CO_2 Equivalent[2]	923,2 kg
Storm Water Mitigation	**€102.68**
Runoff Avoided	48 546,87 L
Rainfall Intercepted	2 106 472,26 L
Air Pollution Removal	**€306.19**
Carbon Monoxide	497,31 g
Ozone	62 010,59 g
Nitrogen Dioxide	19 712,76 g
Sulfur Dioxide	794,71 g
$PM_{2.5}$	14 999,84 g

Benefit estimates are based on USDA Forest Service research and are meant for guidance only. Visit www.itreetools.org to learn more.

See the Project Menu for currency conversions.

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Appendix 3: Green Factor result card for Melodiapiha -city block

Tuloskortti

Täyttäjän nimi
Kalliomaa Fatima

Kortelinumero
-

Päivämäärä
30.9.2024

Kohteen nimi (osoite)
Melodiapiha

Tonttinumero
-

Viherkertoimen laskelma

Viherkerroin < tavoitetaso!	0.66
Tavoitetaso	0.70

Hulevesimäärä m³	
90.1	
Valuma kerroin C	Mahdollisuus viivyttämiseen ulkopuolella
0.8	Ei
Viivytystilavuustarve tontilla m³	
90.1	
Esitettyjen hulevesiratkaisujen viivytystilavuus m³	Jää viivyttämättä m³
0.0	90.1
Läpäisemättömän pinnan osuus	
73 %	

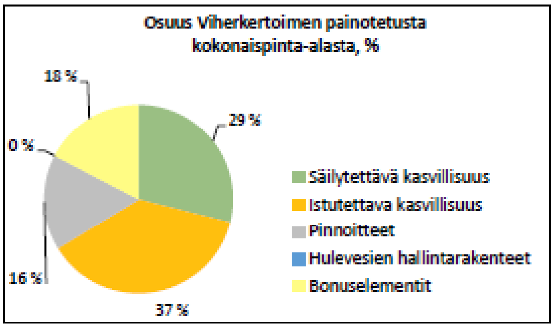
Suunnitelmaan sisällytetyt elementit

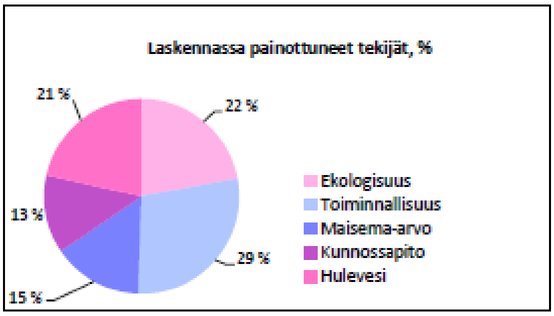
Elementtityyppi	Elementtejä täytetty, kpl	Elementtityypin kokonaislukumäärä, kpl
Säilytettävä kasvillisuus	2	5
Istutettava kasvillisuus	2	10
Pinnoitteet	1	2
Hulevesien hallintarakenteet	ei elementtiä!	9
Bonuselementit	3	12
Yhteensä	8	38

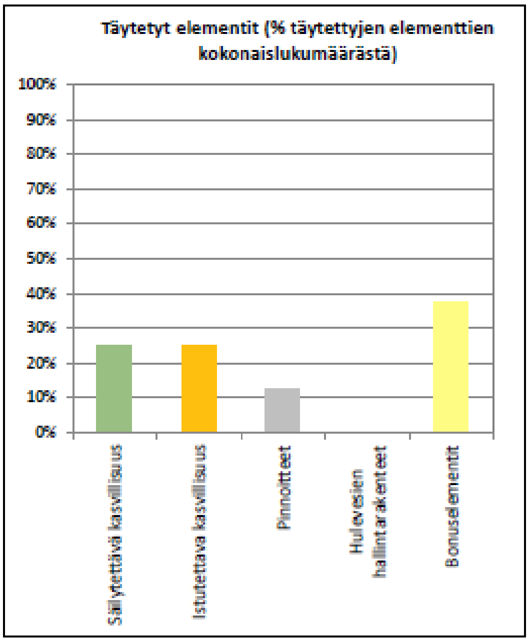
Täyttäjän kommentit:

Huomioitavat asiat:

- Tavoitetasoa laskettu läpäisevän maaperäkerroksen rajallisuuden vuoksi; suositeltavaa hyödyntää runsaasti kasvillisuutta.
- Osa hulevesistä jää viivyttämättä!







Appendix 4. Green Factor result card for Virastotalo -city block

Tuloskortti

Päivämäärä
30.9.2024

Täyttäjän nimi
Kalliomaa Fatima
Kohteen nimi (osoite)
Virastotalokortteli

Korttelinumero
-
Tonttinumero
-

Viherkertoimen laskelma

Viherkerroin < tavoitetaso!	0.35
Tavoitetaso	0.60

Hulevesimäärä m³	
98.3	
Valuma kerroin C	Mahdollisuus viivyttämiseen ulkopuolella
0.9	Ei
Viivytystilavuustarve tontilla m³	
98.3	
Esitettyjen hulevesiratkaisujen viivytystilavuus m³	Jää viivyttämättä m³
0.0	98.3
Läpäisemättömän pinnan osuus	
92 %	

Suunnitelmaan sisällytetyt elementit

Elementtityyppi	Elementtejä täytetty, kpl	Elementtityypin kokonaislukumäärä, kpl
Säilytettävä kasvillisuus	2	5
Istutettava kasvillisuus	1	10
Pinnoitteet	1	2
Hulevesien hallintarakenteet	ei elementtiä!	9
Bonuselementit	0	12
Yhteensä	4	38

Täyttäjän kommentit:

Huomioitavat asiat:
- Tavoitetasoa laskettu läpäisevän maaperäkerroksen rajallisuuden vuoksi; suositeltavaa hyödyntää runsaasti kasvillisuutta.
- Osa hulevesistä jää viivyttämättä!