

THE USE OF ENVIRONMENTAL SUSTAINABILITY REQUIREMENTS IN PUBLIC INFRASTRUCTURE PROCUREMENT

Examples from eight cities in Finland, Norway, and Sweden

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Abstract

The global sustainability crisis and interconnected environmental challenges, such as climate change and biodiversity loss, are undeniably one of the biggest challenges of our time. Finding solutions to these complex challenges requires actions from all sectors and industries. Especially, the carbon emissions and other environmental impacts of the infrastructure sector throughout the entire life cycle of infrastructure are globally significant. Therefore, the potential of this sector is significant in addressing global environmental challenges, especially with the advancement of digital technology.

In terms of infrastructure's environmental impacts, public operators, such as cities, play a central role, because the planning, construction, operation, and maintenance of infrastructure occurs through public procurement. Thus, the execution of public procurement is pivotal regarding the environmental impacts of infrastructure.

This study explored the environmental sustainability requirements, the challenges of incorporating them, and the role of digital tools in promoting environmental sustainability in public infrastructure procurement in eight different cities in Finland, Norway, and Sweden. The grounded theory approach and qualitative methods were utilized in this research. The empirical data was collected through fourteen semi-structured individual interviews. Instead of creating a comprehensive overall picture, the aim was to bring out the practices of different cities regarding the incorporation of environmental sustainability requirements in public infrastructure procurement.

My findings reveal that adopting more sustainable ways of operating in the infrastructure industry is a central goal for the cities under study, but the implementation of concrete practical actions varies between cities. Economic constraints and the immaturity of the market limits the implementation of environmental sustainability requirements in public infrastructure procurement. Reducing the environmental impacts of public infrastructure procurement requires more open and seamless cooperation between various stakeholders and the development of digital tools that enable better procurement follow up and creation of overall picture.

This study helps in understanding the challenges faced by cities and municipalities in promoting environmental sustainability in public infrastructure procurement. This information is important for improving practices in public procurement and developing products and services from the private sector in the industry. The results of the research can also serve as a benchmark for comparing sustainable procurement practices in different countries and sectors, encouraging others to adopt more sustainable approaches.

Keywords Environmental Sustainability, Public Infrastructure Procurement, Sustainable Infrastructure, Cities, Infrastructure Sector, Digital Tools, Green Public Procurement

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Työn nimi Ympäristöllisen kestävyysvaatimusten käyttö julkisissa infrastruktuurihankinnoissa – Esimerkkejä kahdeksasta kaupungista Suomessa, Norjassa ja Ruotsissa

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Globaali kestävyyskriisi ja toisiinsa kytköksissä olevat ympäristöongelmat, kuten ilmastonmuutos ja biodiversiteettikato, ovat kiistämättä aikamme suurimpia haasteita. Ratkaisujen löytäminen näihin kompleksisiin haasteisiin vaatii toimia kaikilta sektoreilta ja aloilta. Erityisesti infra-alan hiilidioksidipäästöt ja muut ympäristövaikutukset koko infrastruktuurin elinkaaren ajalta ovat maailmanlaajuisesti merkittäviä. Tämän takia alan potentiaali on valtava osana globaalien ympäristöongelmien ratkaisua, erityisesti digitaalisen kehityksen myötä.

Infrastruktuurin ympäristövaikutusten kannalta julkiset toimijat, kuten kaupungit, ovat keskeisessä roolissa, sillä infrastruktuurin suunnittelu, rakennuttaminen, käyttö sekä ylläpito tapahtuvat julkisten hankintojen kautta. Julkisten hankintojen toteuttaminen on siten avainroolissa infrastruktuurin ympäristövaikutusten kannalta.

Tämä tutkimus kartoitti ympäristöllisen kestävyysvaatimuksia, niiden sisällyttämisen haasteita sekä digitaalisten työkalujen roolia ympäristöllisen kestävyysvaatimusten edistämiseksi julkisissa infrahankinnoissa kahdeksassa eri kaupungissa Suomessa, Norjassa ja Ruotsissa. Tutkimus oli menetelmäsuuntaukseltaan kvalitatiivinen ja sen metodologia pohjautui ankkuroituun teoriaan (grounded theory). Empiirinen aineisto kerättiin puolistrukturoiduilla yksilöhaastatteluilla, joita oli yhteensä neljätoista. Laajan kokonaiskuvan luomisen sijaan, tarkoituksena oli nostaa esiin eri kaupunkien käytäntöjä ympäristöllisen kestävyysvaatimusten sisällyttämisestä julkisiin infrahankintoihin.

Löydökseni tuovat esiin, että infra-alan toimintatapojen muuttaminen kohti kestävämpää on tutkimuksen kohdekaupungeilla keskeisenä tavoitteena, mutta toteutus konkreettisina käytännön toimina vaihtelee kaupungeittain. Taloudelliset reunaehdot ja markkinoiden kypsyttömyys rajoittavat ympäristöllisen kestävyysvaatimusten edistämistä ja siihen liittyvien vaatimusten sisällyttämistä julkisiin infrahankintoihin. Julkisten infrahankintojen ympäristövaikutusten vähentämiseen tarvitaan avoimempaa ja tiiviimpää yhteistyötä eri sidosryhmien välillä, sekä digitaalisten työkalujen kehittämistä, jotka mahdollistavat paremman hankintojen seurannan ja kokonaiskuvan luomisen.

Tutkimukseni auttaa ymmärtämään julkisten toimijoiden kohtaamia haasteita infrahankintojen ympäristöllisen kestävyysvaatimusten edistämiseksi. Tämä tieto on tärkeää parempien toimintatapojen sekä yksityisten sektorin tuotteiden ja palveluiden kehittämisessä markkinoilla. Tutkimuksen tulokset voivat toimia myös vertailukohtana eri maiden ja sektoreiden kestävien hankintakäytäntöjen vertailussa, kannustaen muita omaksumaan kestävämpiä lähestymistapoja.

Avainsanat Ympäristöllinen Kestävyys, Julkiset Infrahankinnat, Kestävä Infrastruktuuri, Kaupungit, Infra-ala, Digitaaliset Työkalut, Vihreät Julkiset Hankinnat

Abbreviations

CO ²	Carbon dioxide
EU	the European Union
GDP	Gross Domestic Product
GPP	Green Public Procurement
OECD	Organization for Economic Co-operation and Development
SDG	Sustainable Development Goal
TBL	Triple Bottom Line

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1 Introduction

In this chapter I will first elaborate on the background of the study and the perceived research gap. Second, I will present the research objectives and questions. Lastly, I will provide an overview of the thesis structure, describing shortly the content of each of the main chapters.

1.1 Background

Sustainability and sustainable development are global megatrends followed by complex social, environmental, and economic challenges that are all interlinked. Since the sustainability challenges, so called wicked problems, are so complex and interlink all different dimensions of sustainability, the solutions to them cannot be simple fixes but require larger systemic change and actions from every sector and operator. In recent years there has been a growing concern globally for environmental sustainability and its integration into various sectors of society. Environmental sustainability crisis, that includes climate change, biodiversity loss, pollution of land, air, and sea for example, is one of the key drivers of sustainability as a megatrend since it forces societies to change the way they operate, produce, and consume.

Regarding the foundation of human society and its economic activity, physical infrastructure plays a key role (Heard et al. 2012). Infrastructure industry is a major contributor to global sustainability issues, especially from the environmental point of view, hence requiring immediate attention and actions. The construction, operation, and maintenance of public infrastructure, such as roads, bridges, and transportation systems, have a substantial impact on the environment. The industry produces a significant part of the total global CO² emissions, and it is estimated that the construction sector is responsible for almost 40 percent of global CO² emissions from fuel combustion, either directly or indirectly (Blanco et al. 2021). It is difficult to verify the exact share of infrastructure construction in global CO² emissions, but for example in the UK, it is estimated that the construction phase, maintenance, and operations of infrastructure are responsible for 16 percent of the nation's total CO² emissions (Kadefors et al. 2019). Since the sector is a major contributor to greenhouse gas emissions, there lies a huge potential in mitigating climate change in the industry. In addition to this, infrastructure construction industry is very material intensive

and requires significant land use and resource consumption, meaning that there is potential in improving environmental sustainability's other aspects as well.

In addition to the environmental impacts, the infrastructure construction industry is significant from both economic and social points of view. Cities and municipalities as well as other public organizations are key actors in the field of infrastructure construction, since their financial investments are mainly concentrated on long-term public procurements, such as roads, water and sewage networks and other basic infrastructure. In Finland, it is estimated that the share of infrastructure construction in the annual value of public construction procurement is 47% (Kuittinen & le Roux, 2017). These municipal investments maintain growth and employment and municipalities can contribute both directly and in-directly to investments that support circular economy for instance (Myllymaa et al. 2022.) The public sector and its authorities are major consumers, and they can promote sustainable development by using their purchasing power. For this reason, public operators have a vital role to play in integrating environmental sustainability considerations into their projects as they are key decision-makers in infrastructure procurement.

Various sustainability initiatives and frameworks have been introduced at the global, national, and local levels to address the complex environmental challenges and to enhance sustainable practices. One example of such framework is European Commission's Strategic Procurement framework that includes Innovation Procurement, Green Public Procurement, and Socially Responsible Public Procurement. Green Public Procurement (GPP) is a voluntary instrument with which public sector's organizations can contribute to environmental sustainability as well as economic and social sustainability (European Commission n.d.^a). GPP is defined as procurement that mitigates environmental impacts of the product or service throughout its entire life cycle (Rainville, 2017). Utilizing GPP approach in the procurement process helps to ensure that the procured products and services promote sustainable development in all its three dimensions. If the public sector utilizes the GPP approach in their procurement, they can also set an example for the private sector and the general public while moulding the market by stimulating demand for more sustainable products and services. (European Commission, 2008).

In terms of finding solutions to complex sustainability challenges and helping achieving sustainability of the planetary and modern human systems, digitalization plays an important role (Seele & Lock, 2017). It enables the development of digital tools that can be utilized in

different industries. Different digital tools carry potential for developing infrastructure sector's environmental sustainability amongst social and economic sustainability. To develop these digital tools that could be utilized in solving practical challenges public organizations face in public infrastructure procurement, it is essential to understand what the environmental sustainability requirements regarding public infrastructure procurements are. Identifying the current environmental sustainability requirements and mapping the trends on that is needed to be able to develop tools, with which it could be possible to better assess and optimize environmental sustainability aspects.

To combat the complex environmental challenges, and to drive tangible progress and develop practical solutions in infrastructure industry, it is important to understand the current environmental sustainability requirements in public infrastructure procurement. By identifying and mapping public operators' requirements it becomes possible to create digital tools that aid in assessing and optimizing environmental sustainability aspects. Thus, the integration of environmental considerations in public infrastructure projects can be elevated, paving the way for a more sustainable and resilient future for the society.

1.2 Motivation for the study and research gap

The motivation for this study is twofold. First, my personal interest in sustainability topics, and especially in environmental sustainability, arises from my personal values and study background in environmental sciences at the University of Helsinki. During my bachelor studies in environmental sciences, I gained a holistic understanding of sustainability challenges and the relations between different dimensions of sustainability. My previous knowledge on environmental sustainability was more generalist, which is why I was intrigued about the possibility to broaden my environmental sustainability knowledge towards a more specific industry, in this case infrastructure sector.

Second, public operators are key actors in promoting sustainable development by implementing environmental policies and regulations (Miranda & Lacrombe, 2012). The information regarding the requirements and goals that public organizations pursue in terms of environmental sustainability, is essential for private sector actors to develop their products and services to better meet public operators needs in public procurement. This knowledge on this topic is lacking among private operators, and thus, this thesis was commissioned by Infrakit Group Oy. The commissioning company aims to promote the sustainable

development of infrastructure construction industry by providing Infrakit platform that enables the digitalization of infrastructure construction projects throughout every stage of the infrastructure's life cycle. The findings of my research will be further utilized in a product development that aims to find solutions to the practical challenges public operators face in improving the environmental sustainability of public infrastructure procurement.

While the importance of environmental sustainability in all sectors, including infrastructure sector, is widely acknowledged, there is a lack of comprehensive studies that specifically explore the perspectives of public operators, such as cities and municipalities in this domain. Existing literature and municipal strategies usually include broader approach for sustainability and sustainable development goals, rather than detailed information about environmental sustainability requirements and goals regarding public infrastructure procurement. To address this research gap, further investigation is needed to understand the specific environmental sustainability requirements that public organizations are currently using in decision-making about infrastructure procurement. This research seeks to narrow this gap down by exploring local approaches of public operators in their pursuit of environmental sustainability in public infrastructure procurement.

1.3 Research objectives and questions

In this study I will focus on the current state of public infrastructure procurement in the infrastructure construction markets in eight different cities in Finland, Sweden, and Norway. This study is a part of a larger scholarly discussion about sustainability sciences, especially from the environmental sustainability point of view. In addition to this, the study discusses with administrative sciences since I am focusing on public infrastructure procurement and its environmental sustainability requirements. In administrative sciences the subject is organizations and management as well as public policy, as it is in my study since I am focusing on public organizations. This study is empirical in its nature and the aim of the study is to explore how environmental sustainability aspects are present in public infrastructure procurements currently and what are the goals in these environmental requirements in the target cities. This information is essential in narrowing the gap between the practical challenges in environmental sustainability in public infrastructure procurement, and the development of digital tools for solving these issues.

The primary objective of my research is to obtain information about the specific environmental sustainability requirements pursued by public actors during public infrastructure procurement. Within the limits of this research, it is not desirable to try to form a comprehensive overall picture of the infrastructure construction markets of the target countries, but rather to bring out details and practices in different cities considering the integration of environmental sustainability requirements in public infrastructure procurement. The goal is to examine how environmental sustainability is being incorporated into infrastructure procurement in various cities in Finland, Sweden, and Norway. In addition to that, the aim is to assess the level of awareness and importance that is given to environmental considerations in the decision-making process regarding public infrastructure projects, and to explore the challenges that public operators face in implementing sustainable practices in infrastructure procurement. I will also explore how public operators perceive digitalization as a part of improving environmental sustainability in infrastructure procurement. That paves the way for developing digital tools to better meet the needs of public operators.

With this study I aim to answer the following research questions:

RQ1: What environmental sustainability requirements cities use in public infrastructure procurement?

RQ2: What are the main challenges in implementing sustainable practices in public infrastructure procurement?

RQ3: What is the role of digital tools in enhancing the environmental sustainability of public infrastructure procurement?

With these research questions, the aim is to gain information that helps to identify the barriers and limitations that hinder the effective integration of environmental sustainability in public infrastructure procurement. Based on the findings, this study will provide practical recommendations and strategies that can enhance the incorporation of sustainable practices in public infrastructure procurement.

1.4 Structure of the thesis

The first part of this master's thesis is introductory in its nature, after which this study is structured in four main sections. The second part consists of literature review where I review the previous research regarding public procurement and sustainable infrastructure as well as

digitalization and its role in promoting sustainable development and environmental sustainability of infrastructure construction industry.

After reviewing the relevant literature, I describe the research process and discuss the research methodology and data collection and analysis methods used in this study. In addition to that I also elaborate on the trustworthiness of this study.

In the fourth part of this thesis, I present the findings of my study among analysis and discussion. In this part I focus on answering the research questions based on the presented findings. Lastly, I outline some concluding remarks, as well as limitations of the study and recommendations for future research.

2 Literature review

This chapter of the thesis serves as a critical foundation for this research. I explore the existing, relevant literature related to my study, which forms the body of knowledge of the current state of research in this field. This literature review is divided into five sections. First, I discuss sustainable development which is the key phenomena behind pursuing environmentally friendly practices in all sectors. I chose to elaborate on this matter since I want to give the reader a broader context of which my study is a part of, and to share basic knowledge of the topic that works as a core motivation for me personally in my academic studies and in this research. Second, I delve into environmental sustainability and outline the many environmental challenges that today's societies are facing. In the third section I focus on public procurement, its steering instruments and sustainable infrastructure. Following this, in the final section I discuss digitalization and its connection and possibilities regarding sustainable development and infrastructure industry.

2.1 The concept of sustainable development

Recent years, sustainable development has become a widely recognized concept, as governments and other stakeholders globally try to promote economic growth without compromising the well-being of environment and societies. This chapter of the literature review aims to examine the concept of sustainable development, its evolution over time, and to bind the concept of sustainable development and infrastructure constructure shortly together. Elaborating on sustainable development provides the reader a better understanding of the larger entity and phenomena behind this study and its motivations. To find solutions to sustainability challenges on a specific industry, it is essential to have a holistic understanding on sustainability and the phenomena of sustainable development due to the complexity of the topic.

Nowadays, sustainability and sustainable development are something that every actor and industry should consider and pursue in their operations. Sustainable development is not simply defined, and it has multiple different definitions (Hopwood et al. 2005). Possibly the most well-known definition for sustainable development is the United Nations' definition which explains sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations n.d.). It can be argued that sustainability and sustainable development are one of the

most significant phenomena of our time, which have been identified since the early 1980s from scientific perspectives on the relationship between societies and environment (Kates et al. 2001). Sustainability as a megatrend today, is a result of multiple different phenomena which have directed the development in a certain way entailing a larger systemic change (Sitra n.d.).

The key elements of sustainable development are often referred to as the three dimensions of sustainable development. These dimensions are economic, social, and environmental sustainability, which many scholars refer as the triple bottom line, TBL (Elkington, 1998; Ercan et al, 2013; Farooq et al. 2021; Herberger & Dötsch, 2021). It is acknowledged that environment and functioning ecosystems have significant impact on human well-being as well as the well-being of other species. This well-being is currently seriously threatened because of the pursuit of economic growth with the unsustainable exploitation of other nature and natural resources. (Waas et al. 2010.) All the different dimensions of sustainability are interlinked which is why sustainable development cannot be achieved just by focusing on one.

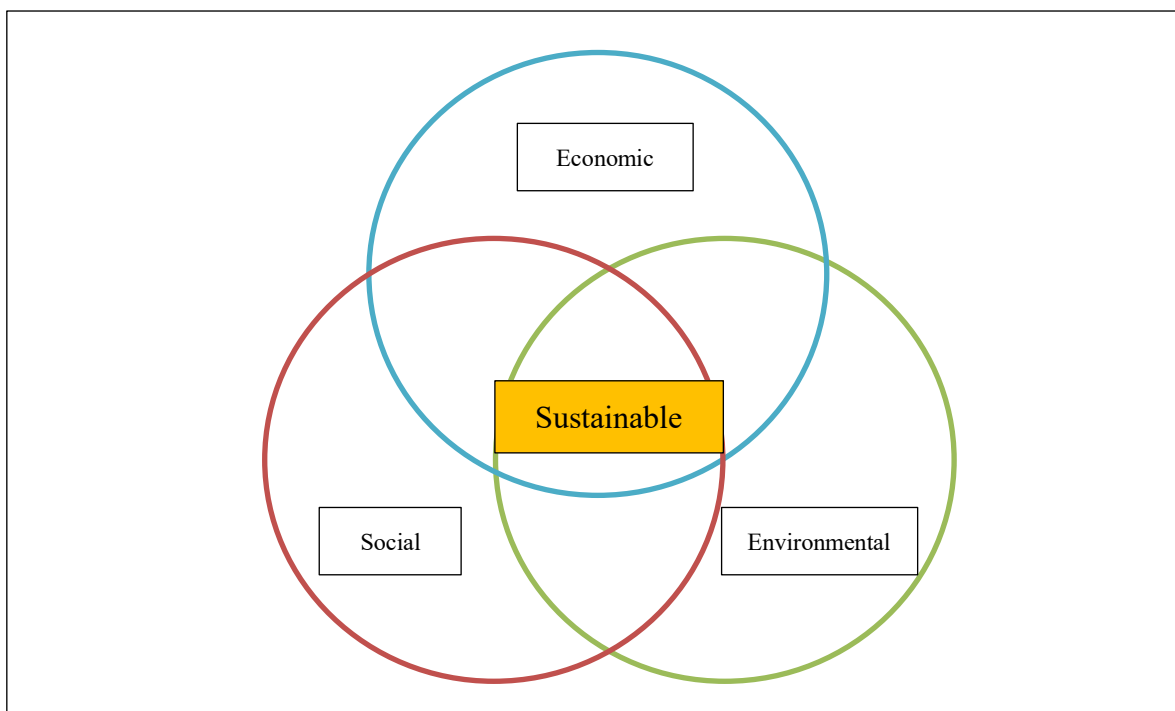


Figure 1. Three sustainability dimensions also referred as triple bottom line. Source: Own illustration.

The concept of sustainable development has evolved over time, reflecting changing priorities and concerns. Since the early 1980s sustainable development has gained significant attention due to its potential to address the urgent and complex challenges humanity is facing today, such as climate change, poverty, and environmental degradation. In 2015 all United Nations Member States adopted the 2030 Agenda for Sustainable Development, that includes 17 Sustainable Development Goals (SDGs). The SDGs aim to promote sustainable development by recognizing the interconnectedness between economic, social, and environmental issues. (United Nations n.d.) Regarding this research the most important SDGs are SDG number 6: clean water and sanitation, SDG number 7: affordable and clean energy, SDG number 9: industry, innovation and infrastructure, and SDG number 12: responsible consumption and production. The icons of these SDGs are shown below in Figure 2. These sustainable development goals are directly linked to infrastructure construction industry, therefore argued to be the most relevant SDGs for this study. However, I want to highlight that all the 17 SDGs are strongly related to each other and cannot be clearly separated, meaning they are all somehow relevant for this research through different interlinks and systems complexities.



Figure 2. United Nation's Sustainable Development Goals number 6, 7, 9, and 12. Source: Own illustration based on United Nation's Sustainable Development Goals' icons.

2.1.1 Sustainable development and infrastructure industry

The infrastructure sector is strongly connected to sustainable development, since infrastructure construction, operation and maintenance has significant impact on the environment, the economy and society, binding all sustainable development dimensions together. Both sustainable development and infrastructure sector have the aim of finding and providing long-term solutions that meet the needs of future generations as well as current generations. Physical infrastructure is key actor as the basis of human society and its economic activity (Heard et al. 2012). It enables the efficient functioning of societies, and their growth and adaptation to changing needs and occurring challenges locally and globally. Regarding the economic aspect of sustainable development, municipal investments on public infrastructure procurements maintain employment and growth. These investments on public infrastructure stimulate societies' economic activity by creating jobs and supporting different industries for instance. Infrastructure sector and its connection to the economic aspect of sustainable development is also significant from the connective point of view since infrastructure facilitates connectivity between regions and communities both locally and globally enabling economic and other social interaction (Banerjee et al. 2020). In addition to that infrastructure has major impacts on the environment since it is very material intensive and by weight it represents the most significant use of materials (Heard et al. 2012). These factors related to infrastructure sector are highly significant and have far-reaching consequences for the achievement of sustainable development. I will elaborate more on sustainable infrastructure later in this literature review, in the section 2.3.

2.2 Environmental sustainability and infrastructure

Environmental sustainability is one of the most often referred dimensions of sustainability, whilst the other two are economic and social sustainability. Humanity faces multiple, complex, and far-reaching environmental problems that are resulted from human operations. To tackle these challenges and to ensure sustainable development, there is a need for humanity to change its operations in every industry and to adapt new mindsets, to fit planetary boundaries. The planetary boundaries framework, which consists of nine different control variables, determines a safe operating space for humanity within Earth's environmental limits (Steffen et al. 2015). This chapter of the literature review examines the concept of environmental sustainability, its challenges, and relation to infrastructure. I

wanted to include this general chapter of environmental sustainability in this literature review, to provide the reader a more thorough base of knowledge regarding the matters that this research about environmental sustainability in public infrastructure procurement is in relation with.

2.2.1 Environmental sustainability challenges

Climate change is undoubtedly one of the most difficult challenges humanities have faced. It is one of the nine planetary boundaries of Earth system, and it is identified as a boundary, the crossing of which causes irreversible consequences. Other planetary boundaries are biosphere integrity, land-system change, freshwater use, biogeochemical flows, ocean acidification, atmospheric aerosol loading, stratospheric ozone depletion, and novel entities (Steffen et al. 2015). All planetary boundaries are demonstrated in Figure 3. As Steffen et al. (2015) argue all planetary processes are interdependent, and the crossing of one planetary boundary may make another process more sensitive to changes. Climate change is a perfect example of such boundary, since it has direct effects on biodiversity for instance, and it has the potential to change the Earth systems into a new state on its own. Atmospheric CO² concentration is the control variable for climate change (Steffen et al. 2015). The main driver for climate change and global warming are increased greenhouse gas emissions, including CO², from human activities, mainly from the burning of fossil fuels. The changing climate causes draughts, extreme weather conditions, and sea-level rise for instance, in addition to causing physical, and health risks. (Ritchie et al. 2020.) It was only this July, in 2023, that was recorder to be world's hottest month in recorded history, breaking the previous record set in July 2019 (Dickie, 2023). The consequences of climate change are undoubtedly visible around the world in various extreme weather conditions, threatening the global and local ecosystems, including societies and economies. These threatening consequences of climate change are especially important for infrastructure since it is in central role regarding the functioning of societies and economy.

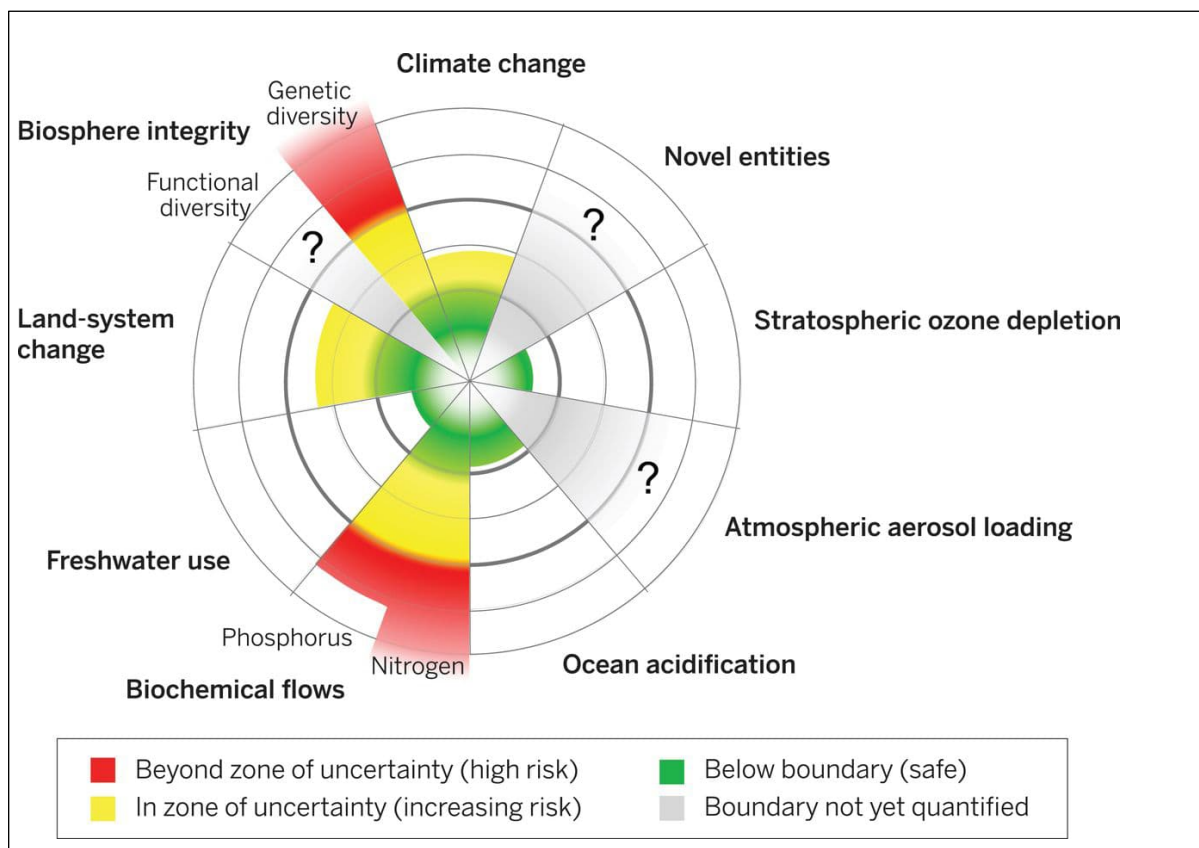


Figure 3. Nine planetary boundaries. Source: Steffen et al. 2015.

Tackling the severe risks and challenges caused by climate change requires both mitigation and adaptation. Climate change mitigation means actions that aim to reduce emissions of greenhouse gases and removing already emitted greenhouse gases from the atmosphere (Lackner et al. 2012). As Lackner et al (2012) describe one of the main actions to mitigate climate change is to reduce the burning of fossil fuels drastically. Regarding infrastructure sector there is huge potential in mitigating climate change since the industry is a significant contributor to CO² emissions. These emissions come mainly from the production of construction materials as well as the use of energy for construction transports and activities on the construction site (Kadefors et al. 2019). Thus, it is essential to adopt a perspective that considers infrastructure's whole life cycle in terms of carbon footprint reduction, beginning from the production of the construction materials to operation and maintenance, all the way to final disposal.

Climate change adaptation on the other hand means reducing the vulnerability of human systems as well as natural systems to climate change (Javeline et al. 2019). Climate change adaptation may include physical preparation in the form of infrastructure for climate change impacts, such as flooding and storms, as well as changing the governmental regulations and

policies. As European Commission (n.d.^b) states it is essential to consider climate change impacts and adaptation regarding infrastructure because of infrastructure's long lifespan. During the planning phase of infrastructure and infrastructure construction it is essential to consider climate change impacts to avoid infrastructure's vulnerability to those. Poor design may cause infrastructure to be untenable in occurrence of severe storms and heavy rainfall caused by climate change. Also rising sea levels put infrastructure at risk in coastal areas as climate change progresses. (European Commission, n.d.^b) Mitigating and adapting to climate change are essential measures for every industry, and especially for the industries where there are huge opportunities in creating positive impact. Infrastructure sector is a good example of such industry due to its significant environmental footprint. In terms of adapting to climate change infrastructure's role is particularly central because of its ability to ensure the provision of vital services and shield communities locally from the harmful effects of climate change (Thacker et al. 2021).

Other examples of environmental sustainability challenges are air and water pollution, soil degradation, biodiversity loss, and deforestation. As with climate change, all these challenges are interlinked. (Arora et al. 2018.) Regarding infrastructure's construction and operation phase especially air and water pollution, noise pollution, as well as waste management play a key role from the environmental sustainability point of view. Infrastructure construction for example can affect air quality both direct and indirect ways (Sun et al. 2021). Alvanchi et al. (2020) argue that the fossil fuels used in infrastructure construction operations, whether it is the production of the materials or the use of machines on the construction sites, or the actual operation of infrastructure affect air quality negatively. Indirect ways infrastructure construction can affect air quality is for example when construction sites change the existing transportation roads causing traffic jams that impact the local air quality negatively. On the other hand, with planning and constructing infrastructure, it is possible to promote more sustainable transportation, for example in the form of bike lanes or railways, which can in turn have a positive impact on local air quality.

Since infrastructure requires significant land use, is material intensive, and represents the greatest use of raw materials by weight, the sector has significant contribution to global waste streams during different steps in the supply chains. The production of the materials requires excessive amounts of energy and water for instance. To reduce the environmental impact of infrastructure in all its different life cycle phases, it is essential to turn waste streams into use, improve supply-chain management, as well as strive for longer life cycle

of infrastructure already from the design phase. (Heard et al. 2012.) Utilizing circular economy by reusing and recycling infrastructure materials promotes environmental sustainability by reducing the emissions and waste streams from the production phase. Infrastructure should also be designed for long-lasting and easily maintained to reduce its negative environmental impacts (Ministry of the Environment Finland, n.d.).

Overall, finding solutions to environmental sustainability challenges requires multidisciplinary approach and participation from all sectors. There are various environmental impacts throughout infrastructure's lifecycle, such as emissions from material production and construction, as well as impacts during construction phase, operation, and maintenance, including for example air and water pollution, and noise pollution. These impacts are challenging to measure which creates difficulties in prioritizing decisions and actions to enhance the environmental sustainability (Marcelo et al. 2016). Thus, a holistic approach to design and construction is essential to be able to minimize environmental impacts while promoting sustainable practises.

2.3 Sustainable public procurement and sustainable infrastructure

In this part of the literature review I discuss public procurement and the concept of sustainable infrastructure. These are central concepts since infrastructure projects, including their development, construction, operation, and maintenance are implemented through procurement, mainly by public operators. Thus, the implementation of procurement plays a key role regarding the environmental impacts of infrastructure. In addition to sustainable public procurement and sustainable infrastructure, I also explore the different concepts and frameworks that work as steering instruments for public infrastructure procurement. For example, I delve into European Commission's Green Public Procurement tool, its limiting factors, and the role in promoting sustainable infrastructure.

2.3.1 Public procurement and sustainable development

From the economic point of view, public organizations and authorities are major consumers, and by using their purchasing power via public procurement they can promote sustainable goods and services, which can impact the overall markets significantly. Public procurement refers to the process of which public sector organization, including cities and municipalities, purchase goods, services, and construction contracts outside their own organizations.

(European Commission, n.d.^o). Public authorities have the possibility to contribute to multiple sustainable development goals, for example SDG 11 “Sustainable Cities and Communities” and SDG 12 “Responsible Consumption and Production”, if they focus their purchasing power to products and services that are environmentally and socially friendly. Procurement by public sector has potential to create jobs, encourage investments and innovation, and to enhance economy that is more resource and energy-efficient while increasing social inclusivity (European Commission, n.d.^o). As Edler and Georghiou (2007) argue, demand is a significant source for innovation, and it has been reported that requirements and demand work as main source for innovations. Thus, the demands and requirements public organizations set in their procurement can potentially have a huge impact on the development of specific markets, meaning that they play a key role in modifying the ways that companies operate and create innovations. It is estimated that public procurement makes up approximately 14% of the whole gross domestic product (GDP) in European Union, being a major part of the European economy. (European Commission n.d.^o) As it is reported in the Organization for Economic Co-operation and Development (OECD) National Accounts Statistic (Figure 4), the general government procurement spending as a percentage of GDP in 2020 was around 18% in Finland, 17% in Norway, and 17% in Sweden, embodying increase in this percentage in all the three countries compared to year 2019. These numbers tell that public procurement plays a substantial role in the target countries’ economy, meaning that public authorities in Finland, Sweden, and Norway have power to potentially modify the overall economy and ways of operating by implementing requirements in their procurement. It can be argued that public procurement has a key role in terms of economic sustainability in these three countries resulting that they can also enhance environmental sustainability by directing money to more environmentally friendly goods and services.

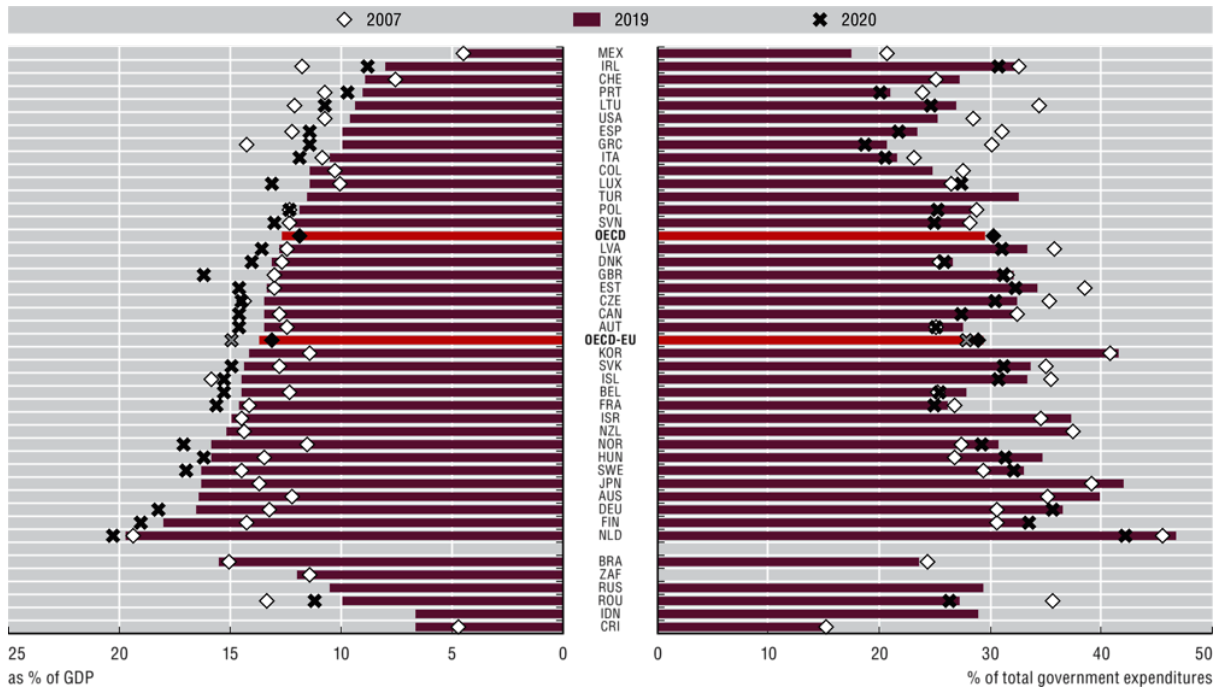


Figure 4. General government procurement spending as percentage of GDP and total government expenditures, in 2007, in 2019, and in 2020. Source: OECD (2021).

Significant share of public procurement’s annual value goes to infrastructure construction. Infrastructure construction refers to constructing and maintaining all the necessary structures and systems that enable the functioning of society, including roads, bridges, water and sewage systems, and power infrastructure to name a few. For example, in Finland between the years 2010 and 2016, 47% of the average annual value of the public building procurement went to infrastructure construction (Kuittinen & le Roux, 2017). In their report, Kuittinen and le Roux (2017) also state that approximately 30% of all public procurement is related to different types of construction projects, including infrastructure construction. In the same report it was also stated that cities, municipalities, and municipal associations are the main procurement units regarding public infrastructure procurement. Consequently, it can be argued that infrastructure construction is a significant focus of public procurement in Finland with dominant involvement of local entities in shaping and advancing these initiatives. Within the limits of my study, I was unable to gather detailed information on cooperatives in public infrastructure projects from all public procurements in Sweden and Norway. However, it is stated in OECD’s article (2021), that one of the key political priorities for advanced economies alike is infrastructure investments. Thus, it can be concluded that public infrastructure procurement plays a key role in public procurement in Sweden and Norway as well.

2.3.2 Sustainable infrastructure and Green Public Procurement

Sustainable infrastructure can be defined in many ways, but one common definition refers to it as infrastructure systems and equipment – including roads, bridges, and hydroelectric power stations for instance – that are designed and built to meet current and future population’s essential service needs (Iberdrola, 2021). IBD Group provides another comprehensive definition of sustainable infrastructure as following: “Sustainable infrastructure refers to infrastructure projects that are planned, designed, constructed, operated, and decommissioned in a manner to ensure economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire life cycle of the project.” (Inter American Development Bank & IDB Invest, 2018, p. 11). Sustainable infrastructure therefore takes environmental sustainability into account in all phases of the infrastructure’s life cycle.

Finland, Sweden, and Norway are all countries that are strongly committed to environmental sustainability and mitigating climate change. This commitment to environmental sustainability embodies in different best practices and policies that are applied in public procurement. If public organizations, such as cities, direct their purchasing power into sustainable procurement they can enhance sustainable development and push the whole market to be “greener”, making Green Public Procurement one of the most effective tools in promoting sustainable development. Green Public Procurement (GPP) is a voluntary instrument that public organizations can utilize while purchasing public goods and services. By using GPP, public sector’s organizations can contribute to environmental sustainability as well as economic and social sustainability. (European Commission n.d.^a). As Reinville (2017) states, GPP is defined as procurement that mitigates environmental impacts of the product or service throughout its entire lifecycle. The benefits of GPP include also social and economic impacts in addition to the environmental impact. Utilizing GPP improves quality of life, for example in the form of improved air quality. From the market shaping perspective, GPP can reduce the prices of environmental technology, which can encourage different actors to adopt them into use in increasing numbers. For that reason, GPP as an instrument is also important in terms of promoting sustainable innovation. From economic perspective, GPP can lead to financial savings over the whole life cycle of the purchased good or service. By utilizing GPP for more sustainable consumption, public authorities can

also demonstrate their commitment to sustainable development, which in turn sets an example for private sector and public in general. (European Commission, 2008.) This example can raise environmental awareness and shape societal values and world views, which are essential part in achieving sustainable development and larger systemic change.

Regarding infrastructure procurements, GPP has potential in decreasing its impact on climate change by reducing greenhouse gas emissions for instance. Utilizing GPP as an instrument for infrastructure procurements can also be instrumental in addressing environmental challenges related resource use, soil, water, and air pollution, and waste management. (European Commission, 2008.) Thus, GPP has a critical role in promoting sustainable infrastructure since it integrates much needed environmental criteria into infrastructure procurement.

Even though GPP is a powerful tool for promoting sustainable development, the majority of countries utilize GPP for a relatively small proportion of their contract procurement, typically less than 5% (see Figure 5). This can be partially explained by the optional nature of GPP. In order to increase the percentage of Green Public Procurement of the total amount of procured contracts in different countries, more political support is needed. (Sapir et al. 2022.) Other limiting factors to utilizing GPP are the lack of practical tools, information, and expertise in applying environmental criteria, as well as the general perception of the higher costs created by utilizing the instrument (European Commission, 2008.). Sapir et al. (2022) also bring out that the utilization of GPP may be limited due to political reasons since the heads of public organizations that execute procurement can be political appointments. Additionally, they bring out the short-term bias of politics, which affects the selection of less expensive but also less environmentally friendly products and services over greener but more expensive alternatives. However, these might end up being more cost-effective in the long run. Sapir et al. (2022) also highlight that there is a significant uncertainty that public operators face in implementing GPP due to the legal complexity of EU's public procurement directives. For example, implementing green criteria in public procurement process can unintentionally lead to discrimination of product and service providers, which is prohibited by EU directives.

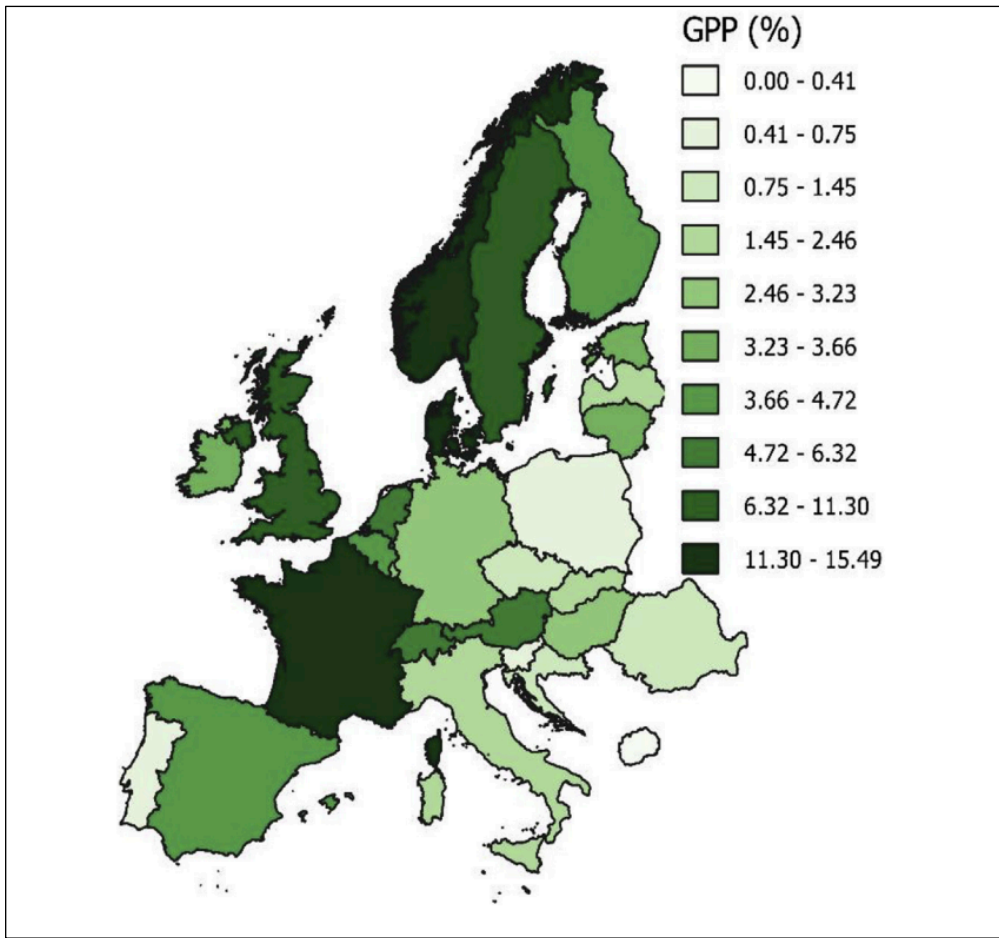


Figure 5. Green Public Procurement proportion by country. Source: Rosell (2021).

To conclude, GPP offers great potential in enhancing public procurements' environmental sustainability. However, there are multiple challenges that hinderance the effective utilization of GPP, including economic factors and lack of awareness among public operators for instance. These challenges need to be tackled in order for GPP to become more widely utilized instrument in public infrastructure procurements. That will be an important step in achieving the SDGs globally.

2.4 Digitalization and sustainable development

In this part of the literature review I discuss digitalization's role in enhancing sustainable development and its potential pitfalls. In addition to this I elaborate more on digital development of infrastructure industry and present a few most common digital tools or processes utilized in this sector. The aim is to examine digitalization and its relation to sustainable development, and sustainable infrastructure.

2.4.1 Digitalization's possibilities in promoting sustainable development

Digitalization, also known as digital transformation, means the introduction and adoption of digital technology in every part of society and its operations. Different digital technologies are increasingly utilized in everyday life's social processes and business operations, and digitalization impact on various fields is significant. It has been identified that digitalization has huge potential in solving modern challenges and different digital technologies are continuously developed.

In terms of sustainability, digitalization's potential in promoting sustainable development has been recognized. Seele and Lock (2017) argue that digitalization plays a key role in helping to reduce the negative impact of human operations on the environment and it has the potential to help achieving different sustainable development goals enabling the sustainability of the planetary and human systems. Different digital technologies, for example in the form of emission mitigation solutions or robotics, can help both individuals and organizations in achieving sustainable development goals (Seele & Lock, 2017). The utilization of digital technologies in sustainability creates bright opportunities for achieving more environmentally and socially friendly economy and society (Del Rio Castro et al. 2021; Geissler, 2021; Seele & Lock, 2017).

As stated before, sustainability sciences and digitalization go tightly hand in hand. Sustainability science can be seen as the scientific way of data gathering which is essential regarding analyzing different pathways to more sustainable human systems. Seele and Lock (2017) argue that digitalization can possibly be the driver that changes and modifies sustainability, or vice versa sustainability adapts to the new possibilities of digitalization considering its transformative nature. Even though the interplay and potential between sustainability and digitalization has been acknowledged, researchers emphasize how little evidence still exists on digital paradigms' contribution to sustainability and that digital technologies come along with yet unknown consequences, environmental concerns, and most likely also ethical issues (Del Rio Castro et al. 2021). For example, Lange et al. (2020) conducted research on digitalization and energy consumption. They studied digitalization's effect on energy consumption and concluded that instead of reducing energy consumption, digitalization has increased energy consumption since the direct effects and economic growth have been greater than the increased energy efficiency and sectoral change. The energy-reducing effects of digitalization tend to cause mechanisms that lead to increased

energy consumption. (Lange et al. 2020.) Thereby, in some cases digitalization may have negative impacts on sustainability for example in terms of increased energy consumption. In addition, as Del Rio Castro et al. (2021) argue, despite the promising opportunities ahead, research indicates that the progress of utilizing digital technologies to address the SDGs is slow paced and strongly context dependent. However, further research on the interplay of digitalization and sustainability in general is needed since it enables minimizing the pitfalls and offers far-reaching opportunities for tackling the complex sustainability challenges.

2.4.2 Digitalization and infrastructure sector

Even though digital technologies have also their downsides regarding sustainability, it is identified that in the field of infrastructure, digitalization offers huge potential in shaping the industry more sustainable. Infrastructure is an essential component of societies, economic development, and social welfare (Heard et al 2012). Infrastructure is also a significant contributor to global carbon emissions throughout its entire life cycle, which is why especially sustainable infrastructure construction has become a priority for governments and construction companies as well as other stakeholders (Brammer & Walker, 2011). In addition to reducing the industry's carbon emissions, sustainable infrastructure and its construction aims to reduce waste, promote efficient use of resources by adopting circular economy, and enhance the durability and resilience of infrastructure (Inter American Development Bank & IDB Invest, 2018, p.12).

Digitalization has the potential to facilitate sustainable infrastructure in its different life cycle phases in many ways. For example, Goger and Bisenber (2020) argue that the processes in construction operations and management will be entirely changed through digitalization. They state that with different digital tools and processes the holistic lifecycle consideration of infrastructure projects is possible, from design phase to construction and the actual operation, since they enable the introduction of integrative working processes. Goger and Bisenberg (2020) discuss that the complexity in implementation and maintenance of infrastructure projects is the reason why the concentration on construction operational processes has been neglected in the past. This analysis of all operational processes forms the backbone of digitalization in infrastructure projects, and thus should not fail.

As Goger and Bisenberger (2020) present, Building Information Modelling (BIM) is one of the most central digital methods in executing infrastructure projects. BIM is a digital process

and approach in construction that enables the identification of inefficiencies through visualization and simulation of construction projects, and it is used to facilitate the information integration and management through the entire life cycle of the construction (Bapat et al. 2021; Lu et al. 2017). This digital approach to infrastructure projects with daily continuous comparison of intended and actual progress using digital process data, provides major added value through the development of the project. This is beneficial for the contractor, since utilizing BIM helps constructors to optimize energy-efficiency and resources and assess productivity (Bapat et al. 2021). Additionally, it benefits the client ensuring security and enabling updates to the budget through documentation (Goger & Bisenberger, 2020). By utilizing BIM in the different phases of infrastructure projects, from the early design phase to operation and management phase, it is possible to design and construct durable and resilient infrastructure while minimizing waste, optimizing resources and energy efficiency. To conclude, as a digital process, BIM enables more efficient, collaborative, and sustainable infrastructure projects, making it a transformative approach in modern construction.

Other examples of digital tools and approaches used in infrastructure projects are machine control systems and drones. Machine control systems refer to the operation and control system of heavy machinery used in construction phase, such as excavators and bulldozers. These systems apply and receive certain instructions based on which makes the heavy machinery produce specific actions in compliance with the requirements of operators through the machine's power transmission device. Utilizing machine control systems in infrastructure's construction phase enhances project efficiency, protection of the environment, and cost savings. (Huang & Liu, 2021.) Unmanned aerial vehicles (UAV) in turn, more commonly known as drones, are utilized in infrastructure projects for change monitoring and construction management helping in the execution of the project (Lee et al. 2020).

To conclude, the use of BIM and drones, and many other digital tools in infrastructure projects can significantly reduce the environmental impacts of infrastructure procurements, which is why infrastructure owners, construction companies, and other stakeholders should invest in digitalization to enable sustainable infrastructure construction. With the utilization of digital tools and approaches throughout infrastructure's whole lifecycle, it is possible to gain time savings in infrastructure construction for example, which can reflect positively on the environment and financial costs. However, the implementation of digital tools and

approaches in infrastructure projects requires interdisciplinary experts with knowledge regarding digital information (Goger & Bisenberg, 2020) and further research is required to identify and develop the optimal digital tools and processes for sustainable infrastructure procurement.

3 Data and methods

In this chapter I will describe the research process and the methods that I used in this study. I will elaborate on why I chose qualitative approach for conducting research on environmental sustainability requirements that cities use in public infrastructure procurements. In addition, I will justify the chosen data collection method, after which I elaborate more on the data collection process and sample. Third, I will explain the process of data analysis step by step. Lastly, I will discuss the trustworthiness of this study.

3.1 Research process

Table 1. below presents the whole research process arranged in chronological sequence. The research process started in March 2023 by getting a comprehensive onboarding to the company to which I conducted this research for. The topic of the research on a more general level was given to me on behalf of the company, but the process continued in April by creating a research plan and identifying more specific research questions that were related to the given topics. In April, I also initiated the process of contacting individuals for interviews, since I was aware that it may be challenging to secure participants. During that time, I also contacted people to form a steering group, with which I had a first meeting in May. With the guidance of the steering group, I created the interview framework for my study. During May I also conducted a test interview to assess both the interview questions and the duration of the interview. The most time-consuming part of the whole process was conducting the interviews and transcribing them. This took part between the end of May and the beginning of July. After collecting the data, the analysis phase and finishing the report took place between June and August 2023, meaning that the whole process took six months in total.

Table 1. Research process in chronological sequence. Source: Own Illustration.

March 2023	April 2023	May 2023	June 2023	July 2023	August 2023
Onboarding to the commissioning company					
Research plan					
Literature review					
	Contacting people for steering group	1 st steering group meeting			2 nd steering group meeting
	Contacting people for interviews	1 st – 7 th interviews	8 th – 14 th interviews		
			Interview	data	analysis
					Final report

3.2 Methods

3.2.1 Qualitative research

The aim of my study is to obtain information about environmental sustainability requirements pursued by public operators in infrastructure procurements, and to create understanding how environmental sustainability is considered and implemented in infrastructure procurements. Since I am looking for empirical answers to open research questions that cannot be answered comprehensively with quantitative data, qualitative study is the appropriate approach for my study. Qualitative approach enables me to produce knowledge about how things are and potentially will be (Eriksson & Kovalainen, 2008, p. 4) in the current Nordic infrastructure construction market regarding environmental sustainability requirements. The prior insights on the topic are modest and the research questions have not been studied in depth, thus my study is exploratory and flexible in its nature. According to Ghauri and Gronhaug (2005, p. 202) qualitative approach is specifically relevant in this type of context. Qualitative approach in my research allows me to explore the subject matter more flexibly and creates possibilities to gain understanding of underlying motivation and attitudes related to the research topic.

3.2.2 Grounded theory

Within qualitative research the choice of method for my study is grounded theory approach. It is one of the most popular qualitative research methods across diverse disciplines and fields of study (Bryant & Charmaz, 2007, p.1). Grounded theory as a methodology focuses on developing theories from the collected data itself, allowing patterns and concepts to emerge without preconceptions and relying on pre-existing theories (Eriksson & Kovalainen, 2008, p. 155). Thus, grounded theory is an inductive methodology. It consists of a systematic set of procedures that are the key tools to produce a theory through empirical data analysis (Eriksson & Kovalainen, 2008, p. 157). As Bryant and Charmaz (2007, p. 1.) discuss, data collection and data analysis proceed simultaneously serving and informing one another. This iterative process of data collection and analysis, enables researcher to uncover patterns and relationships from the data itself, rather than relying solely on theoretical framework and initial anticipations. But instead of inductive analysis that is typical for grounded theory, I will take an abductive approach to my study. As Timmermans and Tavory (2012) argue, abductive analysis emphasizes that instead of setting pre-existing theoretical ideas aside during the process, researcher is encouraged to examine the topic while studying existing theoretical knowledge about it. This enables developing theoretical insights throughout the research process while drawing from the existing knowledge. Thus, abductive approach to my study allows me to delve into existing literature on the research topic before collecting empirical data, therefor helping me to better identify relevant themes and to form my interview guide. With this approach I can conduct my study by allowing the data and emerging findings guide its path. But instead of developing a new theory, the aim is to increase knowledge and understanding on the environmental sustainability requirements and the factors that affect implementing those in public infrastructure procurement.

3.2.3 Semi-structured interviews

Individual interviews were my primary method of collecting empirical data. As Warren (2001) argues, qualitative interview enables establishing common patterns or themes between the chosen respondents that are located in different settings. Within my research the aim is to gain understanding of a certain market and its prospects by interviewing people from eight different cities from Finland, Norway, and Sweden. In terms of qualitative interview type, I chose semi-structured interviews as a method to collect primary data. Conducting semi-structured individual interviews, gives the possibility to have a prepared

outline of the focus themes yet allowing room for conversation and different order of the questions depending on the interviewee's answers (Eriksson & Kovalainen, 2008, p. 83). Since my study is qualitative in its nature, my interview questions are open-ended, which allows the respondents to contribute with as detailed information they desire. With the open-endedness in the questions there is also the possibility for me to ask follow-up questions that evoke from the participants answers. (Turner, 2010.) Before conducting the interviews, I consulted my steering group and thesis supervisors about the interview guide (Appendix 1) which was eventually divided into three main categories based on the research questions. The categories included more general questions regarding the environmental sustainability of public procurement, more specific questions regarding public infrastructure procurement's environmental sustainability by theme, and questions about digital tools.

3.3 Data collection and sample

Based on the interests of the commissioner company, the study's target countries were identified as Finland, Sweden, and Norway. The selection of target cities to represent public organizations was only influenced by the choice of these three countries, and no additional criteria were applied. This approach enabled broader range of possibilities for contacting and finding potential participants. Cities and municipalities as infra owner organizations are the key stakeholders in public procurement market since they are the ones deciding and investing on infrastructure. I started contacting people from various cities across the three specified countries through email. Initially, the goal was to secure two participants from each city, and two cities represented per country. However, securing balanced distribution of interview participants across different cities and countries proved to be challenging. Hence, the number of interviewees per city and country varies, deviating from the original goal of consistency. Finally, the total number of interviewees turned out to be 14 and total number of cities represented turned out to be 8. To ensure the anonymity of the participants, the names of the eight cities are not mentioned. The cities are divided into different size categories based on population (see Table 2.). Cities that are among the five largest cities by population in their country are referred as "large" and cities that do not rank among the top five largest cities by population in their country but are placed within the top ten largest cities are categorized as "medium". Since my aim was to explore the environmental sustainability requirements in public infrastructure procurement, all the interviewed public authorities work somehow with public infrastructure procurement and have expertise in environmental sustainability,

sustainable infrastructure procurement, or municipal engineering and infrastructure construction. For a more detailed information on the interviews, see Table 2. below.

Table 2. Conducted interviews. Source: Own illustration.

Number of the interview	Country	City by size category	Respondent's position	Length of interview
1	Finland	Medium	City Engineer	54 minutes
2	Finland	Medium	Circular Economy Expert	30 minutes
3	Finland	Large	City Engineer	24 minutes
4	Finland	Large	Infrastructure Manager	56 minutes
5	Norway	Large	Climate and environmental advisor	51 minutes
6	Finland	Medium	Infrastructure construction manager	26 minutes
7	Norway	Large	Head of technical services	37 minutes
8	Norway	Large	Environmental advisor	61 minutes
9	Sweden	Medium	Project manager for energy and sustainable construction	47 minutes
10 & 11	Norway	Large	10 Senior engineer in climate and energy 11 Project leader	106 minutes
12	Sweden	Medium	Sustainability coordinator in public procurement	42 minutes
13	Sweden	Large	Development coordinator	52 minutes
14	Norway	Large	Department manager	54 minutes

All the interviews took place on Microsoft Teams and were recorded for transcript. Interviews with participants from Sweden and Norway were conducted in English, and interviews with Finnish participants were held in Finnish. Interviewees number ten and eleven

exceptionally participated in the interview together, but all the other interviews were individual interviews. Each of the interviews were transcribed with the help of Microsoft Word's dictate tool. Despite the automatic transcription using the dictate tool, I went through all the interviews to ensure that the tool had transcribed them correctly and to delete any unnecessary filler words.

3.4 Analysing the data

After transcribing all the interviews, which resulted in over 100 pages of material in Microsoft Word, I familiarized myself more with the data by reading the interviews through a couple of times. During the first step of the data analysis process, I started coding the data utilizing Atlas software provided by Aalto University. Coding is one of the most important elements in research conducted with grounded theory approach. As Eriksson and Kovalainen (2008, p. 16) describe the grounded theory approach's coding process consists of three types of coding, including open, axial, and selective coding.

The first round of coding was open coding, also known as initial coding. This process was bottom-up coding meaning that the codes emerged from the data at word and sentence level and were not suggested by the literature. Grounded theory method is a great example of this approach in coding (Urquhart, 2013). Due to the word and sentence level of coding there were several dozens of codes in the initial coding phase. In the second phase I conducted axial coding, during which I identified categories that describe the open codes. As Lawrence and Tar (2013) describe axial coding is a way to re-build the data through establishing relationships between open code categories and subcategories. Axial coding is a phase during which the researcher starts to put the pieces of the data together that were fractured in the open coding phase (Lawrence & Tar, 2013).

In the final part of the data analysis, I conducted selective coding. As Urquhart (2013) describes it, "selective coding is a process of scaling up your codes into those categories that are important for your research problem". To help the process of selective coding of vast number of codes emerged in the open coding phase, I used subcategories. These subcategories were formed by open codes that made up larger categories in the axial coding phase. In the final phase of the coding specific themes started to emerge from the empirical data. These themes formed the last four main categories that resulted in the data analysis. The process of data analysis was iterative and comparative in its nature and the aim was to

conduct a data-driven analysis resulting in rich research findings. These will be presented after evaluating my study.

3.5 Trustworthiness of the study

3.5.1 Reliability, validity, and generalizability

One essential step in writing a master's thesis or any other academic research is to assure the readers of the study and its scientific nature and trustworthiness. As Eriksson and Kovalainen discuss (2008, p. 290) it is important to adopt explicit evaluation criteria to increase the transparency of the research and to highlight its strength and limitations. The three main concepts that form the basic framework for qualitative research evaluation are reliability, validity, and generalizability. Reliability refers to the degree to which a research method, measurement, or tool produces the same outcomes when applied repeatedly (Eriksson & Kovalainen, 2008, p. 292). To improve the reliability of my study I have described my research process and data analysis process thoroughly. However, I recognize that the findings of my study are affected by my personal interpretations of the data.

As Eriksson & Kovalainen (2008, p. 292) describe validity in research refers "to the extent to which conclusions drawn in research give an accurate description or explanation of what happened". To increase the internal validity of my study I consulted steering group in compiling the interview guide to be sure that I have appropriate questions to answer the research questions. However, due to time limitations in conducting this research I was not able to do member checking which would have also increased the validity of my study. Member checking refers to the procedure of allowing participants to confirm or deny the interpretations I have made as a researcher from what they've told during the interviews (Eriksson & Kovalainen, 2008, p. 293). Another limiting factor was the utilization of two languages during the research process. The empirical data was collected in Finnish and in English. Finnish participants were able to answer in their native language, unlike participants from Sweden and Norway who had to use English. This might have caused misunderstandings resulting in wrong interpretations. In addition to that, translating spoken Finnish to English in representing the findings could potentially cause some inaccuracies in the quoted materials.

Generalizability in turn refers to the questions of whether the findings of the study can be extended into a broader context (Eriksson & Kovalainen, 2008, p. 294). I conducted several interviews per target countries and 14 interviews in total to improve the generalizability of my research. Though, all the cities that I got participants from are relatively large on the scale of the target countries, resulting that the findings of this research may not be generalizable on smaller cities and municipalities in Finland, Sweden, and Norway. However, the results can be generalized in the context of larger cities in the target countries. I will further elaborate on the limitations of this study in chapter 5.3.

3.5.2 Research ethics

As Eriksson and Kovalainen (2008, chap. 6) discuss, research ethics encompass the manners of conducting and reporting research. They emphasize the role of trust created in research community by following ethical principles in research. Essential parts of research ethics are informed and voluntary consent and professional integrity. I argue that these principles have been realized in my research. I have clearly stated that this study is commissioned by Infrakit Group Oy, and I have been financially compensated for it. This sponsorship offered the initial topic for the research that I have conducted. Eriksson and Kovalainen (2008, p. 68) bring out that sponsorship does not usually create problems if the research contents have been agreed and a sponsorship contract is signed in advance, as it has been done in the case of this research sponsorship. Regarding other ethical principles, the voluntary participation was emphasised in the first e-mail that was sent to potential interviewees. In the same email I also informed that the study was commissioned by Infrakit Group Oy, and that all the interviews will be recorded for transcription but will be solely utilized by me during this study, after which they will be destroyed. These matters were also emphasised in the beginning of every interview. Thereby it is justified to argue that informed consent and voluntary participation to the study happened according to ethical guidelines. I have followed professional integrity throughout my research as I have clearly described the methods used in this study and transparently elaborated on the research process. Lastly, I follow the ethical principles of referencing other scholars correctly avoiding silencing and utilize a software to check my text for any signs of plagiarism.

4 Findings and discussion

In this section of the thesis, I focus on the empirical findings from the 14 interviews that I conducted between the end of May and the beginning of July in 2023 with public authorities from eight cities in Finland, Sweden, and Norway. I will also integrate analysis and discussion in this chapter. I have divided the findings into four main themes and furthermore the themes are divided into smaller segments. These four main themes emerged from the empirical data during the final round of coding, forming four final top-level codes. I will present the findings that elaborate more on the main priorities in public infrastructure procurement, after which I address the findings regarding the relationship between public procurement and sustainable development. Third I will delve into environmental sustainability requirements that are currently implemented in public infrastructure procurements as well as challenges that public operators face in setting these requirements. Lastly, I will present the findings on digitalization and the role of digital tools in improving infrastructure procurement's environmental sustainability. In addition to discussing the themes that emerged from the empirical data, answers to the research questions will be provided along the way. However, I will also summarize the answers to the three research questions at the end.

4.1 Main priorities in public infrastructure procurement

First of the four main themes addresses the main priorities regarding public infrastructure procurement. Environmental sustainability requirements in public infrastructure procurement are closely interconnected with other criteria as well. Therefore, I will present all the priorities that emerged from the empirical data. The main priorities include economic aspects, the quality of infrastructure, as well as social and environmental sustainability.

4.1.1 Price

Majority of the interviewees emphasise the role of economic aspects during public infrastructure procurement process. Even though a large part of public operators financial invests are directed into infrastructure procurement, it is typical that public operators' budgets are relatively tight compared to private sector. During the procurement process infrastructure owners identify the need for a new infrastructure procurement and in the design phase of the process a budget for the procurement is determined as well as other

details and requirements. Depending on the specific procurement project there are different eligibility requirements. These requirements usually include technical and professional qualifications and criteria regarding legal capacity for instance. Including all the relevant information regarding the procurement the public organization prepares a request for tender that reaches contractors through different procurement platforms or official government websites. Based on the outlined tender requirements interested contractors submit their bids after which they are evaluated on the behalf of the procurer with different type of weighted criteria. If the eligibility criteria are not met the bidder will be excluded from the tender. The aim in the procurement process and selection process of contractors is to achieve balance between economic factors and other important considerations.

Based on the empirical findings there is a strong will to include environmental sustainability criteria and to achieve more sustainable ways of operating in public infrastructure procurement. However, price is still the criteria that is weighted the most and is often the crucial factor in selecting the contractor that pass the procurement process regarding the minimum requirements. The emphasis of economic aspects did not vary between medium and large-sized cities but was strongly present in the responses of the participants from both size category cities.

“Yes, the lowest price there (in the bid evaluation) will be decisive.” H1

“Well, if we’re talking about all the main priorities, the economy is still definitely the main priority at the moment. Projects need to be financially sustainable”. H2

It was also mentioned that the main priorities vary depending on the size of the project. In smaller infrastructure construction projects, the environmental sustainability priorities seemed to be less important, because the impact of those in small projects were not perceived as influential as in larger projects. However, often there are several smaller infrastructure construction projects across cities and municipalities which all combined create significant impact from the environmental sustainability point of view. Thus, environmental sustainability as a priority should not be underestimated in even smaller projects.

“In practice we currently compete on price. However, we have some criteria with which we aim to consider environmental sustainability as well as social sustainability. But that requires a bigger project to be able to make an impact, since in smaller infrastructure

construction projects those are a bit of an eyesore. You can't really make an impact regarding those aspects in a small infrastructure procurement project." H3

Many participants brought up that the cities need to be able to justify the infrastructure procurements financially, and usually more environmentally friendly solutions cost more, at least in the procurement phase. However, in the long run higher financial investments in infrastructure procurement in the beginning might end up creating savings in the latter life-cycle phases of infrastructure ending up costing less in total. And because currently more environmentally friendly solutions cost more, the role of legislation and policies to steer and support public infrastructure procurement towards more sustainable ways of operating was highlighted. Even though environmental sustainability is something that is increasingly considered in public infrastructure procurement process, it is still not equally weighed criteria with price.

"When the legislation starts to guide this ecological sustainability more strongly, it will come alongside of economic factors. But it seems to require such strong control measures that we as a city can justify those acquisitions, because they are basically not the cheapest from an economic point of view, at least at the procurement stage." H2

"And still, the competition has mainly been that the lowest price wins. But I'm sure that the environmental aspects will be brought up there more, meaning that you can't win the bid with the price alone." H6

"Well, I would say in general in procurement it's money and sustainability as well. But usually, finances are put at the top when it comes to priority." H12

In contrast to the answers of participants from other cities, interviewees from large cities in Norway highlighted scoring percentages of different priorities in their responses. There is an effort to increase the weighing of environmental sustainability criteria in public infrastructure procurement. However, despite these efforts the importance given to environmental sustainability is still not equal with economic priorities, even in Norway's largest cities that seem to act as pioneers in this matter.

"Normally we score the price 50-60% and then the competence and the experience we could score like 20% or something. And then the environmental sustainability aspects we will score 30% as an example." H7

“Before many projects weighed the bids 100% on price, and now they have to weigh the environmental part 20%, so that’s quite an impact on the procurements.” H8

To conclude, the cost is still a priority and deciding factor in public infrastructure procurement, but there is an increasing emphasis on environmental and social sustainability factors in procurement decisions as well, especially in Norway. Participants from large cities in Norway highlighted the increased weighted percentage on environment in the tender evaluation, being currently 30%, which is high compared to other focus cities and municipalities, where this number of weighted criteria on environmental aspects is not a current practice.

4.1.2 Environmental sustainability

Aside from the economic factors that are still the most weighed factor in public infrastructure procurement process, environmental sustainability is another main focus in public infrastructure procurement. Global and local climate goals and environmental sustainability goals are behind municipal strategies, and local politicians push cities towards their environmental goals. When participants were asked about if environmental sustainability in public infrastructure procurement is a topical issue in their municipality, all of them highlighted that it is increasingly considered in public infrastructure procurement and is one of the main themes in city strategies in general.

“Oh yes. The politicians here are really concerned with this (environmental sustainability), and they are pushing us in ministration to really work with it a lot. So, they give us a lot of money and means for us to achieve the goals that they set. So, there’s a strong focus there.” H5

“Yeah, we work a lot with this, and this is a big part of our climate change management for example.” H13

It emerged from the empirical data that there are some differences between the target cities in terms of concrete actions in promoting environmental sustainability. Especially larger cities seem to be more developed in this matter and have more concrete actions implemented to enhance the environmental sustainability of public infrastructure procurement than medium-sized cities. Especially large-sized cities in Norway stood out with their contribution to environmental sustainability in public infrastructure procurement. Norway

in general is a pioneer in Green Public Procurement and is one of the few countries that GPP's proportion is over 11% (Rosell, 2021).

"We've been working with that (environmental sustainability) for several years here in (the name of the city), and we are setting demands, or also having all the contractors competing on the environment in all our procurements." H7

"It's really a relevant issue. The weighted criteria in every procurement we have is 30% environmental." H8

While larger cities are forerunners with this topic, some participants from medium-sized cities brought up that they are still in the beginning phase, trying to come up with realistic, concrete actions which could be implemented in the public infrastructure procurement process. It was also brought up that the implementation of actions to promote environmental sustainability is slow-paced because public operators want to be sure that the selected actions are correctly targeted.

"Yeah more and more. You can say that the focus has been more on these questions, and I think still we are in the start-up phase. But I think we are quite careful when we start working with things, so we are sure that we are doing the right things and focus on the right questions. So, we are still learning how to build up this way of working." H9

Even though environmental sustainability in public infrastructure procurement is a central theme and one of the main priorities in cities and municipalities, the actual implementation of environmentally friendly practices and environmental sustainability criteria is still lacking in many places. Interviewees from medium-sized cities also brought up that the management of environmental sustainability themes from the strategic level to the operational level as concrete actions is still incomplete and requires improvement especially in infrastructure construction, while it is better managed in other sectors.

"The topic (environmental sustainability), spins on the table all the time but at least it hasn't been strongly led. Somehow it has developed more in maintenance but in the construction, it is still a bit sad, and the actions are not that planned there." H1

"Well, let's say that if you think about infrastructure construction projects, sometimes it feels that we are little behind if you think about our tendering and carrying out our projects." H6

There are also differences in national legislations and policies which of course influence the development of this matter creating differences between cities and municipalities in different countries. For example, in Sweden the law creates restrictions in incorporating technical requirement in public procurement.

” We of course look upon also the energy requirements and how much energy such things we would buy use for one thing. But one problem all cities in Sweden have will is a law saying that we are not allowed to put technical requirements in the procurements. We may be able to say that we need a function, but we cannot say that we would like to buy something with technical, very specific to specific technical requirements. Because that must be an open question, so that makes it a little bit difficult for us in this area.” H9

More specific on the environmental sustainability priority in public infrastructure procurement the participants highlighted the actions regarding climate goals. Zero emission construction sites emerged to be the most focused goals in the cities in Norway. The role of electrical machines in achieving zero emission goals in construction sites is the main focus there, and large Norwegian cities are very committed in that matter. The demands about the use of electrical machines, such as excavators and trucks, in construction sites are put in action the most concrete in Norway. Also, Finnish, and Swedish cities have carbon neutrality related goals in general, meaning actions towards those are required also in infrastructure procurement. However, some of the cities, mainly medium-sized ones, are not that developed yet with incorporating concrete actions in public infrastructure procurement process.

“Regarding environmental sustainability here in (the name of the city), it’s really what the politicians want us to focus on. So, we have several goals and one of them is zero emission construction. But we also have this goal about reducing the carbon footprints of the projects including the indirect emissions.” H5

“Carbon neutrality is kind of a main priority since we have the goal to be carbon neutral by 2025. So, that is basically the one that rises on top at the moment in the planning phase of the procurement.” H6

In addition to the emission related focus in public infrastructure procurement, the empirical data brought out focus on circular economy, reusing materials and resource conservation in infrastructure procurement. Preferred strategies included focusing on few key materials with

high climate impact and finding more environmentally friendly solutions for those. Also, the focus is on long-term planning meaning that the planning phase of infrastructure procurement plays a key role in terms of environmental sustainability.

“The main focus is zero emission these days. And of course, reuse.” H14

” We think that it's better that we focus on the four or five most important materials that we know that have the highest impact on the climate. So, I think it's better that we start with a few items and be better there, and then be able to be more broadened in the future.” H9

” It is the first thing how to cut indirect emissions from the materials, how to buy or produce more locally, how to cut the transport, how can we produce more sustainable materials that we can use that will have the same quality as those we are used to use in construction projects. So, the next one is how to reuse; how can we reuse the masses, how can we reduce the use of new elements and how can we actually reuse the same location.” H10

To conclude, environmental sustainability is a very relevant matter in public infrastructure procurement and participants emphasise especially infrastructure’s planning and construction phase when discussing the actions that could promote environmental sustainability. All the target cities have goals regarding carbon emissions and enhancing circularity in public infrastructure procurement, achieving of which is essential in terms of reaching the cities’ climate neutrality goals that are centrally included in city strategies. However, the implementation of concrete actions in this process varies between the studied cities. As mentioned, large cities in Norway seem to be forerunners in incorporating concrete actions in public infrastructure procurement and the environmental sustainability related scoring in the evaluation and selection process of contractors. Environmental aspects are weighed up to 30% in the bid evaluation and selection process. In contrast to the typical scenario where price is the final determining factor, in some projects the environmental criteria ended up being the decisive factor in the selection process of constructor.

“Before many projects maybe had 100% price weighed, and now they have to weigh for the environmental part for 30%. So, that’s quite an impact on the procurements, because in one project for example the environmental part of the criteria was the one that decided who won the contract. So, I think (name of the city) is quite far ahead when it comes to using environmental aspects in the procurements.” H8

Even though environmental sustainability in public infrastructure procurement is one of the main priorities, it is still typical that environmental related criteria is used to get bonus points in the evaluation process of the contractor instead of them being a decisive criterion. The emphasis on environmental sustainability varies between projects and between countries. For cities to be able to achieve their ambitious environmental goals, including carbon neutrality goals, it is essential to find balance between environmental and economic priorities in public procurement. If the minimum requirements in public infrastructure procurement regarding environmental sustainability are not high enough, the industry will not develop in the needed direction fast enough.

4.1.3 Social sustainability

Among environmental sustainability, social sustainability aspects were mentioned as priorities in the interviews. However, the emphasis on the interviews was on environmental sustainability of public infrastructure procurement which guided the conversation more towards those aspects. But when asked about main priorities in the procurement process and infrastructure construction projects a few participants brought up social sustainability as a priority as well. This emerged specifically related to the safety of construction sites emphasizing the social sustainability in the infrastructure construction phase.

” Regarding the whole aspect I think quality and you know security for the workers and how all that it's really central and it's been more and more focus on it.” H5

Social sustainability aspects also go hand in hand with environmental sustainability. Concrete actions that are incorporated in infrastructure construction projects enhance both social and environmental sustainability. For example, implementing requirements regarding the use of electrical machines contributes to both environmental and social sustainability. The electrification of construction sites reduces emissions affecting the site's air quality positively. In addition to the improved air quality, using electric construction machines reduces noise pollution on the construction site.

”With the zero emission machines, I mean now in 2023 we have 70% of the machine hours in our projects from electrical machines. So that is reducing the air pollution on the construction sites.” H8

"Well, you can't toxicate people. But it hasn't been a lot of focus, but it's a lot of focus now. And that's why we are going to the zero emission. But using electricity also makes noise, but in a different kind of noise. Using electricity on machines makes the site very quiet, so it's much more comfortable to work at the site with electrical machines and to live beside it." H14

Social sustainability as a priority in public procurement was also mentioned on a more general level, for instance in purchasing fair trade products and supporting employment through procurement.

"But it could also be that I mean we only buy fair trade bananas, coffee cocoa, and that's more of like social sustainability. --- When it comes to social, we also have this...or we would like to get more people who are not working into work through our procurements." H12

Due to the nature of the research participants emphasised the environmental sustainability in their answers. However, social sustainability is a priority as well and it is incorporated in public procurement process in Finland, Sweden, and Norway for example through legislation regarding worker rights and working conditions. Many environmental sustainability goals in infrastructure procurement also enhance social sustainability by improving the surrounding conditions on construction sites for instance. The planning of sustainable infrastructure also takes social sustainability aspects into consideration regarding accessibility and mobility.

4.1.4 Quality

Regarding the main priorities in public infrastructure procurement the fourth theme that came up frequently in the interviews is quality. Quality of the infrastructure is a top priority in public procurement process and quality related aspects such as competence belong to the eligibility requirements of the procurement criteria. Including quality aspects into the eligibility requirements is essential in terms of ensuring that the selected contractors and suppliers can deliver the desired results.

"I think regarding the whole aspect, quality, and you know security for the workers and all that is really central. And it's been more and more focus on it. As the same time as environmental issues and sustainability." H5

"If you have the necessary machine, you are able to compete on price, right. But when we make parks and public spaces, we also put in a big value to quality. So, first you have to you know electrification, and then we say OK price 50% and quality 50% or 40/60 or whatever. That depends on the project." H14

The quality of infrastructure is also directly linked to safety and infrastructure's lifespan. High quality infrastructure is built to withstand wear and changing conditions over time, which ensures that the basic services and structures continue to work for their intended purposes. This is especially important in today's world where human actions have created unpredictable changes in ecosystems resulting in various natural disasters. High quality of infrastructure contributes to the longevity of its operational lifespan, which reduces the need for frequent replacements and repairs. Well-designed and constructed infrastructure also allows effective and feasible maintenance which is an essential part in extending its lifespan.

"But you have an environmental focus and it's also price, but also quality is important. --- We want a contractor that can build and finish it and it will last for at least 100 years." H11

"I think it's a sustainability in a long run, you know. Most environmental and climate sustainability, but also when it comes to what material you choose. We want materials that last for a long time and be able to use it again. You are thinking in a long term not the short, you don't think three months ahead, you think 10 years or 20 years ahead also." H13

Quality related aspects are eventually strongly interlinked with economical aspects as well as other sustainability aspects. Placing a strong emphasis on quality in the public infrastructure procurement process eventually benefits both society, economy, and environment through the longer lifecycle. However, quality is a priority at the expense of which no compromises are made, for example to promote environmental sustainability. Even though there is an emphasis on adopting more environmentally friendly practices, the quality of essential services will not be compromised.

"You will have the quality and the price will be ok - that people can afford it. This is something that we always have to have in front of us when we talk about climate and environment and energy, because the most important for us is to give the quality to people. So, we cannot for example say that we will reduce the quality of water and we would just redo all the cleaning process at our water treatment plant just to produce 5 gigawatts with pure energy, so this is something that we always need to remember. And we need to balance

it also in procurements; that yes, environmental aspect is really important, but this is not why we are here. So, we try to produce water and give the sanitary services in the most environmentally friendly way.” H10

As well as with economic aspects and environmental sustainability, there is a need for finding a balance between quality and other priorities in public infrastructure procurement. Quality as a priority does not exclude environmental sustainability but further development of more environmentally friendly practices without compromising quality and the longevity of infrastructure is required. As Thacker et al. (2021) argue, infrastructure plays a key role in providing the vital services for societies as well as protection against the harmful effects of environmental sustainability challenges, such as climate change. Thus, the quality and longevity of infrastructure is essential in a modern world where conditions may change fast, and the effect of human activities might be unpredictable. The emphasis needs to be on the planning phase of public infrastructure procurement with approach that considers the whole life cycle of infrastructure.

4.2 Public procurement and sustainable development

This part of the findings addresses the relationship between public infrastructure procurement and sustainable development. I elaborate more on the empirical data regarding public operators' role in promoting environmental sustainability through public procurement. In addition to that I discuss the challenges public operators face in promoting sustainable development and the needed actions to be better able to enhance environmentally friendly practices in procurement process.

4.2.1 Public procurement's role in promoting sustainable development

Public procurement is a powerful tool with which it is possible to influence the market and drive change towards more sustainable ways of operating. When participants were asked about public infrastructure procurement's role in promoting environmental sustainability, majority of them, whether they are working on a more strategic or operational level, recognized public procurement's significant possibilities in enhancing sustainable development.

“As an infrastructure owner we have a significant role. We create a market for that matter with our demands, so that companies can create services and products to promote

sustainable development. So, in that sense, the role is big as infrastructure owner, because we carry out significant projects in terms of size.” H2

“After all, we as public operators work as trendsetters. And public sector is the most important operator that tenders and implements infrastructure projects.” H4

Participants emphasize public operators', and especially cities' role, as the most central actors in implementing infrastructure procurement. Therefore cities have the possibility to shape the whole infrastructure sector by setting demands and requirements in public infrastructure procurement to push the market towards more sustainable.

” As a public we are so large company, and I think it's important that the public is going in the front and are trying to set up what we expect for the future” H11

The empirical data highlights public operators' role in pushing the market more sustainable direction and effecting a green shift. Public procurement is a powerful tool with which cities and municipalities can choose more sustainable options and set requirements that impact the development of the whole industry. It is crucial that public operators take on this role of trendsetter and lead in promoting sustainability. Many private sector operators depend on public procurement, and it is essential for them to meet public sector's needs and requirements regarding environmental sustainability to be able to compete and bid on tenders. Even though there are challenges in implementing requirements in public infrastructure procurement and public procurement in general, without incorporating environmental sustainability criteria in the procurement process the industry won't develop towards more sustainable ways of operating.

Some participants also highlighted the importance of dialogue between public and private sector. This dialogue is seen as an important factor in setting up realistic environmental sustainability related goals and demands in public infrastructure procurement in accordance with the market's possibilities.

”Well, it (public infrastructure procurement's role in promoting environmental sustainability) is very important. I mean that's how we as a large builder can try to affect the market and make sure that there is a green shift actually taking place. But because the market is still immature and there's not too many of these electrical machineries, we cannot make it an absolute demand. We cannot say that this is a no go if you can't deliver electric machinery, so now we are scoring them for it. But in the future, in 2025, nobody will be able

to work in (the name of the city) without hydrogen or electric machinery. So that's sort of the endpoint of the transformation phase. And obviously public procurement is how we can set these demands so it's very important.” H7

The flexibility in the demands and in the current practice of scoring bonus points for electric machines and other environmental sustainability related aspects instead of setting up strict requirements for those in the public procurement process is necessary due to the immaturity of the market. For contractors there lies a risk in financially investing in electric machinery for example. Additionally, the availability of electric equipment is currently limited affecting the possibilities for contractors to participate in tender bids. However, without setting ambitious demands, there lacks a driving force to steer the market in the desired direction. Therefore, finding a balance becomes crucial, enabling both private and public sector entities to collaboratively shift towards more sustainable practices in their operations.

Majority of the participants emphasized public infrastructure procurement's role in advancing environmental sustainability. However, few participants from medium-sized cities brought up that the impact is linked to the size of the projects and that there are better possibilities in sector's where financial investments are greater. Cities may carry out multiple smaller infrastructure construction projects throughout the year rather than executing large projects such as construction of a highway. While the influence may be more limited in smaller projects compared to large infrastructure projects, the compared impact of multiple smaller projects becomes eventually significant.

“And in building construction the euros are bigger, so everything has somehow developed there better --- and infrastructure construction is lacking behind. But I see that it is easy to direct and control public procurement with money. If things are agreed and wanted, things will get done.” H1

” I mean it's a bit difficult, because when I think of public procurement I just think from my municipal perspective. I mean of course we might build and change a few things in the city. But it's not like those huge infrastructure projects we work with. I mean I think we should be a driver of sustainability. Try to at least change the market a little bit towards a more sustainable direction.” H12

4.2.2 Awareness of Green Public Procurement

Public procurement's role in promoting sustainable development and environmental sustainability in public infrastructure projects is strongly recognized. There are different tools and frameworks with which it is possible to enhance the environmental sustainability of public procurements, for example EU Commission's Green Public Procurement tool. It is a voluntary framework that provides guidance on how to assess and prioritize environmental sustainability aspects in public procurement. When participants were asked whether they are familiar with the GPP tool and is it utilized in their organization, the answers were uncertain despite the size of the city.

"This tool is not familiar. Most likely it is not utilized in our organization." H3

"I've never heard about it so I would say no." H10

"I don't know of it, so I don't think it's used." H12

Some of the participants were slightly familiar with the GPP tool, or at least they had heard about it. The GPP tool and its utilization is not something that appears to be common in the daily work of the participants, even if they work on strategic level of public procurement and coordinating the sustainability aspects in those.

"The word is familiar, but it doesn't appear in our daily work." H1

"Yeah, a little bit but not that much. I have colleagues that work through that but.. Well, they work with the procurement, so they have to know about this tool." H13

"I'm not that specific on that one. There are some people in our organization that work with buying and help us when we have these competitions. If we have it, they know it. We are very loyal to the European Union." H14

The unfamiliarity of the GPP tool among participants was somewhat surprising since Finland and Sweden are part of the European Union (EU) meaning that their public procurement is regulated by EU directives. Also, Norway is a part of the European Economic Area (EEA) and voluntarily aligns itself with many EU directives and regulations, also related to public procurement. However, the GPP tool is a voluntary tool that only provides a framework that can be utilized to enhance public procurement's environmental sustainability alongside the mandatory legal framework, based on EU directives. As Sapir et al (2022) argue, the limited adoption of GPP in countries' contract procurement can be partially explained by its optional

nature. The GPP tool offers an additional mechanism to incorporate environmental sustainability into public infrastructure procurement. Even though some of the participants work more on a strategic level related to public procurement the level of familiarity with the GPP tool is surprising, considering that Nordic countries are pioneers in utilizing GPP as Rosell (2021) argues, and the proportion of GPP in contracts is higher there than for example in East European countries. However, as emerged from the empirical data, it is possible that other entities within the target cities might be utilizing the GPP tool to implement environmental sustainability into their procurement processes.

4.2.3 Needed support to enhance public infrastructure procurement's environmental sustainability

All the participants highlighted in the interviews their organization's commitment to environmental sustainability goals. All the cities at target aim to develop their public infrastructure procurement practices to be more sustainable and to consider environmental impacts more effectively. However, there are factors that are hindering the adoption of more environmentally friendly practices. When participants were asked about what kind of support is needed from other sectors, including private sector, national level, EU level, or any other stakeholder, to promote more sustainable practices in procurement, financial support and measures were highlighted in the answers. Investing in electric machinery for example, is an economic risk for contractors, and state governments should minimize these risks with financial support and regulations to make it easier for private and public sector actors to invest in more environmentally friendly equipment and operations. Financial support from EU level, national governments, and organizations is necessary to make sustainable solutions more affordable and accessible.

“There is a need for decent development support and financial contribution from the European Union so that the prices of sustainable solutions would not increase enormously. --- And also, the production of renewable energy is something that society should support more financially, so it would be less expensive to implement or acquire them” H4

“Price policy is one thing that the state can affect, for example taxation.” H6

Also, the role of clear goals, demands and regulations from EU level and state governments were highlighted in the answers, since those are the ones that eventually form the frameworks for municipal level practices as well. The alignment between higher-level

policies and goals, and local-level practices is essential for success in sustainable development.

“Well, what would be needed from central governments is of course to set the direction and set specific goals and demands.” H7

“I think that the key to success is that the government tells that this is what we’re going to do. --- So, the government has to be very sure about what they want us to do and they have to stand by what we are going to do.” H8

“It must be regulated, so it shouldn’t be a choice should we reach the goals or not. When the European Union or Swedish government regulates stuff, that has a direct effect.” H13

Clear goals and demands set by governments provide a shared vision for all the stakeholders which fosters a more coordinated effort towards the aimed change. The central role of cooperation and open dialogue between different stakeholders also stood out in the participants’ answers to the question regarding needed support to enhance sustainable practices. Cooperation between cities, companies, and organizations was also emphasized as an essential factor in driving change and implementing more sustainable practices in public procurement and infrastructure construction industry in general.

“It’s important to have a good dialogue with the people and companies that are potential suppliers.” H12

“Communication and cooperation. I’m sure we will get the big results by better cooperation between the different organizations and different municipalities. I think that is a key for getting better results.” H11

“I believe that the whole infrastructure construction sector can develop these things if we form a united front. Also, the municipal association is quite an important factor in this matter. Through those it is possible to develop frameworks and good practices. So, collaboration between larger cities and networks.” H3

Additionally, the central role of expertise and better leading, education, innovation, and courage also in politics emerged from the empirical data as important factors that are needed to support the implementation of more environmentally friendly practices in public infrastructure procurement.

“We need better in-house management and real experts that know what they are talking about. They can help and support us in developing these practices and achieving our goals in our procurements.” H1

“Education is always something that should be utilized more.” H4

“I think innovation is the key. We really have to think differently and to do things differently. So, I really believe innovation can come from both the public sector and private sector.” H5

Braking away from traditional, less sustainable practices requires courage and cooperation between multiple sectors. More ambitious and clearer goals from higher-level operators are required to successfully implement more environmentally friendly ways of operating in public infrastructure procurement. As Edler and Georghiou (2007) discuss requirements and demands play a substantial role in driving innovation, which was also identified in the empirical data as a key aspect in promoting environmental sustainability of public infrastructure procurement.

4.2.4 Current situation regarding the environmental sustainability requirements in public infrastructure procurement

Public operators are increasingly adopting more environmentally friendly practices within the public procurement process. Public infrastructure procurement process includes a broad variety of requirements that affect the selection of contractors and suppliers, and overall execution of the projects. While cities aim to achieve their sustainability goals and strategies, the implementation of environmental sustainability requirements in public procurement process is essential. In the interviews, the participants were asked about existing requirements related to multiple environmental sustainability aspects. Existing requirements vary depending on the country in which the target cities are located, due to differences in national legislations and policies. Also, the size of the city seems to affect the implemented requirements, since cities in size category “large” have more competition in tender bids than medium-sized cities, leading to the fact that there are more companies that are more likely to able to meet the requirements.

The most highlighted, existing environmental sustainability related requirements that emerged from the empirical data include criteria regarding machinery that is used at construction sites. These requirements are based on the EURO and Stage emission standards

regulated by EU directives. These classifications set the standards for vehicle emissions and fuel efficiency playing a significant role in advancing more environmentally friendly transportation and addressing vehicle emissions' environmental impact. Also, requirements regarding electrical machines on construction sites are developing quickly.

"We have equipment and emission related requirements implemented in the procurement process." H1

"There's a lot of technical requirements about the vehicles. About how much reduction they have to have in each project, and we're updating these requirements right now. --- We have these requirements about EURO class vehicles. We have the requirements about the latest EURO VI." H13

Additionally, measures regarding noise pollution, air pollution and particles, construction site water management, as well as criteria for waste management and reuse of materials are present in the procurement process. The demands regarding these are mostly defined by national environmental legislation and permits and national environmental programs.

"We have noise limits at construction sites for example, and all that stuff. And all those limits come from the environmental legislation." H4

"Yes, so we have requirements, and they are mostly to follow the guidelines from the environmental agency of Norway, they have guidelines there and thresholds and all that. And it's something we follow during the construction from our side with people. And we make sure that, for example water is used to take down all particles created by earth work at construction sites." H5

However, when participants were asked about what environmental sustainability requirements are currently implemented in public infrastructure procurement, in some answers it appeared that specific requirements in the procurement process are still relatively scarce. In the procurement process actions that promote environmental sustainability mainly serve as factors that offers bonus points, rather than being strict demands. It also emerged that the environmental sustainability goals and demands are implemented through planning and are not determined in contract programs.

"I would say that we don't actually have any specific requirements in our normal infrastructure construction projects currently. ---If there are goals and requirements related

to recycled materials for example, those come through plans, so there is nothing specifically determined in our contract programs.” H2

“I would say that in our normal infrastructure contracts there aren’t any specific requirements.” H3

However, there were differences between the target cities, and large cities in Norway stood out with the strictest requirements and the in the procurement process. For example, one city has energy efficiency requirements for the construction booths and in another large city implements requirements regarding the use of biofuel in each project.

“We do have demands for the construction booths. We have demands that they have to be in accordance with the energy demands for houses. They have to have double layered windows and LED lights. Also, the lights on construction sites should be censored, so when no one is on the construction site there shouldn’t be any light on.” H8

“We set up requirements of example for biofuel in each project we have.” H10

In summary, there are multiple different environmental sustainability aspects that are considered in public infrastructure procurement including waste management, air and noise pollution, biodiversity conservation and energy efficiency to name a few. These considerations are mainly implemented in infrastructure procurement through environmental legislation and policies and are widely regarded in the planning phase of the procurement. Somewhat surprisingly, there are still relatively few strict environmental sustainability requirements implemented in the procurement process itself, and many environmental sustainability promoting actions are served as factors providing bonus points in the selection process of contractors. However, cities and municipalities are committed to developing environmental sustainability criteria in their procurement to meet the ambitious global and local environmental sustainability goals, and especially requirements regarding electric machinery at construction sites are getting stricter. For example, couple of large cities in Finland are committed to the Green Deal that is aiming at zero emission construction sites by the year 2025, which will affect the implementation of new criteria and demands in the public infrastructure procurement. To improve the environmental sustainability criteria in public procurement cities and other public organizations are also collaborating with each other. For example, in Sweden, large cities are collaborating with each other and the Swedish central department of traffic, to work together with developing the requirements.

“We have this cooperation between the three largest cities in Sweden, and also the central department of traffic in Sweden (Trafikverket) And we work with the requirements for public procurement. And the purpose of it is to lift the whole industry a level, and then we can have some sharper requirements in each town.” H13

4.2.5 Challenges in setting up requirements

Even though public operators have implemented multiple requirements and criteria in public procurement process, there are also challenges and downsides to setting up requirements that promote sustainable practices. When participants were asked about these challenges in implementing requirements, the increase in cost was highlighted. Incorporating more environmentally friendly and sustainable practices in infrastructure procurement process often requires investment in new equipment and technologies both from the cities and the contractors. Smaller construction companies may have financial limitations that affect investing in electric machinery for instance. This of course affects the tendering phase of public procurement if only larger companies can bid because they have larger budgets and possibilities in investing for more environmentally friendly equipment.

“Money, because obviously it can be more expensive to set very ambitious requirements. And maybe there is less competition and then we don’t get as good offers.” H12

“Smaller companies and entrepreneurs may not have possibilities in investing in equipment and tools as fast as we would want them to. And that affects the tender competition if only larger companies are able to bid.” H6

Additionally, the lack of availability on the markets regarding construction machinery is affecting the incorporation of requirements in public infrastructure procurement. Public operators also need to justify their decisions in procurement regarding economic aspects, and often budget limitations stand in the way of choosing more environmentally friendly and more expensive practices.

“The situation in the global markets affects the availability of machinery. Special equipment and machinery, like electric machinery, has very long delivery times. So, the financial and delivery realities create limitations.” H3

Although, cost and availability related challenges are existing realities in the market, a few participants brought up the increase in cost in public procurement is not necessary a

downside but rather an essential, shorter period step in changing the market and adopting a more far-reaching approach. Public operators should choose more environmentally friendly practices in public infrastructure procurement despite their higher cost to achieve the aimed sustainability transition in the market.

"And of course, it costs more money to implement those measures and I believe it's what procurement is here for; us to have this purchasing power to make the new solutions mainstream. So, I don't think it's really a downside if it costs more money because I think it's part of the process." H5

In addition to the global availability challenges of electric machines, it was also brought up that the limitations of power infrastructure affect setting up requirements in public procurement. Although electric machinery would be available, ensuring the necessary power for them at construction sites is sometimes impossible.

"Using electricity isn't that easy. You have to have electric current at the site. And it's not everywhere you have enough current in the system to use. --- We have to think differently about how we design the projects to make it easier to implement those new electrical machines." H14

Also, national laws and regulations have an impact on implementing different requirements in public procurement. In Sweden, the use of technical requirements in public procurement is limited by the national law. Cities are not able to include specific technical requirements in the procurements, because the law does not allow it.

"One problem all cities in Sweden have, is this law saying that we are not allowed to put technical requirements in the procurements. We may be able to say that we need a function, but we cannot say that we would like to buy something with very specific technical requirements." H9

Additionally, national regulations affect setting up requirements about reusing and recycling materials. To guarantee recycled materials' quality and safety, certification, and testing of them is required, which of course requires resources from public operators. Also, especially in areas where there exists groundwater, there is limitations that affect the use of recycled materials and circular economy practices.

“We are located on above groundwaters, which creates challenges in setting up requirements regarding reusing materials. And most of our projects are on top of groundwater areas, so in the end we are rarely able to use recycled materials in our projects due to the MARA regulation (national regulation on the utilization of certain waste materials in land construction).” H2

“For example, recycling and reusing concrete there are quite strict specifications. It should be proved and verified that the material is clean and does not contain oil or fuel spills or other things in the structures. And ensuring this of course causes more reports and trouble for us. But we have tried to do this.” H4

Despite these obstacles, there is an increasing interest among public operators in reusing materials and especially utilizing excavated land masses more. However, in urban spaces the lack of space for storing the materials creates challenges in implementing this.

“There is a challenge of finding space if we want to just store earthwork in between digging it up and using it for filling again. And that’s the biggest problem when we’re working in cities that there’s no space.” H5

Participants also brought up that sometimes environmental sustainability related requirements in public infrastructure procurement creates contradictories. Setting up a requirement to be able to reduce one environmental impact may create other environmental impacts that end up decreasing the overall sustainability of the infrastructure procurement. For example, utilizing quiet asphalt for pavements and roads reduces noise pollution significantly. However, quiet asphalt’s resistance to wear is weaker than regular asphalt’s, resulting in more frequent maintenance, which in turn increases the infrastructure’s environmental footprint. The same applies to the goal of decreasing the use of energy, but at the same time setting up for requirements regarding electric machines to decrease emissions. Additionally, demanding the use of certain more environmentally friendly materials for infrastructures may require long transportation distances, which also has environmental impacts.

“We have utilized quiet asphalt for example. It decreases the amount of noise pollution significantly but then there is the problem that its wear resistance is much weaker. And it requires more frequent maintenance.” H4

“We have it in the environmental plan to reduce the use of energy, but at the same time we want them (the contractors) to use electric machines which of course requires energy.” H8

In addition, the lack of clear goals due to challenges in measuring public infrastructure procurement’s environmental impacts creates challenges in implementing requirements in the procurement process. Furthermore, since projects can vary substantially, too detailed requirements in infrastructure procurements may not be applicable to all projects. Also, the uncertainty of the future limits placing demands regarding emissions and technical development for instance. The lack of updating the existing standards and handbooks for environmental sustainability was also brought up as a problem in terms of incorporating new requirements.

“The difficulty in this is that the technical development is difficult to see. If we have requirements about zero emission vehicles, the future is very unclear. You don’t know how it looks and what is the next thing and so on. And if you have a contract that last for maybe four years, it could happen a lot in that time, and it’s really difficult to set these requirements.” H13

Overall, numerous challenges and limitations affect the implementation of environmental sustainability requirements in public infrastructure procurement. Finding a balance between ambitious requirements and practical feasibility presents a significant obstacle. Furthermore, a holistic approach and informed prioritizing in public infrastructure procurement is essential for establishing requirements that promote long-term sustainability.

4.3 Digital tools in public infrastructure procurement

In this part of the chapter, I present the findings on digital tools and their role in enhancing public infrastructure procurement’s environmental sustainability. Additionally, I address the challenges that public operators face when implementing different digital tools to improve environmental sustainability in public procurement process. During the interviews there was no specific definition for digital tools, and each of the participants answered the questions based on their experiences in their daily work. If the digital tools had been better defined in the interview questions, for example according to the digital tools used in different stages of the infrastructure life cycle, the answers could have been more in-depth.

4.3.1 The role of digital tools

When participants were asked about the role of different digital tools in reducing the environmental impacts of public infrastructure procurement and enhancing sustainability, the significant potential of digitalization was well recognized.

“I’m sure that digital tools enable lot in the future regarding enhancing environmental sustainability” H1

“I would guess that if you use it right, the potential would be enormous.” H14

Digital tools are broadly used in different stages of public infrastructure procurement process both on strategic and operational level. The role of digital tools in the planning phase of the procurement process is emphasized and the role in connecting different stakeholders throughout the procurement process.

“ I think it's very important to have these tools because then more people can be involved and make a good work without knowing everything in detail. So, if we can trust the digital tools that what they produce is safe and right, I think it can contribute a lot to help more parts of the municipal organization to do good work, good job in these questions. So, I think it's very important.” H9

The awareness of possible tools that could be utilized in different phases of the infrastructure procurement varied between participants depending whether they work more on a strategic or operational level. Participants whose daily work is related to the infrastructure construction phase addressed the significant possibilities there lies in that phase of the procurement in promoting environmental sustainability, but the digital tools need to be incorporated already from the planning phase of the procurement to be able to effectively affect the procurement’s environmental impact. As an example, building information modelling (BIM) was mentioned as a central approach to be able to reduce environmental impacts of the construction phase.

“I would say that BIM approach in construction is in central role. In terms of the infrastructure’s life cycle, it will be more accurate, and not as much waste will be created. Having more detailed plans enables better construction --- so, through that digitalization can also save natural resources.” H3

Overall, public authorities recognize well the potential of digital tools in enhancing public infrastructure procurement's environmental sustainability. However, it would be beneficial to increase the awareness of different digital tools that could be implemented into different stages of the procurement process for the stakeholders to build a more holistic understanding of the entire process. This could lead to more efficient and transparent procurement processes.

4.3.2 The benefits of using digital tools

Different digital tools play significant role in advancing the environmental sustainability of public infrastructure procurement process. It emerged from the empirical data that the utilization of digital tools enables better data collection and analysis providing better insights and enabling more informed decision-making throughout the procurement process. Tools like climate calculations can help assess the environmental impact of different solutions in different life cycle phases of infrastructure for example. Participants brought up that digital systems can also enable better monitoring and management of assets and resources, such as energy and water usage, and help reduce emissions and waste, in addition to enabling better prioritizing. Digitalization plays a key role in data-driven management which is essential in promoting environmental sustainability and avoiding future risks. Data-driven management in public infrastructure procurement process is also important from the economic point of view since it helps assessing carrying out the project in accordance with the planned schedule, possibly even resulting in financial savings.

"The aim is to incorporate BIM approach in all the projects as data modelled. And we have tried to do this with using Infrakit. This approach helps to minimize waste digging and waste filling and makes mass management easier overall. --- So, probably the schedule and therefore maybe the financial benefits as well." H6

"The digital way of work makes us use better decisions. And the digital ways of different kinds of tools on personal computers and so forth, makes us better to simulate and to make better decisions, so what kind of solutions should we make." H14

My findings on the benefits of using digital tools in enhancing infrastructure procurements' environmental sustainability are supported by previous research. Digital tools and approaches utilized in infrastructure projects enables better data management and optimization of resources (Bapat et al. 2021). From the empirical data also emerged the

potential of digital tools in providing better overall situational picture of public infrastructure procurements as well as digital tools' central role in enabling better follow up of procurements. Successful follow up and overall picture of procurements are important in regards of public operators to be able to carry out successful projects in the future as well. Different digital tools also assess the collaboration and involvement of different stakeholders throughout the whole project. During the infrastructure construction phase especially the digitalization of emissions calculation for example, helps public operators' work regarding project follow up which is essential in setting up criteria for the future as well.

“Digital tools make our work easier. If there are ready-made concepts with the help of which we will be able to make procurement for example comparable or to get help assessing criteria. Or if in the procurement phase contractors show that they use some kind of a program, for example for emissions calculations or something like that --- these ready-made services ease our work, and we don't have to create Excels or things like that along with other work.” H2

Overall, the empirical data implies that the integration of different digital tools into public infrastructure procurement has great potential in advancing environmental sustainability, efficiency and transparency of the procurement projects resulting also in economic benefits. Utilization of digital tools enables better data-driven decision-making, project management and prioritizing, ensuring more successful future projects in terms of sustainability. Digital tools are in a central role in making collaborative participation seamless for different stakeholders during the procurement process. Digitalization has enormous potential to improve sustainability in infrastructure projects, but it also needs to be managed thoughtfully to minimize its own environmental footprint.

4.3.3 Challenges in using digital tools

Even though digital tools play central role in promoting environmental sustainability in public infrastructure procurements and are broadly used by public authorities, there are several challenges to overcome for the effective utilization of digital tools. One of the most emphasized challenges that emerged from the empirical data is the lack of standardized tools. Even though digital tools enable more effective collection of data, the standardization of it can be challenging. Different stakeholders may use different data collection methods and measures for assessing sustainability, which makes it difficult to compare or track

sustainability progress in a meaningful way. Operators on public and private sector may each use different software and methods in measuring environmental impacts, which leads to significant variations in results. Standardization in tools and systems across the industry is an essential step in ensuring reliable comparisons and consistent data.

“If we talk about these tools, it would be the most beneficial for public operator and purchaser that the tools that are used are pretty similar nationally. That the used software would work on the same principle and use similar base data and the calculation principles would be consistent.” H2

Related to the challenge regarding lack of standardization in measuring environmental impact, another challenge that public operators face in public procurement is insufficient data management. Digital tools help in collecting vast amounts of data, but processing and analysing it creates struggles. Ensuring reliability of the data, understanding various technical numbers, and selecting the right data points for analysis are something that the participants highlighted in their answers as challenges.

“You have a lot of problems, first of all you have to collect it and you have to control the data, is it correct, and can we combine it, or is it just making false results. So, that's a challenge at least to understand the data. And then you can end up with making some wrong decisions. If you make a decision on false data collections.” H11

Another most emphasized challenge that emerged from the empirical data is the difficulty of obtaining an overall view. Simultaneously this was the most highlighted possibility that digital tools could offer, but currently the implementation is still lacking. Cities have many ongoing infrastructure procurements resulting that it is challenging to form a comprehensive overview of the organization's performance and progress regarding environmental sustainability. This also creates difficulties in defining and measuring their goals, for example in terms of reducing carbon emissions.

“We have approximately 400 infrastructure construction projects going on at the same time. The overall management is quite difficult and there are challenges in gathering all that information and an overall picture.” H4

“Digitalization needs to develop in a way where the data is ready collected, and automatically forms an overall picture.” H1

Other aspects that emerged from the empirical data regarding the challenges and limitation of the utilization of digital tools in promoting public procurement's environmental sustainability are lack of competence and resistance to change. When participants were asked about challenges and limitations in utilizing digital tools, it appeared that the use of digital tools and different software may be challenging, and employees' digital competence is insufficient. Public operators also have challenges in finding resources in educating the employees in the use of digital tools, among the lack of resources working with environmental sustainability in public procurement process in general. Digital tools should develop in a way where the collected data is in ready-to-use form and builds an overall situational picture automatically. This would decrease the amount of manual work and required resources in data management and analysis.

"We don't have enough resources. We have tried collecting all kinds of data resulting enormous amount of it. And then we are not able to utilize it." H1

"We see that the tools are very hard to understand and hard to learn." H8

"I would say competence is a limiting factor. And we are in a lucky situation where we usually can buy what we think is necessary, but you know we have to have people to use it. And it makes it necessary to work in a different way and you need a different kind of knowledge." H14

In addition to the lack of competence, resistance to change is also a challenge that public operators face when incorporating more digital ways of working in their operations. To embrace digitalization fully and to get best out of utilizing different digital tools there is a need for a change in people's mindsets and attitudes. However, societies are digitizing in every aspect, thus resistance to change is a more common problem with older generation rather than the younger one.

"I mean some of the old people don't want to use them, I guess. But you know I think we're way past the point of, I mean we are so used to using digital tools now that we just have to cope with it, I think." H7

One participant also brought up an interesting perspective on digital tools. While those provide significant possibilities in enhancing environmental sustainability of public infrastructure procurement, it is necessary to keep in mind that the use of digital tools also

has its environmental impact. This is a crucial aspect to consider along with the benefits they bring.

“I think that this digital thing has enormous potential. But then again, these digital systems use a lot of current or power. So, I guess it's for the best, but they make a climate footprint. At the end of the day, they also make footprints. --- We are so fascinated with the things that digital tools can help us with, that we forget that they have environmental footprint and there's a downside as well.” H14

Additionally, regarding the digital tools and approaches utilized especially in the construction phase of public infrastructure procurement, one limiting factor that was brought up is that it requires certain equipment and not all contractors have those. Without investing in equipment that support these tools and approaches, such as BIM, contractors may not be able to compete in tender bid.

“Well, the challenge is precisely that it requires certain equipment. But if we put it as a requirement in our contract documents the contractors will have to acquire certain additional things for the machines and equipment.” H6

Overall, there are multiple challenges and limitations that public operators face in utilizing different digital tools to enhance the environmental sustainability of public infrastructure procurement. The advantages and challenges related to the utilization of digital tools are relatively similar regardless of the target country and municipality. To overcome these challenges collaborative approach with different stakeholders is required as well as standardization of measuring environmental impacts.

4.4 Answering the research questions

In the previous chapter I presented the main findings of this study in accordance with the four main themes that emerged from coding the data. In addition to that, answers to the research questions already emerged in the Findings and discussion -chapter. However, in this chapter I will summarize the answers to the three research questions that I presented in the beginning of my study.

RQ1: What environmental sustainability requirements cities use in public infrastructure procurement?

Based on the findings of this study, the environmental sustainability requirements in public infrastructure procurement vary between different cities in the target countries partially based on the size categories of the cities. However, since all the target cities' public procurement is regulated by EU Directives, the minimum requirements are regulated from the EU level and are similar in all the target cities. These requirements include, for example, the emission standards regarding vehicles and machinery that is used on construction sites. These standards include both EURO- and Stage regulation. However, despite these common frameworks, cities have variations in local policies and strategies and allocation of weighted criteria in public infrastructure procurement. For example, in large cities in Norway environmental sustainability criteria is weighed up to 30% in procurement evaluations, while such criteria might not carry the same weight in Finnish and Swedish cities. In addition, requirements regarding electric machines seem to be more developed in large cities in Norway, but also Finnish cities are tightening their demands on them according to Green Deal agreements. In Sweden it is also currently impossible to include specific technical requirements in procurements due to national legislation.

Despite these small variations, all the target cities consider environmental sustainability broadly throughout the procurement process, and environmental aspects are also guided by national environmental laws. Nevertheless, the actual integration of specific environmental requirements into public infrastructure procurement is still somewhat limited, and there is a lot of room for improvements. Since the knowledge about specific environmental requirements varied relatively much between the interviews, conducting a study with quantitative methods and larger sample is required to answer the research question more comprehensively.

RQ2: What are the main challenges in implementing sustainable practices in public infrastructure procurement?

The main challenges that cities face in implementing sustainable practices in public infrastructure procurement are financial constraints and availability limitations regarding electric machinery which hinders the aims regarding zero emission construction sites. Public operators are unable to implement environmental sustainability requirements in their public infrastructure procurement, since the price of the procurement would rise too high, and the current market is immature in a way that private sector operators, such as contractors and suppliers would not be able to meet the requirements.

There is also a lack of clarity in environmental sustainability goals which affects the implementation of practices to achieve these goals. In addition to the lack of clarity, the follow up regarding public procurement is difficult which creates challenges in forming a comprehensive overall picture. Proper overall picture of public infrastructure procurement would be essential for public operators to identify the areas of improvements and develop actions regarding those. Furthermore, the unique nature of the different infrastructure procurements, limits the implementation of strict and detailed environmental sustainability requirements in the procurements since all of them may not be applicable for every project. For example, location above groundwaters limits the adoption of circular economy practices. Additionally, the lack of space for storing reusable materials for later use is a common problem in cities in general, hindering the adoption of circularity in infrastructure projects. In Sweden, the national policies also limit the implementation of technical requirements in the procurement process that would enhance sustainable practices in public infrastructure procurement. Additionally, deficiencies in local power infrastructure limit the use of electric machines at construction sites if the infrastructure there is not able to provide the needed power.

RQ3: What is the role of digital tools in enhancing the environmental sustainability of public infrastructure procurement?

Digital tools play a substantial role in enhancing the environmental sustainability of public infrastructure procurement. By utilizing digital tools in public infrastructure procurement, informed decision-making is more successful, since digitalization enables better data collection and analysis. Digitalization is essential in data-driven management that enhances the overall sustainability of a project for example. Digital tools and approaches can connect people throughout the procurement process enabling better cooperation and transparency between multiple stakeholders. With different digital tools it is easier to measure different environmental impacts and conduct follow up on public procurements. For example, the digitalization of emission calculations during an infrastructure construction project eases the public operators' work on follow up. A proper follow up in turn is essential in terms of succeeding in infrastructure procurements in the future as well.

The use of different digital tools in different phases of public infrastructure procurement has enormous potential in enhancing the procurements' environmental sustainability. The utilization of digital tools and approaches already from the planning phase enables better

project management, decision-making, and prioritizing. Additionally, digital tools and processes in the construction phase of the infrastructure procurement has the potential to facilitate more sustainable construction by making it more efficient. Overall, by utilizing different digital tools and processes in public infrastructure procurement the holistic lifecycle considerations of infrastructure is possible, which is essential in enhancing the environmental sustainability of public infrastructure procurement in addition to its economic benefits.

5 Conclusions

In the final part of this thesis, I provide practical implications and suggestions for future research, as well as elaborate more on the limitations of the study. Additionally, I provide a research summary where I conclude the purpose of my study and summarize the key findings.

5.1 Practical implications

My research on environmental sustainability requirements in public infrastructure procurements and the challenges in implementing those in the procurement process fosters multiple practical implications for various stakeholders. Cooperation between different cities as well as cooperation between public operators and private sector actors is essential in overcoming the challenges in obtaining more environmentally friendly practises in public infrastructure procurement. Open and informative dialogue between the different stakeholders brightens the shared sustainability goals and required actions to achieve them. Advancing contractor and supplier engagement and collaboration public operators can facilitate more meaningful cooperation to address the environmental sustainability issues.

Another important contribution in terms of practical implications I am able to offer with my study, is the information regarding the challenges that public operators face in utilizing digital tools in enhancing public infrastructure procurements' environmental sustainability. By recognizing these challenges and limitations, it is possible to develop digital tools to better meet the needs of public operators. Especially the development of digital tools or approaches that eases the process of forming a comprehensive overall picture of public infrastructure procurements and their environmental impacts is an essential step in identifying the aspects that need improvement and in succeeding in follow-up. The study

also indicates the need for incorporating more expertise in planning and executing of public procurement to lead the environmental sustainability goals into concrete actions in public infrastructure procurement. This includes educating people on the matter as well as the use of environmental sustainability enhancing digital tools.

This study can also serve as a benchmark for comparing environmentally sustainable procurement practises across different countries and sectors. By identifying ambitious yet feasible strategies and best practices from the findings of this study, it is possible to inspire others to adopt these types of approaches. Additionally, my study can provide valuable insights into the gaps and obstacles in current environmental sustainability requirements for public infrastructure procurement in Finland, Sweden, and Norway. This information could be utilized by policymakers and regulatory entities to ensure that they promote environmentally friendly practises effectively.

5.2 Limitations of the study

Although this study resulted in interesting findings and useful insights from public sector operators, it is essential to recognize the limitations of this study. I have done my best to describe my research process and to justify my decisions made throughout it. However, this study has its shortcomings.

With qualitative approach, the aim of my study was to explore what environmental sustainability requirements cities in Finland, Sweden, and Norway currently implement in public infrastructure procurement, and what are the hindrances in enhancing environmentally friendly practises. In addition to that, I focused on the role of digital tools in pursuing environmental sustainability in public procurement. This information is essential in terms of product and service development to better address the needs and challenges that public operators face in enhancing the environmental sustainability of public infrastructure procurement. However, due to the small sample size there is limited diversity and representation of perspectives, resulting that the findings only provide local level insights and details of practices in different cities regarding the implementation of environmental sustainability requirements in public infrastructure procurement. This limits the generalizability of the findings to different contexts and drawing broader, comprehensive conclusions. Additionally, qualitative research and grounded theory method are susceptible

to research subjectivity, meaning that my personal viewpoints and interpretations may have affected the analysis and findings, having an impact on the objectivity of this study.

Due to the tight schedule of the research, the depth of analysis and measures to improve research validity had some shortcomings. Conducting member checking would have contributed to the validity of the research and greater time resources would have enabled a deeper analysis of the empirical data. In addition, an even distribution of interviewees between the different cities and countries, as well as interviewing people with similar job titles would have increased the comparability of the findings between the target cities. Despite the shortcomings of this study, the findings are useful and provide interesting insights from multiple people working in public organizations. With further research for instance with quantitative methods it is possible to gain deeper understanding of the topic and to form a more comprehensive overall picture.

5.3 Suggestions for further research

To build upon the findings of this study I will give a few suggestions for future research. Since the scope and sample of my research was relatively small, and the aim was to only provide insights on different practices on a more local level rather than building up a comprehensive overall picture of practices in different countries, there is a room for a study on the topic with a larger scope. It could be valuable to do similar research with a broader scope and have more cities at target from the same countries, to gain more information on these matters. Also focusing on smaller municipalities in Finland, Sweden, and Norway could provide valuable insights since their unique challenges and resource limitations could lead to creative solutions that could be utilized also in a broader context.

In addition to that, the study could be broadened to other countries and continents as well, which could serve for a comparative study on environmental sustainability requirements and practices in public infrastructure procurement globally. By studying the topic in various countries worldwide it could be possible to identify trends and challenges in implementing more sustainable practises in public procurement globally which would be valuable in developing innovations and approaches to shape sustainable procurement on a broader scale. Also incorporating quantitative methods to complete the qualitative insights is something that the future research could contribute to.

Additionally, conducting a study on the same topic and incorporating multi-disciplinary perspectives, for example from urban planning, economics, and environmental and social sciences, could enrich the research. Collaborating with more experts in various fields would offer diverse viewpoints which is essential in gaining a more holistic understanding of the subject. Based on the findings it would be also beneficial to do research on how to improve collaboration and open dialogue between private and public sector to be able to better succeed in shared sustainable development goals. Yet another interesting suggestion for future research would be to explore the differences in people's awareness of the complex environmental sustainability challenges and environmental sustainability in public infrastructure procurement at different levels within organizations. This could contribute to a better understanding of the challenges that influence the implementation of more sustainable and concrete practices from the strategic level to the operational level.

5.4 Concluding remarks

This qualitative research aimed to explore the environmental sustainability requirements in public infrastructure procurement in cities in Finland, Sweden, and Norway, in addition to identifying challenges in implementing sustainable practices, and examining the role of digital tools in enhancing environmental sustainability of public infrastructure procurement. Grounded theory approach was used in this study and the empirical data was collected through 14 individual interviews with participants from 8 different cities. All the participants are somehow involved in public infrastructure procurement process. This study was commissioned by Infrakit Group Oy, to better understand public operators needs in public infrastructure procurement. Based on the knowledge provided by this study it is possible to develop the product and services to better meet the needs of public actors in enhancing the environmental sustainability of infrastructure procurement.

Considering my personal interests and motivation behind this study, it was interesting to learn more about public procurement and the infrastructure sector and how environmental sustainability is considered there. Based on the findings of this study there is a significant potential for the development of environmental sustainability in public infrastructure procurements. I argue that more research with quantitative methods is necessary to get a comprehensive overall picture of the sustainability practises implemented in public infrastructure procurement within the target countries. A holistic understanding of the

current situation is essential for improving the implementation of concrete practices in the procurement process.

Despite the shortcomings of this research, my findings are valuable for both public and private sector operators and can help finding solutions with which it can be possible to better achieve the shared environmental sustainability goals. Consequently, I will summarize the main findings of this study.

Firstly, the environmental sustainability goals are very similar in all three countries, as their procurement processes are regulated by the same EU directives. Based on these directives, for example, European emission standards have been included in the procurement requirements. However, the local policies and the weighted criteria in public infrastructure procurement vary among the target cities. In large cities in Norway, the environmental sustainability criteria are weighed up to 30% while this is not the case in Finnish and Swedish cities. Though, environmental sustainability aspects are considered throughout the procurement process, and these aspects are also governed by national environmental law, there is still relatively small number of actual environmental sustainability requirements integrated into the public infrastructure procurements. This creates opportunities for these countries to collaborate and share their best practices.

Second, the main challenges in implementing sustainable practices in public infrastructure procurement are related to financial constraints. Price is still the main priority in public infrastructure procurement and environmental sustainability requirements are not yet equal to the price in the procurement process. The implementation of more sustainable practices in public infrastructure procurement process is also limited by the market realities, since with too strict and ambitious demands, local contractors and suppliers may not be able to meet the requirements which affects the tender bidding phase negatively. Additionally, ambiguities in concrete environmental sustainability goals and challenges in measuring them, creates difficulties for public operators in implementing concrete sustainability actions in the procurement process. To improve the environmental sustainability in public infrastructure procurements the cooperation and open dialogue between multiple stakeholders is something that needs to be developed further.

Third, digital tools play a key role in enhancing the environmental sustainability in public infrastructure procurement. There is especially a need for digital tools and processes that help building an overall picture of the infrastructure procurement and assessing the

environmental impacts throughout infrastructure's whole lifecycle. This is important for successful data-driven management and prioritization.

To conclude, public operators have significant possibilities in enhancing the environmental sustainability of public infrastructure procurement, and by setting requirements they play a key role in pushing the overall market towards more sustainable practices. Clarification of common goals and the collaboration among different stakeholders, in addition to integrating digital tools more effectively hold the promise of fostering public infrastructure procurement practices and promoting sustainable development. I encourage public operators in Finland, Sweden, and Norway to be courageous in implementing more environmentally friendly practises in their procurement and continue their work as pioneers in this field. Especially in infrastructure industry there are many opportunities to make a significant impact, hence public infrastructure procurement has promising possibilities in shaping the industry and encouraging contractors to adopt more environmentally friendly practices. Public actors must boldly take on the role of trendsetters as promoters of environmental sustainability by setting up requirements, since they have the ability to influence the market and private sector practises towards sustainability with their purchasing power.

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Appendix 1: Interview guide

Interview guide in Finnish and in English.

Haastattelurunko

1. Lämmittely- ja taustoituskysymyksiä

- a. Tehtävänimike ja päätehtävät?
- b. Aikaisempi koulutus ja ura?
- c. Minkälaista kokemusta löytyy liittyen julkisten hankintojen ja erityisesti kaupungin infrahankintojen ympäristölliseen kestävyYTEEN?
- d. Onko infrahankintojen ympäristöllinen kestävyys ollut ajankohtainen asia kaupungissanne?

2. Yleisiä kysymyksiä julkisiin hankintoihin ja infrahankintojen ympäristölliseen kestävyYTEEN liittyen

- a. Missä roolissa näet julkisten hankintojen olevan kestäväN kehityksen edistämisessä ja infrahankkeiden ympäristövaikutusten vähentämisessä?
- b. Mitkä ovat pääprioriteetteja julkisissa infrahankinnoissa?
 - i. Mitkä ajurit vaikuttavat näihin prioriteetteihin?
 - ii. Mitä eri ympäristöllisen kestävyYDEN ulottuvuuksia tiedät otettavan näissä hankinnoissa huomioon?
 - iii. Kuinka infrahankintojen ympäristöllisen kestävyYDEN vaatimukset ovat linjassa kaupungin kestäväN kehityksen tavoitteiden kanssa?
- c. Mitä ympäristöllisen kestävyYDEN vaatimuksia tiedät tällä hetkellä käytettävän julkisiin infrahankintoihin kaupungissanne?
 - i. Mitä hyötyä näet näiden vaatimusten tuovan?
 - ii. Mitä haittaa näillä vaatimuksilla voi olla tai mitä haasteita näet niiden asettamiselle?
 - iii. Kuinka ympäristöllisen kestävyYDEN vaatimukset sisällytetään hankintaprosessiin ja kuinka niitä arvioidaan urakoitsijan valintaprosessissa?
- d. Onko EU Komission Vihreiden julkisten hankintojen (Green Public Procurement, GPP) työkalu tuttu?
 - i. Tiedätkö, hyödynnetäänkö sitä organisaatiossanne?
 - ii. Minkälaista tukea näkisit tarvittavan valtiotasolta, yksityiseltä sektorilta tai muilta sidosryhmiltä, jotta julkisten infrahankintojen ympäristövaikutuksia saataisiin vähennettyä / tai GPP-työkalun hyödyntäminen olisi helpompaa?
- e. Mitä julkisten infrahankintojen ympäristövaikutuksia tiedät mitattavan tällä hetkellä ja miten organisaatiossanne?
 - i. Mitä haasteita ympäristövaikutusten mittaamiseen liittyy?

3. Kysymyksiä julkisten infrahankintojen ympäristölliseen kestävyteen liittyen teemoittain (näkökulmia hankintaprosessin ja infran elinkaaren eri vaiheisiin?)

- a. Kasvihuonekaasupäästöt / ilmastonmuutoksen hillintä
 - i. Miten kasvihuonekaasupäästöt otetaan huomioon ja mitä niihin liittyviä vaatimuksia tiedät olevan julkisissa infrahankinnoissa organisaatiossanne?
- b. Ilmastonmuutokseen sopeutuminen
 - i. Miten ilmastonmuutokseen sopeutumisen otetaan huomioon, ja mitä vaatimuksia tiedät olevan julkisissa infrahankinnoissa tähän liittyen organisaatiossanne?
- c. Ilmansaasteet ja -epäpuhtaudet
 - i. Miten ilmansaasteet ja -epäpuhtaudet otetaan huomioon, ja mitä vaatimuksia tiedät olevan julkisissa infrahankinnoissa tähän liittyen organisaatiossanne?
- d. Vesien saastuminen
 - i. Kuinka vesien saastuminen ja sen torjunta otetaan huomioon, ja mitä vaatimuksia tiedät olevan tähän liittyen julkisissa infrahankinnoissa organisaatiossanne?
- e. Melusaaste
 - i. Kuinka melusaaste ja sen vähentäminen otetaan huomioon julkisissa infrahankinnoissa ja mitä vaatimuksia tiedät olevan tähän liittyen organisaatiossanne?
- f. Biodiversiteettikato
 - i. Kuinka biodiversiteettikato ja luonnon monimuotoisuuden suojeleminen otetaan huomioon julkisissa infrahankinnoissa, ja mitä vaatimuksia tiedät olevan tähän liittyen organisaatiossanne?
- g. Energiatehokkuus
 - i. Kuinka energiatehokkuus otetaan huomioon julkisissa infrahankinnoissa, ja mitä vaatimuksia tiedät olevan tähän liittyen organisaatiossanne?
- h. Jätevirrat ja kiertotalous
 - i. Kuinka jätevirtojen minimointi ja kiertotalouden hyödyntäminen otetaan huomioon julkisissa infrahankinnoissa, ja mitä vaatimuksia tiedät olevan näihin liittyen organisaatiossanne?

4. Kysymyksiä digitalisaatiosta osana infrarakennushankkeiden ympäristöllisen kestävyden edistämistä

- a. Missä roolissa näet digitaalisten työkalujen olevan julkisten infrahankintojen ympäristövaikutusten vähentäjinä?
- b. Millaisia digitaalisia työkaluja tiedät tällä hetkellä kaupungissanne käytettävän infrahankintojen ympäristöllisen kestävyden edistämiseksi?
 - i. Mitä konkreettisia hyötyjä nämä ovat tuoneet?
- c. Mitä haasteita tunnistat digitaalisten työkalujen käytölle?

5. Lopetuskysymyksiä

- a. Mitä käytännön ratkaisuja organisaationne on löytänyt ympäristöllisesti kestävien infrahankintojen toteuttamiseksi?

- b. Mitkä ovat mielestäsi tärkeimmät ympäristöllisen kestävyuden trendit julkisissa infrahankinnoissa tällä hetkellä?
- c. Onko vielä jotakin muuta, mitä haluaisit nostaa aiheesta esille?

Interview guide

1. Warm-up and background questions

- a. Job title and main tasks?
- b. Educational background and career?
- c. What kind of experience you have regarding environmental sustainability in public procurements or especially in public infrastructure procurement?
- d. Do you think that the environmental sustainability of public infrastructure procurement has been a topical issue in your organization?

2. General questions regarding the environmental sustainability of public procurement and public infrastructure procurement

- a. What is your opinion on public procurement's role in promoting sustainable development and enhancing the environmental sustainability in infrastructure construction projects?
- b. What are the main priorities in public infrastructure procurement?
 - i. What are the drivers that affect these priorities?
 - ii. What different aspects of environmental sustainability are considered in public procurement that you know of?
 - iii. Are the environmental sustainability requirements of public infrastructure procurement in line with your organization's sustainable development goals?
- c. What are the current environmental sustainability requirements in public infrastructure construction procurement that you know of?
 - i. What are the benefits of these requirements in your opinion?
 - ii. What about the downsides or challenges in setting up these requirements?
 - iii. How are the environmental sustainability requirements integrated into the procurement process and how are they evaluated during the selection process of contractors?
- d. Are you familiar with the European Commission's Green public procurement (GPP) tool?
 - i. Do you know whether it is utilized in your organization?
 - ii. What's your opinion on what kind of support is needed from the governmental level, private sector, or other stakeholders in order to be able to reduce the environmental impacts of public infrastructure procurement / in order to be able to utilize the GPP tool more?
- e. What environmental impacts of public infrastructure construction procurement are currently measured and how that you know of?
 - i. What are the challenges in measuring these impacts?

3. Questions regarding public infrastructure procurement's environmental sustainability by theme (views on the different stages of procurement process of infrastructure's different life cycle phases?)

- a. GHG emissions / climate change mitigation
 - i. How are greenhouse gas emissions considered in public infrastructure procurement?
 - ii. Are there any requirements regarding that?
- b. Climate change adaptation
 - i. How is climate change adaptation considered in public infrastructure procurement?
 - ii. Are there any requirements regarding that?
- c. Air pollution
 - i. How is air pollution and its reduction considered in public infrastructure procurement?
 - ii. Are there any requirements regarding this?
- d. Water pollution
 - i. How is water pollution and its reduction considered in public infrastructure procurement?
 - ii. Are there any requirements regarding this?
- e. Noise pollution
 - i. How is noise pollution and its reduction considered in public infrastructure procurement?
 - ii. Are there any requirements regarding this?
- f. Biodiversity conservation
 - i. How is biodiversity conservation considered in public infrastructure procurement?
 - ii. Are there any requirements regarding this?
- g. Energy efficiency
 - i. How is energy efficiency considered in public infrastructure procurement?
 - ii. Are there any requirements regarding this?
- h. Waste streams and circular economy
 - i. How are the minimization of waste streams and utilization of circular economy considered in public infrastructure procurement?
 - ii. Are there any requirements regarding these?
- i. What would you say that are the challenges in setting up requirements for these environmental sustainability aspects?

4. Questions about digitalization's role in reducing the environmental impact of public infrastructure procurement

- a. What role do you see different digital tools playing in reducing the environmental impacts of public infrastructure procurement?
- b. What kind of digital tools you know of that are currently used in your organization to promote the environmental sustainability of public infrastructure procurement?
 - i. What concrete benefits these tools have brought?
- c. What challenges there is that affect the use of digital tools?

5. Wrap-up questions

- a. What practical solutions your organization has found to enhance the environmental sustainability of public infrastructure procurement?
- b. What do you think are the most important environmental sustainability trends in public infrastructure procurement at the moment?
- c. Is there something else that comes into your mind regarding this matter that you want to add?